Introduction to Business Analytics

Advanced Information Systems and Business Analytics for Air Transportation

M.Sc. Air Transport Management

June 1-6, 2015

Slides prepared by N. Kemal Üre

Main Source: Saxena and Srinavisan, Business Analytics: A Practitioner's Guide, 2013, Springer New York

What is Analytics?

A **rational** way to get from ideas to execution

Rational Decisions are

Data Driven

Based on facts

Transparent

Clearly defined costs and benefits

Verifiable

Comparable with alternatives

Robust

Don’t need to consider all the errors and biases

Who uses Analytics?

Data changed the way we do

- Science and Engineering
- Medicine
- Finance

…. And now business!

Data can predict

- What product you are going to buy
- Who is best equipped for a particular job

New job titles:

- Data Scientist, Data Architect
- Chief Analytics Officer

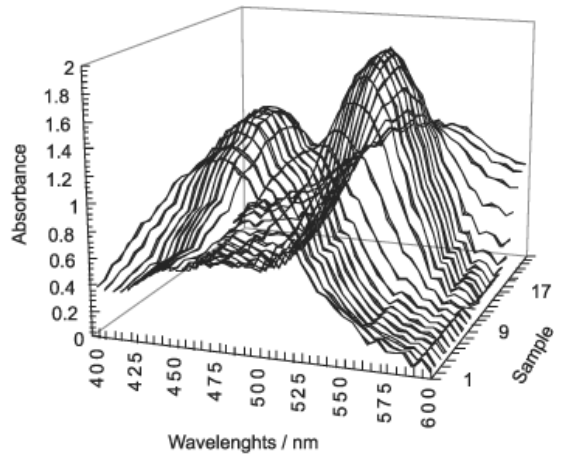
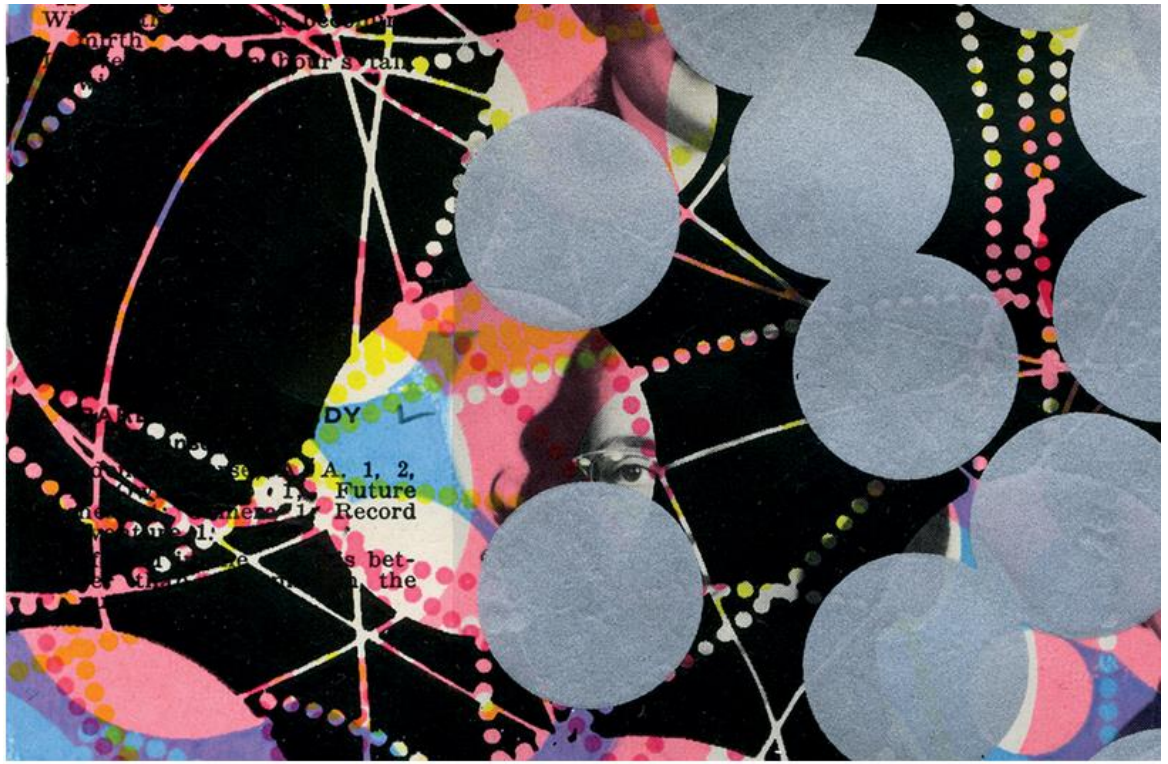


Figure 1. A sample of simulated spectra of prediction set.

Why Analytics?

- Analytics improved massively in recent years
  - Advances in operations research, computer science and statistics
  - Sustained improvements in computation power
  - Huge amounts of data
  - Success stories



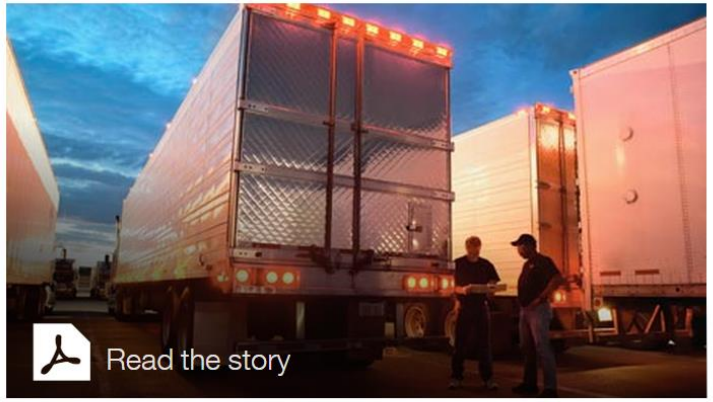
DATA

Data Scientist: The Sexiest Job of the 21st Century

by Thomas H. Davenport and D.J. Patil

Source: Harvard Business Review

Analytics Success Stories



Automotive, Insurance

Daimler FleetBoard - Mercedes Benz uses an analytics-based telematics solution to price insurance based on driver behavior. (81KB)

Industrial

Vestas analyzes a wide range of weather data to help situate wind turbines for optimal energy output. (01:30)

Telecommunications

T-Mobile gains real-time actionable insight into the data flowing through its entire network in seconds. (03:10)

Travel and transportation

Nagoya Railroad drives revenue using analytics to identify customer travel habits and run targeted marketing campaigns.

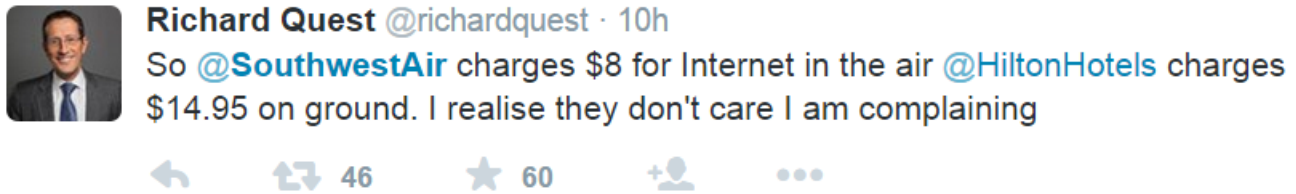
Source: IBM

Analytics in Air Transportation

- **British Airways** spot when passengers choose window seats for short-haul flights and aisle seats for long-haul flights.

- **Delta Airlines** equipped 19,000 flight attendants with handheld devices in 2013 to offer a more personal passenger experience.

- **Southwest Airlines** analyses social media for complaints and improving customer service



Analytics in Air Transportation

- **Sojern** is collecting information across airlines, hotels, rental car agencies and credit card companies determine "when people go, where they go, how many people are travelling, and preferred brands, travel times and class of service,“

- **Multiple airlines** are calculating value of a group of customers who will miss a connection due to a flight delay and then determining whether to delay their connecting flight or book them on the next plane.

- Great! But what can analytics do for me?

