

## UNIT-I

**Business intelligence:** Effective and timely decisions, Data, information and knowledge, the role of mathematical models, Business intelligence architectures, Ethics and business intelligence

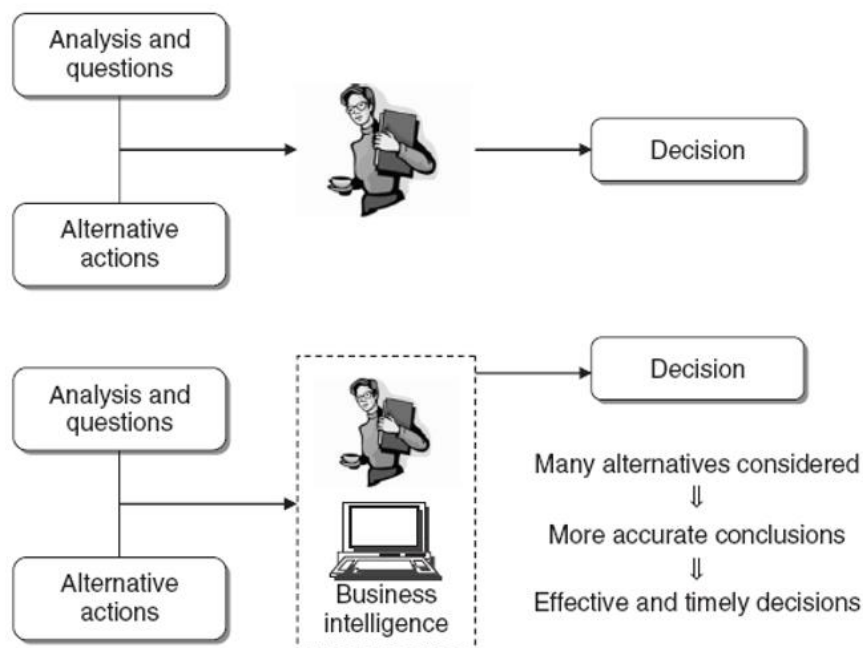
**Decision support systems:** Definition of system, Representation of the decision-making process, Evolution of information systems, Definition of decision support system, Development of a decision support system

### Effective and timely decisions:

The main purpose of business intelligence systems is to provide knowledge workers with tools and methodologies that allow them to make *effective* and *timely* decisions.

**Effective decisions.** The application of rigorous analytical methods allows decision makers to rely on information and knowledge which are more dependable

**Timely decisions.** The ability to rapidly react to the actions of competitors and to new market conditions is a critical factor in the success or even the survival of a company.



### ***Benefits of a Business Intelligence System***

## **Data, information and knowledge**

### **Data:**

For a retailer data refer to primary entities such as customers, points of sale and items, while sales receipts represent the commercial transactions.

Data is unprocessed facts and figures without any added interpretation or analysis. "The price of crude oil is \$80 per barrel."

### **Information:**

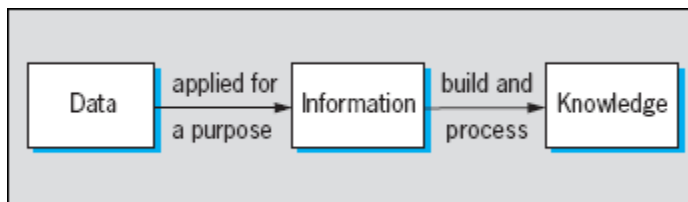
Information is the outcome of extraction and processing activities carried out on data, and it appears meaningful for those who receive it in a specific domain

Information is data that has been interpreted so that it has meaning for the user. "The price of crude oil has risen from \$70 to \$80 per barrel" gives meaning to the data and so is said to be information to someone who tracks oil prices.

### **Knowledge:**

Information is transformed into knowledge when it is used to make decisions and develop the corresponding actions.

Knowledge is a combination of information, experience and insight that may benefit the individual or the organization. "When crude oil prices go up by \$10 per barrel, it's likely that petrol prices will rise by 2p per litre" is knowledge.



**Figure: From data to information to knowledge**

Several public and private enterprises and organizations have developed in recent years formal and systematic mechanisms to gather, store and share their wealth of knowledge, which is now perceived as an invaluable intangible asset. The activity of providing support to knowledge workers through the integration of decision-making processes and enabling information technologies is usually referred to as *knowledge management*.

## **The role of mathematical models:**

A business intelligence system provides decision makers with information and knowledge extracted from data, through the application of mathematical models and algorithms. In some instances, this activity may reduce to calculations of totals and percentages, graphically represented by simple histograms, whereas more elaborate analyses require the development of advanced optimization and learning models.

