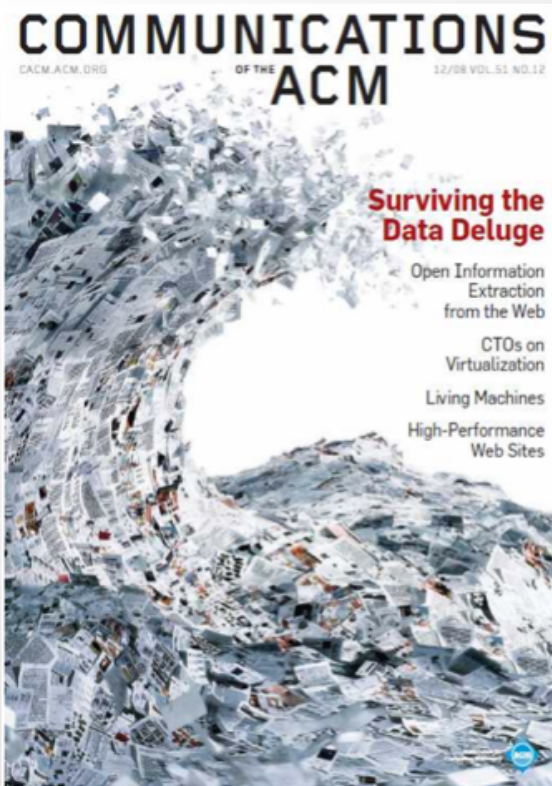# Prescriptive Analytics: Introduction

INCOSE WMA Tutorial

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Surviving the Data Deluge

Open Information Extraction from the Web

CTOs on Virtualization

Living Machines
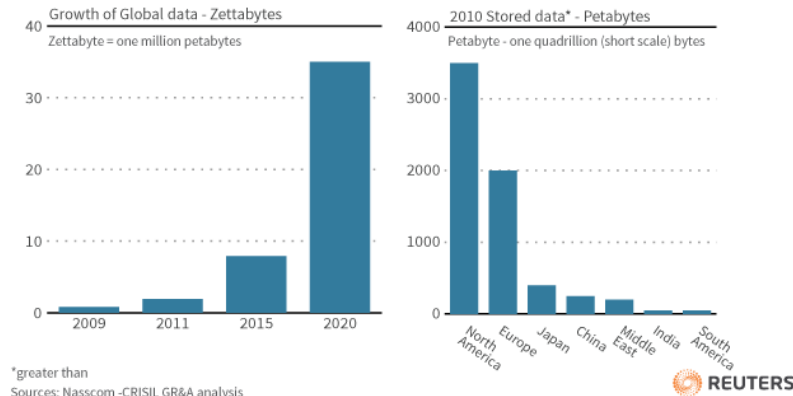
High-Performance Web Sites

- **126 million** – The number of blogs on the Internet (as tracked by BlogPulse).
- **27.3 million** – Number of tweets on Twitter per day (November, 2009)
- **350 million** – People on Facebook.
- **50%** – Percentage of Facebook users that log in every day.
- **4 billion** – Photos hosted by Flickr (October 2009).
- **2.5 billion** – Photos uploaded each month to Facebook.
- **12.2 billion** – Videos viewed per month on YouTube in the US (November 2009).
- **924 million** – Videos viewed per month on Hulu in the US (November 2009).
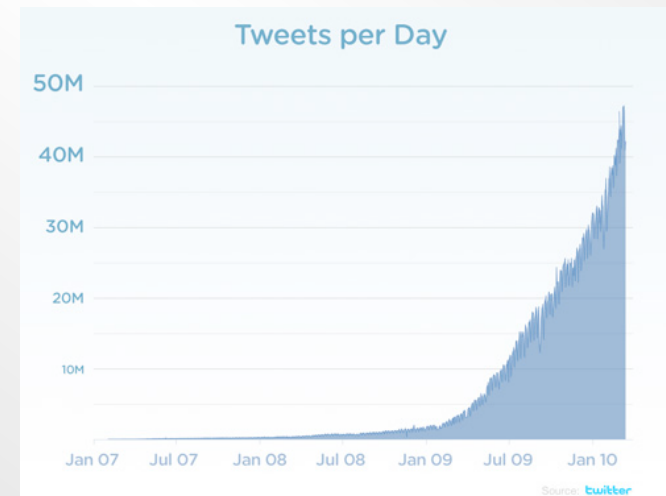
http://royal.pingdom.com/2010/01/22/internet-2009-in-numbers/

