# Introduction to Data Mining

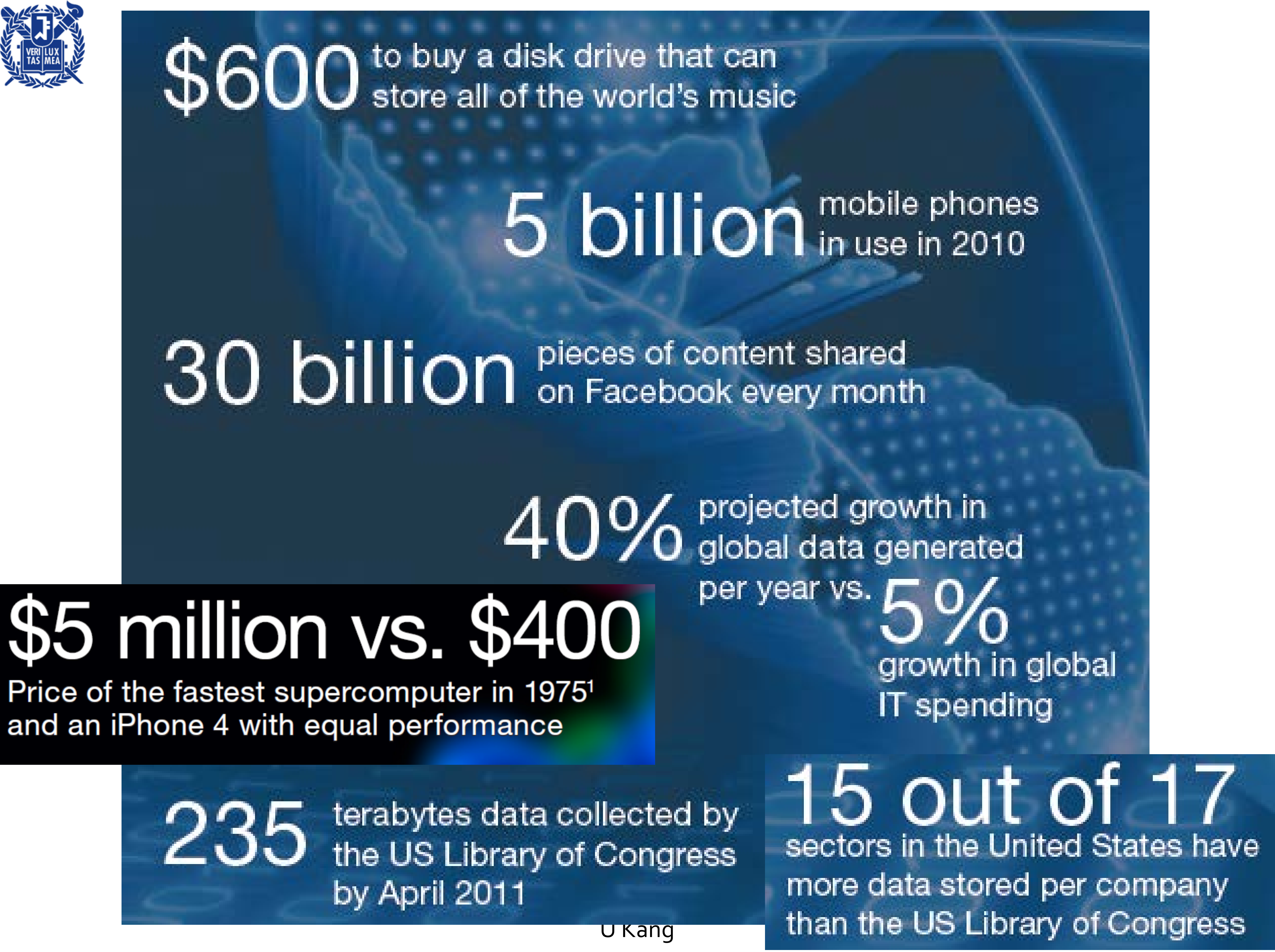
## Lecture #1: Course Introduction

**U Kang**
**Seoul National University**

# Outline

➡ □ **What is Data Mining?**

□ Course Information



**$600** to buy a disk drive that can store all of the world's music

**5 billion** mobile phones in use in 2010

**30 billion** pieces of content shared on Facebook every month

**40%** projected growth in global data generated per year vs. **5%** growth in global IT spending

**$5 million vs. $400**
Price of the fastest supercomputer in 1975[1] and an iPhone 4 with equal performance

**235** terabytes data collected by the US Library of Congress by April 2011

**15 out of 17** sectors in the United States have more data stored per company than the US Library of Congress

POPULAR SCIENCE
