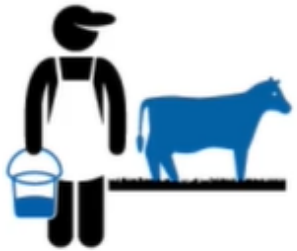
Applied Business Analytics

Week 1 – Introduction to Business Analytics

ISB | Executive Education

A Motivating Example : Dairy Farming in Kenya in 2011



Problems in dairy farming: Uncertain yields from cattle assets (both in milk and money), due to three main reasons:

- Biological cycles such as cattle gestation periods (which affect the milk yield)
- Cattle feed (quantity and quality), diseases
- Volatile market prices

Further problems (specific to Kenya):

- Farmers are small and dispersed over vast areas
- Markets are small and localised

The silver lining:

Mobile penetration was high in Kenya

A Motivating Example : Dairy Farming in Kenya in 2011

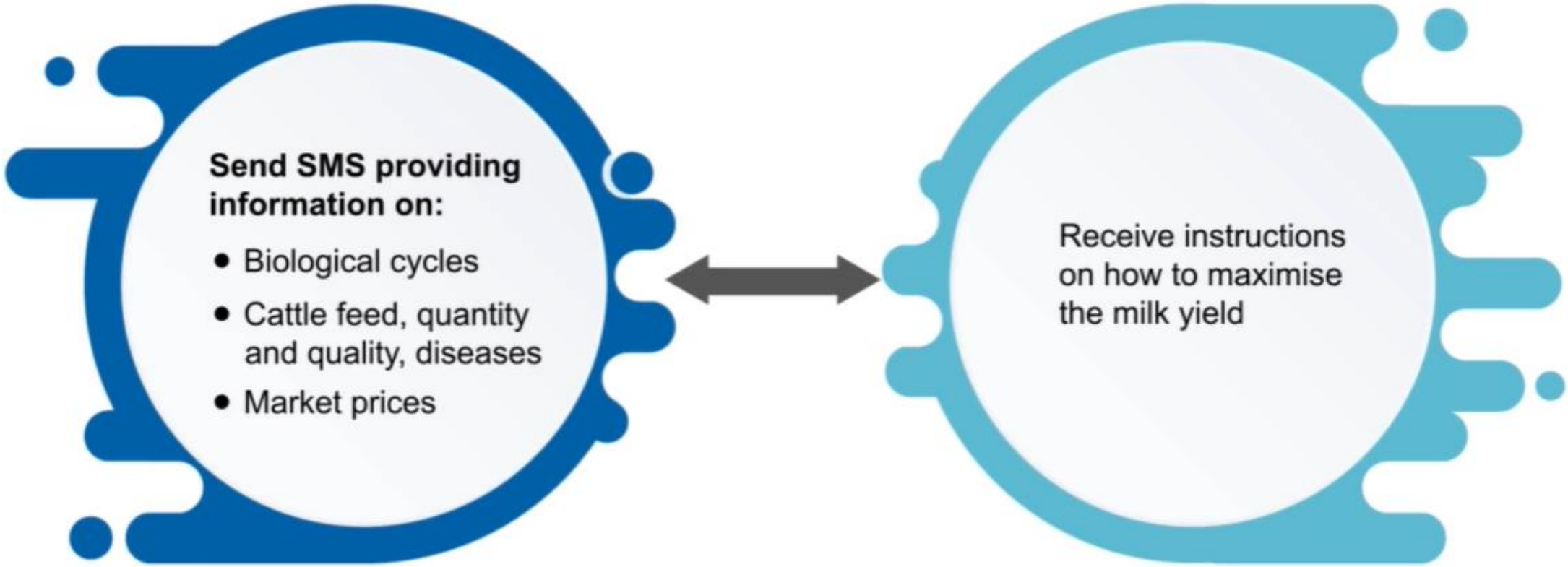
In this scenario, Su Kahumbu Stephanou started a subscription information service named iCow in Kenya

Image source: Image by Bret Hartman for https://fellowsblog.ted.com/meet-su-kahumbu-the-kenyan-agriculturalist helping-farmers-keep-their-herds-healthy-4b926b4a6d7b

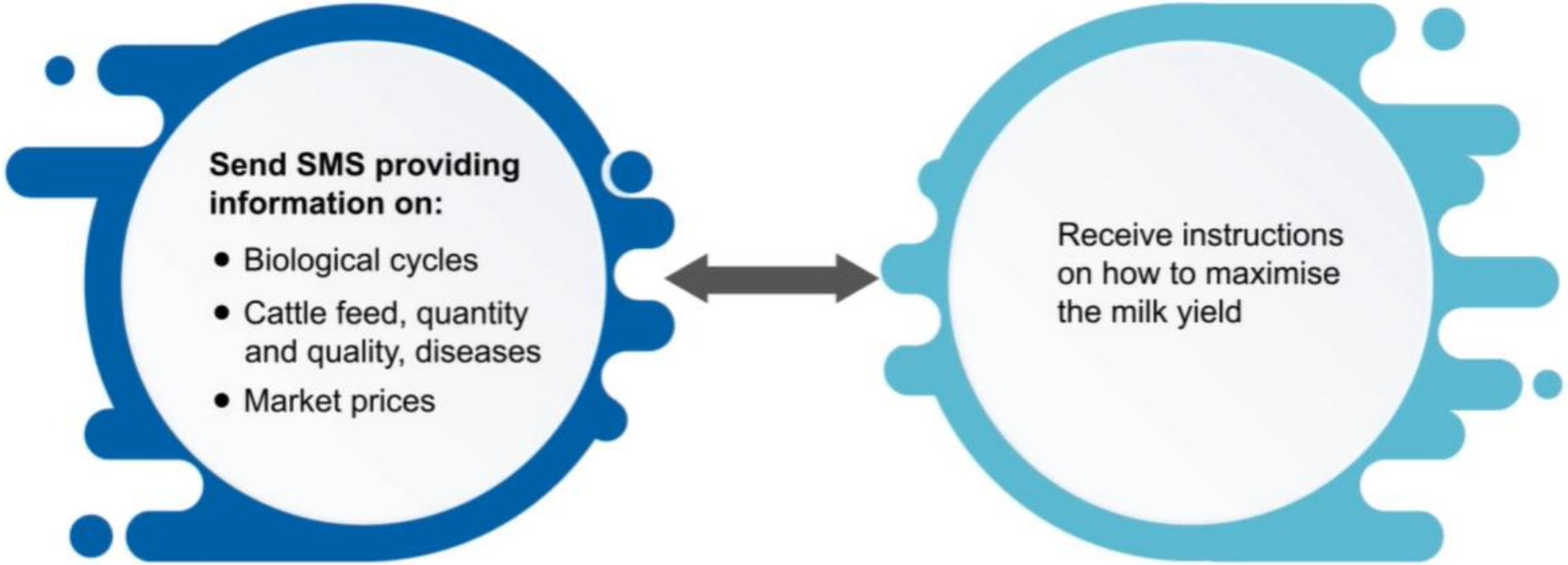
iCow

The iCow Story

How iCow worked



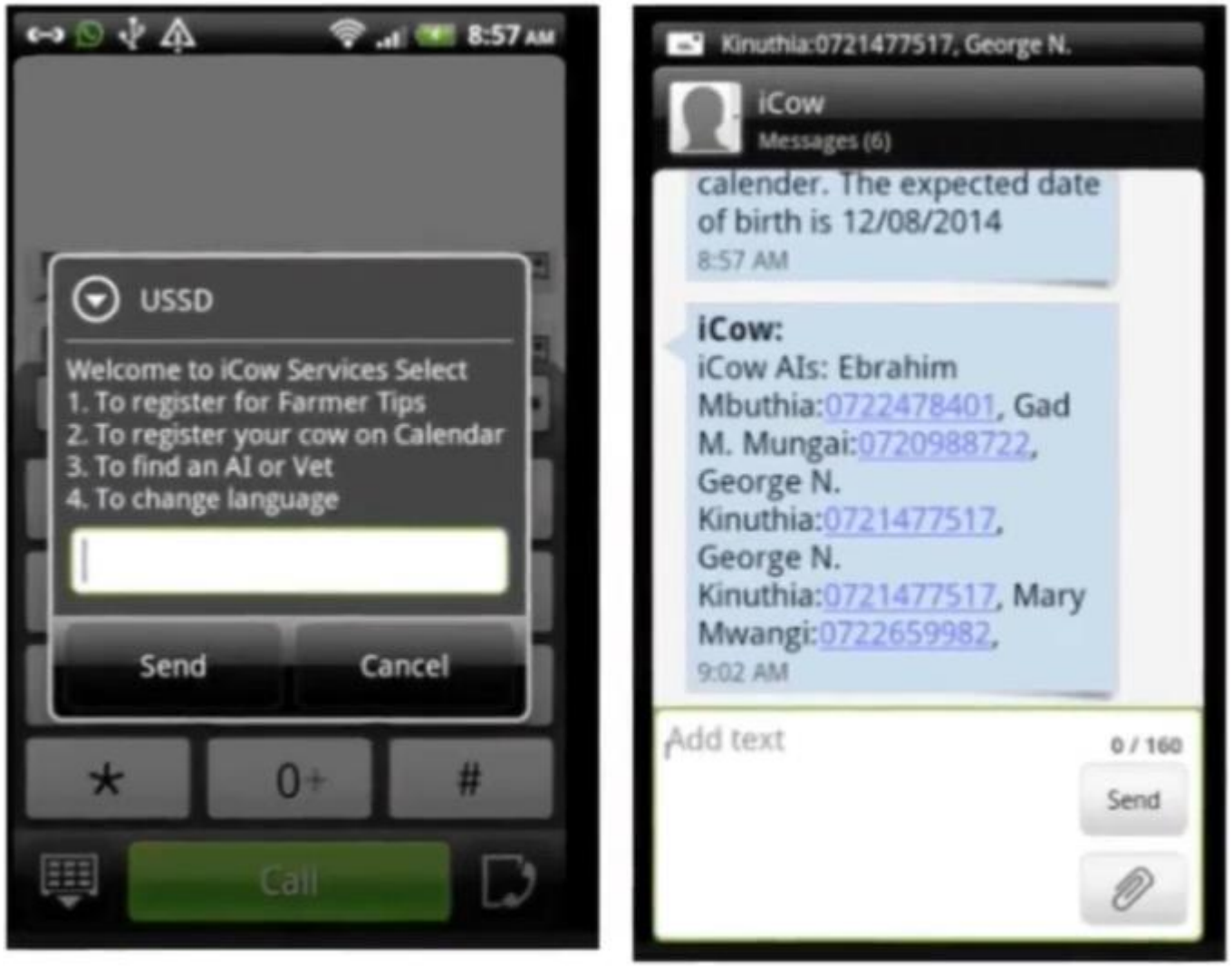
The iCow Story



- In its first year in 2011, 42,000 people signed up
- This in turn helped Kahumbu build a data repository containing livestock data, health and yield data, quantity and quality data on dairy yields and milk production nationwide

The iCow Story

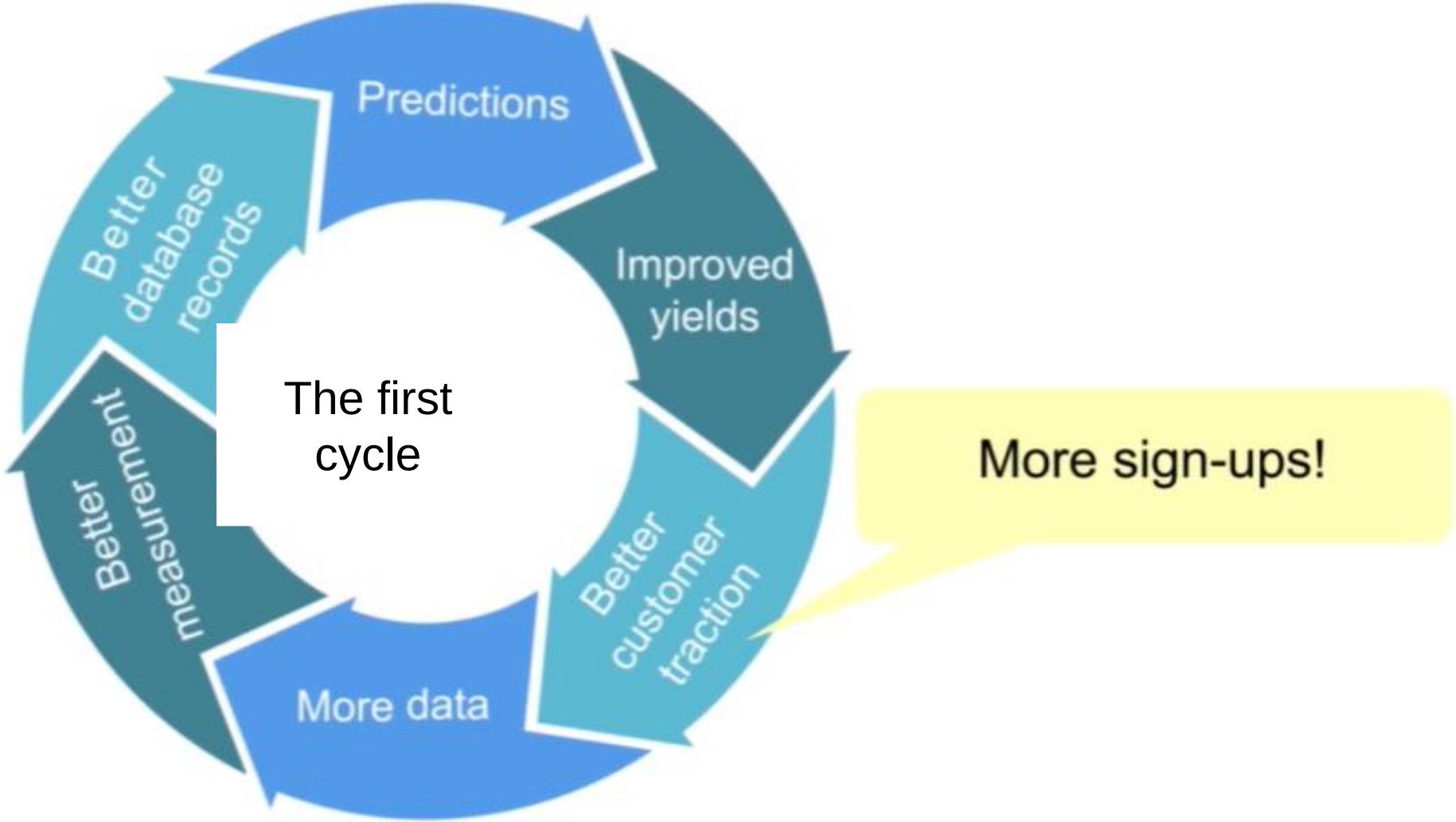
Registration of a cow on iCow:



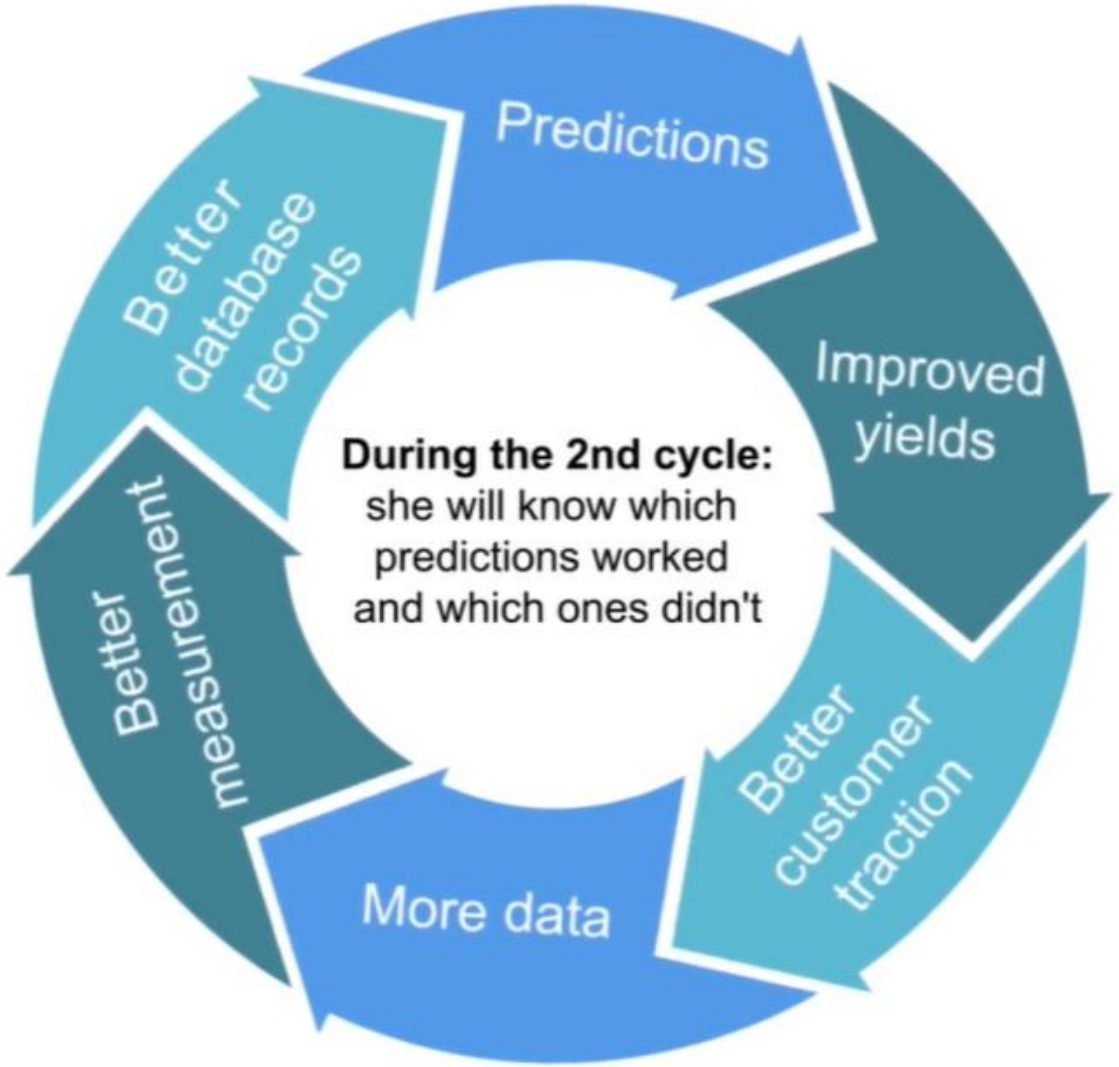
The iCow Story

- In the beginning, Kahumbu started with little or no data and relied primarily on theory and guesswork
- Later, when the data started flowing in, analytics kicked in