Analytics from Different Perspectives

Business

Decision Makers
Consumer of Analytics

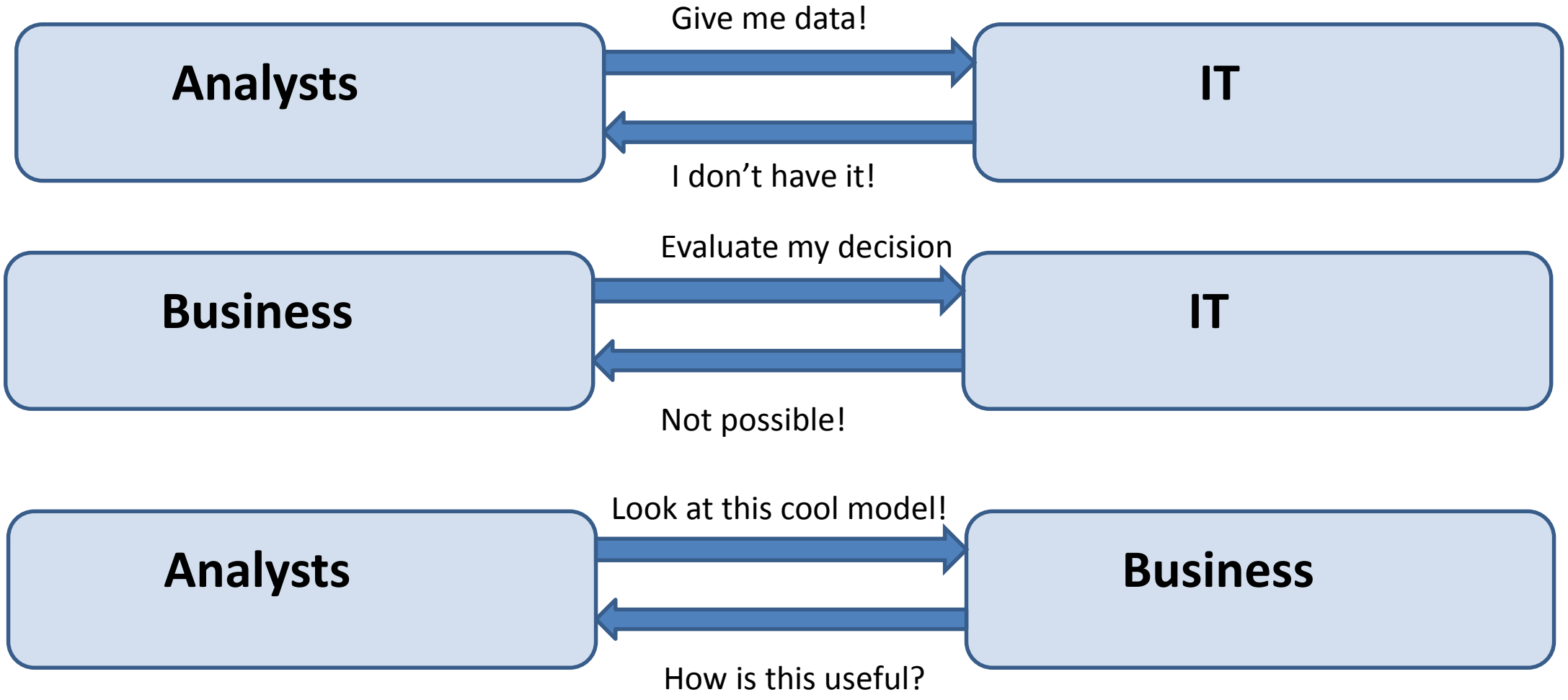
IT

Data providers
Infrastructure for Analytics

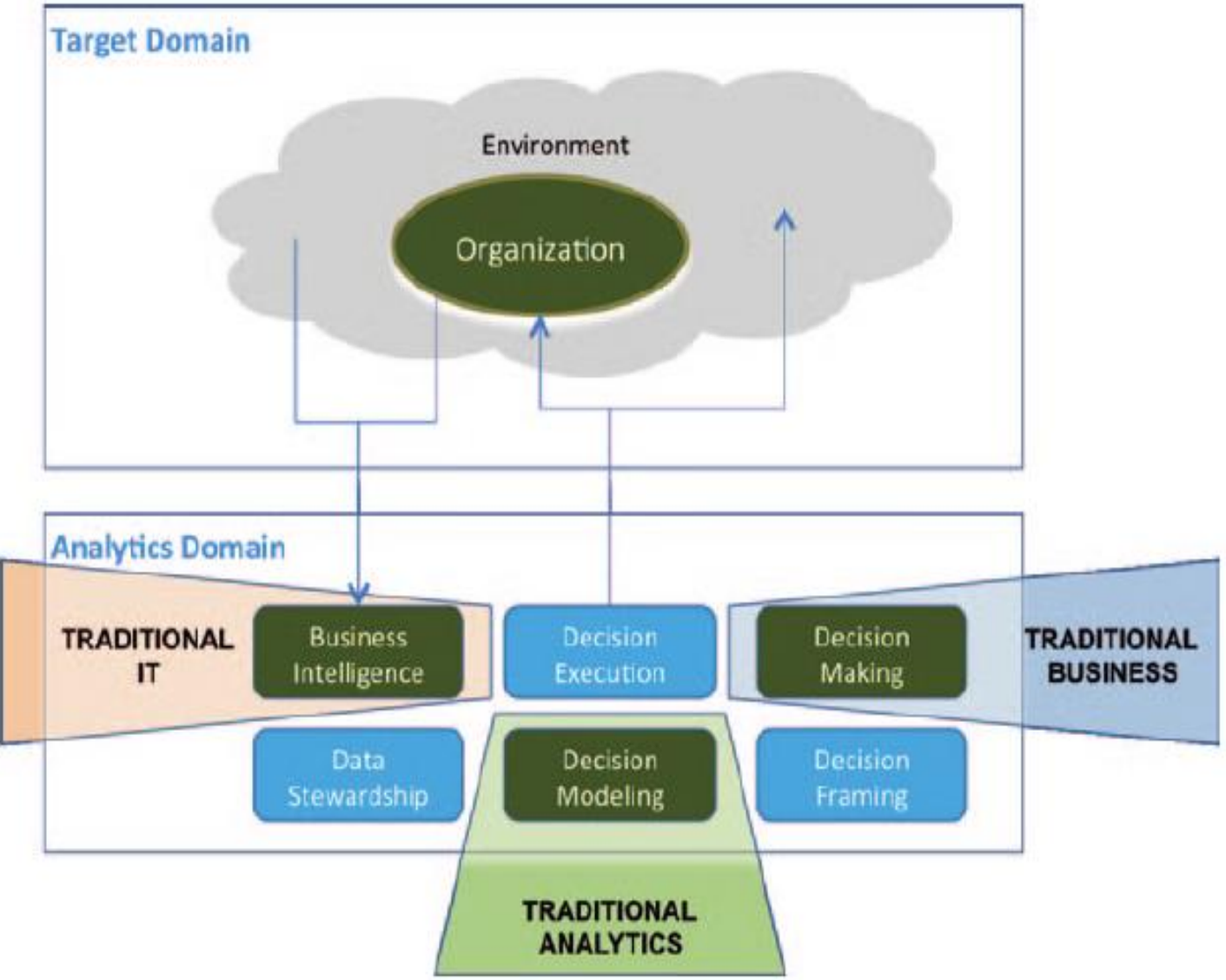
Analysts

Math and Data Experts
Models for Analytics

Common Failures



A Framework for Business Analytics



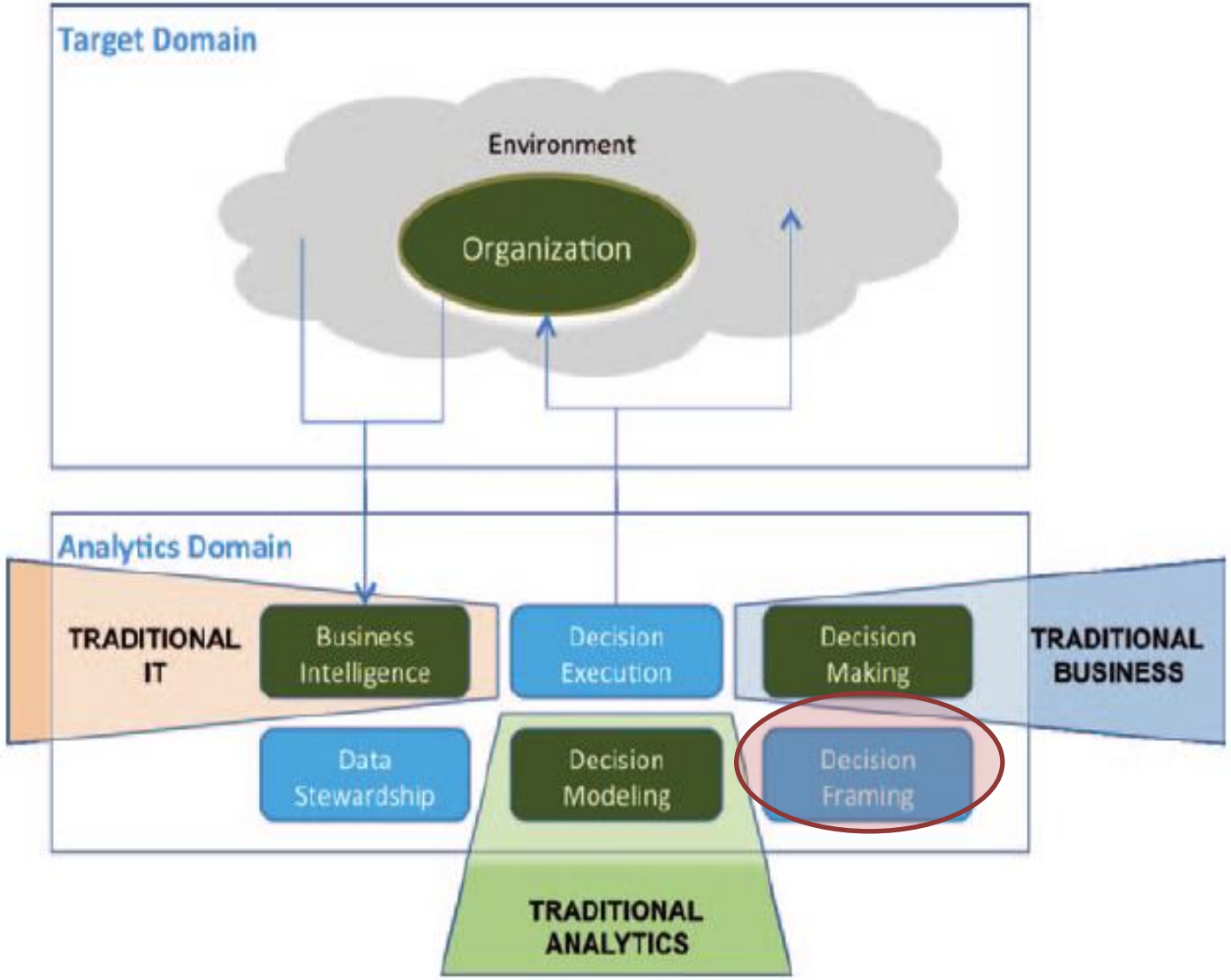
Classical functions

- **Business Intelligence:** Provide data
- **Decision Modelling:** Build and test a decision model that provides rational advice
- **Decision Making:** Use the decision model to make decisions

Coupling Functions

- **Data Stewardship:** Measure the quality of the data and assess its fitness
- **Decision Execution:** Convert decisions to actions and monitor the results, control deviations, track the outcomes
- **Decision Framing:** Articulate the decision need

A Framework for Business Analytics



Decision Framing