Big data growth

Big data market is estimated to grow 45% annually to reach $25 billion by 2015

Growth of Global data - Zettabytes
Zettabyte = one million petabytes

2010 Stored data* - Petabytes
Petabyte - one quadrillion (short scale) bytes

*greater than
Sources: Nasscom -CRISIL GR&A analysis

Reuters graphic/Catherine Trevethan 05/10/12

REUTERS

Tweets per Day

Source: twitter

A Useful Distinction

- Big Data
  - Collection, management and processing of large quantities of complex structured and unstructured data

- Data Analytics
  - Extracting value from data by using formal analysis to:
    - Find patterns
    - Understand meaning of patterns
    - Make predictions
    - Recommend decisions
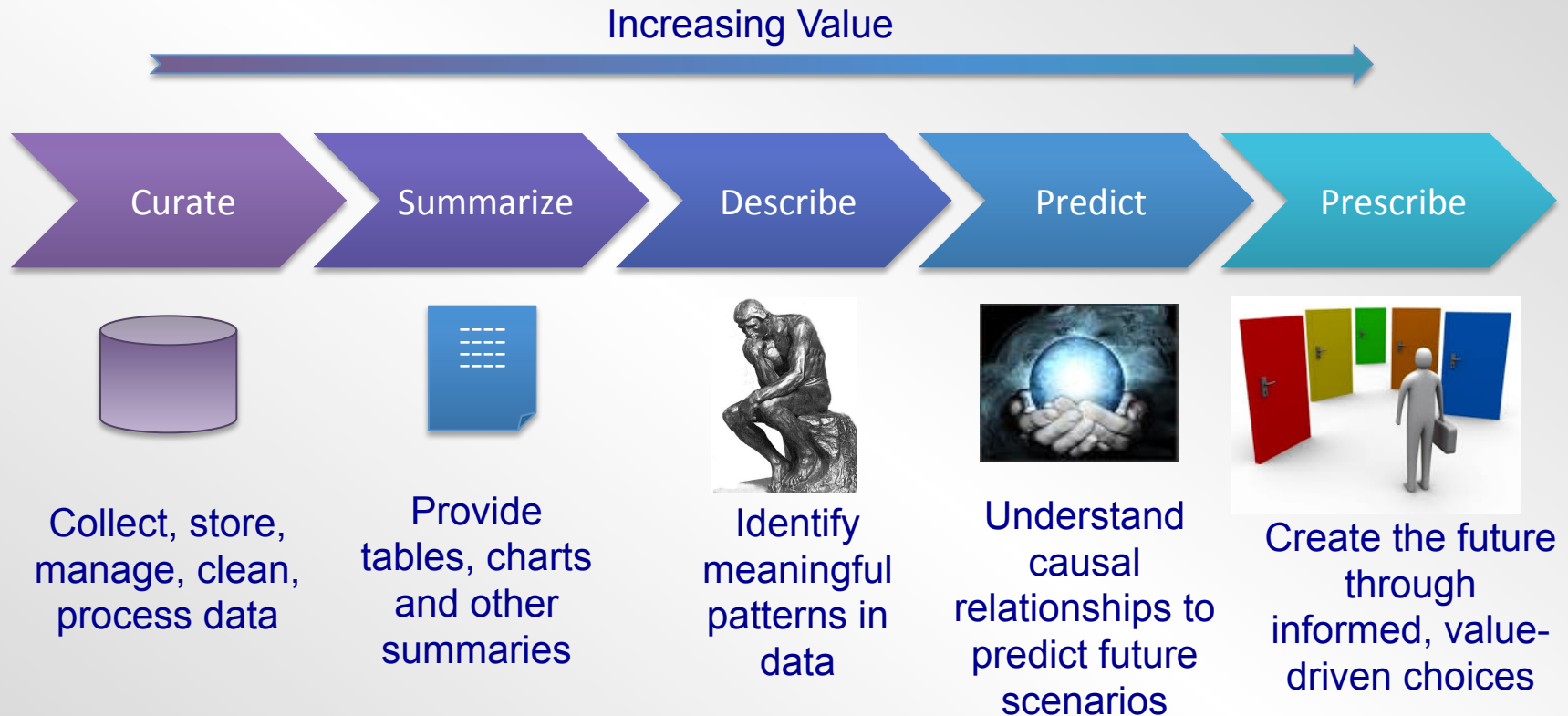
Driving Forces

- Unprecedented data availability

- Intense competition

- Culture of constant improvement

- Changing customer demographic

- Expanding customer expectations

Why Analytics?