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- **First, the objectives of the analysis are identified and the performance indicators that will be used to evaluate alternative options are defined.**
- **Mathematical models are then developed by exploiting the relationships among system control variables, parameters and evaluation metrics.**

- Finally, *what-if analyses* are carried out to evaluate the effects on the performance determined by variations in the control variables and changes in the parameters.

### **Business intelligence architectures:**

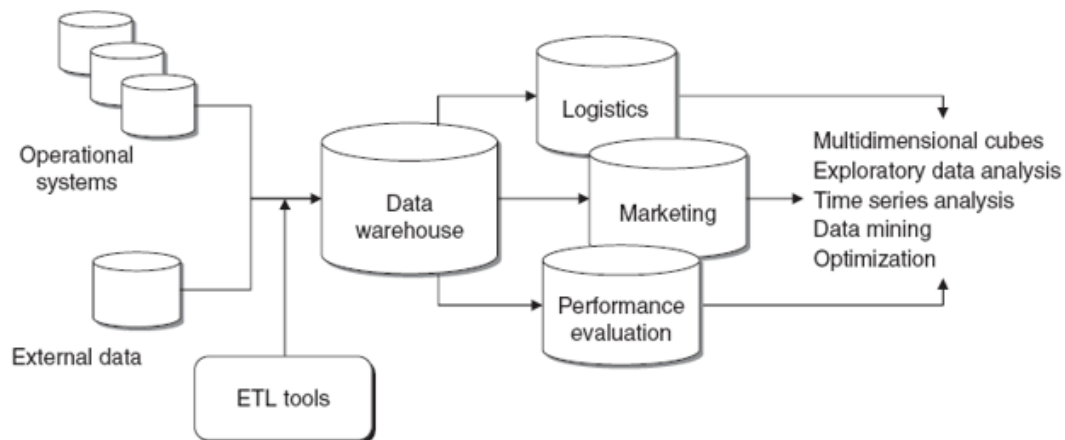
The architecture of a business intelligence system, includes three major components.

**Data sources.** In a first stage, it is necessary to gather and integrate the data stored in the various primary and secondary sources, which are heterogeneous in origin and type. The sources consist for the most part of data belonging to operational systems, but may also include unstructured documents, such as emails and data received from external providers. Generally speaking, a major effort is required to unify and integrate the different data sources.

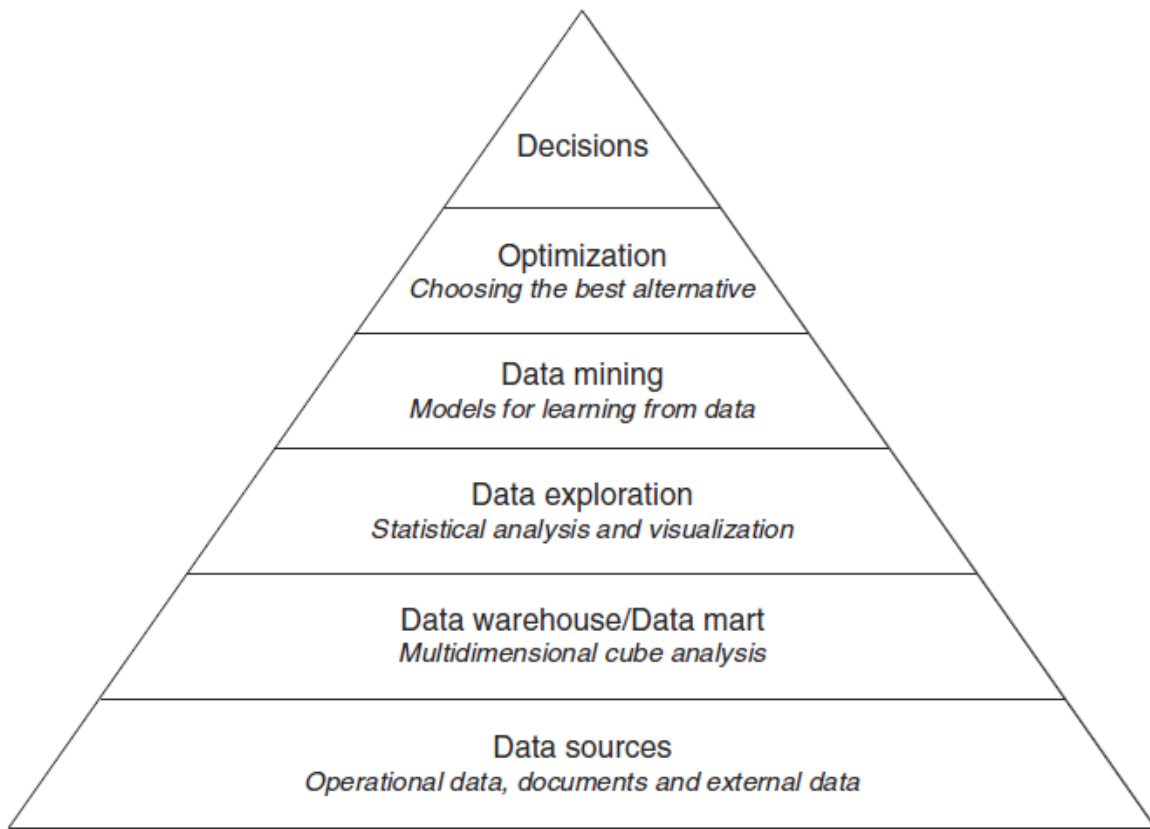
**Data warehouses and data marts.** Using extraction and transformation tools known as *extract, transform, load* (ETL), the data originating from the different sources are stored in databases intended to support business intelligence analyses. These databases are usually referred to as *data warehouses* and *data marts*.

