Demystifying Technologies

December 2023

This brochure aims to provide a concise visual guide for SAI professionals on some technologies that are relevant for public auditors and might impact their work, while also establishing a common vocabulary.

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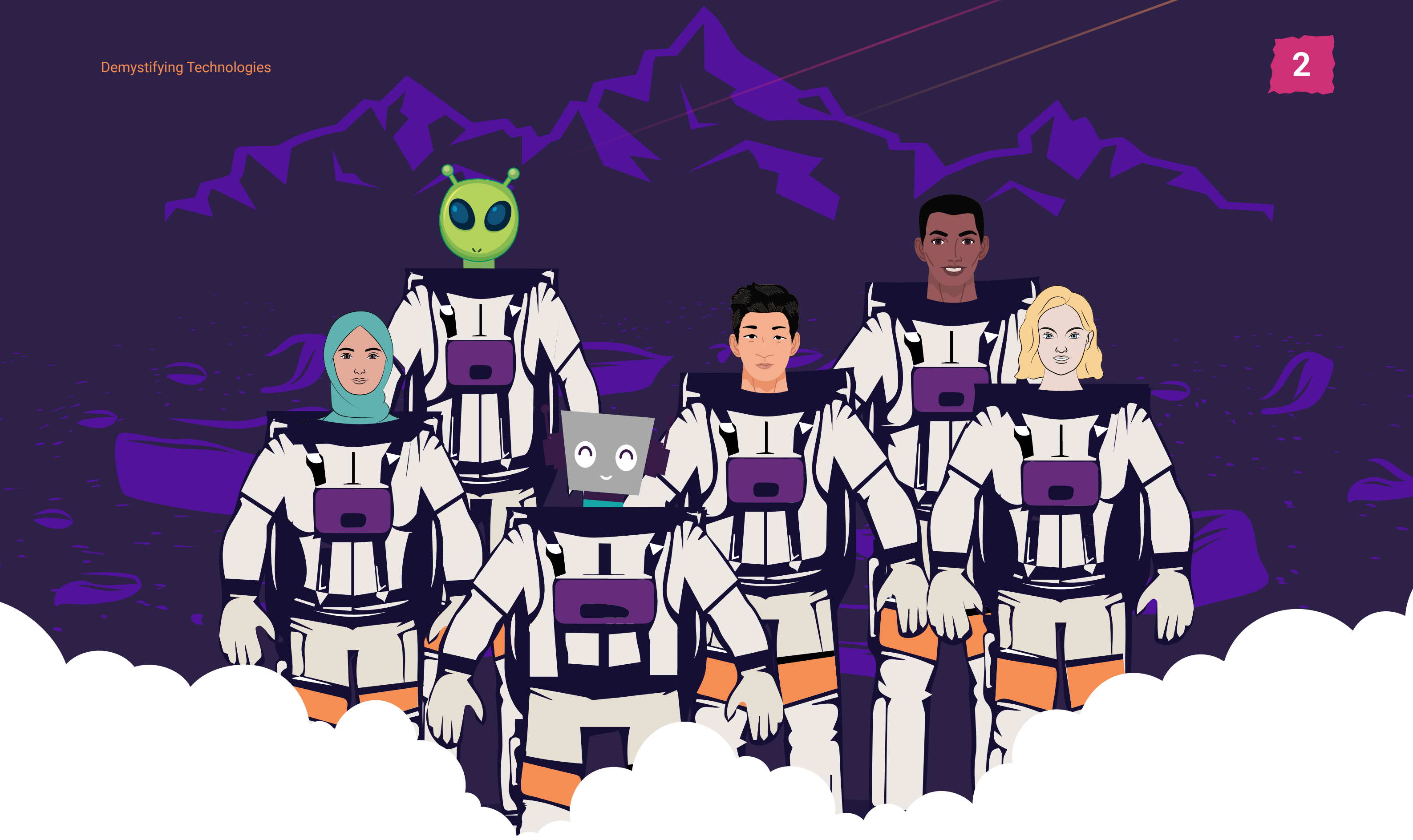


What is the purpose of this document?

This brochure aims to provide a concise visual guide for SAI professionals on some technologies that are relevant for public auditors and might impact their work, while also establishing a common vocabulary. It is primarily intended to provide a high-level overview of key technologies and concepts for non-technology professionals or non-technology Auditors.

What are traditional and emerging technologies?

Technology can be classified into two categories: traditional and emerging.

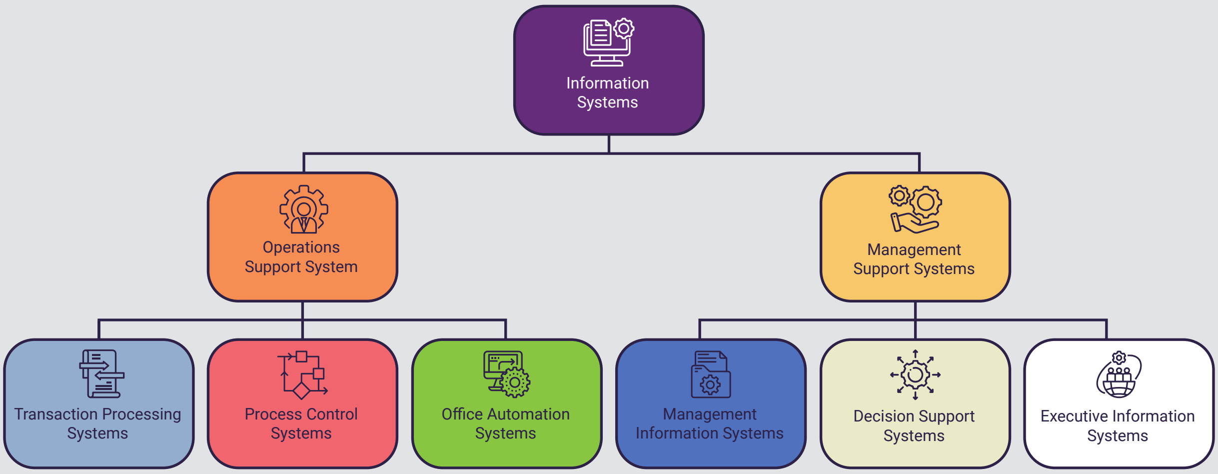
Traditional technology has been in use for a long time and is still relevant today. It has proven to be effective and reliable. Traditional technologies among others include text editing applications, office productivity software, databases, data warehouses, and business intelligence.