THE FUTURE NOW
THE CONTROL CENTERS
Using Data to Feed the World, Solve Cold Cases, Battle Malware, Predict Our Fate
OFFICER ALGORITHM
Can a Crime Be Prevented Before It Begins?
NEW WAYS OF SEEING
A Gallery of Extraordinary Infographics
PLUS
Juan Enriquez Reprograms Life
James Gleick Unsplits the Bit
AND Lawrence Weschler Questions the Cloud
SPECIAL ISSUE
DATA IS POWER
HOW INFORMATION IS DRIVING THE FUTURE

**Data contain value and knowledge**

# Data Mining

- But to extract the knowledge data need to be
  - Stored
  - Managed
  - And **ANALYZED** ← this class

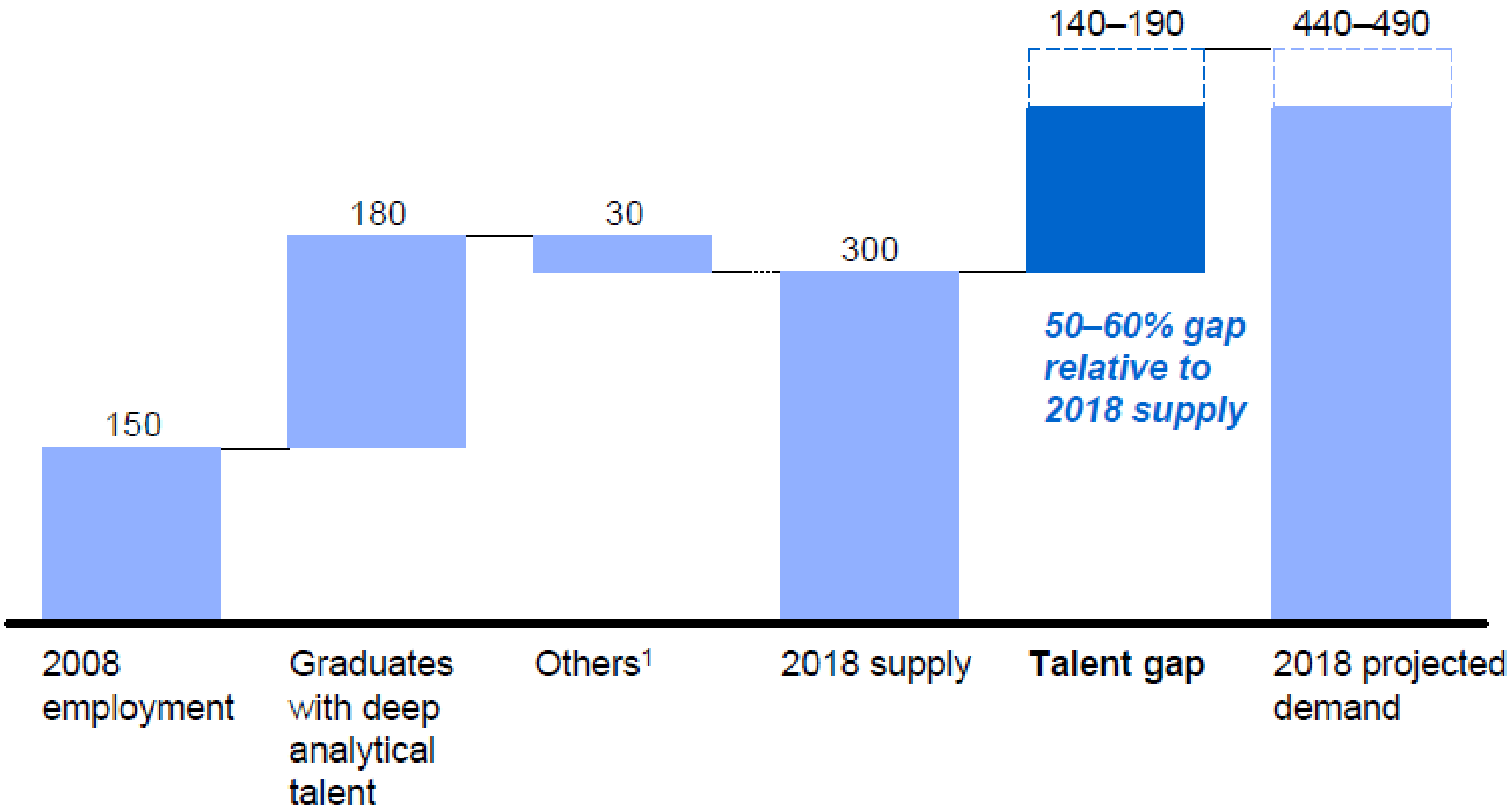
**Data Mining ≈ Big Data ≈ Predictive Analytics ≈ Data Science**