**Business intelligence methodologies.** Data are finally extracted and used to feed mathematical models and analysis methodologies intended to support decision makers. In a business intelligence system, several decision support applications may be implemented.

- Multidimensional cube analysis;
- Exploratory data analysis;



### **Business Intelligence Architectures**



*The main components of a business intelligence system*

**1. Data sources.**

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**2. Data warehouses and data marts**

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**Business intelligence methodologies.**

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- multidimensional cube analysis
- exploratory data analysis
- time series analysis
- inductive learning models for data mining

- optimization models

### 3. Data exploration:

*Passive Business Intelligence Analysis consists of*

1. **Query and Reporting Systems**
2. **Statistical Methods.**

These are referred to as passive methodologies because decision makers are requested to generate prior hypotheses or define data extraction criteria, and then use the analysis tools to find answers and confirm their original insight.

**For instance, consider the sales manager of a company who notices that revenues in a given geographic area have dropped for a specific group of customers. Hence, she might want to bear out her hypothesis by using extraction and visualization tools, and then apply a statistical test to verify that her conclusions are adequately supported by data.**

### 4. Data Mining:

The fourth level includes *active* business intelligence methodologies, whose purpose is the extraction of information and knowledge from data.

These include mathematical models for pattern recognition, machine learning and data mining techniques. Unlike the tools described at the previous level of the pyramid, the models of an active kind do not require decision makers to formulate any prior hypothesis to be later verified. Their purpose is instead to expand the decision makers' knowledge.

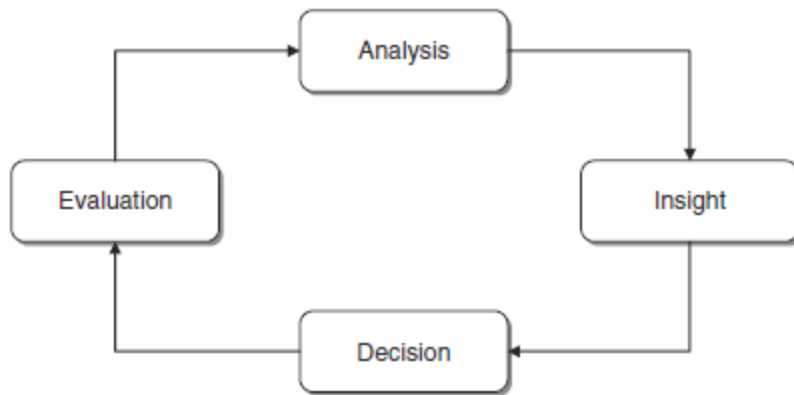
### 5. Optimization.

By moving up one level in the pyramid we find optimization models that allow us to determine the best solution out of a set of alternative actions, which is usually fairly extensive and sometimes even infinite.

### 6. Decision

Finally, the top of the pyramid corresponds to the choice and the actual adoption of a specific decision, and in some way represents the natural conclusion of the decision-making process. Even when business intelligence methodologies are available and successfully adopted, the choice of a decision pertains to the decision makers, who may also take advantage of informal and unstructured information available to adapt and modify the recommendations and the conclusions achieved through the use of mathematical models.