On the other hand, **emerging technologies** are relatively new and have recently come into existence. Some examples of emerging technologies include artificial intelligence, blockchain, robotic process automation, and cloud computing. These technologies are constantly evolving and have the potential to revolutionise the way we live and work.

What are systems and applications?

An **Information System** is a collection of interrelated components that work together to collect, process, store, and disseminate information. The purpose of an Information System is to support decision-making, coordination, control, analysis, and visualisation in an organisation. Information systems are used to support operations, knowledge work, and management in organisations.

It is common for people to use the term "information system" interchangeably with "computer system". However, it is important to note that computer systems are only a part of an Information System. An Information System includes all the components and processes that make up the system, such as people and processes.



Classification of information systems[1]

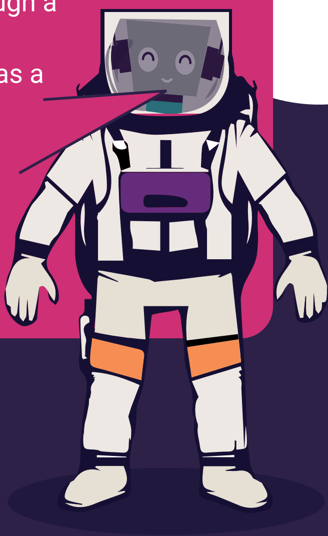
Computer systems encompass both software and hardware components that provide services such as automation, transactions, data processing, and integration.

Computer applications are software designed for use by people or devices, including knowledge tools, information access, decision support, business services, e-commerce, entertainment, media, and games.

Based on the architecture, computer applications can be:

- Desktop application, a software program that runs locally on a computer device and is launched by the operating system.
- Web application, a software application in which the client (or user interface) runs in a web browser. Unlike traditional desktop applications, web applications can only be accessed through a web browser.
- Mobile application, a software application designed to run on a mobile device such as a phone, tablet, or watch.

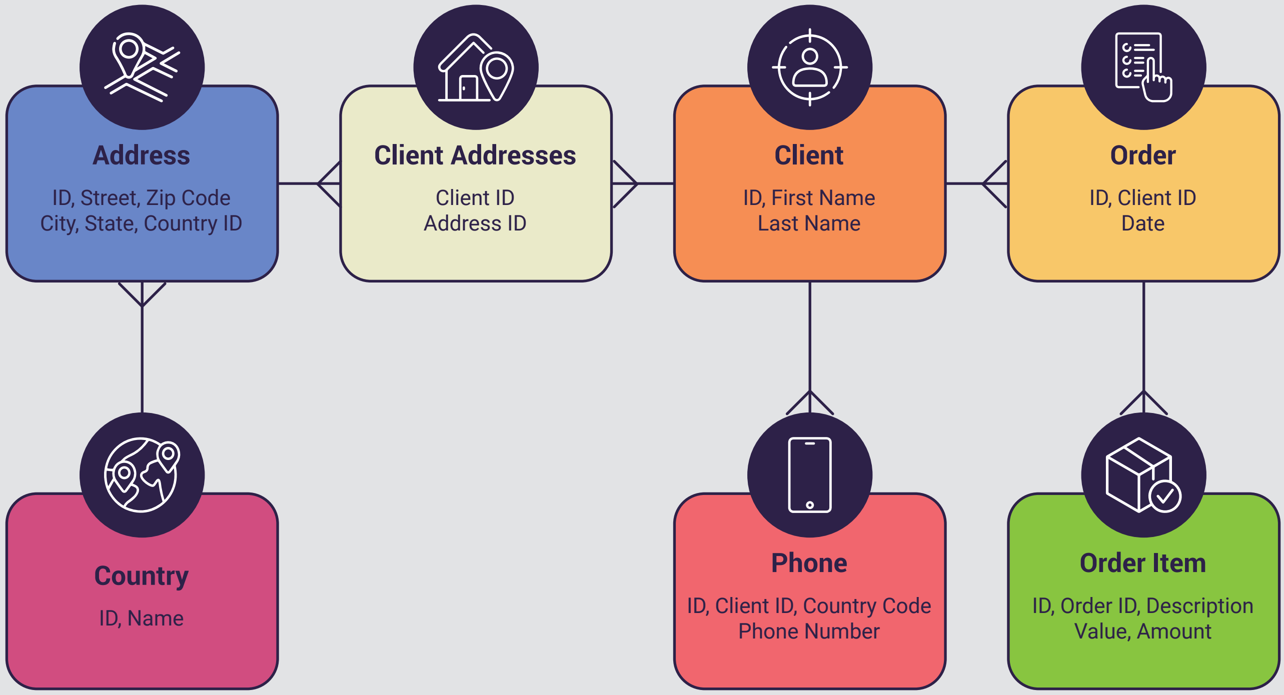
It is important to note that some applications can be delivered in two to three forms at the same time. For example, Microsoft Office is provided as a desktop application installed on a computer device, as a web application that can be accessed through a web browser, and as a mobile application running on a phone or tablet.