- Articulate the decision need in a form and structure that enables effective modelling
- Poor framing => failure in analytics
  - Capabilities and processes are not geared to handle the recommendations of the decision model
  - Models are not structured towards solving the real problem
- Bad: Which customers should I make a special offer so that I get maximum returns (Sales) for minimum cost
  - Good: Which customers should I make a special offer so that I can maximize sales and my cost does not exceed $X?”

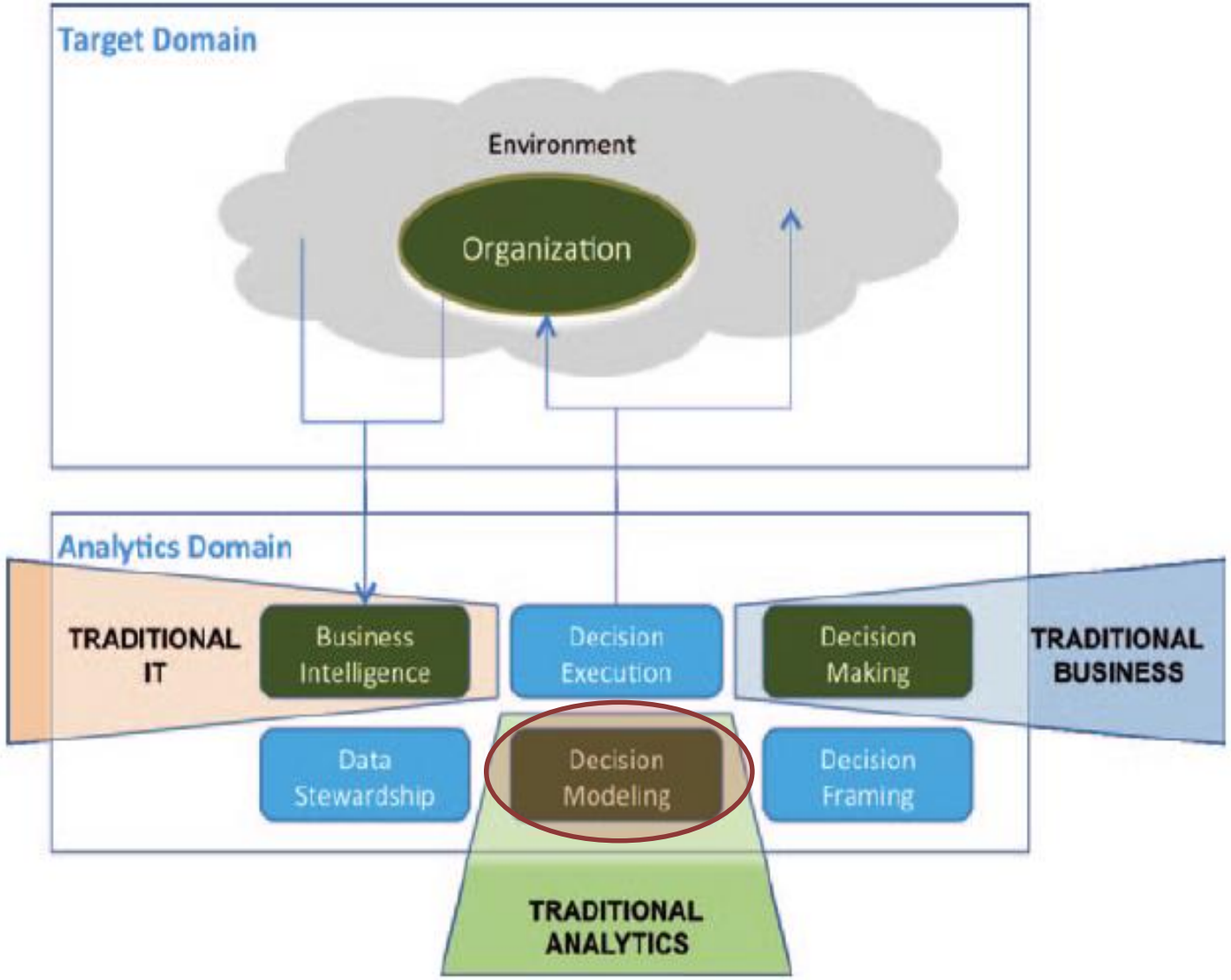
Decision Layers

DECISION LAYERS		
	NETWORK	Used to set vision & strategy, no constraints other than strategic intent
	CAPABILITIES	Used to create the capabilities demanded by the strategy, constrained by strategy
	CONTROL SYSTEM	Used to align resources to workloads, constrained by capacity & strategy
	WORKFLOW	Used to execute the workloads, constrained by the schedule & allocation