Role of Analytics in the iCow Story



Role of Analytics in the iCow Story



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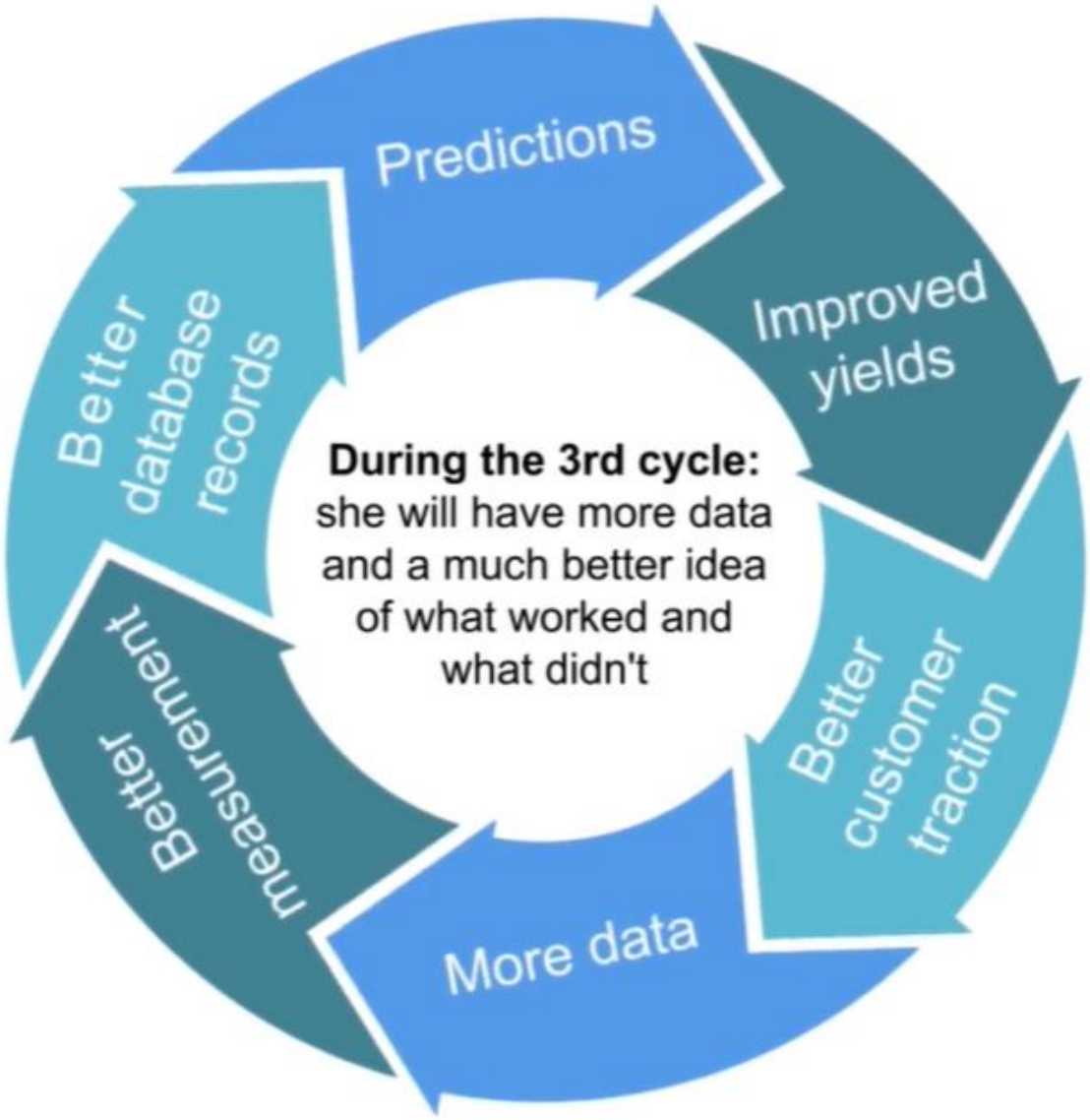
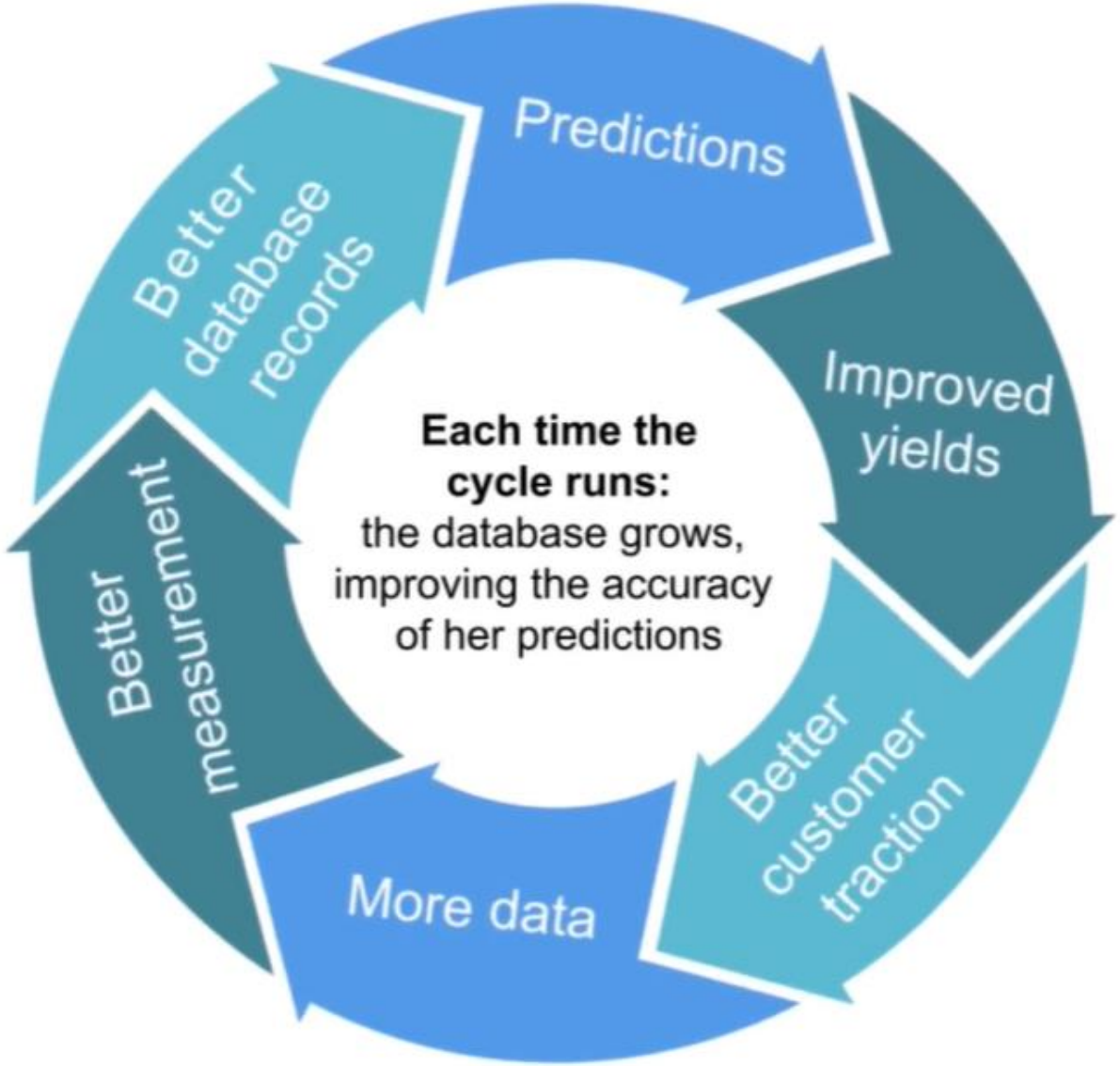
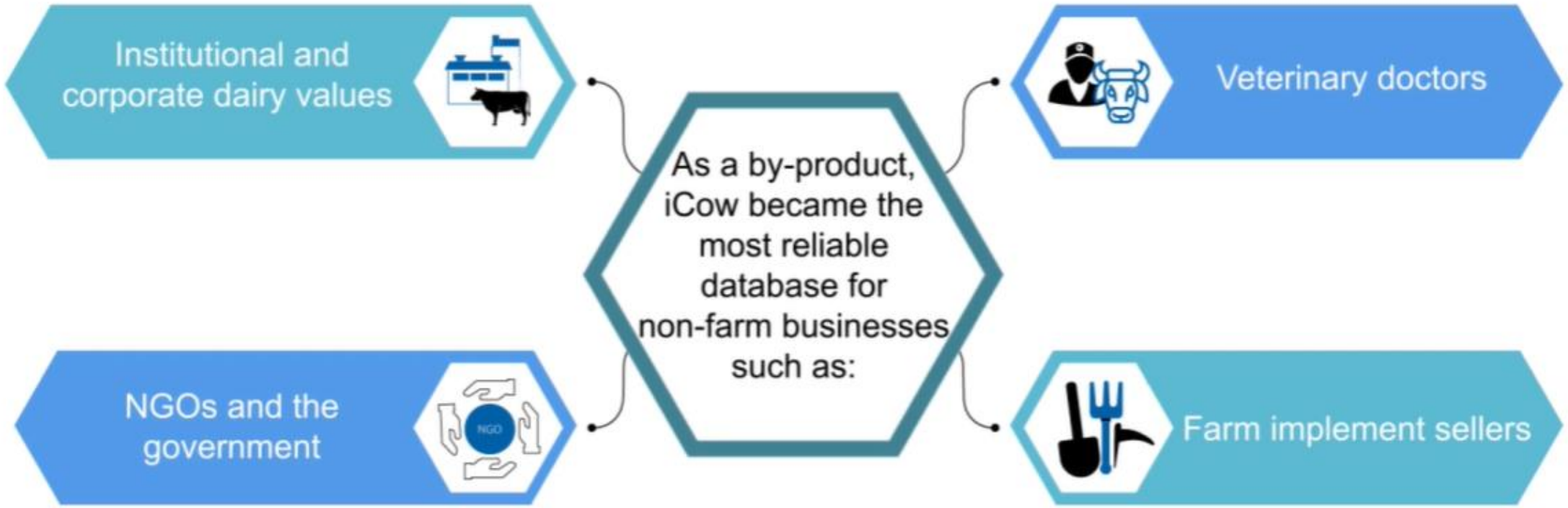


Role of Analytics in the iCow Story



The iCow Story: Offering Reliable Information



The iCow Story

iCow could organically expand:

- its subscription business into value-added services for farmers
- its platform to offer B2B services to both small and large farmers

The iCow Story: Customer Valued Derived

- The average Kenyan farmer owned three cows
- Within seven months of using iCow, farmers reported a 33% jump in yield
- This was equivalent to owning a fourth cow
- Annually, the yields would increase by 50%

- Since iCow services were low-priced, for every $1 farmers spent, they saw the returns of 7,600% ($77)

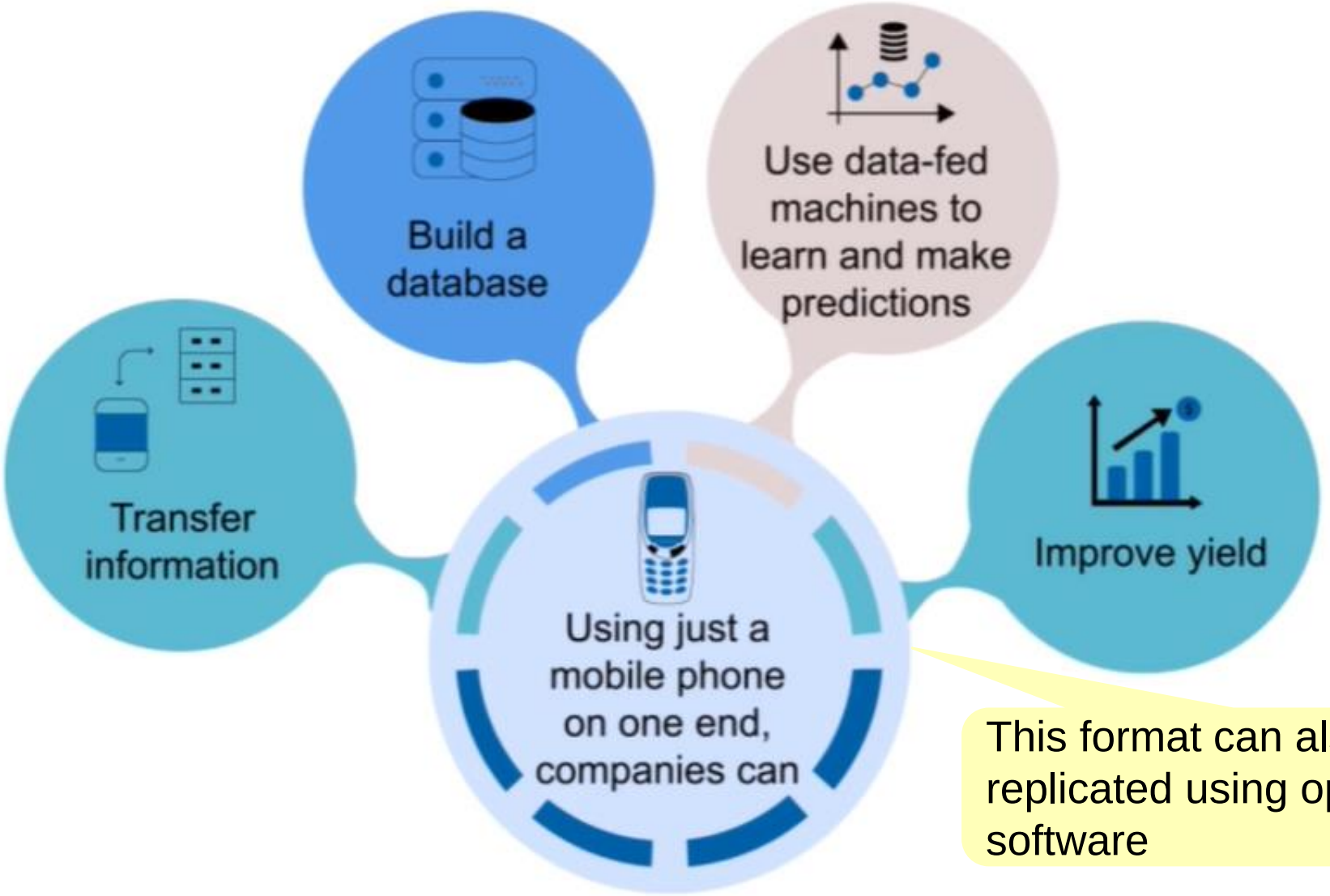
- Simplicity and convenience- farmers only needed to use a simple feature phone to avail of iCow's benefits

The iCow Story

The iCow success story:

Low end analytics not only helped yield huge returns but also created social benefits for farmers

How iCow's Template Can Be Used by Other Countries



This format can also be replicated using open-source software

iCow's Example: Conclusion

Kahumbu's problem statement:
To optimise dairy yield (Y) given a set of input variables (X)

Y variable (dependent)	X variable (input)
Dairy yield	Biological cycles of cattle
	Cattle feed
	Volatile market prices

Solution:
Use a model that predicts how inputs influence the outcome, a model that predicts what-ifs

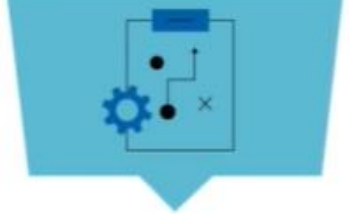
This process of predicting input changes to outcome changes and mapping them is called modelling

ICow's Example: Conclusion

Problem statement:
To optimise dairy yield (Y) given a set of input variables (X)

Solution:
Use a model that predicts how inputs influence the outcome, a model that:

Learns on its own



Makes predictions for individual cows

Mine data for patterns and match patterns

iCow's Example: Conclusion

- Data is the primary asset and the raw material from which we extract insight
- But data needs analytics

What is Business Analytics?

Business analytics is the process of connecting data, imposing structure on it, feeding data into a machine, knowing what modelling is possible by the machine and understanding how the machines learn

Business Analytics

Conceptual questions:

- What is a business?
- What are the objectives of a business?
- What is analytics? What does it do?
- What is data? Where does it come from?

The Objective of a Business

The two fundamental economic axioms

Axiom 1	Axiom 2
Firms exist to maximise economic profits	Consumers exist to maximise utility

An axiom is a statement that can neither be proved nor disproved

The Objective of a Business

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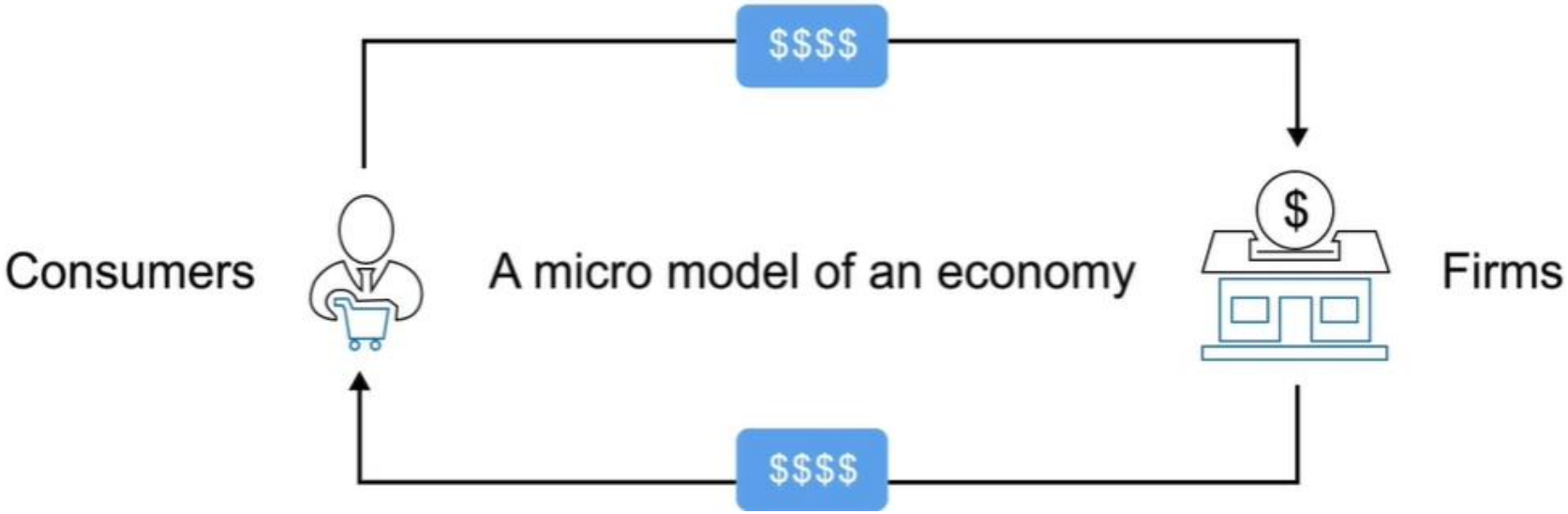


The Objective of a Business

Maximising profits

Profit = revenue – cost → (Supply side of the equation)

Operational costs
(OM domain)

Regulatory and
compliance costs
(Accounting domain)

Capital costs
(Finance domain)

Each domain tries to minimise its respective costs in order to meet the goal of maximising profits

The Objective of a Business

Maximising profits

Profit = revenue – cost

(Demand side of the equation)

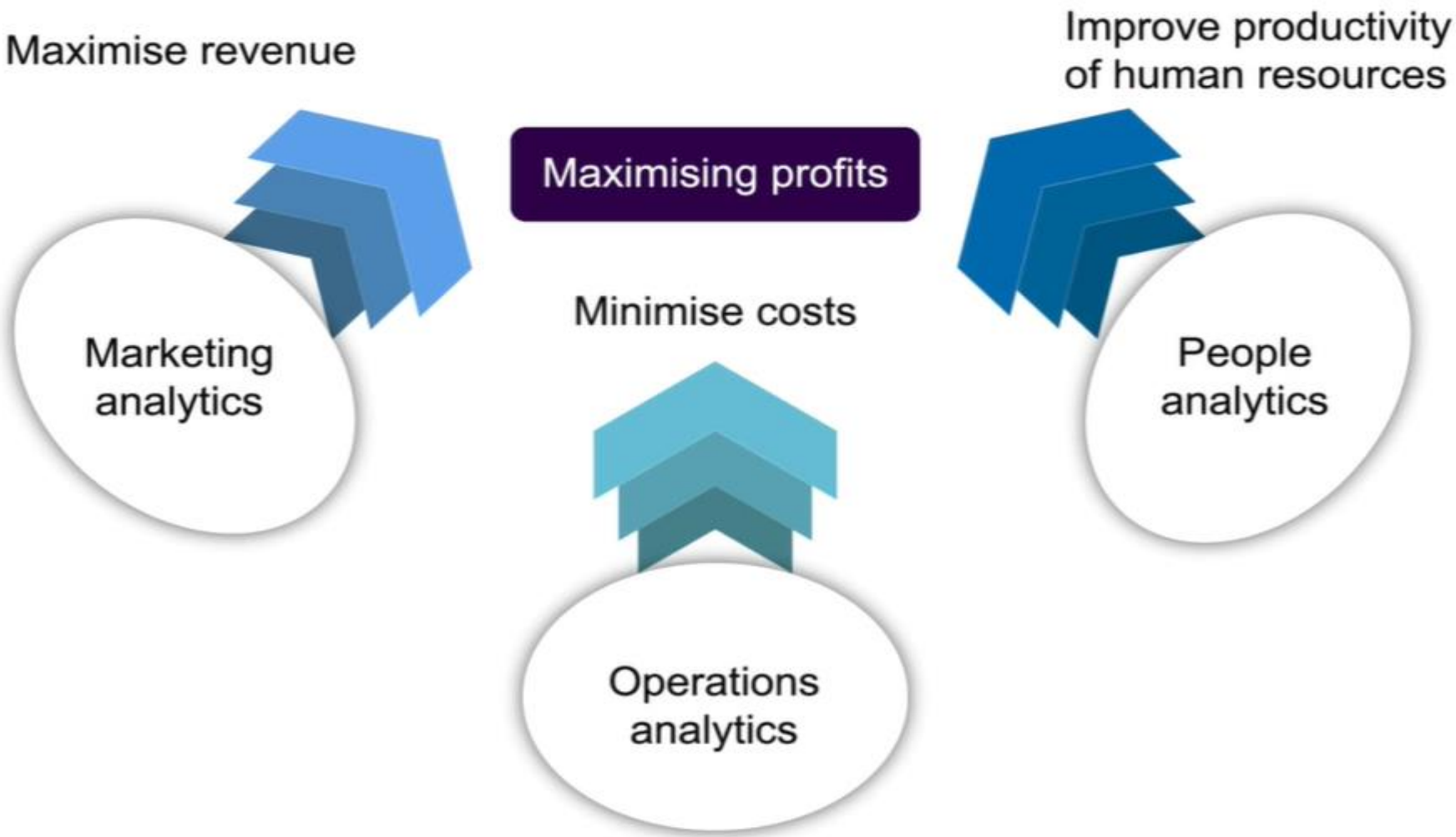
Sales and marketing

Sales and marketing contributes to maximising profit by maximising revenue

Different Functions of a Business

- Different business functions including sales and marketing, operations, accounting, corporate finance constitute an enterprise
- These are different functional parts of an enterprise
- Each of these functions yields its own analytics

How Different Functions Contribute to Profits

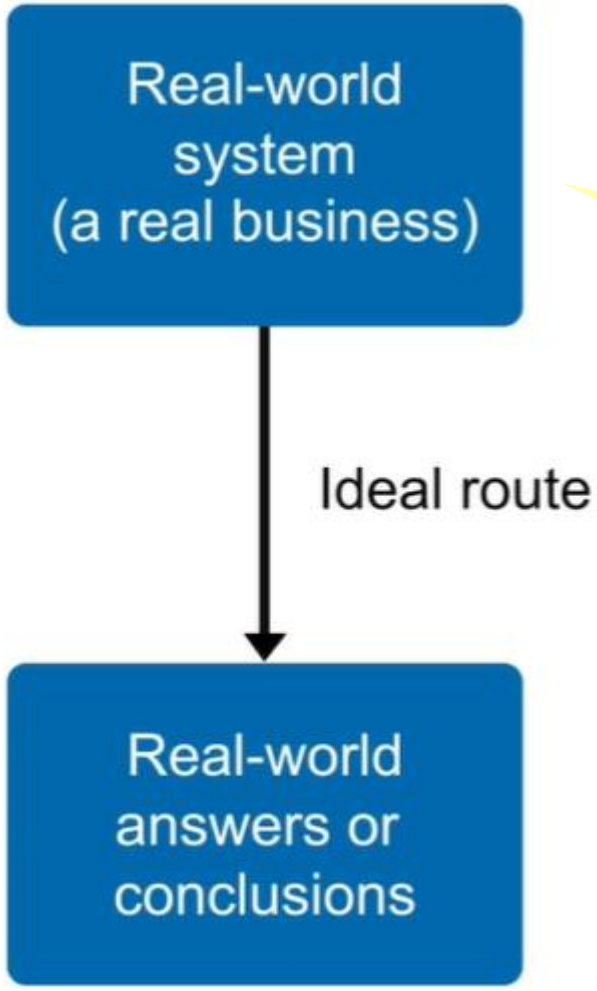


Market Power of a Firm

A firm will have market power if it does well on the demand side or the supply side