1 J. O'Brien, G. Marakas, Management Information Systems, 10th edition, McGraw-Hill Education – Europe, 712p, 2011.

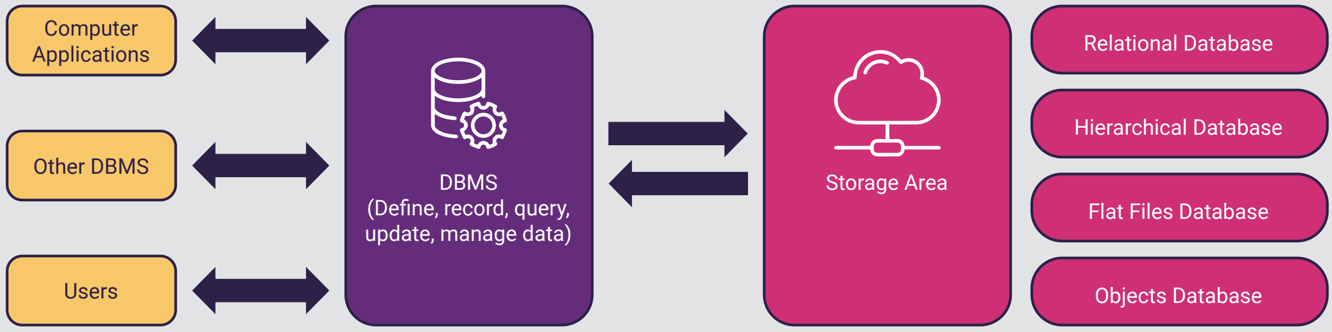
How do we collect, store, and disseminate data?

A data model is an abstract model that organises elements of data and standardises how they relate to one another and the properties of real-world entities. The common types of data models are the flat model, hierarchical model, network model, relational model, and star schema.



Relational data model

A database (DB) is an organised collection of structured information, or data, typically stored electronically in a computer system. A database is usually controlled by a **database management system (DBMS)**.

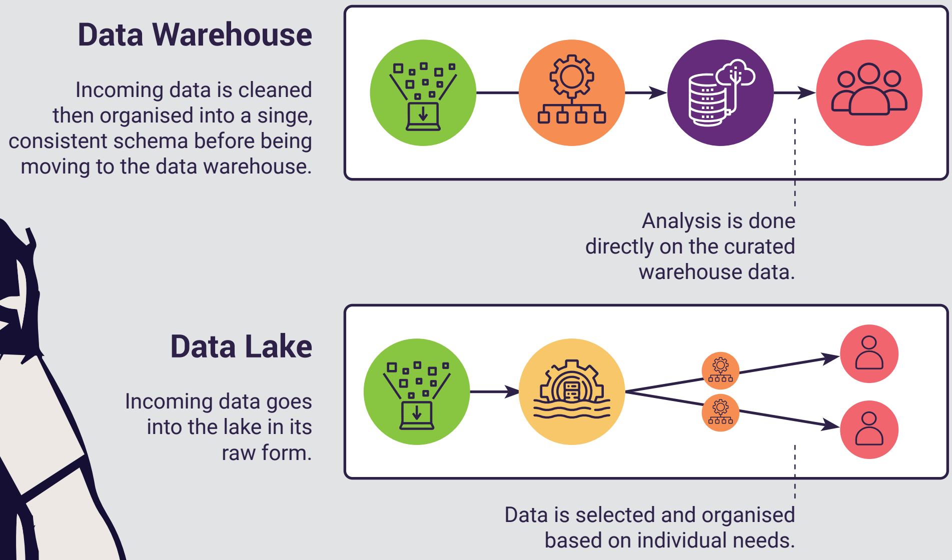


Database management system

A **data warehouse** is a centralised repository that stores all the structured data collected and used by an organisation. It is organised in a way that allows for easy querying and analysis of the data. Typically, a data warehouse is based on a specific database that is organised across star (or snowflake) schemas. The data is normally loaded into a data warehouse using Extract, Transform, and Load **(ETL)** processes.

A **data mart** is a simple form of a data warehouse that is focused on a single subject or line of business, such as sales, finance, or marketing. Given their focus, data marts draw data from fewer sources than data warehouses.

A **data lake** is a large, centralised repository designed to store raw data in its original format. It supports a wide variety of data types and formats and allows for easy access and analysis of the data.



Comparison of data warehouse and data lake [2]

Big data refers to the large, diverse sets of information that grow at ever-increasing rates. It encompasses the *volume* of information, the *velocity* or speed at which it is created and collected, and the *variety* or scope of the data points being covered (3Vs of Big Data). Common examples of big data include transaction processing systems, customer databases, documents, emails, medical records, internet clickstream logs, mobile apps and social networks.

A **data hub** is a centre of data exchange that is supported by data science, data engineering, and data warehouse technologies to interact with endpoints such as applications and algorithms. A data hub is an architecture and strategy for data management, not just a singular product. Think of it as a central data repository, with spokes that radiate to systems and customers. Therefore, a data hub architecture simply enables data sharing by connecting producers of data with consumers of data.

