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INSTITUTE OF SCIENCE AND TECHNOLOGY
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**SCHOOL OF ELECTRICAL AND ELECTRONICS**
**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING**

# UNIT – I – eHEALTH-SECA4004

| SECA4004 | eHealth | | | | | Total marks |
|---|---|---|---|---|---|---|
| | | | | | | 100 |

| Pre requisite: NIL | Co Requisite: NIL |
|---|---|

**Course Objectives**

- To introduce the concepts of eHealth
- To have an in-depth knowledge on medical data analytics and wearable devices used in eHealth systems
- To assess the advantages of eHealth
- To explore the usage of AI in eHealth
- To design and develop applications for eHealth

| UNIT | CONTENTS | HOURS |
|---|---|---|
| I | **INTRODUCTION TO eHealth**<br>Overview and introduction to eHealth and flow of health information-International regulations in eHealth-Advantages, Challenges and future of eHealth. | 9 |
| II | **MEDICAL DATA ANALYTICS AND WEARABLE DEVICES**<br>Health care data and Electronic Health Records (EHR) systems Medical data bases –Wearable devices-Data collection from wearable devices- Clinical use of personal health data- Big data in the field of Medicine. | 9 |
| III | **DIGITAL HEALTH**<br>Introduction to health care digital transformation- Digital health: Tools Strategies of digital health-Technologies in digital health Implementatio of Digital health- Advantages and challenges of Digita health. | 9 |
| IV | **ARTIFICIAL INTELLIGENCE IN eHealth**<br>History of AI in health care-Impacts and Aspects of AI in health care-Current research in AI in eHealth-Regulations and Ethical concerns in using AI in eHealth. | 9 |
| V | **APPLICATION DEVELOPMENT FOR eHEALTH**<br>Introduction to Android, Creating Android Activities, Android Use interface design, Access Wi-fi and Bluetooth with mobile applications Web based App for eHealth applications. | 9 |

**Maximum Hours: 45**

**Course Outcomes**

On Completion Of The Course, Student Should Be Able To

Co1 – Articulate Ehealth And Its Regulations
Co2 – Explore Medical Data Analytics And Records

Co3 – Appraise Digital Transformation in the field of Medicine

Co4 – Analyse Ai In Health Care Systems

Co5 – Design System Level Architecture For HealthInformation Systems

Co6 – Deploy Android Application On Devices.

**TEXT / REFERENCE BOOKS**


1. Shortliffe, Edward H and Cimino James J. Biomedical Informatics, Computer Applicationsin Health Care and Biomedicine, Springer-Verlag London 2014.
2. Lavis, JN (ed). Ontario's Health System: Key Insights for Engaged Citizens, Professionalsand Policymakers. 2016.
3. Hoyt RE, Yoshihashi A, Bailey N. Health informatics: Practical guide for healthcare andinformation technology professionals. Lulu Press. 2014 Seventh edition.
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# UNIT-1 INTRODUCTION TO eHEALTH

Overview and introduction to eHealth and flow of health information- International regulations in eHealth-Advantages, Challenges and future of eHealth.

## 1.1 OVERVIEW AND INTRODUCTION

**e-HEALTH is defined as:**

Application of the Internet and other related technologies in the healthcareindustry to improvethe Access,Efficiency ,Effectiveness,Quality of treatment and Business process utilized by healthcare organizations, practitioners, patients and consumers with the help of next generation networks (NGN) to Improve the health status of patients.

**WHO defines e-Health as...**

**e-Health** is the cost effective and secure use of information and communication technologies in support of the health and health related fields including healthcare, health surveillance and health education, knowledge and research.

**NGN**

**NGN : Next Generation Networks**

With recent trends and technology advancement in the development of converged broadband *next generation networks (NGNs)* and advanced multimedia services, thepotential has increased in delivering of various e-Health services to end users **"anywhere, anytime"**. as shown in figure 1.1


Figure 1.1 Next Generation Network

QoS : Quality of Service

The wide variety of e-Health services impose different *Quality of Service (QoS)* requirements on underlying network as shown in figure 1.2


Figure 1.2. QoS

**QoS Requirements for e-Health Service**

e-Health Service Classification is shown in figure 1.3

e-Health Classification

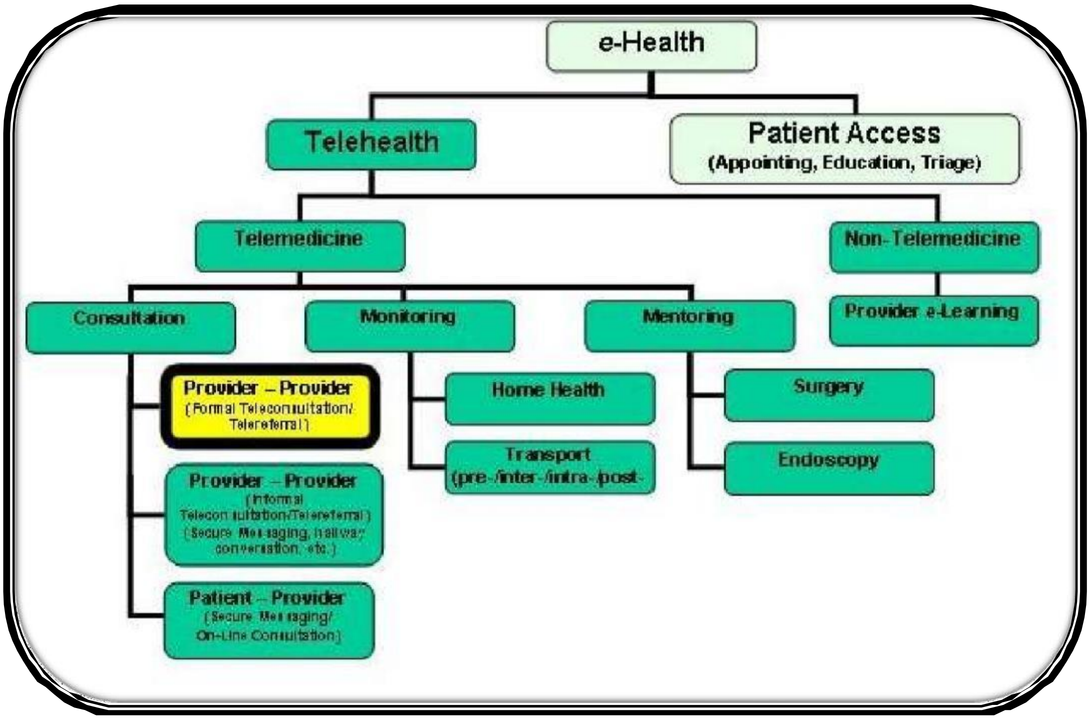



Figure 1.3 ehealth classification

**Tele-Consult or e-consult or Tele-Medicine**

It involves **real-time video conferencing and streaming** of ECG signals between a **patient and a doctor**. The service enables a patient or doctor to initiate an **e-consult session** using an appropriate research prototype client service **media application** as shown in figure 1.4

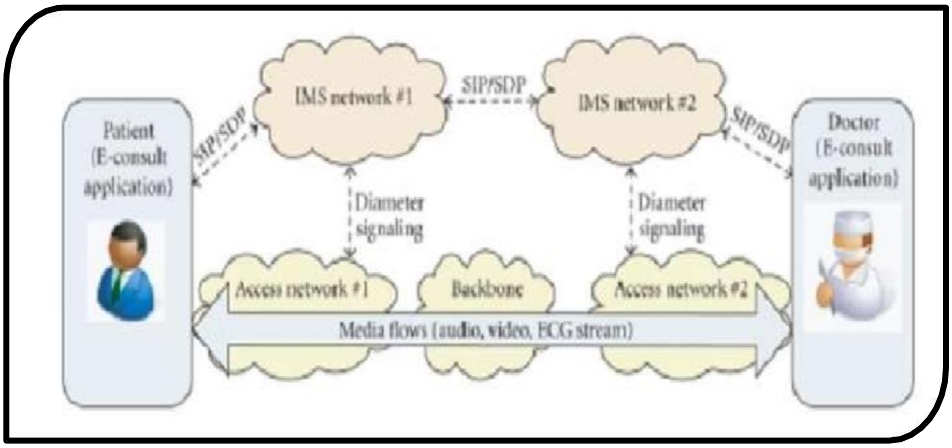



Figure 1.4 Telemedicine

**<u>ehealth Related services</u>**

- Index of available programs and services.
- Calendar of events.
- Patient satisfaction surveys.
- Service provider directories.
- Patient e-mail services.
- Health news.

**m-Health**

- **m-Health** includes the use of mobile devices in collecting aggregate and patient level health data.
- Providing healthcare information to practitioners, researchers, and the patients. It ensures agreat support

Definition of E-Health

- E-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology.
- USF Health points out that e-health uses technology to improve outcomes, certainly, but also suggests that the idea has an additional goal:
- E-Health empowers patients to take an active role in their treatment, allowing them to gain a deeper understanding of their conditions and how to effectively manage them.
- When taken within the context of this definition, e-health could signal an interesting, and potentially seismic shift in the traditional doctor-patient relationship. Using technology to assist in healthcare delivery means that patients have new ways to manage their own treatment. Instead of relying on the physician to provide care, a virtual visit, remote monitoring device, or even a smartphone, can engage the patient in new and sometimes more proactive ways to improve their health. USF Health suggests:
- When patients have e-health resources available at their fingertips, they're better equipped to ask their physicians more pointed questions to understand their conditions and better manage their health. People are more likely to complete treatment plans recommended by physicians when they can research outcomes to learn the benefits of prescriptions, exercises and other health activities designed to improve their conditions. Sharing the burden of their own care increases patient satisfaction, as people are able to gain a deeper understanding of exactly what their physician is doing to help them.

## The 10 E's of E-Health

The implications of this idea are profound and tied to the idea of digital technologies as disruptors to every industry they've impacted, including healthcare. An article in the Journal of Medical Internet Research recommended a framework for the idea of electronics in medicine, providing us with a set of 10 "e's" within the idea of e-health. The author states that any e-health application should include:

- Efficiency in healthcare with the goal of decreasing costs. Telehealth applications meet this goal by reducing overhead costs in a practice, decreasing wait times for appointments, and also cutting encounter times.
- Enhancing care quality by empowering patients to participate in their own treatment while also increasing convenience but cutting travel time and costs to and from a provider.
- Evidence-based medicine tied to rigorous scientific frameworks with benchmarked quality controls.
- Empowerment of consumers by expanding their knowledge base and allowing access to electronic health records over the Internet, providing more patient-centered care and caring.
- Encouragement of patient participation in more proactive care. For example, e-health can help diabetics monitor their blood glucose levels and diet each day with the goal of patient awareness and empowerment.
- Education of patients and their physicians through the use of Internet research and online video or written health education information.
- Enabling easier exchange of information online between healthcare providers and their patients.
- Extending healthcare beyond traditional boundaries, both geographically by providing access to care in rural areas and conceptually.
- Ethically addressing new issues tied to patient-physician interaction, privacy, informed consent, and equity issues.
- Equitable, especially as it pertains to offering care in rural areas where specialty or primary care treatment may be lacking. Equity in care could also be related to the idea of e-health as intersection of business and healthcare. Or even, the ability of consumers to research physician performance scores online.

The U.S. Department of Health and Human Services published a brochure on the reach of consumer e-health tools. The title is apt; the whole point of our digital evolution is that it's

eally a revolution. According to the brochure, e-health tools help consumers engage in their own care in new ways:

Consumers with diverse perspectives, circumstances, capacities, and experiences are included in the design of, and have meaningful access to, evidence-based e-health tools with strong privacy and security protections.

When taken within this framework, the idea of e-health facilitates an entire shift in traditional healthcare models.

## Telemedicine is E-Health

The increasing costs healthcare and the struggle to improve patient outcomes remains driving factors behind the development of e-health tools. Telemedicine offers new ways to treat patients with models that use the “10 e’s.” These models can include:

- Remote home monitoring.
- Patient education.
- Advanced home health.
- Direct patient virtual visits.
- Specialist consultations.

The global market for e-health tools is rapidly expanding. Within this context, OrthoLive has introduced a tool designed for the specialty orthopedic provider to bring healthcare to the patient. Whether at home or at work, the OrthoLive app helps improve quality outcomes in healthcare. To find out more, contact us.

## 1.2HEALTH INFORMATION SYSTEM

**Definition**

Health information system is that that systemin which collection, utilization, analysis and transmission of information is done for conducting health services,training and research.

**Objectives**

- To provide reliable, latest and useful health information toall levels of health
- officers and administrators.
- To amend health policies and working system on the basisof feedback, received
- from health information system.
- To provide information about periodically and time boundprogrammes and formid term evaluation.
- To contribute towards achievement of objectives of healthpolicies andprogrammes.
- To increase efficiency and quality in health management.

**Characteristics**

- Facility for data fee back must be present in health informationsystem.
- Latest technology should be used in health information system.
- Unnecessary figures or data should not be present in informationsystem.
- For information management, organizational structure must be present.

**Domains/fields of health information system**

It includes demography, vital statistics, healthsystem input, output, health determinants, health economics, health status, health infrastructure, resources and outcome, financial statistics, environmental health statistics as shown in figure 1.5

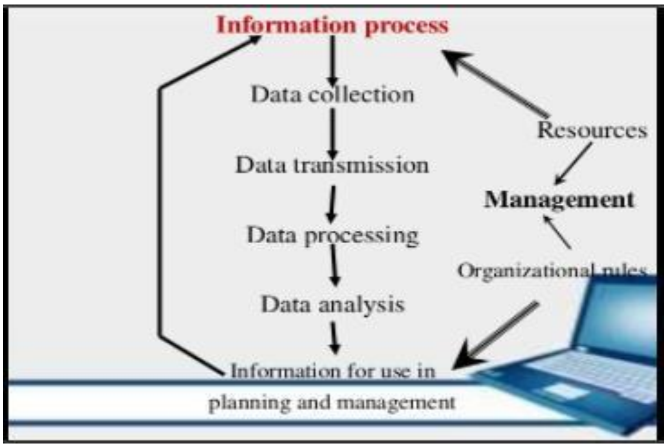



Figure 1.5 Information Process

**Steps Involved inRHIS Restructuring**

**Step 1:** Carrying out service and information systemassessments

**Step 2:** Developing new sets of essential healthindicators

**Step 3:** Defining data sources and developing datacollection instruments for eachof the indicators selected

**Step 4:** Developing a data transmission andprocessing system

**Step 5:** Ensuring use of the information generated

**Step 6:** Planning for RHIS resources

**STEP 1: Assessment of theExisting System**

- Rapid Assessment of the current use andperformance ofthe existing system.
- Find out how and how well the current system works, to describe the variouscomponents of thesystem and the organizational environment

**STEP 2: Develop Essential Indicators**

- Select essential indicators for management functions at each level of thehealth system:

- Health status (and disease surveillance) indicators
- Health services (and national program)indicators
- Resource indicators (human, physical, financial)

**What Data Elements Should beCollected?**

- Can provide useful information (affecting themanagementdecisions)
- Cannot be obtained elsewhere
- Are easy to collect
- Do not require much work or time
- Can be collected relatively accurately
- Data-Led
- Focuses on the need to collect data which is required, is ofinterest, or may be useful
- Is usually vague on what information output can beobtained from data

**Action - led**

- Focuses on the need to collect data that reflect identifiedpriority health needs & are required by pre-determined indicators
- Indicator driven – national & local
- Usually directly linked to specific objectives and targets

Action-led systems are the most practical way to go as shown in figure 1.6

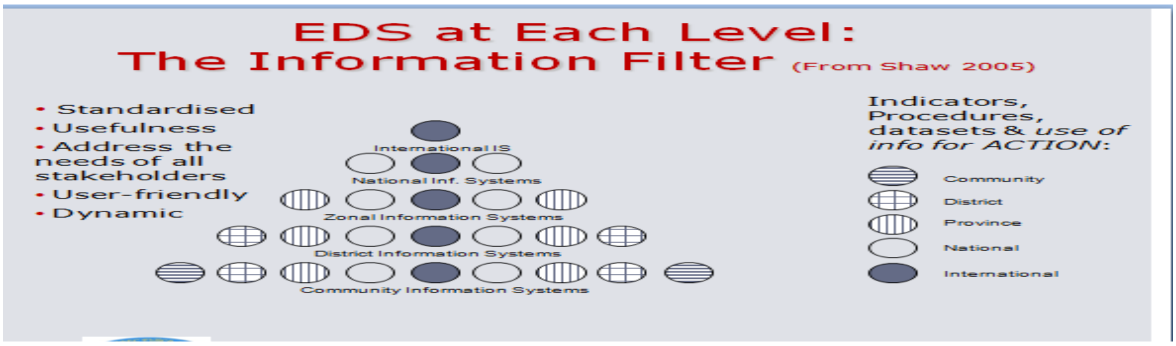



Figure 1.6 EDS at each level

**Step 3: Data Sources and DataCollection Tools**

Defining data sources and developing data collection instruments for eachof the indicatorsselected.

**Data collection**

- start small - as data quality improves & systemsare streamlined - add slowly
- collect data – linked to objectives - that can beused to calculate indicators

**Data Sources and Data CollectionTools(continued)**

- Collect only data that is easily available - determine easiest site forrecording of data - donot duplicate points of data collection
- Use clear & standardised definitions
- Train & provide ongoing support to data collectorsimprove data qualityUse a minimum number of tools - user friendly,familiar & acceptable

**Step 4: DevelopingaDataTransmissionand Processing System**

- Information flows (including referral systems):
- Horizontal data transmission
- Vertical data transmission
- Use appropriate communication technology:
- Paper-based
- Electronic: Telephones, diskettes

**Data Processing and Analysis**

- Paper-based systems:
- Error-prone

- Computerized systems:
- Off-the-shelve versus customized
- Decision support systems
- Use of appropriate technology
- Capacity-building

**Step 5: Ensuring Use of theInformation Generated**

**How can we improve information use?**

- Ownership and relevance of the information must be felt among all potential users of the information,through active participation in the system design
- Data need to be of appropriate quality, aggregatedat the right level, and produced in a timely manner

**Ensuring Use of the InformationGenerated (continued)**

- Performance-based management systems tend toincrease use of information for decision making.
- Cultural differences between data people andaction people can be decreased through consensus building, teamwork, and training.
- Data presentation and communication (feedback)should be customized forusers at all levels

**Step 6: Planning for RHIS Resources**

- Adequate staffing
- Adequate logistic system for printed supplies
- Computer hardware/software and maintenance
- Communications equipment

- HIS line-item in MOH recurrent budget

**The Prism Framework**

- The Prism, or three-point framework, is predicatedon the assumption that improving capacity in RHIS(and subsequently performance) requires
- interventions that address
- the environmental
- behavioral determinants of performance, and
- the technical determinants

It broadens analysis of routine health informationsystems to include the behavior of the collectors and users of data and the context in which theseprofessionals work as shown in figure 1.7

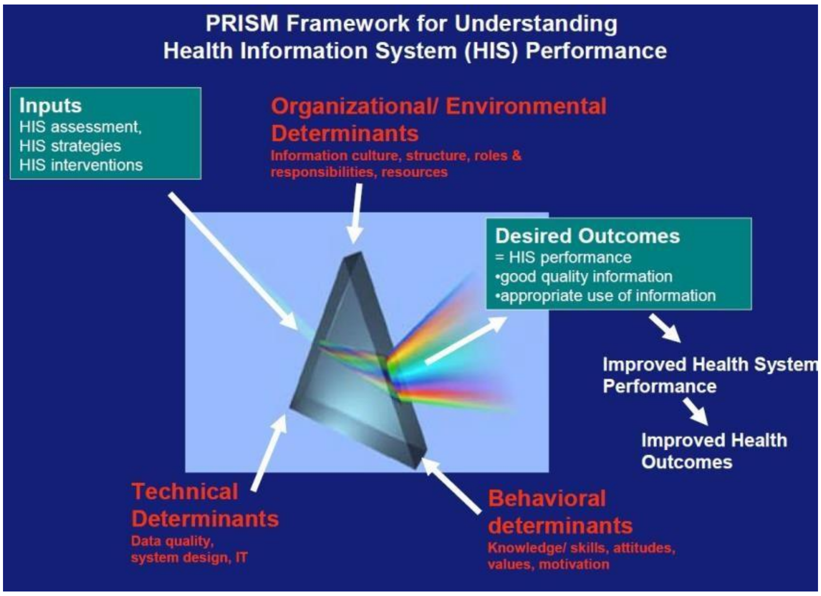
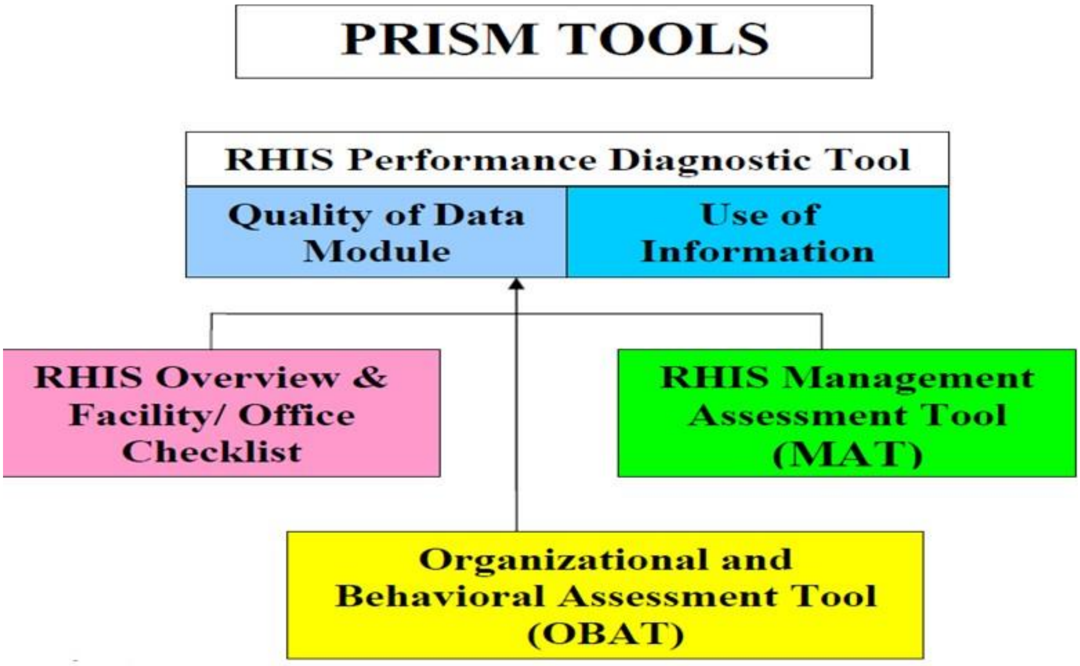



Figure 1.7 Prism work

**<u>RHISPerformanceDiagnosticTool</u>**

1. Data Quality Assessment at District orHigher Level
2. Use of Information Assessment at Districtor Higher Level
3. Data Quality Assessment at Facility Level

4. Use of Information Assessment at FacilityLevel




**INTRODUCTION TO eHEALTH**

- The World Health Organization (WHO) defines eHealth as "the costeffective and secure use of information and communications technologies in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research."

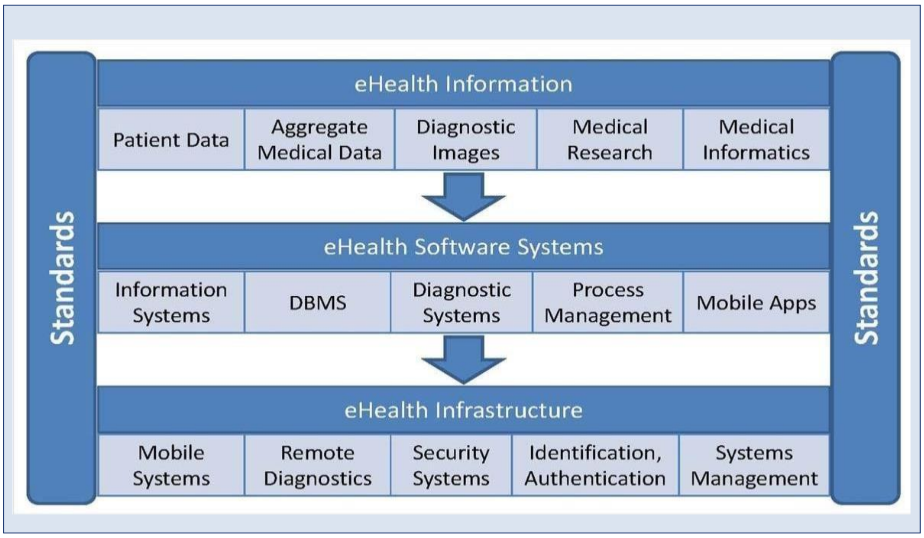
- Electronic health (eHealth) systems continue to hold great promise for improving global access to healthcare services and health informatics, particularly in the developing world.

- Advancements in remotely administered medicine increasingly enable virtual multimedia delivery of medical consultation, remote imaging services, specialized medical diagnostics, and remote medical procedures
- . Standardized electronic medical records promise to facilitate the digital exchange of patient data among a patient's primary care physician and other health providers.

- Aggregated, anonymized health data mined from these digital records hold the potential to improve the efficacy of health research.

- eHealth informatics and online health scholarship increasingly improve healthcare by improving patients knowledge about medical conditions and treatments, provisioning the latest medical scholarship and advancements to medical schools in poor and underserved regions, and providing up-to-date healthcare information for policy makers.

- Another long term trend in medicine is the use of genomic data (e.g. genetic markers), as




- Figure 1.8 Electronic Health Record

- part of personalized electronic health records, to assist with diagnosis and treatment decisions.
- These same technological advancements in electronic healthcare are creating heightenedpublic policy concerns about as shown in figure 1.8
- patient privacy,
- information security,
- Technological obstacles that hinder the promise of eHealth systems include the
- lack of global interoperability standards for eHealth and
- technical infrastructure barriers, particularly in the developing world.

- Many of these challenges can be addressed through advancements in technical standards for eHealth.
- Standards create the necessary interoperability among healthcare systems; • minimize the risks of new technology development; •prevent single vendor lock-in; reduce costs by enabling market competition and eliminating the need for expensive and customized solutions; ensure widespread adoption;
- address specific concerns about privacy, security, and patient identification.
- eHealth standardization landscape including initiatives by CEN, DICOM, HL7, and ISO, as well as the ITU-• Activities within the ITU that will contribute to the global deployment of efficient and secure eHealth systems.

## 1.3 EMERGING TRENDS IN eHealth SYTEMS

Describes four emerging trends in eHealth systems that use information and communication technologies for the delivery of healthcare services and for the digital recordation, storage, and sharing ofmedical information:

- Genomic Medicine
- Standardized Electronic Health Records
- Remote Healthcare and Diagnostics
- Aggregated Public Health Data.

**Genomic Medicine**

- Possibly the most significant trend in medicine will be the use of genomic data (e.g. genetic markers) in assisting with disease prevention, diagnosis, and treatment decisions.
- Accordingly, one of the most forward-looking areas for standardization exists at the

- intersection of information technology and genomic medicine.
- A human genome contains all of a per- son's genes andassociated DNA.
- The international project known as the Human Genome Project completed mapping the entirehuman genome in 2003.
- The medical profession has just begun to use genetic information in direct clinical care.
- Clinical uses of genomic information include the ability to anticipate a patient's response topharmaceutical therapies;
- the detection of diseases or tumors; and
- the identification of inherited conditions or a patient's proclivity to devel- op a disease.

- For example,

- DNA tests for mutations of the BRCA1 andBRCA2 genes are indicators of hereditary patterns of breast cancer.
- Medical experts believe society to be approaching "an era of 'genomic medicine' in which new diagnostic and therapeutic approaches to common multifactorial conditions are emerging."
- As genomic medicine evolves, it will be exceptionally data intensive as well as computationally demanding.
- The future of genomic medicine in clinical practice, also sometimes referred to as personalized medicine, will rely upon the availability of sophisticated medical information systems in provider facilities.
- On a more macro level, medical discoveries related to the identification of gene mutations and variations will require "international collaborations of large-scale sequencing centers generating terabytes of sequence data at speeds and costs that seemed inconceivable 5 years ago."
- At present, electronic health record systems are generally not equipped to accommodate genomic data.
- As genetic testing, diagnosis, and treatment be- comes more commonplace, this information will need to be held in electronic records and be able to be exchanged among providers.

**ITU-T TechnologyWatch**

- There are many other intersections between genomic medicine and information and communication technologies.
- One unique aspect of genetic testing is that patients have the option to bypass healthcareproviders entirely and order genomic tests directly on the Internet.
- This is a rapidly advancing and controversial area of medicine.
- These tests are used for prenatal screening to identify genetic conditions in unborn children; identification of inherited genetic conditions that predispose an individual to certain conditions and illnesses; identification of whether an individual is a carrier of an

altered gene;and diagnoses of specific diseases.

- Standardization efforts related to privacy, pseudonymization, and security have to extend to direct consumption of genetic tests over the Internet in addition to health care provider mediated testing and diagnosis.

**Standardized Electronic Health Records**

- Medical information systems have historically captured and stored clinical and administrative patient data in proprietary formats only understood by a single system and not interoperable with other providers' systems.
- Emerging standards for Electronic Health Records (EHRs) are attempting to create common digital formats and structures for integrating a variety of information about a patient and allowing this information to be exchanged among medical information systems developed by different manufacturers.
- As shown in the ac- companying figure 1.9, the types of information integrated within EHRs include clinical observations, medical histories, treatments, allergies, diagnostic images, legal permissions, patient information, and drugs administered.

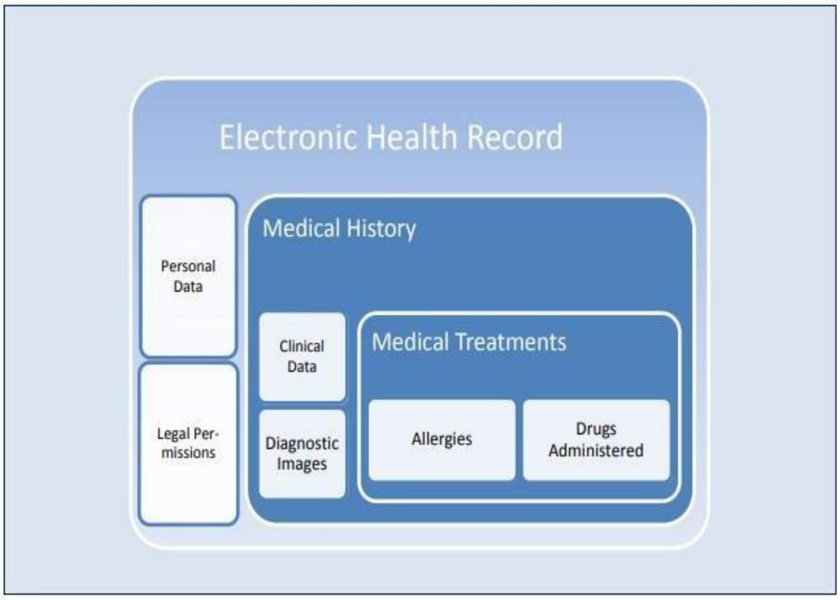



Figure 1.9 Integrated EHR

- It also requires a universal identification number system to uniquely identify each patient.

- On an even more practical level is the question of where, physically, the personalized electronic health records are stored, whether on a computer in a primary care provider's office or on a government or third party server.

- The decision about where to store the information will have repercussions tothe longevity, security, and quality of the stored electronic records.
- Personalized electronic healthcare records also raise concerns about data security and individual privacy.