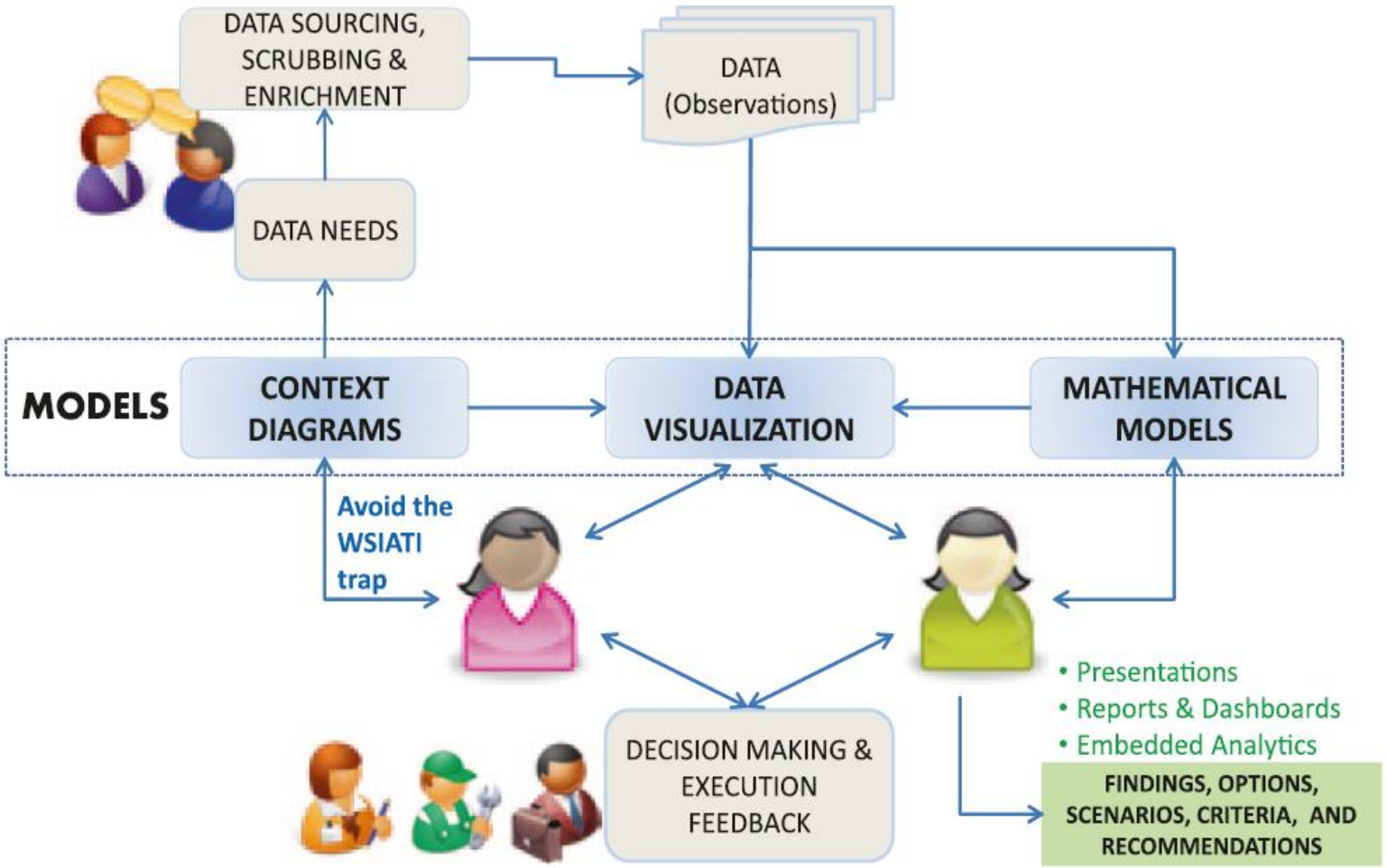
Airline Partnership Example

- An airline wants to expand its operation by a code share agreement
- Network Layer
  - Decision Frame: What are the best set of partners?
  - Model: Identify, evaluate and recommend destinations in the partner network
- Capability Layer
  - Decision Frame: Specific flights and available capacity
  - Model: Choose the best set of flights and capacities that will maximize the airlines ability to serve newer destinations
- Control Systems Layer
  - Decision Frame: What is the best pricing?
  - Model: Consider market dynamics and price elasticity and determine the optimal price
- Workflow Layer
  - Decision Frame: Accept or reject a booking request
  - Model: Maximize the total revenue by considering alternative routes

A Framework for Business Analytics

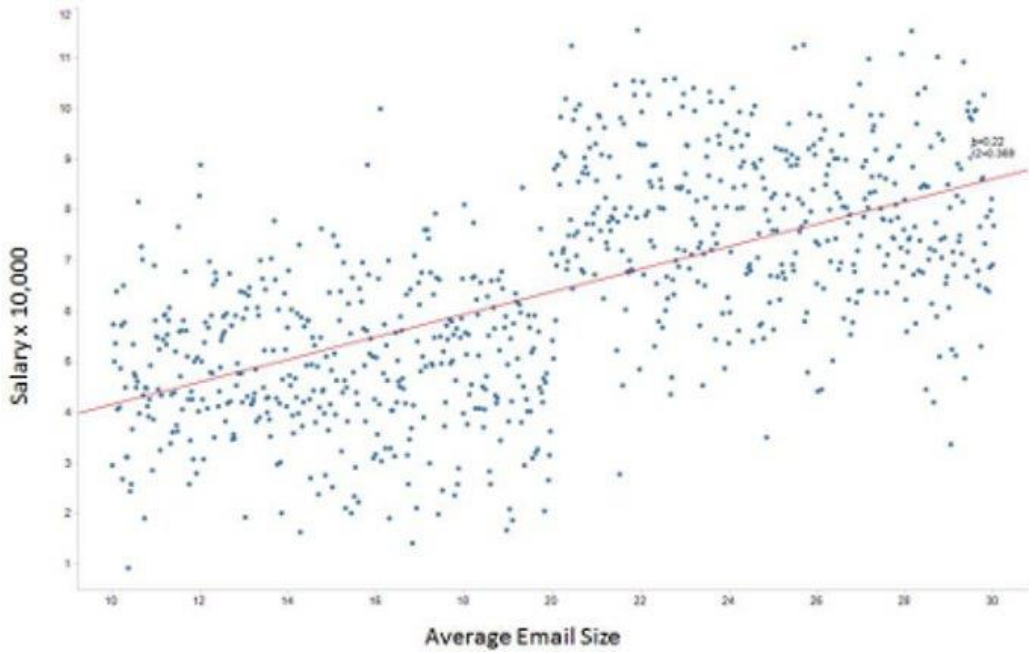


Decision Models



Data Visualization

- A picture is worth a thousand words
- Be careful! Poor visualization techniques lead to loss of data, insight, and usability.