# Good news: Demand for Data Mining

**Demand for deep analytical talent in the United States could be 50 to 60 percent greater than its projected supply by 2018**

Supply and demand of deep analytical talent by 2018

Thousand people



[1] Other supply drivers include attrition (-), immigration (+), and reemploying previously unemployed deep analytical talent (+).

SOURCE: US Bureau of Labor Statistics; US Census; Dun & Bradstreet; company interviews; McKinsey Global Institute analysis

# What is Data Mining?

- **Given lots of data**
- **Discover patterns and models that are:**
  - ❑ **Valid:** hold on new data with some certainty
  - ❑ **Useful:** should be possible to act on the item
  - ❑ **Unexpected:** non-obvious to the system
  - ❑ **Understandable:** humans should be able to interpret the pattern

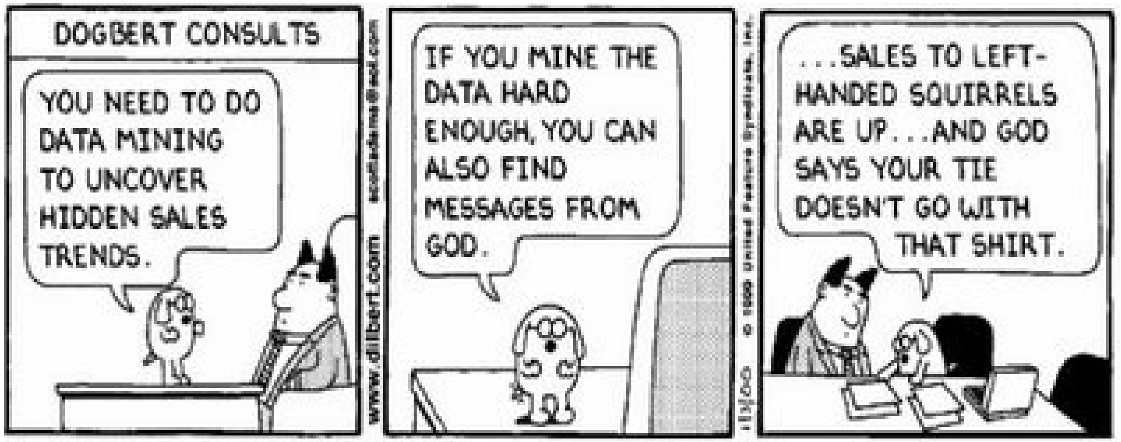
# Data Mining Tasks

- **Descriptive methods**
  - Find human-interpretable patterns that describe the data
    - **Example:** Clustering

- **Predictive methods**
  - Use some variables to predict unknown or future values of other variables
    - **Example:** Recommender systems

# Meaningfulness of Analytic Answers

- **A risk with “Data mining” is that an analyst can “discover” patterns that are meaningless**
- Statisticians call it **Bonferroni’s principle**:
  - Roughly, if you look in more places for interesting patterns than your amount of data will support, you are bound to find crap


DOGBERT CONSULTS
YOU NEED TO DO DATA MINING TO UNCOVER HIDDEN SALES TRENDS.
IF YOU MINE THE DATA HARD ENOUGH, YOU CAN ALSO FIND MESSAGES FROM GOD.
...SALES TO LEFT-HANDED SQUIRRELS ARE UP...AND GOD SAYS YOUR TIE DOESN'T GO WITH THAT SHIRT.
www.dilbert.com