- Social questions include the extent of user control over the content of electronic healthcare records as well as control over who has access to these records.
- One often cited concern is the risk of discrimination in em- ployment or insurance and the extent to which health insurance companies or employers might gain access to these records.
- From a security standpoint, systems have to meet stringent authentication standards for identifying and verifying the individuals attempting to access their own records as well as for providers accessing these records .e protection of data while digitally stored or while transmitted over a telecommu-nication network is similarly a critical requirement.

**Remote Healthcare and Diagnostics**

- In the developing world and in isolated geographical areas with limited access to health providers and advanced medical technologies, remote electronic health services over telecommunications services are increasingly filling gaps in medical care.
- Historically called "telemedicine," remote healthcare services use telecommunication networks and information technology for many medical purposes including remote clinical care, diagnostics, electronic patient monitoring and patient and provider access to medical information.
- None of these remote medical services is possible without telecommunications networksand standards that enable adequate interoperability, quality of service, and security

**Remote Clinical Care**

- Remote clinical care increasingly enables doctors located at a distance from patients to provide electronic medical assessments, diagnoses, and treatments.
- It also allows doctors not in the same location to discuss patient diagnoses.
- If a patient is geographically distant from medical care but has access to a telecommunications network and computer or cell phone, medical providers can administer remote clinical care.
- This approach involves real- time and interactive communications between a doctor and a patient, either on a phone (landline or mobile) or via video communications over acomputer.
- This direct clinical care via a telecommunications network usually requires the simultaneous online or electronic presence of both the patient and the medical provider/s.
- Other forms of remote diagnostics involve "store and forward" electronic health services that acquire some aspect of medical information (such as an MRI, ultrasound, or other radiological image) and then transmit this information to a medical practitioner for analysis at a later time

**Electronic Patient Monitoring**

- Remote patient monitoring refers to the ability of medical providers to electronically observe a patient remotely using medical monitoring devices and telecommunication networks.
- For example, a medical practitioner can monitor such characteristics as a patient's heart rhythms, blood pressure, pulse oximitry, pulmonary functionality, or blood glucose level.
- This type of remote health care monitoring can be used to cost effectively monitor patients with chronic conditions, the elderly, and patients recovering from a specific condition.

Mobile Healthcare

According to ITU statistics, there were an estimated 4.6 billion mobile phone subscribers worldwide at the end of 2009 and more than half of the population of the developing world had mobile phone service.Particularly in the developing world, mobile phones are becoming a new medium for health delivery, both through voice communications and via text messages and multimedia.This is the case both in urban areas and in poorer and more rural areas with limited computing infrastructures other than cellular phone networks.In some cases, government officials and NGOs use mobile phones to gather public health-related data and to monitor general health conditions.Mobile phones also help networks of health providers to stay current about general health issues, medical advancements, pharmaceutical notifications, or to access information about a particular patient.Remote patient-to-physician communication via a mobile device is an increasingly common part of health care as is patient selfeducation and access to medical information via mobile devices.Further advances are expected in medical monitoring technologies that can transmit diagnostic statistics to a provider via a mobile phone network.

Challenges to emerging mHealth (mobile health) applications are numerous,including how to ensure the accuracy of medical information obtained by patients via mobile devices, how to secure patient-to-provider communications over mobile networks, and how to guarantee adequate service reliability for remote monitoring functions.

**Aggregated Public Health Data**

- The global eHealth landscape is still fragmented in that hospitals, physicians' offices, pharmacies, and other healthcare providers have transitioned to digital record keeping systems but do not necessarily have systems that interoperate with each other.
- The data portability and system interoperability expected to accompany electronic health records and emerging eHealth systems will not only improve health delivery and create cost efficiencies, but will present unprecedented opportunities for the mining of aggregated public health data.
- The term "aggregated health data" refers to a large body of data obtained by combining some characteristics of standardized digital health records in a way that removes information that would identify any individual patient.
- This data is not used for direct care of individuals or for insurance and billing purpos- es but for some secondary use related to research, public health assessments, accreditation, patient education, or some commercial purpose.
- These functions are often referred to as "secondary uses of health data."

**Aggregated Public Health Data**

- Even though the vast majority of electronic health information is currently not aggregated, there is already a multi-million dollar business based on collections of health data, flowing through two primary aggregation points.
- Smaller aggregators include provider entities such as hospital networks and pharmacies. Many of these data collection efforts take place through billing systems and other administrative recordation.
- Larger aggregators include hospital associations and corporations who buy anonymized health data from smaller aggregators, further aggregate this information and then sell it for profit.

**Aggregated Public Health Data**

- Standards will play a critical role in both achieving the public health benefits of aggregated patient data and providing solutions to requirements for security, privacy, quality assurance, and interoperability.
- As long as electronic health records are fragmented technically without adequate standardization among providers and vendors, meaningful public aggregation will not be possible.
- This standardization requirement spans all areas of information protocols ranging from standardized codes for specific procedures, data formatting standards, compression standards, and network level standards.
- HL7 partners with other institutions, such as the International Organization for Standardization (ISO) in issuing international eHealth standards, (ISO/HL7 21731:2006 Health Informatics-HL7 version 3-Reference Information Model).

## 1.4 LANDSCAPE OF EHEALTH STANDARDIZATION

Many standardization organizations, including ITU, work on various areasof eHealth.

- The eHealth Standardization Coordination Group (eHSCG), supported by ITU-T Study Group 16, maintains a list of standards in both technical and non-technical areas of eHealth on the World Health Organization web site. This section briefly describes a variety of eHealth standardization initiatives including:
- DICOM
- CEN/TC 251
- HL7
- ISO/TC 215
- ISO/IEEE 11073.

**DICOM**

- Digital Imaging and Communications in Medicine (DICOM) is a standard forexchanging medical images.
- More specifically, it is a file format and transmission standard for exchanging medical images and associated information between medical imaging equipment made by different manufacturers.
- The DICOM standards are widely adopted in equipment and information systems used in hospitals, imaging centers, and in providers' offices to produce, display, store, or exchange medical images.
- The standard provides a number of specifications including:
- Network protocols
- Syntax and semantics of commands and associated information
- Media storage services, file formats, medical directory structure

- There are twenty DICOM working groups, made up of technical and medical professionals, which maintain the various DICOM standards.
- The National Electrical Manufacturers Association (NEMA) oversees and holds a copyright to the DICOM standards, originally developed by a joint committee formed by NEMA and the American College of Radiology.

**CEN/TC 251**

- The Comité Européen de Normalisation or European Committee for Standardization (CEN) is a standards development organization made up of 31 national members developing pan-European standards.
- CEN has a Health Informatics Technical Committee (TC 251) which coordinates the development of standards for eHealth.
- According to its business plan and recent activities, the focus of CEN/TC 251 is primarily on technologies at the content level rather than dealing with communication technologies.
- CEN/TC 251 is further broken down into working groups such as Working Group IV, which focuses on the interoperability of data among devices and information systems.

**HL7**

- Health Level Seven (HL7) is a standards development organization which issues international application layer healthcare standards for the electronic exchange and management of health information such as clinical data and administrative information.
- HL7 refers to the standards organization itself but is also com- monly used to refer to specific standards the institution develops. HL7 dates back to the mid1980s, when it was formed to develop a standard for hospital information systems.
- Like other standards organizations, HL7 is organized into Work Groups chaired by two or more co-chairs and responsible for defining some area of HL7 standards.
- HL7 has dozens of Work Groups, including groups addressing electronic health records, infrastructure and messaging, and imaging integration.
- To provide one example of an HL7 specification, the HL7 Clinical Document Architecture (CDA) serves as an XML-based markup standard defining the structure, encoding parameters, and semantics of electronic clinical documents.
- There is also a Work Group on clinical genomics, formed to develop common standards for genomic information/data across many organizations ranging from research institutions, medical practitioners, and regulatory bodies as appropriate under existing law.
- Part of the Work Group's charter is to review what data needs to be exchanged and to identify and review existing standards for genomic data. HL7 partners with other institutions, such as the International Organization for Standardization (ISO) in issuing international eHealth standards, (ISO/HL7 21731:2006 Health InformaticsHL7 version 3-Reference In- formation Model).

**ISO/TC 215**

- ISO's Technical Committee 215 also addresses health informatics.ISO/TC 215 focuses primarily on elec- tronic health records.
- Various Working Groups (WGs) within TC 215 address topics such as data structure, messaging and communication, security, pharmacy and medication, devices, and business requirements for electronic health records.

- For example, ISO/TS 25237:2008 addresses pseudonymization principles and re- quirements for privacy protection of electronic health records.
- Many of ISO's standards are collaborations or endorsements of standards developedby other standards organizations such as HL7 or IEEE.
- For example, ISO/HL7 27931:2009, "Data Exchange Standards Health Level Seven Version 2.5" establishes an application protocol for electronic data exchange in healthcare environments.

**ISO/TC 215**

- At present, ISO Technical Committee 215, WG 8 (Business Requirements for Electronic Health Records) is also developing a technical report (TR) in partnership with the WHO to make international eHealth standards more accessible to developing countries.
- The objective of this report will be to guide developing countries in adopting universal standards for health informatics systems. The first part of the report will be descriptive and provide an overview of existing international standards for eHealth.
- The second part of the report will offer a "roadmap for identifying business requirements to define an eHealth enterprise architecture."

**ISO/IEEE 11073**

- ISO/IEEE 11073 Medical/Health Device Communication Standards are a set of joint ISO, IEEE, and CEN standards for medical device interoperability.
- In this context, medical devices include primarily personnel, or end user, health devices such as blood glucose monitors, blood pressure monitors, thermometers, pulse oximeters, etc., that patients use in their own homes or other end points to monitor existing medical condi- tions.
- The ISO/IEEE 11073 (formerly called IEEE 1073) standards define messaging structures but not the transport layer upon which messages are transmitted.

**ITU-T MULTIMEDIA FRAMEWORK FOR EHEALTH APPLICATIONS**

- ITU Recommendations underlie much of the telecommunications infrastructure necessary for supporting the virtual multimedia delivery of medical care, remote diagnostic services, and electronic medical records.
- ITU Study Groups address these infrastructural issues as well as generally addressing many emerging eHealth related requirements for
- security (Study Group 17),
- performance and quality of service (Study Group 12),
- multimedia coding and systems (Study Group 16), mobile telecommunications networks (Study Group 13), and a host of other areas.
- For example, the H.300-series, H.260-series, V.18, T.80-series, and T.800-series all have direct bearing upon eHealth systems.
- More specifically though, eHealth standardization studies in the Standardization Sector of theITU-T are addressed "Multimedia Framework for e-health Applications."
- This high-level Question, which coordinates the technical standardization of multimedia systems to support eHealth applications, is allocated under ITU-T Study Group 16, the Lead Study Group on ubiquitous applications (e.g. eHealth and eBusiness).
- This work originally emanated from a workshop held in 2003 involving the key

standardization players at the time, together with the creation of the eHealth Standardization Coordination Group (eHSCG).

- The overarching objective of the eHSCG is to "promote stronger coordination amongst the key players in the e-Health Standardization arena."
- The eHSCG, through informal coordination on a voluntary basis, hopes to facilitate an exchange of information among standardization organizations to avoid duplication of effort.
- It seeks to consider the requirements of developing countries and to serve as a technical rather than regulatory coordination group, albeit taking into consideration social, economic, and regulatory factors.
- The Telecommunication Standardization Bureau of the ITU, through ITU-T Study Group 16, provides direct support for the activities of the eHSCG, including web site and membership management and the provisioning of necessary tools for the organization to work by correspondence.
- Some of the study items for Question 28/16 include the development of an overall framework for
- eHealth applications, and telemedicine in particular;
- the development of a roadmap for eHealth standards;
- a generic architecture for eHealth applications,and specific system characteristics for eHealth applications such as video and still picture coding, audio coding, security, and directory architecture.Some of the study items for Question 28/16 include the development of an overall framework for eHealth applications, and telemedicine in particular; the development of a roadmap for eHealth standards; a genericarchitecture for eHealth applications, and specific system characteristics for eHealth applications such as video and still picture coding, audio coding, security, and directory architecture.
- The tasks of Q28/16 include the following:
- Inventory of existing eHealth and telemedicine standards
- Roadmap for eHealth/telemedicine standards compiling and analyzing standardization requirements from eHealth stakeholders and identifying
- standardization items with priorities
- Involvement in the eHealth Standardization Coordination Group
- Contributions to extensions and improvements of existing Recommendations on multimedia systems (H.323, H.264, V.18, etc.)
- Development of new Recommendations if necessary.
- Q28/16 focuses on the critical need for global interoperability among fragmented eHealth systems based on different standards and seeks to provide the necessary coordination among major global players (e.g. medical institutions, governments, inter-governmental organizations, non-profit groups, private industry).
- Q28/16 also produced a Roadmap for Telemedicine indicating major technologies that applicable to tele-medicine and e-health and could benefit from standardization activities.
- The ITU-T's eHealth Question 28/16, via Study Group 16, works with relevant consortia and standardization bodies such as HL7, DICOM, ISO, ETSI, IETF, IEEE, IEC, CEN and other

bodies, as well as the eHealth
- Standardization Coordination Group.

## 1.5 DIGITAL HEALTH SERVICES

Another of the great advantages of new technologies in the healthcare sector is how versatilethey are. Here are some of the most widespread solutions they offer:

**Telehealth.** Providing care at a distance means people in remote areas with limited access to healthcare can get the medical attention they need. It also saves time, money and travel for both doctors and patients.

**Apps.** Having mobile apps dedicated to health turns our smartphones into personal trainers, sleep monitors, diagnostic, devices and more, with apps for both healthcare professionals and patients.

**Serious Games.** These special video games are used as a learning resource for healthcare professionals and students to enhance their training. They can also be used by people wishing to learn more about specific pathologies.

**Wearable technology.** The well-known term *wearables*, includes smart clothing and accessories such as wristbands, glasses and watches to monitor and collect information on our health and physical condition.

**Augmented reality.** AR can help health professionals to visualise organs in 3D, for example, or check a patient's record in real time. It can even be used in surgical procedures with special AR headsets. **eHealth record.** Having a digital health record means information can be stored in one place but be available anywhere, so patients can share it safely and healthcare staff can access it at any time.

## 1.6 ADVANTAGES AND BENEFITS OF EHEALTH

Thanks to services like these, digital health enables us to apply **new methods, means, tools and channels** that lead to a series of benefits:

- **Improved patient monitoring**

  Communication is easier with this new digital channel, helping to bridge the gap between doctors and patients. Technology also means the patient's condition can be monitored and their progress can be recorded in real time.

- **More informed patients**

  As patients, we can make better health decisions when we understand them and have the power to manage their own health. ICTs also provide us with access to guide books and best practice, something very useful, for instance, during the pandemic if they come from reliable sources.

- **Encouraging healthier habits**

  New technologies are changing the way we look after ourselves with apps and devices that keep track of what we eat, how much exercise we do, how long or soundly we sleep and how fast our heart rate is.

- **Easier decision-making** for healthcare staff

  eHealth is also transforming the way professionals deal with disease. ICTs can help, for instance, to identify optimal treatments more easily or detect illnesses at an early stage.

- **More accessible and equal healthcare**

  Access to healthcare is no longer limited by time and space, which means avoiding unnecessary travel. Moreover, technology brings healthcare to more people, especially patients at risk of exclusion, which means more equal opportunities for everyone.

- **More efficient hospitals and health clinics**

  Connected facilities mean a streamlined health system, minimise the chance of human **error** and cutting costs. In addition, techniques such as big data, processes are being automated.

## 1.7 NEW TECHNOLOGIES IN eHEALTH

Digitising health involves using new technology. Here is some of them and their specific uses:

**Internet of Things (IoT)**

The Internet of Things helps to customise healthcare, save costs, reduce the likelihood of incorrect diagnosis and shorten waiting times. The connection between the physical and digital world will be crucial in equipment such as inhalers and audiometers.

**Big data**

Using big data to perform macro data analysis allows for tailored treatments and helps to detect the risk factors and potential side effects of drugs. The insight gained from it has proven critical in understanding and containing the spread of COVID-19.

**Artificial Intelligence**

Artificial intelligence can help healthcare professionals to make wiser decisions and deliver better treatments. During the coronavirus crisis, AI was used to identify the sequence of antibodies and its compatibility with future treatments.

**Blockchain**

Blockchain affords safe access to a patient's health record, which makes a more efficient administration. It also allows pharmaceutical labs to keep a more precise record in the drug production process. •3D and 4D printing

The use of 4D printing in ultrasound scans, for example, gives us more precise insight into the structural and functional development of the nervous system of the foetus. Furthermore, the shortage of safety equipment during the coronavirus crisis led to the production of medical items using 3D printers.

**Chatbots**

Chatbots provide a tool to enable faster and more direct doctor-patient communication. The World Health Organisation set up one of these channels during the COVID-19 pandemic.

**Virtual reality**

Some of the most significant contributions that VR technology can make include assisting with patient rehabilitation and treating psychological disorders.

## 1.8 IMPORTANCE OF E-HEALTH

E-Health technology plays a significant role in providing healthcare services.

Some of the benefits are as follows:

- It helps in paperless record management as patients' medical record is stored in a centralized database system. This avoids excessive use of papers
- It gives fast access to patients' medical record such as history of the patient, pathology and diagnostic reports, prescription, and billing data. Any information related to patient can be made available with few clicks
- It initiates easy collaboration between multiple departments in the hospitals as the same data can be viewed by various physicians and surgeons
- It enhances efficiency of hospital and healthcare work as e-health technology is automated and helps in fetching records which saves time and efforts of the staff
- E-Health technology provides accurate information so less chances of error in the entire process of medical record maintenance
- It allows to book appointments for medical checkup. It also allows prior booking of equipment which eliminates the chances of double booking
- It provides variable pricing list based on insurance policies, which makes billing process easy and less time-consuming
- It generates graphical reports from the patients' data and provides secure storage of medical records. It is user-friendly application with mobiles which is easy to navigate patient information.
- Healthcare software is categorized on the basis of e-health information type.

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**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING**

# UNIT – II – eHEALTH– SECA4004

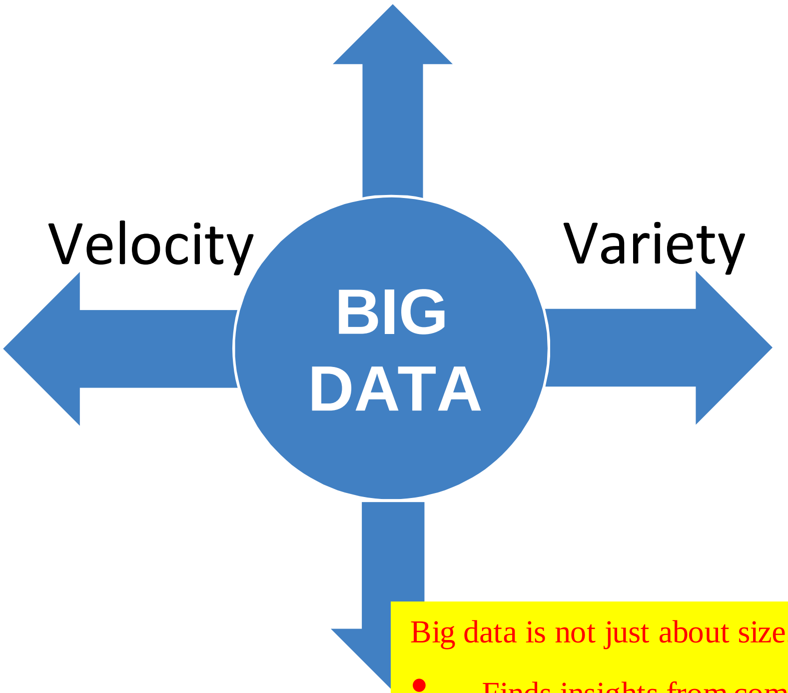
**UNIT-II MEDICAL DATA ANALYTICS AND WEARABLE DEVICES**

Health care data and Electronic Health Records (EHR) systems- Medical data bases – Wearable devices-Data collection from wearable devices- Clinical use of personal healthdata- Big data in the field of Medicine.

## 2.1 INTRODUCTION TO BIG DATA

Large and complex data sets which are difficult to process usingtraditional database technology.

***Volume***
Veracity




Big data is not just about size.

- Finds insights from complex, noisy,heterogeneous, longitudinal, and voluminous data.
- It aims to answer questions thatwere previously

## HEALTHCARE ANALYTICS IN THE ELECTRONIC ERA

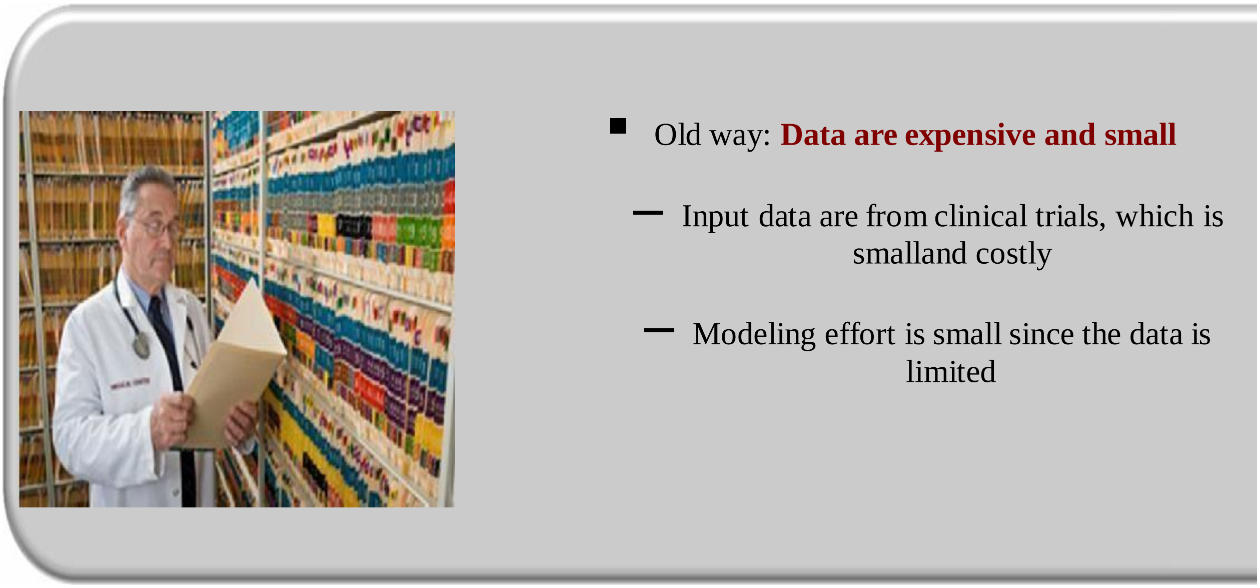



Figure 2.1 HER era in old way

- EHR era: **Data are cheap and large as shown in figure 2.1**
- Broader patient population
- Noisy data
- Heterogeneous data
- Diverse scale
- Longitudinal records

## EXAMPLES FOR BIG DATA ANALYTICS IN HEALTHCARE

### Government Initiatives

- **Medicare Penalties:** Medicare penalizes hospitals that have high rates ofreadmissions among patients with Heart failure, Heart attack, Pneumonia.
- **BRAIN Initiative:** Find new ways to treat, cure, and even prevent brain disorders, such as Alzheimer's disease, epilepsy, and traumatic brain injury. A new bold $100 million research initiative designed to revolutionizeour understanding of the humanbrain.

### Industry Initiatives

- **Heritage Health Prize:** Develop algorithms to predict the number of daysa patient will spendin a hospital in the next year. http://www.heritagehealthprize.com
- **GE Head Health Challenge:** Methods for Diagnosis and Prognosis of Mild Traumatic Brain Injuries. Develop Algorithms and Analytical Tools, and Biomarkers and othertechnologies. A total of $60M in awards as shown in figure 2.2

**DATA COLLECTION AND ANALYTICS**

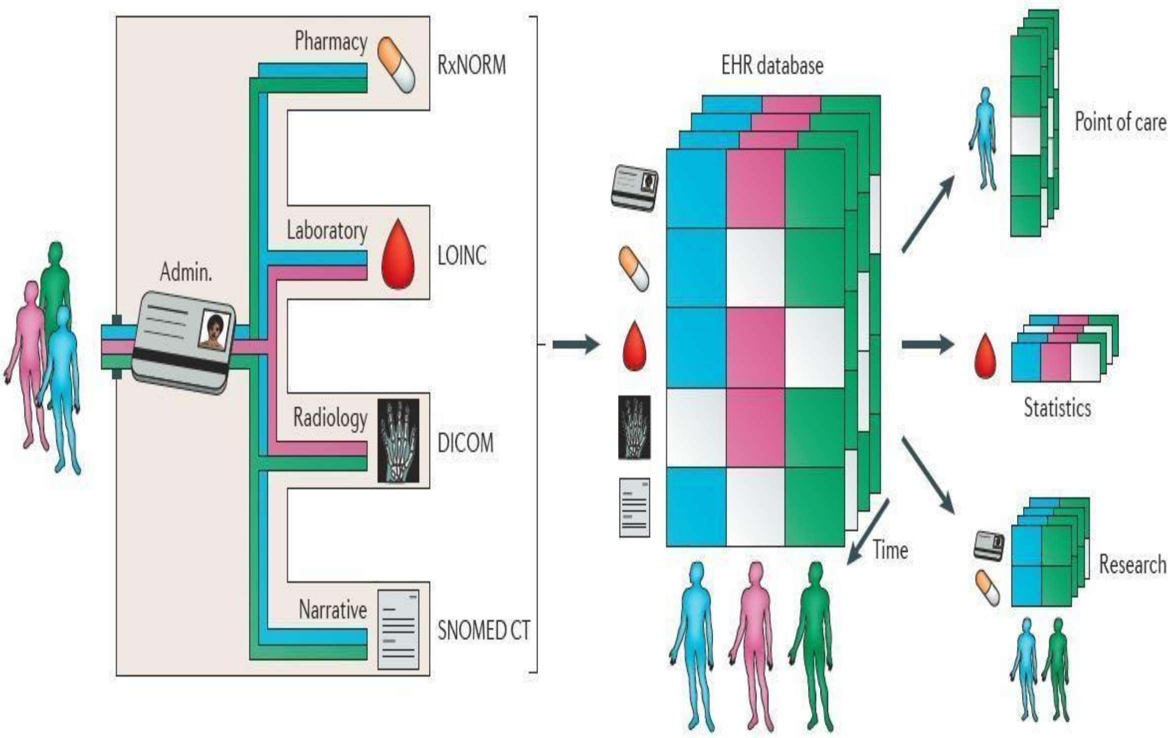
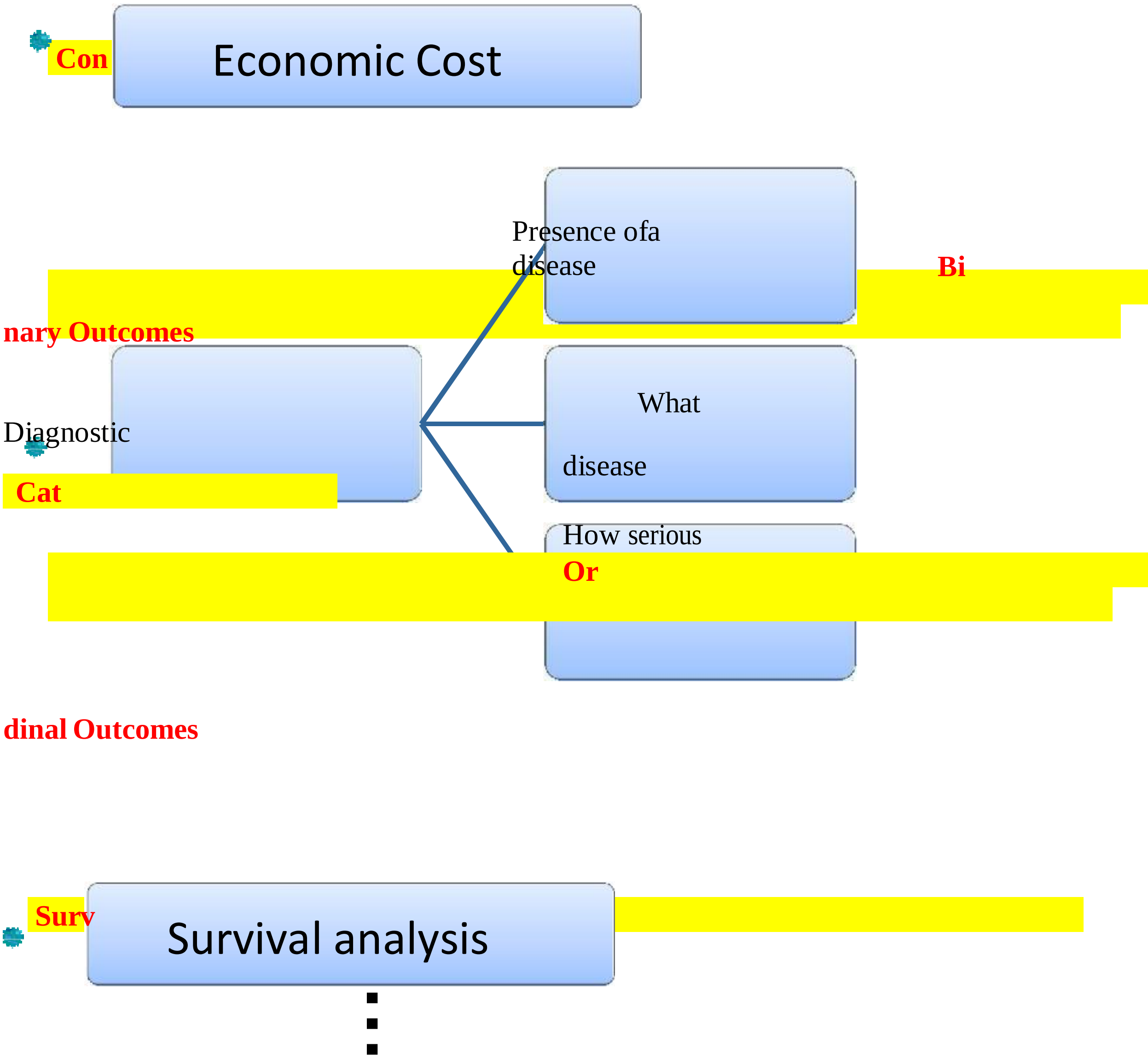



Figure 2.2 Data Collection and Analytics

Effectively integrating and efficiently analyzing various forms of healthcare data over a period of time can answer many of the impending healthcare problems.

**DIFFERENT KINDS OF OUTCOMES**



- Binary Outcomes

  Death: yes/no

  Adverse event: yes/no

  Continuous Outcomes

- Days of Hospital stay

  Visual analogue score

- Ordinal Outcomes

  Quality of life scale

  Grade of tumour progression

- Count data (Number of heart attacks)

  Survival Outcomes

  Cancer survival

  Clinical Trials

Big data has changed the way we manage, analyze, and leverage data across industries. One of the most notable areas where data analytics is making big changes is healthcare

## 2.2 BIG DATA IN HEALTHCARE

Big data in healthcare is a term used to describe massive volumes of information created by the adoption of digital technologies that collect patients' records and help in managing hospital performance, otherwise too large and complex for traditional technologies.

The application of big data analytics in healthcare has a lot of positive and also life-saving outcomes. In essence, big-style data refers to the vast quantities of information created by the digitization of everything, that gets consolidated and analyzed by specific technologies. Applied to healthcare, it will use specific health data of a population (or of a particular individual) and potentially help to prevent epidemics, cure disease, cut down costs, etc.

