Business Information Systems I

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Abstract

This course offers a methodology to align IT design decisions with business goals. It introduces the concept of IT architecture, classifies key IT design choices, and examines how these choices impact IT architecture from both a software and infrastructure perspective. The course explores IT architecture within the manufacturing, utilities, and financial services sectors, focusing on both internal and external organizational processes along the industry value chain (e-business). It also equips students with the tools to analyze organizational requirements, with a particular emphasis on executive information systems, including the use of Key Performance Indicators.

Building on the concept of IT architecture, the course outlines a functional map of Enterprise Resource Planning systems, distinguishing between core and extended functionalities. It traces the evolution of information systems over time and highlights how ERPs have emerged through an ongoing process of functional integration. The course begins with a review of organizational theory from an information perspective, providing a framework to understand the organizational changes driven by ERP implementations. It then delves into the core functional areas of ERP systems, such as accounting and finance, operations, and management and control.

Contents

CHAPTER 1

Information processing

1.1 Introduction

Definition (*Technology*)**.** A technology represents a process that a given organization can perform, together with all the resources needed to perform the process.

Definition (*Techincal system*)**.** A technical system represents a set of machines supporting a given technology.

Definition (*Information system*)**.** An information system is a set of coordinated processes producing an information output and executing information processing activities.

Definition (*Information Technology architecture*)**.** An Information Technology (IT) architecture is a technical system supporting a given information system.

For a long time, there has been an ongoing debate about how technical innovation influences organizations. A well-established set of beliefs links technological advancements to organizational change, shaping how companies adapt and evolve:

1. *Efficiency over effectiveness*: technological innovation primarily enhances efficiency rather than improving overall effectiveness. It streamlines processes but doesn't necessarily guarantee better decision-making or outcomes.

2. *Economies of scale*: as technology advances, businesses can scale operations more efficiently, reducing costs per unit as production increases.

3. *Larger optimal size*: the minimum viable size of an organization tends to grow with technological progress, as larger entities can better leverage new systems.

4. *Increased specialization*: automation and sophisticated systems often lead to a workforce that is more specialized, with employees focusing on narrower, highly technical roles.

5. *Tayloristic perspective*: the traditional view, inspired by Taylorism, assumes that an optimal organizational structure exists.

6. *Limited focus on group work*: early studies largely ignored the impact of technology on teamwork and collaboration, focusing instead on individual efficiency.

7. *Greater bureaucracy and formalization*: as technical systems evolve, so do organizational rules, procedures, and levels of bureaucracy, making work more structured but also more rigid.

8. *More complex management*: with increased technology comes greater managerial complexity, requiring leaders to navigate intricate systems, regulations, and workflows.

1.1.1 Information processing

Emerging in the 1970s, the information processing perspective transformed how organizations viewed technology. As IT became widespread within businesses, it led to a fundamental shift in traditional beliefs about the impact of technical innovation. A radical shift in management principles, as technology was no longer just a tool for efficiency but a driver of decision-making and strategy. When information systems were well-integrated, they improved decision-making, coordination, and adaptability. However, poor implementation or information overload could lead to inefficiencies, miscommunication, and bureaucratic bottlenecks. As organizations embraced IT and information processing became central to management, three major theoretical approaches emerged: decision theory, transaction cost economics, and agency theory.

1.2 Decision theory

Galbraith (1973-1977) introduced the decision theory which is based on the idea that organizations function as open systems, constantly interacting with their environment. A key challenge they face is uncertainty, which defines the conditions in which they operate and reflects their ability to predict market demand. Several factors contribute to uncertainty, including market dynamism, the number of suppliers, variations in market requirements, and the level of innovation.

1.2.1 Bounded rationality

Bounded rationality refers to the cognitive limitations of individuals in processing information. Since no single person can handle all the necessary data for decision-making, cooperation becomes essential. Through cooperation, individuals and organizational units develop specialized roles, which, in turn, create interdependencies in information flow. To function effectively, organizations must manage these interdependencies, as coordination is crucial for overcoming individual cognitive constraints. This need for coordination is the fundamental reason organizations exist. IT plays a vital role in this process, serving as a tool for organizing and managing information beyond individual capabilities.

1.2.2 Hierarchy

Hierarchy is a coordination mechanism based on command and control, where decision-making authority is centralized rather than delegated. It forms the foundation of many companies and institutions, ensuring the structured flow of information within an organization. To try to reduce uncertainty effectively, hierarchies rely on two main types of information systems:

- *Vertical information systems*: manage the flow of information along hierarchical lines, reinforcing structured decision-making. However, they have limitations when dealing with environmental uncertainty. As uncertainty increases, exceptions arise, creating the need for more planning and control mechanisms. These exceptions lead to additional information processing demands, often requiring information to flow upward toward higher hierarchical levels for resolution.

- *Horizontal information systems*: facilitate direct communication between units at the same hierarchical level. These systems improve coordination by enabling decision-making at lower levels, reducing the reliance on top-down control. With a higher degree of delegation, horizontal systems enhance flexibility and responsiveness in dynamic environments.

1.2.3 Summary

Organizations can address environmental uncertainty in two main ways:

1. They can increase their information processing capacity by implementing vertical and horizontal information systems.

2. They can increase slack resources, such as maintaining warehouses or creating independent organizational units.

However, it assumes that hierarchies are the only coordination mechanism, overlooking market-based coordination as a viable alternative when hierarchies become inefficient. Additionally, it considers environmental uncertainty as the primary challenge, ignoring behavioral uncertainty caused by opportunistic individual behavior, which can also undermine hierarchical effectiveness.

1.3 Transaction cost economics

Williamson (1975) introduced the concept of transaction cost economics, which examines the costs associated with coordinating economic exchanges. A transaction occurs when a customer receives a product or service from a supplier in exchange for payment. Transactions represent one of the oldest and most fundamental ways for individuals and organizations to cooperate, as they enable objectives that go beyond individual or organizational rationality.

1.3.1 Market systems

A key function of transactions is to reduce behavioral uncertainty by mitigating opportunism. In market systems, individuals produce goods and services for themselves and maximize the benefits of their own efficiency. However, achieving coordination often requires executing transactions, which come with an associated transaction cost.

The total cost of a coordination mechanism is the sum of production costs and transaction costs. Market systems tend to have low production costs because individuals and firms operate efficiently. However, transaction costs remain low only under conditions of perfect competition.

Transaction An economic transaction typically unfolds in four key phases:

1. *Matchmaking*: this stage involves identifying potential suppliers based on initial requirements. The outcome is a list of candidates that meet the specified criteria.

2. *Negotiation*: from the set of potential suppliers, one is selected through discussions that refine the requirements. The result is a formal agreement, often documented in a contract with defined Service-Level Agreement (SLA).

3. *Execution*: the transaction is carried out according to the contract. The expected output includes the delivery of the product or service, along with any deviations or exceptions from the agreed SLA.

4. *Post settlement*: if exceptions or issues arise, this phase involves managing them through established procedures to resolve disputes, enforce agreements, or make necessary adjustments.

Price system The price system serves as the market's primary coordination mechanism, conveying crucial information about supply and demand. Prices are influenced not only by production costs but also by market dynamics. When the market functions efficiently, prices remain close to production costs and serve as a reliable indicator of product quality.

Perfect market Several factors can disrupt market efficiency:

1. *Shortages*: when supply fails to meet demand.

2. *Complexity*: when goods or services are too intricate for standard pricing.

3. *Customization*: when products require personalization, limiting standardization.

4. *Uncertainty and information asymmetry*: when buyers and sellers have unequal access to relevant information.

5. *Negotiation power imbalance*: when either buyers or sellers dominate price-setting.

6. *Transaction frequency*: when repeated transactions influence cost-efficiency.

When markets fail, businesses often resort to hierarchical coordination rather than relying on external suppliers. The decision between market-based transactions and hierarchical structures is primarily driven by cost considerations. IT acts as an organizational tool that reduces coordination costs. By improving information flow and transaction efficiency, IT strengthens market systems, leading to smaller, more numerous companies and reducing reliance on hierarchical structures.

1.3.2 Summary

Viewing markets and hierarchies as mutually exclusive coordination mechanisms overlooks hybrid models. Traditional theories ignore behavioral uncertainty within organizations.

1.4 Agency theory

Agency theory challenges the traditional view that markets and hierarchies are entirely separate coordination mechanisms. Instead, it suggests a continuum between the two, recognizing that market-like coordination mechanisms exist even within organizations. By applying these mechanisms effectively, organizations can improve efficiency.

Organizations function as networks of contracts between individuals. Internal coordination is not solely based on command and control but also involves transactional exchanges. Just like external markets, organizations incur transaction costs, referred to as agency costs. Agency costs arise whenever decision-making responsibilities are delegated to lower levels of the hierarchy.

1.4.1 Agency cost

Delegation within an organization mirrors market transactions, creating an internal market with its own coordination expenses, known as agency costs. These costs include:

- *Control costs*: expenses related to monitoring and ensuring compliance.
- *Warranty costs*: costs associated with guaranteeing performance.
- *Residual loss*: inefficiencies that arise despite control measures.

1.4.2 Hierarchy

In a perfectly competitive market, customers have no direct control over their suppliers (transactions are based entirely on trust and delegation). However, in imperfect markets, customers (or suppliers) may have some level of control over their counterparts. This control can take the form of visibility into production processes or even hierarchical oversight, where suppliers operate under certain constraints imposed by their customers. As a result, the distinction between internal markets and hierarchical coordination is not always perfect.

1.4.3 Summary

The main limitations of agency theory are:

1. Hierarchical mechanisms exist within market transactions, blurring the boundaries between markets and organizations.
2. Agency theory overlooks task-related uncertainty, which affects the efficiency of coordination mechanisms.
3. The role of technology is task-dependent: technical innovation influences organizational structures and can shift the cost balance between market-based and hierarchical coordination.