What Is Analytics

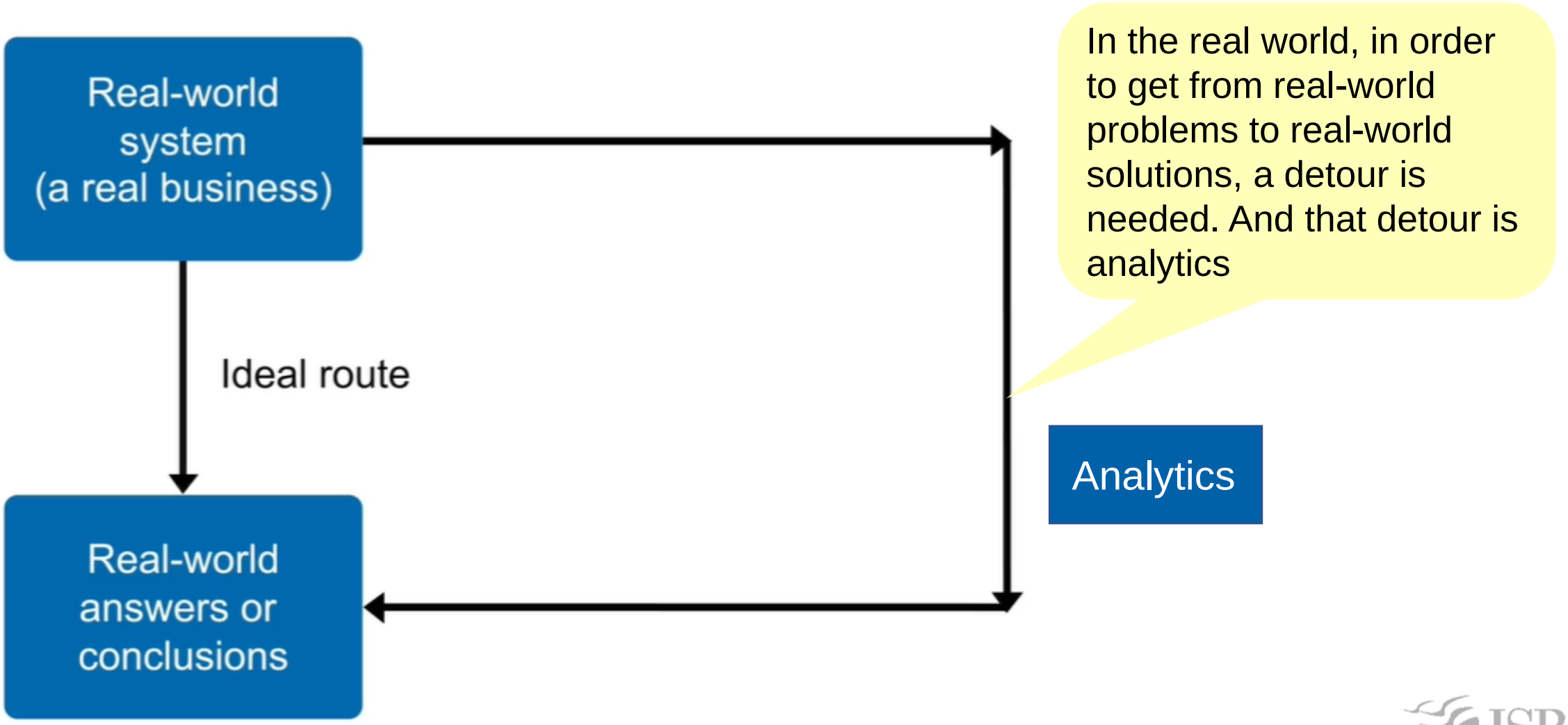
The anatomy of analytics



A real business that faces real constraints, challenges and questions

What Is Analytics

The anatomy of analytics



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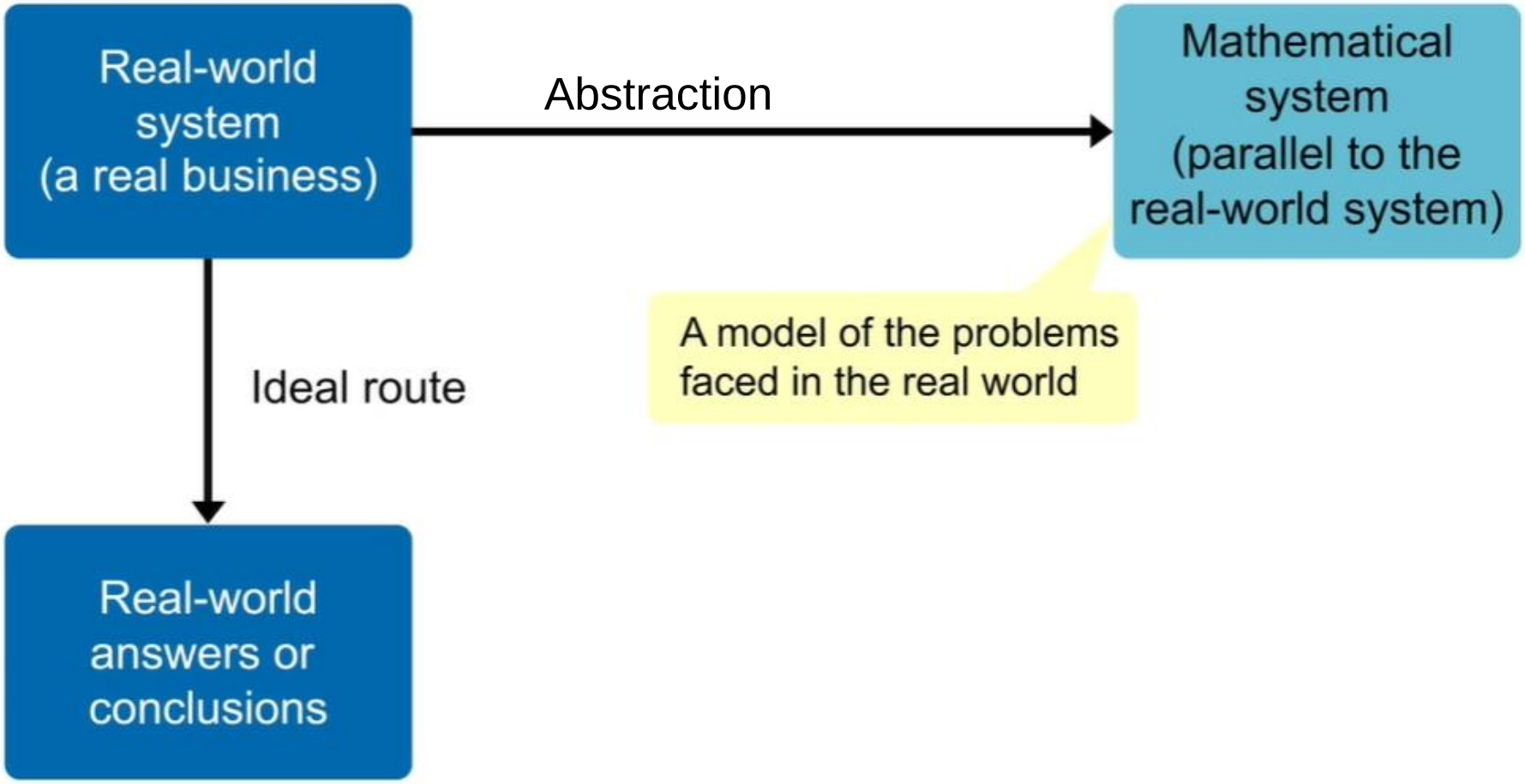
The anatomy of analytics



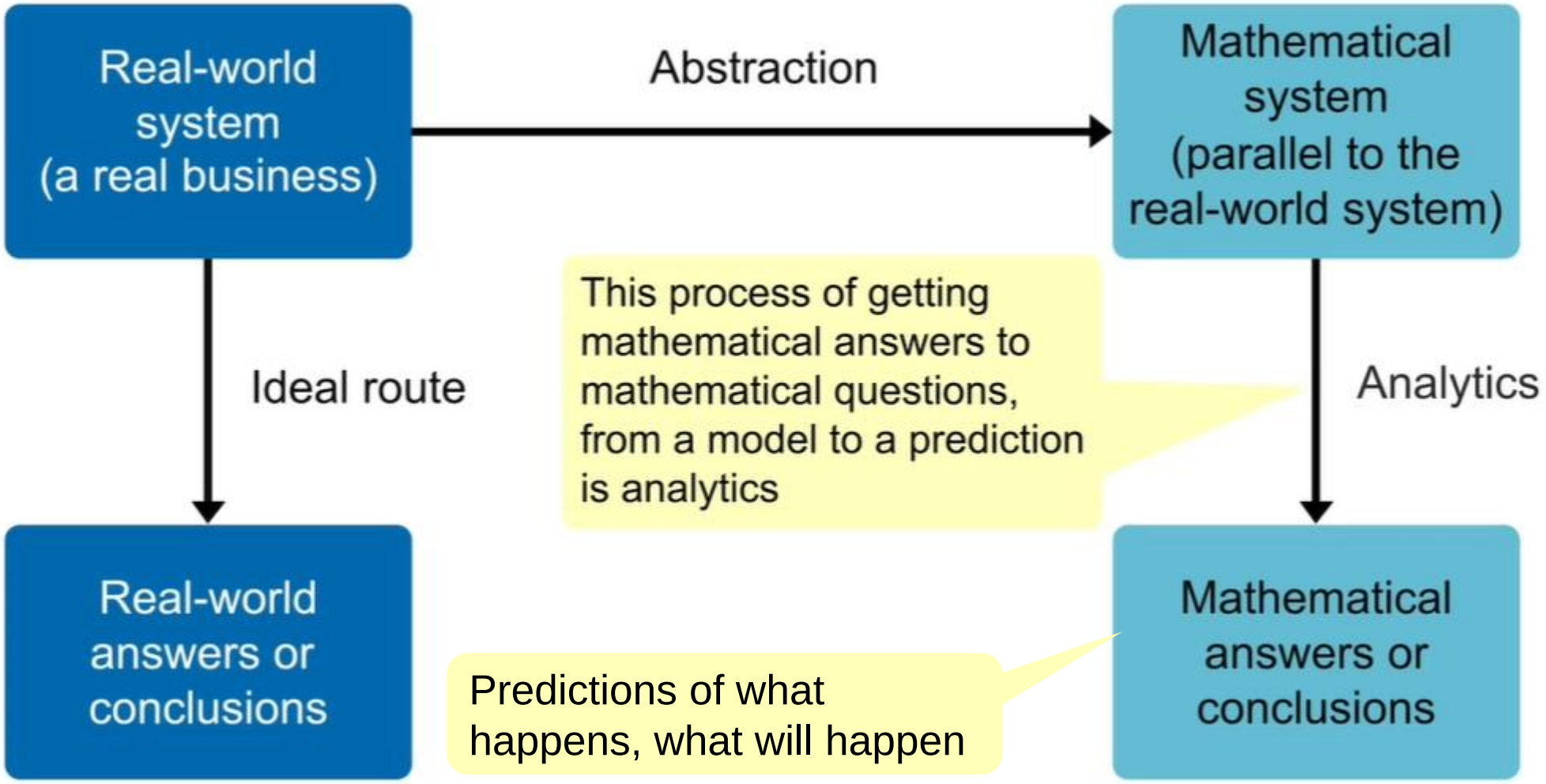
How the Detour of Analytics Works

In order to get from real-world problems to real-world solutions, a mathematical model needs to be built

Building a model is necessary because it helps explore different possibilities and optimise outputs

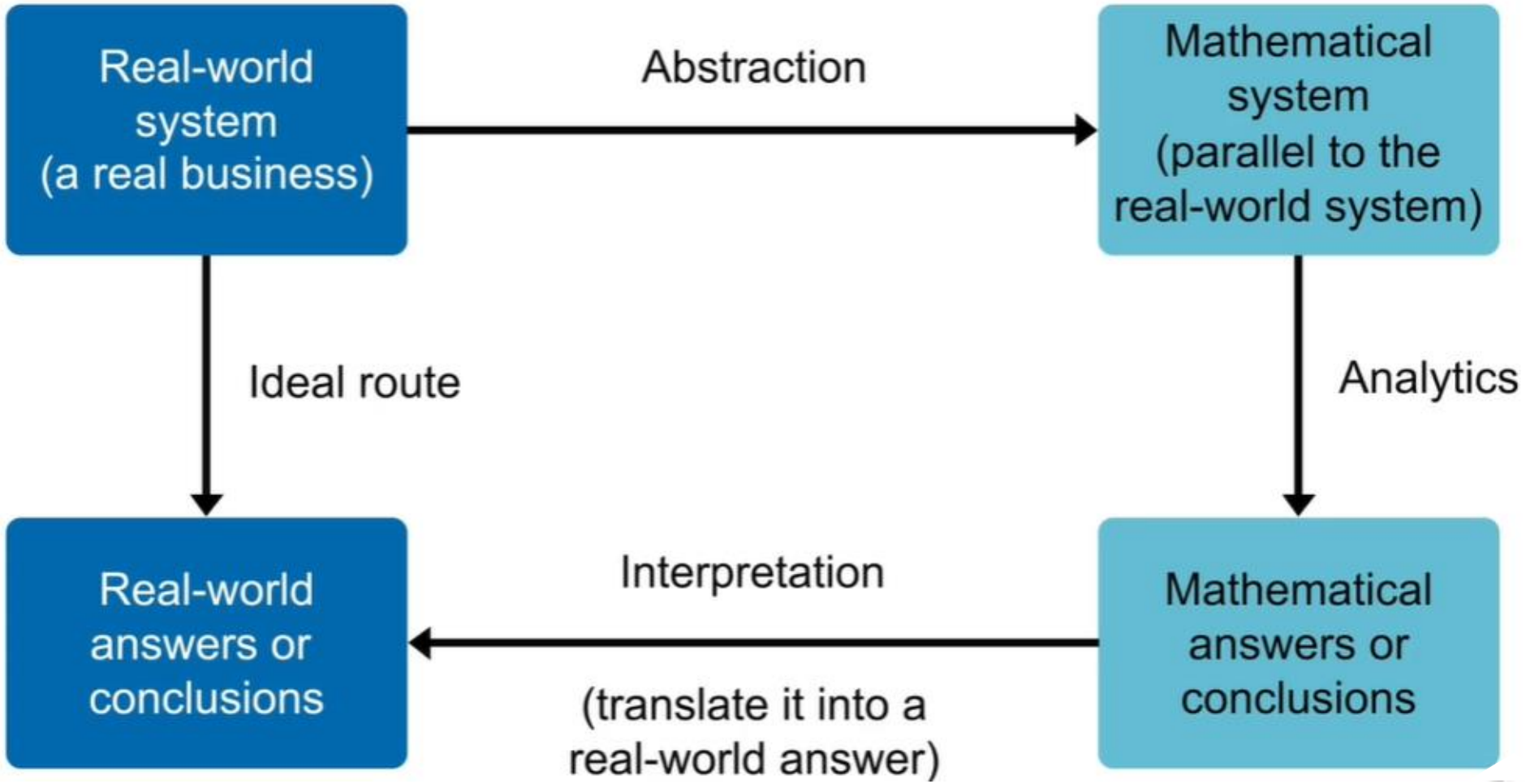
What Is Analytics

The anatomy of analytics



What Is Analytics

The anatomy of analytics



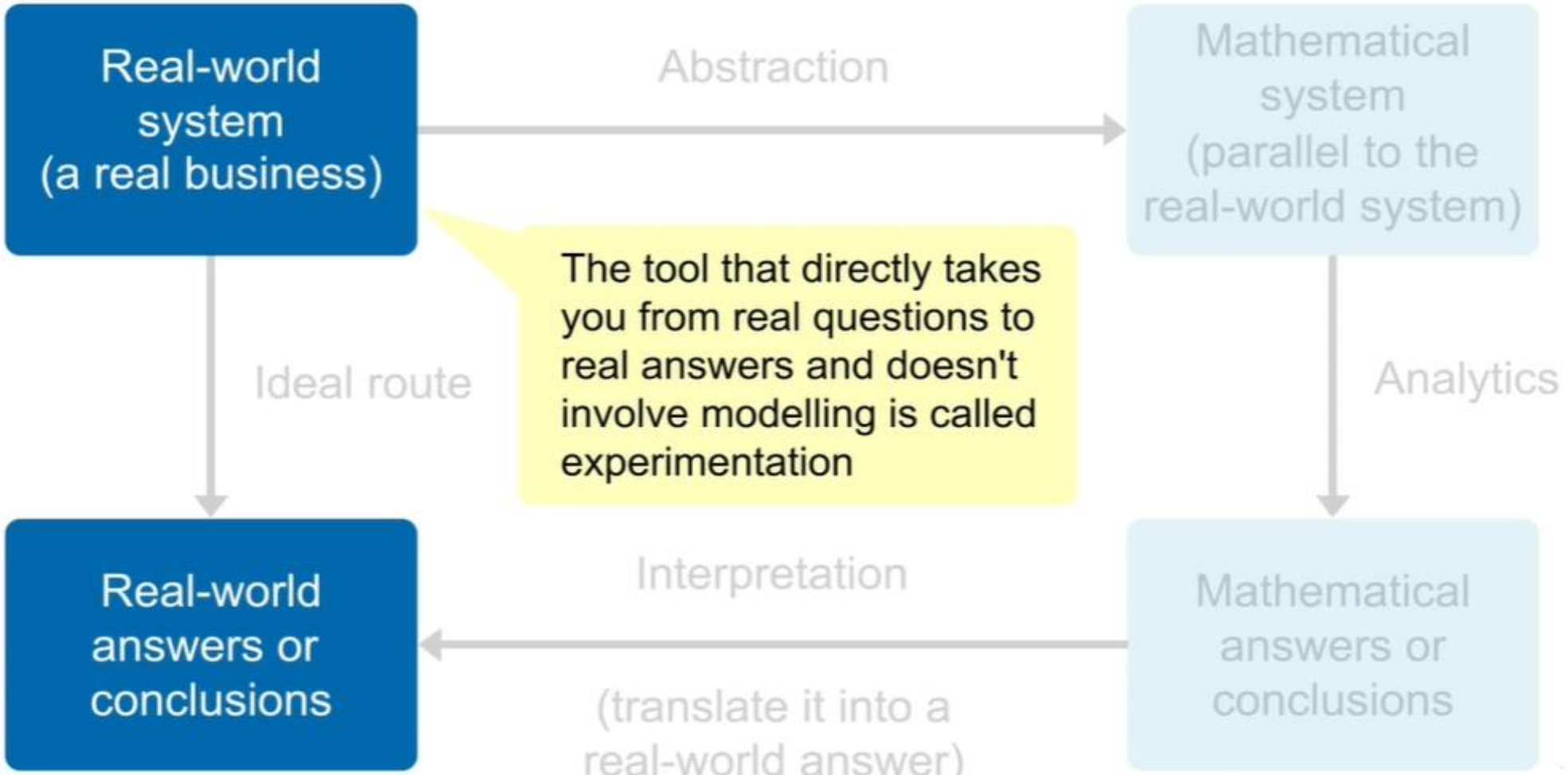
Why Analytics Is Useful

Analytics de-risks your job because:

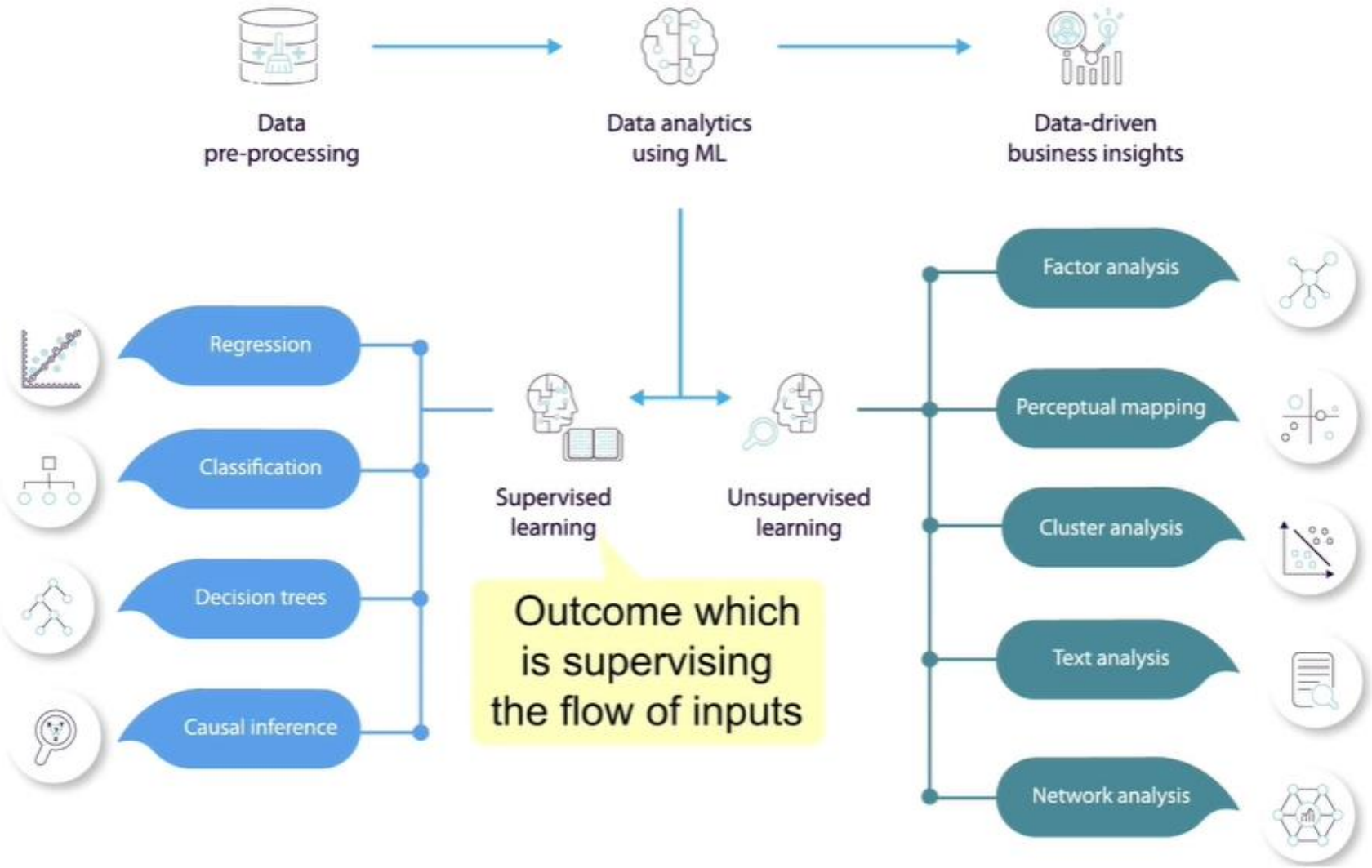
It allows you to make mistakes in a mathematical model without any real-world cost implications

What Is Analytics

The anatomy of analytics



Business Analytics Programme Map



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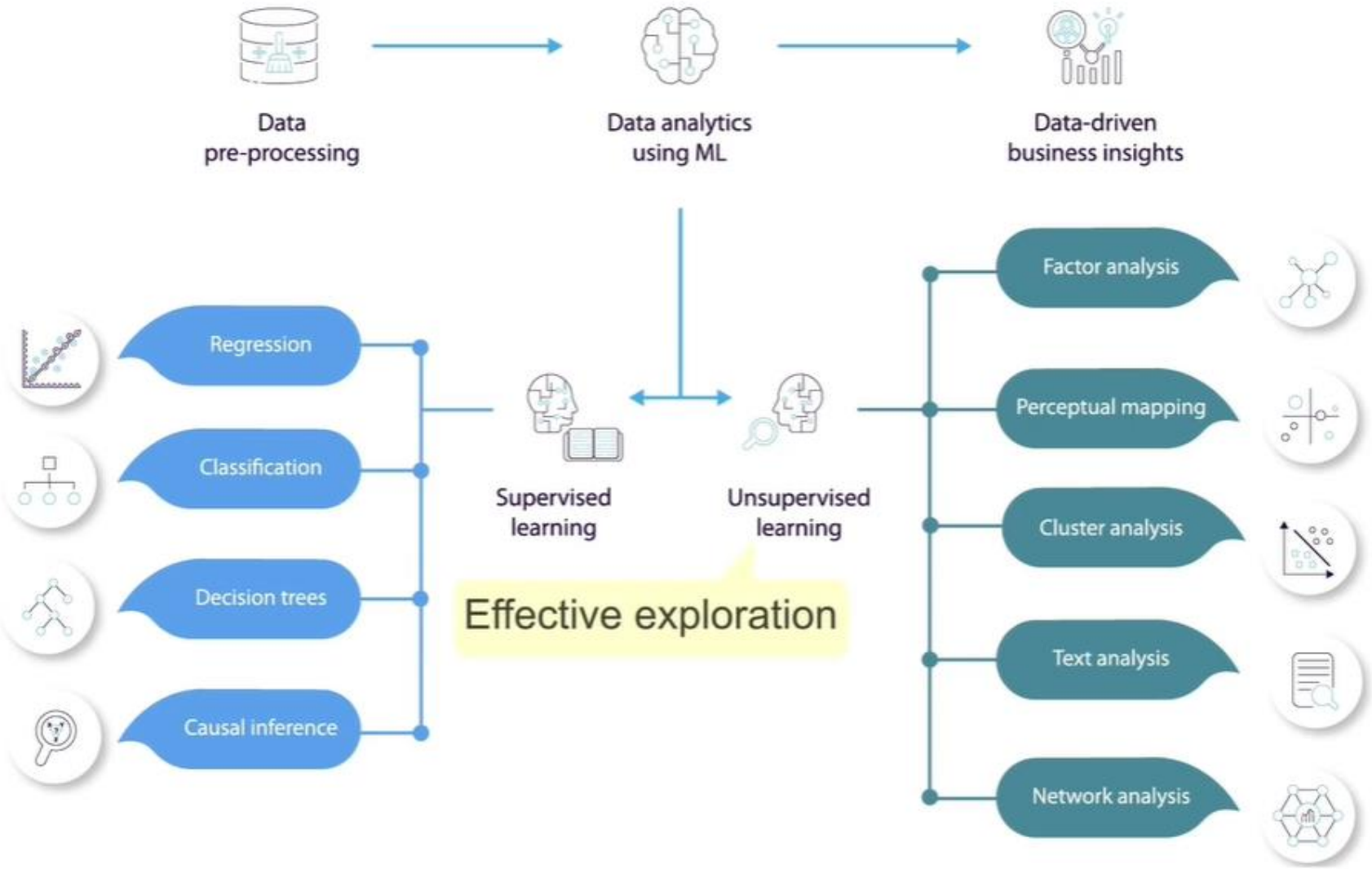

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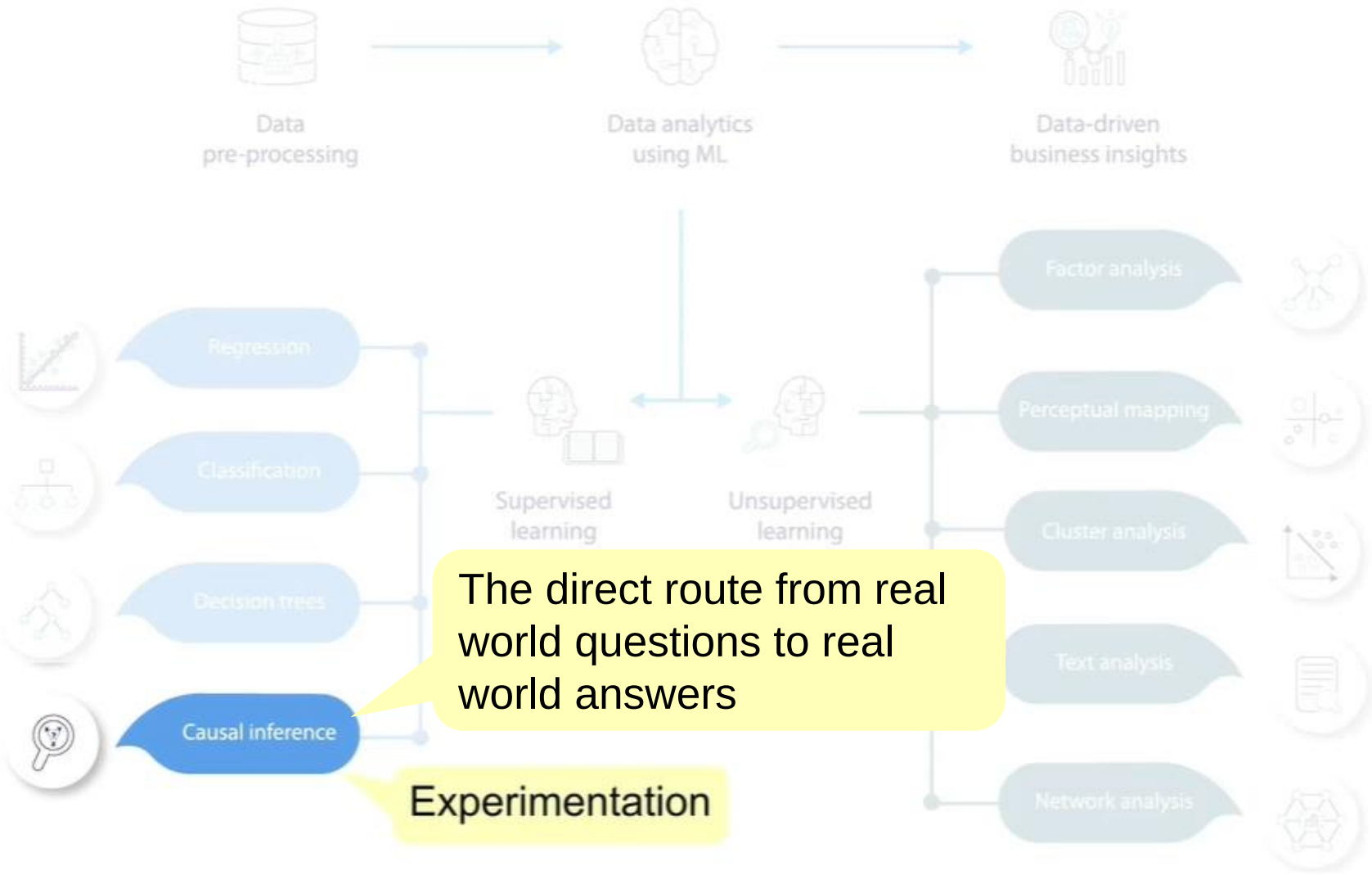


Problem Formulation

Problem formulation is like building a box within which we find solutions

- A box that's too small will not provide optimal solutions
- A box that's too big will become time and effort-intensive to find the right solution

The Anatomy of a Business Problem

Musings of a decision-maker and country head for a corporation

"Sales fell short last year. But sales would've approached target except for six territories in two regions where results were poor. Of course, we implemented a price increase across-the-board last year, so our profit margin goals were just met, even though sales revenue fell short. Yet, two of our competitors saw above-trend sales increases last year. Still, another competitor seems to be struggling, and word on the street is that they have been slashing prices to close deals. Of course, the economy was pretty uneven across our geographies last year and the two regions in question, were weak anyway, particularly so last year. Then there was that mess with the new salesforce compensation policy coming into effect last year. One of the two weak regions saw much salesforce turnover last year....."

Business Problems

Question on Business Problems

Is reality orderly?

- No. Reality is not orderly, but messy
- Life seldom simplifies issues (As in textbook, once you see the question, you know the solution is given in the question itself along with the book and the chapter it is from. So, you know which way to start thinking. But in life it is exactly opposite. You don't even know where to start with

The Medical Analogy for Business Problems

Symptoms versus ailments

A symptom is the visible manifestation of an underlying problem (the ailment)

If a business is sick, fighting the symptoms may not be enough to cure the ailment

Decline in sales is the most common symptom of a sick business

The Medical Analogy for Business Problems

Symptoms and possible ailments in a business

- The problem is diagnosed by looking at the symptoms
- Here, the problems could be interacting with one another

The Medical Analogy for Business Problems

- In businesses, using data can be a fast and cheap tool to narrow the field of ailments (problems)
- The data required to solve the problem depends on how the problem is formulated

Problem Formulation Framework

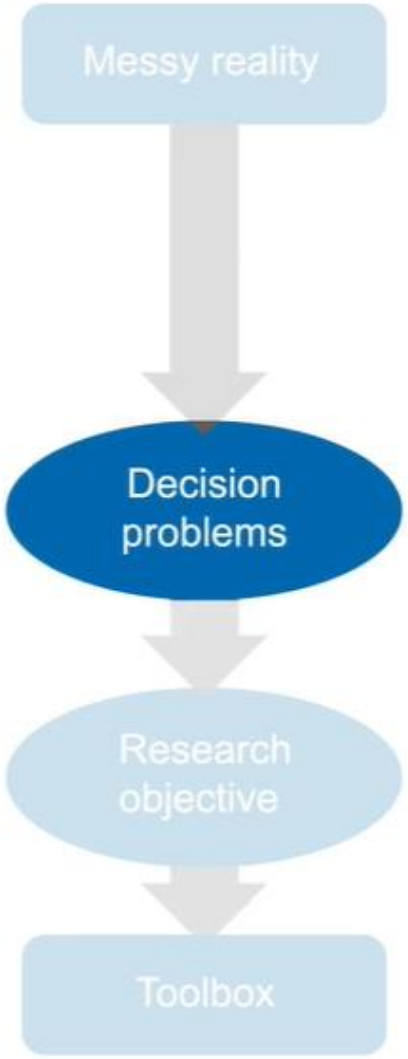
Problem Formulation Framework

Probable causes:

- Product line is obsolete
- Customer connect is ineffective
- Product pricing is uncompetitive

These come from exploratory research which helps shortlist the major probable causes

Exploratory tools help us extract major problem heads from messy reality
Once we do this, we move from messy reality to a decision problem

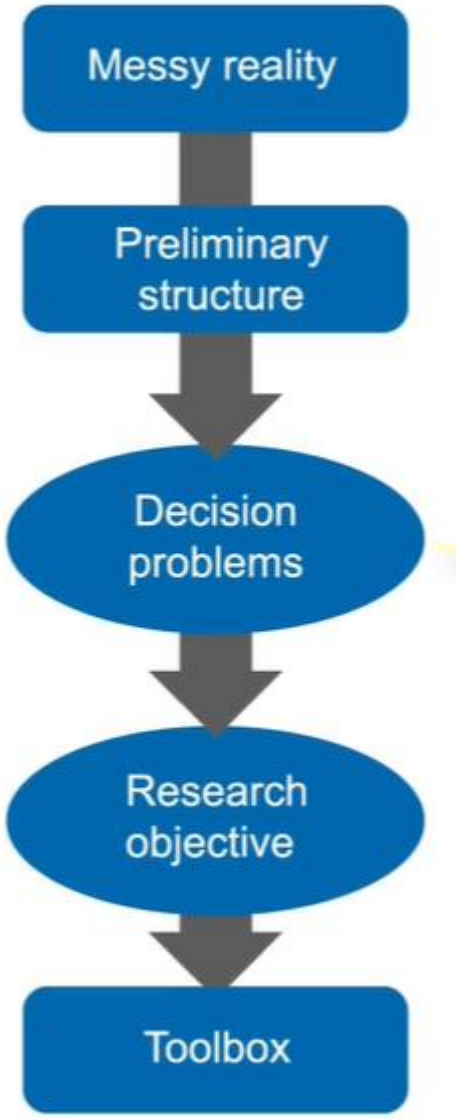


Problem Formulation Framework

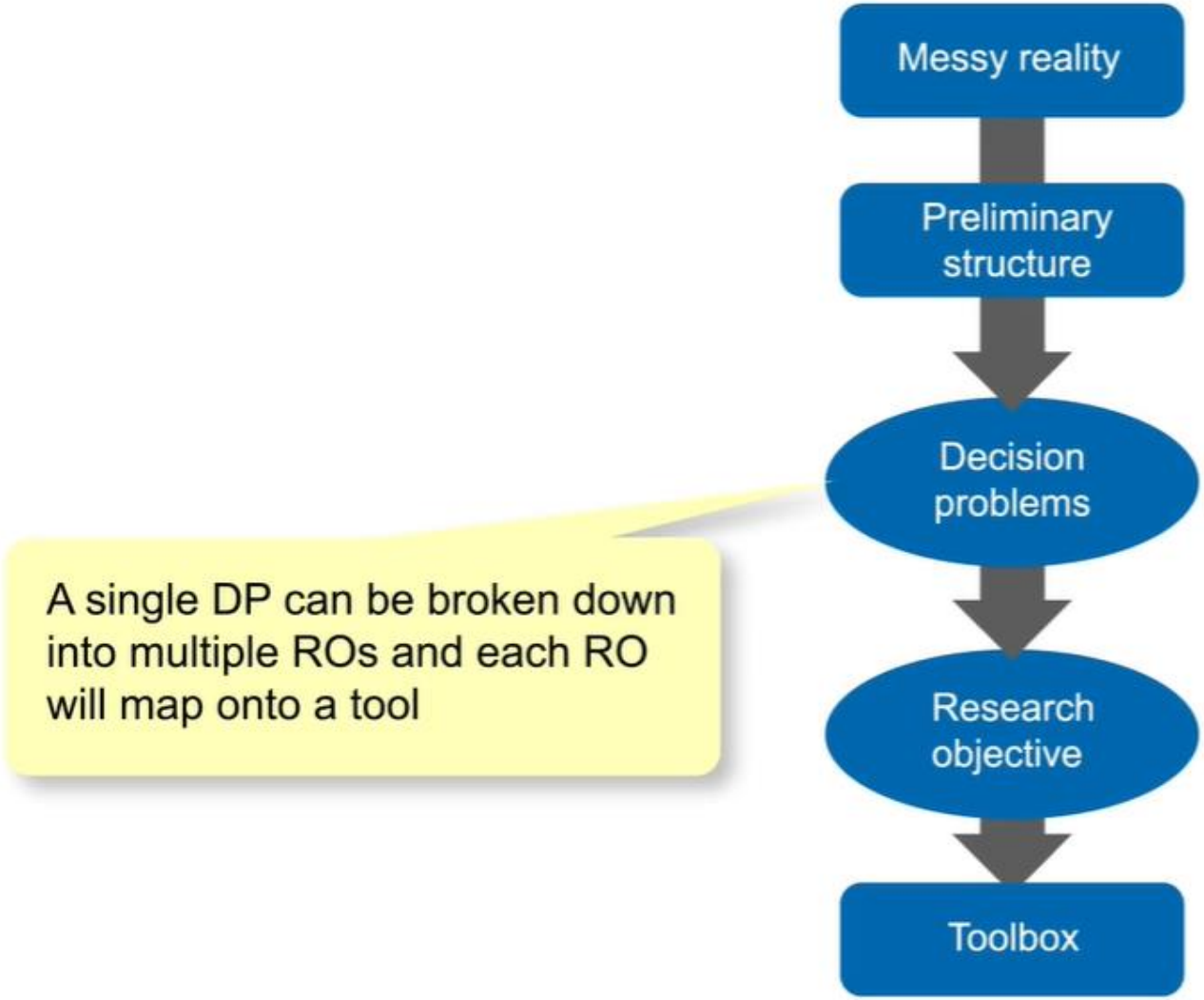
Once we move from messy reality to a set of DPs, we impose preliminary structure on messy reality

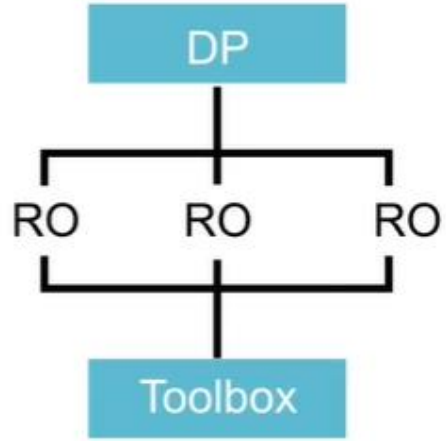
Problem Formulation Framework

- May not contain sufficient information to map directly onto tools
- So another level of refinement may sometimes be needed (RO)



Problem Formulation Framework





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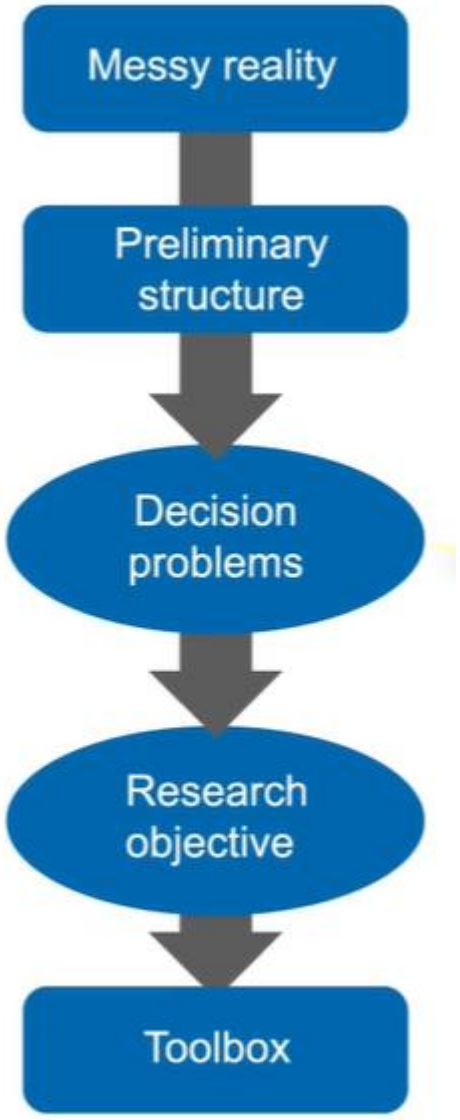
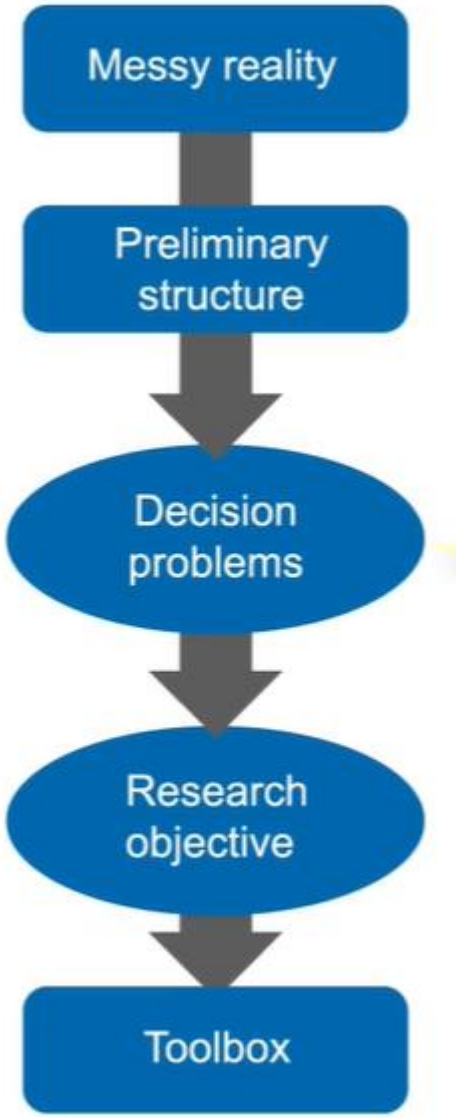
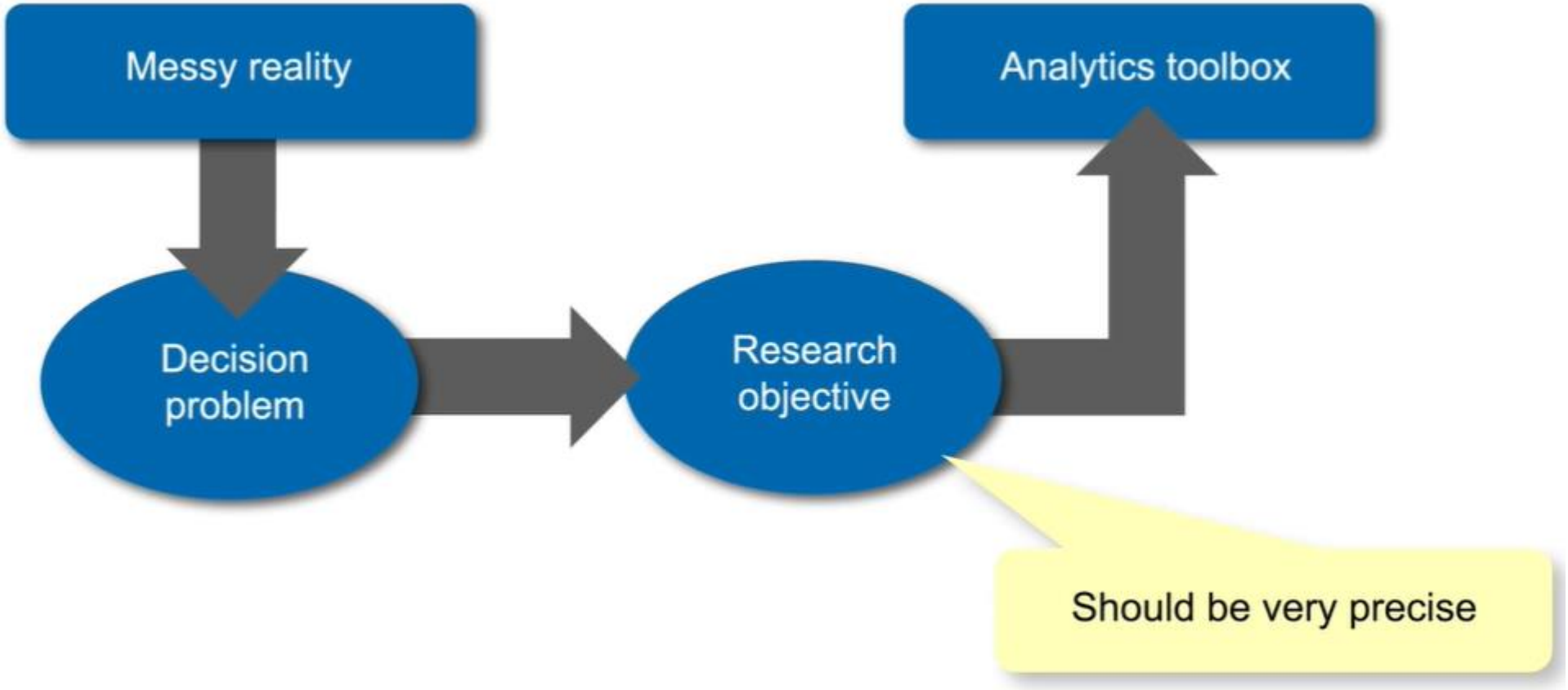


Problem Formulation Framework

The two-way stations to move from messy reality to analytics tools are decision problems and research objectives



The Anatomy of a Research Objective



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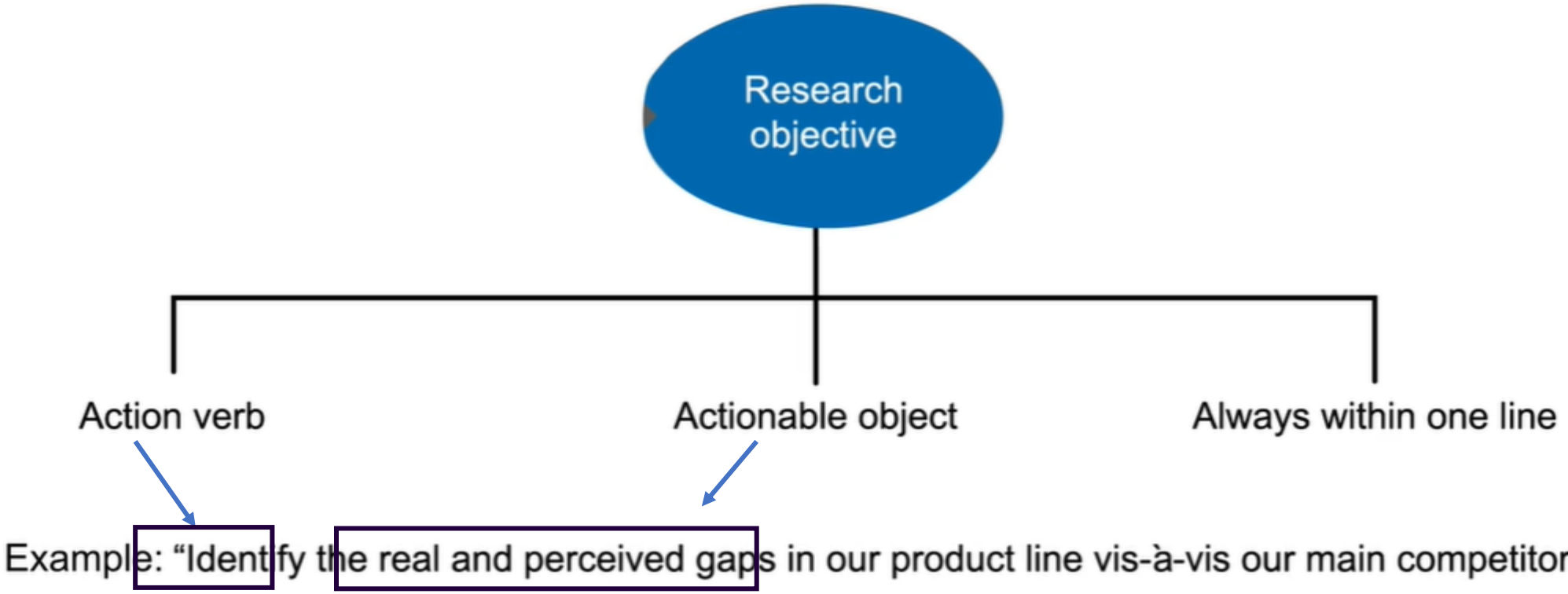


Problem Formulation: Examples of Research Objectives

	Verb	Actionable objects
1	Identify	Problems, opportunities, choice criteria...
2	Define	Concept, design, potential...
3	Describe	Design process, usage, work environment...
4	Explore	Perceptions, reactions, remedies...
5	Generate	Hypotheses, alternatives, explanations...
6	Evaluate	Feasibility, attractiveness, potential...
7	Select	Product, concept, ad execution...
8	Test	Preference, direction, ad execution...
9	Measure	Growth, size, frequency...
10	Priortise	Segments, needs, opportunities...
11	Monitor	Trends, competition, events...
12	Track	Spending, satisfaction, awareness...

Once the RO is clearly defined, the toolbox is ready to open and deploy

What is Business Analytics: Summary

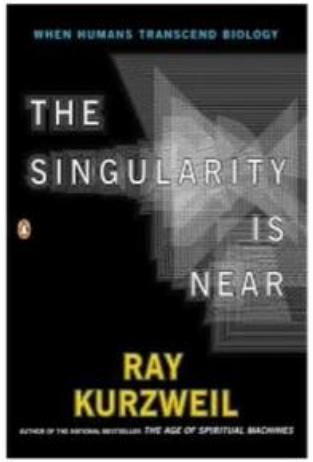
iCow's example demonstrated that analytics can be very powerful to solve real-world business problems even in a low-tech environment

Conceptual preliminaries to understand the anatomy of a business are based on questions such as "what are the objects of a business?" and "what is data analytics?"

The problem formulation framework for solving business problems demonstrated that it is important to precisely formulate problems so that the tools that we have will have maximum ROI

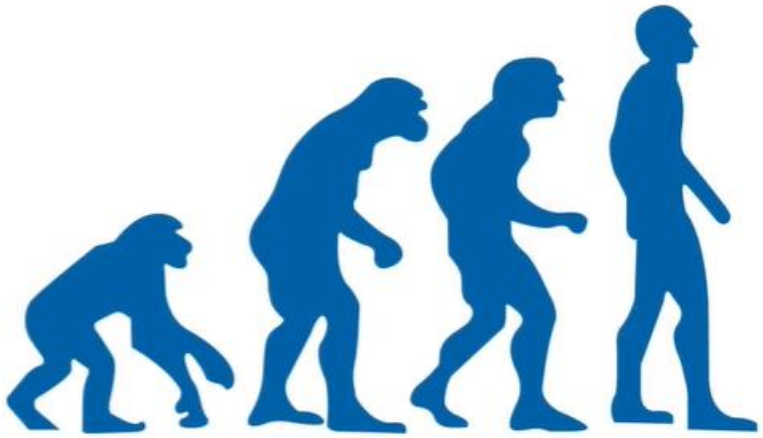
Humans and Machines

Humans and Machines



A book by Ray Kurzweil

The book talks about,



Evolution of AI

How Human Tools and Machines Have Evolved

Hand-held tools

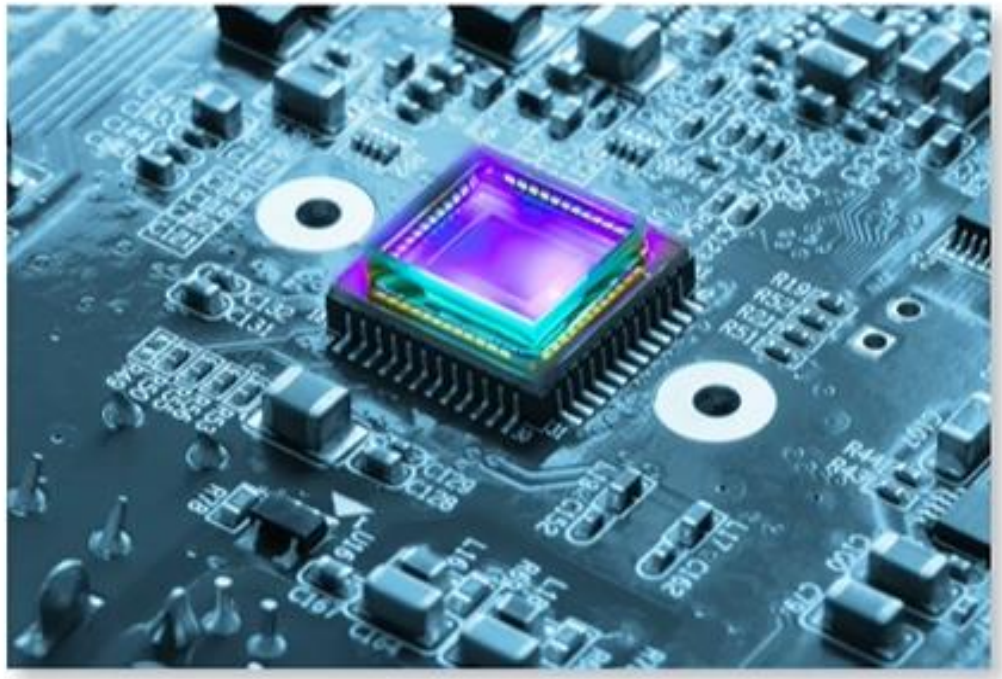
Big and heavy machines

Lathe machines

Automated tools

How Human Tools and Machines Have Evolved

Sensors and coomunication devices have evloved over time

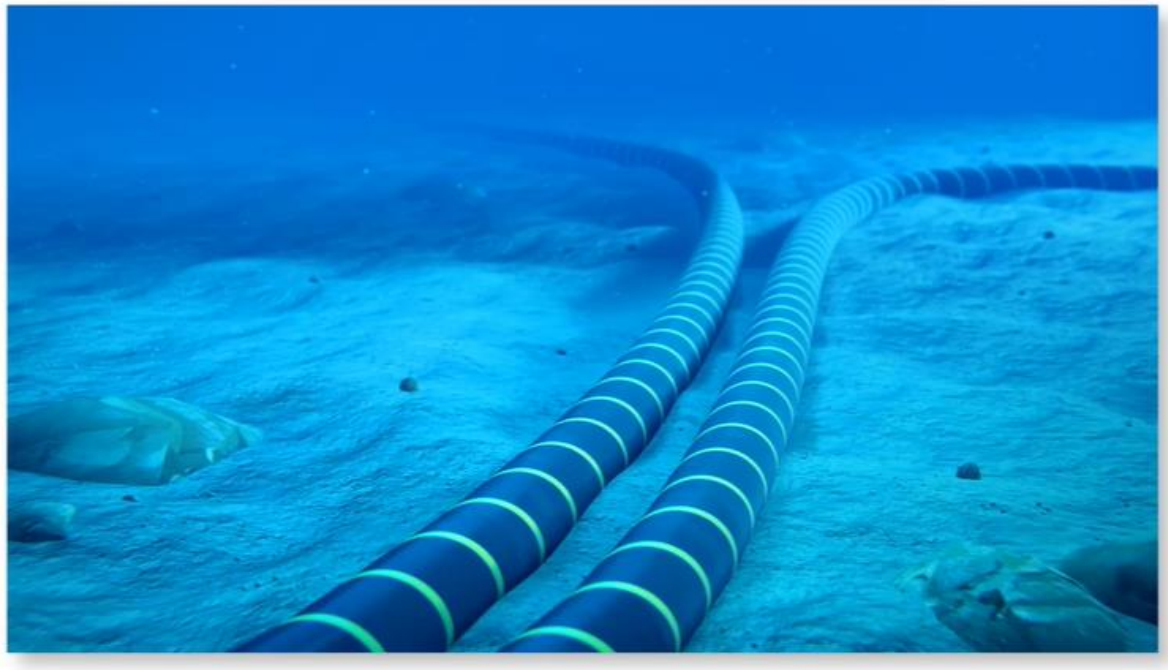


Better sensors

Smart communication devices

Technological Advancements

It is now possible to transfer tetrabytes of data and collect data from space



Data transfer through undersea cables

Data collection through satellites

Advancement in Computational Powers

From a room-sized computer

To a tiny microchip

Quantum computers to boost computation

Advancement in Computational Powers

It is now possible to store zetabytes of data through cloud servers

Cloud servers to store data

Data Generation

Data is generated through:

Grocery stores transactions

Credit card transactions

Stock exchange

Satellites

Data Generation

Data is generated through:

Blogs and social media

The Internet (roughly 2.5 quintillion bytes of data every day)

Internet of things (lot)

Using Data

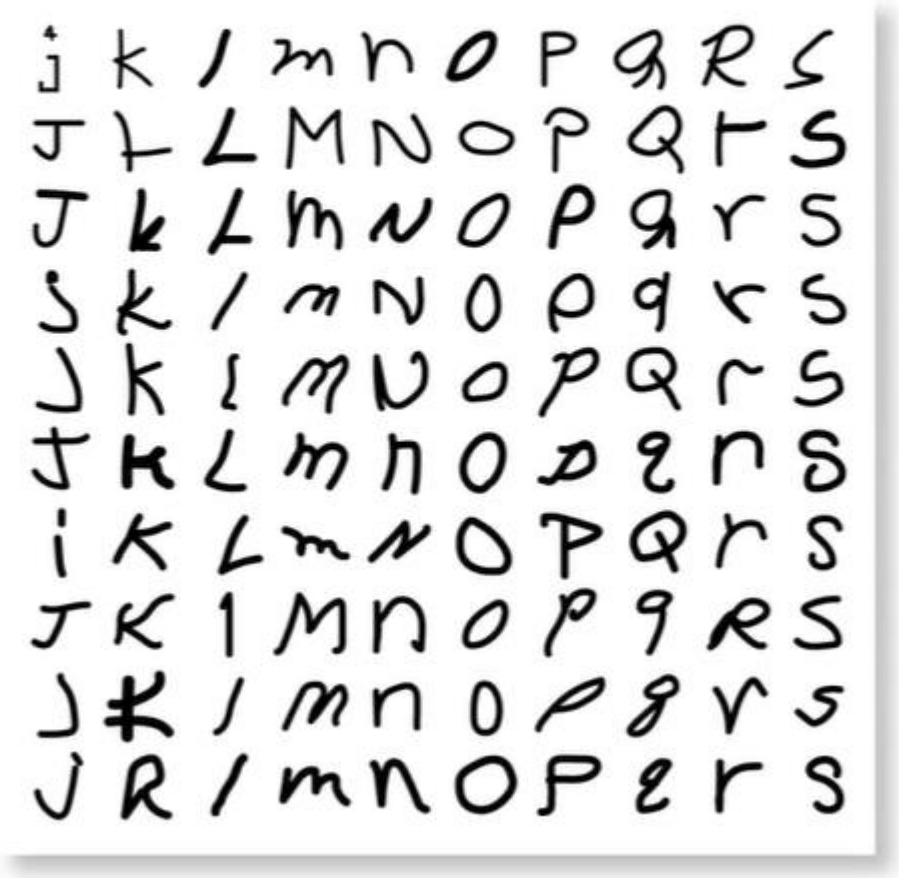
Data needs to be organised in order to find patterns or derive insights from it

What is Artificial intelligence?

Artificial intelligence refers to the simulation of human intelligence in machines that are programmed to think like humans and mimic their actions

How AI Mimics Human Actions

Intelligence is the ability to predict or assign a label to a “new” observation based on the model built from past observations

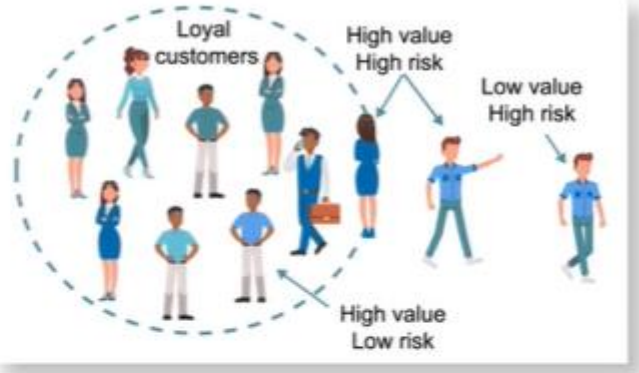


Can machines too identify letters?

Examples of AI

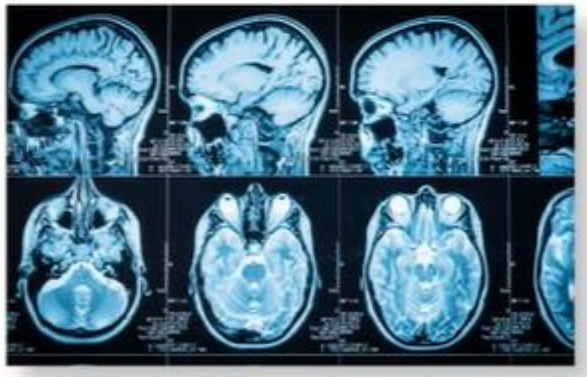
Can machines identify or predict

If this a fraudulent transaction?



Which customers are going to churn?

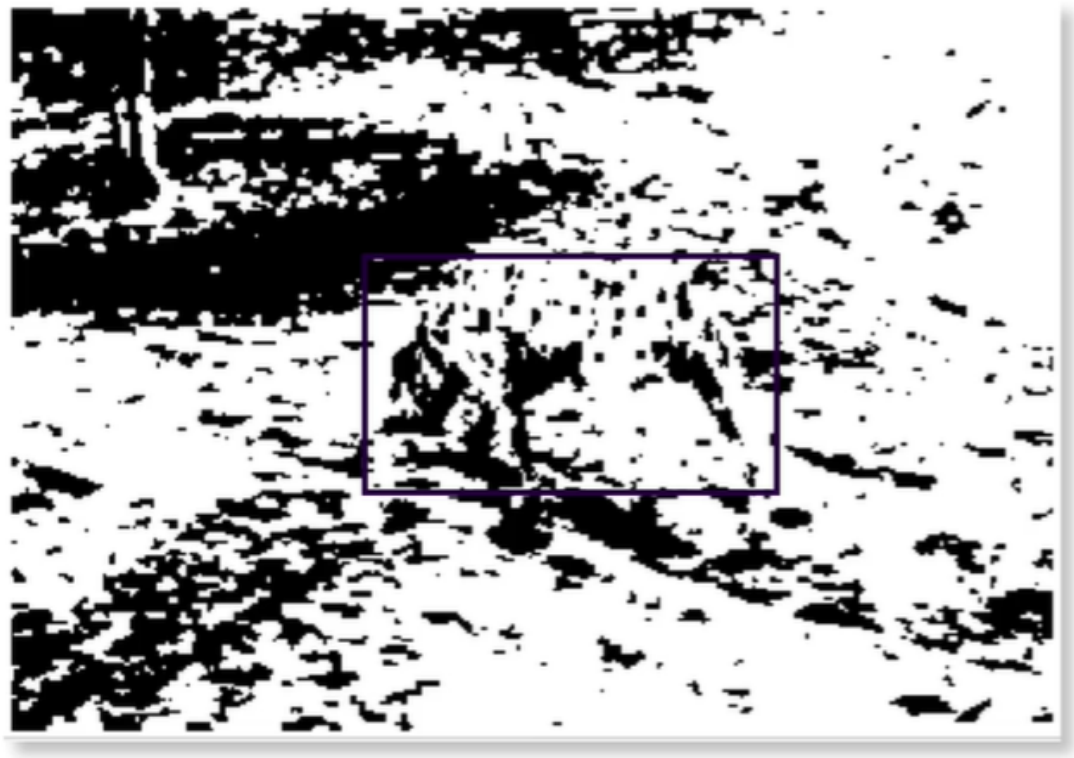
Who will respond to these coupons?



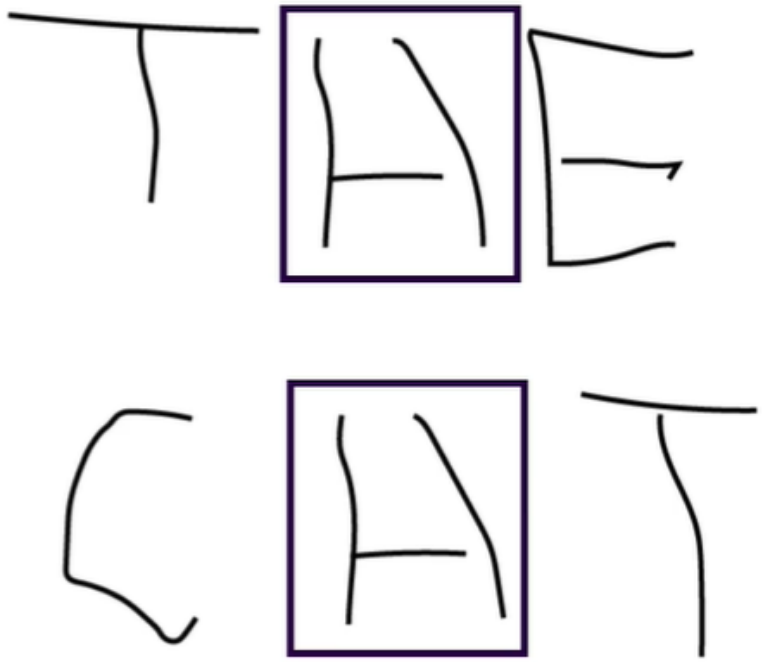
If there is a medical condition?

Examples of AI

Can machines identify or predict



An image of the pixels



What Is Intelligence

The ability to make sense of an individual component in the context is what intelligence is

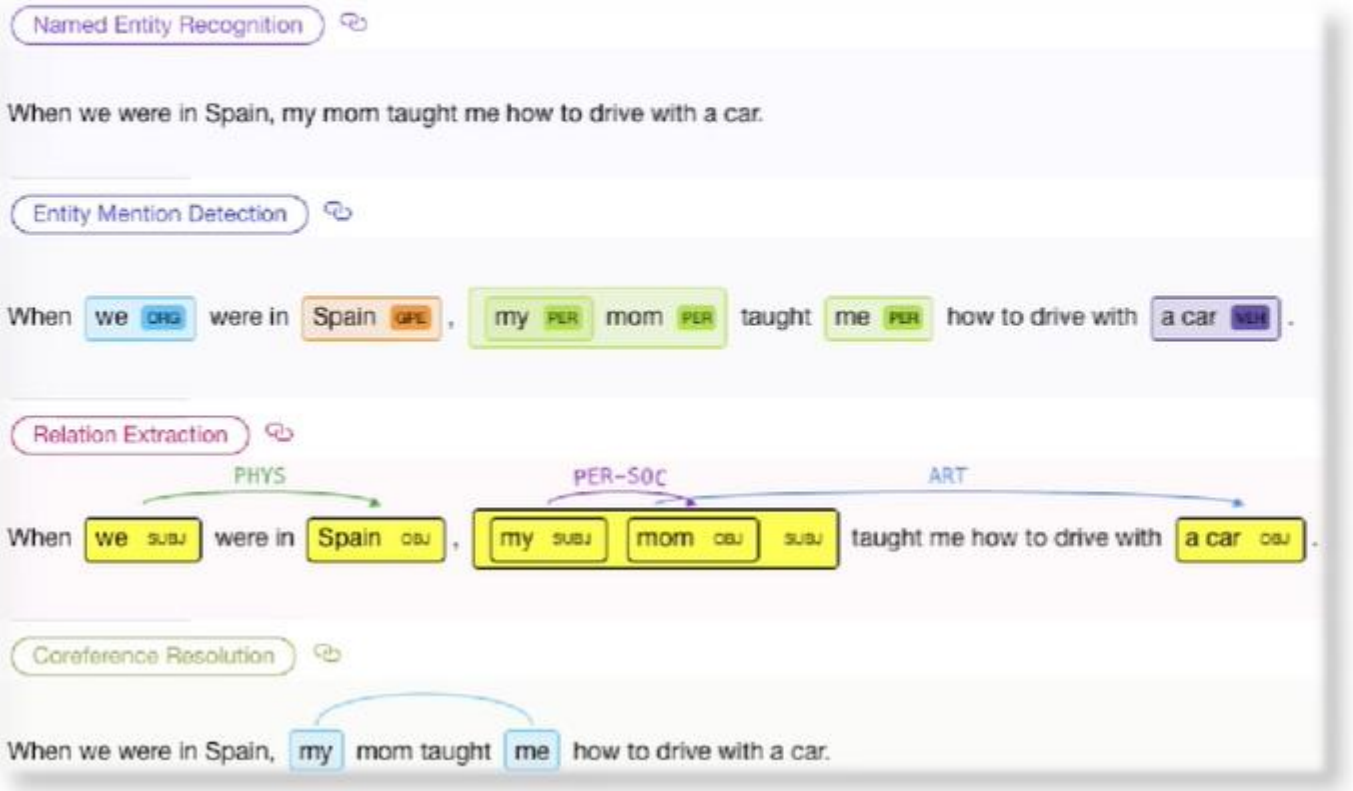
Examples of AI

Can machines recognise?

Can machines (computer vision) identify different objects in a given image?

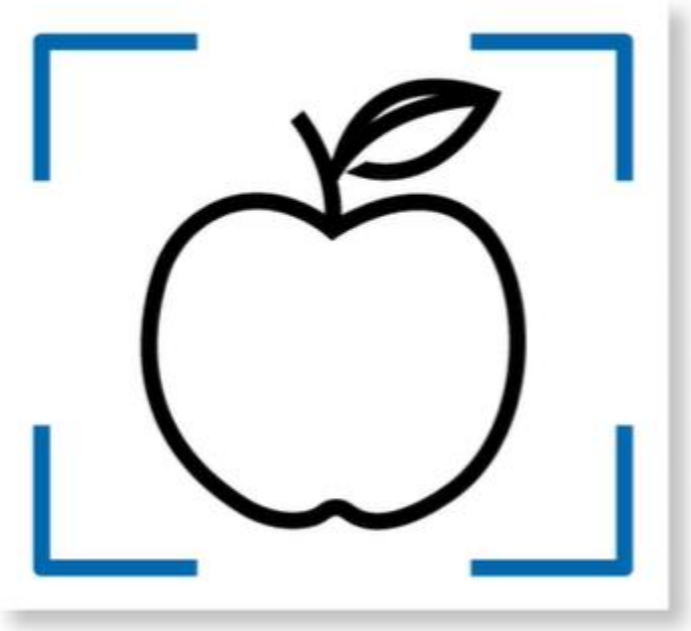
Examples of AI

Can machines recognise?



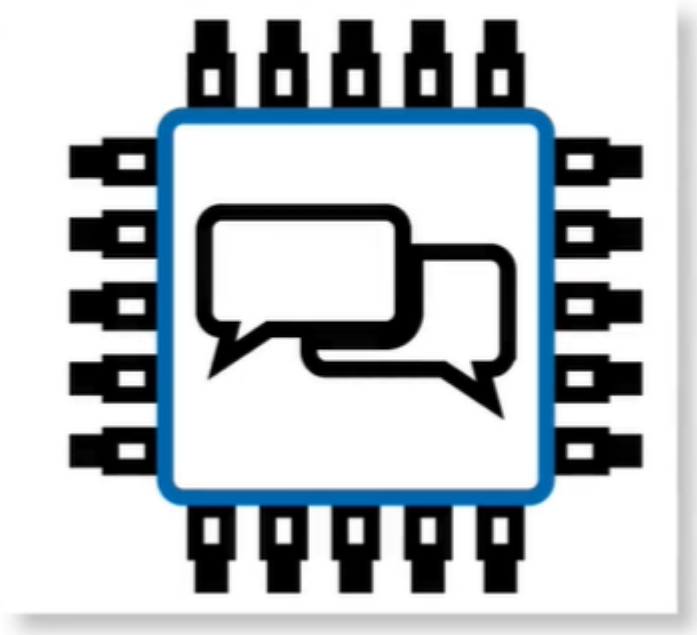
Can machines identify different words or parts of a text and their functions?

Advancements in AI



There are algorithms that help machines look at the pictures and identify objects in the picture

Advancements in AI



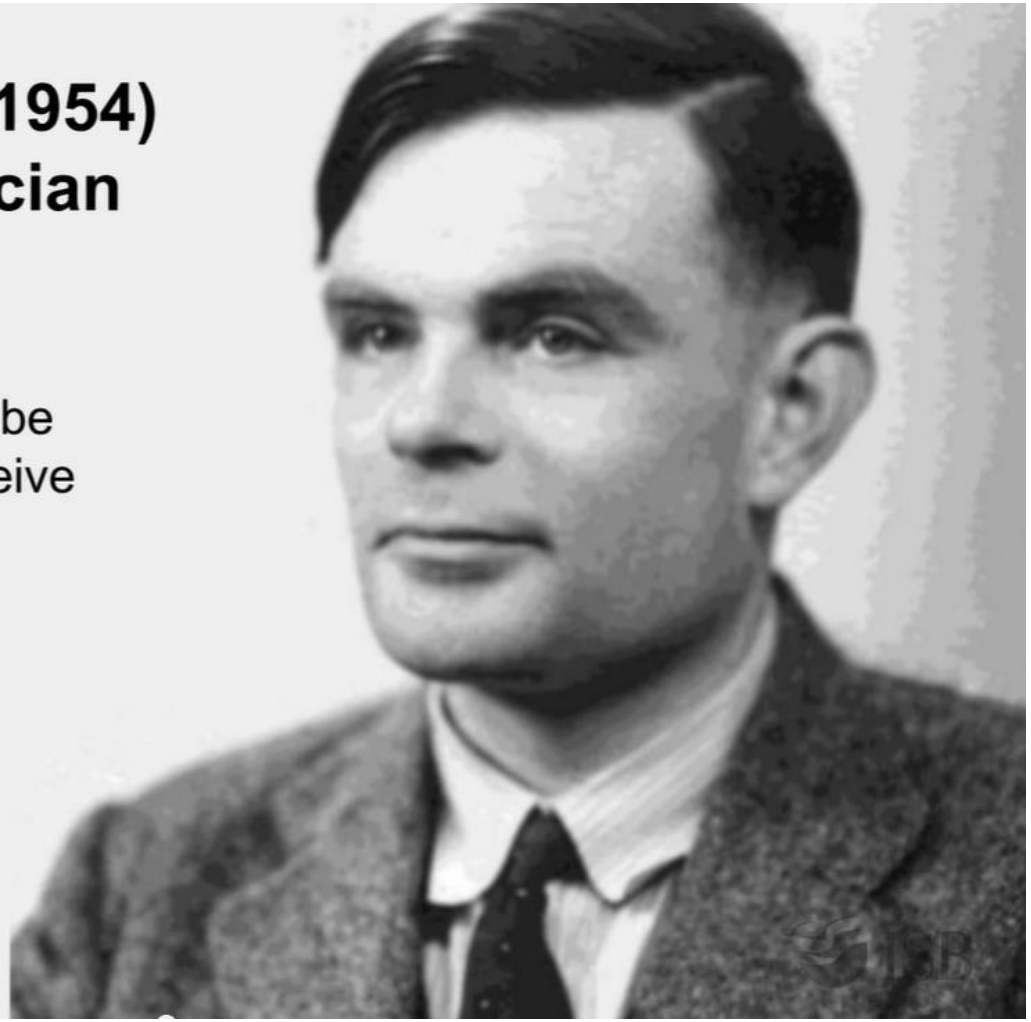
Natural language processing helps machines read and understand the meaning of a text and identify different parts of a text

Turing's Thoughts on an Intelligent Machine

Alan Turing, (1912 – 1954)
Educator, Mathematician

"A computer would deserve to be called intelligent if it could deceive a human into believing that it was human"

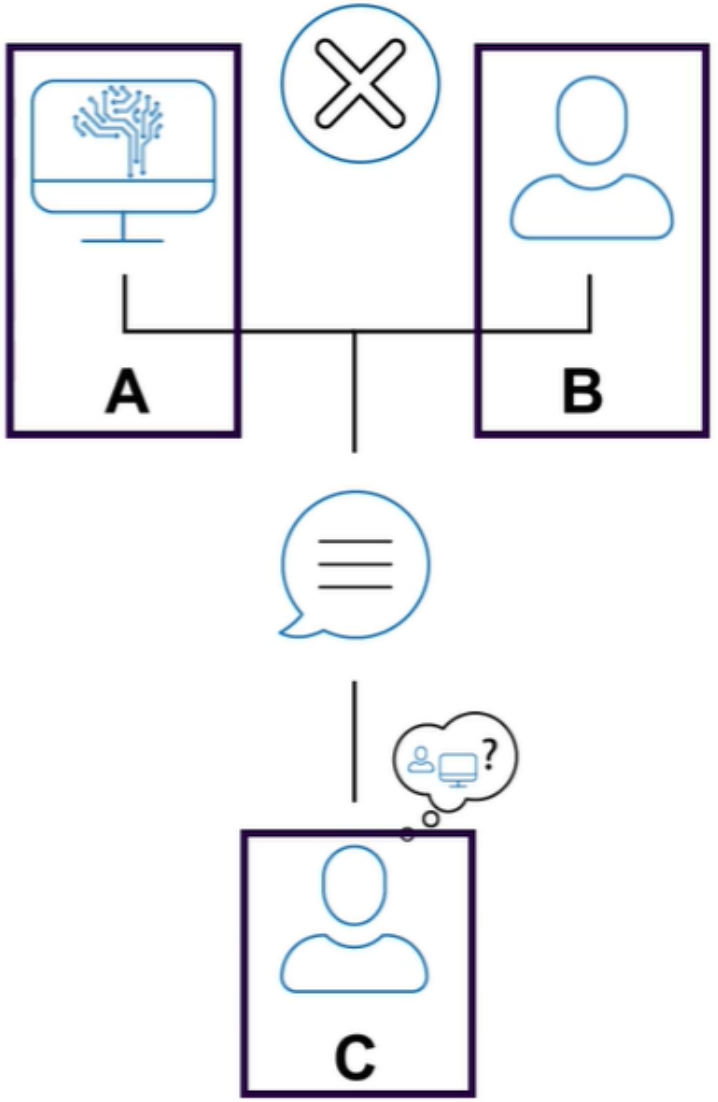
https://www.biography.com/scientist/alan-turing



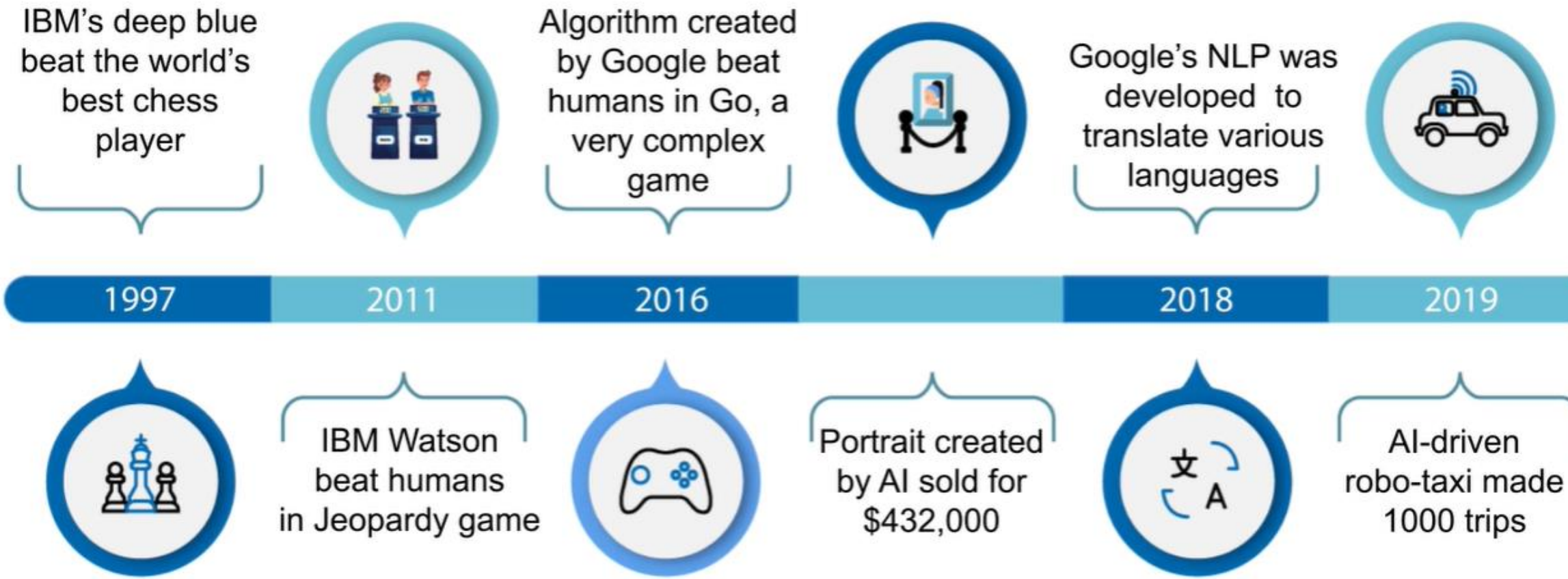
The Turing Test for Intelligence

- C asks the question. Human and machine respond to the question. If person C identifies which is human's response and which is machine's, the test fails

- But if the machine answers and person C cannot identify or differentiate between the two answers, then the machine is considered intelligent



How Machines Have Outsmarted Humans



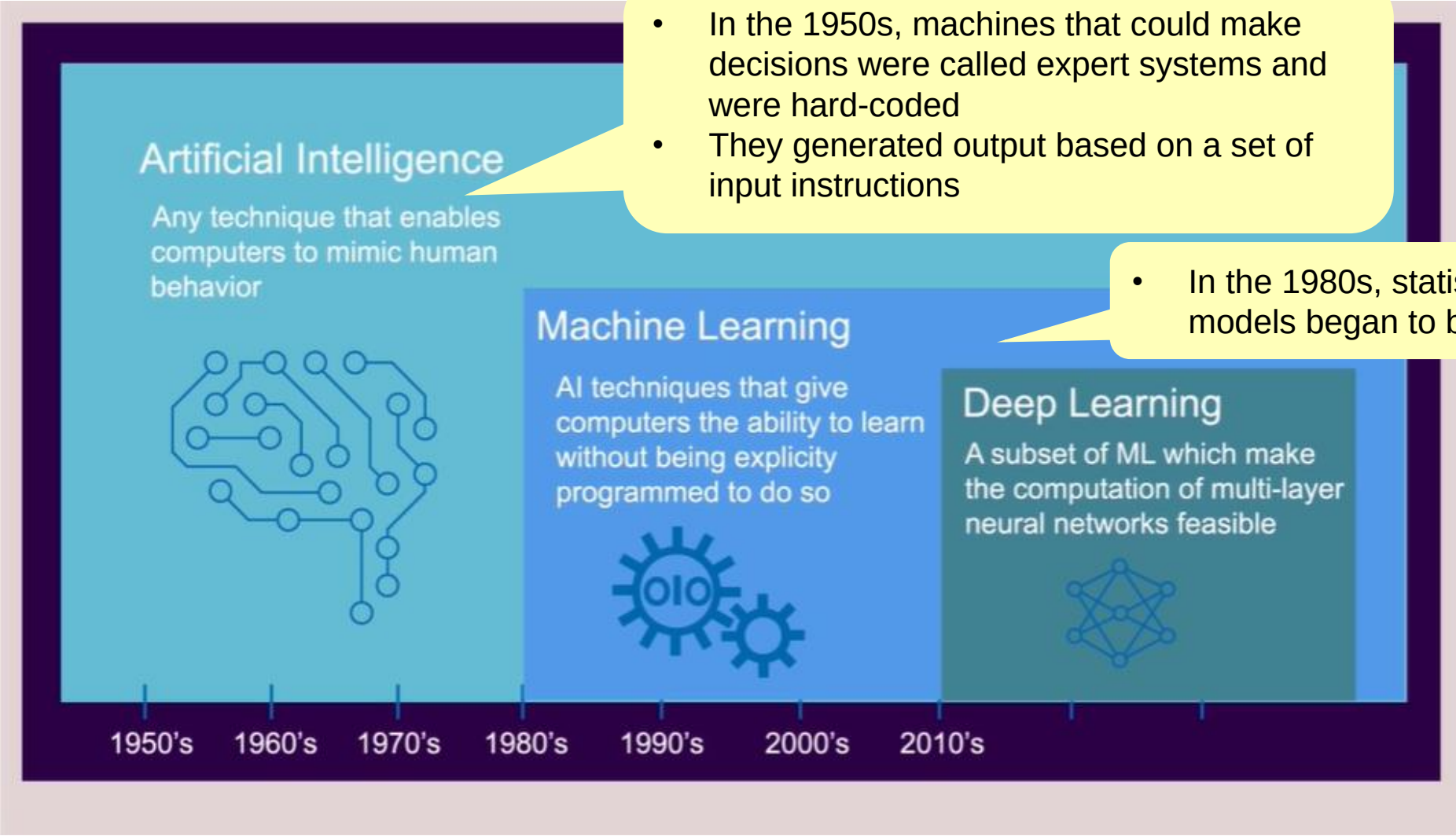
The Future of AI

> By 2050 robot "brains" based on computers that execute 100 trillion instructions per second will start rivaling human intelligence – Hans Moravec, March 2009, Scientific American

What is Artificial Intelligence

Artificial intelligence is a machine's ability to mimic human intelligence

Artificial Intelligence Is Not New



- In the 1950s, machines that could make decisions were called expert systems and were hard-coded
- They generated output based on a set of input instructions

- In the 1980s, statistical models began to be used

Machine Learning vs Deep Learning

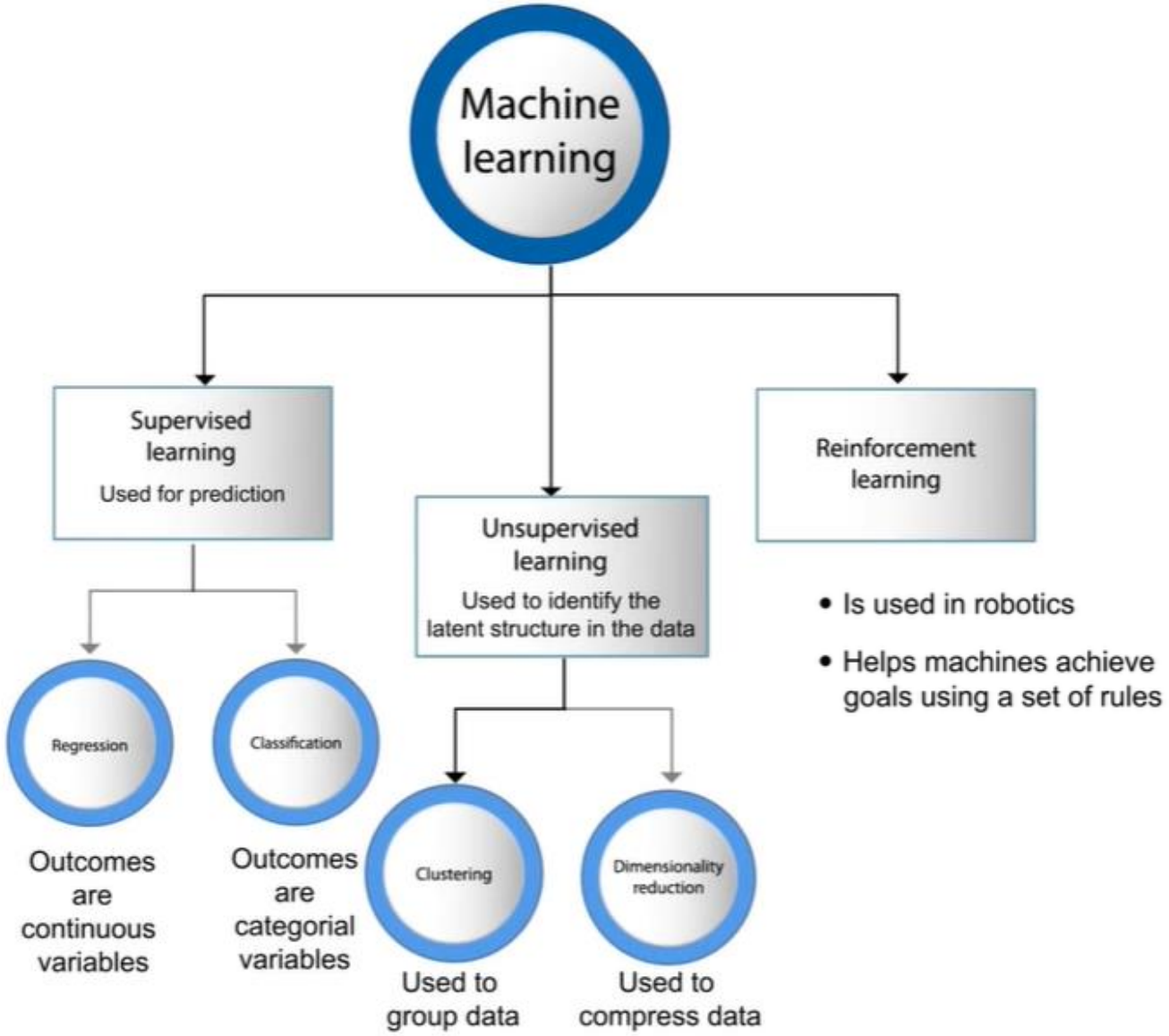
Machine learning

- Takes input in a matrix form—structured data with columns and rows
- Requires prepared structured data for processing

Deep learning

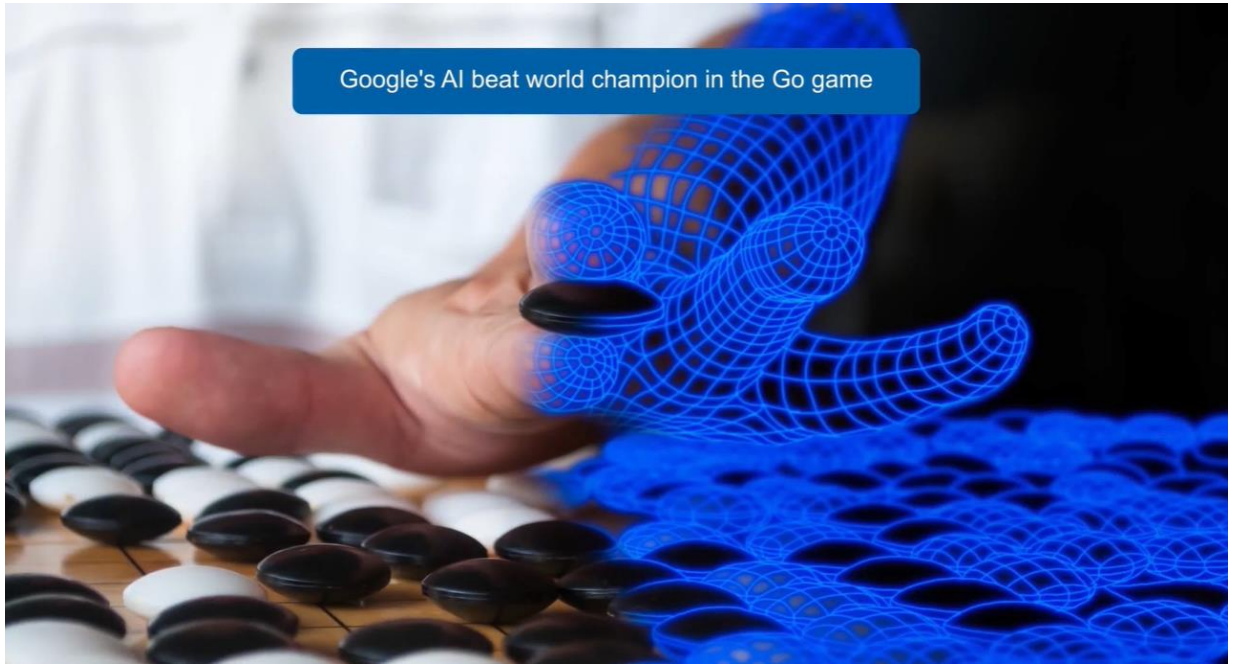
- Does not require feature data; instead, convert raw input into output
- Does not require guidance; follows self-learning
- Requires a large volume of data to learn