Now that we live longer, treatment models have changed and many of these changes are namely driven by data. Doctors want to understand as much as they can about a patient and as early in their life as possible, to pick up warning signs of serious illness as they arise – treating any disease at an early stage is far more simple and less expensive. By utilizing key performance indicators in healthcare and healthcare data analytics, prevention is better than cure, and managing to draw a comprehensive picture of a patient will let insurance provide a tailored package. This is the industry's attempt to tackle the siloes problems a patient's data has: everywhere are collected bits and bites of it and archived in hospitals, clinics, surgeries, etc., with the impossibility to communicate properly.

Indeed, for years gathering huge amounts of data for medical use has been costly and time-consuming. With today's always-improving technologies, it becomes easier not only to collect such data but also to create comprehensive healthcare reports and convert them into relevant critical insights, that can then be used to provide better care. This is the purpose of healthcare data analytics: using data-driven findings to predict and solve a problem before itis too late, but also assess methods and treatments faster, keep better track of inventory, involve patients more in their own health, and empower them with the tools to do so.

## 2.3 BIG DATA APPLICATIONS IN HEALTHCARE

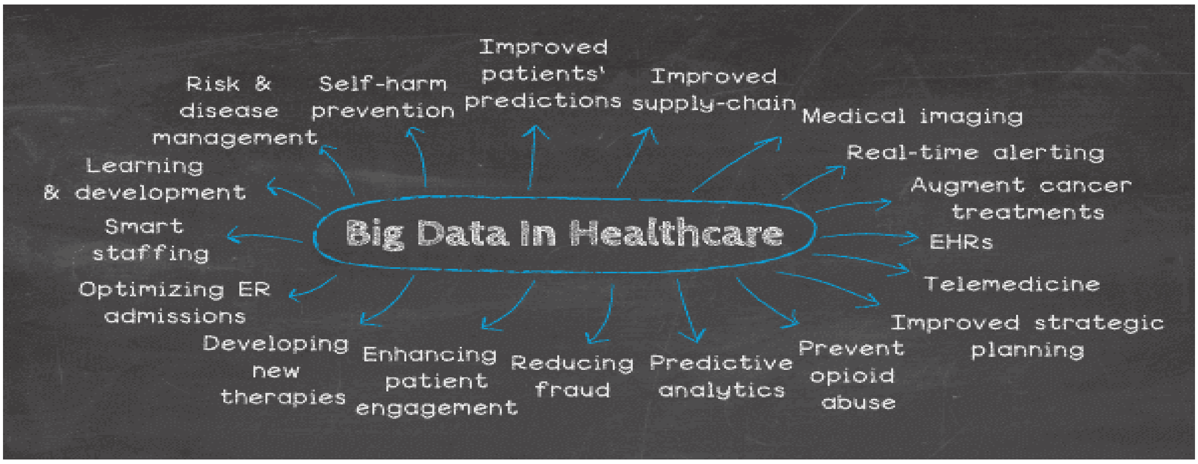



Figure 2.3 Big data in Healthcare

Now that you understand the importance of health big data, let's explore 18 real-world applications that demonstrate how an analytical approach can improve processes, enhance patient care, and, ultimately, save lives as shown in figure 2.3

### 1) Patients Predictions For Improved Staffing

For our first example of big data in healthcare, we will look at one classic problem that any shift manager faces: how many people do I put on staff at any given time period? If you put on too many workers, you run the risk of having unnecessary labor costs add up. Too few workers, you can have poor customer service outcomes – which can be fatal for patients in that industry.


Figure 2.4.Example of Big data

Big data is helping to solve this problem, at least at a few hospitals in Paris. A white paper by Intel details how four hospitals that are part of the Assistance Publique-Hôpitaux de Paris have been using data from a variety of sources to come up with daily and hourly predictions as shown in figure 2.4 how many patients are expected to be at each hospital.

One of the key data sets is 10 years' worth of hospital admissions records, which data scientists crunched using "time series analysis" techniques. These analyses allowed the researchers to see relevant patterns in admission rates. Then, they could use machine learning to find the most accurate algorithms that predicted future admissions trends.

Summing up the product of all this work, the data science team developed a web-based user interface that forecasts patient loads and helps in planning resource allocation by utilizing online data visualization that reaches the goal of improving the overall patients' care.

**2) Electronic Health Records (EHRs)**

It's the most widespread application of big data in medicine. Every patient has his own digital record which includes demographics, medical history, allergies, laboratory test results, etc. Records are shared via secure information systems and are available for providers from both the public and private sectors. Every record is comprised of one modifiable file, which means that doctors can implement changes over time with no paperwork and no danger of data replication.

EHRs can also trigger warnings and reminders when a patient should get a new lab test or track prescriptions to see if a patient has been following doctors' orders.

Although EHR is a great idea, many countries still struggle to fully implement them. U.S. has made a major leap with 94% of hospitals adopting EHRs according to this HITECH research, but the EU still lags behind. However, an ambitious directive drafted by the European Commission is supposed to change it.

Kaiser Permanente is leading the way in the U.S. and could provide a model for the EU to follow. They've fully implemented a system called HealthConnect that shares data across all of their facilities and makes it easier to use EHRs. A McKinsey report on big data healthcare states that "The integrated system has improved outcomes in cardiovascular disease and achieved an estimated $1 billion in savings from reduced office visits and lab tests."

### 3) Real-Time Alerting

Other examples of data analytics in healthcare share one crucial functionality – real-time alerting. In hospitals, Clinical Decision Support (CDS) software analyzes medical data on the spot, providing health practitioners with advice as they make prescriptive decisions.

However, doctors want patients to stay away from hospitals to avoid costly in-house treatments. Analytics, already trending as one of the business intelligence buzzwords in 2019, has the potential to become part of a new strategy. Wearables will collect patients' health data continuously and send this data to the cloud.

Additionally, this information will be accessed to the database on the state of health of the general public, which will allow doctors to compare this data in a socio-economic context and modify the delivery strategies accordingly. Institutions and care managers will use sophisticated tools to monitor this massive data stream and react every time the results will bedisturbing.

For example, if a patient's blood pressure increases alarmingly, the system will send an alert in real-time to the doctor who will then take action to reach the patient and administer measures to lower the pressure.

Another example is that of Asthmapolis, which has started to use inhalers with GPS-enabled trackers in order to identify asthma trends both on an individual level and looking at larger populations. This data is being used in conjunction with data from the CDC in order to develop better treatment plans for asthmatics.

### 4) Enhancing Patient Engagement

Many consumers – and hence, potential patients – already have an interest in smart devices that record every step they take, their heart rates, sleeping habits, etc., on a permanent basis. All this vital information can be coupled with other trackable data to identify potential health risks lurking. Chronic insomnia and an elevated heart rate can signal a risk for future heart disease for instance. Patients are directly involved in the monitoring of their own health, and incentives from health insurance can push them to lead a healthy lifestyle (e.g.: giving money back to people using smartwatches).

Another way to do so comes with new wearables under development, tracking specific health trends, and relaying them to the cloud where physicians can monitor them. Patients suffering from asthma or blood pressure could benefit from it, and become a bit more independent and reduce unnecessary visits to the doctor.

### 5) Prevent Opioid Abuse In The US

Our fourth example of big data healthcare is tackling a serious problem in the US. Here's a sobering fact: as of this year, overdoses from misused opioids have caused more accidental deaths in the U.S. than road accidents, which were previously the most common cause of accidental death.

Analytics expert Bernard Marr writes about the problem in a Forbes article. The situation has gotten so dire that Canada has declared opioid abuse to be a "national health crisis," and President Obama earmarked $1.1 billion dollars for developing solutions to the issue while he was in office.

Once again, an application of big data analytics in healthcare might be the answer everyone is looking for: data scientists at Blue Cross Blue Shield have started working with analytics experts at Fuzzy Logix to tackle the problem. Using years of insurance and pharmacy data, Fuzzy Logix analysts have been able to identify 742 risk factors that predict with a high degree of accuracy whether someone is at risk for abusing opioids.

Figure 2.5 Drug Issue

To be fair, reaching out to people identified as “high risk” and preventing them from developing a drug issue as shown in figure 2.5 is a delicate undertaking. However, this project still offers a lot of hope towards mitigating an issue which is destroying the lives of many people and costing the system a lot of money.

### 6) Using Health Data For Informed Strategic Planning

The use of big data in healthcare allows for strategic planning thanks to better insights into people’s motivations. Care managers can analyze check-up results among people in different demographic groups and identify what factors discourage people from taking up treatment.

The University of Florida made use of Google Maps and free public health data to prepare heat maps targeted at multiple issues, such as population growth and chronic diseases. Subsequently, academics compared this data with the availability of medical services in most heated areas. The insights gleaned from this allowed them to review their delivery strategy and add more care units to the most problematic areas.

### 7) Big Data Might Just Cure Cancer

Another interesting example of the use of big data in healthcare is the Cancer Moonshot program. Before the end of his second term, President Obama came up with this program thathad the goal of accomplishing 10 years’ worth of progress towards curing cancer in half that time.

Medical researchers can use large amounts of data on treatment plans and recovery rates of cancer patients in order to find trends and treatments that have the highest rates of success in the real world. For example, researchers can examine tumor samples in biobanks that are linked up with patient treatment records. Using this data, researchers can see things like how certain mutations and cancer proteins interact with different treatments and find trends that will lead to better patient outcomes.

This data can also lead to unexpected benefits, such as finding that Desipramine, which is an antidepressant, has the ability to help cure certain types of lung cancer.

However, in order to make these kinds of insights more available, patient databases from different institutions such as hospitals, universities, and nonprofits need to be linked up. Then, for example, researchers could access patient biopsy reports from other institutions. One of the potential big data use cases in healthcare would be genetically sequencing cancer tissue samples from clinical trial patients and making these data available to the wider cancer database.

But, there are a lot of obstacles in the way, including:

- Incompatible data systems. This is perhaps the biggest technical challenge, as making these data sets able to interface with each other is quite a feat.
- Patient confidentiality issues. There are differing laws state by state which govern what patient information can be released with or without consent, and all of these would have to benavigated.

- Simply put, institutions that have put a lot of time and money into developing their own cancer dataset may not be eager to share with others, even though it could lead to a cure much more quickly.

However, as an article by Fast Company states, there are precedents to navigating these types of problems and roadblocks while accelerating progress towards curing cancer using the strength of data analytics.

**8) Predictive Analytics In Healthcare**

We have already recognized predictive analytics as one of the biggest business intelligence trends two years in a row, but the potential applications reach far beyond business and much further in the future. Optum Labs, a US research collaborative, has collected EHRs of over 30 million patients to create a database for predictive analytics tools that will improve the delivery of care.

The goal of healthcare online business intelligence is to help doctors make data-driven decisions within seconds and improve patients' treatment. This is particularly useful in the case of patients with complex medical histories, suffering from multiple conditions. New BI solutions and tools would also be able to predict, for example, who is at risk of diabetes and thereby be advised to make use of additional screenings or weight management.

**9) Reduce Fraud And Enhance Security**

Some studies have shown that 93% of healthcare organizations have experienced a data breach. The reason is simple: personal data is extremely valuable and profitable on the black markets. And any breach would have dramatic consequences. With that in mind, many organizations started to use analytics to help prevent security threats by identifying changes in network traffic, or any other behavior that reflects a cyber-attack. Of course, big data has inherent security issues and many think that using it will make organizations more vulnerable than they already are. But advances in security such as encryption technology, firewalls, anti- virus software, etc, answer that need for more security, and the benefits brought largely overtake the risks.

Likewise, it can help prevent fraud and inaccurate claims in a systemic, repeatable way. Analytics help to streamline the processing of insurance claims, enabling patients to get better returns on their claims and caregivers are paid faster. For instance, the Centers for Medicare and Medicaid Services said they saved over $210.7 million in fraud in just a year.

**10) Telemedicine**

Telemedicine has been present on the market for over 40 years, but only today, with the arrival of online video conferences, smartphones, wireless devices, and wearables, has it been able to come into full bloom. The term refers to the delivery of remote clinical services using technology.

It is used for primary consultations and initial diagnosis, remote patient monitoring, and medical education for health professionals. Some more specific uses include telesurgery – doctors can perform operations with the use of robots and high-speed real-time data delivery without physically being in the same location with a patient.

Clinicians use telemedicine to provide personalized treatment plans and prevent hospitalization or re-admission. Such use of healthcare data analytics can be linked to the use of predictive analytics as seen previously. It allows clinicians to predict acute medical events in advance and prevent deterioration of patient's conditions.

By keeping patients away from hospitals, telemedicine helps to reduce costs and improve the quality of service. Patients can avoid waiting in lines and doctors don't waste time on unnecessary consultations and paperwork. Telemedicine also improves the availability of care as patients' state can be monitored and consulted anywhere and anytime.

### 11) Integrating Big-Style Data With Medical Imaging

Medical imaging is vital and each year in the US about 600 million imaging procedures are performed. Analyzing and storing manually these images is expensive both in terms of time and money, as radiologists need to examine each image individually, while hospitals need to store them for several years.

Medical imaging provider Carestream explains how big data analytics for healthcare could change the way images are read: algorithms developed analyzing hundreds of thousands of images could identify specific patterns in the pixels and convert it into a number to help the physician with the diagnosis. They even go further, saying that it could be possible that radiologists will no longer need to look at the images, but instead analyze the outcomes of the algorithms that will inevitably study and remember more images than they could in a lifetime. This would undoubtedly impact the role of radiologists, their education, and the required skillset.

### 12) A Way To Prevent Unnecessary ER Visits

Saving time, money, and energy using big data analytics for healthcare is necessary. What if we told you that over the course of 3 years, one woman visited the ER more than 900 times? That situation is a reality in Oakland, California, where a woman who suffers from mental illness and substance abuse went to a variety of local hospitals on an almost daily basis.

This woman's issues were exacerbated by the lack of shared medical records between local emergency rooms, increasing the cost to taxpayers and hospitals, and making it harder for this woman to get good care. As Tracy Schrider, who coordinates the care management program at Alta Bates Summit Medical Center in Oakland stated in a Kaiser Health News article:

*"Everybody meant well. But she was being referred to three different substance abuse clinics and two different mental health clinics, and she had two case management workers both working on housing. It was not only bad for the patient, it was also a waste of precious resources for both hospitals."*

In order to prevent future situations like this from happening, Alameda county hospitals came together to create a program called PreManage ED, which shares patient records between emergency departments.

This system lets the ER staff know things like:

- If the patient they are treating has already had certain tests done at other hospitals, and what the results of those tests are.

- If the patient in question already has a case manager at another hospital, preventing unnecessary assignments.
- What advice has already been given to the patient, so that a coherent message to the patientcan be maintained by providers.

This is another great example where the application of healthcare analytics is useful and needed. In the past, hospitals without PreManage ED would repeat tests over and over, and even if they could see that a test had been done at another hospital, they would have to go old school and request or send long fax just to get the information they needed.

### 13) Smart Staffing & Personnel Management

Without a cohesive, engaged workforce, patient care will dwindle, service rates will drop,and mistakes will happen. But with big data tools in healthcare, it’s possible to streamline your staff management activities in a wealth of key areas. By working with the right HR analytics, it’s possible for time-stretched medical institutions to optimize staffing while forecasting operating room demands, streamlining patient care as a result.

Too often, there is a significant lack of fluidity in healthcare institutions, with staff distributed in the wrong areas at the wrong time. This imbalance of personnel management could mean a particular department is either too overcrowded with staff or lacking staff when it matters most, which can develop risks of lower motivation for work and increases the absenteeism rate. An HR dashboard, in this case, may help:

Though data-driven analytics, it’s possible to predict when you might need staff in particular departments at peak times while distributing skilled personnel to other areas within the institution during quieter periods.

Moreover, medical data analysis will empower senior staff or operatives to offer the right level of support when needed, improve strategic planning, and make vital staff and personnel management processes as efficient as possible.

### 14) Learning & Development

Expanding on our previous point, in a hospital or medical institution, the skills, confidence, and abilities of your staff can mean the difference between life and death. Naturally, doctors and surgeons are highly skilled in their areas of expertise. But most medical institutions have a range of people working under one roof, from porters and admin clerks to cardiac specialists and brain surgeons.

In healthcare, soft skills are almost important as certifications. To keep the institution running at optimum capacity, you have to encourage continual learning and development. By keeping track of employee performance across the board while keeping a note of training data, you can use healthcare data analysis to gain insight on who needs support or training and when. Ifeveryone is able to evolve with the changes around them, you will save more lives — and medical data analytics will help you do just that.

### 15) Advanced Risk & Disease Management

Big data and healthcare are essential for tackling the hospitalization risk for specific patients with chronic diseases. It can also help prevent deterioration.

By drilling down into insights such as medication type, symptoms, and the frequency of medical visits, among many others, it's possible for healthcare institutions to provide accurate preventative care and, ultimately, reduce hospital admissions. Not only will this level of risk calculation result in reduced spending on in-house patient care, but it will also ensure that space and resources are available for those who need it most. This is a clearcut example of how analytics in healthcare can improve and save people's lives.

As a result, big data for healthcare can improve the quality of patient care while making the organization more economically streamlined in every key area.

## 16) Suicide & Self-Harm Prevention

Globally, almost 800,000 people die from suicide every year. Plus, 17% of the world's population will self-harm during their lifetime. These numbers are alarming. But while this is a very difficult area to tackle, big data uses in healthcare are helping to make a positive change concerning suicide and self-harm. As entities that see a wealth of patients every single day, healthcare institutions can use data analysis to identify individuals that might be likely to harm themselves.

In a 2018 study from KP and the Mental Health Research Network, a mix of EHR data and a standard depression questionnaire identified individuals who had an enhanced risk of a suicide attempt with great accuracy. Utilizing a predictive algorithm, the team found that suicide attempts and successes were 200 times more likely among the top 1% of patients flagged according to specific datasets. Speaking on the subject, Gregory E. Simon, MD, MPH, a senior investigator at Kaiser Permanente Washington Health Research Institute, explained:

*"We demonstrated that we can use electronic health record data in combination with other tools to accurately identify people at high risk for suicide attempt or suicide death."*

This essential use case for big data in the healthcare industry really is a testament to the fact that medical analytics can save lives.

*"If somebody tortures the data enough (open or not), it will confess anything." – Paolo Magrassi, former vice president, research director, Gartner.*

## 17) Improved Supply Chain Management

If a medical institution's supply chain is weakened or fragmented, everything else is likely to suffer, from patient care and treatment to long-term finances and beyond. That said, the next in our big data in healthcare examples focus on the value of analytics to keep the supplychain fluent and efficient from end to end.

Leveraging analytics tools to track the supply chain performance metrics, and make accurate, data-driven decisions concerning operations as well as spending can save hospitals up to $10 million per year.

Both descriptive and predictive analytics models can enhance decisions for negotiating pricing, reducing the variation in supplies, and optimizing the ordering process as a whole. By doing so, medical institutions can thrive in the long term while delivering vital treatment to patients without potentially disastrous delays, snags, or bottlenecks.

### 18) Developing New Therapies & Innovations

The last of our healthcare analytics examples centers on working for a brighter, bolder future in the medical industry. Big data analysis in healthcare has the power to assist in new therapy and innovative drug discoveries. By utilizing a mix of historical, real-time, and predictive metrics as well as a cohesive mix of data visualization techniques, healthcare experts can identify potential strengths and weaknesses in trials or processes.

Moreover, through data-driven genetic information analysis as well as reactionary predictions in patients, big data analytics in healthcare can play a pivotal role in the development of groundbreaking new drugs and forward-thinking therapies. Data analytics in healthcare can streamline, innovate, provide security, and save lives. It gives confidence and clarity, and it isthe way forward.

## How To Use Big Data In Healthcare

All in all, we've noticed three key trends through these 18 examples of healthcare analytics: the patient experience will improve dramatically, including quality of treatment and satisfaction levels; the overall health of the population can also be enhanced on a sustainable basis, and operational costs can be reduced significantly.

Let's have a look now at a concrete example of how to use data analytics in healthcare:

### a) Big Data In Healthcare Applied On A Hospital Dashboard

This healthcare dashboard below provides you with the overview needed as a hospital director or as a facility manager. Gathering in one central point all the data on every division of the hospital, the attendance, its nature, the costs incurred, etc., you have the big picture of your facility, which will be of great help to run it smoothly.

### b) Big Data Healthcare Application On Patients' Care

Another real-world application of healthcare big data analytics, our dynamic patient dashboard is a visually-balanced tool designed to enhance service levels as well as treatment accuracy across departments

## Why We Need Big Data Analytics In Healthcare

There's a huge need for big data in healthcare as well, due to rising costs in nations like the United States. As a McKinsey report states: *"After more than 20 years of steady increases, healthcare expenses now represent 17.6 percent of GDP — nearly $600 billion more than the expected benchmark for a nation of the United States's size and wealth."*

In other words, costs are much higher than they should be, and they have been rising for the past 20 years. Clearly, we are in need of some smart, data-driven thinking in this area. And current incentives are changing as well: many insurance companies are switching from fee- for-service plans (which reward using expensive and sometimes unnecessary treatments and treating large amounts of patients quickly) to plans that prioritize patient outcomes

As the authors of the popular Freakonomics books have argued, financial incentives matter – and incentives that prioritize patients' health over treating large amounts of patients are a good thing. Why does this matter?

Well, in the previous scheme, healthcare providers had no direct incentive to share patient information with one another, which had made it harder to utilize the power of analytics. Now that more of them are getting paid based on patient outcomes, they have a financial incentive to share data that can be used to improve the lives of patients while cutting costs for insurance companies.

Finally, physician decisions are becoming more and more evidence-based, meaning that they rely on large swathes of research and clinical data as opposed to solely their schooling and professional opinion. As in many other industries, data gathering and management are getting bigger, and professionals need help in the matter. This new treatment attitude means there is a greater demand for big data analytics in healthcare facilities than ever before, and the riseof SaaS BI tools is also answering that need.

**Obstacles To A Widespread Big Data Healthcare**

One of the biggest hurdles standing in the way to use big data in medicine is how medical data is spread across many sources governed by different states, hospitals, and administrative departments. The integration of these data sources would require developing a new infrastructure where all data providers collaborate with each other.

Equally important is implementing new online reporting software and business intelligence strategy. Healthcare needs to catch up with other industries that have already moved from standard regression-based methods to more future-oriented like predictive analytics, machine learning, and graph analytics.

However, there are some glorious instances where it doesn't lag behind, such as EHRs (especially in the US.) So, even if these services are not your cup of tea, you are a potential patient, and so you should care about new healthcare analytics applications. Besides, it's good to take a look around sometimes and see how other industries cope with it. They can inspire you to adapt and adopt some good ideas

## 2.4 ELECTRONICHEALTHRECORD(EHR)

- Electronic health record, is the electronic versionof the client data found in the traditional paper record.
- EHRs are defined as "a longitudinal electronic recordof patient health information generated by one or more encounters in any care delivery setting.

**ROLES OF HER**

REPRESENTS patient's health history

- Medium of Communication among health carepractitioners
- Legal document for health care
- Source for clinical outcomes and healthservices research
- Resource for practitioner education
- Alerts, reminders, quality improvement

**DATACOMPONENTS DOCUMENTEDINEHR**

An electronic health record should contain important data such as;

- Patient profile and demographics
- Medical history includes information about allergies, illness,immunization, disorderand diseases.
- Medicine taken and its compatibility with druginteraction
- Records of appointment

Data components documented in EHRs:

- admission nursing note,
- daily charting,
- physical assessment,
- present complaints (e.g. symptoms),
- diagnoses, tests, procedures, treatment,
- nursing care plan,
- medication administration, progress notes
- laboratory data, and radiology reports
- referral,
- Discharge history,
- Billing recordsCOMPONENTS OF HER

**CLINICAL DECISION SUPPORT SYSTEM (CDSS),**

- Computerized physician order entry(CPOE) systems,and
- Health information exchange (HIE).

CLINICALDECISIONSUPPORTSYSTEM(CDSS)

- A CDS system is a software that assists theprovider in making decisions with regard to patient care.
- CDSS provides physicians and nurses with real-time diagnostic and treatment recommendations.

**FUNCTIONS OF CDSS**

- Managing clinical complexities
- Monitoring medication errors

- Avoiding duplicate and unnecessary tests
- Supporting clinical diagnosis &Treatment plan processes
- Promoting use of best practices & condition specificguidelines
- Population based management.
- providing the latest information about a drug,
- cross-referencing a patient allergy to a medication, and
- alerts for drug interactions and other potential patient issues

**Patient safety with HER**

Researchers found that computerized physician reminders increased the use of influenza and pneumococcal vaccinations from practically 0%to 35% and 50%, respectively, for hospitalized patients.

**Prevention of complicationwith EHR**

Willson et al, found a significant association between computerized reminders and pressure ulcer prevention in hospitalized patients.

They found a 5% decrease in the development of pressure ulcers 6 months after the implementation of computerized reminders that targeted hospital nurses.

## COMPUTERIZED PHYSICIAN ORDER ENTRY(CPOE)

CPOE is a software that allow physicians to enterorders directlyinto the computer rather than doing so on paper.

Example

- drugs,
- laboratory tests,
- radiology,
- physical therapy

**Benefits of CPOE**

- Eliminates potentially dangerousmedical errors caused by poor penmanship of physicians.
- Eliminate errors caused by uncleartelephone orders
- It also makes the ordering process more efficient because nursing andpharmacy staffs do not need to seekclarification or to solicit missing information from illegible or incomplete orders.

- Enhances patient safety

**Evidence**

- Studies suggest that serious medication errors can be reduced by 55% when a CPOE system is used alone, and by83% when coupled with a CDS system thatcreates alerts based on what the physicianorders.
- Using a CPOE system, especially when it islinked to a CDS, can result in improved efficiencyand effectiveness of care.

**HEALTH INFORMATION EXCHANGE**


Figure 2.6 Healthinformationexchange

HIE is the process of sharing patient's electronic health information between differentorganizations and can create many efficiencies inthe delivery of health care as shown in figure 2.6

Once health data are available electronicallyto providers, EHRs facilitate the sharing of patient information through HIE.

**Health information exchange-Benefits**

- Allows for the secure and potentially real-time sharing of patient information,
- HIE can reduce costly redundant tests
- HIE facilitates the exchange of this information via EHRs, which can result in much more cost-effective and higher- quality care.

**Technologies involved in EHR**

- Picture archiving and communications system
- Bar coding

- Radio frequency identification
- Automated dispensing medicines
- Electronic medication administration records

**Picture archiving and communication system:**

This technology captures and integrates diagnostic and radiological images from various devices, stores them, and disseminates them to a medical record, a clinical data repository, or other points of care.

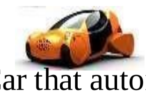
e.g., x-ray, MRI, computed tomography scan

Bar coding : An optical scanner is used to electronically capture information encoded on a product Initially, it is used for medication.

## 2.5 IoT IN HEALTH CARE

- IoT is a combination of hardware and software technology that produces trillions of data through connecting multiple devices and sensors with the cloudand making sense of data with intelligent tools

- Anything can be IoT device, if it can transmit and receivedata over the cloud and designed to process a unique task



Car that automatically senses the wear and tearand self-schedules the maintenance

Train that dynamically calculates arrival times and intimates to waiting passengers

**The Learning**

- Massive impact on life and business and Global economy
- There will be a huge influx of data from connected devices
- Raw, unstructured and unpredictable data
- Challenge to IT system to manage the enormous volume of data
- Conventional IT system cannot sustain this tremendous pressure

**The Act**

- Need innovations in sensor technology Setup an intelligent network
- Superior high performance cloud computing

## IOT IN HEALTHCARE

**IoT in Healthcare** is a heterogeneous computing, wirelessly communicating system of apps and devices that connects patients and health providers to diagnose, monitor, track and store vital statistics andmedical information as shown in figure 2.7

### Few examples of IoT in Healthcare

- Headsets that measure brainwaves
- Clothes with sensing devices
- BP monitors
- Glucose monitors
- ECG monitors
- Pulse oximeters
- Sensors embedded in medical equipment
- dispensing systems,
- surgical robots and device implants
- Any wearable technology device

Figure 2.7 IoT in Health care

## WHAT IS TELEHEALTH?

- TeleHealth is the delivery of healthcare services and clinicalinformation toremote locations
- TeleHealth is an FDA approved, HIPPA compliant platform that interactively connects patients with a nationwide network of licenseddoctors 24/7 using Internet, Internet of Things (IoT), video chats, smartphones and Electronic Medical Record (EMR) clouds
- TeleHealth is an hour-in-need solution in the $21^{st}$ century TeleHealth is a new paradigm in the Healthcareindustry

## SERVICES UNDER TELEHEALTH UMBRELLA

- **TeleMedicine:** Providing a professional consultation to a patient in a remote location or assisting a primary care physician in rendering a diagnosis. According to the American Medical Association (AMA), 78% of emergency carecare could be handled efficiently using TeleMedicine
- **TeleMonitoring:** Collecting patient data using IoT and sending the data to a healthcare monitoring agency for remote testing and diagnosis. TeleMonitoringTeleMonitoring services also include personalized alerts that inform a patient's patient's healthcare provider in times of physical/mental trauma
- **TeleSurgery:** Enabling the surgeon to perform an operation on a patient from adistant location using TeleRobotics technology
- **Remote Medical Education:** Providing medical education to the health care service community and targeted groups from a geographically different locationlocation
- **TeleHealthData Service:** Share specialized health information with other Healthservice providers, the education industry, research firms, and the government etc.