To address these gaps, information systems theory explores how technology can enhance coordination and reshape organizational structures.

1.5 Enterprise Resource Planning

Enterprise Resource Planning (ERP) systems often feature vertical solutions specifically designed to meet the needs of different industries. These solutions are tailored to be highly specialized. However, we can make a broader distinction between manufacturing and service companies:

- Manufacturing companies produce tangible products.

- Service companies provide intangible products.

Companies typically rely on three main IT functional portfolios within their ERP systems: administrative, operational, and executive. These portfolios, while initially developed separately, are now integrated within modern ERP systems, forming the core functionalities of these systems.

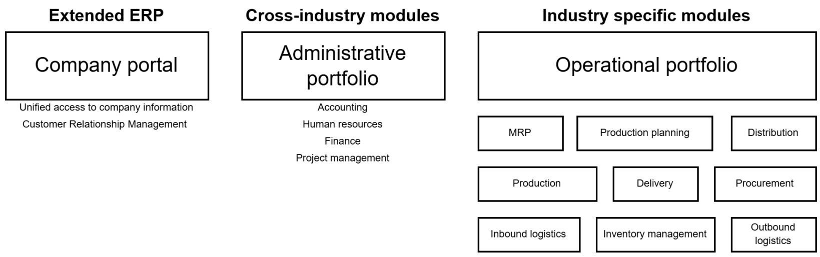


Figure 1.1: ERP architecture

CHAPTER 2

Administrative portfolio

2.1 Introduction

The administrative portfolio focuses on automating organizational activities that are often administrative and bureaucratic in nature, including: accounting and tax management, finance, human resources, project management (from an accounting perspective), and governmental procedures.

This portfolio is largely industry-agnostic, although it is country-specific. It represents an early stage of automation, alongside office automation, by streamlining tasks that involve number crunching. It typically involves minimal decision-making, as its processes are procedural and repetitive. Although traditionally viewed as stand-alone, it often links to other processes. Despite its simplicity in design, the administrative portfolio can be functionally complex.

2.2 Activity Based Costing

The complete integration of operational, executive, and administrative portfolios within an ERP system facilitates a real-time reconciliation of budgets, resource consumption, operational progress, and cash flows. This seamless integration is made possible through the implementation of Activity Based Costing (ABC).

ABC links operations directly to their associated costs, enabling organizations to better understand the financial impact of specific activities. By associating operations with an internal pricing system, businesses can allocate resources more effectively and gain deeper insights into cost drivers. This approach allows for a dual perspective on progress: it can be evaluated from both a project management standpoint and a financial standpoint, focusing on cost efficiency.

CHAPTER 3

Operational portfolio

3.1 Manufacturing company

Definition (*Information intensity*)**.** Information intensity refers to the amount and complexity of information required in an organization's processes.

Generally, service industries require higher information intensity than manufacturing. IT Intensity measures how well IT systems meet an organization's information processing needs. However, IT intensity can sometimes be greater in manufacturing than in services, depending on automation and digital integration.

Definition (*Management inclination*)**.** Management inclination reflects how much a company's leadership views IT as a strategic asset.

This varies based on factors like digital literacy, organizational culture, and company history. Historically, manufacturing companies have adopted IT earlier, while service industries experienced a lag of around ten years.

Drivers Several factors determine how IT intensive a company or industry can be:

1. *Structure of information processes*: the more structured and rule-based an activity is, the easier it is to automate using IT.
2. *Data volume*: the sheer amount of information that needs to be processed influences IT requirements.
3. *Operational frequency*: tasks that are repeated frequently benefit more from IT automation.
4. *Computational complexity*: simpler processes are easier to digitize and automate efficiently.

3.1.1 Manufacturing value chain

Porter's value chain concept highlights how IT supports various business activities to create competitive advantages.

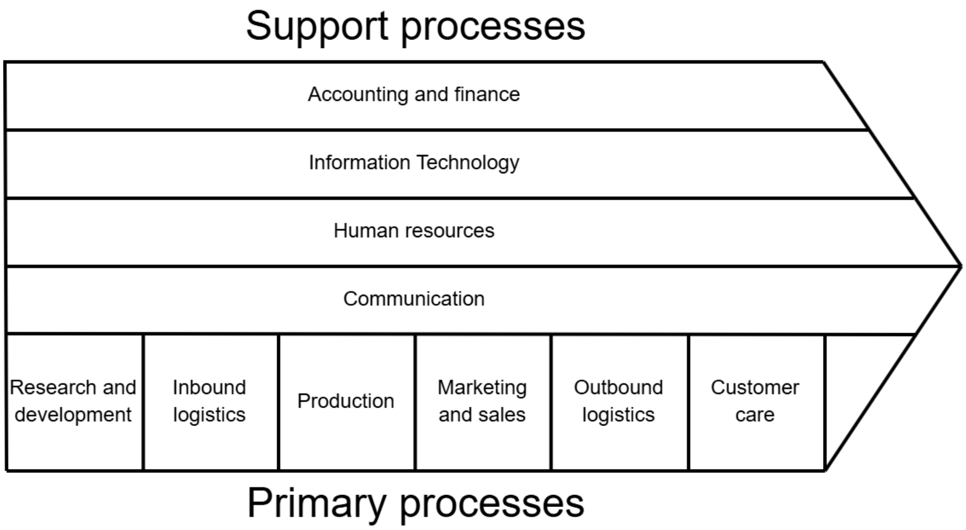


Figure 3.1: Porter value chain

Activity cycles Manufacturing involves continuous, iterative cycles that ensure efficiency and product quality. These cycles include:

1. *Development cycle*: focuses on designing and industrializing both products and production processes.

2. *Logistics cycle*: manages customer orders through:

    - *Procurement*: acquiring and handling materials, including reception, warehousing, and distribution to production plants.
    - *Production*: the physical transformation of raw materials into finished goods.
    - *Sales and distribution*: managing orders, external logistics, and post-sale services such as maintenance and customer support.

3.1.2 Inter-functional information processes

Inter-functional information processes play a key role in managing various aspects of production and operations within a company:

1. *Order management process*: it manages the information regarding orders from order check in to post-sale services.

2. *Materials management process*: it manages the information regarding materials from outgoing orders towards suppliers to usage within transformation processes.

3. *Operations management process*: it manages the information regarding operations from materials dispatching to production plants to product delivery.

These processes are interconnected across different products and divisions within the organization, making the information systems closely tied to the organizational structure. All production processes rely on the exchange of information across different functions. The use of inter-functional information extends beyond production and operations into planning and control processes. It also plays a vital role in administrative tasks.

3.1.3 Production

Companies may produce two types of goods:

- *Standard production*: products have a finite set of predetermined features that can be changed to accommodate customer preferences. In this case, companies produce according to a sales plan, before actual orders are received.
- *Custom production*: products are designed according to customer requirements and then produced on demand.

While custom and standard production represent opposite ends of the production spectrum, there is a continuum between the two. Custom production is often seen in complex products, while standard production is associated with simpler goods. IT supports all production types, although its functionalities vary depending on the degree of customization or standardization in the production process.

Product structure The product structure defines the hierarchical arrangement of components that make up a finished product. It ranges from individual components to larger product parts, outlining the relationships and dependencies between them.

3.1.4 Information taxonomy

Operational databases are organized to store various types of information that support the flow of activities within an organization. These can be categorized into three primary types:

- *Transaction information*: describes the flow of operational activities, focusing on exchanges between different organizational units and external parties. It is the largest in terms of volumes.
- *Operation information*: details the objectives and expected results of operational activities.
- *Catalog information*: basic, static knowledge that exists independently of the flow of production activities. It is quite complex and requires continuous updates and maintenance. This information plays a key role in organizational learning.

Operations planning information is a key link between the operational and the executive portfolios. Therefore, the level of detail of operational information is a driver of the efficiency of coordination inside an organization. Operational information has intrinsic value as an organizational asset. Its usefulness extends beyond internal operations, as it can sometimes be monetized or sold.

3.1.5 Information Technology integration

Initially, IT functionalities were developed independently for each organizational function, without a comprehensive view of processes. The focus was on automating existing activities rather than supporting or re-engineering them to improve performance. Each function operated with separate data, and objectives were often misaligned, resulting in inefficiencies.

The traditional approach involved information being created at the start of a cycle and used later. However, to truly optimize organizational performance, a more proactive approach is needed. This involves using information at the executive level and integrating the various functions within an organization to create a unified view that enhances decision-making and operations. There are two key approaches to IT integration:

- *Horizontal integration*: this refers to the integration of systems along the operating processes of an organization, specifically those that align with Porter's primary processes. This is done by the Computer Integrated Manufacturing (CIM), which is a system that supports the integration of manufacturing processes.
- *Vertical integration*: this focuses on connecting the operational portfolio with the executive portfolio. This is done by the Material Requirements Planning (MRP), which ensures materials are available for production at the right time, helping optimize the production process and minimize waste.

Computer Integrated Manufacturing CIM integrates various manufacturing processes, with the main objective of achieving an optimal scheduling and production resource management, which results in production efficiency. The main functionalities are: activities, workforce, plant, materials and quality management.

Materials Requirements Planning MRP is a production planning and inventory control system designed to manage manufacturing processes and ensure the availability of materials for production. It emerged in the 1970s and 1980s with the aim of achieving flexibility and economies of scale through optimal planning. This is achieved with concurrent engineering (design and produce in parallel) and inside-out production processes (streamline production processes). MRP helps organizations achieve greater effectiveness by allowing them to respond more quickly to market demands while simultaneously benefiting from scale economies.