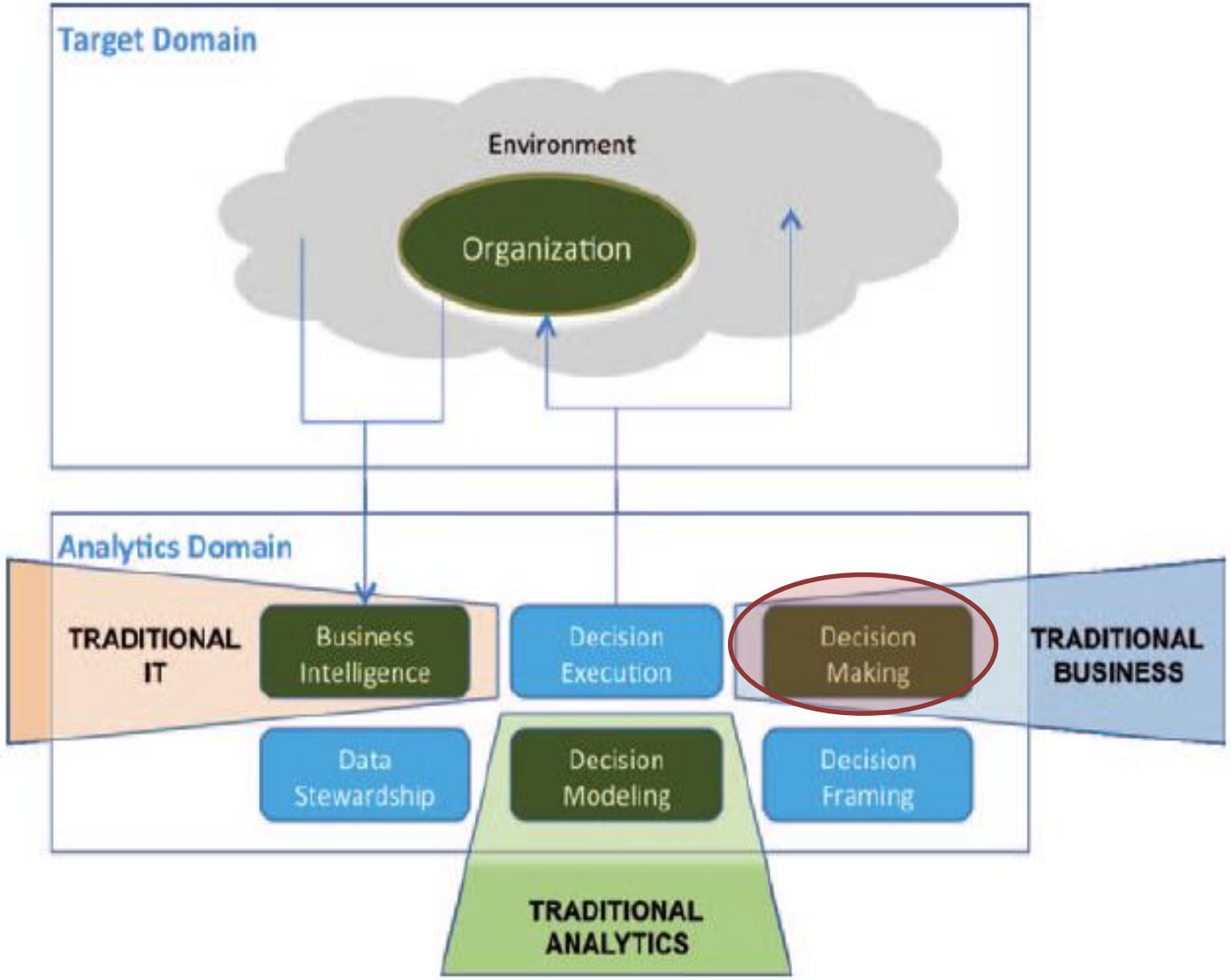


Source: http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen.html.

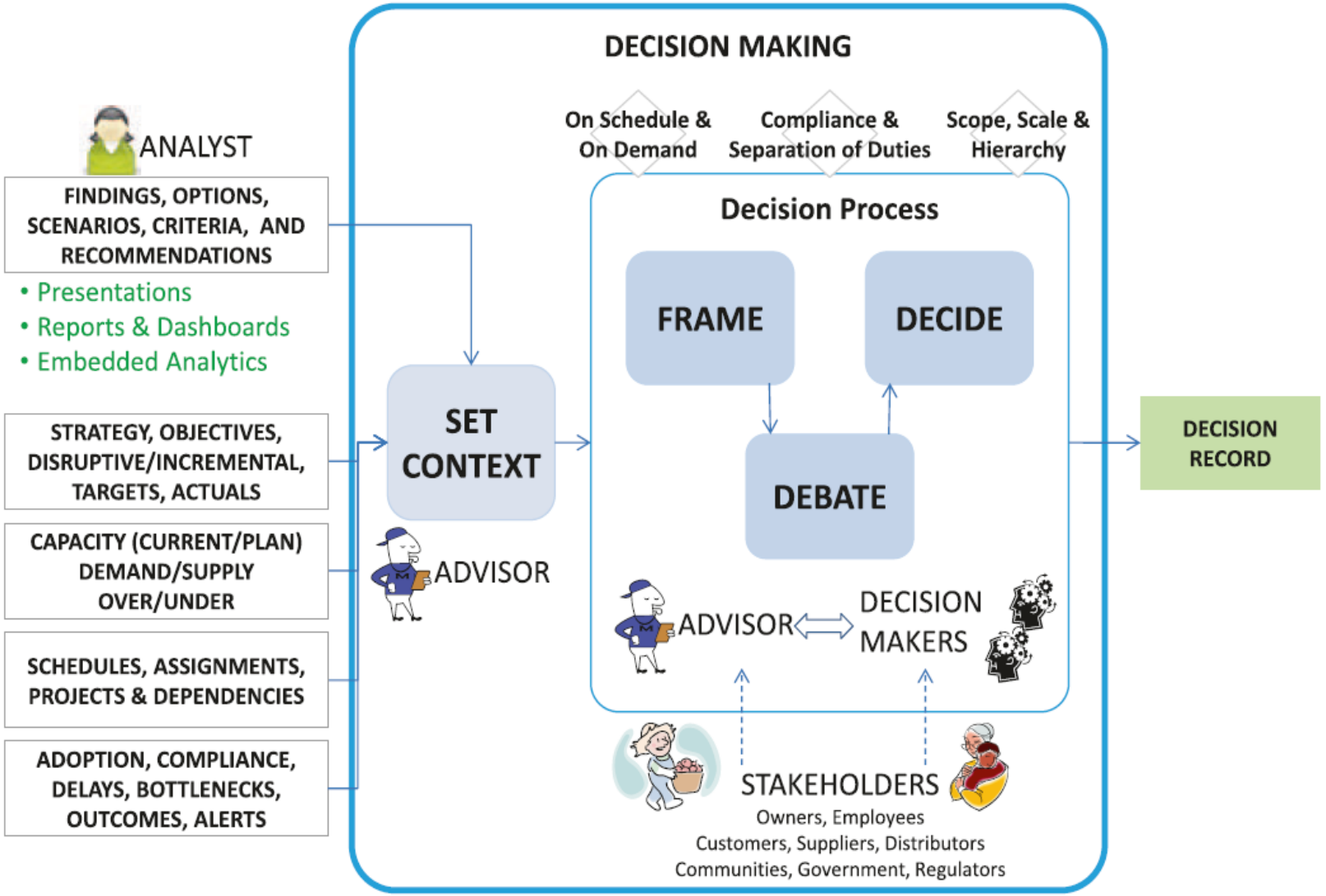
Mathematical Models

- Hypothesis Testing
- Correlation, Regression, Forecasting
- Sampling
- Queueing Theory and Simulation
- Linear Programming
- Network Optimization
- Dynamic Programming
- Nonlinear Optimization
- Game Theory
- Decision Trees
- System Dynamics
- Markov Chains and Hidden Markov Models
- Bayesian Statistics