- Competitive differentiator
  - Individualized customer experience
  - Faster and better service
  - Cost effective processes
- Increasingly pervasive
  - Do you remember life without your computer? Your cell phone? The web?
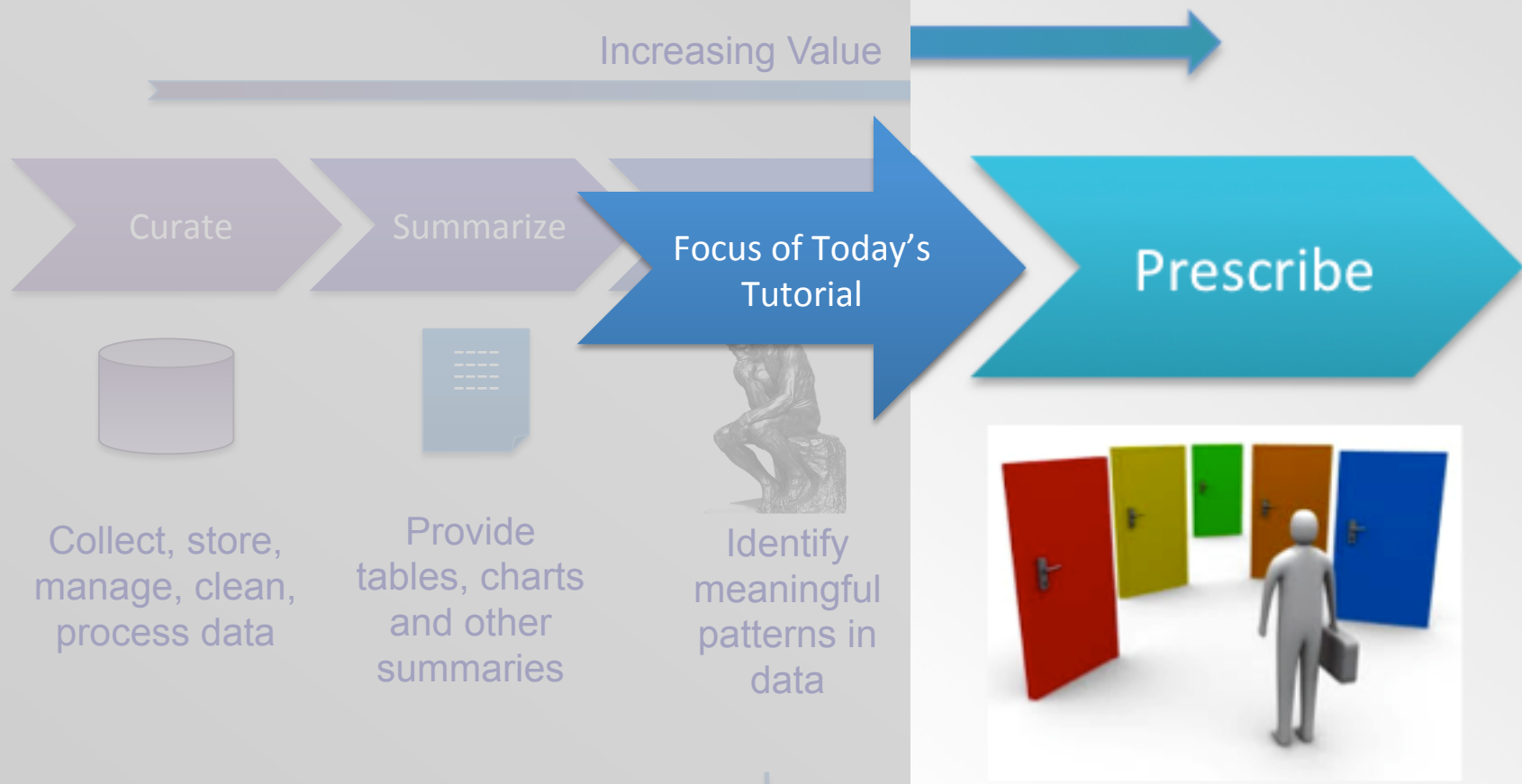 - Soon it will inconceivable to do business without analytics