**Cycle of a business intelligence analysis:**



*Cycle of a business intelligence analysis*

#### **Analysis.**

During the analysis phase, it is necessary to recognize and accurately spell out the problem at hand. Decision makers must then create a mental representation of the phenomenon being analyzed, by identifying the critical factors that are perceived as the most relevant. The availability of business intelligence methodologies may help already in this stage, by permitting decision makers to rapidly develop various paths of investigation. For instance, the exploration of data cubes in a multidimensional analysis, according to different logical views, allows decision makers to modify their hypotheses flexibly and rapidly, until they reach an interpretation scheme that they deem satisfactory. Thus, the first phase in the business intelligence cycle leads decision makers to ask several questions and to obtain quick responses in an interactive way.

#### **Insight.**

The second phase allows decision makers to better and more deeply understand the problem at hand, often at a causal level. For instance, if the analysis carried out in the first phase shows that a large number of customers are discontinuing an insurance policy upon yearly expiration, in the second phase it will be necessary to identify the profile and characteristics shared by such customers. **The information obtained through the analysis phase is then transformed into knowledge during the insight phase.** On the one hand, the extraction of knowledge may occur due to the intuition of the decision makers and therefore be based on their experience and possibly on unstructured information available to them. On the other hand, inductive learning models may also prove very useful during this stage of analysis, particularly when applied to structured data.

#### **Decision.**

During the third phase, knowledge obtained as a result of the insight phase is converted into decisions and subsequently into actions. The availability of business intelligence methodologies allows the analysis and insight phases to be executed more rapidly so that more effective and timely decisions can be made that better suit the strategic priorities of a given organization. This leads to an overall reduction in the execution time of the *analysis–decision–action– revision* cycle, and thus to a decision-making process of better quality.

#### **Evaluation.**

Finally, the fourth phase of the business intelligence cycle involves performance measurement and evaluation. Extensive metrics should then be devised that are not exclusively limited to the financial aspects but also take into account the major performance indicators defined for the different company departments.

### **Enabling factors in business intelligence projects`**

Some factors are more critical than others to the success of a business intelligence project: *technologies*, *analytics* and *human resources*.

#### **Technologies.**

Hardware and software technologies are significant enabling factors that have facilitated the development of business intelligence systems within enterprises and complex organizations. On the one hand, the computing capabilities of microprocessors have increased on average by 100% every 18 months during the last two decades, and prices have fallen. This trend has enabled the use of advanced algorithms which are required to employ inductive learning methods and optimization models, keeping the processing times within a reasonable range. Moreover, it permits the adoption of state-of-the-art graphical visualization techniques, featuring real-time animations. A further relevant enabling factor derives from the exponential increase in the capacity of mass storage devices, again at decreasing costs, enabling any organization to store terabytes of data for business intelligence systems. And network connectivity, in the form of *Extranets* or *Intranets*, has played a primary role in the diffusion within organizations of information and knowledge extracted from business intelligence systems. Finally, the easy integration of hardware and software purchased by different suppliers, or developed internally by an organization, is a further relevant factor affecting the diffusion of data analysis tools.