2 M. Fowler, DataLake, Online: https://martinfowler.com/bliki/DataLake.html [accessed: 06.12.2023]

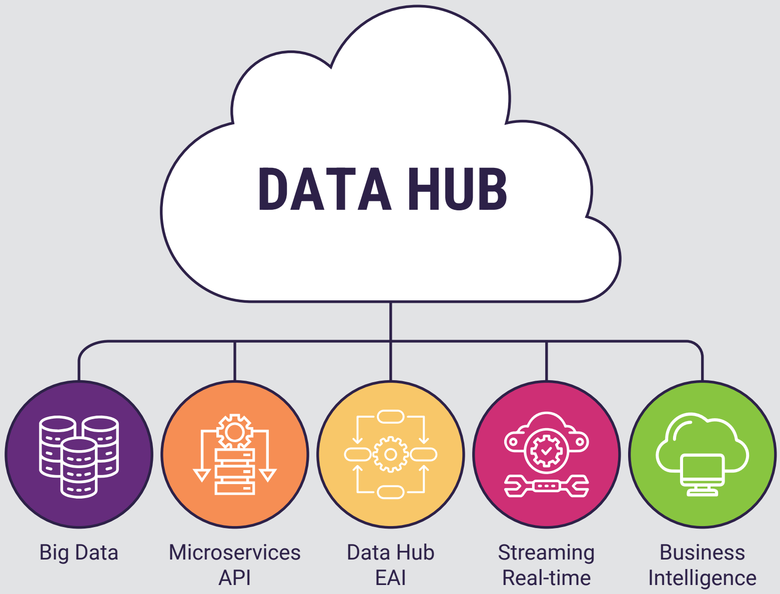


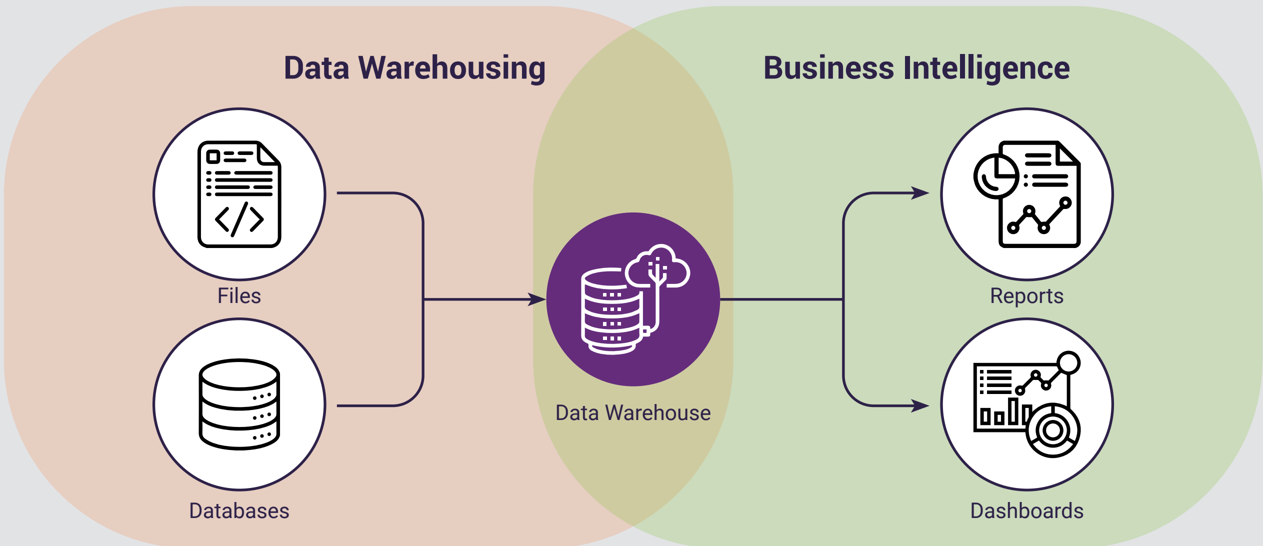
Illustration of the data hub architecture

How do we analyse data?

Data reporting involves collecting and formatting raw data to assess the ongoing performance of your organisation. Reports can answer basic questions about your business.

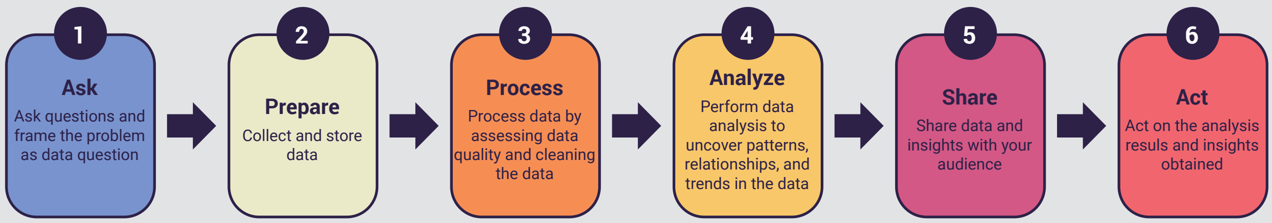
Data visualisation refers to the use of common graphics, such as charts, plots, infographics, and even animations, to represent data. These visual displays of information help to communicate complex data relationships and data-driven insights in a way that is easy to understand.

Business Intelligence refers to processes that convert raw data into meaningful reports and help to disseminate them across the organisation. This actionable knowledge helps managers make better decisions. The business intelligence can be implemented on top of the database and warehouse. This usually includes interactive dashboards, reports etc.