A Framework for Business Analytics



Decision Making



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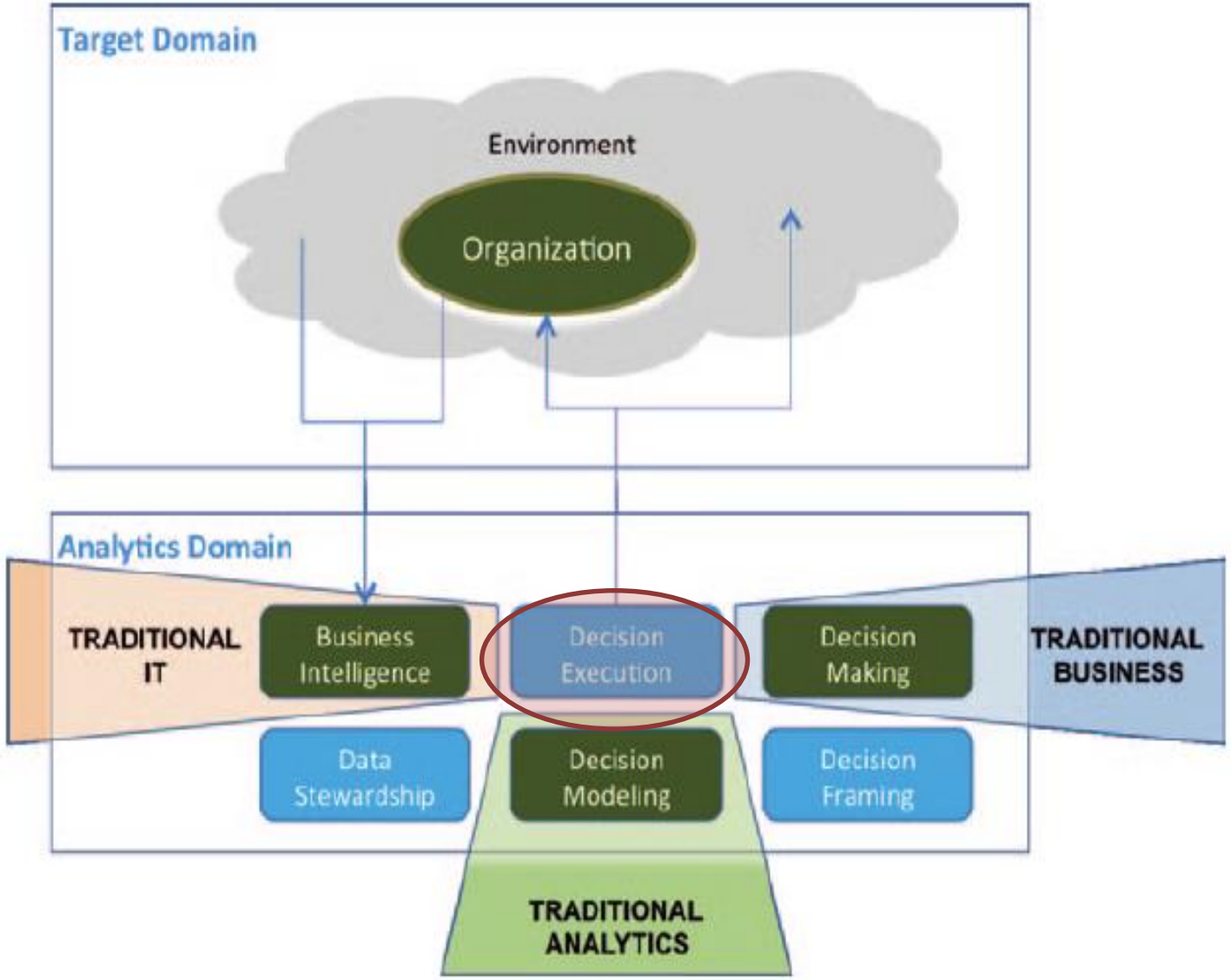
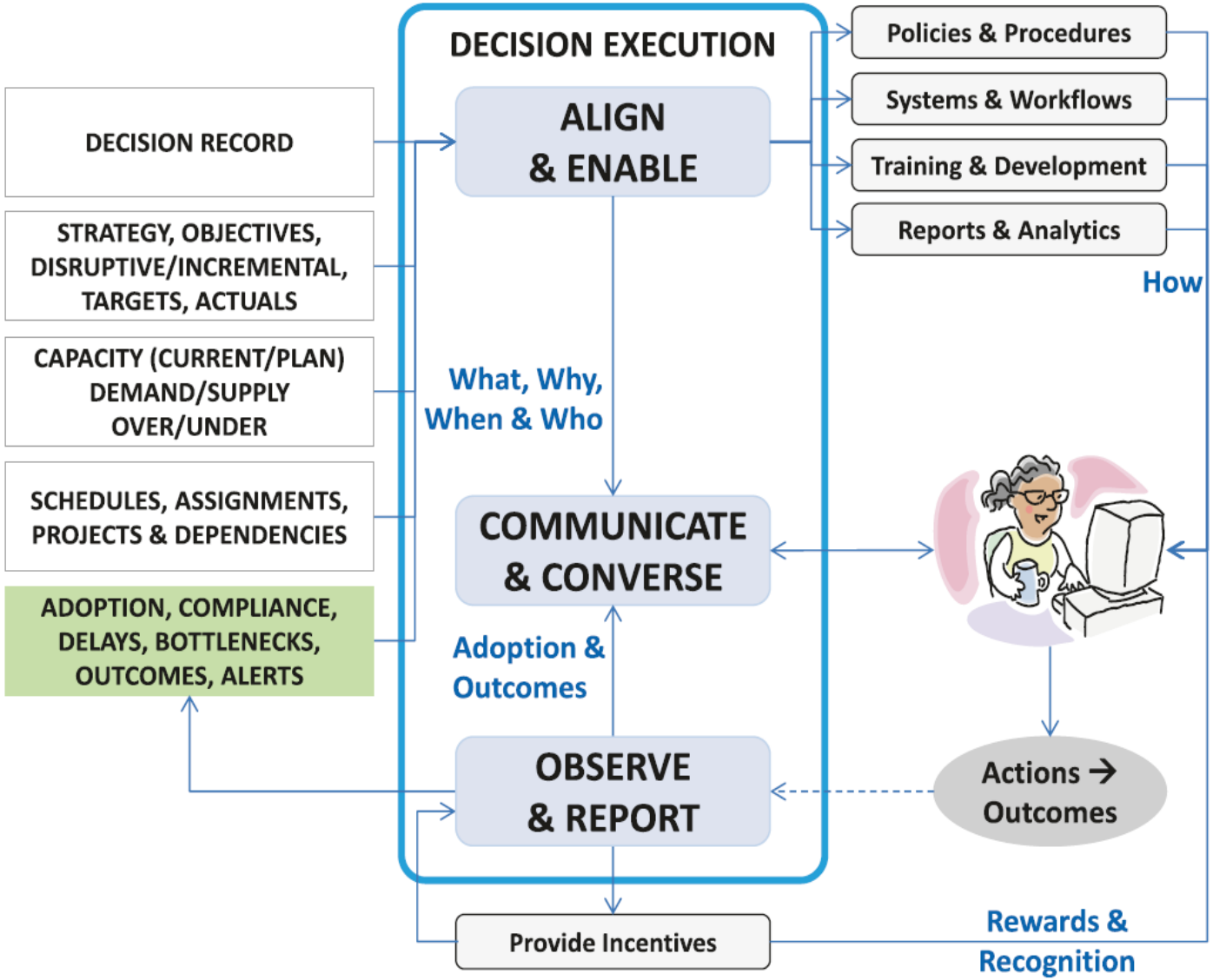