Analytics Value Chain

Increasing Value

Curate	Summarize	Describe	Predict	Prescribe

Collect, store, manage, clean, process data

Provide tables, charts and other summaries

Identify meaningful patterns in data

Understand causal relationships to predict future scenarios

Create the future through informed, value-driven choices

Analytics:
Descriptive / Predictive / Prescriptive

Analytics Value Chain

Increasing Value

| Curate	Summarize	Focus of Today's Tutorial	Prescribe
Collect, store, manage, clean, process data	Provide tables, charts and other summaries	Identify meaningful patterns in data	

Analytics:
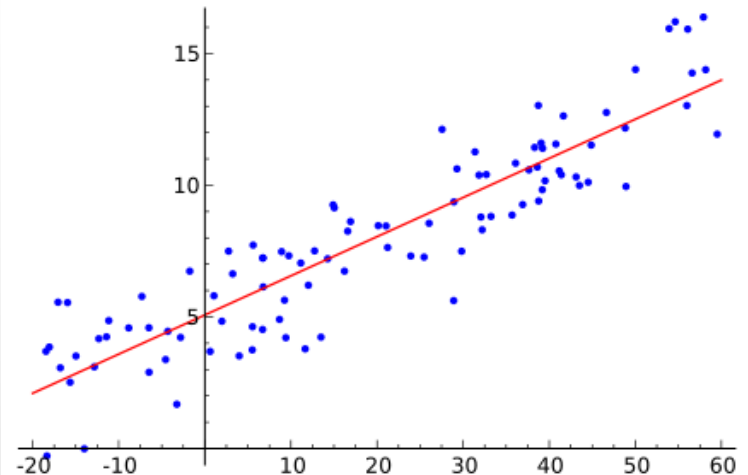Descriptive / Predictive / Prescriptive

Descriptive Analytics

- Identify patterns in data
- Common categories of analytical methods
  - Data visualization methods
  - Data transformation
  - Outlier detection
  - Data mining methods
  - Clustering
  - Exploratory identification of trends and patterns
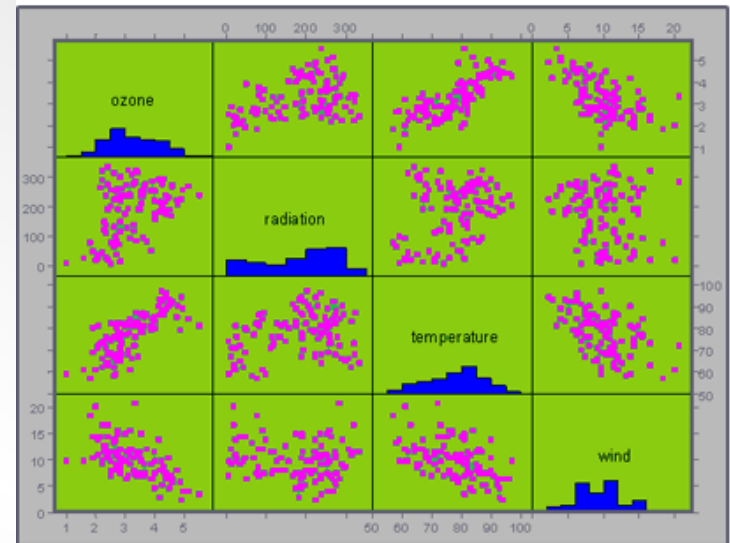
Predictive Analytics

- Analyze data to make predictions
  - Identify and formally verify patterns in data
  - Understand cause and effect relationships
  - Extrapolate patterns to future
- Common categories of analytical methods
  - Regression analysis
  - Time series models
  - Machine learning methods

Prescriptive Analytics

- Suggest actions to decision maker based on descriptive and predictive analytics
  - Frame the problem
  - Identify candidate actions
  - Predict consequences of actions
  - Assess value of consequences
  - Suggest highest value actions
- Common categories of analytical methods
  - Optimization
  - Simulation

Analytics Supports Better Decisions

- Example: FedEx
  - Package scans and active sensors in high-value packages provide data on shipments
  - Events are analyzed in real time and shipments rerouted in case of problems
  - Analytics are used to identify and respond to customer service issues

- Example: Petroleum industry
  - Analytics improves problem diagnosis, improves maintenance and repair policies, reduces cost and prevents catastrophic failures
  - Analytics helped ConocoPhillips predict ice floe movement and extend the drilling season by weeks