3.2 Service company

In service industries, IT plays a dual role: it's both a tool for creating services and a channel for delivering them. Unlike in manufacturing, services are typically produced at the same time they are delivered to the customer.

3.2.1 Service value chain

The concept of the value chain, originally introduced by Porter, can also be applied to service businesses. However, in services, the boundaries between production and delivery are often blurred.

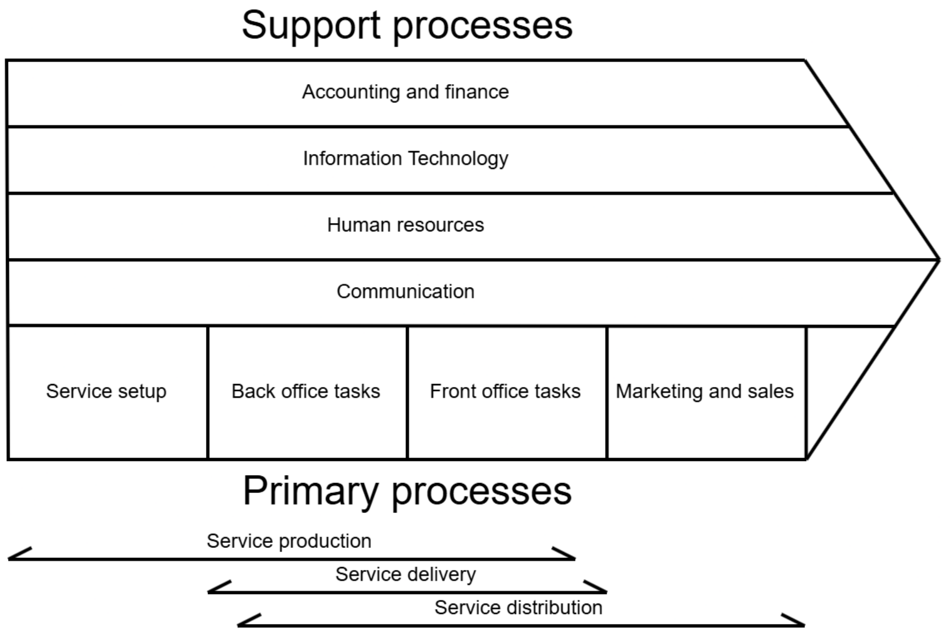


Figure 3.2: Service value chain

Definition (*Service set-up*)**.** Service set-up is the set of tasks required to prepare the company's production capacity.

Definition (*Back-office tasks*)**.** Back-office tasks are are production tasks carried out without the presence of the customer.

Definition (*Front-office tasks*)**.** Front-office tasks are tasks involve direct interaction with the customer and are also triggered by a specific customer request.

Definition (*Marketing and sales*)**.** Marketing and sales are activities focused on promoting the company's services, attracting potential clients, and closing service contracts with new customers.

3.2.2 Inter-functional information processes

Inter-functional information processes are essential for coordinating production and operations across different functions within a company. In service companies, two key processes stand out:

- *Order management*: this process handles all the information related to customer orders In service companies, order management plays a role similar to operations management in manufacturing firms.

- *Knowledge management*: this process deals with collecting and organizing new customer-related information acquired during service production and delivery. The goal is to transform this raw, often unstructured, data into structured knowledge that can be used to improve future services and enhance customer satisfaction. In the context of service companies, knowledge management effectively replaces traditional materials management.

Customizing services to individual customer needs is a key driver of customer satisfaction. To do this well, companies need detailed knowledge about each customer. This knowledge is typically gathered informally during interactions with customers. However, this information is often unstructured and difficult to act on directly. Knowledge management helps by converting these scattered insights into organized, actionable knowledge and linking them to specific service processes.

Knowledge management is not a one-time activity; it's a continuous learning cycle. As customer needs evolve and external environments change, companies must adapt their processes accordingly.

The knowledge management process involves three main stages:

1. Extracting customer knowledge from employees (often called knowledge workers) based on their direct service experiences.
2. Transforming that knowledge into structured, usable information, which is then stored in the company's systems.
3. Designing or updating procedures that use this information to enable greater service personalization and efficiency.

This process is far more complex than traditional planning systems like MRP, because it requires insight, interpretation, and innovation. That's why knowledge management is considered a hybrid of production planning and service innovation.

3.2.3 Information Technology integration

As in manufacturing, IT integration in service companies follows two main approaches:

- *Horizontal integration*: enabled by Personal Computers (PC).
- *Vertical integration*: enabled by client-server architectures.

Personal Computer PCs began to gain traction in the 1980s, marking a major shift in how work was done. Unlike manufacturing environments where robots automate production, service companies rely heavily on knowledge workers (individuals who create, process, and apply information to deliver services). PC aren't the equivalent of robots in service production. While robots automate tasks, studies on office work have shown that PCs serve more as support tools rather than automation technologies. This distinction sparked a wave of research into non-hierarchical, decentralized organizations, where individuals use PCs to make independent decisions and contribute more flexibly. PCs introduced: flexibility, variety and usability.

Client-server architectures Mainframes and data centers are powerful systems for managing and storing centralized data. But on their own, they don't empower individual users. Client-server architectures bridged this gap by connecting personal computers to centralized systems. This integration allowed knowledge workers not only to access shared data but also to communicate and collaborate across the organization. With client-server systems, information can flow between knowledge workers and higher management. The organization benefits from seamless, integrated management processes that support both autonomy and coordination.

3.2.4 Business Process Re-engineering

Definition (*Business Process Re-engineering*)**.** Business Process Re-engineering (BPR) refers to the transformational changes involved in integrating IT into service companies.

While it originated in manufacturing, by the 1990s it was clear that BPR had an even greater impact on the service sector. Several trends illustrate how BPR reshaped service delivery:

- *Increased delegation*: tasks were pushed downward in the organization, giving more responsibility and autonomy to frontline employees.
- *More complex sales roles*: sales staff evolved from simply selling services to guiding customers through service procedures.
- *Shift toward customer care*: he focus moved from one-time service sales to long-term customer relationships. This required storing detailed customer histories in centralized systems, enabling better support and personalization.

CHAPTER 4

Executive portfolio

4.1 Traditional control model

Anthony's Pyramid is a well-established framework for understanding how organizations manage control across different levels. It breaks down the process into three distinct types of control

1. *Strategic control*: setting and monitoring the organization's overall business objectives.
2. *Management control*: managing financial resources effectively.
3. *Operational control*: ensures daily operating activities are carried out efficiently and effectively.

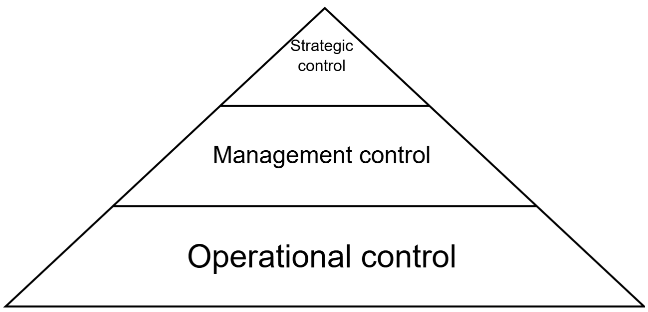


Figure 4.1: Anthony's pyramid

4.2 Executive information systems

Executive information systems are designed to provide senior leaders with the tools and insights they need to make informed, strategic decisions. These systems integrate data from various functional areas of an organization into a cohesive framework:

- *Financial performance*: monitor and optimize the financial health of the organization. Planning, budgeting and reporting with Activity Based Costing.

- *Process performance*: evaluate and enhance the efficiency of internal processes. Management dashboards with input-output process models
- *Clients and markets*: understand and engage with customers and markets effectively. Executive CRM with analytical CRM
- *Innovation and critical resources*: foster innovation and manage critical resources strategically. Strategic planning with strategic control (balanced scorecard).
- *Information to stakeholders*: communicate effectively with internal and external stakeholders. Communication through portals.

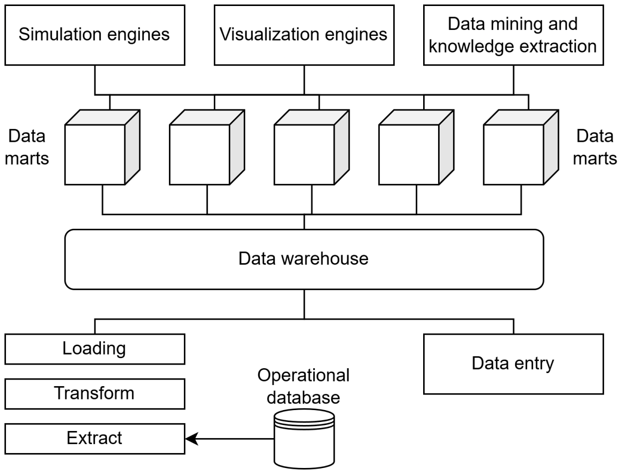


Figure 4.2: Executive information system

At the heart of an executive information systems are Key Performance Indicators (KPI): metrics that summarize the performance of specific activities or parameters. These indicators are defined by multiple dimensions, including: time, organizational unit, customer, product, process and activity, and other dimensions.

4.3 Design

The design of an executive information system involves a structured process to ensure that the system meets organizational needs and provides actionable insights for decision-makers. Below is a detailed breakdown of the key steps involved in designing an executive information system:

- *Define business requirements*: start by identifying the KPIs that align with the organization's strategic goals. These KPIs will serve as the foundation for the system, ensuring it provides relevant and meaningful insights to executives.
- *Identify information sources*: data required to populate the executive information system typically comes from various operational databases and systems. These data comes from ERP, CRM, operational information from legacy systems and customer, and administrative information.
- *Process the information*: once the data sources are identified, the next step is to process the data to ensure accuracy, consistency, and usability: selection, cleaning, integration, and aggregation.

- *Store the processed data*: efficient storage is crucial for maintaining performance and accessibility in warehouses and marts with a proper schema. Fact tables store the actual values of the KPIs, while key tables describe the dimensions that provide context to the facts.
- *Presentation and processing*: delivering insights to users through intuitive interfaces and advanced analytics tools.

4.3.1 Critical Success Factor

Critical Success Factor (CSF) refers to a business decision variable that is essential for the success of an organization. These factors serve as the backbone of the requirements analysis and specification process for designing an executive information system.

CSFs are high-level, abstract ideas that represent strategic priorities. Each CSF is not a single metric but rather a complex concept that corresponds to multiple KPIs. The steps needed for this approach are:

1. *Pre-definition*: conduct an initial analysis to identify potential CSFs based on industry standards, benchmarks, and existing documentation.
2. *Top managers interview*: engage in discussions with senior executives and decision-makers to pinpoint the CSFs most critical to the organization's success.
3. *Robustness analysis*: evaluate and select the appropriate KPIs that best represent each CSF. This involves assessing the relevance, reliability, and feasibility of potential KPIs. The KPis are chosen based on cost of information, significance, frequency and quantitatively.
4. *Refinement and documentation*: present the identified CSFs and KPIs to stakeholders for feedback and refinement. Finalize the documentation, ensuring it is clear, informal, and accessible to all relevant parties

CHAPTER 5

Enterprise Resource Planning

5.1 Introduction

Enterprise Resource Planning (ERP) systems have marked a transformative shift in the IT industry since the mid-1990s. This transformation is characterized by three key aspects:

1. It has become a global phenomenon.
2. It has shifted the focus from custom-built software solutions to packaged systems supported by consulting services.
3. It has unified and integrated three critical portfolios into a cohesive framework.

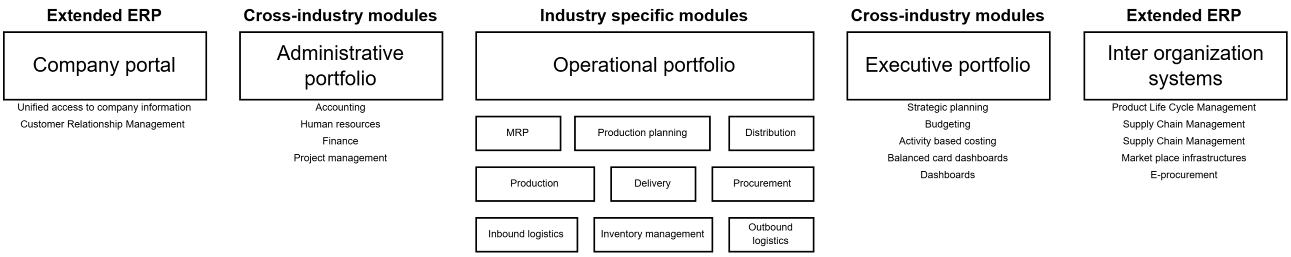


Figure 5.1: ERP architecture

A fundamental distinction exists between two types of ERP modules:

- *Core ERP*: these modules support internal processes within an organization. They encompass administrative functions, vertical operational tasks, and executive decision-making tools.
- *Extended ERP*: these modules facilitate interactions with external entities. They include Customer Relationship Management (CRM), Supply Chain Management (SCM), e-procurement platforms, and online marketplaces.

Principles ERP systems are built on three foundational principles:

1. *Information integration*: ERP systems aim to unify data across all levels of an organization. This includes vertical, horizontal and conceptual consistencies through a single, integrated data model that eliminates silos and promotes unified insights.
2. *Extension and modularity*: ERP systems are designed to be functionally comprehensive while offering flexibility through modular components:
   - *One-stop shopping*: a single supplier provides all modules, ensuring compatibility and streamlined implementation.
   - *Best-of-breed*: organizations can choose modules from multiple suppliers, allowing for tailored solutions but potentially increasing integration complexity.
3. *Process prescriptiveness*: ERP systems embed predefined process logic, which often necessitates organizational change. While this prescriptiveness offers advantages, it also presents challenges, including potential constraints on diversification and competitiveness.

No single ERP provider can deliver all functionalities required across every industry. Instead, niche players often specialize in offering industry-specific solutions tailored to unique business needs. This creates opportunities for system integration, allowing companies to combine software from multiple vendors to create a comprehensive and customized solution.

Small and medium-sized businesses typically opt for more flexible and cost-effective options, such as simplified ERP packages (often referred to as ERP Light), Software-as-a-Service (SaaS), or Cloud-based solutions.

5.2 Light ERP

Classic ERP systems are designed to cater to the complex needs of large enterprises. These solutions emphasize BPR to streamline and optimize workflows, ensuring alignment with organizational goals. They also provide industry-specific functionalities, often referred to as vertical solutions, tailored to meet the unique demands of sectors. System integration plays a critical role, allowing businesses to consolidate multiple software systems into a unified platform for seamless data flow. However, these systems come with high costs, not only in terms of licensing but also for customization and maintenance. Additionally, their implementation typically requires a significant time investment, often exceeding six months, due to the complexity and scale of deployment.

In contrast, small and medium-sized enterprises tend to adopt lighter, more cost-effective ERP solutions. These systems, often described as plug and play, are designed for quick and easy deployment without the need for extensive BPR. They focus on delivering simple administrative functionalities along with basic reporting tools for straightforward analytics. While these solutions are ideal for smaller businesses with limited budgets, they offer limited scalability.

CHAPTER 6

Customer Relationship Management

6.1 Introduction

In today's interconnected business environment, multi-channel integration plays a pivotal role in ensuring consistent service delivery across various customer touch points. By leveraging analytic Customer Relationship Management (CRM), organizations can extract valuable insights from customer data, enabling more informed decision-making and personalized experiences. Furthermore, executive functionalities within CRM systems facilitate a deeper understanding and real-time monitoring of customer behavior, empowering businesses to anticipate needs and enhance satisfaction. Operational CRM complements these efforts by streamlining interactions through diverse distribution channels, including physical stores, sales agents, call centers, web platforms, mobile applications, and direct mail, thereby creating a seamless and cohesive customer journey.

6.2 Analytical Customer Relationship Management

Analytical CRM focuses on leveraging customer data to derive actionable insights, enabling businesses to make informed decisions and enhance customer relationships. It encompasses various techniques and processes aimed at understanding customer behavior, predicting trends, and optimizing marketing strategies.

6.2.1 Data mining

Data mining involves the systematic analysis of large datasets to uncover hidden patterns, correlations, and insights that are critical for strategic business management. This process can be executed using a variety of techniques, ranging from traditional methods such as descriptive statistics, data visualization, and statistical correlations to more advanced approaches like machine learning algorithms.

These patterns must be presented in an intuitive and interpretable manner to ensure they can be effectively utilized by decision-makers. With the growing volume of operational data stored in corporate databases, data mining has become an essential tool for knowledge management, helping organizations unlock valuable insights embedded within their data.

6.2.2 Customer profiling

Customer profiling involves segmenting customers based on identifiable characteristics and behaviors, often facilitated by tools like loyalty cards or transaction histories. Customers can be categorized along multiple dimensions, including:

- *Loyalty*: analyzing purchasing habits to determine how frequently and consistently customers engage with the brand.
- *Price sensitivity*: assessing how responsive customers are to pricing changes or discounts.
- *Lifestyle*: evaluating behavioral orientations across various dimensions, such as preferences, interests, and demographic factors.

Customer segmentation serves as the foundation for targeted marketing efforts. By identifying specific segments or combinations of segments, businesses can tailor promotions to align with the average characteristics of each group. This approach not only enhances the effectiveness of marketing campaigns but also enriches the understanding of individual customer preferences.

6.2.3 Campaign management

Campaign management refers to the set of functionalities designed to support the planning, execution, and evaluation of marketing campaigns. A typical campaign lifecycle consists of four key phases, each with its associated tasks and objectives:

1. *Planning and budgeting*: defining campaign goals, target audiences, resource allocation, and financial constraints.
2. *Design*: developing campaign materials, messaging, and strategies to engage the intended audience effectively.
3. *Execution*: implementing the campaign across selected channels.
4. *Evaluation*: measuring campaign performance through key metrics.

6.3 Operational Customer Relationship Management

Operational CRM focuses on streamlining customer-facing processes to enhance efficiency, improve customer satisfaction, and support business growth. It encompasses tools and functionalities that enable seamless interactions across various channels, including sales, marketing, and customer service.

6.3.1 Sales Force Automation

Sales Force Automation (SFA) refers to the implementation of CRM functionalities designed to empower the sales force in both Business-to-Consumer (B2C) and Business-to-Business (B2B) environments. SFA offers significant advantages for organizations from both a management and sales perspective. Provides governance over the sales force, ensuring alignment with organizational goals. Enhances sales capabilities by equipping teams with the necessary tools and insights to perform effectively.

The primary operating objectives of SFA include: reducing the costs associated with customer acquisition, increasing customer retention rates, minimizing bureaucratic processes to improve responsiveness during the sales cycle, and enhancing the overall effectiveness of the sales force.

In physical sales channels, CRM systems play a critical role by providing data that supports the design of individual incentive systems. Additionally, the sales force requires comprehensive access to customer information, including invoicing details, to ensure personalized and efficient service delivery. While the physical channel is often more expensive to operate, it is particularly well-suited for high-value products, especially in B2B contexts. However, one challenge is that the sales force may tend to own customer data.

Performance The performance of physical sales channels is typically evaluated using a set of KPIs, which are categorized as: effectiveness, efficiency, and service level.

6.3.2 Document

In operational CRM, documents serve as critical tools for communication and record-keeping. A typical document is composed of two main sections:

- *Static sections*: fixed content that remains consistent across all instances of the document.
- *Dynamic sections*: content that is updated in real-time based on inputs from configuration tools, order management systems, and other sources.

6.3.3 Call centers

Call centers are a critical component of operational CRM, integrating telephone and computer technologies to provide efficient customer support and service. They serve as a central hub for managing inbound and outbound customer interactions across various channels.

A call center's infrastructure is built on several key technical components:

- *Client phone or terminal*: devices used by customers to initiate contact, including traditional fixed or mobile phones, smartphones, and personal computers with web access.
- *Telecommunication network*: the network that connects customers to call center operators, ensuring seamless communication.
- *Computer architecture of the call center*: includes personal computers used by operators, server machines, and Interactive Voice Response (IVR) systems to manage and process customer interactions.
- *Integration technologies*: these technologies bridge the telephone network with the call center's computer network. They also enable the integration of multiple geographically dispersed call centers into a single logical entity, enhancing operational efficiency.

Architecture The architecture of a call center can vary based on its maturity and level of integration with the organization's information systems. The three main types of architectures are:

- *Basic architecture*: represents the simplest and least mature type of call center. Utilizes hardware components like Private Branch Exchange (PABX) to distribute calls to operators. Lacks integration with the company's information system, limiting access to customer data during interactions.

- *Integrated architecture*: integrates the call center with the company's information system through Computer Telephony Integration (CTI) servers. Automatically identifies callers and associates them with relevant customer information, which is displayed in real-time on the operator's screen. Enhances service quality by enabling personalized and efficient customer interactions.

- *Contact center*: incorporates advanced automated systems such as Interactive Voice Response (IVR) and Automatic Speech Recognition (ASR). IVR allows customers to interact with the system using keypad inputs or voice commands, while ASR recognizes speech patterns and iteratively refines responses. Integrates multiple communication channels into a unified platform. Operators handle inbound requests from all channels and manage outbound communications for campaigns. While this architecture is more costly to implement, it significantly reduces operating costs and improves service levels.

Performance The performance of a call center is measured based on its ability to handle customer interactions efficiently and effectively. Key factors influencing performance include:

- *Number of calls per time unit*: a higher volume of calls requires more resources to maintain service levels.

- *Target level of service*: defined in a SLA, this specifies acceptable waiting times and effectiveness in resolving customer issues.

Common performance indicators include:

- *First Call Resolution* (FCR): measures the percentage of issues resolved during the first interaction, indicating effectiveness.

- *Percentage of calls with waiting time lower than x seconds*: tracks how many calls are answered within a specified time frame.

- *Average call time*: evaluates the efficiency of operators by measuring the average duration of customer interactions.

Sizing Proper sizing of a call center ensures optimal resource allocation and adherence to SLAs. Need to determine the ideal number of operators and their schedules based on activity volumes and SLA requirements with the inbound call volumes are unevenly distributed over time, requiring dynamic adjustments. To perform a correct sizing we need:

- *Medium-term planning*: focuses on sizing infrastructure and staffing levels to meet anticipated demand.

- *Short-term planning*: drives the scheduling of outbound activities and revises operator schedules in real-time to optimize performance.

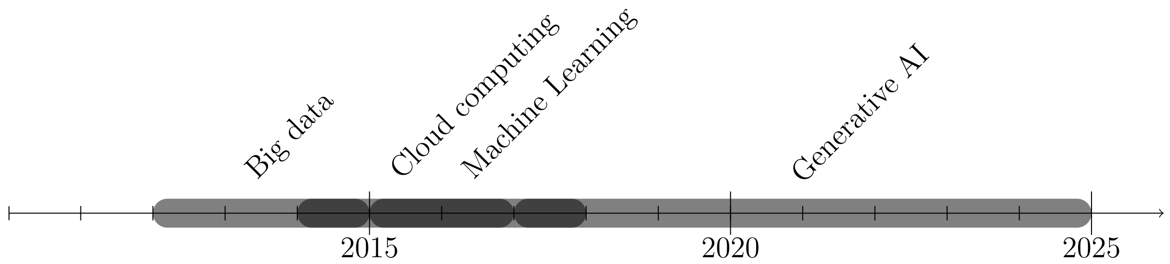
- *Resource allocation*: each operator represents a resource that is dynamically allocated based on demand fluctuations.

CHAPTER 7

Data analytics

7.1 Introduction

In today's world, data has emerged as the cornerstone of decision-making, driving innovation and redefining strategies across industries. The evolution of data-driven technologies can be traced through several transformative phases, each contributing to the way businesses harness information for growth and efficiency.



Big data The era of Big Data began with the exponential surge in structured and unstructured data generated daily. This phase introduced significant challenges in terms of storage, management, and analysis, but it also opened up unprecedented opportunities for deriving business intelligence and actionable insights.

Machine Learning Machine Learning marked a pivotal shift in data utilization, empowering computers to identify patterns and make decisions without explicit programming. Its applications grew rapidly, enabling predictive analytics and automation that transformed industries and streamlined operations.

Cloud Computing Cloud computing revolutionized data infrastructure by offering scalable, cost-effective solutions accessible over the internet. It eliminated traditional infrastructure constraints, providing businesses with flexible computing power and facilitating seamless data processing and storage.

Generative Artificial Intelligence Generative AI represents the cutting edge of technological advancement, where systems exhibit human-like understanding and creativity. These AI models are capable of producing new content, analyzing complex datasets, and solving problems across diverse domains, reshaping industries and redefining how humans interact with technology.

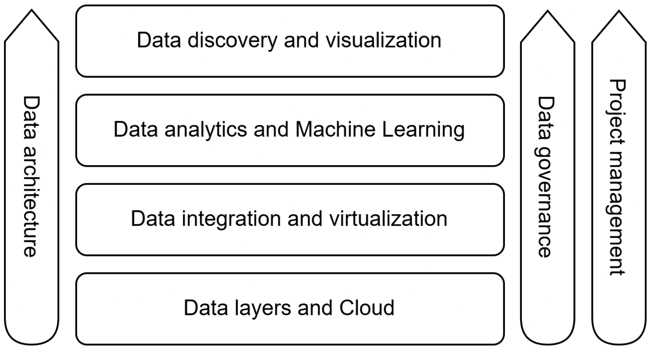


Figure 7.1: Data framework

The growing importance of data has given rise to specialized roles critical to managing and leveraging this resource effectively:

- *Data and Cloud architect*: design robust data infrastructures aligned with business goals, ensuring efficient integration and optimal storage. Cloud architects focus on building scalable, cloud-based systems to meet modern data demands.
- *Data engineer*: develop and maintain systems for collecting, processing, and storing data. They design ETL pipelines, work with big data tools, and transform raw data into formats suitable for analysis.
- *Data analyst*: interpret datasets to extract meaningful insights. They clean and analyze data, perform statistical evaluations, and create visualizations to guide strategic decisions.
- *Data scientist*: apply advanced analytics and machine learning techniques to uncover patterns and predictions from complex datasets. Using programming languages like Python, they drive deeper insights and develop innovative solutions.
- *Data privacy and security specialist*: these professionals ensure compliance with data protection laws and implement robust security measures to safeguard organizational data from cyber threats and breaches.

7.2 Project management

Definition (*Project*)**.** A project is a set of tasks that must be completed within a defined timeline to achieve specific objectives and deliverables.

A project is characterized by its scope, which defines the goals, deliverables, and constraints. It involves multiple stakeholders and is executed by a dedicated project team. The project's methodology acts as a guiding framework, encompassing processes, methods, and best practices to ensure the successful achievement of project objectives.

The main KPIs or evaluating project success include:

- *Revenue*: total income generated by the company from its consulting services before deducting expenses.

- *Earning before tax*: measures profitability before accounting for income tax expenses.
- *Cost on revenues*: ratio of costs directly associated with generating revenue.
- *Un-allocation*: refers to staff who are not assigned to revenue-generating activities.

7.2.1 Requirements

For data teams to deliver effective analytics solutions, collaboration with business stakeholders is essential to understand their needs and desired outcomes. A structured requirements-gathering process is critical for determining the appropriate type of analysis and selecting the right solution. Without clear requirements, data teams cannot accurately define the project scope or develop an effective solution.

7.2.2 Project development

Two primary methodologies dominate project development: Waterfall and Agile. Each approach has distinct strengths and limitations, making them suitable for different types of projects.

7.2.2.1 Waterfall

The waterfall model follows a sequential process, where each phase (analysis, design, development, testing, and implementation) progresses linearly. Once a phase begins, changes to requirements are difficult to incorporate. This approach is ideal for projects with well-defined and stable requirements from the outset.

Waterfall methodology is particularly effective for projects requiring strict compliance, comprehensive documentation, and structured processes. Key components include project management, the project team, and subject matter experts.

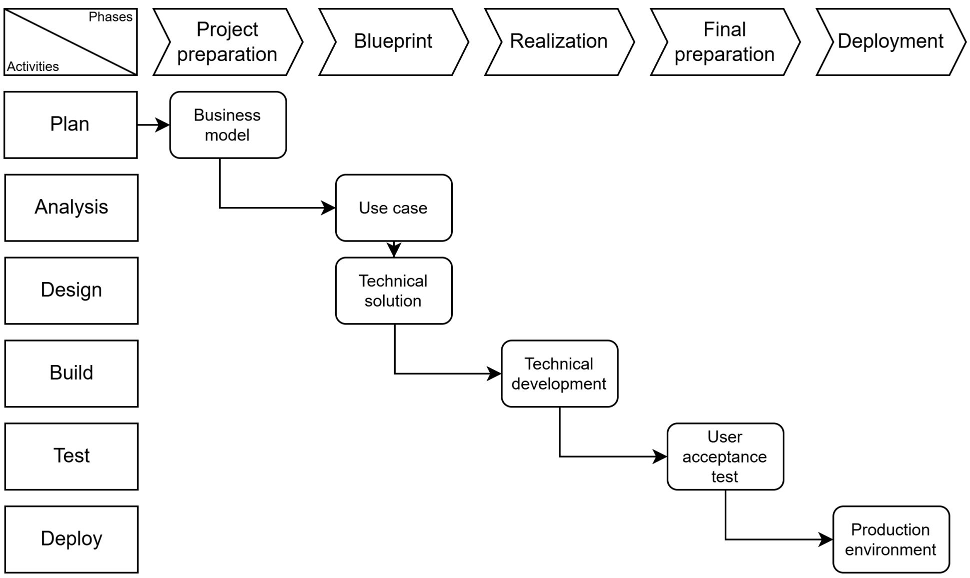


Figure 7.2: Waterfall project phases

7.2.2.2 Agile

Agile adopts an iterative and incremental approach, offering greater flexibility. Work is organized into sprints, each delivering a functional product increment. Agile emphasizes continuous collaboration with clients and adapts seamlessly to evolving requirements.

Agile is well-suited for projects where requirements may change frequently or when rapid, tangible results are needed. Key roles in agile include:

- *Product owner*: responsible for defining and communicating the product goal, creating the product backlog, and prioritizing backlog items based on business value.
- *Developers*: plan and execute sprints, create the sprint backlog, maintain quality standards, and adjust plans as necessary to meet the sprint goal.
- *Scrum master*: acts as a coach for the team, removes obstacles, and ensures focus on delivering high-value increments while adhering to agile principles.

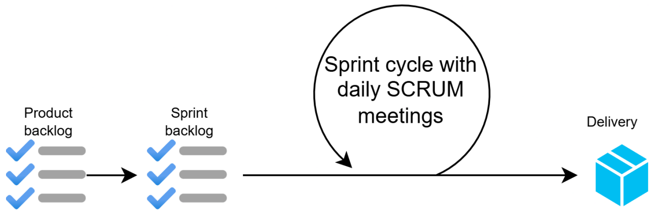


Figure 7.3: Agile project phases

7.2.2.3 Hybrid

A hybrid methodology combines elements of both waterfall and agile, adapting to the unique needs of the project. This approach provides flexibility while maintaining structured planning, making it suitable for projects that require a balance of predictability and adaptability.

7.3 Data management

The data architecture is organized into the following key components:

1. *Source layer*: origin of raw data, which comes from operational systems, websites, e-commerce platforms, and other sources.
2. *Data ingestion*: data undergoes transformations to make it usable within the data platform. This step ensures proper formatting for analysis, enabling businesses to derive value from the data.
3. *Data platform*: this is where core data analysis occurs. Given the large volume of data, robust systems are essential for effective processing. The data refinement process follows a tiered approach:
   - *Bronze layer*: raw ingested data.
   - *Silver layer*: data undergoes ETL processing.
   - *Gold layer*: fully analyzed and user-friendly data, optimized for reporting and decision-making.

4. *Machine Learning* (optional): advanced analytics and machine learning techniques are applied to extract valuable insights and patterns from the processed data.

5. *Data consumer*: processed data and insights are delivered to end users or integrated into other applications.

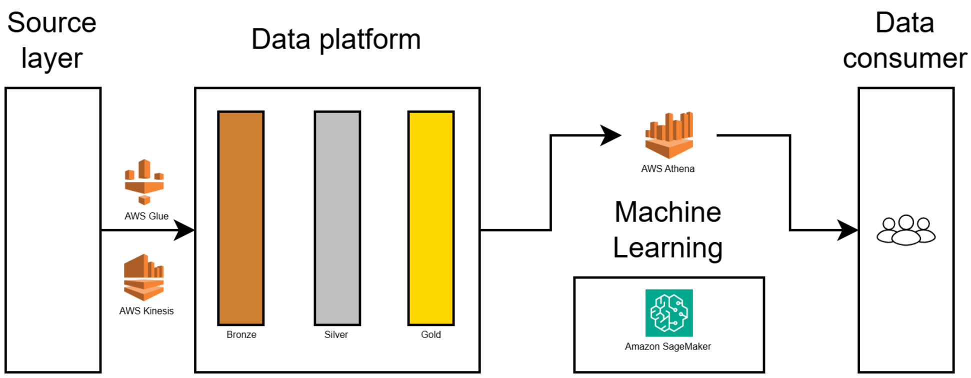


Figure 7.4: Data architecture

7.3.1 Data architecture

A data architecture defines how data is managed throughout its lifecycle, from collection and transformation to distribution and consumption. It serves as a blueprint for how data flows through various storage systems, ensuring efficient processing and delivery.

In traditional data architectures, the Extract, Transform, Load (ETL) model is used. This method involves extracting data from sources, transforming it into a usable format, and loading it into a data warehouse for storage and analysis.

Modern data architectures, however, have shifted to the Extract, Load, Transform (ELT) approach. Instead of transforming all data before storage, raw data is directly placed in a data lake. From there, it can be analyzed as needed. This approach offers greater flexibility and enables real-time analytics, allowing organizations to process and analyze data dynamically without waiting for full transformation.

7.3.1.1 Data storage

Definition (*Data warehouse*)**.** A data warehouse is a centralized repository that stores large volumes of structured data from various sources within an organization.

Unlike transactional databases, which prioritize real-time operations, data warehouses are designed for analytical queries and historical data analysis. They facilitate reporting, business intelligence, and decision-making by providing a consolidated and structured view of organizational data.

Definition (*Data lake*)**.** A data lake is a scalable repository that allows organizations to store vast amounts of raw, structured, semi-structured, and unstructured data.

Unlike a data warehouse, a data lake does not impose a schema on the data upon ingestion. Instead, it retains data in its original format until it is needed for processing or analysis. While data lakes provide flexibility for advanced analytics and machine learning, they require careful governance and security measures to maintain data quality.

Definition (*Data lakehouse*)**.** A data lakehouse combines the strengths of data warehouses and data lakes.

Data lakehouse integrates data warehouses and data lakes as part of a comprehensive data strategy, leveraging their respective advantages:

- *Data integration*: raw data is ingested into the data lake, preserving its original format and serving as a staging area before further processing.
- *Data transformation*: ETL processes can occur in both the data lake and the data warehouse. Structured data required for immediate reporting is transformed and stored in the warehouse, while raw and unstructured data remains in the lake for exploratory analysis.

Definition (*Polyglot persistence*)**.** Polyglot persistence refers to the practice of using multiple types of data storage technologies and databases within a single system.

Instead of relying on a single storage solution, organizations select the best-suited technology for each specific data type and use case, optimizing performance and scalability across different applications.

Definition (*Data mesh*)**.** Data mesh is a modern approach to analytical data architecture that treats data as a product.

It is domain-driven, meaning data ownership is distributed among teams with the best understanding of their data and its usage. The key idea behind data mesh is that no one understands data better than its owner. Instead of relying on a centralized data team, data mesh distributes data responsibilities to domain-specific teams. Each domain aligns with a business function rather than specific applications or systems. Domains manage their own data pipelines within a shared infrastructure and provide access to domain-specific data and functionalities via APIs.

Feature	**Data warehouse**	**Data lake**	**Data mesh**
Centralization	Centralized	Centralized	Decentralized
Data structure	Structured	Unstructured	Both
Use cases	Reporting	Advanced analytics	Data product
Integration	Data lake	Data warehouse	Autonomous
Flexibility	No	No	Yes

7.3.1.2 Data modeling

Definition (*Data modeling*)**.** Data modeling refers to the process of creating a structured representation of data to analyze its relationships, constraints, and organization.

Data modeling plays a critical role in structuring data to guide database design and enable smooth, reliable operations. It involves defining entities, their attributes, and the connections between them within a database. By doing so, it provides a blueprint that supports efficient data management and retrieval.

Data modeling encompasses various approaches and tools, including:

- *Data dictionaries*: comprehensive references that describe each data element within a system or database.
- *Entity-relationship diagrams*: visual representations of relational databases, illustrating the relationships between entities.
- *Semantic models*: logical layers containing transformations, calculations, and relationships between data sources, often used for creating reports and dashboards.

In data warehousing and business intelligence, data is typically categorized into two primary types:

- *Dimensions*: represent descriptive attributes or entities within the model.
- *Facts*: store measurable, quantitative data related to specific observations or events.

Two fundamental approaches to organizing data in relational databases are normalization and denormalization. The choice between these methods depends on the application's requirements and objectives.

Normalization Normalization prioritizes data integrity by minimizing redundancy and avoiding anomalies. It is particularly suitable for transactional databases where accuracy and consistency are paramount.

Denormalization Denormalization focuses on optimizing query performance, especially for read-heavy workloads or reporting databases. While it introduces some level of redundancy, it significantly enhances query execution speed.

7.3.1.3 Data visualization

Data visualization offers an intuitive way to explore and analyze data by transforming raw numbers into meaningful graphical insights. It serves as a powerful tool for uncovering hidden patterns, trends, and relationships that may not be evident through traditional analysis.

Application Data visualization enables interactive exploration and graphical representation of data, regardless of dataset size or origin. It empowers managers and decision-makers to: identify key trends and outliers, gain actionable insights from complex datasets, and make informed, data-driven decisions.

7.3.2 Data governance

Data governance refers to the framework that defines how an organization manages its data to ensure accuracy, security, and compliance. It encompasses processes, roles, policies, standards, and metrics aimed at optimizing data usage, enabling organizations to become truly data-driven.

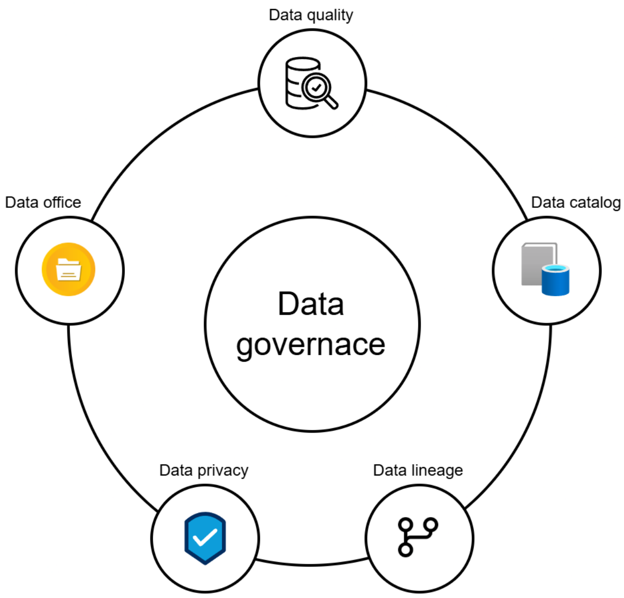


Figure 7.5: Data governance pillars

Data governance is built on several key pillars that collectively ensure the integrity, usability, and protection of data assets:

- *Data quality*: ensures that information is accurate, reliable, and well-maintained throughout its lifecycle.
- *Data catalog*: helps organizations manage and understand their data assets by integrating metadata from diverse sources, including databases, cloud platforms, ETL processes, and business intelligence tools.
- *Data lineage*: tracks the entire lifecycle of data, from its origin to its final destination.
- *Data privacy*: focuses on identifying and safeguarding sensitive information.
- *Data office*: plays a central role in overseeing data governance initiatives.

Organizations rely on specialized technology platforms to implement robust data governance strategies. These tools provide comprehensive capabilities for: managing data quality, cataloging metadata, tracking data lineage, and ensuring data privacy. However, technology alone is insufficient. Effective governance requires a combination of tools, processes, and dedicated personnel within a structured data office to ensure alignment with organizational goals.

Beyond compliance and data management, data governance serves as a strategic enabler for organizations. By establishing strong governance practices, companies can achieve data as a service and data monetization.

7.4 Data creation

Definition (*Synthetic data*)**.** Synthetic data refers to artificially generated data designed to replicate the characteristics, patterns, and statistical properties of real-world datasets.

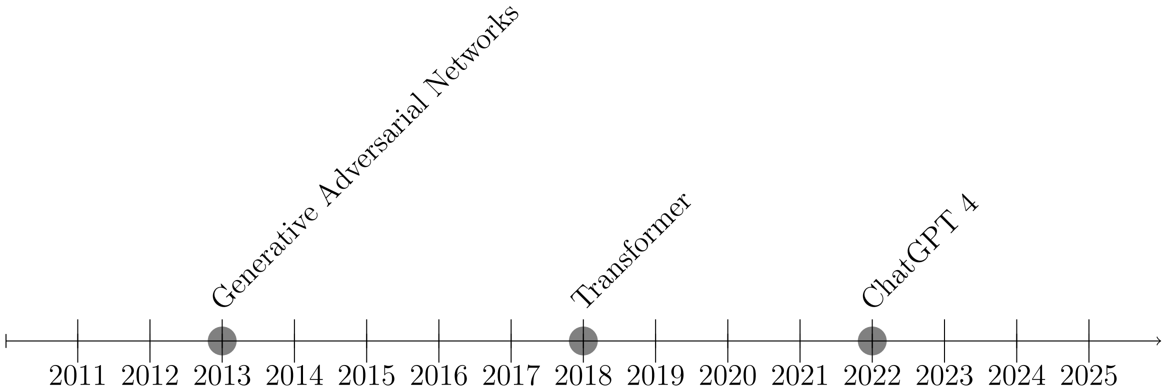
This type of data can be produced in large volumes and is crafted to closely resemble original datasets, often making it indistinguishable from real data. Unlike actual observations, synthetic data does not contain any real-world instances but instead mimics the structure, trends, and relationships found in authentic datasets.

The primary goal of synthetic data generation is to address scenarios where real data is scarce, insufficient, or inaccessible, particularly when privacy concerns limit access to sensitive information. Synthetic data can either supplement or replace real-world data, especially in cases where using real data is impractical or restricted. The key benefits include handling missing data, mitigating bias, balancing class distributions, enabling secure data sharing, and reducing costs.

Simulation Synthetic data leverages the underlying mechanisms that govern real-world phenomena, allowing for the exploration of new or rare conditions. It facilitates the simulation of extreme or uncommon scenarios, which are difficult to observe in real-world settings.

7.4.1 Data synthetization

The concept of data synthesis dates back to 1928 with the advent of sample bootstrapping techniques and has evolved significantly over time.



Key methods for synthesizing data include:

- *Generative Adversarial Networks* (GAN): a Neural Network architecture comprising two components (a generator and a discriminator) that collaborate to produce realistic synthetic data.
- *Variational Autoencoder*: models that compress data into a latent space and then reconstruct it, enabling the generation of new samples that closely resemble the original dataset.

These techniques can be applied across diverse domains, including tabular data, text generation, relational databases, time series, 3D modeling, and computer vision.

Applications Synthetic data frameworks are utilized in various use cases:

- *Data monetization*: enables secure data sharing and monetization, fostering innovation and competitiveness among businesses of all sizes. Companies with valuable but sensitive data often struggle to share it due to privacy regulations like GDPR. Synthetic data allows them to share insights without compromising privacy.
- *Fraud detection*: creates balanced datasets to enhance fraud detection models, automates the identification of fake IDs, and removes sensitive customer information from the process. Detecting counterfeit IDs used for fraudulent activities is challenging due to privacy

concerns and limited access to such documents. Synthetic data helps augment datasets and improve model accuracy.

- *Data masking for development*: facilitates the generation of large quantities of data for testing and development, ensuring reproducible scenarios and customizable data for specific needs. Sensitive data cannot typically be moved to non-production environments, and random or masked data often lacks realism. A synthetic data model trained on production data can replicate sensitive information while preserving privacy.

According to Gartner, by 2030, synthetic data will surpass real data as the primary input for Artificial Intelligence (AI) models.

Challenges Despite its potential, synthetic data faces several challenges:

- *Representativeness*: ensuring that synthetic data accurately reflects the statistical properties and complexity of real-world data is a significant hurdle. The generated data must capture the diversity and intricacies of actual scenarios to remain useful.
- *Validation*: validating synthetic data is critical to ensure that models trained on it generalize effectively to real-world applications. This involves confirming that the synthetic data faithfully represents underlying patterns and relationships.
- *Bias and fairness*: the process of generating synthetic data must avoid introducing or amplifying biases, which could lead to unfair or misleading outcomes.
- *Transparency*: maintaining transparency in the creation and use of synthetic data is essential. Understanding its origins, characteristics, and limitations ensures responsible and ethical application.

7.4.2 Generative Artificial Intelligence

Definition (*Generative Artificial Intelligence*)**.** Generative AI refers to a specialized branch of Artificial Intelligence focused on developing systems capable of producing new data samples that closely resemble the training dataset.

Unlike discriminative models, which classify input data into predefined categories or make predictions, generative models aim to understand the underlying structure and distribution of the data. By capturing these patterns, generative AI can create novel instances that reflect the characteristics of the original dataset. In essence, generative AI mimics human-like creativity by learning from examples and producing contextually relevant content across various domains.

Applications Generative AI has a broad range of applications across multiple domains, including:

- *Image Generation and Editing*: techniques such as GANs are widely used to generate realistic images. They are also effective for tasks like style transfer, colorization, and image-to-image translation.
- *Text Generation and Summarization*: language models can produce coherent and contextually relevant text, making them valuable for tasks like summarization and content creation.

- *Content Creation and Augmentation*: generative AI can create entirely new forms of content. Additionally, these models can enhance existing content by generating variations or filling in missing parts.
- *Data Synthesis and Simulation*: generative models can create synthetic data that closely resembles real-world data, making them useful for data augmentation, training Machine Learning models, and simulating realistic scenarios.

Definition (*Large Language Models*)**.** A Large Language Model (LLM) is a type of Artificial Intelligence designed to understand and generate human-like text based on the input it receives.

These models are trained on vast amounts of text data, typically sourced from the internet or other extensive corpora, enabling them to learn the intricate patterns and structures of human language. LLMs are built using deep learning architectures, often based on transformer architectures, which consist of multiple layers of neural networks. These layers process input text hierarchically, capturing both local and global dependencies within the text. The result is a model capable of producing highly coherent and contextually relevant text.

Once trained, LLMs can perform a wide variety of natural language processing tasks, including text generation, completion, translation, summarization, and question answering. Their ability to generate fluent and contextually appropriate text has made them indispensable in applications such as virtual assistants, content creation, and more.

7.4.2.1 Prompt engineering

Definition (*Prompt engineering*)**.** Prompt engineering is the practice of designing and crafting prompts or inputs to interact with language models or AI systems in order to achieve specific, desired outputs.

The goal of prompt engineering is to optimize how questions or requests are framed to ensure the AI generates accurate, useful, and relevant responses. Key strategies for effective prompting include being clear and specific, providing relevant context, asking open-ended questions, using important keywords, avoiding ambiguity, engaging in conversation, offering feedback, and experimenting with different approaches.

7.4.2.2 Multimodal generative AI

Multimodal generative AI refers to systems capable of creating content across multiple modalities. These advanced AI systems leverage machine learning techniques to process and generate content from various types of data.

Unlike traditional generative models that focus on a single modality, multimodal models can handle multiple data types simultaneously, enabling richer and more comprehensive content generation. These models understand the relationships between different forms of data, resulting in more contextually relevant and dynamic outputs.

Training Training multimodal AI models requires large, diverse datasets that include paired examples of different data types. These datasets help the model learn the correlations and connections between various modalities, enhancing its ability to generate accurate and coherent content across different media formats.

7.4.2.3 Enterprise applications

Definition (*Retrieval Augmented Generation*)**.** Retrieval Augmented Generation (RAG) is a technique in natural language processing that combines retrieval-based methods with generative models to improve the quality and relevance of generated text.

In RAG, a retriever component searches a large database or text corpus to find information relevant to the input query or context. This retrieved information is then used to enhance the generative model's output, producing responses that are more accurate, coherent, and contextually relevant. With RAG, enterprise data can be leveraged to enrich prompts and improve performance.

Architecture Enterprise architectures incorporating generative AI typically include the following components:

- *Vectorial database layer*: a storage layer that organizes data in a format easily understood by large language models.
- *Feedback*: a mechanism to collect feedback and contextual information, enabling continuous improvement and evolution of the model.
- *RAG agent*: the core component responsible for managing inputs and outputs, integrating retrieval and generation processes.
- *Guard rail*: a safeguard to prevent model leakage or malicious attacks, ensuring the quality and security of outputs. However, limiting the LLM's capabilities may degrade performance and increase latency, as all inputs and outputs must be checked.
- *LLM gateway and catalog*: responsible for routing prompts to the most suitable large language model for processing.

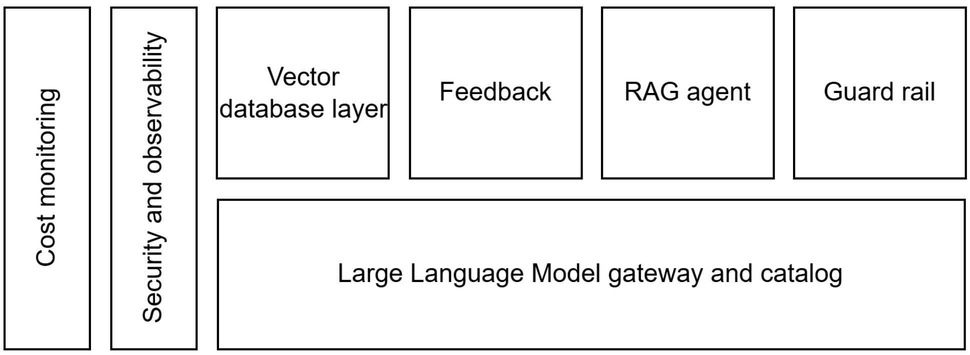


Figure 7.6: Architecture

7.4.3 Explainable Artificial Intelligence

Explainable Artificial Intelligence (XAI) is a research field dedicated to developing techniques that interpret machine learning models and explain their predictions in terms understandable to humans. As Machine Learning models become more accurate and sophisticated, their complexity often increases, turning them into black boxes where the decision-making process is opaque and difficult to comprehend. This lack of transparency raises concerns about the trustworthiness, fairness, and accountability of AI systems.

The growing reliance on AI in critical domains—such as healthcare, finance, and law. When AI systems make decisions that impact individuals or society, it is essential to understand the rationale behind those decisions. XAI addresses these challenges by ensuring that AI models are not only accurate but also interpretable, fair, and free from biases.

7.4.3.1 Post-hoc methods

Post-hoc explainability methods aim to make predictions from existing machine learning models interpretable without altering the model itself. These methods can be categorized as follows:

- *Model specific*: these methods leverage the internal structure and learning algorithm of a specific model to provide explanations tailored to its architecture.
- *Model agnostic*: these methods analyze the relationship between model inputs and predictions in a generalizable way, making them applicable to any type of model.
- *Global*: these methods provide an overarching explanation of the model's behavior across the entire dataset, offering insights into how the model operates as a whole.
- *Local*: these methods focus on explaining individual predictions or subsets of data, providing detailed insights into specific instances.

Common post-hoc XAI approaches include feature importance, surrogate models, rule-based models, and saliency maps.

7.4.3.2 Reponsible AI

Responsible AI is a broader framework that encompasses various sub-disciplines aimed at ensuring AI systems are developed and deployed ethically and responsibly. These sub-disciplines include: explainable AI, human-centered AI, compliance, ethical AI, secure AI, and interpretable AI.

7.5 Advanced data analytics

Advanced analytics encompasses a range of sophisticated data analysis methods that are pivotal in the business context. These techniques span varying levels of complexity and value, categorized into four primary types: descriptive, diagnostic, predictive, and prescriptive analytics. The overarching goal is to uncover hidden patterns, predict future trends, and facilitate data-driven decision-making.

Definition (*Data*)**.** Data are raw, unprocessed facts that serve as the basic unit of measurable information.

Definition (*Information*)**.** Information is processed and organized data that becomes meaningful and useful.

Definition (*Knowledge*)**.** Knowledge arises when information is combined with experience, expertise, and authoritative judgment, leading to actionable decisions.

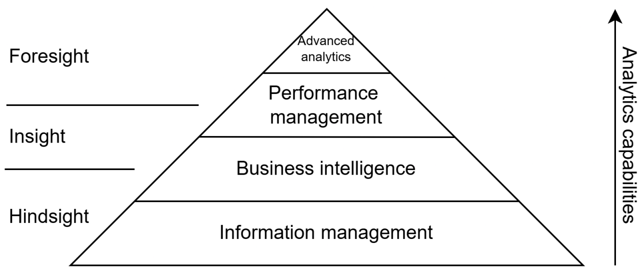


Figure 7.7: Data analytics levels

7.5.1 Business intelligence

Business Intelligence (BI) refers to a set of methodologies, processes, architectures, and technologies that transform raw data into meaningful and actionable information. BI enables more effective strategic, tactical, and operational decision-making.

BI primarily focuses on historical reporting, utilizing descriptive and diagnostic analytics to help organizations understand past performance. Advanced analytics builds upon this foundation by incorporating predictive and prescriptive capabilities, enabling deeper insights into future trends and optimal actions.

Design A BI system is typically designed through the following steps:

1. *Data identification and structuring*: identifying relevant data and organizing it into a usable format.
2. *Expected output definition*: defining the expected results and objectives of the analysis.
3. *Database model and design*: creating appropriate data structures to store and manage the data.
4. *Dashboards and visual design*: developing user-friendly dashboards and visualizations to present data meaningfully.

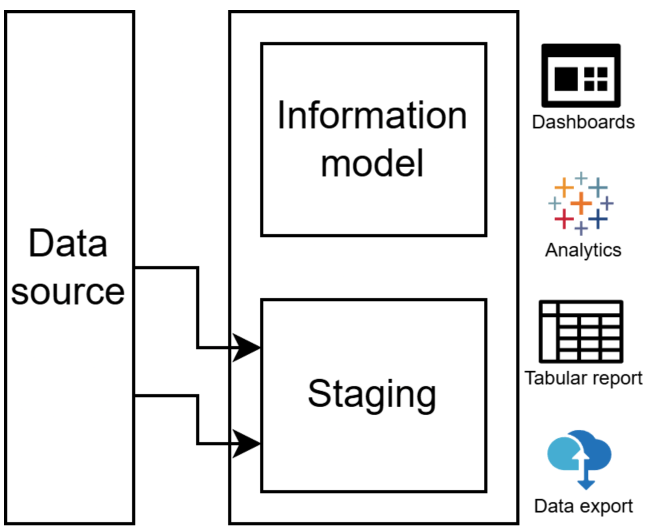


Figure 7.8: Business intelligence architecture

Levels BI systems cater to three primary user groups:

1. *Technical BI* (IT end users): focuses on the infrastructure and backend of BI systems.

2. *Self-service BI* (analysts): enables business analysts to explore data and generate insights independently.

3. *End-user BI* (everyone): designed for general users across the organization to access insights and make data-driven decisions.

To transform raw data into actionable knowledge and tangible value, the following considerations are essential: quality of data, context, business relevance, and agility

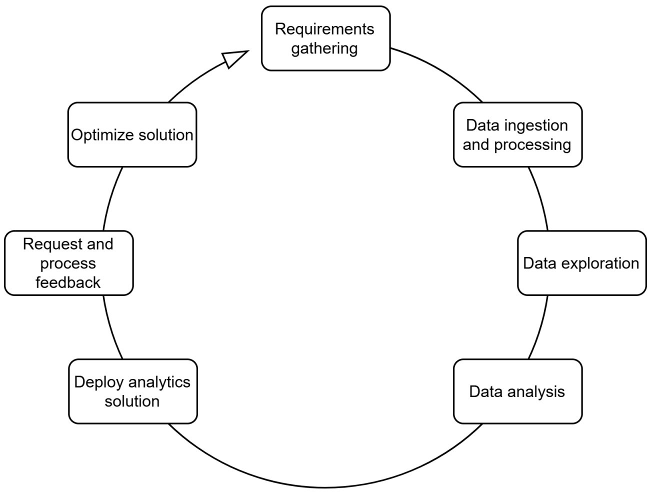


Figure 7.9: Business information lifecycle

7.5.2 Power BI

Power BI Desktop is a free tool that empowers users to create rich, interactive reports with visual analytics from hundreds of data sources. Its development methodology follows these key steps:

1. *Query creation*: filtering, formatting, and refining data to ensure accuracy and relevance.

2. *Relationship configuration*: establishing the foundations of a data model by defining relationships between datasets.

3. *Data model enrichment*: adding calculation logic, measures, and formatting to enhance the data model.

4. *Data exploration*: using drag-and-drop functionality on the Canvas to explore data in innovative ways.

5. *Interactive report design*: creating reports with a wide range of customizable data visualizations.

6. *Publishing*: sharing and consuming the report content online for broader accessibility and collaboration.