Decision Execution



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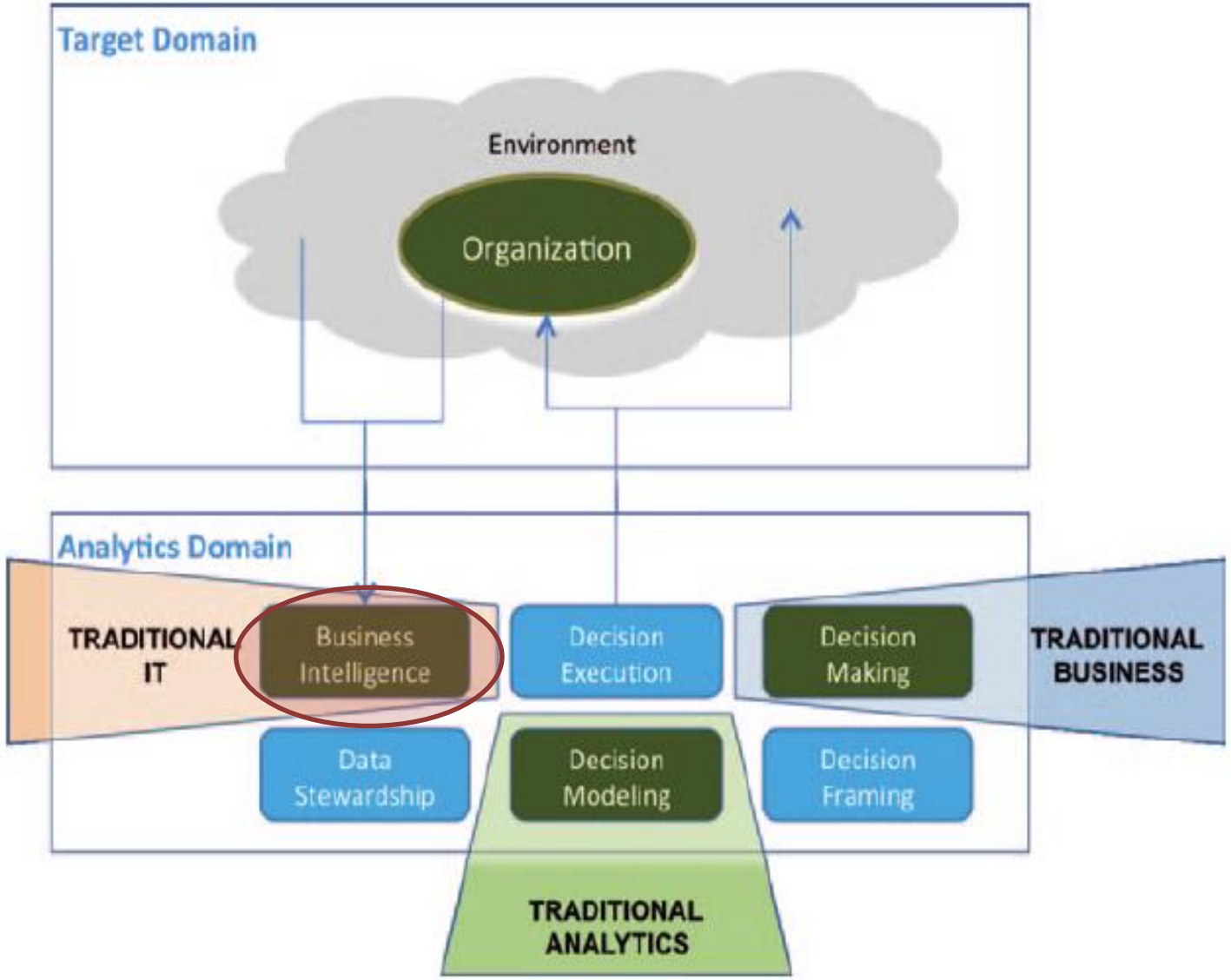
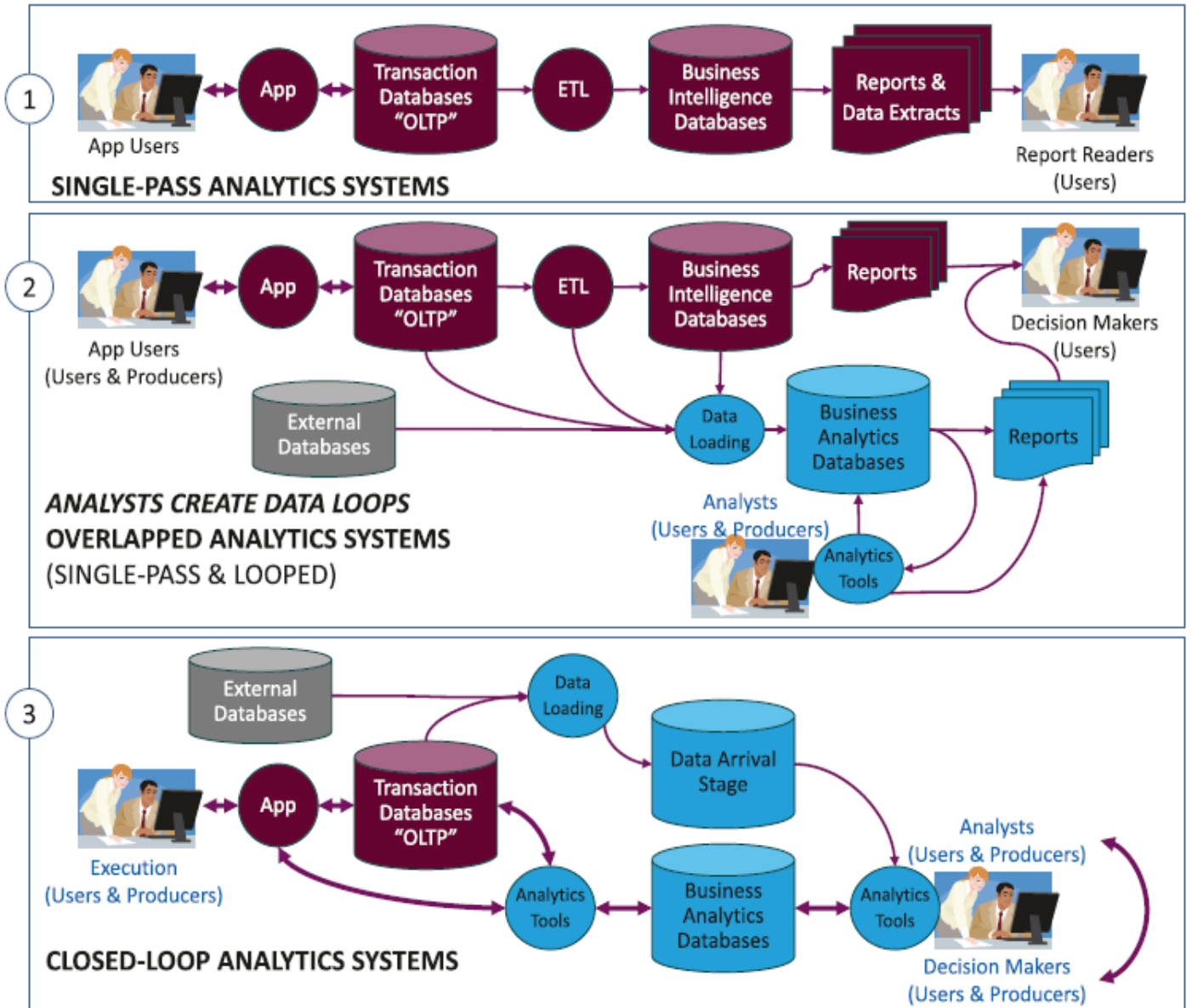


Business Intelligence



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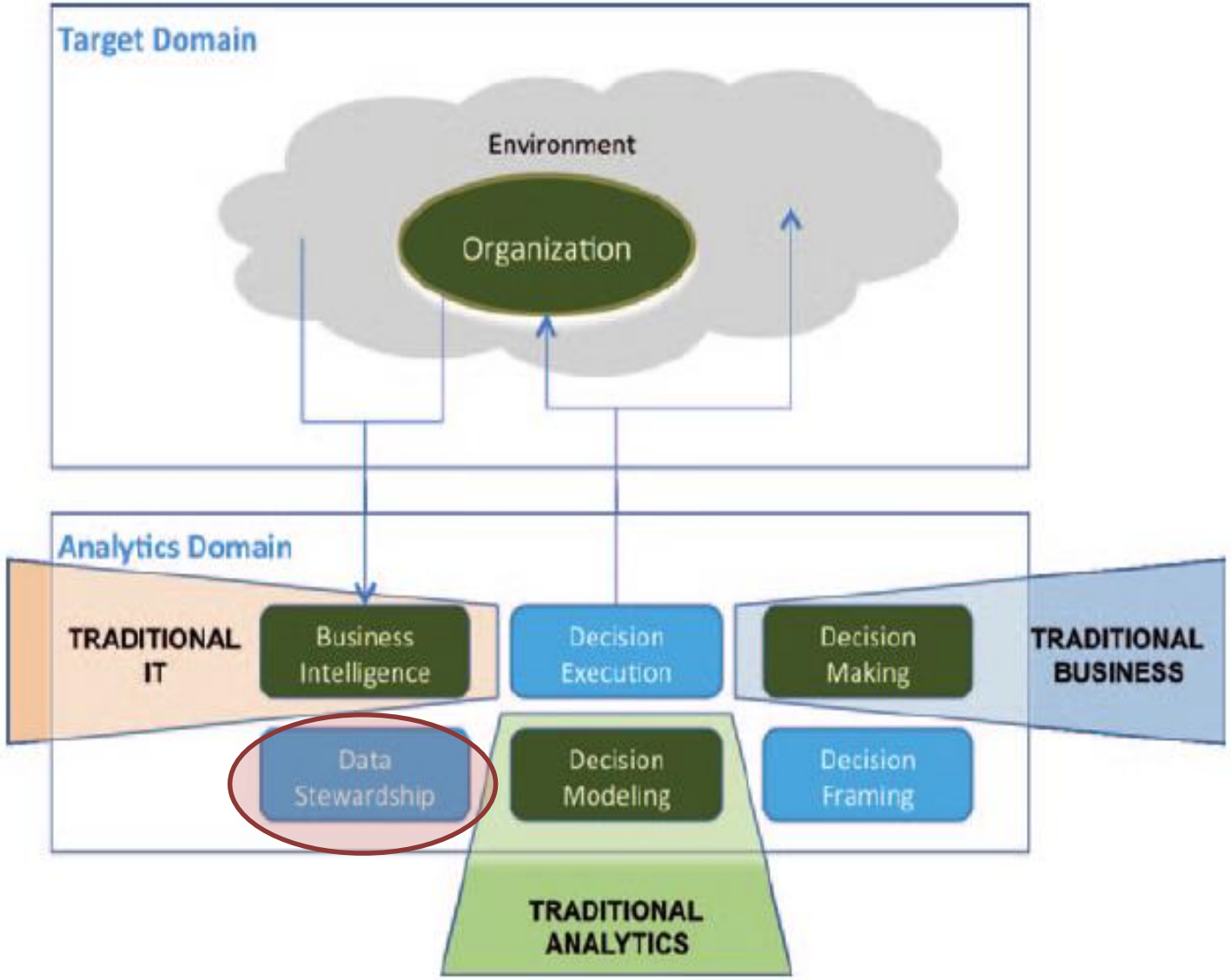


