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- All other honourable audience available
- All Colleagues, academics and practitioners within UNISA and across the world
- And general community

- I great you all and
- all protocols are observed

- I want to start by recognising all those who contributed immensely towards achievement of this profesorialship today:
  - My family, Mother: Mrs Sekedi Mamaropene Marutha; wife: Elizabeth; daughters: Makwena, Naledi, Koketjo, Modjadji, Mapula; Granddaughter: Kamogelo
  - Colleagues in the department of information science

- Thank you for being a pillars of my strength in different ways towards this far

Moving patients' queue to the cloud for quality healthcare in South Africa, using fourth industrial revolution technology

07 SEPTEMBER 2022

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Define tomorrow.

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OUTLINE

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5. Artificial intelligence in the Fourth Industrial Revolution

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INTRODUCTION

- The study investigated the provision of quality patient care in South Africa, using Fourth Industrial revolution (4IR) technology

- Technology has evolved supersonically during the past few decades and today we are in the Fourth Industrial Revolution where most tasks are discharged virtually using computers on networks.

- "increased adoption of emerging technologies such as Internet of Things (IoT), blockchain, big data and behavioural/predictive analytics, Artificial Intelligence (AI), etc., stands to revolutionalise the way government departments do their businesses", (Bwalya 2020: 2) and this should not be exclusive to government department of health in South Africa.

- Technology is introduced in the public services to ensure business processes efficiency in government is improved for delivery of public service in such a manner that is effective (Bwalya 2020: 2).

INTRODUCTION…

- Technology has evolved exponentially during the past few decades.

- For instance, around 1949 computer technologies were only able to take user commands and discharge them and were not able to recall those commands or transactions in future during the following related, similar or different transactions executed by different or the same users (Hewlett Packard 2022).

- They could, for instance, keep an audit trail, but could not act on it in a future transaction.

- AI saw a paradigm shift in the 1980s, when the algorithm toolkit was expanded, with more funds dedicated to its projects.

- With this development, computer experts came up with different concepts for programming and enhancing AI.

- For instance,
  - John Hopefield and David Rumelhart came up with the concept of **"deep learning"**, which has to do with programming computers to learn from their experience of the previous use; and
  - Edward Feigenbaum introduced the concept of **"expert systems"** to program computers to imitate decision-making in humans (Hewlett Packard 2022).

INTRODUCTION…

- This is the reason why so many services can be rendered virtually online nowadays.

- Innovative technology has been used by suppliers and producers of different kinds of goods and services to improve their services to clients (Lee, Ardakani, Yang & Bagheri 2015).

- The paradigm of the Fourth Industrial Revolution (4IR) challenges organizations to rethink their mode of operation in relation to globalization and innovation (Petrillo, De Felice, Cioffi & Zomparelli 2017).

- To mention a few examples, grocery shops such as Checkers and Pick 'n Pay and restaurants like KFC, Debonairs Pizza, McDonald's, Nando's, Galito's and many more render online services to their clients using the current technology.

- Healthcare services are different, but applying the current technology to this sector may assist in improving the quality of healthcare services to patients by reducing waiting time, overcrowding in the facilities and the transfer of infections among patients, and missing of medical and healthcare history information during treatment.

Synopsis of the healthcare system in South Africa

- There are many operational challenges in different industries that 4IR technologies may solve.
  - For instance, in the year 2015, countries across the world failed to achieve the targets of the Millennium Development Goals (MDG) by the set deadline.
- This might have been due to the nature of technology during that era.
- Ultimately, the MDGs were transformed into the Sustainable Development Goals (SDG).
- In both plans, most goals were about resolving healthcare-related issues such as maternal health, child mortality, HIV/AIDS and malaria, to list only a few.

Synopsis of the healthcare system in South Africa…

- Looking at the South African context, Shipalanaa, Masangob and Phago (2020:1) state that
  - "For post-1994 in South Africa, challenges of streamlining the provision of public services such as health, education, water and housing, among other key government services are palpable. The government at both national and sub-national level is expected to enhance the quality of life for those South Africans who were deprived of their dignity and fundamental human rights during apartheid".

- However, there is an increase in the need for the government to attempt and reform in the 21st century using technologies available such as the 4IR to face the current reality. (Shipalanaa, Masangob and Phago 2020:1)

- For example, the platforms such as "bots and robo-advisors" may be integrated, to enable access to information to happen at any-time and any-place where business happens with the use of blockchain on the "distributed ledgers and smart contracts" (Bwalya 2020: 2).

Synopsis of the healthcare system in South Africa…

- South Africa is one of 54 countries in Africa, located in the Southern part of the continent (see https://visaguide.world/africa/ 2022).
- The government of the country is categorized into national, provincial and local governments.
- The country is made up of 9 provinces, with each province divided into districts.
- Each district is then sub-divided into local government municipalities.
- At every level of government there is a department dealing with healthcare services.
- The provincial government renders healthcare services through diverse facilities, based on the services they render or those required by patients.
- Healthcare facilities are structured into clinics and health centers, district hospitals, regional hospitals, tertiary or academic hospitals and central hospitals .
- The intention of this arrangement was to save costs (Steve Biko Academic Hospital 2022), since each service-level facility is bigger than the previous one, with more facilities/technologies/equipment and specialists.

Synopsis of the healthcare system in South Africa…

- One key issue that compromises quality patient care is the lack of collaboration among the healthcare facilities, and this is something which 4IR technology may redress, if implemented.
- Currently, with healthcare distributed across so many levels, patients' healthcare history is not shared.
- This means that when patients visit different healthcare facilities, clinicians are not able to access their information created at the other facilities where the patients may have been treated in the previous days.
- Collaboration is very important against the backdrop of the current explosive population growth resulting from immigration and the high birth rate (Marutha, 2020).
- "Decision-making in the healthcare industry among clinicians and managers requires an awareness of the ever-changing landscape of healthcare in order to ensure quality care and services to patients" (Cantiello, Kitsantas, Moncada & Abdul, 2016).
- Healthcare institutions need to share patients and their medical and healthcare history and avoid working in silos.

Synopsis of the healthcare system in South Africa…

- Cooperation among healthcare facilities may involve sharing many things, including systems, the laws governing their operation, and patients' information, to list only a few.
- Current technology makes it possible for healthcare facilities to collaborate on many things, including sharing cloud storage and providing virtual patient services.
- Technology has overcome the problem of distance in the collaboration among healthcare facilities to provide healthcare services (Marutha, 2020).
- The South African healthcare service is challenged with long patient waiting times, overcrowding in different facilities at different structural levels, and missing patient records.
- This may result in some patients losing their lives or experiencing complications from illnesses, and their next of kin suing healthcare facilities and the Departments of Health across the provinces.
- However, the 4IR has come up with enhanced technologies to render service delivery with ease and efficiency, to achieve high productivity and quality.

Evolution of technology in the Fourth Industrial Revolution

The Fourth Industrial Revolution was initiated or developed in Germany during the year 2013 and it started spanning the globe as a "new work model" focused on an integrated man-machine approach for production that is sustainable (Zhou, Liu and Zhou 2015).

The Fourth Industrial Revolution is about "the integration of tools already used in the past (e.g. big data, the cloud, robots, 3D printing, simulation, and more) that are now connected into a global network by transmitting digital data" (Petrillo et al., 2017).

In the Fourth Industrial Revolution cyber-physical systems (CPS) are used to integrate human and machine skills to achieve a smart factory technology to manage and control the personalized-products value chain to achieve customer satisfaction (De Felice, Petrillo & Zomparelli, 2016).

This is done with the use of digitization for man–technology inter-connection (Varghese & Tandur, 2014).

Evolution of technology in the Fourth Industrial Revolution…

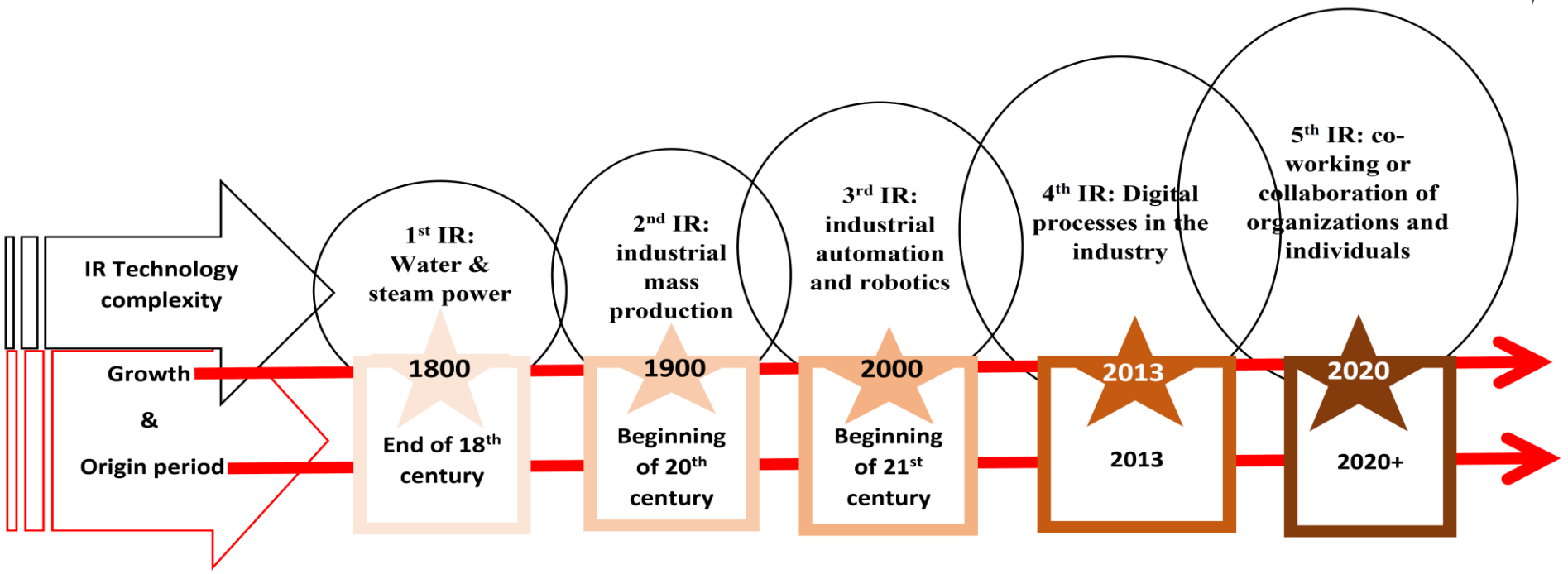
The focus of the 4IR technology was to transform the traditional modus operandi in industries from an old-fashioned approach to work to modern and integrated production technologies with new machinery, materials and inputs (Petrillo et al., 2017).

In the industrial processes, the Fourth Industrial Revolution plays an important disruptive role (Lasi, Kemper, Fettke, Feld & Hoffmann 2014), bringing about important improvements in the world economy and society (ViNT, 2014).

The 4IR is made up of smart systems with whose operation employees need to be conversant to deal with "automation, digitization and information technology" (Petrillo et al. 2017).

According to Petrillo et al. (2017), the world has been in the 5th industrial revolution since the year 2020, when people and organizations started focusing on collaboration in the application of technology introduced throughout the previous industrial revolutions, up to the 4IR.