**BENEFITS OF TELEHEALTH SERVICES**

- Immediate medical attention especially during times of medical emergency andnatural disasters
- No need for waiting in long queues to see a physician
- Eliminate the need to physically go to a medical facility. TeleHealth reduces thedistance barriers
- Reduced documentation and paperwork

**Cost effective** – The growth in TeleHealth space will extensively reduce insurance premiums and potentially reduce the time a patient has to be away from work

Equal and comprehensive healthcare provisions to everyone by eliminatinggeographical barriers

**Better communication** - Communication to the primary care doctor and specialist happens at the same time because everyone is virtually present in the same room during diagnosis

Expanded reach to various health service providers

## 2.6 WEARABLE DEVICES

“Wearable” means whatever a subject can wear, as sweaters, hats, pants, eyeglasses, bras, socks, watches, patches or devices just fixed on the belt, without encumbering daily activities or restricting the mobility. The concept of wearability is of particular importance in fields like monitoring for healthcare, wellbeing and fitness/sport

- Very often wearable technology is based on conventional electronics, either rigid or bendable, powered by conventional batteries. This includes mobile phone peripherals or similar, i.e. devices, interfaces or sensors connected to the phone.
- In other cases, wearable technology is more ‘disruptive’ and includes apparel and textiles with distributed functions, in which electronics is intimately combined. In thiscase, the development is not obvious because devices have to be washable, stretchable, foldable, sometime printable or transparent as shown in figure 2.8

NEW WEARABLES –APPLICATIONS

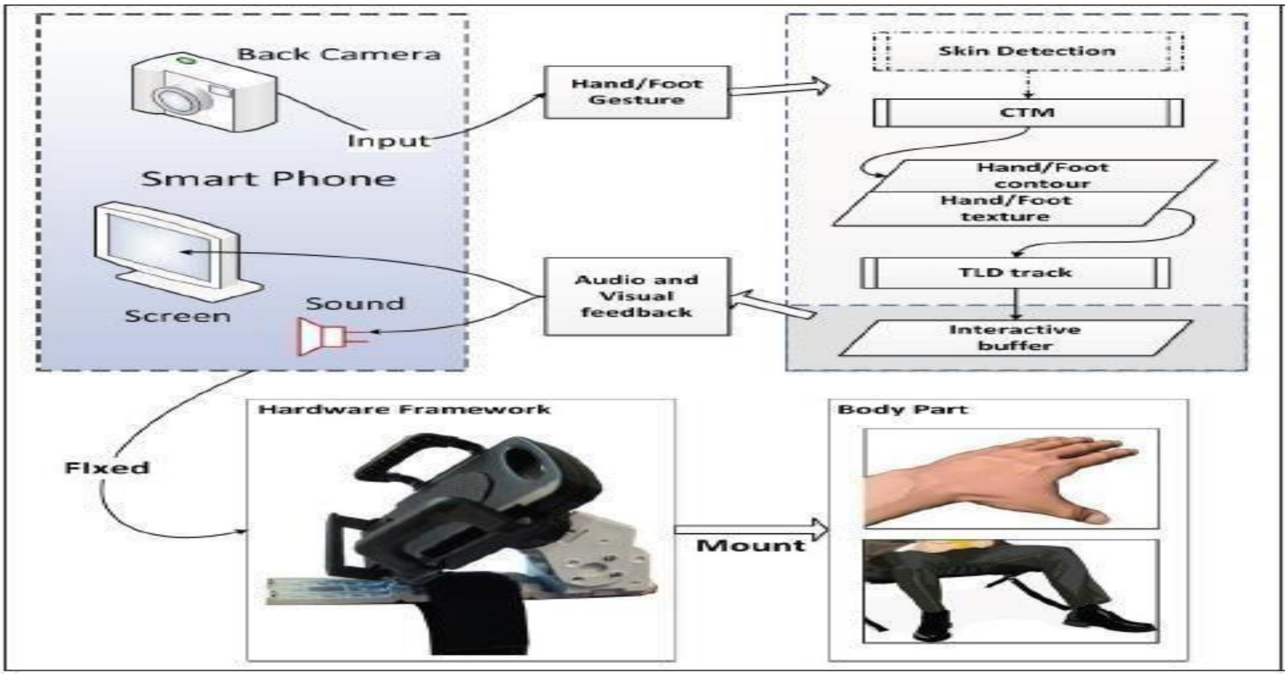



Figure 2.8Wearable Smartphone: Wearable Hybrid Framework for Hand and Foot Gesture

**TEXT / REFERENCE BOOKS**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**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING**

# UNIT – III – eHEALTH – SECA4004

**UNIT-III DIGITAL HEALTH**

Introduction to health care digital transformation- Digital health: Tools, Strategies of digital health-Technologies in digital health-Implementation of Digital health- Advantages and challenges of Digital health

## 3.1 INTRODUCTION TO HEALTH CARE DIGITAL TRANSFORMATION

Value Pathways in Digital Healthcare

- One of the key obstacles to rolling out the Digital Healthcare Ecosystem is bio-medical data availability, immediacy and liquidity - the flow of clinical data to every stakeholder - including patients, clinical practitioners, service providers and fund holders. Manystakeholders are now using “Big Data” methods to overcome this challenge, as part ofa modern data architecture.
- This section describes some example Digital Healthcare use cases, a Digital Healthcare reference architecture and how “Big Data” methods can resolve the risks, issues and problems caused by poor clinical data latency.In January 2013, McKinsey & Company published a report entitled “The ‘Big Data’ Revolution in Healthcare”. The report points out how big data is creating value in five “new value pathways” allowing data to flow more freely between stakeholders.
- The Diagram below is a summary of five of these new value pathway use cases and an example of how “Big Data” can be used to address each use case. Examples are taken from the Clinical Informatics Group at UC Irvine Health - many of their use cases are described in the UCIH case study

| Pathway | Benefit | “Big Data” Use Case |
|---|---|---|
| **Patient Health and Wellbeing** | Patients can build stakeholder valueby taking an active role in their own health, wellbeing and treatment, including disease prevention. | **Predictive Analytics:** Heart patients weigh themselves at homewith scales that transmit data wirelessly to their health center. Algorithms analyze the data and flag patterns that indicate ahigh risk of readmission, alerting a physician. |
| **Patient Monitoring** | Patients get the most timely and appropriate diagnoses, treatment and clinical intervention | **Real-time Monitoring:** Patient vital statistics are transmitted from wireless sensors every minute. If vital signs cross certain |

| | | |
|---|---|---|
| | available. | risk thresholds, staff can attend to thepatient immediately. |
| **Healthcare Provisioning** | Healthcare Provider capabilities matched to the complexity of the assignment— for instance, nurses or physicians' assistants performing tasks that do not require a doctor. Also the specific selection of the provider with the best outcomes. | **Historical EMR Analysis:** Big Data reduces the cost to store data on clinical operations, allowing longer retention of data onstaffing decisions and clinical outcomes. Analysis of this data allows administrators to promote individuals and practices that achieve the best results. |
| **Patient Value Proposition** | Ensure cost-effectiveness of care provision, such as tying Healthcare Provider reimbursement to patient outcomes, or eliminating fraud, waste,or abuse in the system. | **Medical Device Management:** Biomedical devices stream geo-location and biomedical sensor data to manage patient clinical outcomes from medical equipment. The biomedical team know where all the patients and equipment are, so they don't waste time searching for a location. Over time, determine the usage ofdifferent biomedical devices, and use this information to make rational decisions about when to repair or replace equipment. |
| **Digital Innovation** | The identification of new therapies and approaches to delivering care, across all aspects of the system and improving Medical Analytics engines themselves. | **Collaborative Research :** Clinical Researchers attached to hospitals can access patient data stored in Hadoop Cluster "Big Data" Stores for discovery, then present theanonymous sample data to their Internal Review Board for approval, without ever having seen uniquely identifiable information. |

## Digital Healthcare

- Changing demographics and regulations are putting tremendous pressure on the healthcare sector to make significant improvements in care quality, cost control, clinical management, organizational efficiency and regulatory compliance. To stay viable, it is paramount to effectively address issues such as missed and mis- diagnosis, coding error, over / under treatment regimes, unnecessary procedures and medications, insurance fraud, delayed diagnosis, lack of preventive health screening and proactive health maintenance. To that end, better collaboration across and beyond the organization with improved information sharing, and a holistic approach to capture clinical insights across the organization are critical.

- In an environment prevalent with multiple unstructured data silos and traditional analytics focused on structured data, healthcare organizations struggle to harness 90% of their core data - which is mostly medical images, biomedical data streams and unstructured free text found in clinical notes across multiple operational domains. Connecting healthcare providers directly with patient data reduces risk, errors and unnecessary treatments; thus enabling better understanding of how delivery affects outcomes - and uncovering actionable clinical insights in order that proactive and preventive measures decrease the incidence of avoidable diseases.

- Digital Healthcare is a cluster of new and emerging applications and technologies that exploit digital, mobile and cloud platforms for treating and supporting patients. The term is necessarily general as this novel and exciting Digital Healthcare innovation approach is being applied to a very wide range of social and health problems, ranging from monitoring patients in intensive care, general wards, in convalescence or at home – to helping doctors make better and more accurate diagnoses, improving drugs prescription and referral decisions for clinical treatment.

- Digital Healthcare has evolved from the need for more proactive and efficient healthcare delivery, and seeks to offer new types of prevention and care at reducedcost – using methods that are only possible thanks to sophisticated technology.

## Digital Healthcare Technologies – Bioinformatics and Medical Analytics.

Novel and emerging high-impact Biomedical Health Technologies such as Bioinformatics and Medical Analytics are transforming the way that Healthcare Service Providers can deliver Digital Healthcare globally – Digital Health Technology entrepreneurs, investors and researchers becoming increasingly interested in and attracted to this important and rapidly growing Life Sciences industry sector. Bioinformatics and Medical Analytics utilises Big Data / Analytics to provide actionable Clinical insights.

- Case Study 1 – HP Autonomy Medical Analytics. Changing healthcare service provisioning, regulation and patient demographics are putting increasing pressure on the healthcare industry to make significant improvements in care quality, cost management, organizational efficiency and compliance. Priorities include the need to address challenging issues such as misdiagnosis, coding error, over / under treatment, unnecessary procedures and medications, fraud, delayed diagnosis, lack of preventive screening and proactive health maintenance. Improved collaboration within the organization with better information sharing, and a holistic approach to capture and action medical insights across the organization are crucialto success.

- Case Study 2 – Telefónica Digital was created as a Special Purpose Vehicle to lead Telefónica's transformation into an M2M / M2C / C2C Digital Services provider - cloud computing / digital telecommunications value added network services (VANS). Telefónica Digital is the vehicle for launch / bringing to market digital products and services - which will help to improve the lives of customers by leveraging the power of digital technology. This ranges from developing new technologies for healthcare providers to communicate with other stakeholders, to helping Healthcare Providers, Life Sciences businesses and government HealthDepartments discover actionable clinical insights, address new opportunities as shown in figure 3.1 and Table 3.1

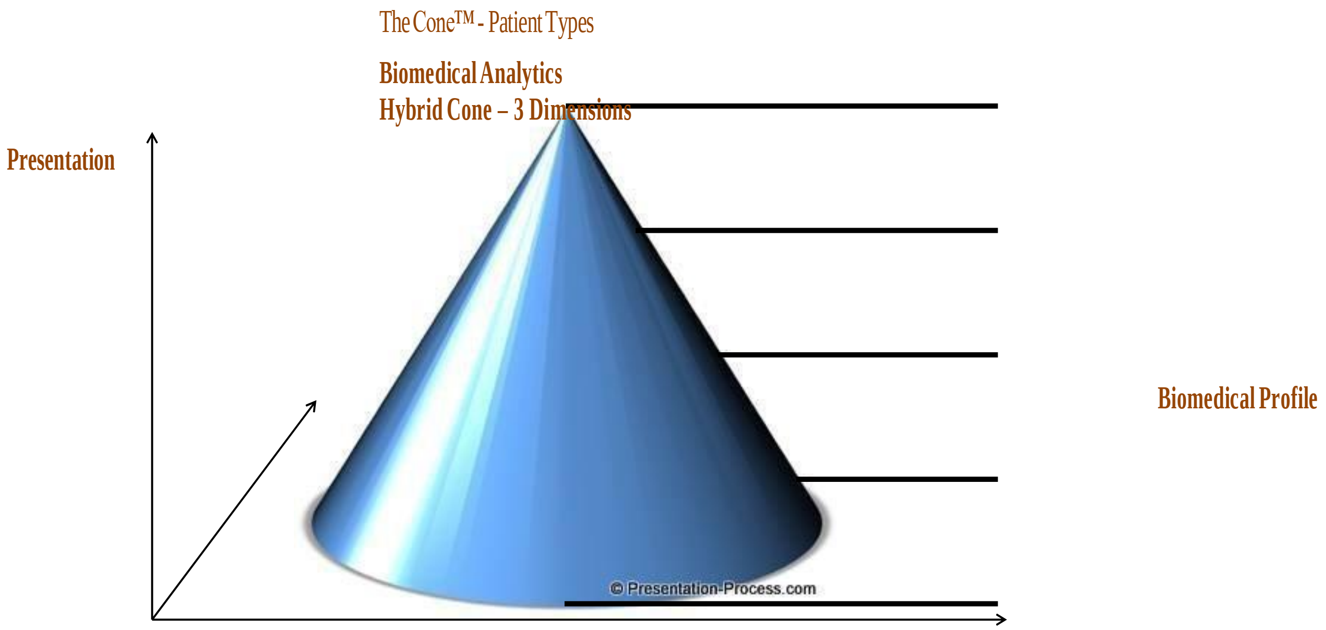



Figure 3.1Biomedical Epidemiology – Groups (Streams), Types (Segments)

Table 3.1 TheCone™- Eight Primitives

| Primitive | Domain | Function | Product |
|---|---|---|---|
| **Who ?** | People - Patient | EMR | SalesForce.com |
| **What ?** | Event | Appointment, Walk-in, Referral, 1st Responders and Emergency Services | Primary Care, GPs HealthcareProvider Hospitals, Clinics |
| **Why ?** | Motivation | Triage - Acute / Chronic | Biomedical Analytics |
| **Where ?** | Places - Location | GIS / GPS / Analytics | Geospatial Analytics |
| **When ?** | Time / Date | Procedure | Biomedical Analytics |
| **How ?** | Biomedical Data | Streaming Medical Data | Smart Devices / AppsMobile Platforms, IoT |
| **Which ?** | Clinical Procedure | Investigate, Diagnose,Treatment, Follow-up | Nurse, Consultant |
| **Via ?** | Referral Channel Delivery Partner | Healthcare Service Delivery, Procedure | Healthcare Provider Hospitals, Clinics |

## 3.2 DIGITAL HEALTH: TOOLS, STRATEGIES OF DIGITAL HEALTH

**Data Science in Digital Healthcare**

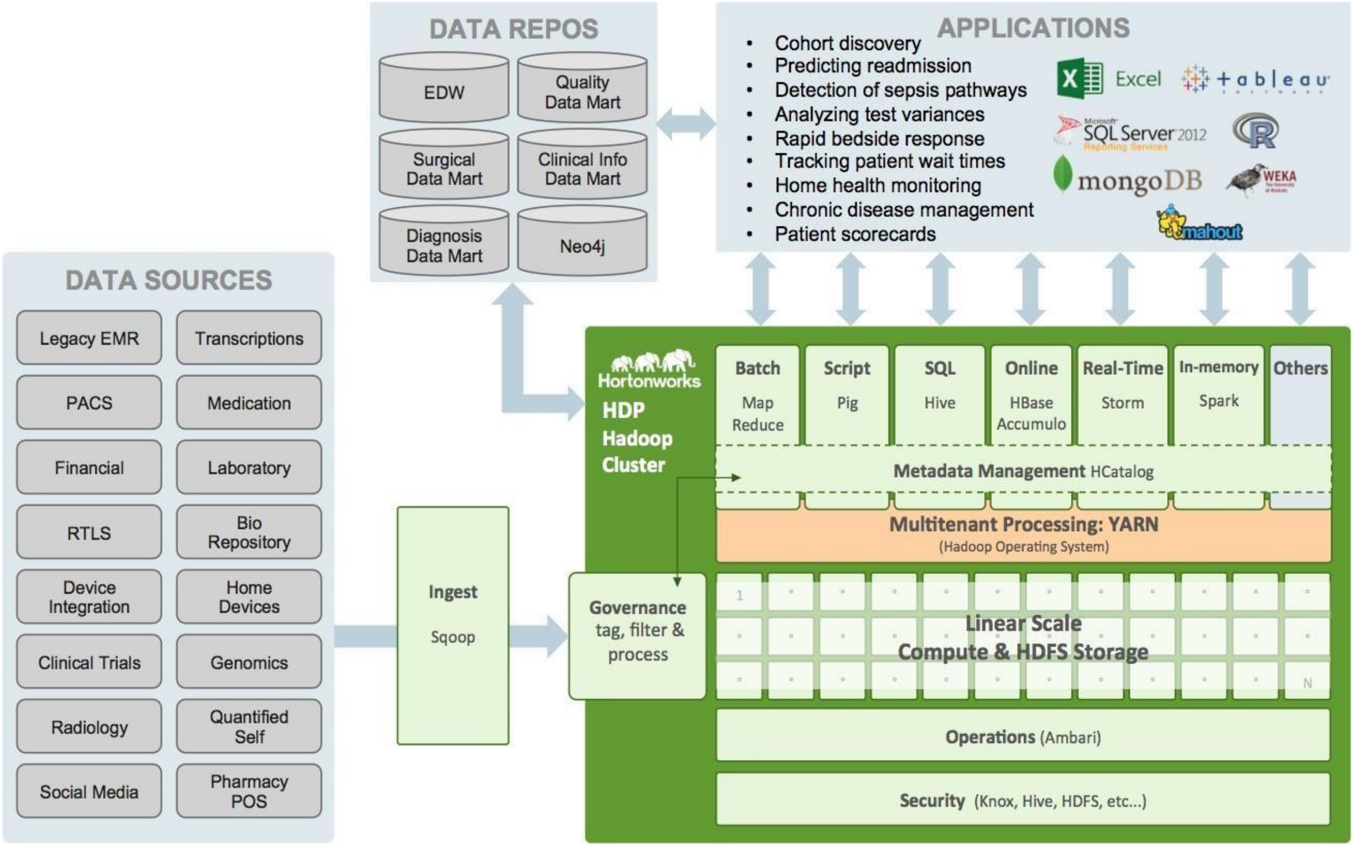



Figure 3.2 Data science in Digital Health care

These are some of the most important **DIGITAL HEALTH CATEGORIES**...as shown in figure 3.2.

- Digital Imaging – (MRI / CTI / X-Ray / Ultrasound)
- Robotic Surgery – (Microsurgery / Remote Surgery)
- Patient Monitoring – (Clinical Trials / Health / Wellbeing)
- Biomedical Data – (Data Streaming / Biomedical Analytics)
- Emergency Incident Management – (Response Team Alerts)
- Epidemiology – (Disease Transmission / Contact Management)

Here are some of the most important **DIGITAL MONITORING SMART APPS**.....

- Activity Monitor – (Pedometer / GPS)
- Position Monitor – (Falling / Fainting / Fitting)
- Sleep Monitor – (Light Sleep / Deep Sleep / REM)
- Cardiac Monitor – (Heart Rhythm / Blood Pressure)

- Blood Monitor – (Glucose / Oxygen / Liver Function)
- Breathing Monitor – (Breathing Rate / Blood Oxygen Level)

**Digital Healthcare – Executive Summary**

- Digital Healthcare is a cluster of new and emerging applications and technologies that exploit digital, mobile and cloud platforms for treating and supporting patients. The term "**Digital Healthcare**" is necessarily broadand generic as this novel and exciting Bioinformatics and Medical Analytics innovation driven approach is applied to a very wide range of social and health problems - from monitoring patients in intensive care, general wards, in convalescence or at home – to helping general practitioners make better informed and more accurate diagnoses, improving the effect of prescription and referral decisions for clinical treatment.

- Bioinformatics and Medical Analytics utilises Data Science to provide actionable clinical insights. Digital Healthcare has evolved from the need for more proactive and efficient healthcare service delivery, and seeks to offer new and improved types of pro- active and preventive monitoring and medical care at reducedcost – using methods that are only possible thanks to emerging SMAC Digital Technology.

**Digital Healthcare Technologies – Bioinformatics and Medical Analytics: -**

- Digital Patient Monitoring
- Biomedical Data Streaming
- Biomedical Data Science and Analytics
- Epidemiology, Clinical Trials, Morbidity and Actuarial Outcomes

  - Novel and emerging high-impact Biomedical Health Technologies such as Bioinformatics and Medical Analytics are transforming the way that Healthcare Service Providers can deliver Digital Healthcare globally
  - Digital Health Technology entrepreneurs, investors and researchers becoming increasingly interested inand attracted to this important and rapidly expanding Life Sciences industry sector.

- While many industries can benefit from **SMAC** digital technology – **Smart** Devices, **Mobile** Platforms, **Analytics** and the **Cloud** – this is especially the case for Life Sciences, Pharma and Healthcare industry sectors – resulting in more accurate diagnosis, improved treatment regimes, more reliable prognosis, better patient monitoring, care and clinical outcomes. Let's take a look at some of the Digital Technologies that are bringing significant improvements and benefits to Healthcare

- Today, thanks to the regulatory compliance requirements for HIPAA, HITEC, PCI DSS and ISO 27001, the reluctance to adopt Digital Technology has been overcome, and Digital Healthcare adoption is gaining increased traction. Many of the security features required for data protection and patient confidentiality are being addressed by Digital Healthcare service providers, therefore relievinghealthcare delivery organizations from tedious and complex security and data protection frameworks.

**Biomedical Data Analytics:**

The exploitation of data by applying analytical methods such as statistics, predictive and quantitativemodels to patient segments or groups of the population will provide better insightsand achieve betteroutcomes. As far back as 2010, **there was evidence that**: "93 percent of healthcare providers identified the digital information explosion as the major factor which will drive organizational change over the next 5 years."

**Data Security and Privacy:**

Today, thanks to the regulatory compliance requirements for HIPAA, HITEC, PCI DSS and ISO 27001, reluctance to adopt emerging technologies is starting to be addressed and digital technology is beginning to gain traction - bear in mind also that many of the security features required for data security and protection are addressed by the service providers, therefore relieving the healthcare organization from tedious and complex security frameworks.

**Mobility:**

Mobility Services, where Smart Devices, Smart Apps, Mobile Platforms and Cloud Infrastructure is providing the backbone for medical personnel to access all sorts of patient information from any place, any where - and from a wide range of mobile devices.

**Collaboration with patients:**

Mobility means that complete patient records are now available to healthcare professionals anytime, anywhere – allowing physicians to access historical patient case records , images and clinical data to fine-tune their diagnosis and make informed decisions on treatment – thus reducing diagnosis latency, increasing accuracy and improving patient care and clinical outcomes from initial consultation to specialist referrals. Some scenarios are illustrated in the following: -

**Physician Collaboration Solutions (PCS) •**

- PCS solutions offers video conferencing to facilitate remote consultations and care continuity, allowing patients to be viewed remotely. PCS allows physicians to consult withpatients and even perform remote robotic surgery. This is dubbed "tele-health solutions."

**Electronic Medical Records (EMR) •**

- Every piece of information pertaining to a specific is recorded and stored. The solution is designed to capture and provide a patient's data at any time of the patient's monitoring cycle, including the complete medical records and history.

**Patient Information Exchange (PIE) •**

- This allows for the healthcare information to be shared electronically across organizations within a region, community or hospital system. There are currently several Digital Healthcare cloud service providers addressing this market, taking the role of collecting and distributing medical information from and among multiple organizations.

- The New York Times has published an interesting **article illustrating the use of the cloudin healthcare** - leveraging big data in the cloud to manage patient relationships and clinical outcomes.

**Collaboration among peers:**

Technology can provide medical assistance to doctors in the field, b e it in remote areas orin emergency relief operations through satellite communications. Refer to the Remote Assistance for Medical Teams Deployed Abroad (T4MOD project) which could easily findits place in the Digital Healthcare cloud space.

## 3.3 BIG DATA IN DIGITAL HEALTHCARE

**"Big Data"** in Pharma / Life Sciences

Big data now plays an important role in medical and clinical research. Digital Patient Records are now being harvested and analysed in large-scale patient population studies – which are yielding actionable clinical insights. The UK Government has made anonymised patient records from the National Health Service openly available. Medical Centres, Research Institutes and Pharma /Life Sciences funding agencies have all made major investments in this area.

**SENSE LAYER – Remote Monitoring and Control – WHAT and WHEN?**

- Remote Sensing – Sensors, Monitors, Detectors, Smart Appliances / Devices
- Remote Viewing – Satellite. Airborne, Mobile and Fixed HDCCTV
- Remote Monitoring, Command and Control – SCADA

**GEO-DEMOGRAPHIC LAYER – People and Places – WHO and WHERE?**

- Person and Social Network Directories - Personal and Social Media Data
- Location and Property Gazetteers - Building Information Models (BIM)
- Mapping and Spatial Analysis – Landscape Imaging & mapping, Global Positioning (GPS)Data
- Temporal / Geospatial data feeds –Weather and Climate, Land Usage, Topology / Topography

**INFORMATION LAYER – "Big Data" and Data Set "mashing" – HOW and WHY?**

- Content – Structured and Unstructured Data and Content
- Information – Atomic Data, Aggregated, Ordered and Ranked Information
- Transactional Data Streams – Smart Devices, EPOS, Internet, Mobile Network

**SERVICE LAYER – Real-time and Predictive Analytics – WHAT / WHEN NEXT?**

- Global Mapping and Spatial Analysis - GIS
- Service Aggregation, Intelligent Agents and Alerts
- Data Analysis, Data Mining and Statistical Analysis
- Optical and Wave-form Analysis and Recognition, Pattern and Trend Analysis an Extrapolation

**COMMUNICATION LAYER – Mobile Enterprise Platforms and the Smart Grid**

- Connectivity - Smart Devices, Smart Apps, Smart Grid
- Integration - Mobile Enterprise Application Platforms (MEAPs)
- Backbone – Wireless and Optical Next Generation Network (NGE) Architectures

**INFRASTRUCTURE LAYER – Cloud Service Platforms**

- Public, Mixed / Hybrid, Enterprise, Private, Secure and G-Cloud Cloud Models
- Infrastructure – Network, Storage and Servers
- Applications – COTS Software, Utilities, Enterprise Services
- Security – Principles, Policies, Users, Profiles and Directories, Data Protection

**DIGITAL HEALTH CARE –CLUSTER THEORY**


Figure 3.3 Cluster Theory

**Medical Education and Remote Diagnostics**

Capabilities in Remote Diagnostics and Medical Education are evolving rapidly. Companies that are innovating on this front and encompassing solutions such ascrowd-sourcing and peer- 2-peer learning. Some of those companies really taking advantage of the explosion in Biomedical "Big Data' include **HP, GE Healthcare, Siemens Healthcare, Boardvitals** and **AgileM** as shown in figure 3.3

**Secure Storage and Sharing of Biomedical Information**

Box is a platform that is HIPAA and HITECH compliant for secure capture, storage and management of Protected Personal Health Information (PPHI).

**Medical Service Provider's Tools**

- More and more service providers continue to jump on board with the new **Medical Service Provider's Tools** that are out there.
- Two companies that are particularly interesting are **Clinicast** and **Reify Health** (currently in beta test)

## 3.4 DIGITAL DIAGNOSTICS TOOLS

- Researchers are now taking advantage of new and emerging biomedical technologies which integrate with Mobile Phones and other Smart Devices in orderto add diagnostic capabilities to the arsenal of the general and clinical physician. One company that looks promising in the future is Cellscope - FDA approved.

- Proteus Digital Health takes endoscopy to an extraordinary new level. This device is housed in a small capsule which can be swallowed - and contains a range of sensors and detectors, automatically streaming continuous digital information – and even images - to Mobile Phones and other Smart Devices. The device is capable of monitoring and tracking how the patient's alimentary canal anddigestive system behaves when an oral drug is being administered or when food ordrink is being consumed. Nephosity - imaging - FDA approved.

- Dexcom markets a device that monitors blood glucose levels which is tucked neatly under theskin of the patient's abdomen - FDA approved. Google are trialling a soft contact lens with an embedded bluetooth device and a sensor that monitors blood glucose levels - which continuously streams blood glucose level data to a monitoring service in the cloud, via a bluetooth mobile phone connection.

**Patient Communities – Chronic Disease Management**

- Reducing the cost of treating chronic illness is a major goal – because it can dramatically improve health indices in populations of individuals suffering fromchronic long-term illness Focusing on those highest-cost patient population'sis an exciting approach thata number of companies are exploring. Chronic Disease management can be improved by supporting care providers and extenders that take on the task of assisting with the healthcare and improving the outcomes of these high-cost patients.

- Patients that have chronic illness have a variety of needs. Some patients require planned, regular interactions with support to their carers, focusing on function and prevention of acute episodes and complications. Community Healthcare Coaches can provide ongoing assessments in compliance with the treatment plan. Another important issue could be behavioural modification, and an organised support system for the patient

**Electronic Medical Records (EMR's)**

- EMR's are Active web applications that can intervene directly in order to effect positive patient outcomes. “Prioritising positive patient care becomes a naturalconsequence when the EMR is built with the intent of facilitating the patient- physician relationship. EMR's focus on supporting the physician – so that the physician can focus on treating the patient” - says ***Kyna Fong*** - *ElationEMR*

- Companies developing Active Patient Management in order to promote positive Medical Outcomes include the following Digital Health Technology providers: -

- ElationEMR, GEHealthcare, Curemd and Drchrono and 5 O'Clock Records, CareCloud between them offer a variety of web-based EMR‘s in addition to General Practice patient administration systems and revenue cycle management solutions

- DoseSpot is an e-prescribing platform. Medopad and Practice Fusion are EMR's which are marketed to community practitioners and doctors in primary health groups.

**Telemedicine**

- With systems such as ***Teladoc*** you can obtain an on-line consultation froma consultant physician or specialist anywhere in the world via an on-line video-link. ***Teladoc*** is bringing this facility over to the 'brick and mortar' side by working on the development of walk-in patient kiosks situated in Health Centres and high-street Pharmacies .

**Grid Computing World**

- Community Grid for grid computing applications - Mobile Phones and other smart devices will make use of sensor and imaging technology to gather passive and active data for statistical analysis and diagnosis via Remote Healthcare Monitoring and Emergency Event Management Centres.

**Care Delivery**

- Delivery of care can always be improved. Some of the winners in thiscategory are going to be: -

- –One Medical, Sherpaa, Metamed (personalized medical research) and Statphone (patient transfers)

**Behavioural Health Analytics**

Patient Behaviour Analysis is the diagnostic tool of the future. Every patient has unique genetic characteristic and environmental exposure - habits and behaviour patterns - and any changes to those everyday habits and behaviour patterns may be an indicator of a change in health status requiring intervention or a predictive determinant of the future path a patient may take in terms of health and wellbeing.Mobile Phones and other smart devices will make use of sensor and imaging technology to gather passive and active data for statistical analysis and diagnosis.

**Biomedical "Big Data" Management and Analytics**

- Anapsis and EMBI, focus on **Biomedical "Big Data" Management and Analytics.** This service is highly customisable for every client.

- Ginger.io is another example of a Behavioural Analytics platform. Ginger.io examines patterns of everyday activity which are used as points of entry for understanding larger issues such as paediatrics requirements, geriatrics needs and mental health care for schemes such as Care in the Community and AssistedLiving at Home.

**Transitional Care**

- "Care transitions" is a term that describes the flow of patients from clinical settings to settings in the community - which are socially more appropriate relative to their needs. Every patient's needs change over time. Patients mayencounter a Primary Care Provider, a hospital physician, the nursing team and even Social Services before they are "whisked off" to a nursing facility or care home. Promising companies in the area of Care Transition include: -Care At Hand, Independa and OpenPlacement

- Companies such as these are building Smart Apps for Mobile Phones and other smart devices which will make use of sensor and imaging technology for streaming data to monitoring services that will bring new possibilities in the transition from Intensive Care Units and General Hospital Wards, into a convalescent nursing facility or care home and on into other patient care schemes such as Care in the Community and Assisted Living at Home.

**Patient Management** and **Patient Administration Systems**

- Integrated new clinical and back-office **Patient Management** and **Patient Administration Systems** will be in demand to manage the changing landscape of healthcare services provisioning, funding and cross-charging.

- Some of the challenges that are being addressed range from the simple capture at source of one-off chargeable consultation, medication and point medical procedures – to fully-featured clinical billing systems for managing the provision of complex multi-stage and continuous medication and clinical procedures, re-charging costs and administering payments from Primary Carebudget holders and Health Insurance Companies – or patients themselves.

- Solutions from those companies listed below are of interest: -

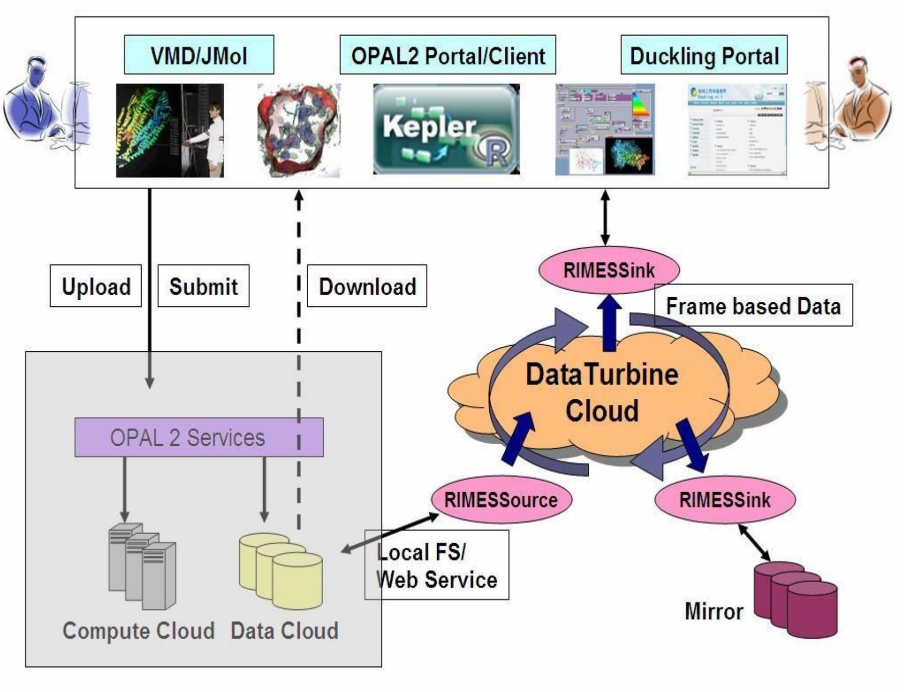
- Medmonk, Medikly, Simplee, Cake Health, Castlight Healthcare, SwiftPayMD.

**WAVE-FORM ANALYTICS -** an analytical tool based on Time-frequency Wave- form analysis – which has been “borrowed” from spectral wave frequency analysis in Physics. Deploying the Wigner-Gabor-Qian (WGQ) spectrogram – a method which exploits wave frequency and time symmetry principles – demonstrates a distinct trend forecasting and analysis capability in Wave-form Analytics. Trend-cycle wave-form decomposition is a critical technique for testing the validity of multiple (compound) dynamic wave-series models competing in a complex array of interacting and inter- dependant cyclic systems - waves driven by both deterministic (human actions) and stochastic (random, chaotic) paradigms in the study of complex cyclic phenomena.

**WAVE-FORM ANALYTICS in “BIG DATA** - characterised as periodic alternate sequences of, high and low trends regularly recurring in a time-series – resulting in cyclic phases of increased and reduced periodic activity – Wave-form Analytics supports an integrated study of complex, compound wave forms in order to identify hidden Cycles, Patterns and Trends in Big Data. The existence of fundamental stablecharacteristic frequenciesin large aggregations of time-series Economic data sets (“Big Data”) provides us with strong evidence and valuable information about the inherent structure of Business Cycles. The challenge found everywhere in business cycle theory is how to interpret very large scale / long period compound-wave (polyphonic) temporal data sets which are non-stationary (dynamic) in nature.

## BIOMEDICAL DATA SENSORS AND DETECTORS

Data Captured via Biomedical sensors, detectors, metering (measurement), monitoring (looking for changes) and control (maintaining vital statistics) systems - can now be managed in vast “Biomedical Clouds” which exploit grid computing devices in order to capture, store and interrogate a wide spectrum of real-time Biomedical Data Types – ranging from simple measurements of patients temperature, blood oxygen, sugar and carbon dioxide levels – to the most complex Image Processing and Visual Rendering in real time using data streamed from MRI, CTI, Ultra-sound and X-ray scanning machines as shown in figure 3.4 and 3.5



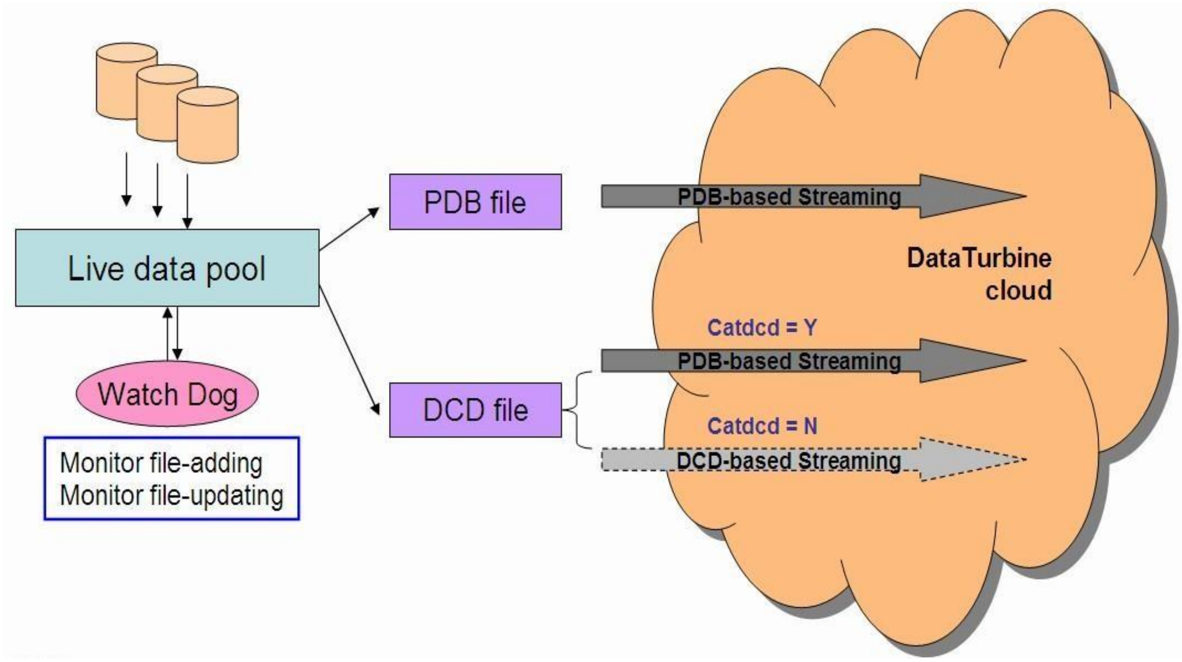




Figure 3.4 and 3.5 Data turbine cloud

There are three major areas of opportunity – these are some of the applications that Biomedical companies are currently working on: -

- Biomedical data collection, storage and communication - from individual patients
- Biomedical data integration – combining multiple data sets for analysis / interpretation
- Biomedical data aggregation and summarisation – vast clinical data sets collected and integrated from thousands of patients – driving Geo-demographic clustering and statistical analysis for Clinical Trials, Epidemiology, Morbidity and Actuarial Science

- Companies that have great potential in these areas include: - Sanyo Intelligence, Apple and GEHealthimagination, Cardiio, MC10, AliveCor, AgaMatrix, Proteus

**Real-time Biomedical Data Streaming**

Biomedical Scientists around the world are deeply committed to advanced Medical Programmes which are capable of automatically generating and processing, Exobytes (millions of Petabytes) of Biomedical Data. in real-time This data is captured via Biomedical, sensors, detectors, measurement, monitoring and control systems - and is managed in vast "Biomedical Clouds" which utilise grid computing devices in order to capture, store and analyse a wide spectrum of real-time Biomedical Data Types – ranging from simple measurements of patients temperature, blood oxygen, sugar and carbon dioxide levels – to complex Image Processing and Visual Rendering in real time using data from MRI, CTI, Ultra-sound and X-ray scanning machines

**REAL-TIME BIOMEDICAL DATA STREAMING (RIMES*)***

**Real-time Biomedical Data Streaming**

- Most of these Biomedical datasets are huge – potentially containing Exobytes (millions of Petabytes ) of Biomedical "Big Data". Biomedical Data Streams are composed of machine-generated metering, sensing and monitoring data captured by scientific instruments deployed in support of large-scale Biomedical Research programs. Biomedical Software features intelligent agents and alerts which can automatically trigger alarms and interventions. Various types of biomedical data are supported by the Biomedical Cloud environment, including .pdb and .dcd files.

- As Biomedical Data in the working repository is continuously updated, appended image frames may be streamed to an RBNB Data-turbine Cloud by the RIMES Synchronisation client - which ensures that data from the Biomedical Data Stream is continuously synchronized with the Biomedical Data Cloud. User Clinicians may deploy various extended user services over the core biomedical grid computing features and mass storage

- systems – including various Biomedical Software Portals,such as intelligent agents and alerts, visualization and analytics tools portals – whichare continuously processing incoming dynamic realtime biomedical data stream

## 3.5 DIGITAL HEALTH

**Hadoop Framework**

- The workhorse relational database has been the tool of choice for businesses for well over 20 years now. Challengers have come and gone but the trusty RDBMS is the foundation of almost all enterprise systems today. This includes almost all transactional and data warehousing

- systems. The RDBMS has earned its place as a proven model that, despite some quirks, isfundamental to the very integrity and operational success of IT systems around the world.

- The relational database is finally showing some signs of age as data volumes and network speeds grow faster than the computer industry's present compliance with Moore's Law cankeeppace with. The Web in particular is driving innovation in new ways of processing information as the data footprints of Internet-scale applications become prohibitive using traditional SQL database engines.

  When it comes to database processing today, change is being driven by (at least) fourfactors:

- **Speed.** The seek times of physical storage is not keeping pace with improvements in network speeds.

- **Scale.** The difficulty of scaling the RDBMS out efficiently (i.e. clustering beyond a handful of servers isnotoriously hard.)

- **Integration.** Today's data processing tasks increasingly have to access and combine data from manydifferent non-relational sources, often over a network.

- **Volume.** Data volumes have grown from tens of gigabytes in the 1990s to hundreds of terabytesandoften petabytes in recent years.

**Hadoop Framework**

- These datasets would previously have been very challenging and expensive to take on with a traditional RDBMS using standard bulk load and ETL approaches. Never mind trying to efficiently combining multiple data sources simultaneously or dealing with volumes of data that simply can't reside on any single machine (or often even dozens). Hadoop deals with this by using a distributed file system (HDFS) that's designed to deal coherently with datasets that can only reside across distributed server farms. HDFS is also fault resilient and so doesn't impose the overhead of RAID drives and mirroring on individual nodes in a Hadoop compute cluster, allowing the use of truly lowcost commodity hardware.

- So what does this specifically mean to enterprise users that would like to improve their data processing capabilities? Well, first there are some catches to be aware of. Despite enormous strengths in distributed data processing and analysis, MapReduce is not good in some key areas that the RDMS is extremely strong in (and vice versa). The MapReduce approach tends to have high latency (i.e. not suitable for real-time transactions) compared to relational databases and is strongest at processing large volumes of write-once data where most of the dataset needs to be processed at one time. The RDBMS excels at point queries and updates, while MapReduce is best when data is written once and read many times.

- The story is the same with structured data, where the RDBMS and the rules of database normalization identified precise laws for preserving the integrity of structured data and which havestood the test of time. MapReduce is designed for a less structured, more federated world where schemas may be used but data formats can be much looser and freeform.

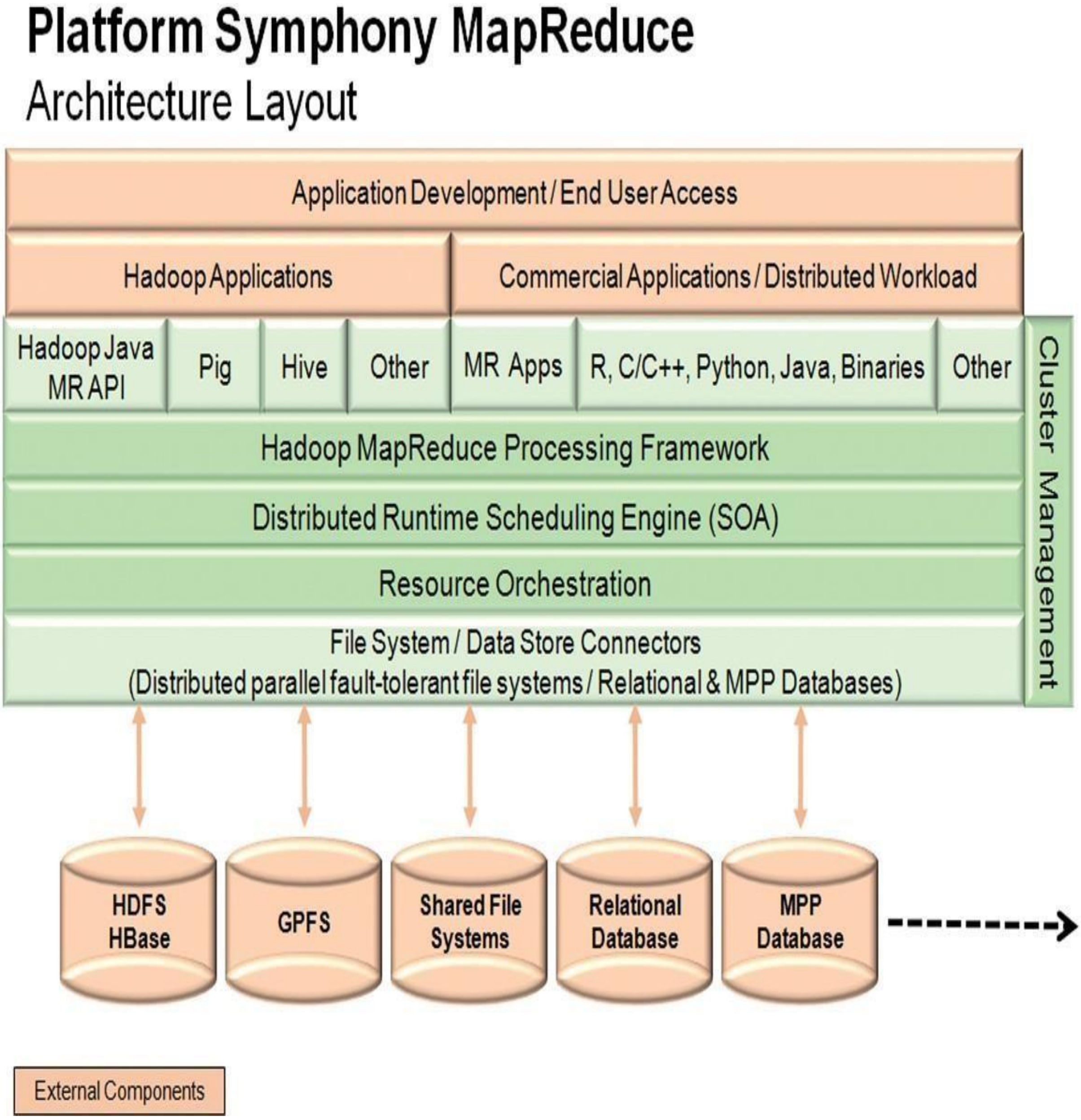


**Figure 3.6 Hadoop architecture**

## Hadoop Framework

- Each of these factors as shown in figure 3.6 is presently driving interest in alternatives that are significantly better at dealing with these requirements. I'll be clear here: The relational database has proven to be incredibly versatile and is the right tool for the majority of business needs today. However, the edge cases for many large-scale business applications are moving out into areas where the RDBMS is often not the strongest option. One of the most discussed new alternatives at the moment is Hadoop, a popular open source implementation of MapReduce. MapReduce is a simple yet verypowerful method for processing and analyzing extremely large data sets, even up to the multi- petabyte level. At its most basic, MapReduce is a process for combining data from multiple inputs(creating the "map"), and then reducing it using a supplied function that will distill and extract thedesired results. It was originally invented by engineers at Google to deal with the building of production search indexes. The MapReduce technique has since spilled over into other disciplinesthat process vast quantities of information including science, industry, and systems management. For its part, Hadoop has become the leading implementation of MapReduce.

- While there are many non-relational database approaches out there today (see my emerging ITand business topics post for a list), nothing currently matches Hadoop for the amount of attention it's receiving or the concrete results that are being reported in recent case studies. A quick look at thelist of organizations that have applications powered by Hadoop includes Yahoo! with over 25,000 nodes (including a single, massive 4,000 node cluster), Quantcast which says it has over 3,000 cores running Hadoop and currently processes over 1PB of data per day, and Adknowledge who uses Hadoop to process over 500 million clickstream events daily using up to 200 nodes

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**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING**

# UNIT – IV– eHEALTH – SECA4004

**UNIT-IV ARTIFICIAL INTELLIGENCE IN eHealth**

History of AI in health care-Impacts and Aspects of AI in health care- Current research in AI in eHealth-Regulations and Ethical concerns in using AI in eHealth.

## 4.1 OBJECTIVES

- The symptomatology affecting us is hyper-variable. Current practice guidelines, the variability of experience in medicine, the translatability and two-way outcome tracking suffers. This can lead
- to sub-optimal handling of the disease. Patient outcome is unpredictable.
- In 'Machine Learning', machine is made to learn the various parameters including, symptoms, behavior, biochemical and pathologic variables, among others. With help of a specially-designed software, the computer can develop effective learning.
- AI needs machine-learning, facilitates heightened diagnostic sensitivity, specificity and treatment.
- SahaManthran proposes a knowledge based initiative around medical virtualism to beutilized for co-creating machine-learning derived AI in Medicine.
- Innovations in Medical andBiological Engineering

1950s and earlier

- Artificial Kidney
- X ray
- Electrocardiogram
- Cardiac Pacemaker
- Cardiopulmonary bypass
- Antibiotic Production technology
- Defibrillator
- 1970s

Computer assisted tomography

- Artificial hip and knee replacement
- Balloon catheter
- Endoscopy
- Biological plant food engineering

1960s

- Heart valve replacement
- Intraocular lens
- Ultrasound
- Vascular grafts
- Blood analysis and processing

1980s

- Magnetic resonance imaging
- Laser surgery
- Vascular grafts
- Recombinant therapeutics

Present day

- Genomic sequencing and microarrays
- Positron Emission tomography
- Image guided surgery

New generations of medical technology products are
Combination of different technologies which lead to the crossing of borders between traditional categories of medical products such as medical devices, pharmaceutical productsor human tissues as shown in figure 4.1

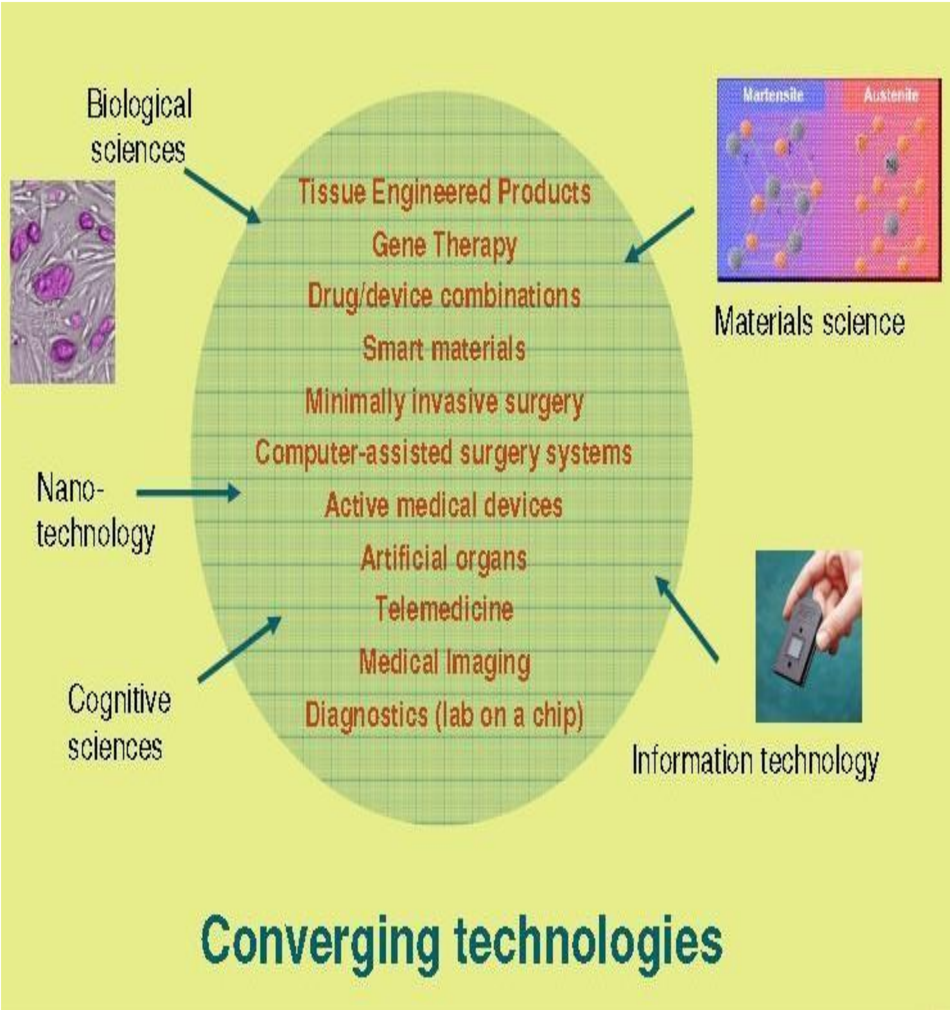


Figure 4.1 Converging Technologies

- Definition--"Use of a computer to model intelligent behaviour with minimal human intervention"
- Machines & computer programs are capable of problem solving and learning, like a human brain.
- Natural Language Processing ("NLP") and translation,
- Visual perception and
- Decision making.
- Machine Learning ("ML"), one of the most exciting areas for Development of computational approaches to automatically make sense of data

**Advantage of Machine**

- Can retain information
- Becomes smarter over time
- Machine is not susceptible to Sleep deprivation, distractions, information overload and short-term memory loss

## 4.2 ARTIFICIAL INTELLIGENCE AND BIG DATA IN HEALTHCARE

Artificial Intelligence and big data are more commonly used in healthcare every year. With this article, we will take a closer look at both these disciplines and see the benefits of implementing Artificial Intelligence and big data in the healthcare industry. We will also go through the history of Artificial Intelligence and big data in healthcare and its future.

Similarly, as in the pharmacy – Artificial Intelligence is a new trend in the healthcare industrysector and you can easily say that it's still in its infancy. When most people hear *"Artificial Intelligence in healthcare"* their first thoughts may be related to the Star Wars movies, where there are no human doctor as shown in figure 4.2. Everything related to healthcare is done by intelligent robots and systems. Is this our future? Well, probably. But we are still far away from that. Let's stick to the Earth.

### ARTIFICIAL INTELLIGENCE IN HEALTHCARE

We should start at the beginning! What is artificial intelligence in healthcare exactly about? Take a look at the definition provided by Wikipedia: "is the use of complex algorithms and software to emulate human cognition in the analysis of complicated medical data. Specifically, AI is the ability for computer algorithms to approximate conclusions without direct human input".

Figure 4.2 Intelligence in Humans

To put it in more "human" language – Artificial Intelligence is everything including applications, systems, algorithms and devices that help human physicians in providing healthcare and is based on computer analysis and big data. For instance: robot-assisted surgery units, diagnostics algorithms, drug research algorithms, devices monitoring patient's body condition and many more. It is hard to imagine modern medicine without additional artificial intelligence support, even though the way to its real role in the healthcare industry has "just" started. So long story short: what is artificial intelligence and big data in healthcare? It's a necessity.

## 4.3 HISTORY OF AI IN HEALTHCARE

History of Artificial Intelligence in healthcare is quite short as it needs many modern time inventions to work, to name just computers and the internet. The first attempts to implement Artificial Intelligence in healthcare were in the late XX century around the 1970s when Dendral was introduced at the Stanford University, USA. It is assumed to be the very first Artificial Intelligence in the healthcare system. Originally it was used to help chemists in identifying unknown organic molecules, by analyzing their mass spectra and using knowledge of chemistry. Dendral was written in the LISP programming language and was a father for many following Artificial Intelligence systems in healthcare, to name just the MYCIN – system that used Artificial Intelligence to identify bacteria as shown in figure 4.3

adjusted for patient's body weight.

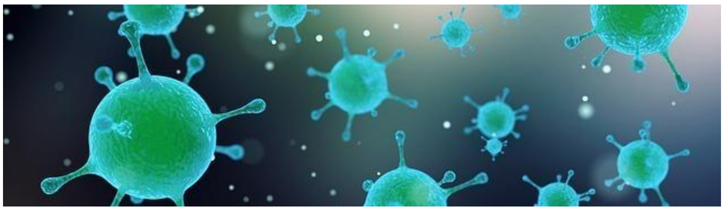

Figure 4.3 Bacteria in human

The next milestone happened in around 1990 in the minds of the artificial intelligence systems. They decided that if AI has to offer any assistance it has to be based on the expertise of physicians and take into consideration the lack of perfect and vast data. That was necessary for the following development and improvements of artificial intelligence in healthcare. Since then much has changed and today Artificial Intelligence in healthcare is much more advanced.

**EXAMPLES OF ARTIFICIAL INTELLIGENCE**.

- Today, Artificial Intelligence in healthcare brings much more value to the industry. It is developing rapidly and is predicted to do so, or even faster in the near future. We will takea look at the future of AI in healthcare, but first, let's find out what goes on right now.
- Take a look at some examples of how is Artificial Intelligence used in healthcare and check what benefits Artificial Intelligence brings to the healthcare industry.

.

**EXAMPLES OF ARTIFICIAL INTELLIGENCE IN HEALTHCARE**

Diagnostics

One of the examples of Artificial Intelligence in healthcare is diagnostics. We wrote about that previously in the article about AI in pharmacy. Diagnostics consist of tons of data – to name just medical imaging analysis, patient medical records, patient treatment history, patientgenetics, and his or her circumstances as shown in figure 4.4

Figure 4.4 Diagnosis with AI

recommending optimal treatment. The best example is the cancer diagnosis. Standard, radiological methods are not sufficient. As it turns out, traditional radiological imaging misses signals indicating cancer in about 30% cases! On the other hand, Artificial Intelligence is much more accurate. In 2013 data scientists from the KAIST University in South Korea introduced an Artificial Intelligence algorithm called LUNIT, that's capable of identifying cancer cells basing on x-rays images and mammography images to detect lung and breast cancer. Its accuracy was mind-boggling 97% in detecting lung cancer and breast cancer.

According to the Accenture company, automated image diagnosis itself can save a whopping $3 billion a year

**Robot-assisted surgery**

- Take a look at another example of Artificial Intelligence in healthcare – robot-assisted surgery. This is one of the most essential applications of Artificial Intelligence in healthcare. In this case, there are two main benefits – huge money savings and more effective surgery. Accenture estimates that AI robot-assisted surgery could save the US healthcare industry $40 as shown in figure 4.5billion annually by 2026.

Figure 4.5 AI robot assisted surgery

- And what about the surgery itself? Well, as we said, robot-assisted surgery is much more effective and precise. In 2017 alone there were executed almost 700 000 robot-assisted procedures. Thanks to its precision and miniaturization, the results are undisputable – smaller incisions, decreased blood loss, less pain, and quicker healing time. However, there is the other side of the coin. The robot-assisted procedures are more expensive, as one robotic unit costs at least $1M, and it takes time to properly train surgeons in using Artificial Intelligence support. Surgeons have to perform 100-250 surgical procedures in order to use their new robot assistants with the benefit of the patient*.
- Now you know how is artificial intelligence used in healthcare. Let's turn to the big data.

**Big data in health care**

- Although big data in healthcare is strictly related to Artificial Intelligence in healthcare, these two disciplines are not exactly the same thing. To simplify it, think of big data as a source for Artificial Intelligence. Big data is exactly what powers up the Artificial Intelligence and allows it to work efficiently.
- When you deal with large amounts of data, at some point it becomes very difficult or even impossible to master all of those gigabytes. The data scientists are trying to automate the storage and analysis of these large amounts of data in order to get as many advantages as possible from them.

- Big data in healthcare consists of billions of entries about patients, treatments, drugs, surgicalprocedures, research results, and many more. If you want to use all that data on a regular basis, you simply have to think of the way to analyze and process it efficiently. And this is what big data in healthcare is about.
- Now, take a look at the benefits of artificial intelligence and big data in healthcare. Generally speaking, big data can help in improving patient service, determining and implementing appropriate methods for patient treatment, supporting clinical treatment or monitoring efficiency of the healthcare companies. There is much more, but today we will name and lookcloser to the three most important benefits.

**BENEFITS OF BIG DATA IN HEALTHCARE**

- Much more improved patient care: thanks to the electronic data records, collecting patient data is much more effective and easier to use to find the best treatment for the given patient. Big data helps in collecting demographic and medical data such as lab tests, clinical data, diagnoses, medical conditions, treatment history, family member's clinical data, etc. What's more, big data can help in the prediction of disease incidence or detecting trends that lead to better health and lifestyle of society as shown in figure 4.6

Figure 4.6 Big data in Health care

- Improved operational and R&D efficiency. Healthcare companies can cut down on

- healthcare costs and provide better care. All that with the help of predictive analysis of the staff efficiency and patient admissions for example to the hospital. Big data in healthcare helps in organizing workflow and provide not only better care but also more effective in terms of the costs. And what about R&D? Big data is supporting work on new drugs and clinical trials thanks to the ability to analyze all data instead of the selection of the test samples. Big data also has the ability to identify specific patients with wanted biological characteristics who will participate in specialized clinical trials.
- Finding a cure for diseases. Big data can help in uncovering earlier unknown disease correlations, hidden patterns, and insights. All thanks to examining large sets of data to find new cures for the diseases or prescribe the best treatment. Big data has the possibility of predicting the occurrence of specific diseases or prognosis of disease progression and factors determining it.
- Surely, you will agree that the benefits of big data in healthcare are staggering, creating great new possibilities and perspectives for the future.

**FUTURE OF ARTIFICIAL INTELLIGENCE AND BIG DATA IN HEALTHCARE**

- Now you know what big data and artificial intelligence look like currently and how they are helpful in modern medicine. What we should do now is to concentrate on the future as shown in figure 4.7 What future of artificial intelligence and big data in healthcare is going to look like?

Figure 4.7 AI using robots for Health care

- Because artificial intelligence is producing great savings (it is estimated that by 2026 it will save up to $150 billion!). Its development will definitely go on. Firstly, we go back to the question from the beginning of this article – will machine doctors replace humans? It is probable. Actually, it happens already – for instance there is almost no need for human presence in radiology! Artificial algorithms are much more accurate in their judgments and above all – noticeably faster. When it comes to human life, time is the most important factor. Just seconds can change everything. So we expect to see a much bigger role of artificial intelligence in a diagnosis.Another thing – AI systems are "armed" with a lot of information so they can assist in clinical decision making. And their role in that part of medicine will go sky-high in no time. The minimization of diagnostic errors and therapeutic errors .

- Future doctors will base their work and judgments almost entirely on artificial intelligence. To sum up this part we might say that the future of artificial intelligence and big data inhealthcare is full of great perspectives and fantastic potential!
- That happens already, but shortly they will be much more advanced and complicated. *Imagine Google Assistant telling you it is time to do your blood tests. Or even doing these tests by itself through your smartwatch.* Healthcare apps will be something more than they are now. They will act as a personal health assistant, keeping you updated about everything going on within your body. That will considerably shorten treatment time and lower its intensity. As it is well known that the faster you detect the disease, the easier it is to cure as shown in figure 4.8

Figure 4.8 Examples of AI

These are just a few examples of what the future of artificial intelligence and big data in healthcare may look like. The physician of the future will only have to supervise the work done by the AI algorithms and robots. And maybe in a much longer time, there will be no need for a human physician? Just as it was in the Star Wars movies. Time will tell.

**THE GENESIS OF AI IN MEDICINE AND HEALTHCARE**

In 1959, Robert Ledley and Lee Lusted published a paper in Science, explaining the importance of reasoning processes in medical diagnosis, and discussed the potential role of electronic computers. This work is considered by many as the initiating paper that launched the field of medical informatics. They used mathematical methods like Boolean algebra, Bayes theorem, and symbolic logic to help identify the disease diagnosis. The next important development, in 1965, was the DENDRAL project at Stanford University, by AI pioneer, Edward Feigenbaum, and Nobel Prize winner, Joshua Lederberg. The rule-based and hypothesis-list approaches used in the system helped identify unknown organic molecules by analysing their mass spectrometry data.

AlphaGo playing against Lee Sedol.

Around this time, the National Institutes of Health in the US created the Stanford University Medical Experimental – Artificial Intelligence in Medicine (SUMEX-AIM) laboratory. The idea was to leverage the computing capabilities of the then newly introduced time-sharing computer, PDP-10, and support the AIM research of various groups at Stanford, Rutgers

University, MIT, and the University of Pittsburgh. From these groups, four different AI systems – INTERNIST 1, MYCIN, CASNET, and PIP – emerged in the 1970s.

- INTERNIST 1 – In 1972, Jack Myers, chairman of department of medicine at University of Pittsburgh, and Harry Pople, a computer scientist with special interest in AI, collaborated to develop a system for differential diagnosis in internal medicine. Called Internist-1, the system contained a knowledge base of causal and taxonomic relationships between clinical findings and diagnostic hypotheses, and used a powerful ranking algorithm to reach diagnoses.
- MYCIN – In 1976, E.H. Shortliffe developed the MYCIN rule-based expert system for infectious disease therapy assistance at the Stanford Medical School. In a comparative test, case histories of ten patients suffering from meningitis were submitted to MYCIN and to eight human physicians, for their diagnosis and recommendations. An independent assessment found that MYCIN scored higher on both accuracy of diagnosis and effectiveness of treatment.
- PIP – That same year, Steven Pauker and Anthony Gorry at MIT and Tufts New England Medical Center, developed the Present Illness Program (PIP) system, an early diagnostic tool in the evaluation of patients with oedema. PIP had four major components: patient data, the knowledge repository of disease (representing a long- term memory), the intersection of patient data and the knowledge repository (representing a short-term memory), and a supervisor program to filter knowledge andact on patient input.
- CASNET – In 1978, Saul Amarel and Casimir Kulikowski of Rutgers University developed CASNET, Causal Associational NETwork model for consultation in glaucoma. It brought together ideas from two fields of computer science: statistical pattern recognition (inference networks and probabilistic scoring of hypotheses) and Artificial Intelligence (conceptual structure to represent disease processes, a model of disease separated from decision-making strategies).

These went on to inspire the next generation of AI applications in the US. In the Indian context, one of the earliest examples of AI in healthcare was a project by H.N. Mahabala and a team at IIT Madras as part of India’s Knowledge-Based Computing Systems initiative in 1986. Eklavya was a knowledge-based program designed to support a community health worker in dealing with symptoms of illness in toddlers. Much later in the late 1990s, AI systems like IBM’s DeepBlue and Watson emerged. In 2013, Watson was deployed at the Memorial Sloan Kettering Cancer Centre. In 2020, Google DeepMind used AI to solve the ‘protein folding problem’, a grand challenge that existed for over fifty years – and predict a protein’s three-dimensional structure from its amino-acid sequence.

**AI IN MEDICINE AND HEALTHCARE – IMPLICATIONS FOR THE FUTURE**

- Let us go back to the two developments with which we started the article – AlphaFold and WHO’s AI-in-health guidelines – and understand their implications for the future.

- What any given protein can do depends on its unique 3D structure. For example, antibody proteins utilised by our immune systems are ‘Y-shaped’, and that shape helps them latch onto viruses and bacteria. A tool like AlphaFold, with the power of AI techniques, might help researchers predict the shape of a protein of interest for a rare disease, rapidly and economically. A better understanding of protein folding and design will help in areas like

- efficient drug discovery – the use of 3D models can help understand why a certain drug compound is an inhibitor or why certain proteins have more sites for drug delivery. The availability of the AlphaFold database will provide opportunities for new research in areas like structural biology and structural bioinformatics

## 4.5 ARTIFICIAL INTELLIGENCE IN HEALTHCARE APPLICATIONS AND THREATS

- Remember Big Hero 6's beloved Baymax? The lead character's personal pudgy robotic healthcare companion was much loved and adored by the audience. We might not have wondered back then but the fascinating machine had actually been powered with Artificial Intelligence, programmed to scan a human body for any illnesses or injury while also examining the environment, offering treatment, and even catering to the emotional requirements of the patient.

- Although Baymax may appear as a complete fantasy creation from a children's movie, yet technology and robotics engineers throughout the globe are now working on making healthcare AI become a practicality and reality from a fantasy.

- In line with this, over the years, the power of technology particularly AI has escalated by leaps and bounds in various industries like AI in education, Sports such as AI in football, AI in manufacturing, as well as AI in the healthcare industry.

## AI IN HEALTHCARE

- At the initial stage, technology was merely used to automate the most routine and monotonous tasks and cut down on the use of paper through digitization of health records while also aiding in the easy flow of this information among insurance companies, hospitals, and patients.

- While these tasks continue to be worked upon, Artificial Intelligence has expanded its applications from being restricted to enhancing back-office productivity, to emerge as an enabler to improve healthcare outcomes. Particularly in the present scenario of the COVID era. While taking a toll on the personal health of the people, COVID has played a huge part in putting the developing AI technologies into practice. The technology has paved its way to developing new models, exploring new treatments, as well as in developing the vaccine.

- From hospital care to clinical research, drug development to insurance, AI applications are recasting the workings of the health sector to cut down on spending and enhance the outcomes of the patient.

## APPLICATIONS OF AI IN HEALTHCARE

From employing it to detect links between genetic codes, put to use surgical robots, or even for maximizing hospital efficiency, AI has proven to be a boon for the healthcare industry

### Support in Clinical Decisions

It's obviously imperative for health professionals to take every crucial piece of information into consideration while diagnosing patients. As a result, this leads to sifting through various complicated unstructured notes kept in medical records. If there's a mistake in keeping track of even a single relevant fact, the life of a patient could be put atrisk.

The assistance of Natural Language Processing (NLP) makes it more convenient for doctors to narrow down all relevant information from patient reports.

Artificial Intelligence holds the ability to store and process large sets of data, which can provide knowledge databases and facilitate examination and recommendation individually for each patient, thus helping to enhance clinical decision support.

This technology can be relied upon by doctors for aid in detecting risk factors through unstructured notes. An interesting example of this is IBM’s Watson has been employing AI for predicting heart failure.

### Enhance Primary Care and Triage through Chatbots

People have a tendency of booking appointments with their GP at the slightest threat or medical issue, which could often turn out to be a false alarm or something which could be cured of self-treatment.

Artificial Intelligence assists in enabling smooth flow and automation of primary care, allowing doctors to stress over more crucial and dire cases.

Saving money on avoidable trips to the doctor, patients can benefit from medical chatbots, which is an AI-powered service, incorporated with smart algorithms that provide patients with instant answers to all their health-related queries and concerns while also guiding them on how to deal with any potential problems.

These chatbots are 24/7 available and have the capacity to deal with multiple patients at the same time.

**Robotic Surgeries**

AI and collaborative robots have revolutionized surgeries in terms of their speed, and depth while making delicate incisions. Since robots don't get tired, the issue of fatigue in the middle of lengthy and crucial procedures is eliminated.

AI machines are capable of employing data from past operations to develop new surgical methods. The preciseness of these machines reduces the possibility of tremors or any unintended or accidental movements during the surgeries as shown in figure 4.9


Figure 4.9 Robotic Surgery

A few examples of Robots developed for surgeries are Vicarious Surgical which combines virtual reality with AI-enabled robots so surgeons can perform minimally invasive operations as well as Heartlander, a miniature mobile robot developed by the robotics department at Carnegie Mellon University, which was developed to facilitate therapy on the heart.

### Virtual nursing assistants

AI systems facilitate virtual nursing assistants that can perform a range of tasks from conversing with patients to directing them to the best and effective care unit. These virtual nurses are available 24/7 and can respond to queries as well as examine patients and provide instant solutions.

Presently many AI-powered applications of virtual nursing assistants presently enable more regular interactions between patients and care providers between office visits to avoid any unnecessary hospital visits. The world's first virtual nurse assistant Care Angel, can even facilitate wellness checks through voice and AI.

### Aiding in the accurate diagnosis

AI has the capacity to surpass human doctors and help them detect, predict, and diagnosediseases more accurately and at a faster rate. Likewise, AI algorithms have proved to be not only accurate and precise at specialty-level diagnostics, but also cost-effective in terms of detecting diabetic retinopathy.

For instance, PathAI is developing machine learning technology to aid pathologists in making more accurate diagnoses. The company's current goals include reducing error in cancer diagnosis and developing methods for individualized medical treatment.

Buoy Health is an AI-based symptom and cure checker that uses algorithms to diagnose and treat illness. Here's how it works: a chatbot listens to a patient's symptoms and health concerns, then guides that patient to the correct care based on its diagnosis.

### Minimizing the burden of EHR use

EHRs have played an integral role in the healthcare industry's journey towards digitalization, yet its switch has introduced a variety of issues in association with cognitive overload, endless documentation, and user burnout.

The EHR developers have started making use of AI for creating more intuitive interfaces and automating a couple of the routine processes that consume a great degree of the user's time.

While voice recognition and dictation are helping in enhancing the clinical documentation process, yet natural language processing (NLP) tools may not go as far. AI can also aid in processing routine requests from the inbox, such as medication refills, and result in notifications. It can also aid in prioritizing tasks that require the clinician's attention, makingit simpler for the users to operate with their to-do lists.

## THREATS OF ARTIFICIAL INTELLIGENCE IN HEALTHCARE

As per a report from the Brookings Institution, there are several risks associated with AI in healthcare that need to be addressed. Below are a couple of the threats which had been identified by the Institution's report :

**Errors and Injuries**

- One of the biggest risks that AI in healthcare holds is that the AI system might at times be wrong, for instance, if it suggests a wrong drug to a patient or makes an error in locating a tumor in a radiology scan, which could result in the patient's injury or dire health-related consequences.
- AI errors are potentially different for at least two reasons. While errors can obviously take place by human medical professionals as well yet what makes this crucial is that an underlying error, an error in an AI system could lead to injuries for thousands of patients.

**Data availability**

- Yet another threat posed by AI systems is that training these systems requires massive amounts of data from multiple sources which include pharmacy records, electronic health records, insurance claims records, etc.
- Since the data is fragmented and patients often see different providers or switch insurance companies the data gets complicated and less comprehensible as a result of which the risk of error and the cost of data collection escalates as shown in figure 4.10

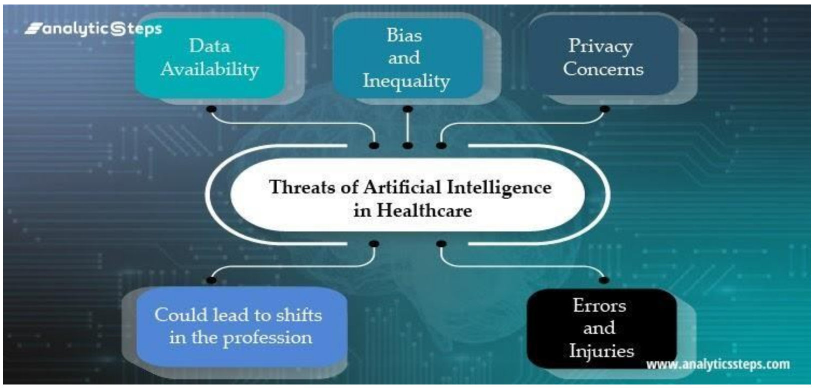


Figure 4.10Threats of AI in Healthcare

**Privacy concerns**

- The collection of huge datasets and the exchange of data between health systems and AI developers to enable AI systems leads to many patients believing that this could violate their privacy, leading to the filing of lawsuits.

- Another area where the employment of AI systems raises this issue is that AI has the capability of predicting private information about patients even if the patient has never given the information.

- For instance, Parkinson's disease could be detected by an AI system with the trembling on a computer mouse even if the person hasn't revealed the information to anyone else which could be considered a violation of privacy by the patient.

**Bias and inequality**

- Since AI systems absorb and learn through the data with which they are trained, they can also absorb the biases of the available data. For example, if the data incorporated in AI is mainly collected in academic medical centers, the developing AI systems will have less awareness about, and as a result, will treat less effectively, patients from populations that do not typically frequent academic medical cent In the long run, the employment of AI systems could lead to shifts in the medical profession. Particularly in areas like radiology where most of the work gets automated.

- This raises the concern that a high degree of employment of AI might lead to a fall in human knowledge and capacity over the years, making providers fail in detecting AI errors as well as in the further development of medical knowledge.

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**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING**

# UNIT – V– eHEALTH-SECA4004

## UNIT-VAPPLICATION DEVELOPMENT FOR eHEALTH

Introduction to Android, Creating Android Activities, Android User interface design, Access Wi-fi and Bluetooth with mobile applications-Web based App for eHealth applications.

## ANDROID

Android is an open source and Linux-based operating system for mobile devices such as smart phones and tablet computers. Android was developed by the Open Handset Alliance, led by Google, and other companies. This tutorial will teach you basic Android programming and will also take you through some advance concepts related to Android application development.

## 5.1 ANDROID - OVERVIEW

- Android is an open source and Linux-based **Operating System** for mobile devices such as smartphones and tablet computers. Android was developed by the *Open Handset Alliance*, led by Google, and other companies.
- Android offers a unified approach to application development for mobile devices which means developers need only develop for Android, and their applications should be able to run on different devices powered by Android.
- The first beta version of the Android Software Development Kit (SDK) was released by Google in 2007 where as the first commercial version, Android 1.0, was released in September 2008.
- On June 27, 2012, at the Google I/O conference, Google announced the next Android version, 4.1 **Jelly Bean**. Jelly Bean is an incremental update, with the primary aim of improving the user interface, both in terms of functionality and performance.
- The source code for Android is available under free and open source software licenses. Google publishes most of the code under the Apache License version 2.0 and the rest, Linux kernel changes, under the GNU General Public License version 2 as shown in Figure 5.1.

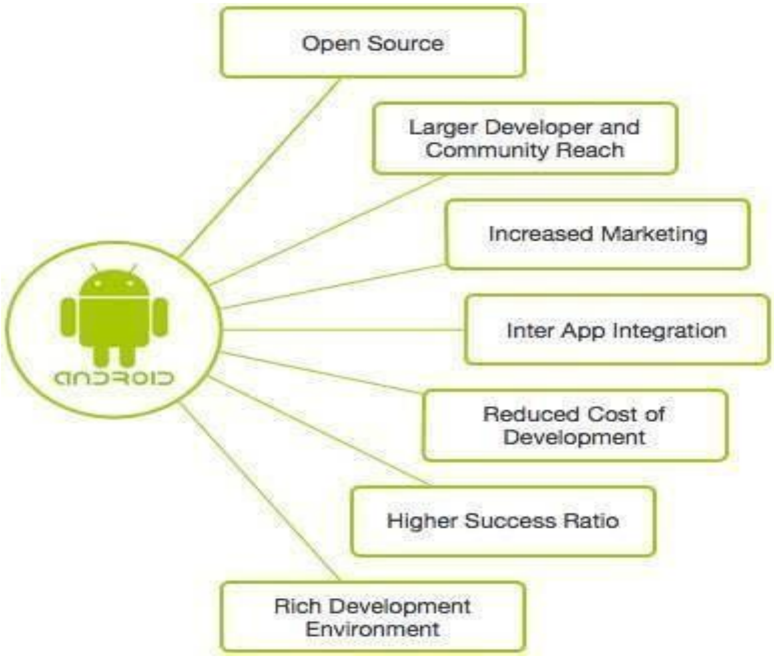



Figure 5.1 Android Features

Features of Android

Android is a powerful operating system competing with Apple 4GS and supports greatfeatures. Few of them are listed below −

| | Feature & Description |
|---|---|
| | **Beautiful UI**<br>Android OS basic screen provides a beautiful and intuitiveuser interface. |
| | **Connectivity**<br>GSM/EDGE, IDEN, CDMA, EV-DO, UMTS, Bluetooth, Wi-Fi, LTE, NFC and WiMAX. |
| | **Storage**<br>SQLite, a lightweight relational database, is used for datastorage purposes. |

| | |
|---|---|
| | **Media support**<br>H.263, H.264, MPEG-4 SP, AMR, AMR-WB, AAC, HE-AAC, AAC 5.1, MP3, MIDI, Ogg Vorbis, WAV, |
| | GIF, and BMP. |
| | **Messaging**<br>SMS and MMS |
| | **Web browser**<br>Based on the open-source WebKit layout coupled with Chrome's V8 JavaScript supporting HTML5 and CSS3. |
| | **Multi-touch**<br>Android has native support for multi-touch was initially made available in handsets such HTC Hero. |
| | **Multi-tasking**<br>User can jump from one task to another an time various application can run simultaneous |
| | **Resizable widgets**<br>Widgets are resizable, so users can expand t show more content or shrink them to save spa |
| | **Multi-Language**<br>Supports single direction and bi-directional te |
| | **GCM**<br>Google Cloud Messaging (GCM) is a servi lets developers send short message data t users on Android devices, without nee proprietary sync solution. |
| | **Wi-Fi Direct**<br>A technology that lets apps discover an directly, over a high-bandwidth peer- connection. |

| | | |
|---|---|---|
| | | **Android Beam**<br>A popular NFC-based technology that let instantly share, just by touching two NFC-( phones together. |
| | JPEG, PNG, | |

## ANDROID APPLICATIONS

- Android applications are usually developed in the Java language using the Android SoftwareDevelopment Kit.
- Once developed, Android applications can be packaged easily and sold out either through a store such as **Google Play**, **SlideME**, **Opera Mobile Store**, **Mobango**, **F-droid** and the **Amazon Appstore**.
- Android powers hundreds of millions of mobile devices in more than 190 countries around the world. It's the largest installed base of any mobile platform and growing fast. Every day more than 1 million new Android devices are activated worldwide.
- This tutorial has been written with an aim to teach you how to develop and package Android application. We will start from environment setup for Android application programming andthen drill down to look into various aspects of Android applications.

## CATEGORIES OF ANDROID APPLICATIONS

History of Android

The code names of android ranges from A to N currently, such as Aestro, Blender, Cupcake, Donut, Eclair, Froyo, Gingerbread, Honeycomb, Ice Cream Sandwitch, Jelly Bean, KitKat, Lollipop and Marshmallow. Let's understand the android history in a sequence as shown in Figure 5.2.


Figure 5.2 History of Android

**ANDROID - ENVIRONMENT SETUP**

You will be glad to know that you can start your Android application development on either of the following operating systems

- Microsoft Windows XP or later version.
- Mac OS X 10.5.8 or later version with Intel chip.
- Linux including GNU C Library 2.7 or later.

Second point is that all the required tools to develop Android applications are freely available and can be downloaded from the Web. Following is the list of software's you will need before you start your Android application programming.

- Java JDK5 or later version
- Android Studio

Here last two components are optional and if you are working on Windows machine then these components make your life easy while doing Java based application development. So let us have a look how to proceed to set required environment.

**SET-UP JAVA DEVELOPMENT KIT (JDK)**

You can download the latest version of Java JDK from Oracle's Java site − Java SE Downloads. You will find instructions for installing JDK in downloaded files, follow the given instructions to install and configure the setup. Finally set PATH and JAVA_HOME environment variables to refer to the directory that contains **java** and **javac**, typically java_install_dir/bin and java_install_dir respectively.

If you are running Windows and installed the JDK in C:\jdk1.8.0_102, you would have to put the following line in your C:\autoexec.bat file.

set PATH=C:\jdk1.8.0_102\bin;%PATH% set
JAVA_HOME=C:\jdk1.8.0_102

Alternatively, you could also right-click on *My Computer*, select *Properties*, then *Advanced*, then *Environment Variables*. Then, you would update the PATH value and press the OK button.

On Linux, if the SDK is installed in /usr/local/jdk1.8.0_102 and you use the C shell, youwould put the following code into your **.cshrc** file.

setenv PATH /usr/local/jdk1.8.0_102/bin:$PATH
setenv JAVA_HOME /usr/local/jdk1.8.0_102

Alternatively, if you use Android studio, then it will know automatically where you have installed your Java.

**ANDROID IDES**

There are so many sophisticated Technologies are available to develop android applications, the familiar technologies, which are predominantly using tools as follows

- Android Studio
- Eclipse IDE(Deprecated)

## 5.2 ANDROID - ARCHITECTURE

Android operating system is a stack of software components which is roughly divided into five sections and four main layers as shown below in the architecture diagram as shown in figure 5.3.

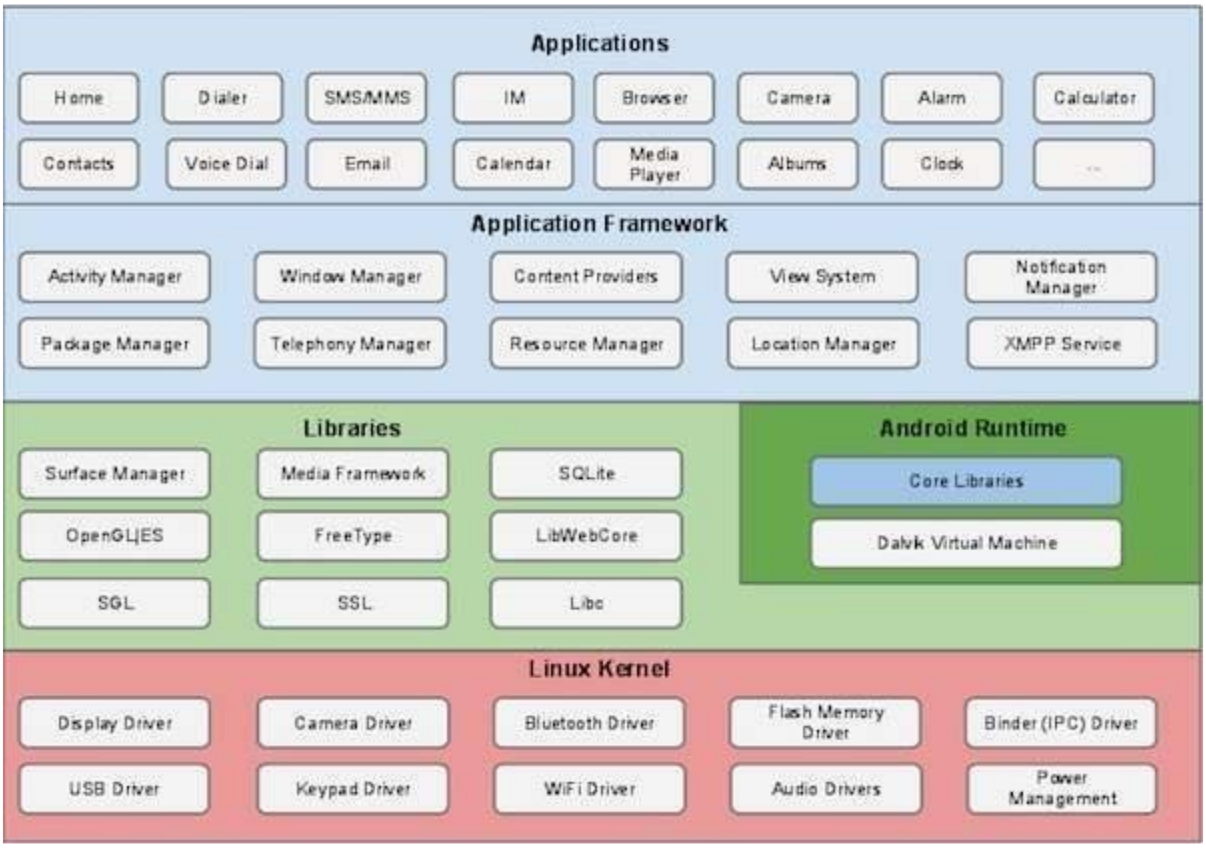



Figure 5.3 Android Architecture

**LINUX KERNEL**

At the bottom of the layers is Linux - Linux 3.6 with approximately 115 patches. This provides a level of abstraction between the device hardware and it contains all the essential hardware drivers like camera, keypad, display etc. Also, the kernel handles all the things that Linux is really good at such as networking and a vast array of device drivers, which take the pain out of interfacing to peripheral hardware.

**LIBRARIES**

On top of Linux kernel there is a set of libraries including open-source Web browser engine WebKit, well known library libc, SQLite database which is a useful repository for storage and sharing of application data, libraries to play and record audio and video, SSL libraries responsible for Internet security etc.

**ANDROID LIBRARIES**

This category encompasses those Java-based libraries that are specific to Android development. Examples of libraries in this category include the application framework libraries in addition to those that facilitate user interface building, graphics drawing and database access. A summary of some key core Android libraries available to the Android developer is as follows −

- **android.app** − Provides access to the application model and is the cornerstone of all Android applications.

- **android.content** − Facilitates content access, publishing and messaging betweenapplications and application components.
- **android.database** − Used to access data published by content providers and includesSQLite database management classes.
- **android.opengl** − A Java interface to the OpenGL ES 3D graphics rendering API.
- **android.os** − Provides applications with access to standard operating system services including messages, system services and inter-process communication.
- **android.text** − Used to render and manipulate text on a device display.
- **android.view** − The fundamental building blocks of application user interfaces.
- **android.widget** − A rich collection of pre-built user interface components such as buttons, labels, list views, layout managers, radio buttons etc.
- **android.webkit** − A set of classes intended to allow web-browsing capabilities to be built into applications.

Having covered the Java-based core libraries in the Android runtime, it is now time to turn our attention to the C/C++ based libraries contained in this layer of the Android software stack.

**ANDROID RUNTIME**

- This is the third section of the architecture and available on the second layer from the bottom. This section provides a key component called **Dalvik Virtual Machine** which is a kind of Java Virtual Machine specially designed and optimized for Android.
- The Dalvik VM makes use of Linux core features like memory management and multi-threading, which is intrinsic in the Java language. The Dalvik VM enables every Android application to run in its own process, with its own instance of the Dalvik virtual machine.
- The Android runtime also provides a set of core libraries which enable Android application developers to write Android applications using standard Java programming language.

**APPLICATION FRAMEWORK**

The Application Framework layer provides many higher-level services to applications in the form of Java classes. Application developers are allowed to make use of these services in their applications.

The Android framework includes the following key services −

- **Activity Manager** − Controls all aspects of the application lifecycle and activity stack.
- **Content Providers** − Allows applications to publish and share data with other applications.
- **Resource Manager** − Provides access to non-code embedded resources such asstrings, color settings and user interface layouts.
- **Notifications Manager** − Allows applications to display alerts and notifications tothe user.

- **View System** − An extensible set of views used to create application user interfaces.

## ANDROID - APPLICATION COMPONENTS

Application components are the essential building blocks of an Android application. These components are loosely coupled by the application manifest file *AndroidManifest.xml* that describes each component of the application and how they interact.

There are following four main components that can be used within an Android application −

| | Components & Description |
|---|---|
| | **Activities**<br>They dictate the UI and handle the user interaction to the smartphone screen. |
| | **Services**<br>They handle background processing associated with anapplication. |
| | **Broadcast Receivers**<br>They handle communication between |
| | **Content Providers**<br>They handle data and database management issues. |

## ACTIVITIES

An activity represents a single screen with a user interface,in-short Activity performs actionson the screen. For example, an email application might have one activity that shows a list of new emails, another activity to compose an email, and another activity for reading emails. If an application has more than one activity, then one of them should be marked as the activity that is presented when the application is launched.

An activity is implemented as a subclass of **Activity** class as follows −

```
public class MainActivity extends Activity {
}
```

## SERVICES

A service is a component that runs in the background to perform long-running operations. For example, a service might play music in the background while the user is in a different application, or it might fetch data over the network without blocking user interaction with an activity.

A service is implemented as a subclass of **Service** class as follows −

```
public class MyService extends Service {
}
```

## BROADCAST RECEIVERS

Broadcast Receivers simply respond to broadcast messages from other applications or from the system. For example, applications can also initiate broadcasts to let other applications know that some data has been downloaded to the device and is available for them to use, so this is broadcast receiver who will intercept this communication and will initiate appropriate action.

A broadcast receiver is implemented as a subclass of **BroadcastReceiver** class and each message is broadcaster as an **Intent** object.

```
public class MyReceiver  extends  BroadcastReceiver {
   public void onReceive(context,intent){}
}
```

## CONTENT PROVIDERS

A content provider component supplies data from one application to others on request. Such requests are handled by the methods of the *ContentResolver* class. The data may be stored inthe file system, the database or somewhere else entirely.

A content provider is implemented as a subclass of **ContentProvider** class and must implement a standard set of APIs that enable other applications to perform transactions.

```
public class MyContentProvider extends  ContentProvider {
   public void onCreate(){}
}
```

.

## ADDITIONAL COMPONENTS

There are additional components which will be used in the construction of above mentioned entities, their logic, and wiring between them. These components are

| | Components & Description |
|---|---|
| | **Fragments** |
| | Represents a portion of user interface in an Activity. |
| | **Views**<br>UI elements that are drawn on-screen including buttons, listsforms etc. |
| | **Layouts**<br>View hierarchies that control screen format and appearance ofthe views. |
| | **Intents**<br>Messages wiring components together. |
| | **Resources**<br>External elements, such as strings, constants and drawablepictures. |
| | **Manifest**<br>Configuration file for the application. |

## ANDROID - HELLO WORLD EXAMPLE

- Let us start actual programming with Android Framework. Before you start writing your first example using Android SDK, you have to make sure that you have set-up your Android development environment properly as explained in Android - Environment Set-up tutorial. I also assume that you have a little bit working knowledge with Android studio.
- So let us proceed to write a simple Android Application which will print "Hello World!". Create Android Application
- The first step is to create a simple Android Application using Android studio. When you click on Android studio icon, it will show screen as shown below


Figure 5.4 Android new studio

- You can start your application development by calling start a new android studio project as shown in figure 5.4. ina new installation frame should ask Application name, package information and location of the project as shown in figure 5.5

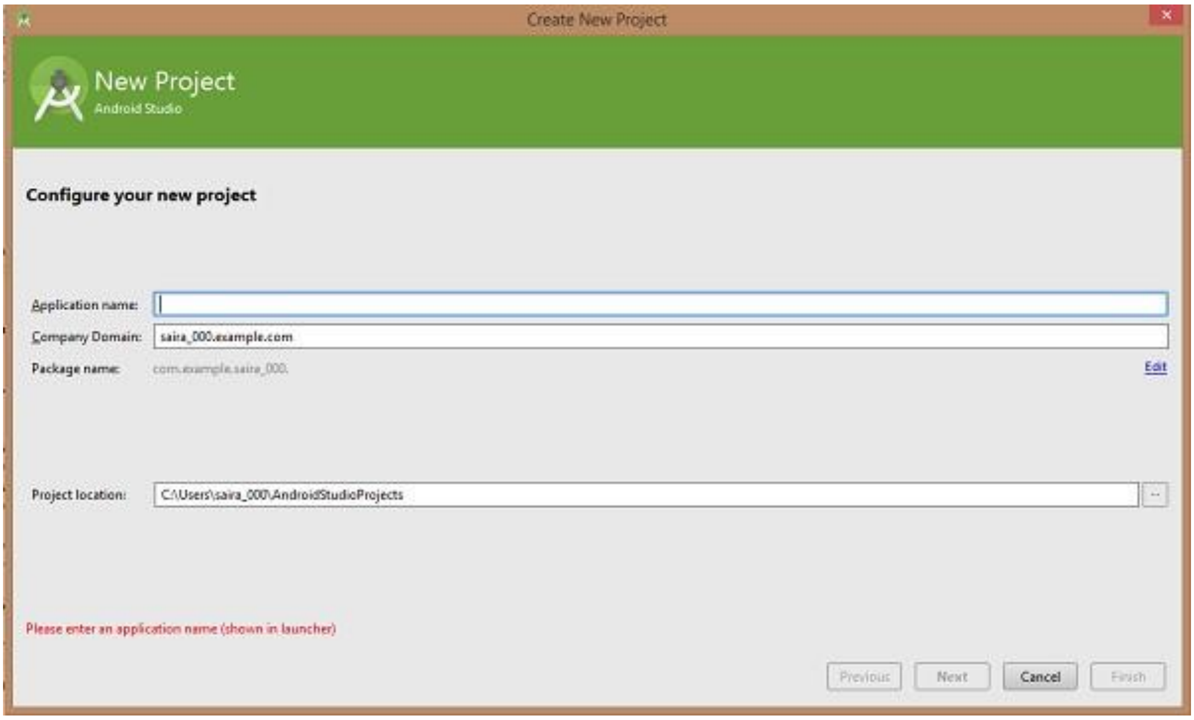



Figure 5.5 Android project

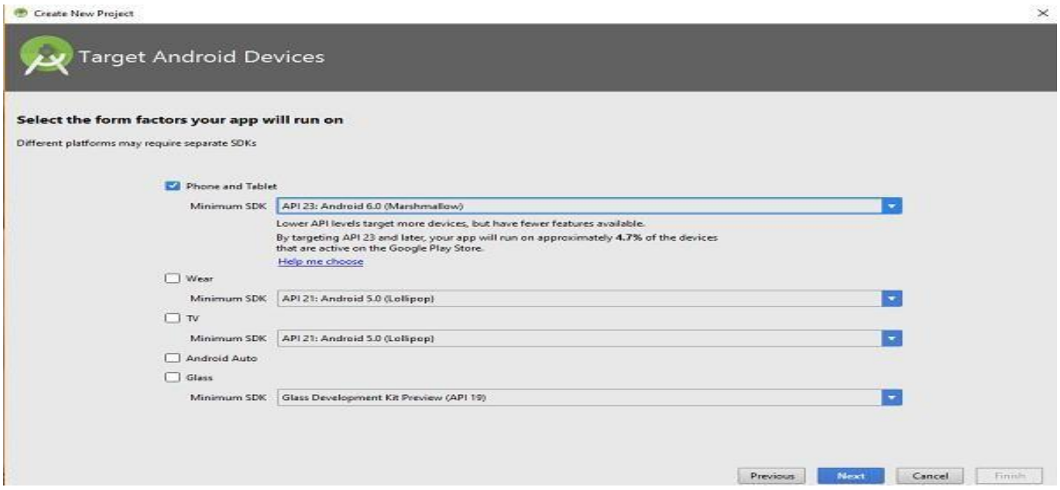



Figure 5.6 Android target devices

- After entered application name, it going to be called select the form factors your application runs on, here need to specify Minimum SDK, in our tutorial, I have declared as API23: Android 6.0(Mashmallow) – as shown in figure 5.6
- The next level of installation should contain selecting the activity to mobile, it specifiesdefault layout for Applications as shown in figure 5.7


Figure 5.7 Adding an activity

- At the final stage it going to be open development tool to write the application code as shown in figure 5.8

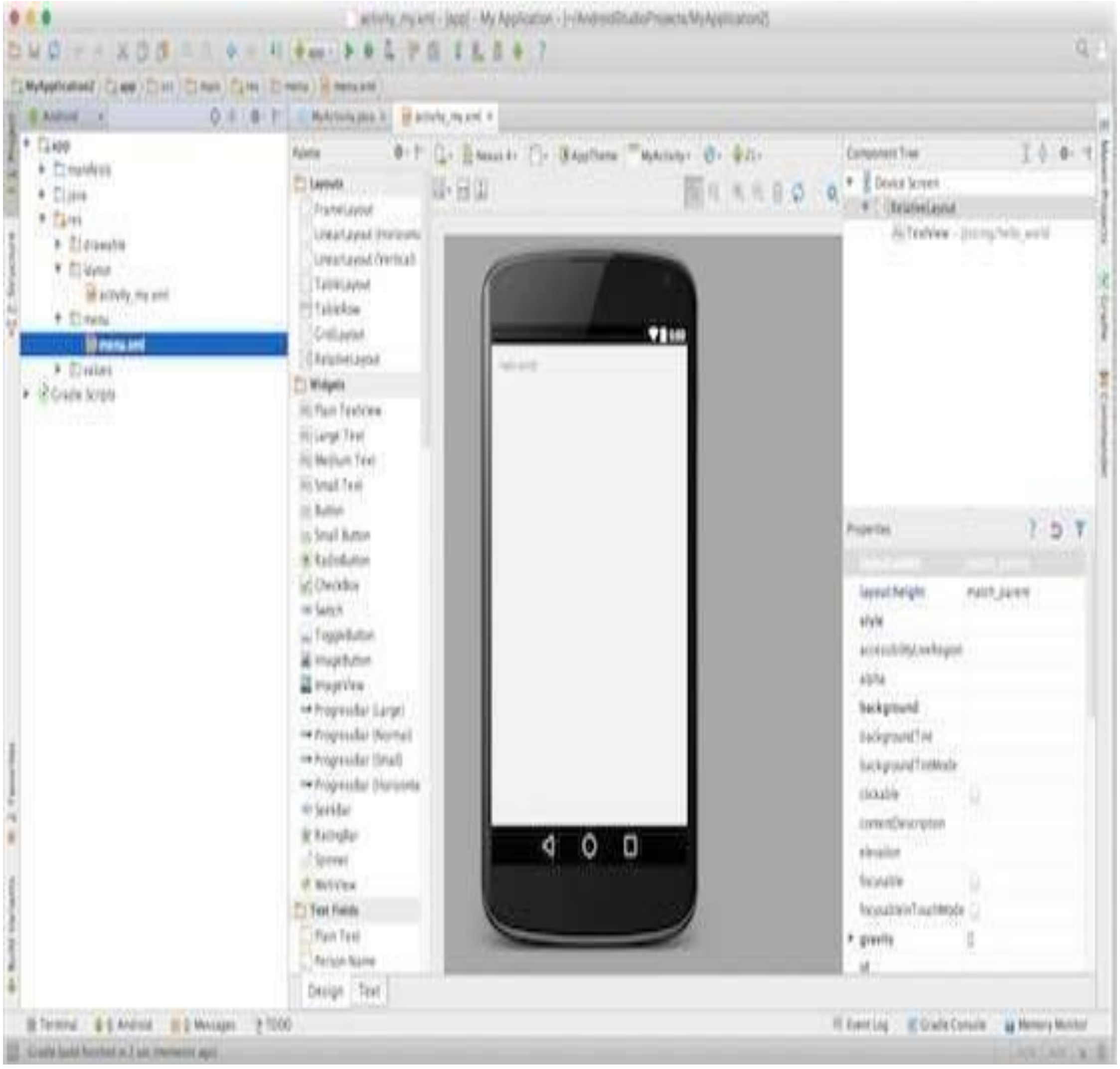
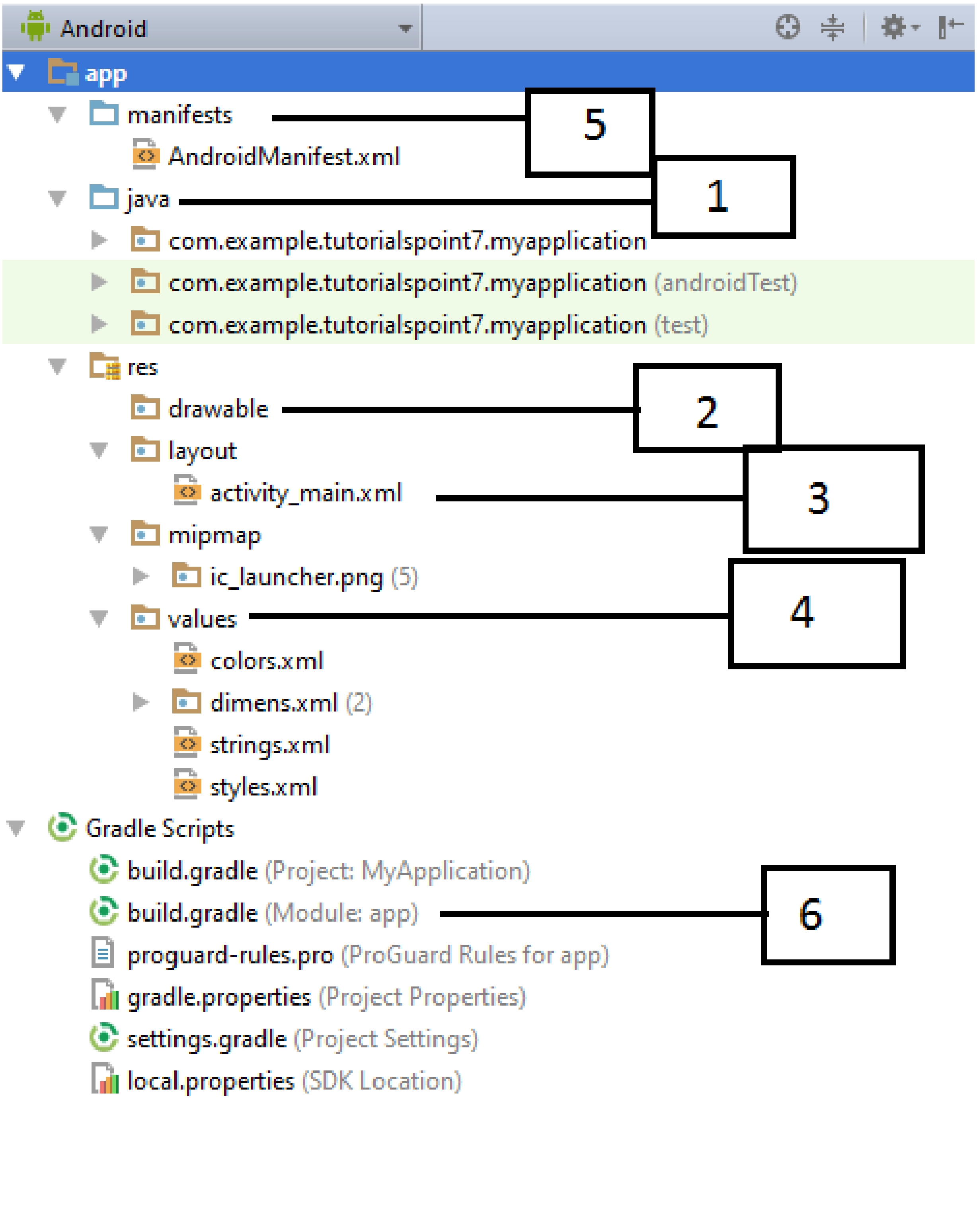


Figure 5.8Anatomy of Android Application

Before you run your app, you should be aware of a few directories and files in the Android project


Android
app
manifests
AndroidManifest.xml
java
com.example.tutorialspoint7.myapplication
com.example.tutorialspoint7.myapplication (androidTest)
com.example.tutorialspoint7.myapplication (test)
res
drawable
layout
activity_main.xml
mipmap
ic_launcher.png (5)
values
colors.xml
dimens.xml (2)
strings.xml
styles.xml
Gradle Scripts
build.gradle (Project: MyApplication)
build.gradle (Module: app)
proguard-rules.pro (ProGuard Rules for app)
gradle.properties (Project Properties)
settings.gradle (Project Settings)
local.properties (SDK Location)
5
1
2
3
4
6

Following section will give a brief overview of the important application files. The Main Activity File

- The main activity code is a Java file MainActivity.java. This is the actual application file which ultimately gets converted to a Dalvik executable and runs your application. Following is the default code generated by the application wizard for Hello World! application −
- Here, R.layout.activity_main refers to the activity_main.xml file located in the res/layout folder. The onCreate() method is one of many methods that are figured when an activity is loaded.

**THE MANIFEST FILE**

- Whatever component you develop as a part of your application, you must declare all its components in a *manifest.xml* which resides at the root of the application project directory. This file works as an interface between Android OS and your application, so if you do not declare your component in this file, then it will not be considered by the OS. For example, a default manifest file will look like as following file −
- Here <application>...</application> tags enclosed the components related to the application. Attribute *android:icon* will point to the application icon available under *res/drawable-hdpi*. The application uses the image named ic_launcher.png located in the drawable folders
- The <activity> tag is used to specify an activity and *android:name* attribute specifies the fully qualified class name of the *Activity* subclass and the *android:label* attributes specifies a string to use as the label for the activity. You can specify multiple activities using <activity> tags.
- The action for the intent filter is named android.intent.action.MAIN to indicate that this activity serves as the entry point for the application. The category for the intent-filter is named android.intent.category.LAUNCHER to indicate that the application can be launch from the device's launcher icon.
- The @string refers to the strings.xml file explained below. Hence, @string/app_name refers to the app_name string defined in the strings.xml file, which is "HelloWorld". Similar way, other strings get populated in the application.

Following is the list of tags which you will use in your manifest file to specify different Android application components −

- <activity>elements for activities
- <service> elements for services
- <receiver> elements for broadcast receivers
- <provider> elements for content providers

The **STRINGS FILE**

The **strings.xml** file is located in the *res/values* folder and it contains all the text that your application uses. For example, the names of buttons, labels, default text, and similar types ofstrings go into this file. This file is responsible for their textual content. For example, a default strings file will look like as following file −

## THE LAYOUT FILE

- The activity_main.xml is a layout file available in res/layout directory, that is referenced by your application when building its interface. You will modify this file very frequently to change the layout of your application. For your "Hello World!" application, this file will have following content related to default layout −
- This is an example of simple RelativeLayout which we will study in a separate chapter. The TextView is an Android control used to build the GUI and it have various attributes like android:layout_width, android:layout_height etc which are being used to set its width and height etc.. The @string refers to the strings.xml file located in the res/values folder. Hence, @string/hello_world refers to the hello string defined in the strings.xml file, which is "Hello World!".

## RUNNING THE APPLICATION

- Let's try to run our **Hello World!** application we just created. I assume you had created your **AVD** while doing environment set-up. To run the app from Android studio, open one of your project's activity files and click Run icon from the tool bar. Android studio installs the app on your AVD and starts it and if everything is fine with your set-up and application, it will display following Emulator window

- Congratulations!!! you have developed your first Android Application and now just keep following rest of the tutorial step by step to become a great Android Developer. All the very best.

## ANDROID RESOURCES ORGANIZING & ACCESSING

- There are many more items which you use to build a good Android application. Apart from coding for the application, you take care of various other **resources** like static content that your code uses, such as bitmaps, colors, layout definitions, user interface strings, animation instructions, and more. These resources are always maintained separately in various sub-directories under **res/** directory of the project.
- This tutorial will explain you how you can organize your application resources, specify alternative resources and access them in your applications.
- Organize resource in Android Studio

## ALTERNATIVE RESOURCES

- Your application should provide alternative resources to support specific device configurations.
- For example, you should include alternative drawable resources ( i.e.images ) for different screen resolution and alternative string resources for different languages. At runtime, Android detects the current device configuration and loads the appropriate resources for your application.

To specify configuration-specific alternatives for a set of resources, follow the following steps −

- Create a new directory in res/ named in the form **<resources_name>-**

- **<config_qualifier>**. Here **resources_name** will be any of the resources mentioned in the above table, like layout, drawable etc. The **qualifier** will specify an individual configuration for which these resources are to be used. You can check official documentation for a complete list of qualifiers for different type of resources.
- Save the respective alternative resources in this new directory. The resource files must be named exactly the same as the default resource files as shown in the below example, but these files will have content specific to the alternative. For example though image file name will be same but for high resolution screen, its resolution will be high.

## ACCESSING RESOURCES

During your application development you will need to access defined resources either in your code, or in your layout XML files. Following section explains how to access your resources in both the scenarios −

## ACCESSING RESOURCES IN CODE

- When your Android application is compiled, a **R** class gets generated, which contains resource IDs for all the resources available in your **res/** directory. You can use R class to access that resource using sub-directory and resource name or directly resource ID.
- Example
- To access *res/drawable/myimage.png* and set an ImageView you will use following code −
- Here first line of the code make use of *R.id.myimageview* to get ImageView defined with id *myimageview* in a Layout file. Second line of code makes use of *R.drawable.myimage* to get an image with name **myimage** available in drawable sub-directory under **/res**.
- If you have worked with C, C++ or Java programming language then you must have seen that your program starts from **main()** function. Very similar way, Android system initiates its program with in an **Activity** starting with a call on *onCreate()* callback method. There is a sequence of callback methods that start up an activity and a sequence of callback methods that tear down an activity as shown in the below Activity life cycle diagram: (*image courtesy : android.com* ) as shown in Figure 5.9.

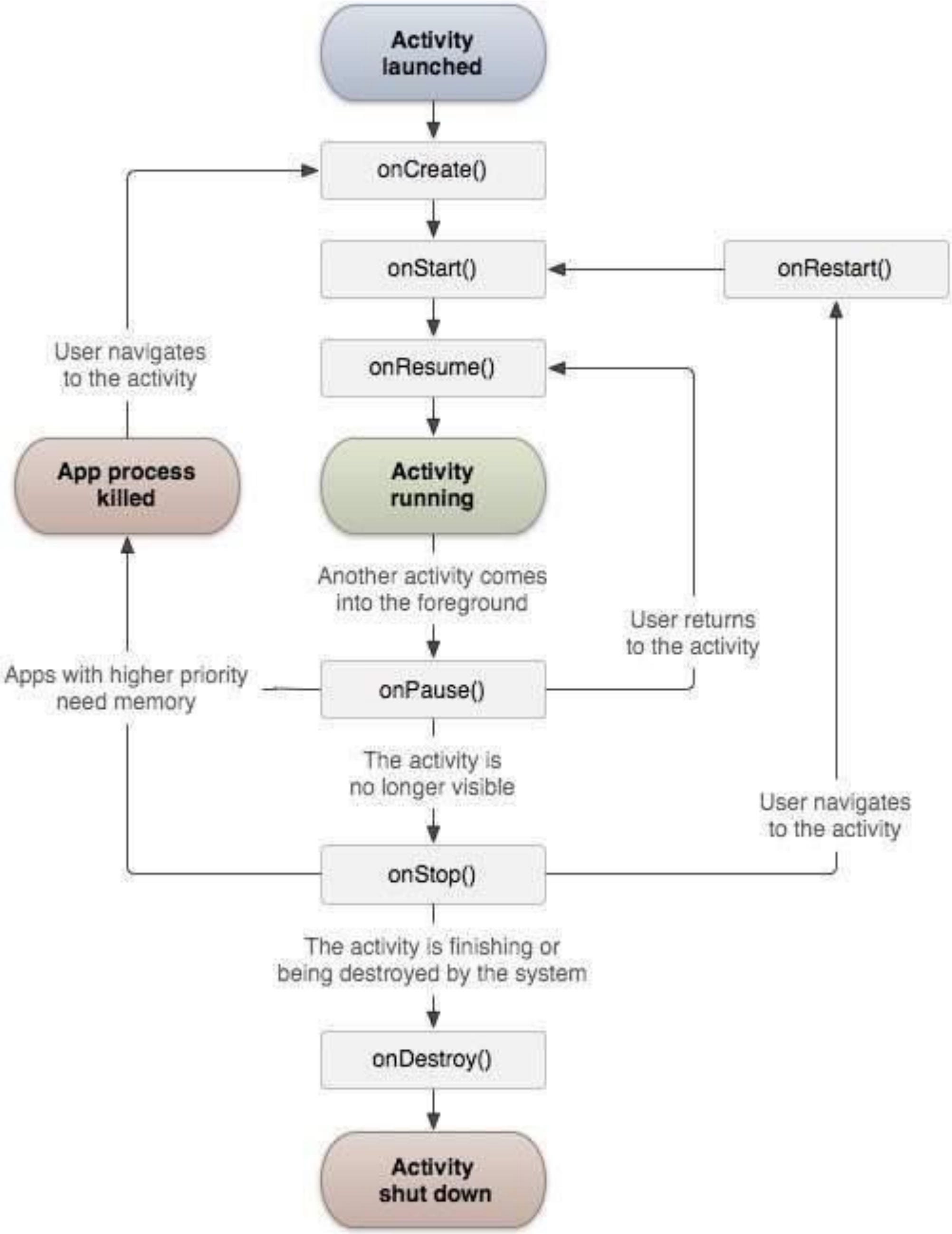



Figure 5.9 Activity life cycle diagram

The Activity class defines the following call backs i.e. events. You don't need to implement all the callbacks methods. However, it's important that you understand each one and implement those that ensure your app behaves the way users expect.

- An activity class loads all the UI component using the XML file available in *res/layout* folder of the project. Following statement loads UI components from *res/layout/activity_main.xml file*:

```
setContentView(R.layout.activity_main);
```

- An application can have one or more activities without any restrictions. Every activity you define for your application must be declared in your *AndroidManifest.xml* file and the main activity for your app must be declared in the manifest with an <intent-filter> that includes the MAIN action and LAUNCHER category as follows:

- If either the MAIN action or LAUNCHER category are not declared for one of your activities, then your app icon will not appear in the Home screen's list of apps.
- Let's try to run our modified **Hello World!** application we just modified. I assume you had created your **AVD** while doing environment setup. To run the app from Android studio, open one of your project's activity files and click Run icon from the toolbar. Android studio installs the app on your AVD and starts it and if everything is fine with your setupand application, it will display Emulator window and you should see following log messages in **LogCat** window in Android studio −
- Let us try to click lock screen button on the Android emulator and it will generate following events messages in **LogCat** window in android studio:
- Let us again try to unlock your screen on the Android emulator and it will generate following events messages in **LogCat** window in Android studio:
- Next, let us again try to click Back button on the Android emulator and it will generate following events messages in **LogCat** window in Android studio and this completes the Activity Life Cycle for an Android Application.

A service has life cycle callback methods that you can implement to monitor changes in the service's state and you can perform work at the appropriate stage. The following diagram on the left shows the life cycle when the service is created with startService() and the diagram on the right shows the life cycle when the service is created with bindService(): *(image courtesy : android.com* as shown in figure 5.10

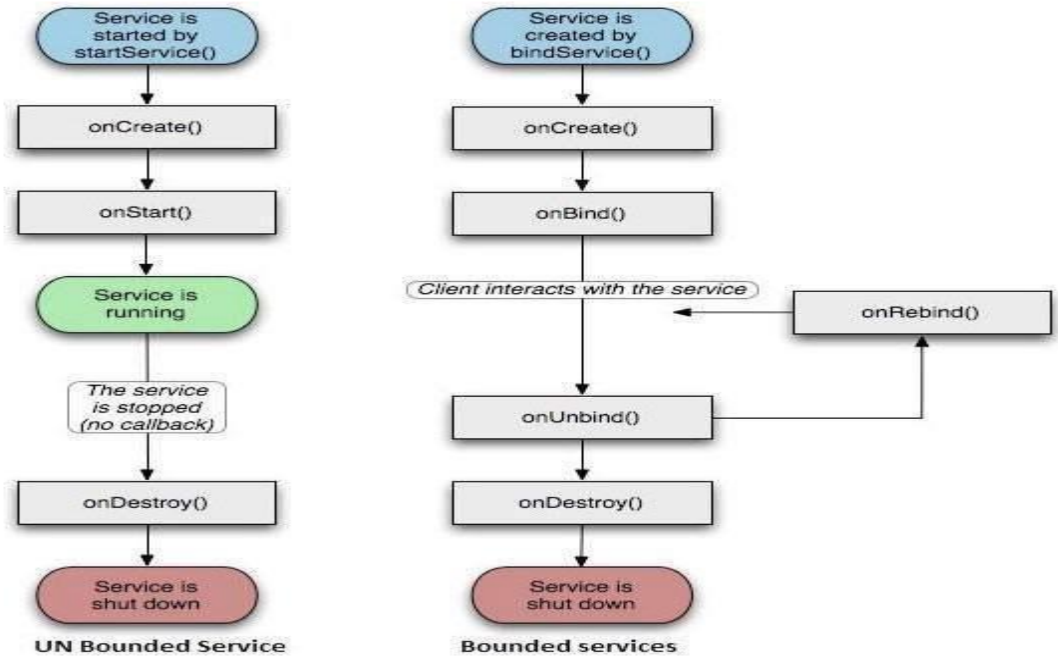



Figure 5.10 Service life cycle

To create an service, you create a Java class that extends the Service base class or one of its existing subclasses. The **Service** base class defines various callback methods and the most important are given below. You don't need to implement all the callbacks methods. However, it's important that you understand each one and implement those that ensure your app behaves the way users expect.

Lets try to run our modified **Hello World!** application we just modified. I assume you had created your **AVD** while doing environment setup. To run the app from Android studio, open one of your project's activity files and click Run icon from the tool bar. Android Studio installs the app on your AVD and starts it and if everything is fine with your set-up as shown in figure 5.11


Figure 5.11 Examples of service

and application, it will display following Emulator window −

Now to start your service, let's click on **Start Service** button, this will start the service and as per our programming in *onStartCommand()* method, a message *Service Started* will appear on the bottom of the the simulator as follows as shown in figure 5.12

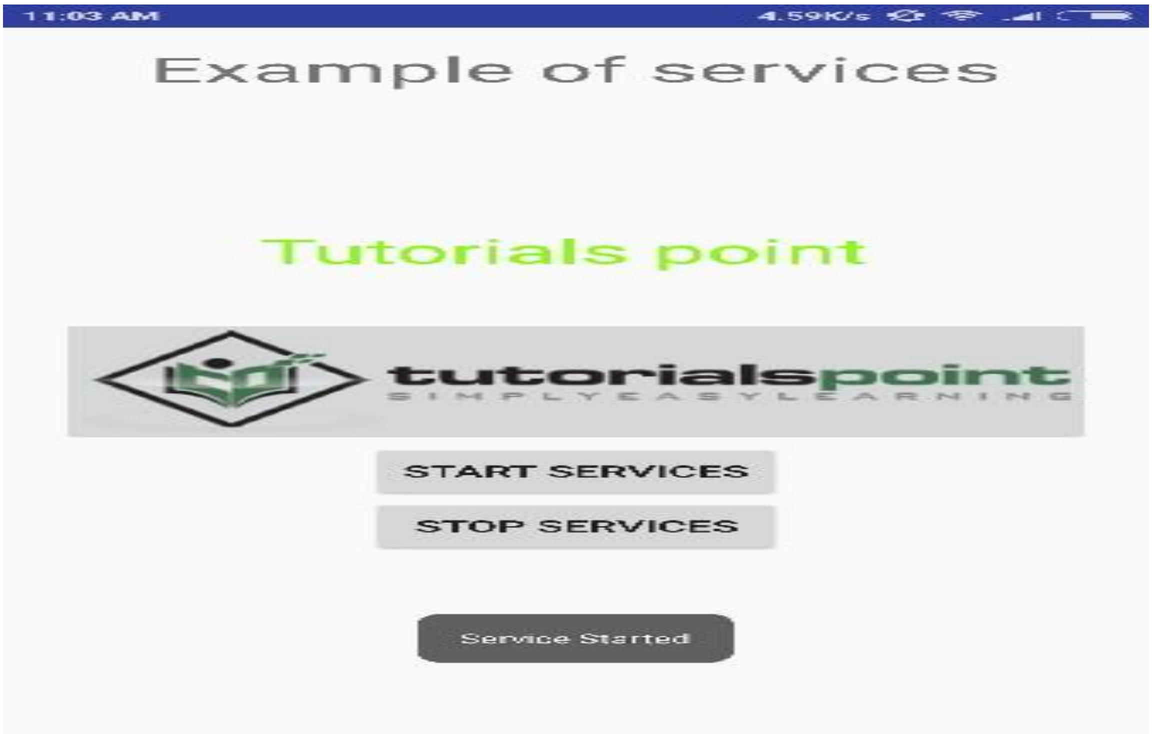



Figure 5.12To stop the service,

you can click the Stop Service buttonAndroid - UI Layouts

- The basic building block for user interface is a **View** object which is created from the View class and occupies a rectangular area on the screen and is responsible for drawing and event handling. View is the base class for widgets, which are used to create interactive UI components like buttons, text fields, etc.
- The **ViewGroup** is a subclass of **View** and provides invisible container that hold other Views or other ViewGroups and define their layout properties.
- At third level we have different layouts which are subclasses of ViewGroup class and a typical layout defines the visual structure for an Android user interface and can be created either at run time using **View/ViewGroup** objects or you can declare your layout using simple XML file **main_layout.xml** which is located in the res/layout folder of your project as shown in figure 5.13

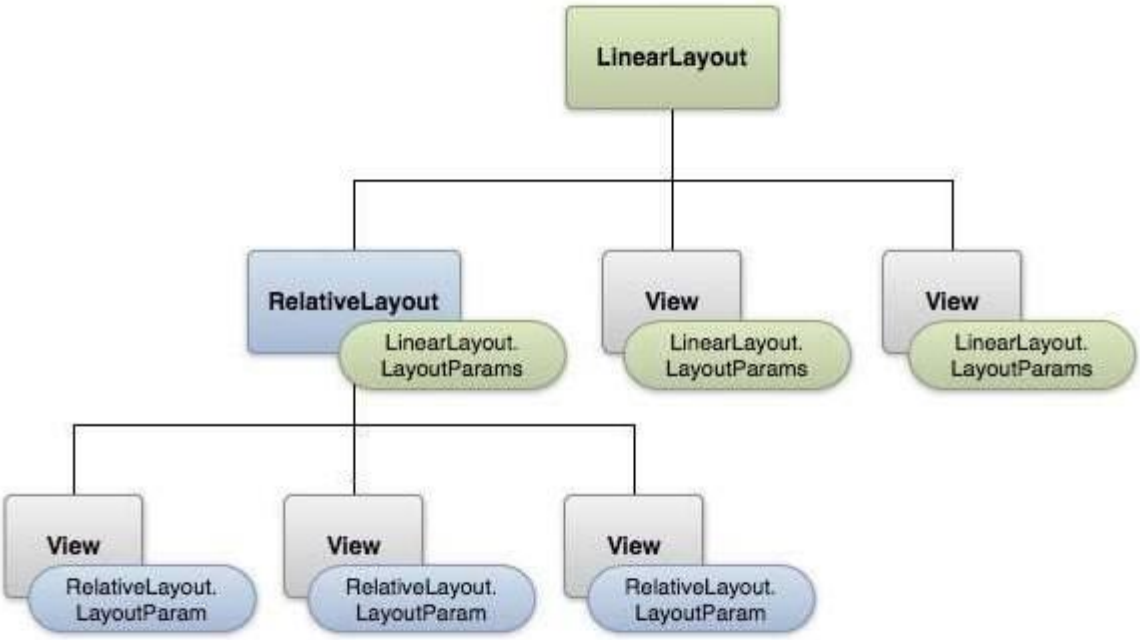



Figure 5.13 Layout params

- This tutorial is more about creating your GUI based on layouts defined in XML file. Alayout may contain any type of widgets such as buttons, labels, textboxes, and so on.
- Android Layout TypesThere are number of Layouts provided by Android which you will usein almost all the Android applications to provide different view, look and feel.

## VIEW IDENTIFICATION

Following is a brief description of @ and + signs −

- The at-symbol (@) at the beginning of the string indicates that the XML parser should parse and expand the rest of the ID string and identify it as an ID resource.
- The plus-symbol (+) means that this is a new resource name that must be created and added to our resources. To create an instance of the view object and capture it from the layout, use the following −

## ANDROID - UI CONTROLS

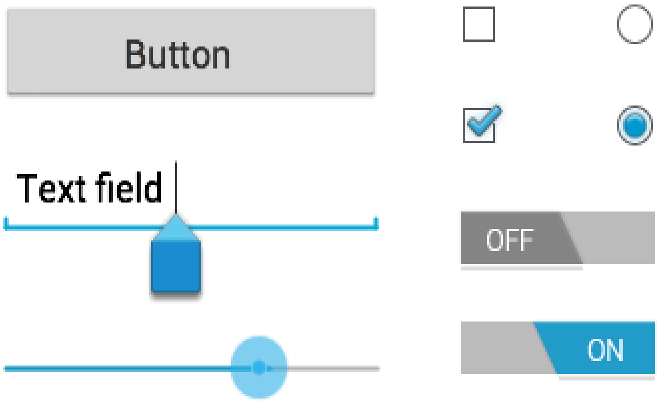



Figure 5.14 UI Elements

A **View** is an object that draws something on the screen that the user can interact with anda **ViewGroup** is an object that holds other View (and ViewGroup) objects in order to definethe layout of the user interface.

## CREATE UI CONTROLS

Input controls are the interactive components in your app's user interface. Android providesa wide variety of controls you can use in your UI, such as buttons, text fields, seek bars, check box, zoom buttons, toggle buttons, and many more

There are following three concepts related to Android Event Management −

- **Event Listeners** − An event listener is an interface in the View class that contains a single callback method. These methods will be called by the Android framework when the View to which the listener has been registered is triggered by user interaction with the item in the UI.
- **Event Listeners Registration** − Event Registration is the process by which an Event Handler gets registered with an Event Listener so that the handler is called when the Event Listener fires the event.
- **Event Handlers** − When an event happens and we have registered an event listener for the event, the event listener calls the Event Handlers, which is the method that actually handles the event.

There are many more event listeners available as a part of **View** class like OnHoverListener, OnDragListener etc which may be needed for your application. So I recommend to refer official documentation for Android application development in case you are going to develop a sophisticated apps.

## EVENT LISTENERS REGISTRATION

Event Registration is the process by which an Event Handler gets registered with an Event Listener so that the handler is called when the Event Listener fires the event. Though there are several tricky ways to register your event listener for any event, but I'm going to list down only top 3 ways, out of which you can use any of them based on the situation.

- Using an Anonymous Inner Class

- Activity class implements the Listener interface.
- Using Layout file activity_main.xml to specify event handler directly.

Below section will provide you detailed examples on all the three scenarios −

- Touch Model

  Users can interact with their devices by using hardware keys or buttons or touching the screen.Touching the screen puts the device into touch mode. The user can then interact with it by touching the on-screen virtual buttons, images, etc.You can check if the device is in touch mode by calling the View class's isInTouchMode() method.

- Focus

  A view or widget is usually highlighted or displays a flashing cursor when it's in focus. Thisindicates that it's ready to accept input from the user.

- **isFocusable()** − it returns true or false
- **isFocusableInTouchMode()** − checks to see if the view is focusable in touch mode. (A view may be focusable when using a hardware key but not when the device is in touch mode)

## EVENT HANDLING EXAMPLES

- Event Listeners Registration Using an Anonymous Inner Class
- Here you will create an anonymous implementation of the listener and will be useful if each class is applied to a single control only and you have advantage to pass arguments to event handler. In this approach event handler methods can access private data of Activity. No reference is needed to call to Activity.
- But if you applied the handler to more than one control, you would have to cut and paste the code for the handler and if the code for the handler is long, it makes the code harder to maintain.
- Following are the simple steps to show how we will make use of separate Listener class to register and capture click event. Similar way you can implement your listener for any other required event type.

| | **Description** |
|---|---|
| | You will use Android studio IDE to create an Android application and name it as *myapplication* under a package *com.example.myapplication* as explained in the *Hello World Example* chapter. |
| | Modify *src/MainActivity.java* file to add click event listeners andhandlers for the two buttons defined. |

| | |
|---|---|
| | Modify the default content of *res/layout/activity_main.xml* file toinclude Android UI controls. |
| | No need to declare default string constants.Android studio takescare default constants. |
| | Run the application to launch Android emulator and verify theresult of the changes done in the aplication. |

- Following is the content of the modified main activity file **src/com.example.myapplication/MainActivity.java**. This file can include each of the fundamental lifecycle methods.
- Let's try to run your **myapplication** application. I assume you had created your **AVD** while doing environment setup. To run the app from Android Studio, open one of your project's activity files and click Run icon from the toolbar. Android Studio installs the app on your AVD and starts it and if everything is fine with your setup and application, it will display following Emulator window

Now you try to click on two buttons, one by one and you will see that font of the **Hello World** text will change, which happens because registered click event handler method is being called against each click event.

**DEFINING STYLES**

- A style is defined in an XML resource that is separate from the XML that specifies the layout. This XML file resides under **res/values/** directory of your project and will have **<resources>** as the root node which is mandatory for the style file. The name of the XML file is arbitrary, but it must use the .xml extension.
- You can define multiple styles per file using **<style>** tag but each style will have its name that uniquely identifies the style. Android style attributes are set using **<item>** tag as shown below −

**STYLE INHERITANCE**

- Android supports style Inheritance in very much similar way as cascading style sheet in web design. You can use this to inherit properties from an existing style and then define only the properties that you want to change or add.
- Your color resource can then be applied to some theme attributes, such as the window background and the primary text color, by adding <item> elements to your custom theme. These attributes are defined in your styles.xml file. For example, to apply the custom color to the window background, add the following two <item> elements to your custom theme, defined in MyAndroidApp/res/values/styles.xml file −

- A nine-patch drawable is a special kind of image which can be scaled in width and height while maintaining its visual integrity. Nine-patches are the most common way to specify the appearance of Android buttons, though any drawable type can be us.

**STEPS TO CREATE NINE-PATCH BUTTONS**

- Save this bitmap as /res/drawable/my_nine_patch.9.png
- Define a new style
- Apply the new button style to the buttonStyle attribute of your custom theme
- Android Themes
- Hope you understood the concept of Style, so now let's try to understand what is a **Theme**. A theme is nothing but an Android style applied to an entire Activity or application, rather than an individual View.
- Thus, when a style is applied as a theme, every **View** in the Activity or application will apply each style property that it supports. For example, you can apply the same **CustomFontStyle** style as a theme for an Activity and then all text inside that **Activity** will have green monospace font.
- To set a theme for all the activities of your application, open the **AndroidManifest.xml** file and edit the **<application>** tag to include the **android:theme** attribute with the style name. For example −
- <application android:theme="@style/CustomFontStyle">
- But if you want a theme applied to just one Activity in your application, then add the android:theme attribute to the <activity> tag only. For example −
- <activity android:theme="@style/CustomFontStyle">
- There are number of default themes defined by Android which you can use directly or inherit them using **parent** attribute as follows −
- To understand the concept related to Android Theme, you can check Theme Demo Example.
- Styling the colour palette
- The layout design can implementable based on them based colours, for example as following design is designed based on them colour(blue)

The Android platform provides a large collection of styles and themes that you can use in your applications. You can find a reference of all available styles in the **R.style** class. To usethe styles listed here, replace all underscores in the style name with a period. For example, you can apply the Theme_NoTitleBar theme with "@android:style/Theme.NoTitleBar". You can see the following source code for Android styles and themes −

Android offers a great list of pre-built widgets like Button, TextView, EditText, ListView, CheckBox, RadioButton, Gallery, Spinner, AutoCompleteTextView etc. whichyou can use directly in your Android application development, but there may be a situation when you are not satisfied with existing functionality of any of the available widgets. Android provides you with means of creating your own custom components which you can customized to suit your needs.

If you only need to make small adjustments to an existing widget or layout, you can simply subclass the widget or layout and override its methods which will give you precise control over the appearance and function of a screen element.

This tutorial explains you how to create custom Views and use them in your application using simple and easy steps as shown figure 5.15.

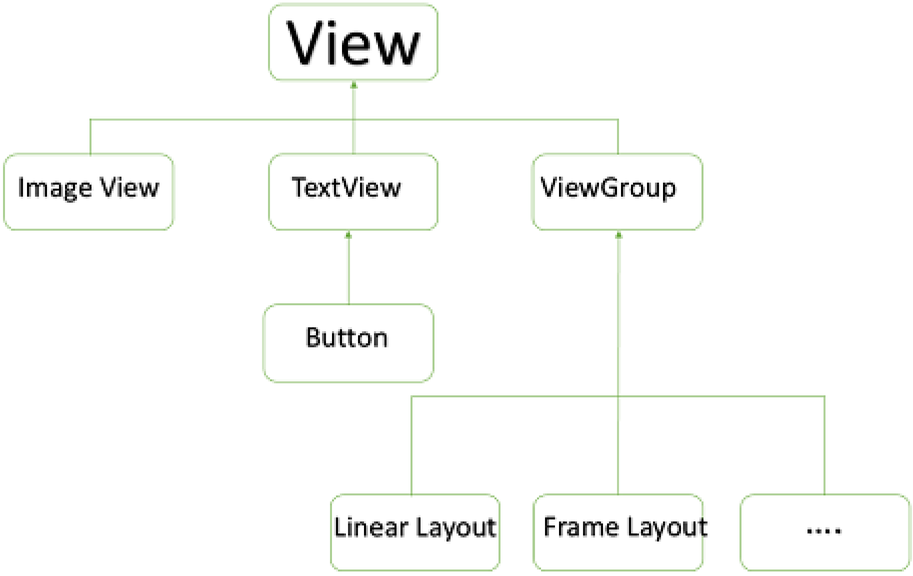



Figure 5.15 Example of Custom Components in Custom View hierarchyCreating a Simple Custom Component

| | Description |
|---|---|
| | You will use Android studio IDE to create an Androidapplication and name it as *myapplication* under a package *com.example.tutorialspoint7.myapplication* as explained in the *Hello World Example* chapter. |
| | Create an XML *res/values/attrs.xml* file to define newattributes along with their data type. |
| | Create *src/mainactivity.java* file and add the code todefine your custom component |

| | |
|---|---|
| | Modify *res/layout/activity_main.xml* file and add the codeto create Colour compound view instance along with few default attributes and new attributes. |
| | Run the application to launch Android emulator and verify the result of the changes done in the application. |

## 5.3 ACCESS WI-FI ON AN ANDROID PHONE

- Making Wi-Fi work on your Android phone requires two steps. First, you must activate Wi-Fi by turning on the phone's wireless radio. The second step is connecting to a specific wireless network.
- Wi-Fi stands for *wireless fidelity*. It's brought to you by the numbers 802.11 and the letters B, N, and G.

**Activating Wi-Fi**

Follow these steps to activate Wi-Fi on your Android phone:

- At the Home screen, touch the Apps icon.Open the Settings app.
- Ensure that the Wi-Fi master control icon is on.
- If not, slide the master control from Off to On to activate the phone's Wi-Fi radio.
- If you've already configured your phone to connect to an available wireless network, it's connected automatically. Otherwise, you have to connect to an available network, which is covered in the next section.
- To turn off Wi-Fi, repeat the steps in this section, but in Step 3 slide the master control icon from On to Off. Turning off Wi-Fi disconnects your phone from any wireless networks.
- Some phones may come with a Power Control widget affixed to a Home screen. One of the buttons on that widget is used to turn Wi-Fi on or off.

Using Wi-Fi to connect to the Internet doesn't incur data usage charges.

- The Wi-Fi radio places an extra drain on the battery, but it's truly negligible.
- If you want to save a modicum of juice, especially if you're out and about and don't plan to be near a Wi-Fi access point for any length of time, turn off the Wi-Fi radio.

**CONNECTING TO A WI-FI NETWORK**

After activating the Wi-Fi radio on your Android phone, you can connect to an availablewireless network. Heed these steps:

Open the Settings app.

- It's found in the apps drawer, but you'll also find a shortcut in the quick actions drawer. Choose Wi-Fi or Wireless & Networks.
- Don't touch the Master Control icon, which turns the Wi-Fi radio on or off; touch theWi-Fi text on the left side of the Settings app screen.

- You see a list of Wi-Fi networks. In the figure, the Imperial Wambooli network is
- currently connected as shown in figure 5.16

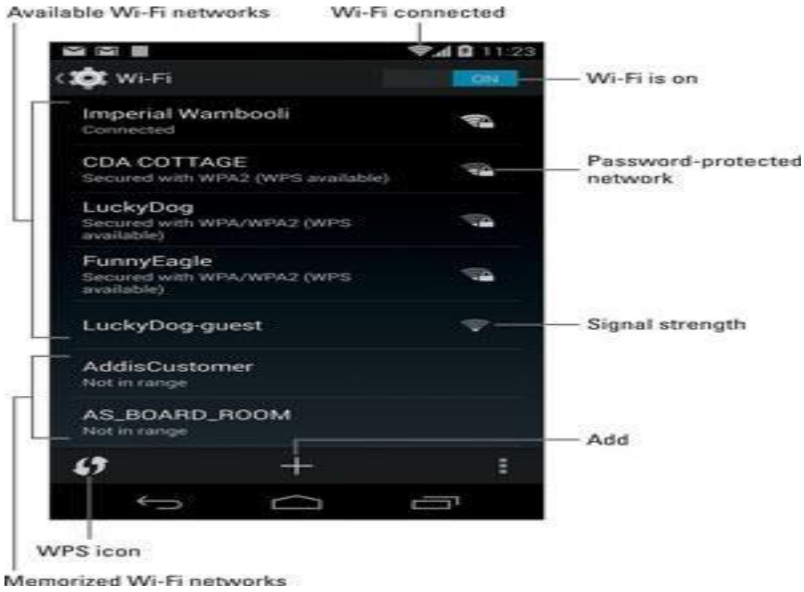



Figure 5.16 Choose a wireless network from the list.

- When no wireless networks are shown, you’re sort of out of luck regarding Wi-Fi access from your current location.
- If prompted, type the network password.
- Putting a check mark in the box by the Show Password option makes it easier to type a long, complex network password.
- Touch the Connect button.
- You should be immediately connected to the network. If not, try the password again.
- When the phone is connected, you see the Wi-Fi status icon atop the touchscreen, looking similar to the icon shown. This icon indicates that the phone’s Wi-Fi is on — connected and communicating with a Wi-Fi network.

- Some wireless networks don’t broadcast their names, which adds security but also makes accessing them more difficult. In these cases, touch the Add icon to manually add the network. The command might be titled Add Network.

You need to type the network name, or *SSID*, and specify the type of security. You also need the password, if one is used. You can obtain this information from the girl with the pink hair and pierced lip who sold you coffee or from whoever is in charge of the wireless network at your location.

- Not every wireless network has a password. They should!
- Some public networks are open to anyone, but you have to use the web browser app to get on the web and find a login page that lets you access the network. Simply browse to any page on the Internet, and the login page shows up.
- The phone automatically remembers any Wi-Fi network it's connected to as well as its network password. An example is the AS_BOARD_ROOM network, shown.
- To disconnect from a Wi-Fi network, simply turn off Wi-Fi.
- Unlike the mobile network, a Wi-Fi network's broadcast signal goes only so far. Use Wi-Fi when you plan to remain in one location for a while. If you wander too far away, your phone loses the signal and is disconnected.

**CONNECTING VIA WPS**

- Many Wi-Fi routers feature WPS, which stands for Wi-Fi Protected Setup. It's a network authorization system that's really simple and quite secure. If the wireless router features WPS, you can use it to quickly connect your phone to the network.
- To make the WPS connection, touch the WPS connection button on the router. The button is labeled WPS or sports the WPS icon. On your phone, visit the Wi-Fi screen in the settings app. Touch the WPS icon to connect to the network.
- If the WPS router requires a PIN (Personal Identification Number), touch the Action Overflow icon on the Wi-Fi settings screen and choose the WPS Pin Entry item.

## 5.5 BLUETOOTH

The Android platform includes support for the Bluetooth network stack, which allows a device to wirelessly exchange data with other Bluetooth devices. The app framework provides access to the Bluetooth functionality through Bluetooth APIs. These APIs let apps connect to other Bluetooth devices, enabling point-to-point and multipoint wireless features.

Using the Bluetooth APIs, an app can perform the following:Scan for other Bluetooth devices.
Query the local Bluetooth adapter for paired Bluetooth devices.

- Establish RFCOMM channels.
- Connect to other devices through service discovery.
- Transfer data to and from other devices.
- Manage multiple connections.
- This topic focuses on *Classic Bluetooth*. Classic Bluetooth is the right choice for more battery-intensive operations, which include streaming and communicating between devices. For Bluetooth devices with low power requirements, consider using Bluetooth Low Energy connections.
- This documentation describes different Bluetooth profiles and explains how to use the Bluetooth APIs to accomplish the four major tasks necessary to communicate using Bluetooth:
- Setting up Bluetooth.
- Finding devices that are either paired or available in the local area. Connecting devices.
- Transferring data between devices.
- For a demonstration of using the Bluetooth APIs, see the Bluetooth Chat sample app.

**THE BASICS**

For Bluetooth-enabled devices to transmit data between each other, they must first form achannel of communication using a pairing process. One device, a discoverable device, makes itself available for incoming connection requests. Another device finds the discoverable device using a service discovery process. After the discoverable device accepts the pairing request, the two devices complete a bonding process in which they exchange security keys. The devices cache these keys for later use. After the pairing and bonding processes are complete, the two devices exchange information. When the sessionis complete, the device that initiated the pairing request releases the channel that had linked it to the discoverable device. The two devices remain bonded, however, so they can reconnect automatically during a future session as long as they're in range of each other and neither device has removed the bond.

- Use of the Bluetooth APIs requires declaring several permissions in your manifest file. Once your app has permission to use Bluetooth, your app needs to access the BluetoothAdapter and determine if Bluetooth is available on the device. If Bluetooth is available,

  There are three steps to make a connection:

- Find nearby Bluetooth devices, either devices that are already paired or new ones.Connect to a Bluetooth device.
- Transfer data with the connected device.
- Certain devices use a specific Bluetooth profile that declares the data it provides.

**KEY CLASSES AND INTERFACES**

- All of the Bluetooth APIs are available in the android.bluetooth package.
- The following are the classes and interfaces you need in order to create Bluetooth connections:BluetoothAdapter
- Represents the local Bluetooth adapter (Bluetooth radio).
- The BluetoothAdapter is the entry-point for all Bluetooth interaction.
- Using this, you can discover other Bluetooth devices, query a list of bonded (paired) devices, instantiate a BluetoothDevice using a known MAC address, and create a BluetoothServerSocket to listen for communications from other devices.

**BLUE TOOTH DEVICE**

REPRESENTS A REMote Bluetooth device. Use this to request a connection with a remote device through a BluetoothSocket or query information about the device such as its name, address, class, and bonding state.

**BLUE TOOTH SOCKET**

Represents the interface for a Bluetooth socket (similar to a TCP Socket). This is the connection point that allows an app to exchange data with another Bluetooth device using InputStream and OutputStream.

**BLUE TOOTH SERVER SOCKET**

Represents an open server socket that listens for incoming requests (similar to a TCP ServerSocket). In order to connect two devices, one device must open a server socket with this class. When a remote Bluetooth device makes a connection request to this device, the device accepts the connection and then returns a connected BluetoothSocket.

**BLUE TOOTH CLASS**

Describes the general characteristics and capabilities of a Bluetooth device. This is a read-only set of properties that defines the device's classes and services. Although this information provides a useful hint regarding a device's type, the attributes of this class don't necessarily describe all Bluetooth profiles and services that the device supports.

**BLUE TOOTH PROFILE**

An interface that represents a Bluetooth profile. A Bluetooth profile is a wireless interface specification for Bluetooth-based communication between devices. An example is the Hands-Free profile. For more discussion of profiles, see Bluetooth profiles.

**BLUE TOOTH HEADSET**

Provides support for Bluetooth headsets to be used with mobile phones. This includes both the Bluetooth Headset profile and the Hands-Free (v1.5) profile.

**BLUETOOTH A2DP**

Defines how high-quality audio can be streamed from one device to another over a Bluetooth connection using the Advanced Audio Distribution Profile (A2DP).

**BLUETOOTH HEALTH**

Represents a Health Device Profile proxy that controls the Bluetooth service.

**BLUE TOOTH HEALTH CALLBACK**

An abstract class that you use to implement BluetoothHealth callbacks. You must extend this class and implement the callback methods to receive updates about changes in the app's registration state and Bluetooth channel state.

**BLUE TOOTH HEALTHAPP CONFIGURATION**

Represents an app configuration that the Bluetooth Health third-party app registers to communicate with a remote Bluetooth health device.

**BLUE TOOTH PROFILE.SERVICELISTENER**

An interface that notifies BluetoothProfile interprocess communication (IPC) clients when they have been connected to or disconnected from the internal service that runs a particular profile.

**ANDROID - BLUETOOTH**

- Among many ways, Bluetooth is a way to send or receive data between two different devices. Android platform includes support for the Bluetooth framework that allows a device to wirelessly exchange data with other Bluetooth devices.
- Android provides Bluetooth API to perform these different operations. Scan for other Bluetooth devices
- Get a list of paired devices

Connect to other devices through service discovery

Android provides BluetoothAdapter class to communicate with Bluetooth. Create an object of this calling by calling the static method getDefaultAdapter(). Its syntax is given below.

Apart from this constant, there are other constants provided the API , that supports different tasks. They are listed below.

| S | **Constant & description** |
|---|---|
| 1 | **ACTION_REQUEST_DISCOVERABLE**<br>This constant is used for turn on discovering ofBluetooth |
| 2 | **ACTION_STATE_CHANGED**<br>This constant will notify that Bluetooth state has beenchanged |
| 3 | **ACTION_FOUND** |

| | |
|---|---|
| | This constant is used for receiving information abouteach device that is discovered |

Apart form the parried Devices , there are other methods in the API that gives morecontrol over Blueetooth. They are listed below.

| S | Method & description |
|---|---|
| 1 | **enable()**<br>This method enables the adapter if not enabled |
| 2 | **isEnabled()**<br>This method returns true if adapter is enabled |
| 3 | **disable()**<br>This method disables the adapter |
| 4 | **getName()**<br>This method returns the name of the Bluetooth adapter |
| 5 | **setName(String name)**<br>This method changes the Bluetooth name |
| 6 | **getState()**<br>This method returns the current state of the BluetoothAdapter. |
| 7 | **startDiscovery()**<br>This method starts the discovery process of the Bluetooth for 120 seconds. |

Example

This example provides demonstration of BluetoothAdapter class to manipulate Bluetoothand show list of paired devices by the Bluetooth.

To experiment with this example , you need to run this on an actual device.

| | | Description |
|---|---|---|
| | | You will use Android studio to create an Android application a package com.example.sairamkrishna.myapplication. |
| | | |
| | | Modify src/MainActivity.java file to add the code |
| | | Modify layout XML file res/layout/activity_main.xml add any GUI component if required. |
| | | Modify AndroidManifest.xml |
| | | Run the application and choose a running android device and install the application on it and verify the results. |

## 5.5 STEPS OF HEALTHCARE MOBILE APP DEVELOPMENT SERVICES

- **Step 1. Choose your technological partner among healthcare software development companies**
  When choosing the best healthcare dev company, consider previous projects, clientreviews, and the company's tech expertise.
- **Step 2. Ask developers for a quote to create a healthcare app**
  Fill in the contact form to schedule a meeting with a business development manager to clarify more details of your project.
- **Step 3. Receive a rough estimate on medical app development**
  Based on the project's details, a business analyst, project manager, and solutions architect will create a rough estimation for your project and send it to you.
- **Step 4. Launch the inception phase with a team of medical app developers**
  When you agree on the initial estimation, healthcare app developers will clarify more details on your project to create user stories, mockups, and wireframes.
- **Step 5. Start the healthcare software development process**
  When you agree on all deliverables of the inception phase, the team will start building the app iteration by iteration.

### TYPES OF MOBILE HEALTH APPS

There are different types of apps for health aimed at various end-users, including medical professionals, labs, and patients, which impact their features, some integrations, and the degree of data security required.

### PROFESSIONAL HEALTHCARE APP

Targeted at medical personnel, such apps include patient data, such as name, date of birth, insurance number, address, and so on. Thus, when launching a professional healthcare development process, you need to make a medical personal mobile app HIPAA compliant and pay extra attention to private data encryption to avoid data breaches. mHealth apps for medical specialists include the following types:

### CLINICAL COMMUNICATION APPS

- Such applications are developed to improve clinical decision-making and communication with clinical specialists in a particular hospital. They include messaging and voice chat, file sharing, and electronic health record systems.
- One example of such an app is Halo, a communication, and collaboration platform for clinical specialists, which includes the following features:
- Send physicians and nurses Lab and PACS results
- Integrate with EHR (electronic health records) to edit patient records in real-time Store files on a cloud-based platform, Amazon Web Services

## PATIENT COMMUNICATION APPS

- This type of app boosts customer satisfaction, loyalty, health outcomes, and provides more transparency between patients and doctors.
- That is how the EASE mobile app works, offering users the following features: Invite relatives to the network within the app to keep them informed about updates
- Include HIPAA compliant texts, photos, and videos that will self-destruct after 60seconds
- Send premade bulk messages to patients and their families to keep them informed
- Prohibit saving files, texts, or other documents from the app to the device to ensure patient privacy and avoid data breaches

## MEDICAL RECORD APPS

- Such apps simplify updating patient records, including blood pressure, medical visits, examinations, prescriptions, and other information to keep track of a patient's progress.
- Medical Record is an app that belongs to this mHealth app category. In addition to the features above, the app also includes:
- Prescription module allowing doctors to save medical info Appointment feature to schedule an appointment with patients Recording videos or procedures instead of text messages Searching patients by I.D.

## RISK ASSESSMENT APPS

- Such apps are integrated with Electronic Health Records (EHR) and wearable devices, which allows monitoring patients' health conditions in real-time, tracking heart rate, and identifying patients at risk. To build a risk assessment mobile app, developers often use machine learning for pattern recognition, as we did for our recent project, a skin cancer detection neural network.
- An example of such an app is FHR 5-Tier(Forecast Health Risk and Predication), aimed at obstetricians, midwives, and nurses who use electronic fetal monitoring (EFM) for patients in labor. Let's look at its features:
- The app allows interpreting fetal heart rate (FHR) tracings to decide about further patient treatment in real-time
- The five-color (green, blue, yellow, orange, and red) system is used in the app to allow medical specialists to standardize the management of different fetal heart rate tracings.
- When the app finds a risk to a patient's health, it uses colors Yellow, Orange, or Red to notify the doctor about the patient's state of urgency and provide a list with recommended actions.

## BARCODE SCANNING APPS

- Barcode scanning mobile apps in healthcare allow scanning a patient's electronic health records and medication barcodes using a built-in camera in their mobile devices, avoiding expensive barcode scanning devices.

- Epic Rover is one healthcare app that belongs to this category, empowered by Scandid Barcode scanner SDK. Apart from scanning a patient's medications barcodes, develop a healthcare mobile app with the following features:
- Integration with Epic electronic health records for better admission of medicines and treatment
- Visualization of patient-related info and progress in the form of charts
- Build-in messenger to communicate with patients and other medical personnel And other functions to make the doctors' work even more efficient.

## MEDICATION DOSAGE APPS

- Such applications are used by physicians to calculate individualized doses of medicine based on the patient's age, weight, and other personal info, avoiding laborious manual calculations, spreadsheets, and sophisticated tools.
- One example is the DoseMeRx app for medical professionals. Let's find out more about its features:
- Integration with EHR, where the doctor can leave notes on the patient's state, medications, and dosage assigned
- Set up reminders so that patients can track their medication intakeBuild-in feature to predict treatment outcomes
- Integrated dose optimization feature that leverages Bayesian dosing methods to guide dose optimization, based on clinically validated pharmacokinetic drug models, patient characteristics, drug concentrations, and genotype

## HOSPITAL MOBILE APP DEVELOPMENT

### Healthcare mobile apps for patients

The patient-oriented mobile app market includes two main categories: medical and wellness. Below, we highlight every type of app from both of these groups, their examples, and essential features.

### Doctor-on-demand or Telemedicine apps

- Even in a busy environment, patients can receive treatment and consultations from medical specialists using telemedicine apps, without leaving their offices or homes. Such mobile applications help patients to find a necessary medical specialist from a pool of doctors, book an appointment, and attend it via video call and pay for the consultation via an integrated payment gateway.
- One typical doctor-on-demand mobile app is EVisit that includes other features:
- Virtual waiting room with waiting time tracking where patients can prepare the information required
- Two-way video connection so patients can see the doctors they communicate with
- Built-in messaging, EHR, search for medication, prescriptions, and other features to deliver patients the medical experience of attending an offline appointment with a doctor.

**Condition-based apps**

- Such apps are popular among users with epilepsy, diabetes, cardiovascular disease, asthma, allergies, and even depression. While some apps in this category are more sophisticated versions of a digital diary with visual medication management, others
- use predictive analytics and machine learning to notify a user about a particular health condition one should be aware of.
- Founded by Munroe-Meyer Institute, Seizure Tracker is a perfect example of apps that allow users to log their seizures, and includes a bunch of other features:
- Video recording, so patients can describe their seizures, their triggers, and what happened afterward
- Manual input of seizure info, so the user can specify their seizure type, time of day, length of the seizure, and other related information
- Option to synchronize user profile with private Youtube channel to record info about seizures and share it with relatives

**Fitness apps**

- Such apps help users keep fit by tracking their daily activity, weight, number of calories burned, a list with workout programs, and integration with wearable devices. In our previous article devoted to fitness app development, we described other features of such apps and gave you a guide on how to develop one.
- MyFitnessPal is the most popular fitness mobile app, which includes:
- Diet tracking with recommendations on calorie consumption based on the user's age, weight, sex
- User community where other users share their success stories about losing weight Calorie counter to control the amount of food, water and coffee consumed

**Diet and nutrition apps**

- Diet and nutrition apps are another popular category in the mHealth market, targeted at users who want to lose weight. The standard set of a diet app includes a comprehensive library with food and nutrition, a calorie counter, a diary with meals, and a progress chart.
- Lose It! app belongs to this mobile app category and provides users with the following features:
- Barcode scanner to receive information about product nutrients within seconds, and track intake of carb, macro, and calorie
- Snap It allows users to log images of food taken on a mobile device
- Meal planning to customize the user's eating and track macro, carb, protein, and overall calorie intake

**Meditation apps**

- Meditation mobile apps also belong to the mHealth market since they help users to maintain their mental health with the help of guided meditations. As a rule, such apps include a library with pre-recorded sessions of guided meditations, timer, gamification, and useful tips about breathing exercises.
- Calm, the best-known meditation mobile app, valued at $1 billion, helps users reduce stress and improve sleep. To achieve these goals, they use not only ancient methods of relaxation, but also a scientific approach based on ongoing studies conducted by scientist from Arizona State University, Ryerson University in Toronto, Massachusetts General Hospital, and others.
- The main features of the Calm app are:
- Guided meditations for different purposes (relationships, breaking habits, happiness, etc.
- Mediations of different lengths for users with varying levels
- A library with podcasts, sleeping stories, relaxing music, breathing programs, and masterclasses

**Regulations to consider before starting a healthcare app development**

- If you want to build a mobile medication app, things to consider are security regulations and compliances across different countries that are mainly concerned with patient data safety. Otherwise, if your app does not meet these regulations, no matter how good your app is, it will be deleted from app marketplaces.
- The good thing is to build a weight loss, calorie counter, or meditation app, you do not need to make it compliant.

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