# Meaningfulness of Analytic Answers

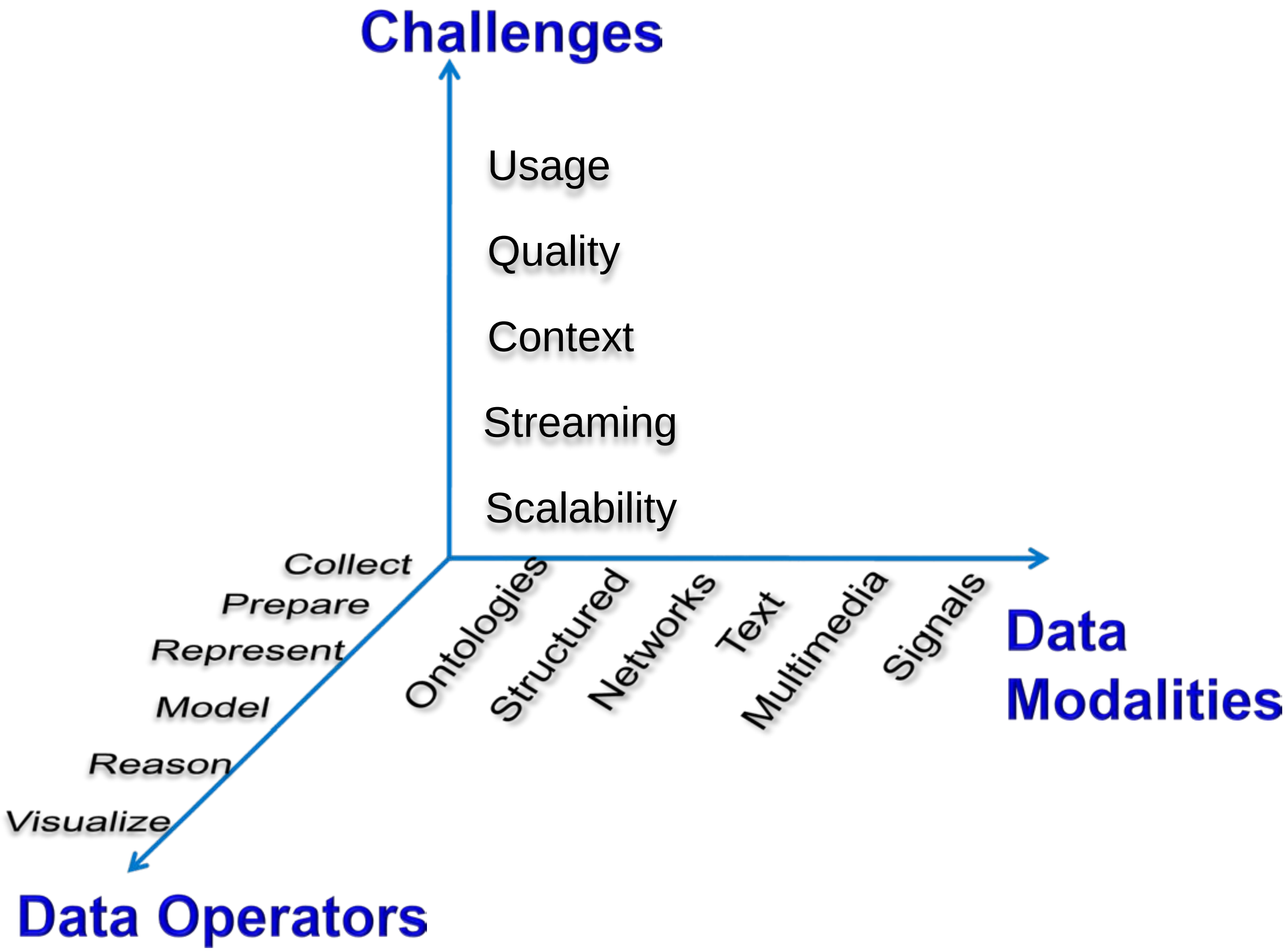
**Example:**

- We want to find (unrelated) people who **at least twice have stayed at the same hotel on the same day**
  - $10^9$ people being tracked
  - 1,000 days
  - Each person stays in a hotel 1% of time (1 day out of 100)
  - Hotels hold 100 people (so $10^5$ hotels)
  - **If everyone behaves randomly (i.e., no terrorists), will the data mining detect anything suspicious?**
- **Expected number of "suspicious" pairs of people:**
  - 250,000 (details in next slide)
  - … too many combinations to check – we need to have some additional evidence to find "suspicious" pairs of people in so me more efficient way