#### **Analytics.**

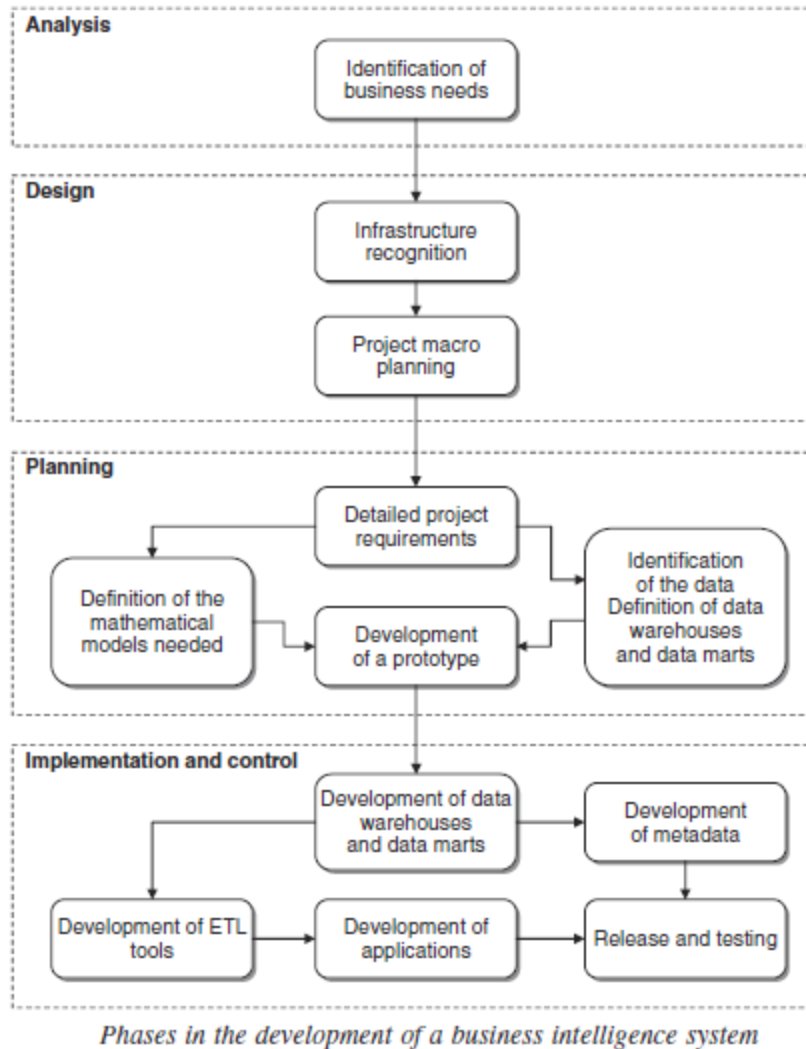
As stated above, mathematical models and analytical methodologies play a key role in information enhancement and knowledge extraction from the data available inside most organizations. The mere visualization of the data according to timely and flexible logical views, as described in Chapter 3, plays a relevant role in facilitating the decision-making process, but still represents a passive form of support. Therefore, it is necessary to apply more advanced models of inductive learning and optimization in order to achieve active forms of support for the decision-making process.

#### **Human resources.**

The human assets of an organization are built up by the competencies of those who operate within its boundaries, whether as individuals or collectively. The overall knowledge possessed and shared by these individuals constitutes the *organizational culture*. The ability of knowledge workers to acquire information and then translate it into practical actions is one of the major assets of any organization, and has a major impact on the quality of the decision-making process. If a given enterprise has implemented an advanced business intelligence system, there still remains much scope to emphasize the personal skills of its knowledge workers, who are required to perform the analyses and to interpret the results, to work out creative solutions and to devise effective action plans. All the available analytical tools being equal, a company employing human resources endowed with a greater mental agility and willing to accept changes in the decision-making style will be at an advantage over its competitors.

#### **Development of a business intelligence system:**

The development of a business intelligence system can be assimilated to a project, with a specific final objective, expected development times and costs, and the usage and coordination of the resources needed to perform planned



#### Analysis:

During the first phase, the needs of the organization relative to the development of a business intelligence system should be carefully identified.

This preliminary phase is generally conducted through a series of interviews of knowledge workers performing different roles and activities within the organization. It is necessary to clearly describe the general objectives and priorities of the project, as well as to set out the costs and benefits deriving from the development of the business intelligence system.

#### Design:

The second phase includes two sub-phases and is aimed at deriving a provisional plan of the overall architecture, taking into account any development in the near future and the evolution of the system in the mid-term. First, it is necessary to make an assessment of the existing information infrastructures. Moreover, the main decision-making processes that are to be supported by the business intelligence system should be examined, in order to adequately determine the information requirements. Later on, using classical project management methodologies, the project plan will be laid down, identifying development phases, priorities, expected execution times and costs, together with the required roles and resources.



**Planning:**

The planning stage includes a sub-phase where the functions of the business intelligence system are defined and described in greater detail. Subsequently, existing data as well as other data that might be retrieved externally are assessed. This allows the information structures of the business intelligence architecture, which consist of a central data warehouse and possibly some satellite data marts, to be designed. Simultaneously with the recognition of the available data, the mathematical models to be adopted should be defined, ensuring the availability of the data required to feed each model and verifying that the efficiency of the algorithms to be utilized will be adequate for the magnitude of the resulting problems. Finally, it is appropriate to create a system prototype, at low cost and with limited capabilities, in order to uncover beforehand any discrepancy between actual needs and project specifications.

**Implementation and control:**

The last phase consists of five main sub-phases. First, the data warehouse and each specific data mart are developed. These represent the information infrastructures that will feed the business intelligence system. In order to explain the meaning of the data contained in the data warehouse and the transformations applied in advance to the primary data, a *metadata* archive should be created, as described in Chapter 3. Moreover, ETL procedures are set out to extract and transform the data existing in the primary sources, loading them into the data warehouse and the data marts. The next step is aimed at developing the core business intelligence applications that allow the planned analyses to be carried out. Finally, the system is released for test and usage.

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Definition of system: