ADAPTIVE BUSINESS INTELLIGENCE

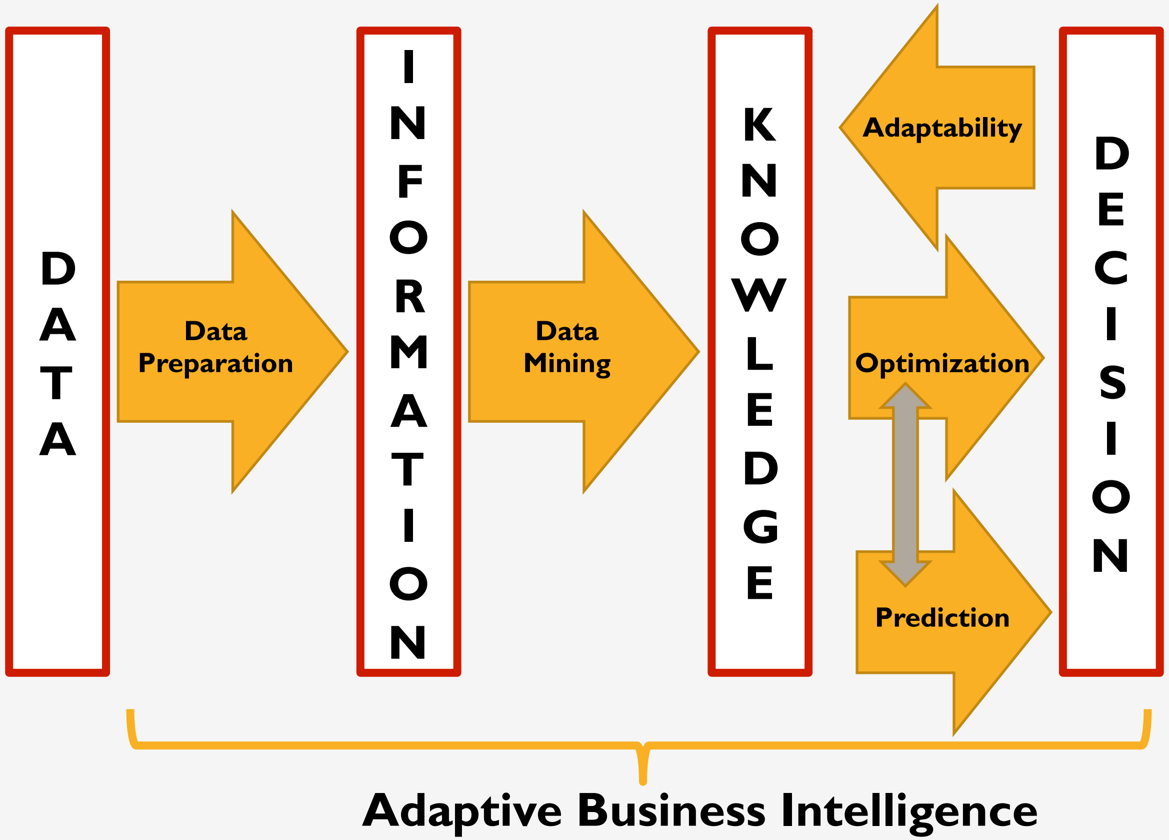
- The future of BI lies in systems that can provide answers and recommendations, rather than mounds of knowledge in the form of reports.
- As a result, there is a new trend emerging in the market place called

Adaptive Business Intelligence.

ADAPTIVE BUSINESS INTELLIGENCE

- In addition to performing the role of traditional BI (transferring data to knowledge), ABI also includes the decision making process which is based on **prediction** and **optimization**.

ADAPTIVE BUSINESS INTELLIGENCE



ADAPTIVE BUSINESS INTELLIGENCE

- ABI uses **prediction** and **optimization** techniques to build self-learning decision systems and to recommend near-optimal decisions
- ABI uses **adaptability** module for improving future recommendations.

ADAPTIVE BUSINESS INTELLIGENCE

Q: Why a complex method like ABI?

A: Complex business problems are difficult to solve.

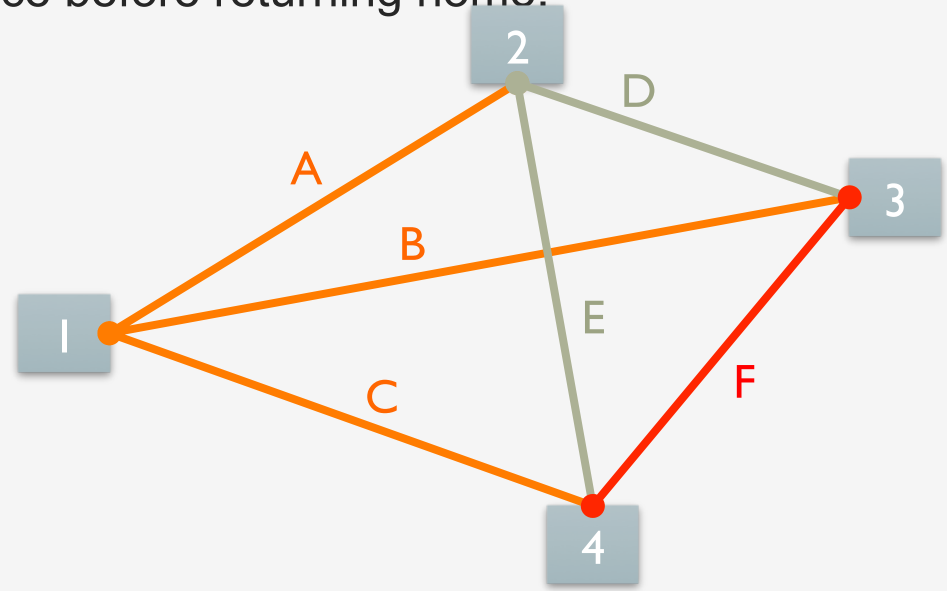
Q: Why business problems are difficult to solve?

A: Because of the following characteristics:

- the number of possible solutions is so large
- time-changing environment
- problem-specific constraints
- multi objective problems (possibly conflicting)
- other items e.g. noisy data, uncertainty and etc

NUMBER OF POSSIBLE SOLUTIONS

- Example: Traveling salesman problem
- The salesman must travel the shortest possible distance and he must visit every city in his region once before returning home.

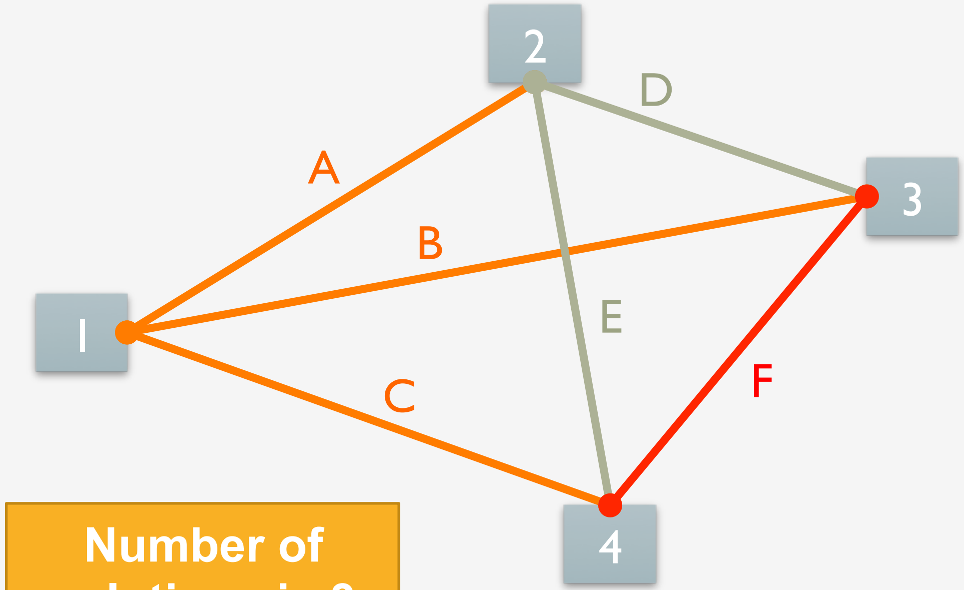


NUMBER OF POSSIBLE SOLUTIONS

Example: Traveling salesman problem

Case 1	A	D	F	C
Case 2	A	E	F	B
Case 3	B	D	E	C
~~**Case 4**~~	~~B~~	~~F~~	~~E~~	~~A~~
~~**Case 5**~~	~~C~~	~~F~~	~~D~~	~~A~~
~~**Case 6**~~	~~C~~	~~E~~	~~D~~	~~B~~

Number of solutions is 3



NUMBER OF POSSIBLE SOLUTIONS

Example: Traveling salesman problem

- for 4 cities:
  - 3 choices for the first trip, 2 choices for the second trip, 1 choice for the third trip
  - symmetric trips should be removed
  - N = (3×2×1) ÷ 2 = 3
- for 5 cities: (4×3×2×1) ÷ 2 = 12
- for 6 cities: (4×3×2×1) ÷ 2 = 60
- for 7 cities: (4×3×2×1) ÷ 2 = 360
- For 10 cities: 181440
- …
- For 50 cities: **about 10^{62}**

Our planet holds about 10^{21} liters of water!

Each year has about 3×10^{8} seconds!

Even if 1 Sec is needed for processing each case, we need more than our universe age to process all the possible solutions.

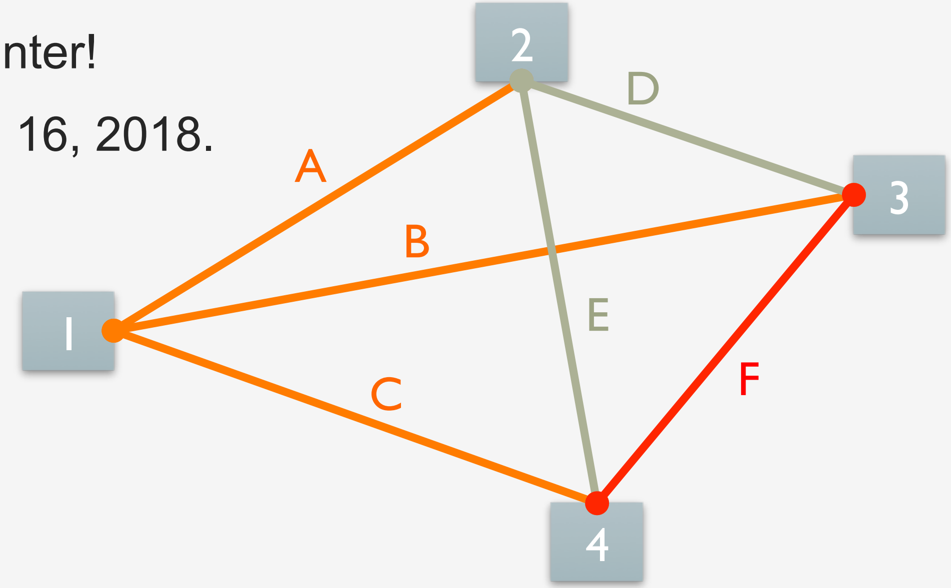
TIME CHANGING ENVIRONMENT

- Because real-world business problems are **set in time-changing environments**, it is important to address the time factor clearly and in detail.

- The **optimal solution** at this time period **may not** be optimal for the next time period.

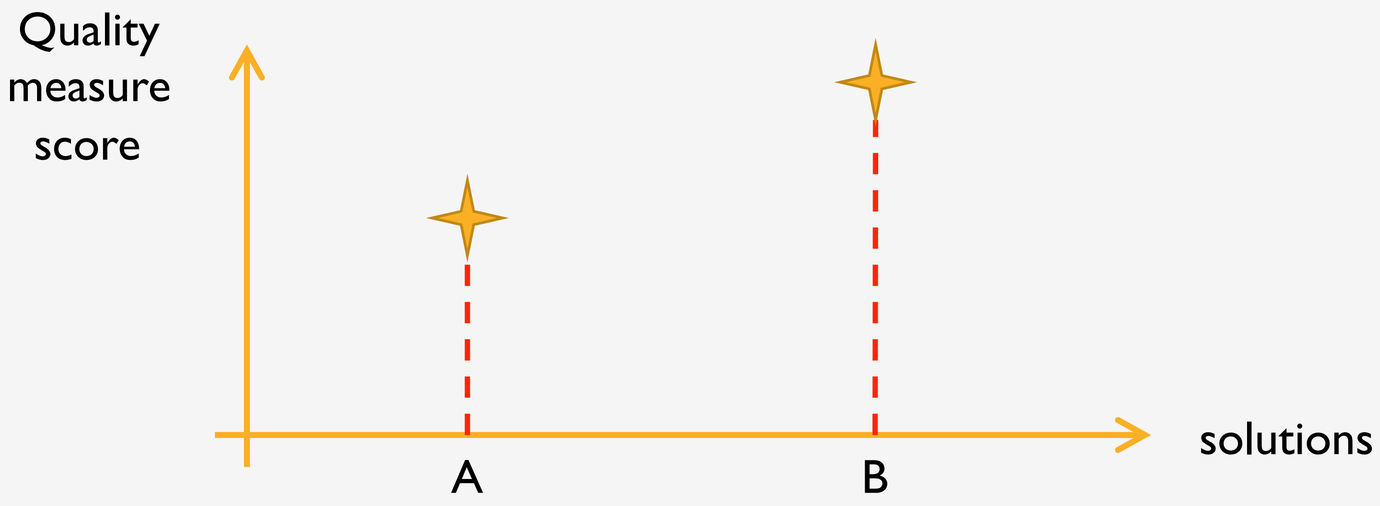
TIME CHANGING ENVIRONMENT

- Examples of time changing environment factors for the traveling salesman problem:
  - Roads B and C are dangerous in Winter!
  - Construction on Road D from March 16, 2018.



TIME CHANGING ENVIRONMENT

- Imagine that we are considering the implementation of solution A or solution B. **Which of these two solutions would we select?**



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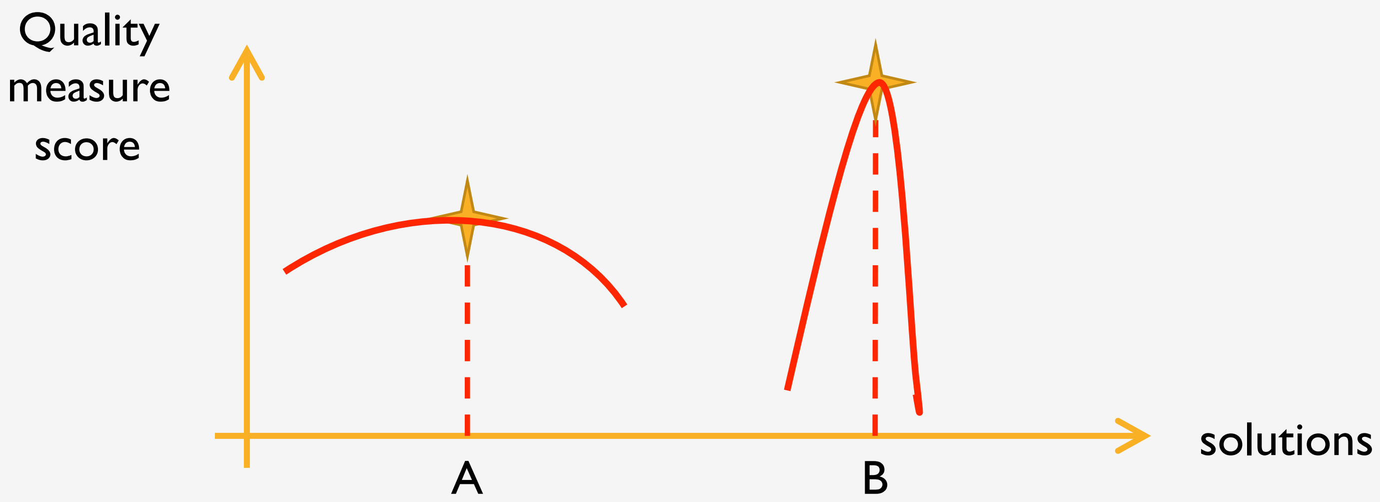
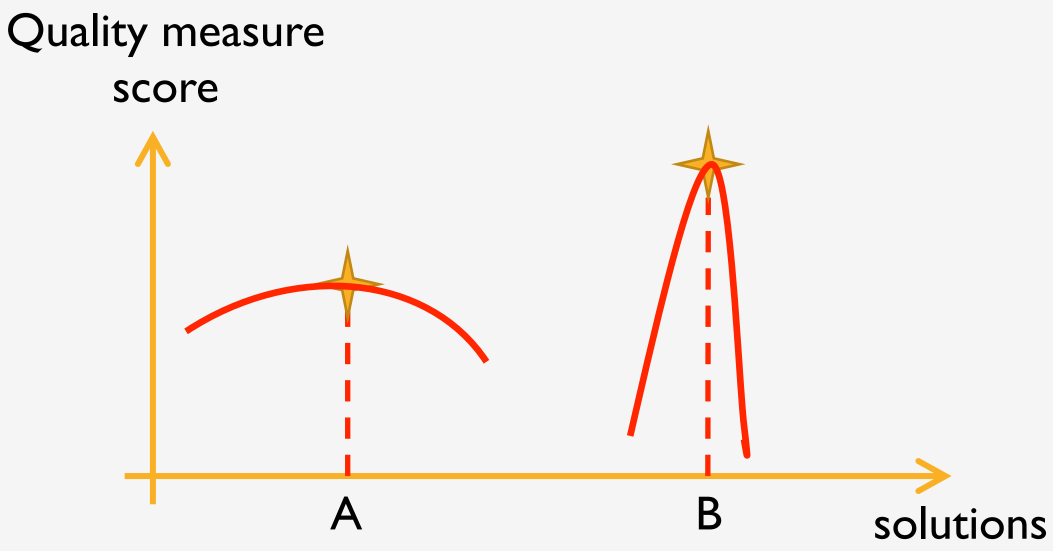


TIME CHANGING ENVIRONMENT

- If we are forced to modify solution B for any reason (equipment failure, bad weather, etc.), then the quality of solution B will deteriorate very quickly.
- Solution A, on the other hand, is much more “stable” in the sense that it can tolerate changes and modifications without a sharp drop in quality.
- Solution A is less risky than solution B



PROBLEM-SPECIFIC CONSTRAINTS

- All real-world business problems **have constraints** **of some sort**, and
- If a particular solution **does not** satisfy these constraints then **we cannot** consider this solution.

PROBLEM-SPECIFIC CONSTRAINTS

- Examples of problem-specific constraints for the **traveling salesman** problem:
  - capacity limits,
  - delivery time windows,
  - maximum driving time, etc.
  - not transporting chemicals and food together on the same truck
  - personnel preferences

PROBLEM-SPECIFIC CONSTRAINTS

- It is necessary to assert the relative importance of each constraint (hard or soft) by assigning numeric weights to it

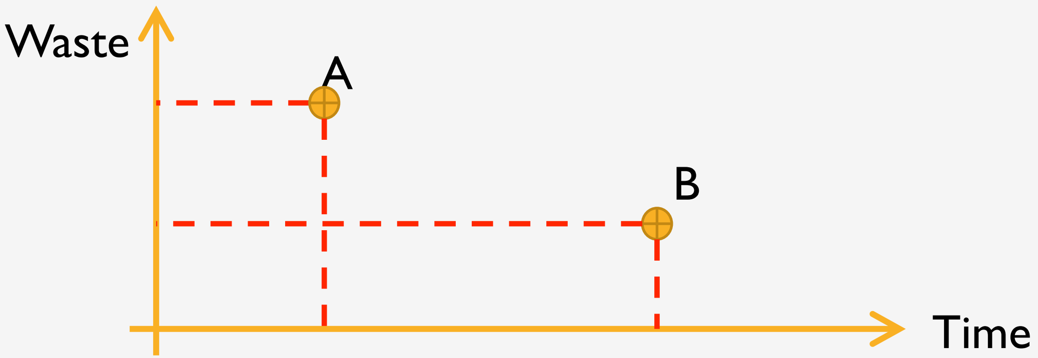
- When solving the problem, we can then use **these weights** to calculate a final quality measure score for each possible solution.

MULTI-OBJECTIVE PROBLEMS

- It is quite unusual for any real-world business problem to have only one objective.
- For example: The objectives may include the **minimization of production time** and the **minimization of material waste**. These objectives might "work" against each other, as the minimization of production time may trigger an increase in material waste, and vice versa.

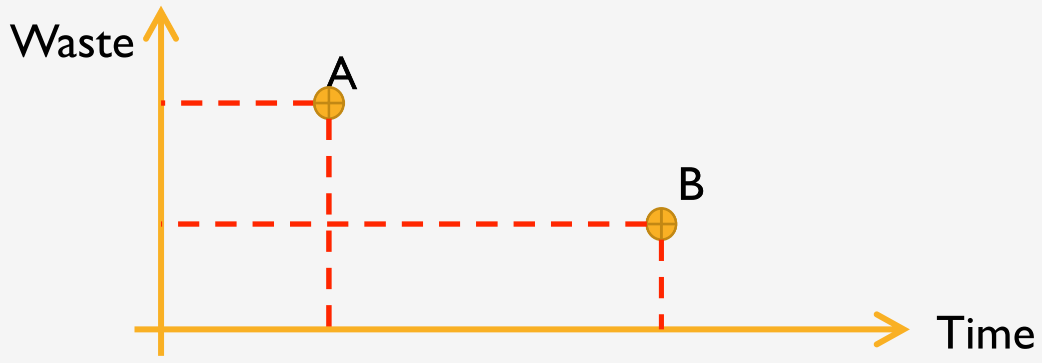
MULTI-OBJECTIVE PROBLEMS

- Let us consider **solutions A and B,** Which one is better?
  - Solution A is faster, but the amount of material waste is higher, and vice versa.



MULTI-OBJECTIVE PROBLEMS

- In problems with multiple objectives, it is possible to find a solution that is best with respect to the first objective, but not the second, and a different solution that is best with respect to the second objective, but not the first.

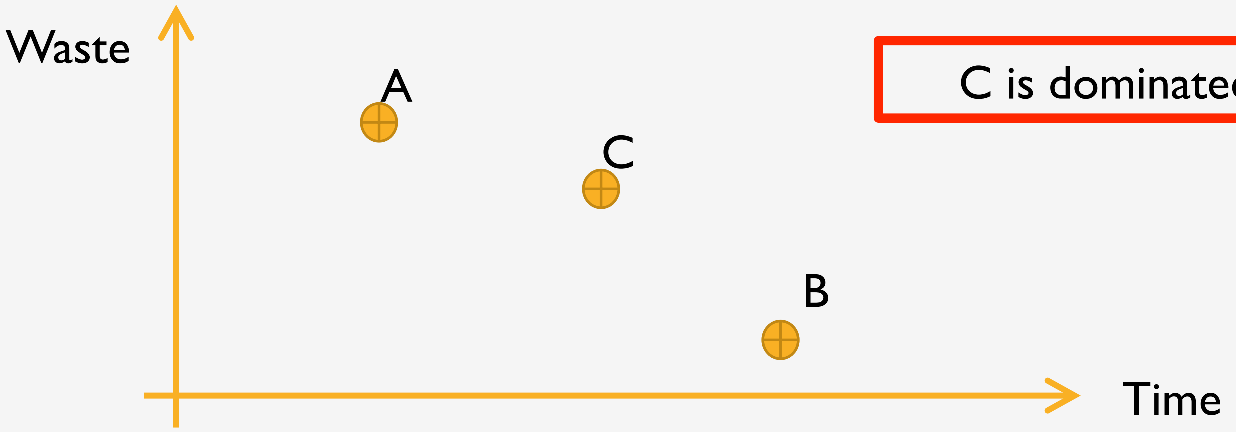


MULTI-OBJECTIVE PROBLEMS

- It is impossible to answer this question without first agreeing on a **common denominator** for time and waste:
  - We can translate both objectives into $ by calculating that five minutes of production time is worth $100, and each pound of material waste is worth $180.
  - We can then calculate the merits (expressed in $) of both solutions, compare the numbers, and select the solution with the lowest dollar figure.
    - **A or B?**

MULTI-OBJECTIVE PROBLEMS

- A solution is **dominated** if a feasible solution exists that is
  1. **at least as good** with respect to **every objective**,
  2. Strictly better with respect to **at least one** objective.

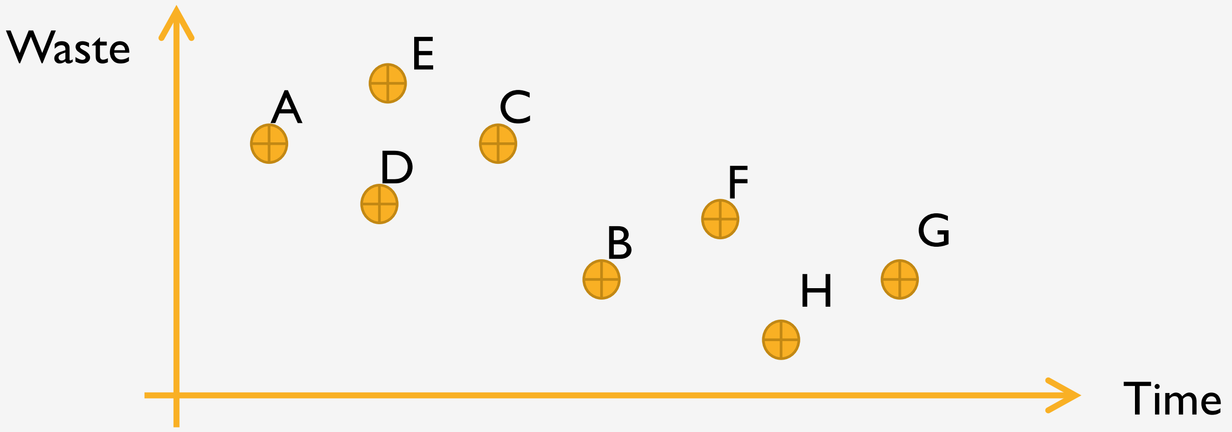


C is dominated!

MULTI-OBJECTIVE PROBLEMS

- A solution that is not dominated by any other feasible solution is called a ***non-dominated*** solution. (of our interest)

A, D, B, and H are non-dominated



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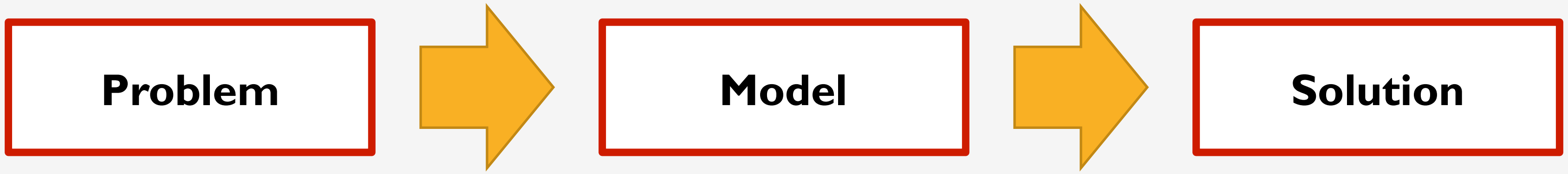
- For each of the cases below, describe what are the objectives and constraint criteria involved to ensure your solution is accurate and adaptable
  - Bank loan
  - Energy savings
  - Currency exchange
  - Postal local deliveries
  - Flight path

PROBLEM SOLVING PROCESS

- The problem solving process consists of two separate steps:
  - **Creating a model of the problem**
  - **Using the model to generate a solution**



PROBLEM SOLVING PROCESS

- We can only find a solution to the model; hence, the accuracy of the model is very important.

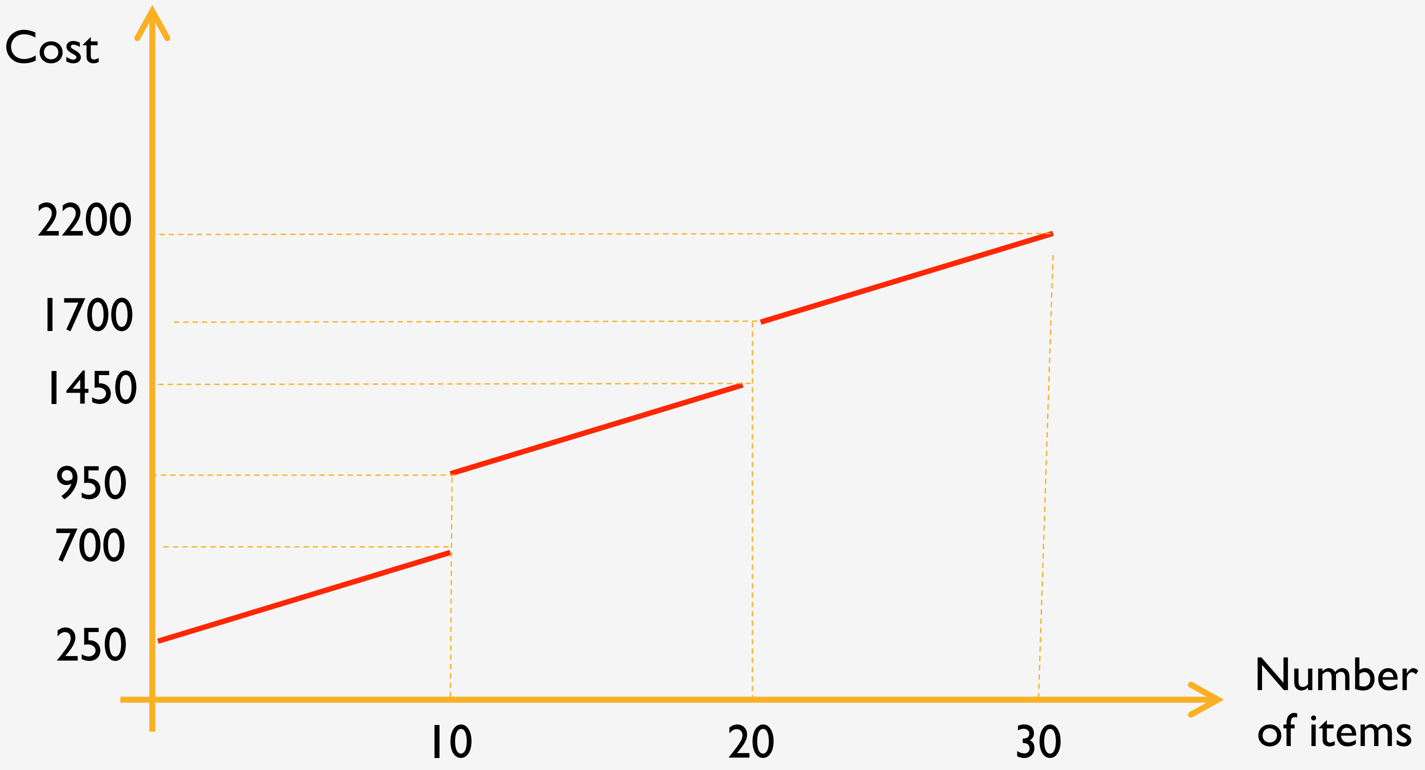
- Accurate model → meaningful solutions

- Vague model → meaningless solutions

PROBLEM SOLVING PROCESS

- **Example**: modelling cost for the transportation between a warehouse and a distribution centre given that
  - The cost is zero when there is no delivery.
  - Each truck can transfer up to 10 items.
  - Hiring a driver costs 250$ per truck
  - Each item costs an extra transportation 50$ (fuel and etc…)

PROBLEM SOLVING PROCESS



PROBLEM SOLVING PROCESS

- In **real-world situation**, the problem and, thereby, the model is **more complicated**:
  - There are 80 warehouses and 5 distribution centres (80 x 5 = 400 variables)
  - Constraint (transportation law, environmental issue, driving regulations) should be considered.
  - The total transportation cost should be minimized.

PROBLEM SOLVING PROCESS

- Model is **discontinuous** (non-linear):
  - difficulties for traditional optimization techniques
  - approximate solutions can be obtained.
- In this case, even a perfect model is useless for deciding what to do.

Problem → **Precise Model** → **Approximate Solution**

PROBLEM SOLVING PROCESS

- We **can simplify the model**, so that traditional optimization techniques can be used

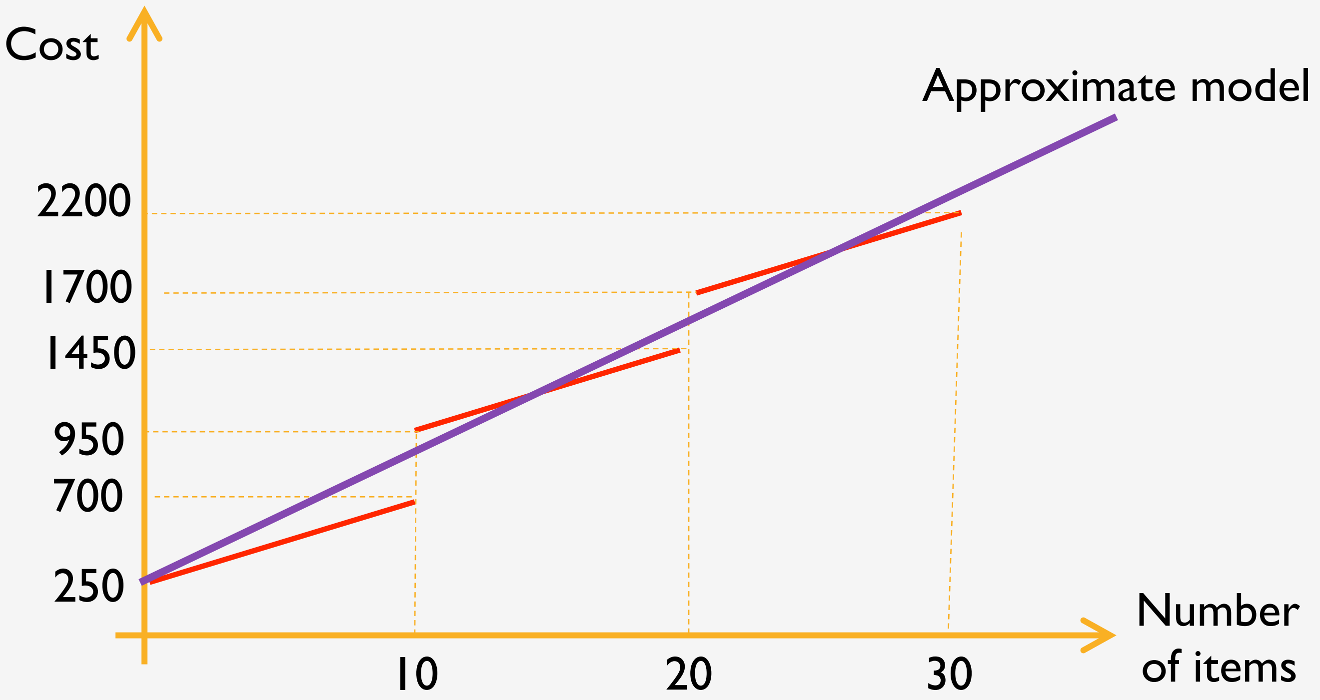
Problem → **Approximate Model** → **Precise Solution**

- Or we can leave the precise model unchanged and use untraditional optimization techniques.

Problem → **Precise Model** → **Precise Solution**

PROBLEM SOLVING PROCESS

- Example for simplifying a model



ADAPTIVE BUSINESS INTELLIGENCE

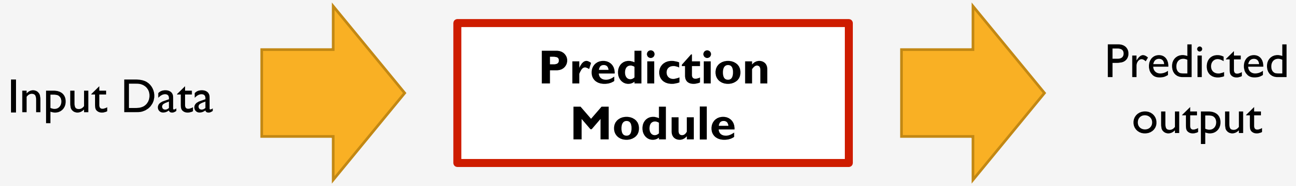
- **ABI** systems include **4 major components**:
  - A data mining module (data preparation and analysis)
  - A prediction model (on the data mining results)
  - An optimization module (recommend the best solutions based on the prediction results)
  - An adaptability module (responsible for adapting the prediction module to the time-changing environment)

ADAPTIVE BUSINESS INTELLIGENCE

- **Data Mining Module**
  - Although knowledge discovery is an important goal of data mining, we are more interested in **using the data mining results to build a prediction model**.
  - Predictions are directly applicable to **Decision Making**, whereas knowledge discovery is closer to **Decision Support**

ADAPTIVE BUSINESS INTELLIGENCE

- **Prediction Module :**



To make the prediction module functional, it is necessary to "**train**" **the various underlying models using historical data**.

During this process, **the prediction model learns how to predict**.

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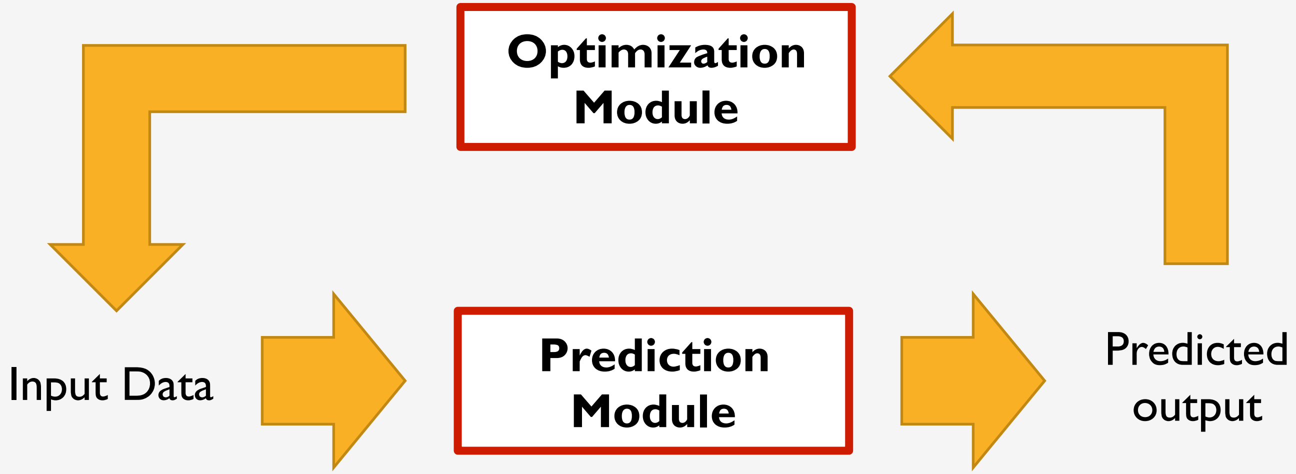
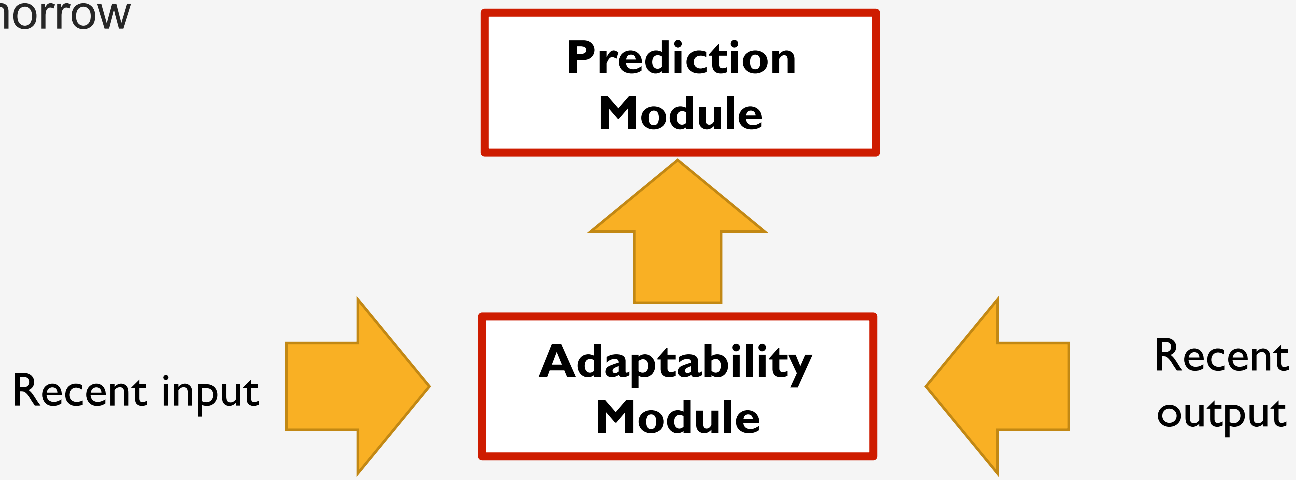
- **Optimization Module:** Generates a distribution solution that serves as input data for the prediction module



ADAPTIVE BUSINESS INTELLIGENCE

- **Adaptability Module:** Today's accurate prediction might be inaccurate tomorrow



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