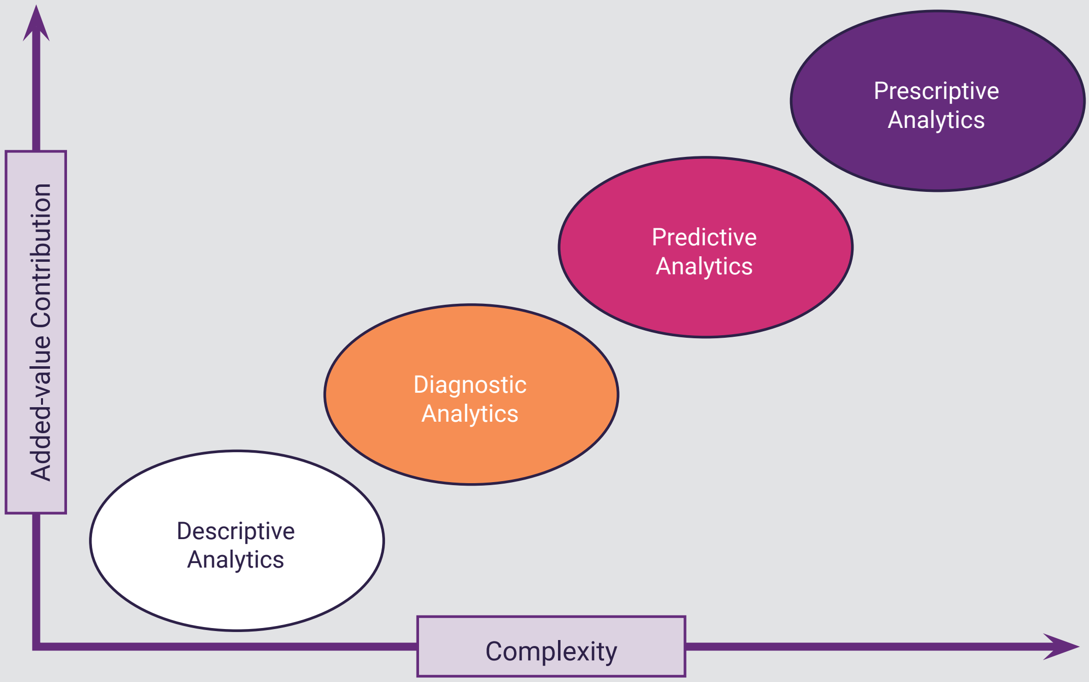


Data warehousing and business intelligence

Data analytics (DA) is the process of examining raw data to draw conclusions and insights from it. It is a broad field that involves using data and tools to make informed business decisions. The process of data analytics includes collecting and analysing data. On the other hand, data analysis is a subset of data analytics. It involves observing, transforming, cleaning, and modelling raw data to draw actionable insights that can be used to optimise a strategy or process. However, data analysis is limited to an already prepared dataset.



Data analytics process



Descriptive	Descriptive analytics looks at data statistically to tell you **what happened** in the past. This can be in the form of data visualisations like graphs, charts and reports.
Diagnostic	It explains the root cause behind the outcome of descriptive analytics. This technique is used to determine why something happened. It provides deeper analysis to answer the question **why did this happen.**
Predictive	Based on the data set, predict what could happen in the future. It helps to answer **what will happen next**.
Prescriptive	Based on the analysis and prediction, it advises how to proceed further. It describes **what do I need to do**.

Types of data analytics

What languages can we use when talking to computers?

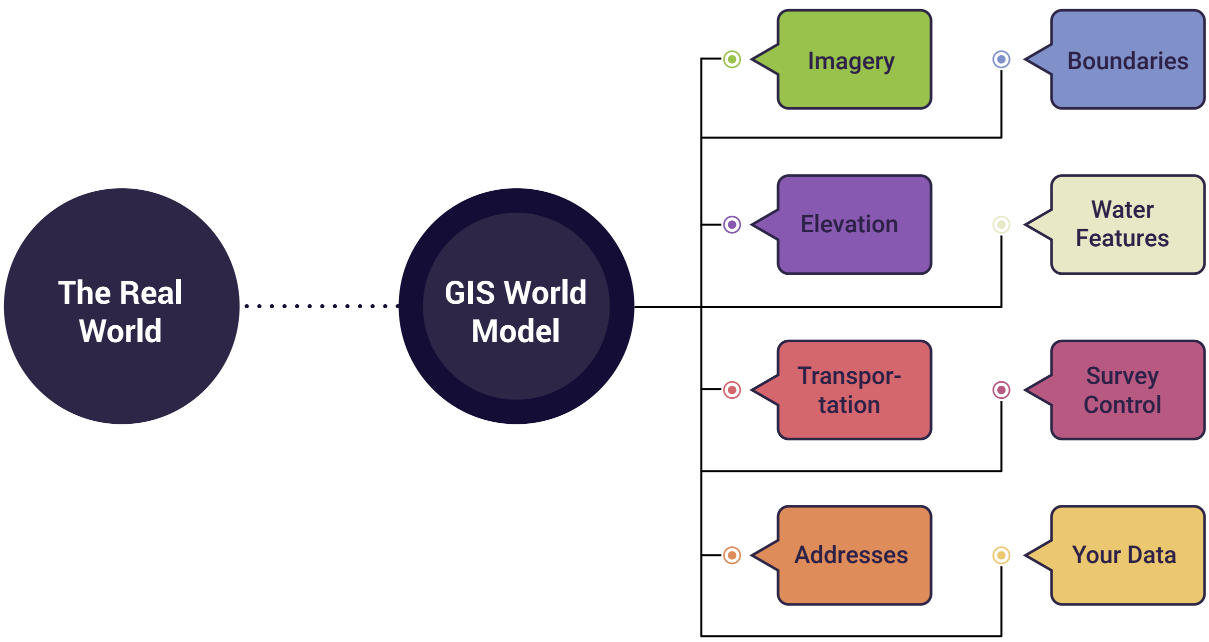
Programming languages are notations used to write computer programmes. Developers use a wide range of programming languages for various purposes. These languages are designed for different platforms and operating systems. According to some sources, there are almost 9,000 coding languages, but only a few are in use today. Some of the most popular coding languages include Python, JavaScript, and C++. You can start coding after learning just one language. Here are three common languages used for working with data.

- **Structured Query Language (SQL)** is a domain-specific language used in programming and designed for managing data held in a relational database management system.
- **R** is a language and environment for statistical computing and graphics.
- **Python** is an interpreted, object-oriented, high-level programming language with dynamic semantics.

Software development methodology refers to the process or series of processes used in software development. This includes a design phase, a development phase, and other ways of thinking about the development process. Software development methodology takes the form of a structured approach to software development. Popular software development methodologies are agile development methodology, DevOps deployment methodology, waterfall development method, and rapid application development.

What else is out there?

Geographic information systems or GIS, are computer-based tools used to store, visualise, analyse, and interpret geographic data. Geographic data (also called spatial, or geospatial data) identifies the geographic location of features.