Evolution of Decision Support

Operations Research /
Management Science

Statistics

Information Systems

AI/Expert Systems

1940's

Optimization

Statistical
Analysis

Cognitive Science

Transaction
Processing Systems

Expert Systems

Statistical
Design

Judgment & Decision
Making

Simulation

MIS

Knowledge
Representation

Visualization

World Wide Web

Human/Computer
Interaction

BigTable

2000+

Cloud

Data Mining

Decision Support Systems

11

Decisions and Models

- A model is a representation of a system that can be used to answer questions about the system
  - "All decisions are based on models… and all models are wrong." – John D. Stearman
  - "All models are wrong but some are useful" – George Box

- Models are constructed from:
  - Past data on the system
  - Past data related to the system
  - Judgment of subject matter experts
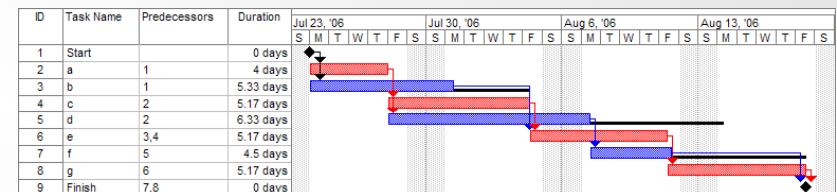 - Judgment of experienced model builders

Models in Engineering

- Engineers design a system by:
  - Building a model to represent the system they want to design
  - Manipulating the model
  - Using behavior of the model to
    - Predict behavior of the system
    - Evaluate and compare alternative design options
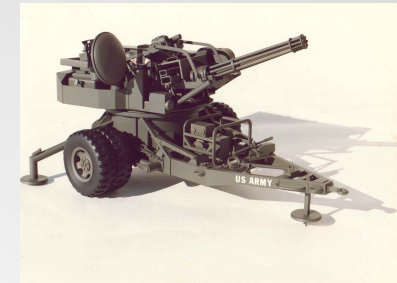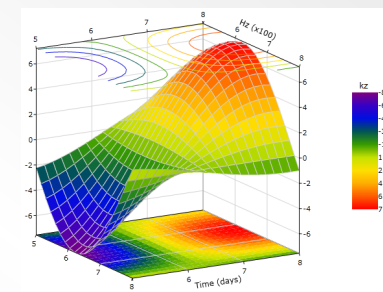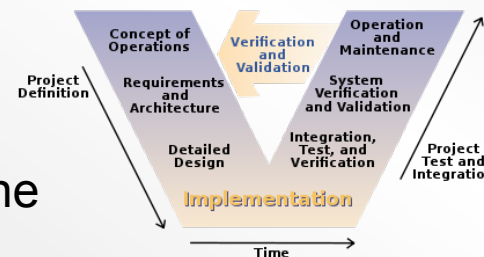
- Types of representation
  - Physical
  - Mathematical
  - Computer
  - Verbal

- Examples
  - Wind tunnel and model airplane
  - CAD model of a bridge
  - Computer simulation of traffic flows on highway network
  - Linear program model for inventory planning
  - Bayesian spam filter

Human Decision Makers and Models

- People are good at:
  - Identifying what objectives are important
  - Identifying what features are relevant
  - Identifying relationships
  - Generating options

- People need support to:
  - Bump out of pre-conceived ideas and established conventions
  - Integrate large numbers of factors
  - Combine numerical and statistical information with judgment
  - Perform tedious bookkeeping
  - Coordinate among multiple actors

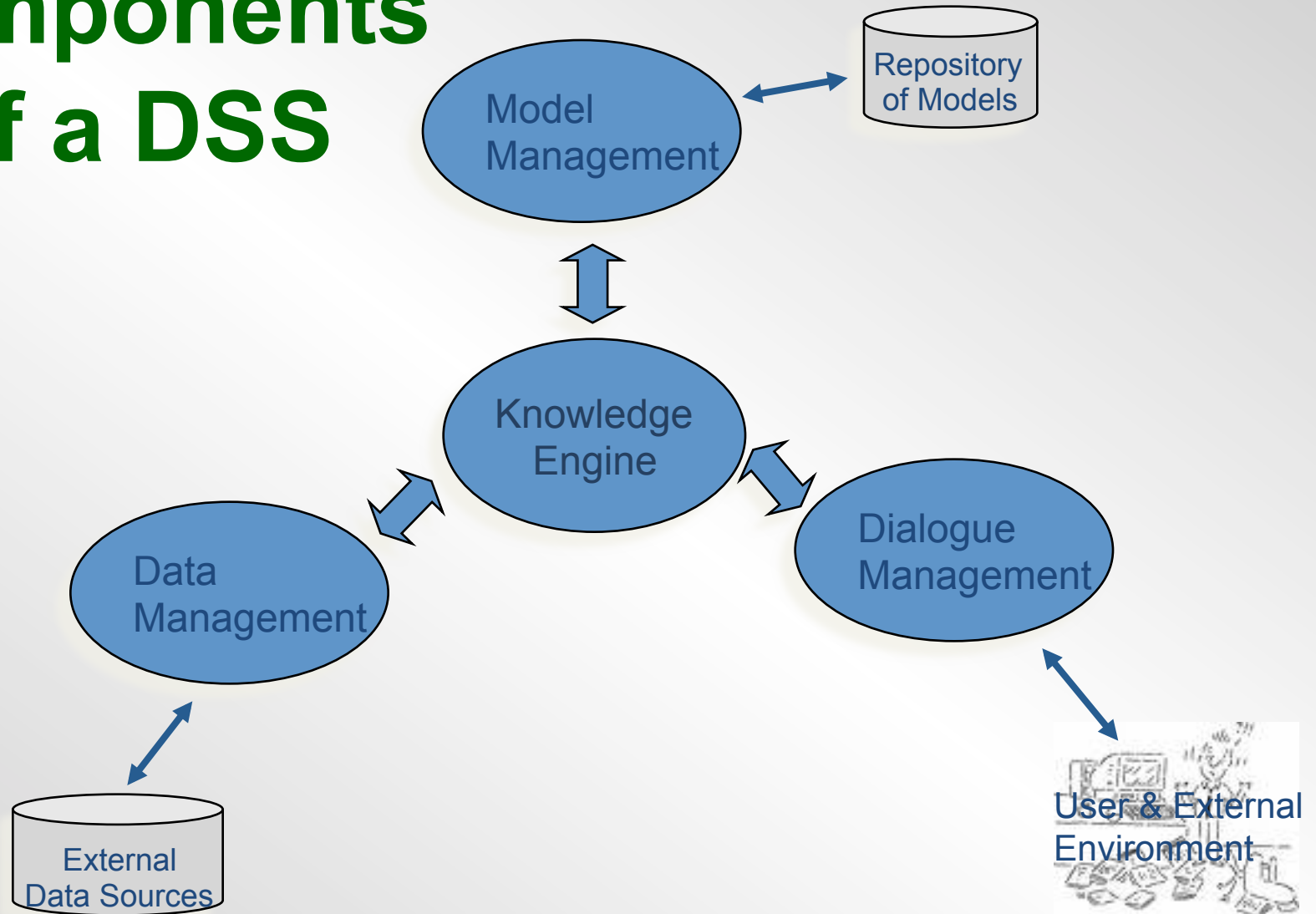- Effective models produce _understandable rationale_ for recommendations

Cognitive Tools
(von Winterfeldt and Edwards)

- We would never start a construction project without tools
- We should not make important decisions without effective *cognitive tools*
- Cognitive tools can assist with:
  - Problem structuring
  - Elicitation of human judgmental inputs
  - Organizing and displaying relevant data
  - Aggregating inputs to produce
    - Predictions of outcomes for options suggested by decision maker
    - Recommendations of options for decision maker to consider
  - Understanding strengths and weaknesses of candidate solutions
  - Selecting a solution
  - Justifying the selected solution
  - Implementing the selected solution
- Prescriptive analytics gives us cognitive tools

Functional Components of a DSS

Model Management

Repository of Models

Knowledge Engine

Data Management

Dialogue Management

External Data Sources

User & External Environment

Decision Support Trends

- IT is increasingly pervasive
- Computer hardware is increasingly smaller and more powerful
- Systems are increasingly interconnected
- The Web is interwoven into all aspects of life
- Demand for usable, flexible, powerful decision support will continue to grow
- Decision support is increasingly embedded into consumer and business products
- User expectations are exploding

Data Analytics at GMU

- Graduate certificate program starts Fall 2013
  - Broad overview of value chain for Big Data Analytics
  - Framework for methodologies to organize, visualize, analyze, and generate value from data
  - Interdisciplinary
- MS program awaits state approval
- Prescriptive analytics
  - Course in certificate program
  - Track in MS program

http://volgenau.gmu.edu/graduates/GraduateCertificateDataAnalytics.php

Schedule

9:00 Introduction

9:30 Modeling Decision Problems

10:15 Break

10:30 Model-Based Systems Engineering and Prescriptive Simulation

11:15 Optimization Methods for Prescriptive Analytics

12:15 Conclusion

Enjoy the Tutorial!