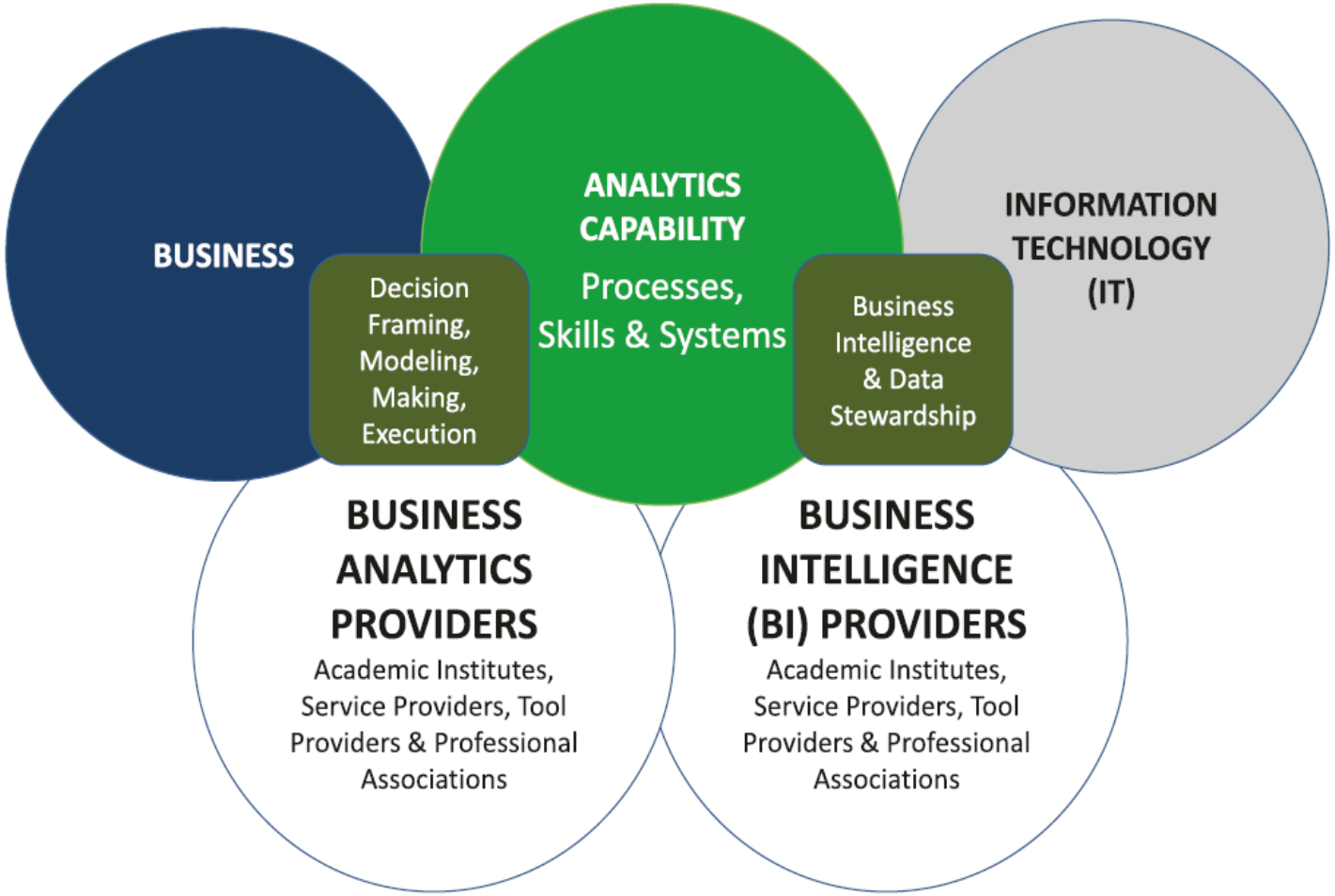
Data Stewardship

- Can we use the data?
  - Data sets may contain problems that can make the analysis incorrect and the recommendations misleading.

- Initial Data Provision
  - First cut review of the data
    - Is it rounded?
    - Is it complete?
    - Cut/paste artifacts
    - Is it consistent?
  - Sort, Scatter and Histograms
  - Fitness for use
  - Privacy and Surveillance

- Data Scrubbing and Enrichment
  - Scrubbing
    - Drop the unnecessary data
  - Enrichment
    - Feed the analytics data to database
      - Internal
      - External

Building Analytics Capability



- Identify the value of external resources
- Allocate right people for the right job
  - Business
    - Management, domain specialists
  - Analysts
    - Data and **applied** math expertise, visualization
  - IT
    - Software development, data stewardship
  - Everyone should have good communication skills!

Case Study: Next Likely Purchase

- The imaginary company XYZ would like to introduce intelligence to their marketing campaign
  - Identify the “best” customers to target, with the right products/services
  - Maximize the return on marketing spend
- Decision Framing:
  - Assume every product has the same marketing cost
  - What are the most customer-product pairings what would result in a possible purchase?
- Data Collection:
  - We need all the purchase history! At minimum:
    - Customer ID
    - Product ID
    - Transaction Date
    - Transaction Value

Case Study: Next Likely Purchase

- Data Assessment
  - Completeness: All purchases made by all customers should be reflected in the data
    - Can be verified by comparing total transaction value to reported revenue
    - Offline sales might be missing
  - Quality: Individual fields shouldn't have missing values
    - Customer ID is difficult to get in offline sales
  - Data Enhancement:
    - Use customer survey data
    - Customer Demographics
    - Customer data from social media

Case Study: Next Likely Purchase

- Decision Modeling
  - Predict the probability that a customer will respond favorable to a product
  - Identify the inputs to the model
    - Total number of transactions up to the purchase
    - Total value of transactions
    - List of products in customers portfolio leading up to the purchase
  - **Multinomial logistic regression** supplied with the input data can predict the probability of purchase for a given customer-product pair

Case Study: Next Likely Purchase

- Decision Making:
  - Communicate with each customer using an interaction agent. Promote the product most suited for him/her.
  - Identify the best customers for a particular product you want to promote
- Decision Execution:
  - Make sure to enhance the dataset by collecting purchase data from the advertised product

Case Study: Resource Management

- XYZ manage a large number of projects simultaneously. It would like to distribute the staff in the most efficient way
- Decision Framing: Maximize the margins from the project portfolio, while meeting the constraints
  - A resource cannot be assigned more than 8hrs a day/40hrs a week
  - Each project have a minimum amount of resources needs to be assigned
  - Certain types of tasks have to be executed in certain regions
  - Resource assignment should remains stable across the project schedule
  - If tasks extend beyond the scheduled date, we should still be able to maintain the resource assignment

Case Study: Resource Management

- Data Collection:
  - Project Work Breakdown Structure (WBS)
    - Outlines all the detailed tasks that need to be completed
    - Tasks, schedules, dependencies
    - Budget, forecasts of costs and hours
  - Resource Skill Inventory
  - Resource Calendar
  - Resource Cost and Location
- Data Assessment
  - WBS are notoriously incomplete… => Project Management Office (PMO) fills the gaps
  - Rest of the data is usually available from HR

Case Study: Resource Management

- Decision Modelling:
  - Use a **Mixed Integer Linear Program**
    - Encodes the objectives and constraints as mathematical inequalities
    - For reasonable number of tasks and resources, easy to solve and understand
    - Outputs the optimal solution
- Decision Making
  - Simply accept/reject MILP solution
- Decision Execution
  - Educate the managers about compliance to optimal policies
  - Train the managers to provide input on external considerations
  - Update the model to add new constraints