GIS representation of the real-world model

Robotic Process Automation (RPA) is the implementation of specialised automation software to perform high-volume, labour-intensive, repeatable tasks.

Identify single routine manual process and create a business case for automation → Re-engineer and optimise process for automation → Record process with a bot or programme a bot to execute the process → Process exceptions in the automated process manually → Look for continuous improvement and new routine processes to be automated

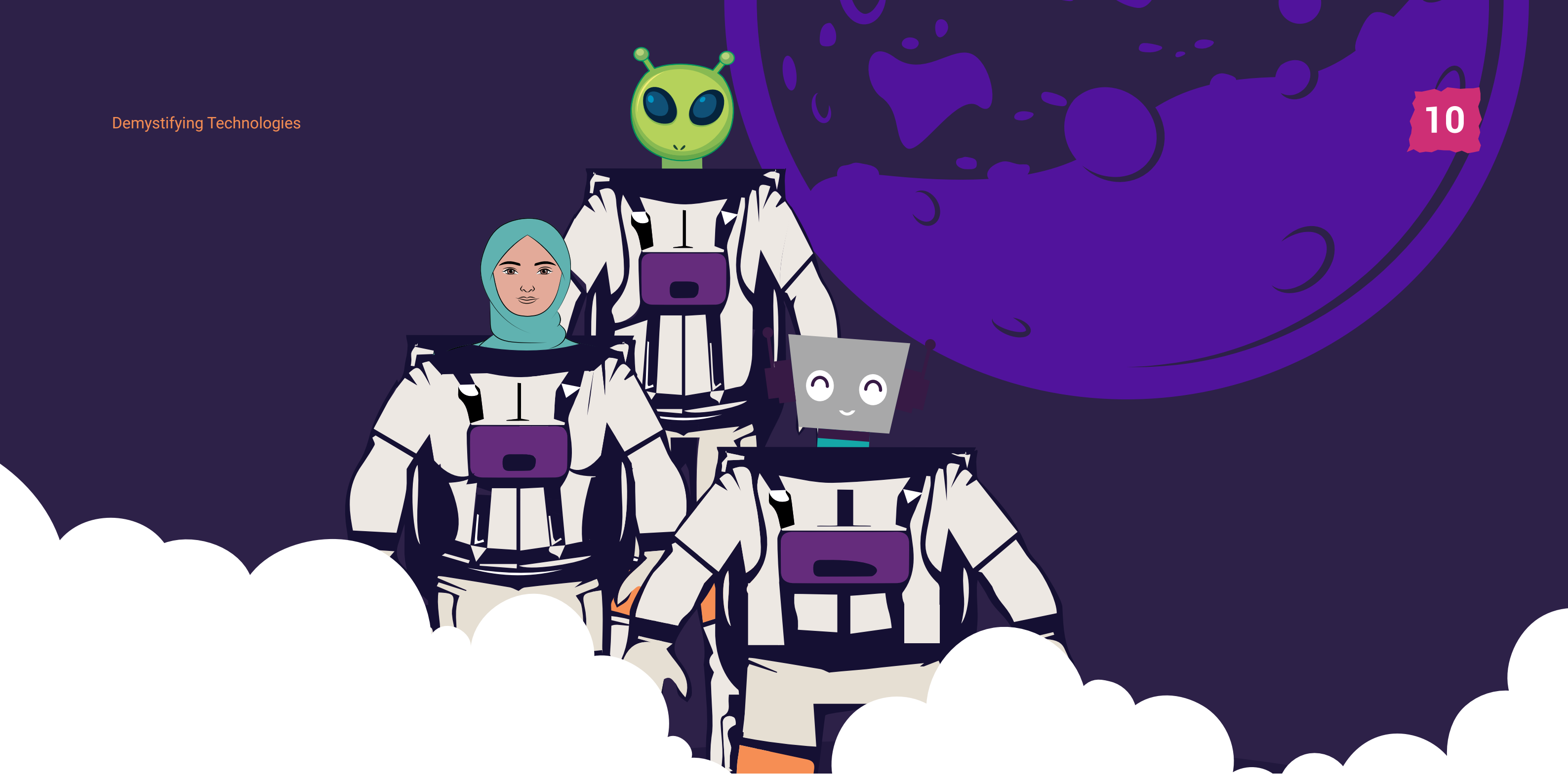
Illustration of the RPA implementation process

Cloud computing is the on-demand availability of computer system resources, especially data storage and computing power, without direct active management by the user. Large clouds often have functions distributed over multiple locations, each of which is a data centre. Most cloud computing services are divided into three broad classifications: infrastructure as a service, platform as a service, and software as a service.

	On-premises	**IaaS** *Infrastructure as a Service*	**PaaS** *Platform as a Service*	**SaaS** *Software as a Service*
Data				
Applications				
Runtime Environment				
Operating System				
Servers				
Storage				
Networking				

Red is managed by a service provider. Green is managed by the organisation.

Cloud platform classification



Cloud computing has five essential characteristics:

1. On-demand self-service
2. Broad network access
3. Resource pooling
4. Rapid elasticity
5. Measured service

These characteristics allow consumers to easily and quickly provision computing capabilities, access them over the network, pool resources, elastically provision capabilities, and control and optimise resource use.

Blockchain is a distributed ledger with growing lists of records (blocks) that are securely linked together via cryptographic hashes. Because of its distributed ledger, the transactions recorded on the blockchain are not easily tampered with.