Machine Learning Techniques



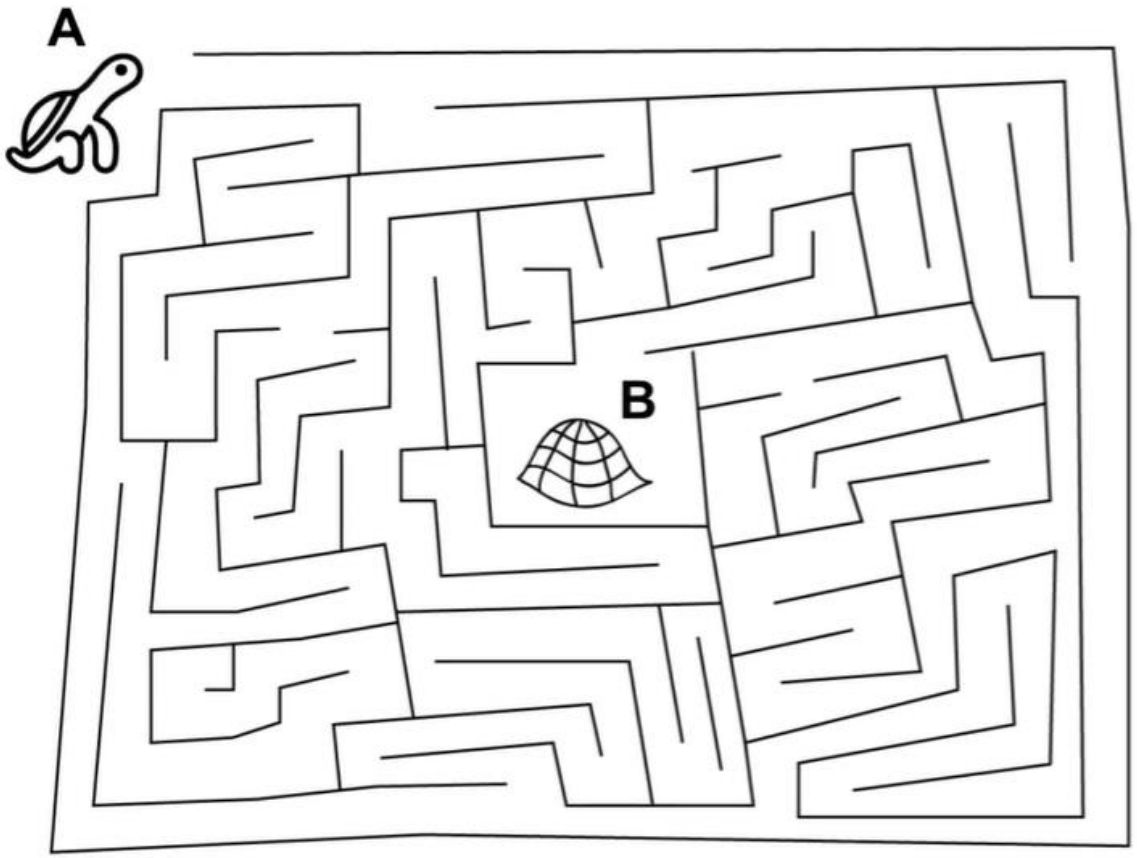
Example of Reinforcement Learning

IBM's Deep Blue AI beat the world chess champion



Example of Reinforcement Learning

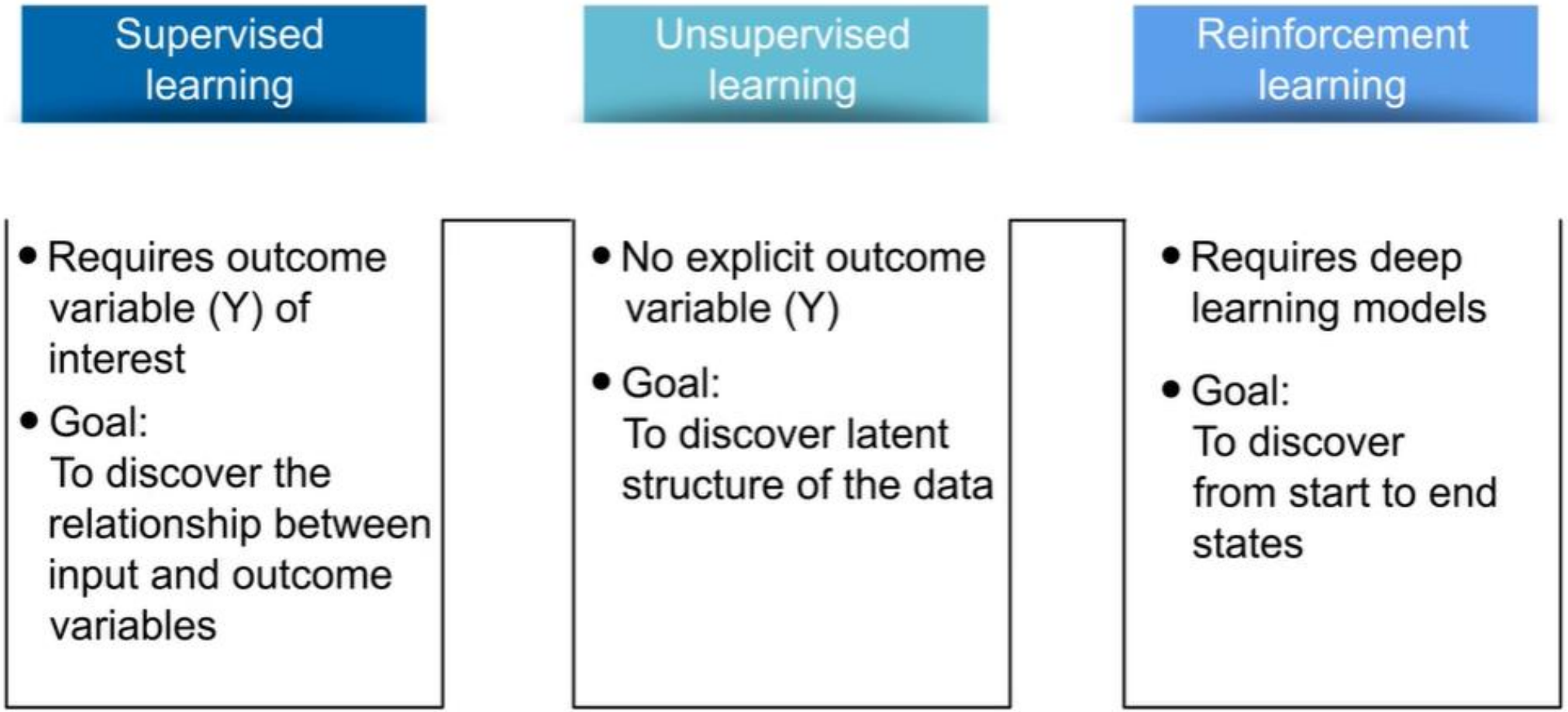
Help Tommy Tortoise find his shell



In reinforcement learning, machines are provided with:

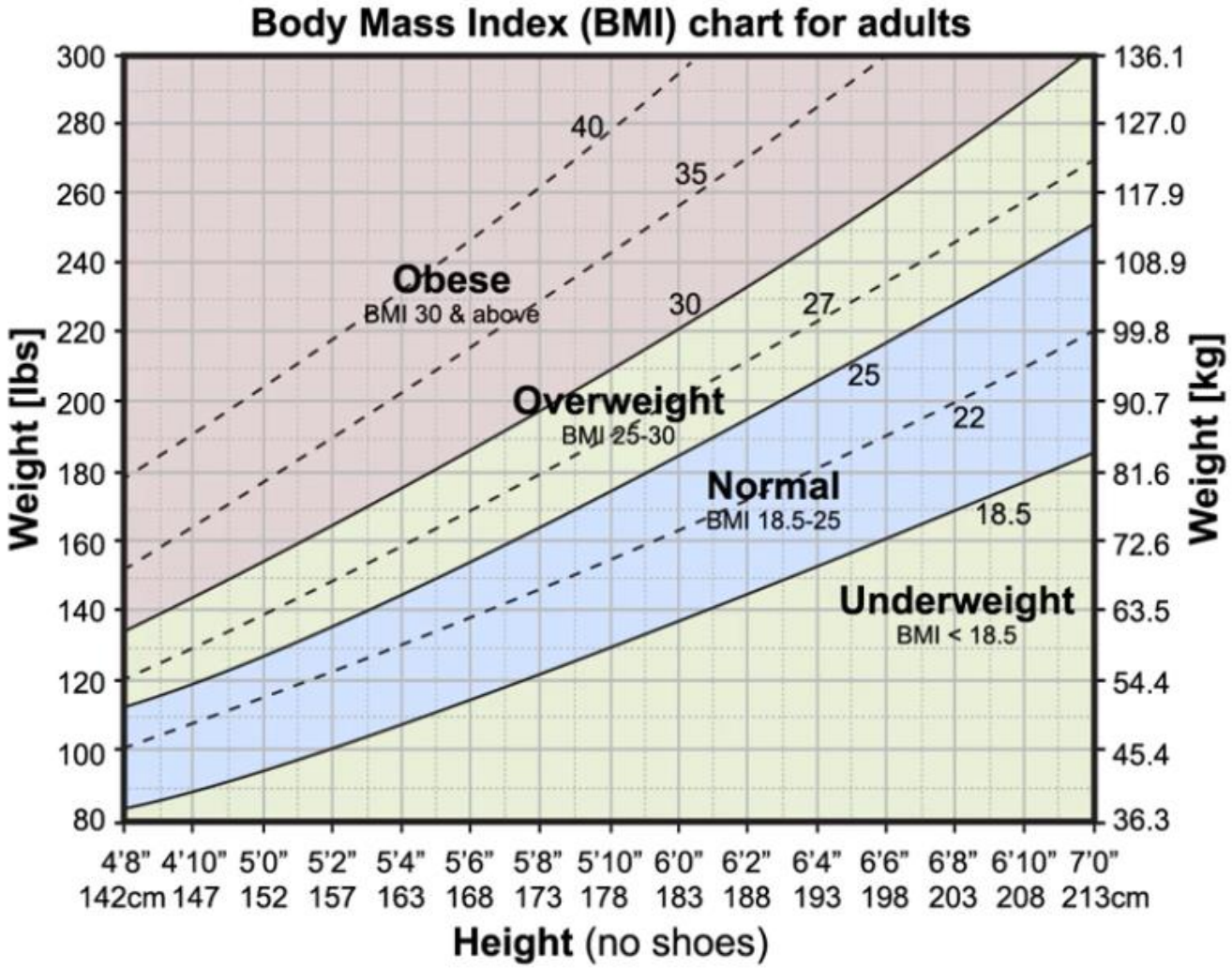
- A goal
- A set of rules to achieve the goal

ML Approaches



Classification Example

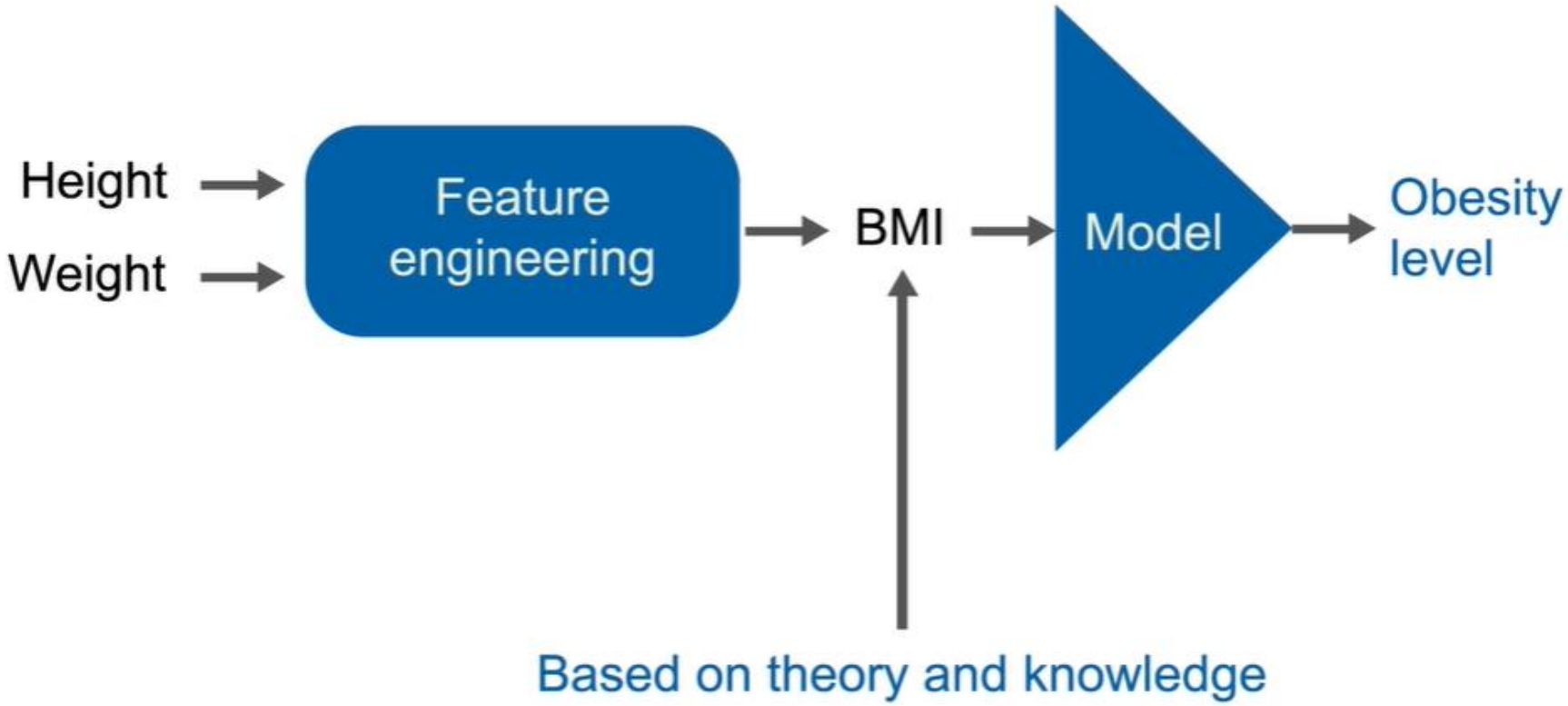
How doctors identify a patient's weight



Traditional Knowledge-Based Classification

Doctors measure height and weight and convert them into BMI index

In traditional knowledge-based classification, the input variables and the formula are converted into output variables using the theory



Machine Learning Context

In the machine learning context, the theory doesn't identify the rules. Rather, the machines discover the rules

Example of Machine Learning Classification

Given input and output,

Input	Output
Height	Obesity levels
Weight	

The machine will identify the formula for computing the input variables into the output

Machine Learning Classification

Example

Iris setosa

Iris versicolour

Iris virginica

It is possible for machines to identify these **using two approaches- machine learning and deep learning**

Approaches for Classification

Iris setosa

Iris versicolour

Iris virginica

Machine learning

Guide the machine by feeding it information such as the:

- Length of the petal
- Length of the sepal
- Width of the petal
- Width of the sepal

to help the machine identify each flower correctly

Deep learning

- Feed pictures of the flowers into the machine
- The machine will analyse the pixels and make the associations

Machine Learning vs Deep Learning

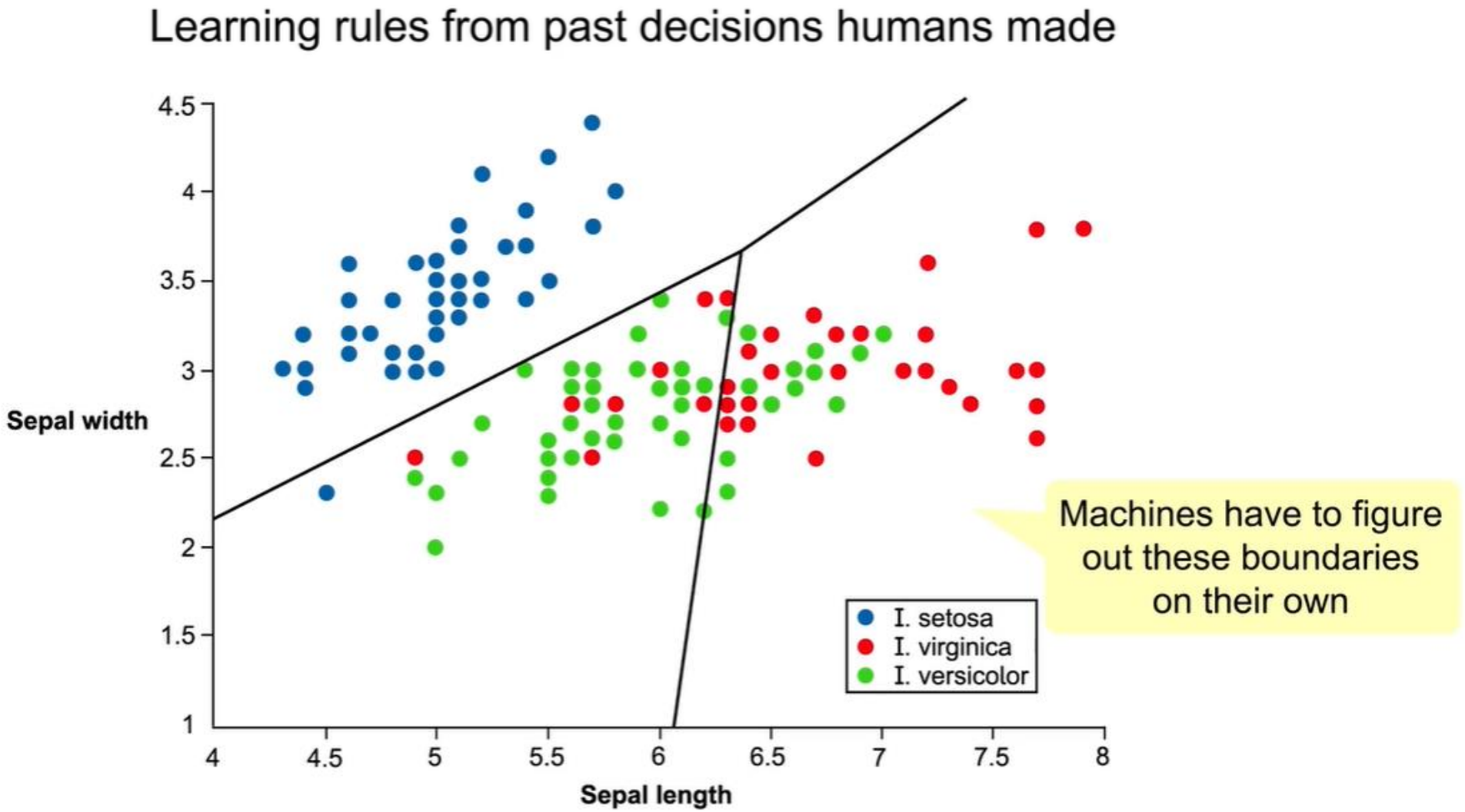
Machine Learning

- Requires features to be fed into the machine
- Does not require the rule
- Discovers the rule using the features

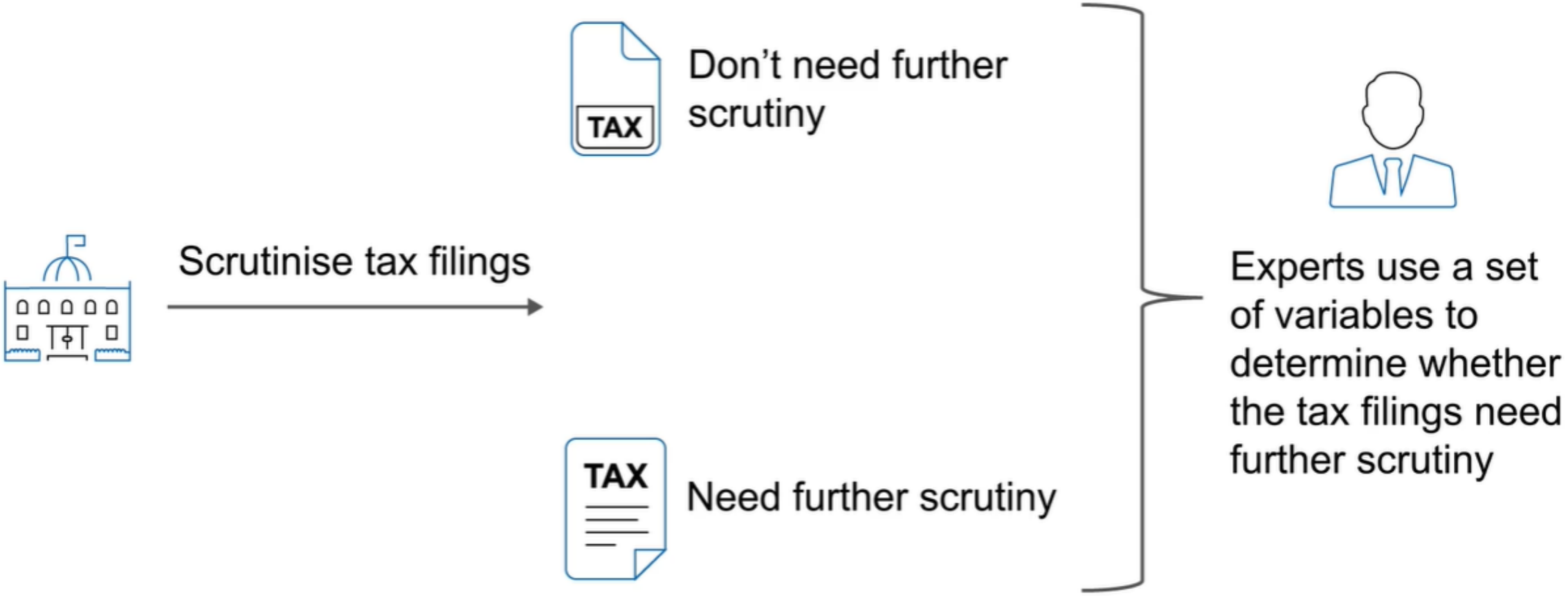
Deep Learning

- Requires only raw data and not features
- Discovers how to convert the raw data into the outcome variable

Machine Learning-Based Classification



Example: How Tax Filings Are Assessed for Further Scrutiny



How Machines Scrutinise Tax Filings

- Provide past tax filings data as input along with features such as:
  - Refund request status
  - Marital status
  - Taxable income
  - Previous classification status (further scrutiny or not)

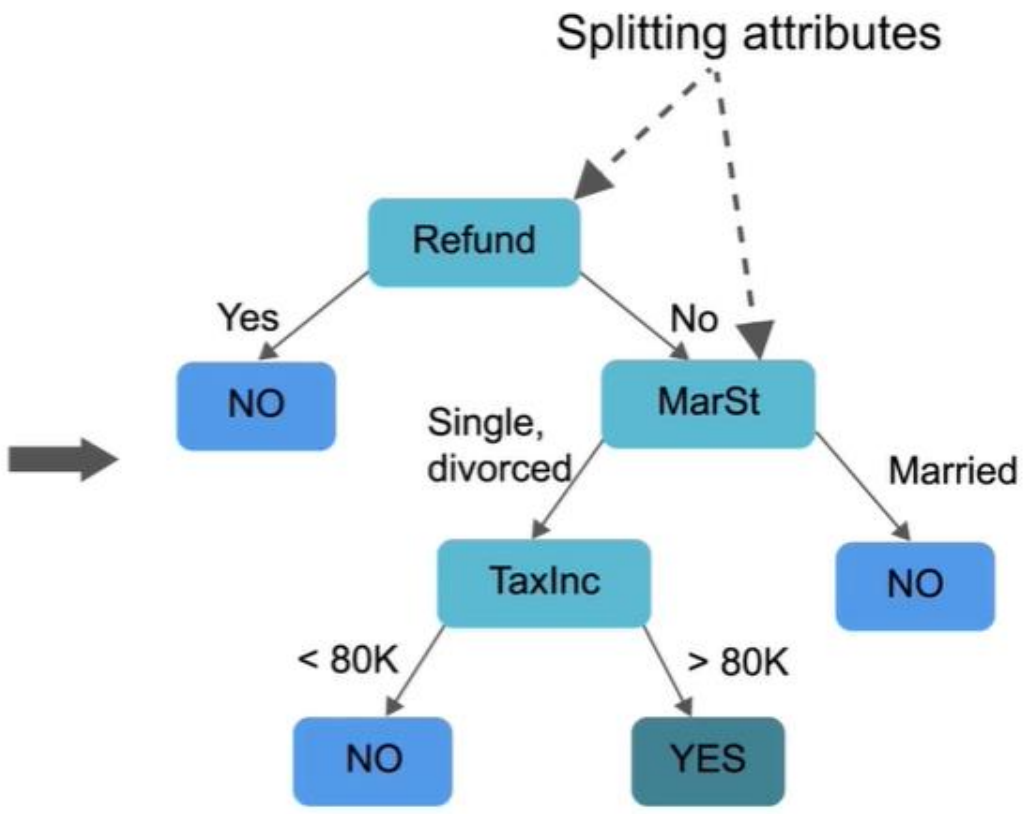
- Have machines create a rule similar to human decision-making

Classification by Machine Learning

Machines create decision trees or if-else statements to determine how to classify each observation

	categorical	categorical	continuous	class
Tid	**Refund**	**Marital status**	**Taxable income**	**Cheat**
1	Yes	Single	125K	No
2	No	Married	100K	No
3	No	Single	70K	No
4	Yes	Married	120K	No
5	No	Divorced	95K	Yes
6	No	Married	60K	No
7	Yes	Divorced	220K	No
8	No	Single	85K	Yes
9	No	Married	75K	No
10	No	Single	90K	Yes

Training data



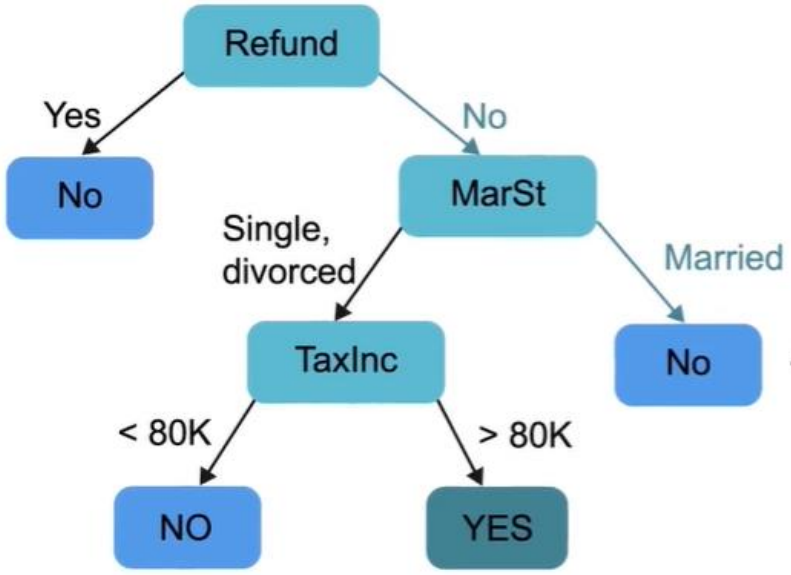
Decision tree model

Classification by Machine Learning

- Once machines determine the rule, it can be used to classify every tax filing
- With the data as input, machines will predict whether a tax filing requires further scrutiny using the rule

Example Classification Tree

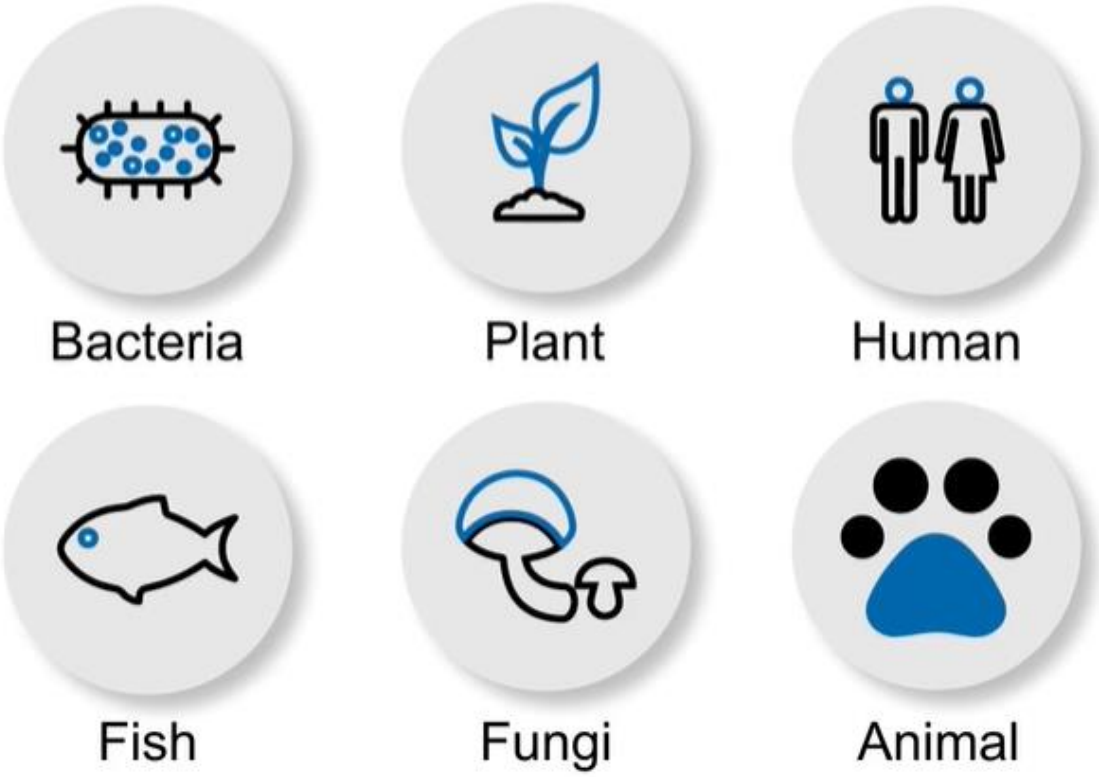
Instead of thousands of experts going through each and every tax, one single machine can identify all these tax filings and classify them for further scrutiny

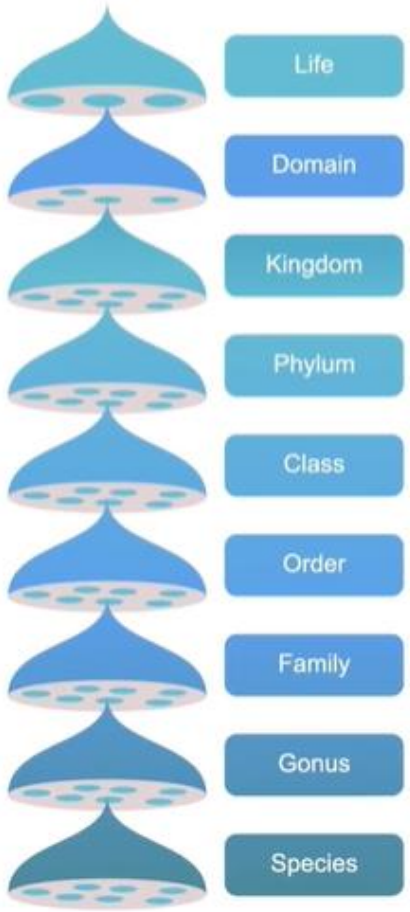


Refund	Marital status	Taxable income	Cheat
No	Married	80K	?

Clustering Objects into Groups: Example 1

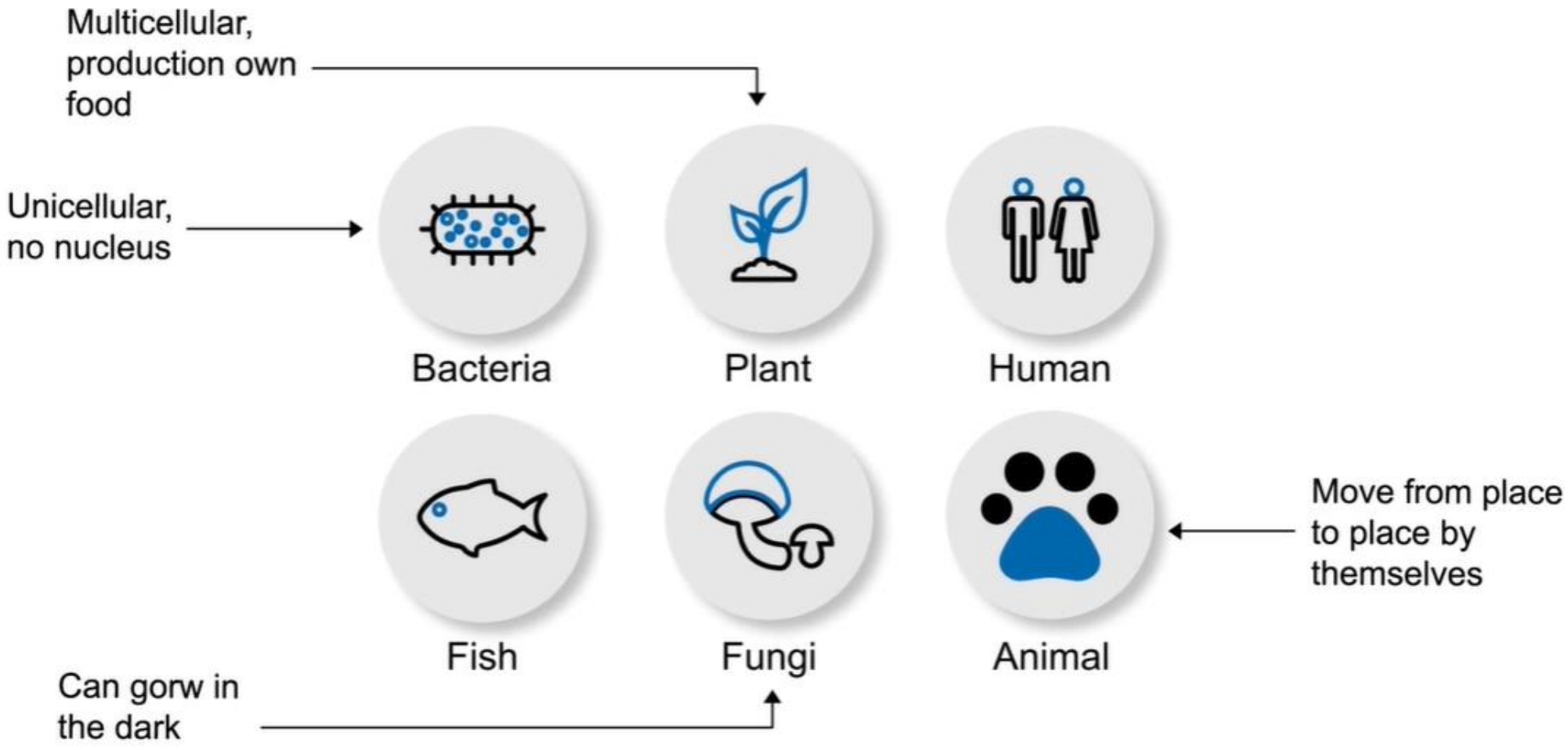
Having a structure helps classify new observations easily



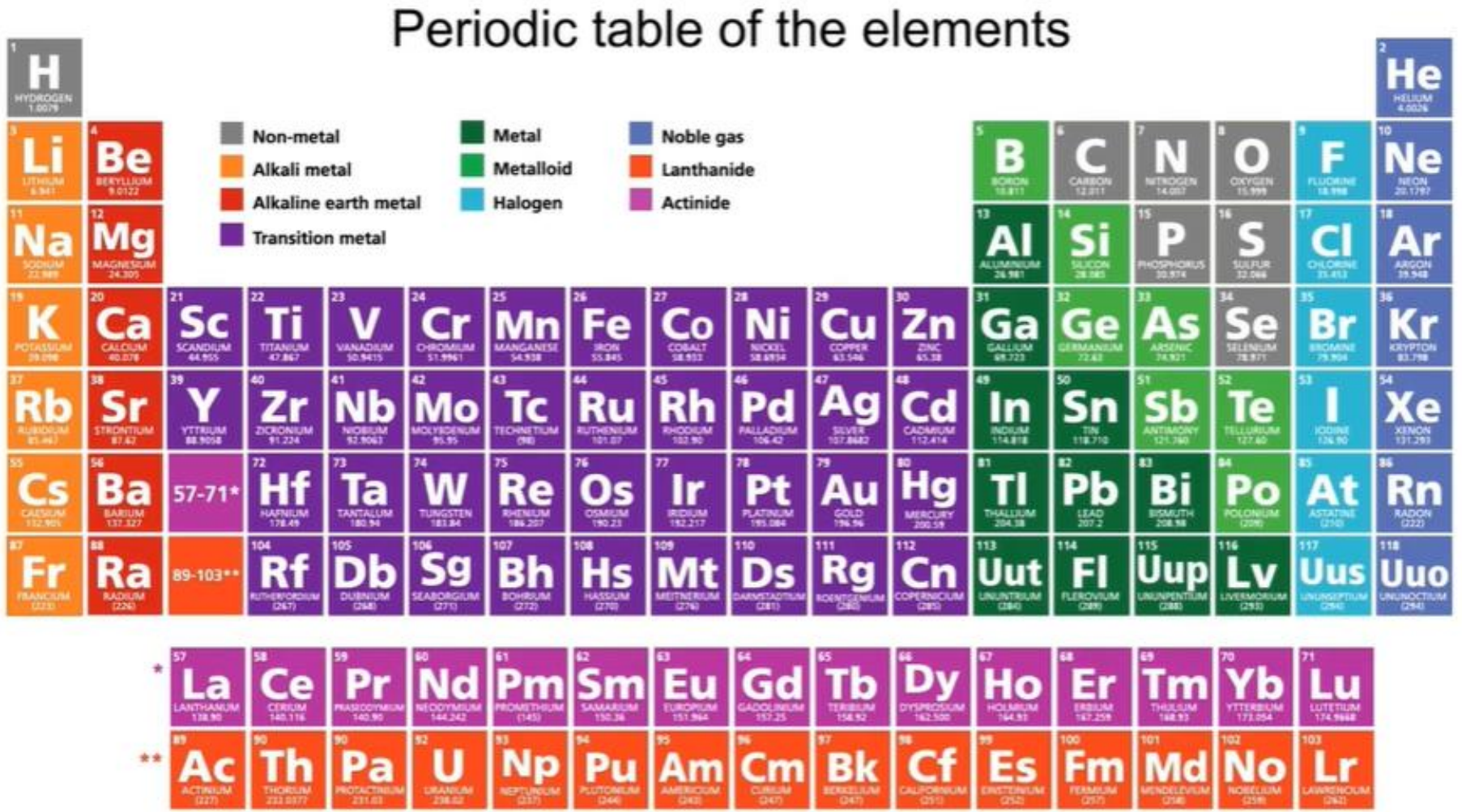


Clustering Objects into Groups: Example 1

Clustering observations into groups is based on domain knowledge and theory



Clustering Objects into Groups: Example 2

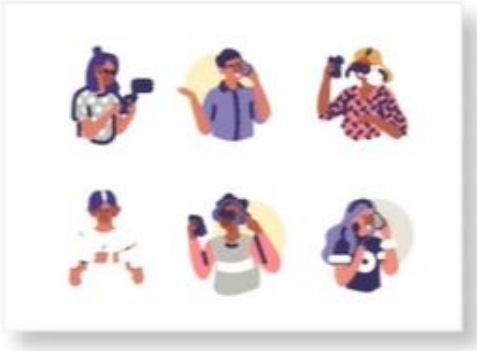


Benefit of Cluster Analysis

Cluster analysis helps organise objects into some order so that useful information could be retrieved

Other Examples of Clustering

Number and types of web pages



Types of consumers in a market

Types of people on social network

Types of genes in the human genome

Types of songs, podcasts or movies in a library

Clustering Objects into Groups: Example 3

Fruits can be clustered into groups based on their colours

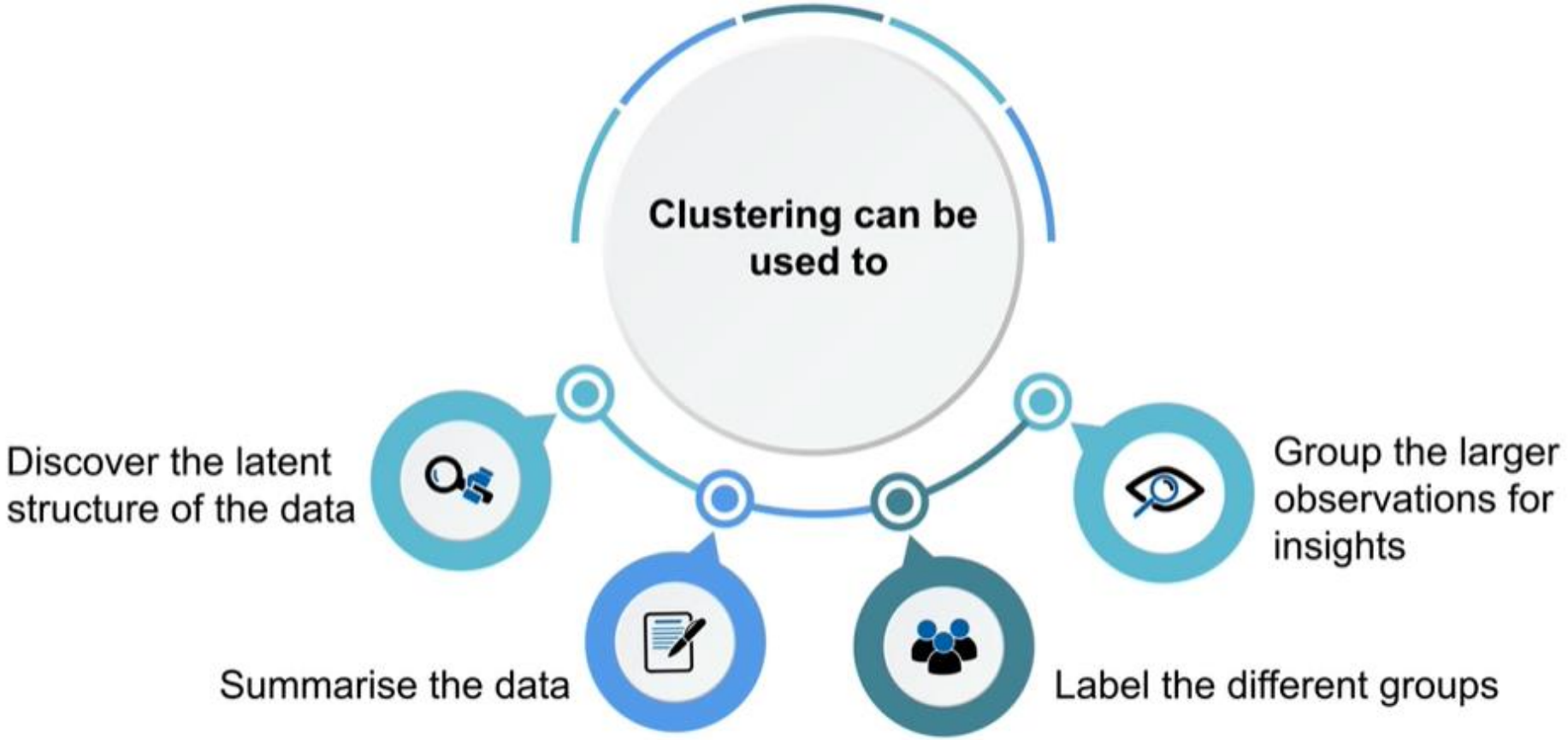
Clustering Objects into Groups: Example 3

Fruits can be clustered into groups based on their shape

Cluster Analysis

- Clustering is exploratory in nature
- Based on a given set of features, machines can cluster objects into several groups
- Domain knowledge can then be applied to identify the useful clusters and extract insights

Why Do We Need Clustering?



Business Application of Clustering

- Customers could be classified into groups based on features such as age, location and education
- Such customers groups could then be used to identify segments and better tailor products

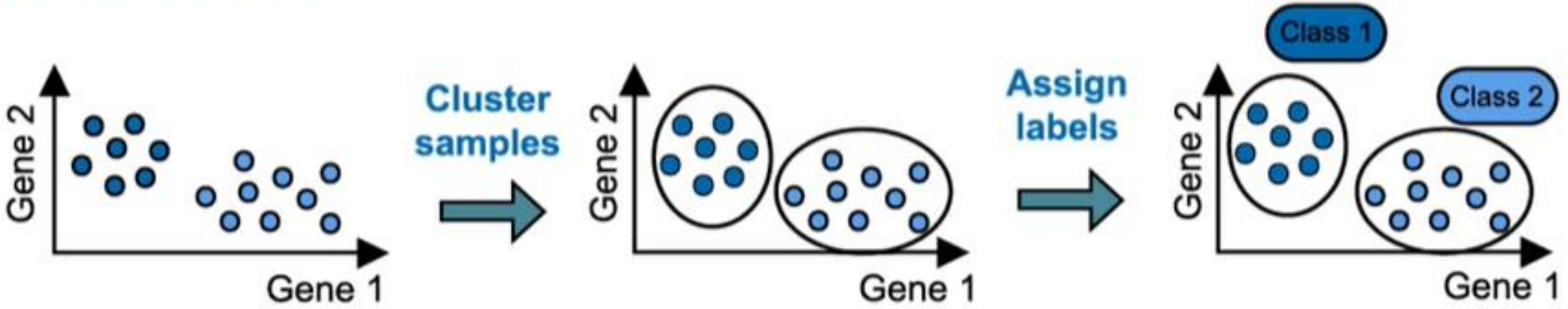
Classification: Unsupervised vs Supervised learning

Unsupervised learning (Clustering)

Use features and factors describing a particular object to organise objects into different groups such that similar objects are in one group and two groups are very different

Unlabeled data set

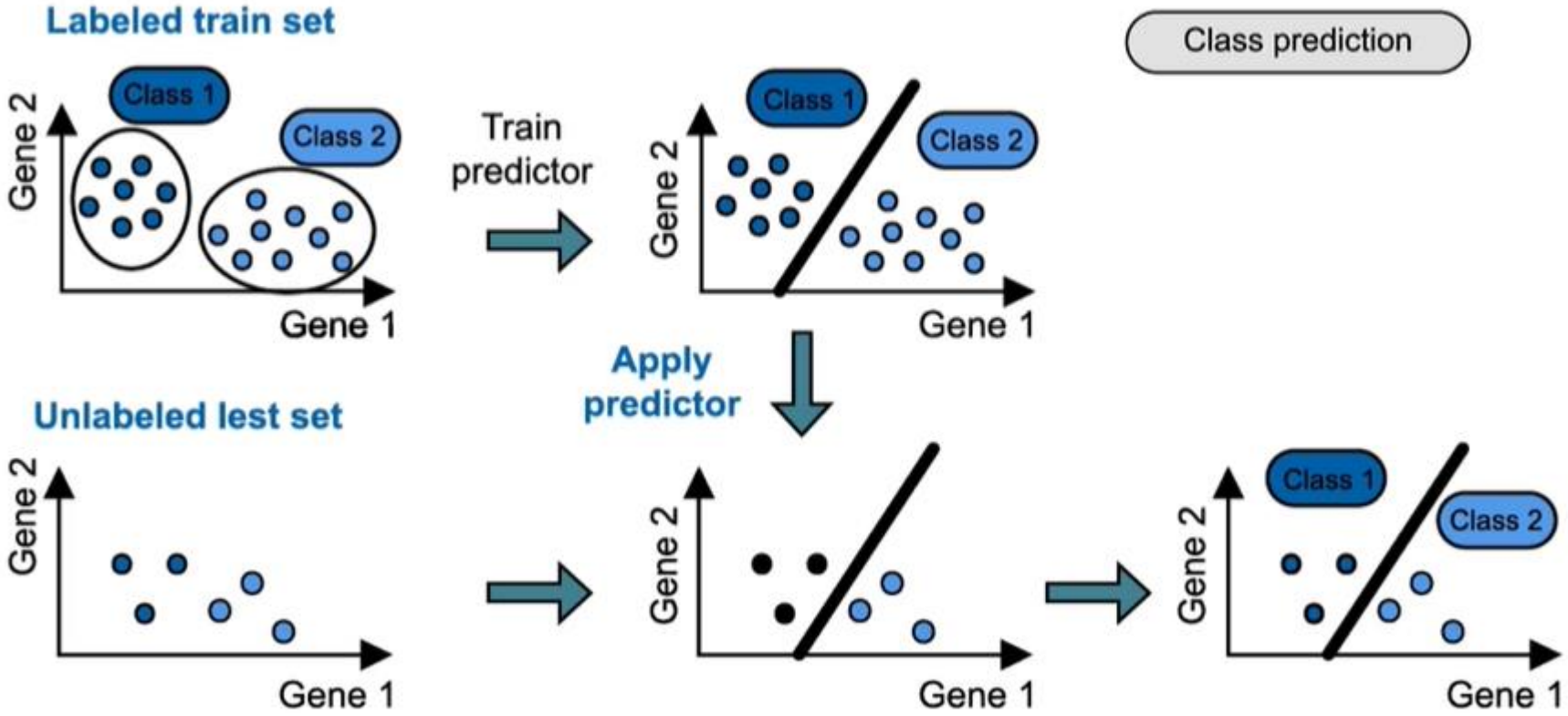
Class discovery



Classification: Unsupervised vs Supervised learning

Supervised learning (Classification)

Based on a set of features with known classes, machine learning models predict the class of a new observation



ML Framework for Business Problems

Key analytics questions : business decisions

What decisions does the business make?

Example:

Which offers should be sent to which customers?

On what basis are the decisions made?

Example:

By observing the past purchase behaviour of the customers

How do we measure the success of our decisions?

Example:

- By measuring whether a campaign was successful
- By determining the metrics of success

ML Framework for Business Problems

Key analytics questions: data analytics

What kind of data should be collected to evaluate the decision?

Example:

How many customers redeemed the coupon?

What data should be collected to improve the decision?

Which variables or features can help the machine make better decisions?

What kind of a model to use?

- Supervised learning
  - Decision Tree
  - Logit Model
  - Regression
- Unsupervised learning

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