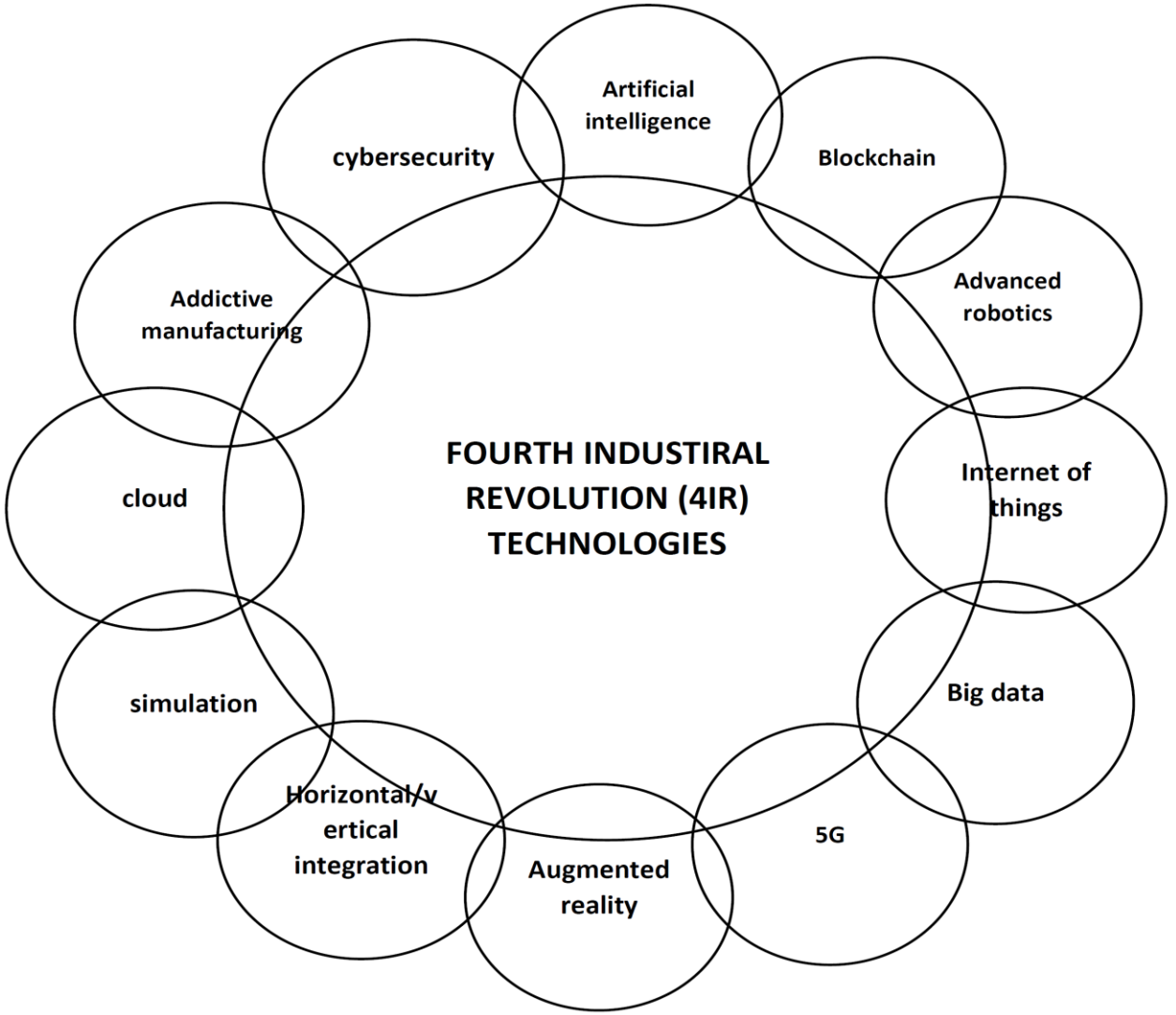
Illustration of Evolution of technology in the Fourth Industrial Revolution…



Evolution of technology in the Fourth Industrial Revolution …

- Looking at these different industrial revolutions, it is clear that changes from time to time are about improvements in technology to enable organisations across the world to improve their production processes in terms of quantity, quality and time spent in producing their products or rendering their services.
- These improvements also bring about more flexibility and increased production (Berger, 2014).
- The Fifth Industrial Revolution gives rise to many opportunities, flexibility and efficiency in industrial production (Petrillo et al., 2017).
- This striving to provide the industry with intelligent networks results in the merging of the real world and virtual world in cyber-physical systems (CPS) (Capgemini Consulting 2014; Petrillo et al., 2017).
- Cyber-physical systems come about when IT systems, and mechanical and electronic components are merged together on an online network to enable communication across different machines, imitating social network communication (Lee, Bagheri & Kao 2014; Petrillo et al., 2017).

Enabling technologies for the Fourth Industrial Revolution



- ***Big data*** is a technology used for the collection, processing, and analysis of a large amount of structured or unstructured data.

Enabling technologies for the Fourth Industrial Revolution …

- ***Cloud computing*** has to do with the use of open systems to manage large amounts of data. It renders data accessible anywhere and anytime, allowing flexible production and communication (Haiping, Yu, Qin & Yunqing. 2014; Petrillo et al., 2017).
- ***Cyber-security*** ensures the security of data during collection, capturing, processing, analysis and sharing throughout the system and network.
- ***Automated robots*** are programmed machines which are used to discharge heavy, difficult and tiring jobs.
- ***Additive manufacturing*** (also known as 3-D printing) is used for the construction of prototypes of a complete product – usually for personalized products.
- ***Augmented reality*** brings about virtual reality systems to replace current manual modus operandi.
- Horizontal and vertical integration is about the integration or interconnection of computer technologies across different organizations scattered in different locations, for the operators to share information.
- ***Simulation software*** is used for business systems and manufacturing process simulations, providing timely analyses of system inputs and outputs (Petrillo et al., 2017).

Enabling technologies for the Fourth Industrial Revolution …

- ***Artificial intelligence*** is “the simulation of human intelligence processes by machines, especially computer systems” (TechTarget 2022).
- ***5G*** stand for “5th generation mobile network”, that is designed in a manner to connect everyone and everything such as devices, machines and other objects (Qualcomm 2022).
- ***Blockchain is a*** “shared, immutable ledger that facilitates the process of recording transactions and tracking assets in a business network” (IBM, n.d).
- ***Key challenges*** for developing countries include the training of operators, scalability, collaboration with other companies, and funding.

- Nevertheless, technology holds many ***benefits*** for organisations, including but not limited to improved productivity in terms of quality and quantity, minimized waste, economic growth and consistency in production and consumption (United Nations Industrial Development Organization n.d.; Petrillo et al., 2017).

- The current age of technology is named the Fourth Industrial Revolution because most of the tasks that were expected to be discharged by human beings in the past are being done by computer-assisted machines – what is known as artificial intelligence (AI).

Artificial intelligence in the Fourth Industrial Revolution

- This includes services rendered in different industries or fields, especially in the private sector and parastatals in the field of education, engineering and finance, to list only a few.

- artificial intelligence (AI) is "any human-like behavior displayed by a machine or system".

- In AI's most basic form, computers are programmed to 'mimic' human behavior using extensive data from past examples of similar behavior. (Hewlett Packard 2022).

– "Artificial intelligence can be a very powerful tool for both large corporations generating significant data and small organizations that need to process their calls with customers more effectively. AI can streamline business processes, complete tasks faster, eliminate human error, and much more" (Hewlett Packard 2022)

- For instance, AI technologies include "automatic speech recognition, natural language processing, virtual recognition, text recognition, big data, expert systems, robotics, machine learning, deep learning, (and) cognitive intelligence" (Auraquantic, 2021).

Artificial intelligence in the Fourth Industrial Revolution…

- **Automatic speech recognition**, for example, serves to store or process the voice of the user delivered through the microphone, identifying the words of the system user, and even converting voice to text.

- **Natural language processing** deals with linguistics, mostly to gain a clear understanding of the meaning of the user in their statements delivered via voice or text, and to realise user expectations conveyed by commands, statements or even questions. It relies on understanding the sound and written data messages exchanged between the human and the computer.

- **Virtual recognition** deals with the recognition or understanding of video signals and/or images by recognising different elements in them, such as patterns and shapes (Auraquantic 2021).

- **Text recognition**, in turn, uses optical character recognition tools to understand characters in the text, particularly text in an image format, and it functions as part of visual recognition.

- **Big data** has to do with the generation of a large amount of data, normally throughout the transactions or interactions between machine and human, which eventually needs to be managed and accessed as required for business continuity. Normally data is produced in a structured and/or unstructured form.

Artificial intelligence in the Fourth Industrial Revolution…

- **Expert systems** serve to generate complete collections of human knowledge on specific topics or issues. For example, a system for playing chess collects data about opponent moves to establish the best move to win the game.

- **Robotics** involves software for a wide range of devices that often relieve humans of repetitive or dangerous tasks.

- **Machine learning** is part of artificial intelligence that leads to computer systems learning and relating to information like human beings by using algorithms to detect patterns in data provided previously, to help with predictions and the identification of new trends for the future.

- **Deep learning** is part of machine learning and was developed based on the functioning of human neural networks in the brain when processing information. It also relies on previous experience of the data processed or received to come to conclusions or achieve accuracy.

- **Cognitive intelligence** is built from a combination of all the other technologies already presented, such as visual recognition, machine learning and more (Auraquantic, 2021)..

Artificial intelligence in the Fourth Industrial Revolution…

- It is helpful to categorise artificial intelligence technologies based on specific needs.

- Auraquantic (2021) mentions the following categories of systems:
  - *(i) Systems that think like humans,*
  - *(ii) Systems that act like humans,*
  - *(iii) Systems that think rationally, and*
  - *(iv) Systems that act rationally (ideally).*

- Two main categories of artificial intelligence were also identified as:
  - (a) *Weak "or Narrow AI"* (artificial narrow intelligence/ANI), which is more focused on specific sets of issues and may not act beyond tasks without further programming, and
  - (b) *Strong or General AI* (artificial general intelligence/AGI), which goes beyond human intelligence capability in terms of reasoning and deduction (Auraquantic 2021).

- In order to achieve intellectual automation, organisations must be able to achieve applications for machine to machine, predictive analytics, machine and systems learning from recuring data traits analysis, machine and systems big data analytics, and machine and systems following business rules and policies for informed decisions in automatic activities. (Bwalya 2020:5)

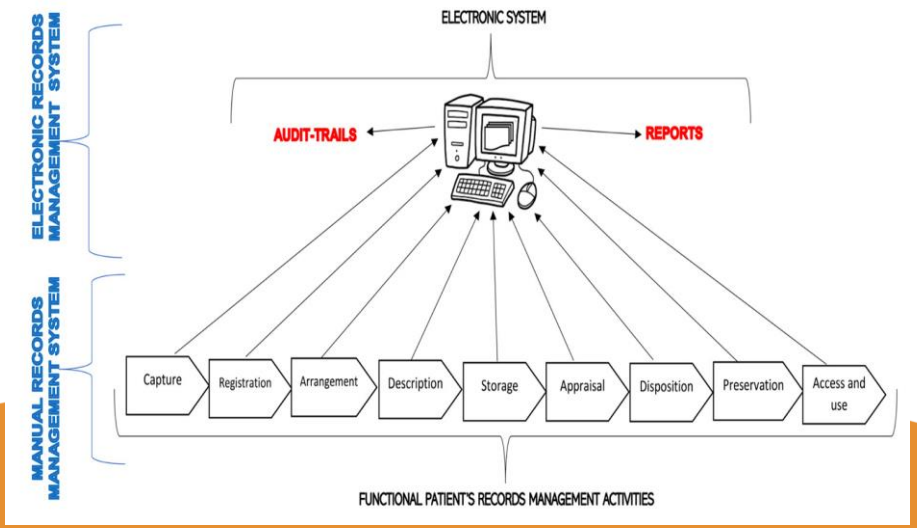
- Infusion of the International Classification of Diseases (ICD) coding into AI technology may assist the healthcare fraternity in addressing illiteracy among patients as system users.
- The ICD coding is a systematic classification of diseases from the general to specific.
- The ICD is used for many different healthcare purposes, including the "systematic recording, analysis, interpretation and comparison of mortality and morbidity data collected in different countries or regions and at different times".
- It also "ensures semantic interoperability and reusability of recorded data for the different use cases beyond mere health statistics, including decision support, resource allocation, reimbursement, guidelines and more" (WHO 2022).

Integration of the International Classification of Diseases coding to address system user illiteracy gab

- The WHO further explains that "ICD serves a broad range of uses globally and provides critical knowledge on the extent, causes and consequences of human disease and death worldwide via data that is reported and coded with the ICD".
- Healthcare institutions have been using Version 10 of the ICD for many years and Version 11 has just been introduced now as a result of the COVID-19 pandemic (WHO 2022).
- Classified illnesses may be integrated into a virtual system, making it possible for patients to choose the name of a disease relating to their problem
- With ICD coding, artificial intelligent technology system may offer more alternatives to users, such as the use of voice or text by either speaking to the system or typing text or even choosing options from dropdown lists. Smartphone or computer-related applications may be user-friendly for most citizens.

Discussion of the envisaged Fourth Industrial Revolution technology to move patients' queue to the cloud for quality healthcare in South Africa…

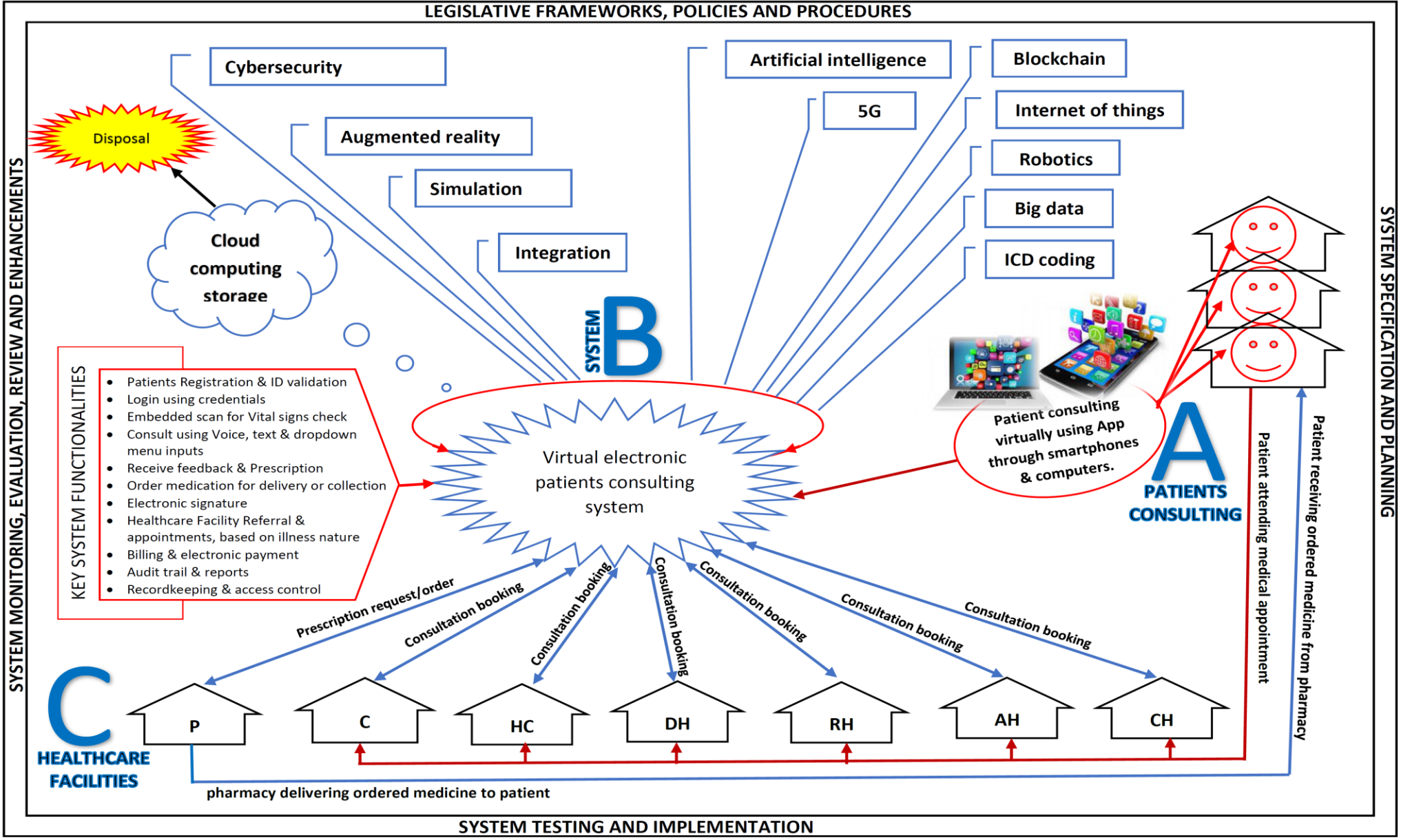
- This implies that the healthcare in implementing 4IR technology, department does not have to start a new system altogether. Instead, they can just convert their manual workflow into an electronic format.
- Organizations simply have to convert their existing manual modus operandi into electronic form, with every activity still getting discharged.
- Consideration must be given to record preservation strategies, because one key reason for a proper operational system is to keep records about all the transactions in the workflow.
- **Preservation strategies** such as trusted digital repositories (TDRs), refreshing, backup and byte replication, emulation, encapsulation, migration, normalisation/conversion, cloud computing and using application programming interfaces (APIs) and preservation file forms may have to be considered for the new system (Magama, 2017; Marutha 2021c).
- **Records of enduring value** must remain usable throughout their life cycle.



Discussion of the envisaged Fourth Industrial Revolution technology to move patients' queue to the cloud for quality healthcare in South Africa…

- In planning the system, the department may need to establish a task team comprising different professionals, including pharmacists, clinicians, ICT specialists, and records and information management professionals, to draft the envisaged system specifications.
- This will assist in closing the gaps in functionalities of the system in all spheres of operation.
- Records appraisal and retention may need to be done during the system planning to ensure that disposal is also discharged systematically on the workflow from time to time.

- Some of the patients, depending on the nature of their illness, may get full healthcare online, to their total satisfaction, although a few may end up visiting the clinicians physically at the healthcare institutions.
- The healthcare facility will be informed by the system about the patient's impending visit and their problems,
- Only the few patients who need to pay an emergency visit or go for a follow-up treatment then have to visit the healthcare institutions without first going through the virtual system.



NOTES: **P=** Pharmacy **C=** Clinic **HC=**Health Centre **DH=** District hospital **RH=** Regional hospital **AH=** Academic hospital **CH=** Central hospital

A framework for moving the patients' queue to the cloud using artificial intelligence, to ensure quality healthcare in South Africa

Concluding remarks

- Fortunately, with 4IR technology, information will start out digital and be managed through the same technology throughout its life cycle.
  - This will include storage, preservation, access and control, classification, distribution and usage, termination, and disposal.
- During this collaboration, data and information may be shared on the cloud by all stakeholders involved, across the country, so that patients may receive optimal treatment.

- It is hoped that the system will enhance the quality of patient care, because the healthcare delivered to each patient will be thoroughly planned in advance, a few days before the patient's visit.
- With proper planning, patient overcrowding and long waiting times for healthcare services may be reduced in this manner.
- Reduced crowding will also reduce the risk of patients transferring illnesses or infections to each other.
- Finally, the patients may have to spend very little time in healthcare facilities.
- To ensure the success of the system, everyone using it will need to be trained on their roles and responsibilities, with due consideration of legislation, policies, and procedures.

Thank you