# Meaningfulness of Analytic Answers

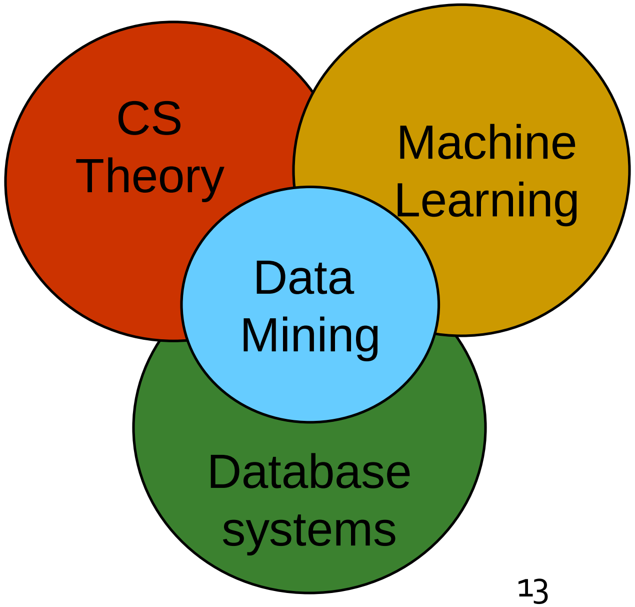
- We want to find (unrelated) people who **at least twice have stayed at the same hotel on the same day**
  - $10^9$ people being tracked, 1,000 days, each person stays in a hotel 1% of time (1 day out of 100), hotels hold 100 people (so $10^5$ hotels)
- **Expected number of "suspicious" pairs of people:**
  - P(any two people both deciding to visit a hotel on any given day) = $10^{-4}$
  - P(any two people both deciding to visit the same hotel on any given day) = $10^{-4}$ x $10^{-5}$ = $10^{-9}$
  - Useful approximation: $\binom{n}{2} \sim \frac{n^2}{2}$
  - Expected # of suspicious pairs of people = (number of pairs of people) x (number of pairs of days) x P(any two people both deciding to visit the same hotel on any given day) ~ (5 x $10^{17}$) x (5 x $10^5$) x $10^{-18}$ = 250,000

# What matters when dealing with data?



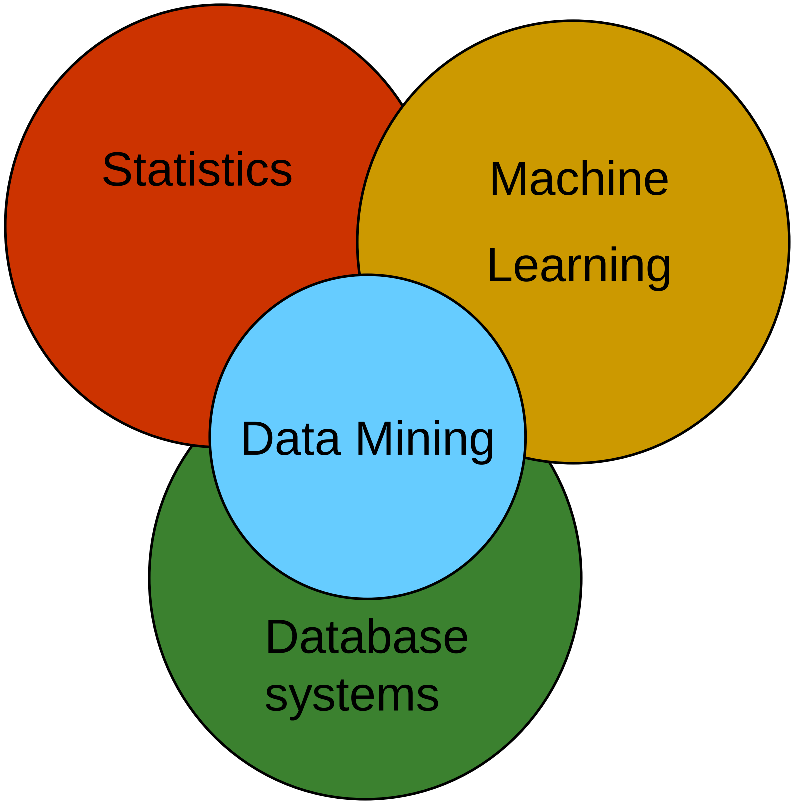
# Data Mining: Cultures

- **Data mining overlaps with:**
  - **Databases:** Large-scale data, simple queries
  - **Machine learning:** Small data, Complex models
  - **CS Theory:** (Randomized) Algorithms
- **Different cultures:**
  - To a DB person, data mining is an extreme form of **analytic processing** – queries that examine large amounts of data
    - Result is the query answer
  - To a ML person, data-mining is the **inference of models**
    - Result is the parameters of the model
- **In this class we will do both!**