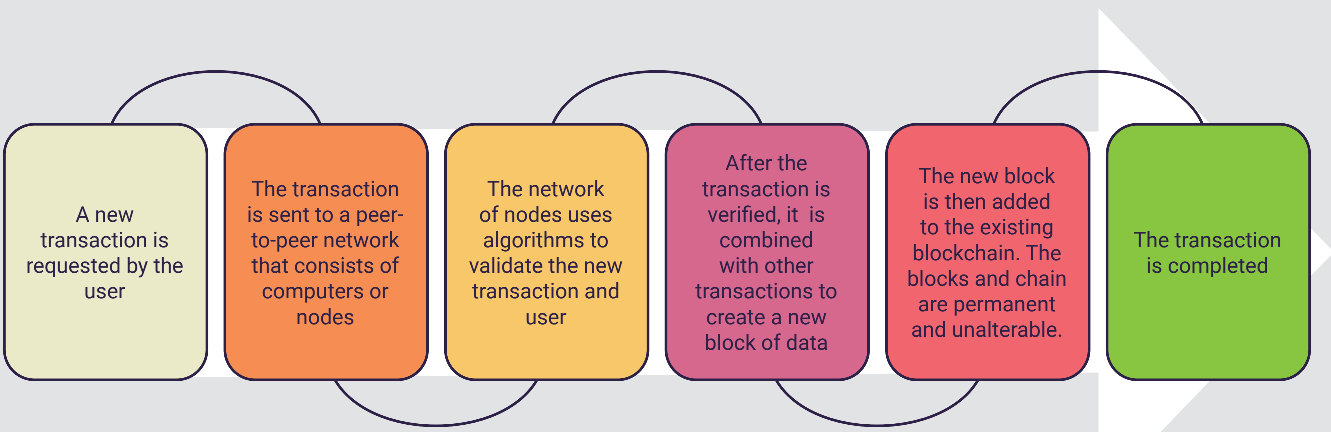


Illustration of the blockchain operating process

Artificial intelligence (AI) is the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings. The term is frequently applied to developing systems endowed with the intellectual processes characteristic of humans, such as the ability to reason, discover meaning, generalise, or learn from experience.

Machine Learning
Using sample data to train computer programs to recognise patterns based on algorithms

Neural Networks
Computer systems designed to imitate the neurons in a brain

Natural Language Processing
The ability to understand speech, as well as understand and analyse documents

Generative AI
The ability to create new content, such as text, images, audio, and video

Types of the AI

5G refers to a fifth-generation wireless network, which has the potential to greatly improve mobile communication.

1G

Analogue voice.

Voice communication only, with no data capabilities. Limited network coverage and poor call quality make it susceptible to interference.

2G

Digital voice.

Improved voice quality and better network coverage compared to 1G,. Introduced SMS messaging, data transfer rates up to 64 kbps, and international roaming. Still limited data capabilities compared to later generations.

3G

Emphasis on high-speed wireless connection.

Data transfer rates of up to 2 Mbps are possible with 3G technology. It also provides access to the internet and streaming on mobile devices. Compared to 1G and 2G, 3G offers better call quality and reduced latency. However, it's important to note that 3G was initially designed for voice and SMS, and not optimised for data transfer.

4G

Faster than 3G.

Data transfer rates up to 100 Mbps. Improved call quality and better network coverage compared to 1-3G. 4G is optimised for high-speed data transfer but still has limited availability in some areas and requires newer devices.

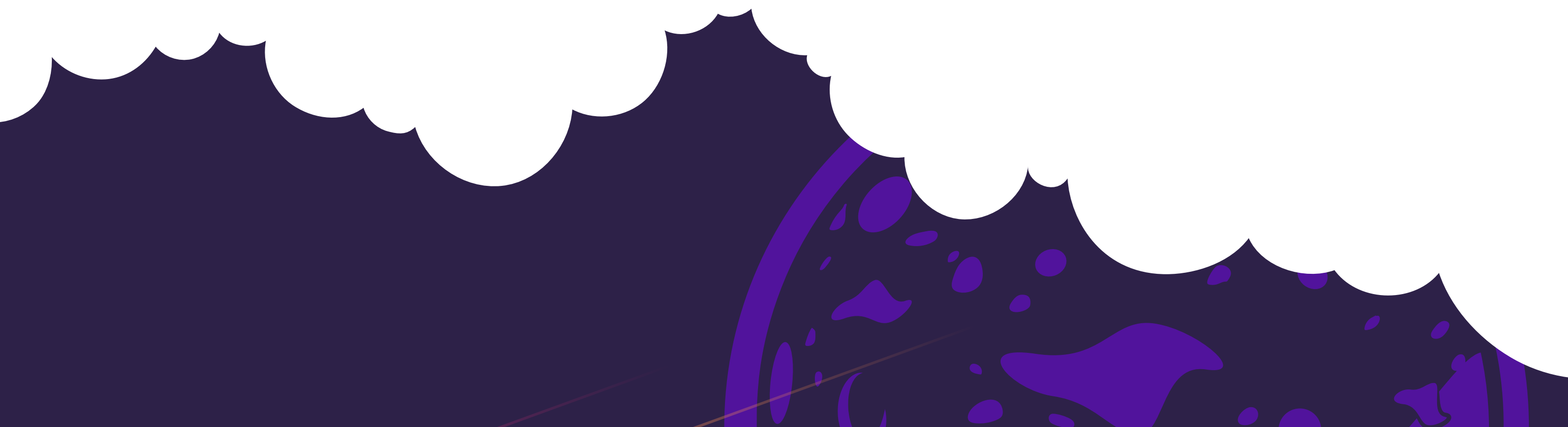
5G

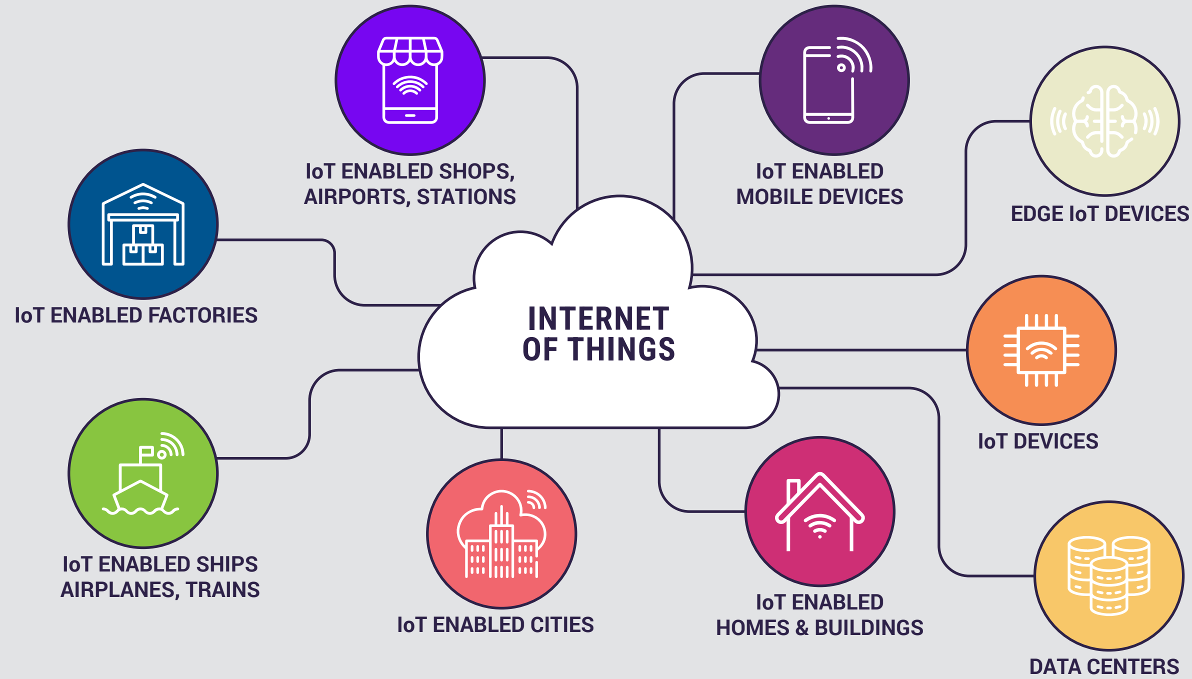
All devices will be able to connect to the Internet.

Data transfer rates of up to 20 Gbps are possible with 5G technology. Compared to all previous generations, 5G offers lower latency, better network coverage, and improved call quality. It also enables new technologies such as IoT, including autonomous vehicles and smart cities. However, 5G is not widely available in all areas and requires newer devices to be used.

Evolution of wireless networks

The **Internet of Things (IoT)** refers to a network of physical objects, also known as "things," that are equipped with sensors, software, and other technologies. These devices are designed to connect and exchange data with other devices and systems over the internet or other communication networks. The Internet of Things encompasses the fields of electronics, communication, and computer science engineering.





Applications of the IoT [3]

What does this mean for SAI auditors?

We live in a world that is constantly changing, and Supreme Audit Institutions (SAIs) need to adapt to these changes if they want to remain relevant. Technological advancements have been transforming the way we live, and this process will only be accelerated. Even those who were once sceptical about digitalisation are now investing in technology as it has become crucial for survival. With these advancements, organisations and individuals must deal with enormous volumes of data and process it faster than ever before.

Governments are investing in technology and introducing new systems. On the one hand, this allows governments to optimise their functions and provide better services for their citizens. On the other hand, it demands that SAIs acquire new skills and knowledge to cope with the new audit subjects. The Capacity Building Committee (CBC) paper "The Relevant Value-Adding Auditor" and INTOSAI P12 "The Value and Benefits of Supreme Audit Institutions - making a difference to the lives of citizens" both highlight the same point.

The role of the SAI auditor will have to **evolve and obtain new capacities** required to:

1. Use technological solutions to stay relevant and maximise impact. The use of technology by the audit team contributes to further *sustainable development* and operations, ensuring the *relevance* of the conducted audits and SAI for the benefit of citizens. Technology audits also maximise the *impact* from the use and audit of technology, as well as from delivered audit work. Finally, they help to maintain the *capacity* required for staying relevant, professional, and impactful organization.

3 Tibco, IoT Explained diagram, Online: https://www.tibco.com/reference-center/what-is-the-internet-of-things-iot [accessed: 06.12.2023]

2. Audit the government's use of technology to provide trust in the government. Technology audits provide the public with extra *confidence in government technology* systems. Additionally, technology audits contribute to *better societies* and *improved lives* through the use of technology. They also create a culture of *transparency*, *accountability*, and *compliance*, which leads to trust in government use of technology.

Technology audits are examinations of an organisation's use of technology, including its infrastructure, policies, procedures, applications, use of data, and emerging technologies that at the moment of publication of this brochure might include Artificial Intelligence, Robotic Process Automation, Blockchain and Cloud Computing. The purpose of technology audits is to ensure that technology implementations in government meet business needs without compromising security, privacy, cost, equity and inclusion, and other critical business elements. These audits also involve reviewing whether the development, implementation, and maintenance of technologies meet business goals, protect information assets, and maintain data integrity. Technology audits identify instances of deviation from criteria, which are based on the type of audit engagement, such as a performance, financial, or compliance audit.

Technology Audits vary based on the types of audits within which they are performed. For example:

- In the context of a **financial audit**, an example Technology Audit could be an examination of general controls that ensure the operation of the information systems that underlie an entity's financial processes, as depicted through its financial statements.
- In the context of a **performance audit**, an example Technology Audit could be a determination of the extent to which agency adoption of new technology has produced measurable government-wide benefits and cost savings.
- In the context of a **compliance audit**, an example Technology Audit could be a compliance of the developed information system and/or information system development process with the international standards and practices.