# This Class

- **This class overlaps with machine learning, statistics, artificial intelligence, databases but more stress on**
  - ❑ **Scalability** (big data)
  - ❑ **Algorithms**
  - ❑ **Computing architectures**
  - ❑ Automation for handling **large data**



# What will we learn?

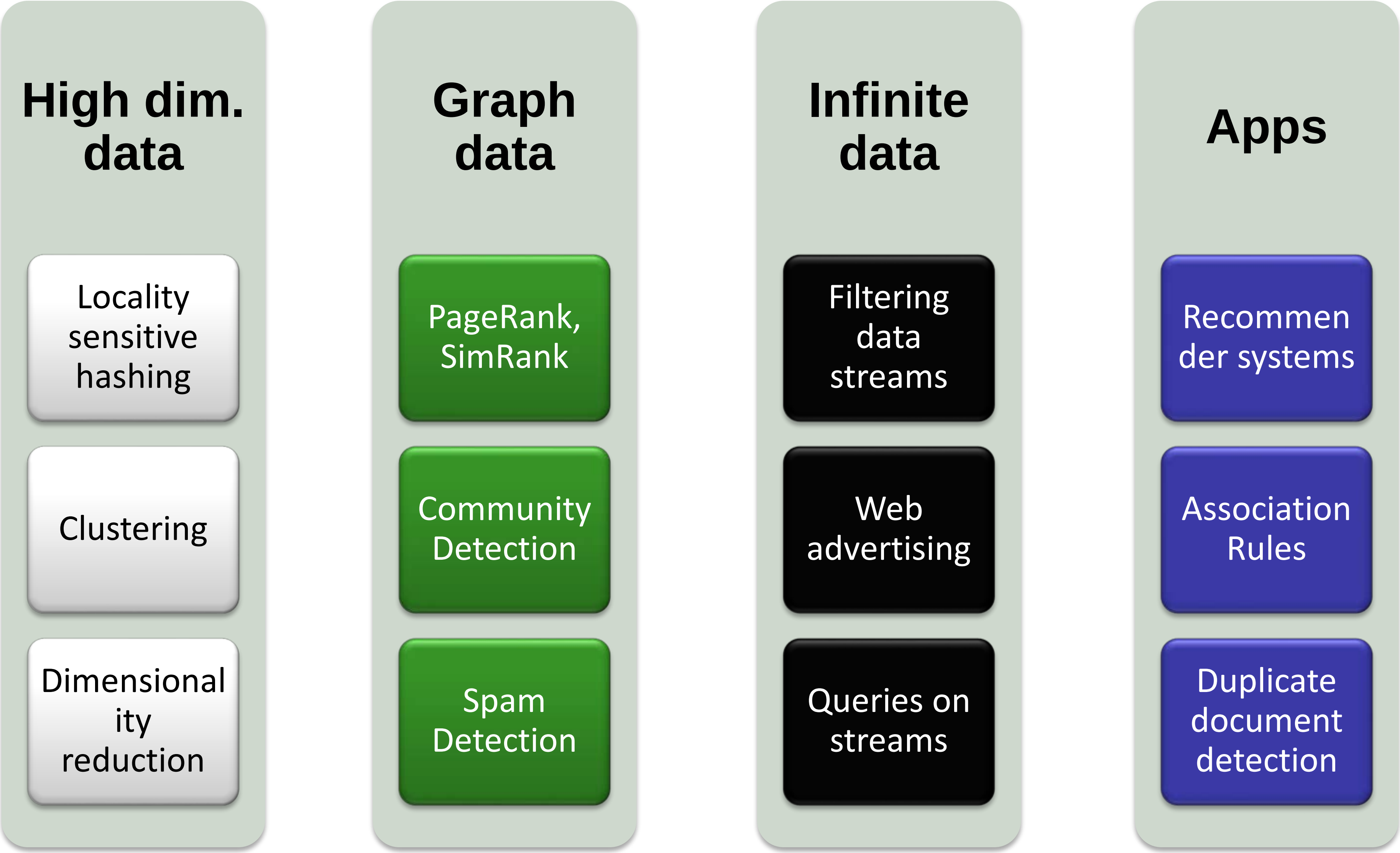
- **We will learn to mine different types of data:**
  - Data is high dimensional
  - Data is a graph
  - Data is infinite/never-ending

- **We will learn to use different models of comput ation:**
  - MapReduce
  - Streams and online algorithms
  - Single machine in-memory

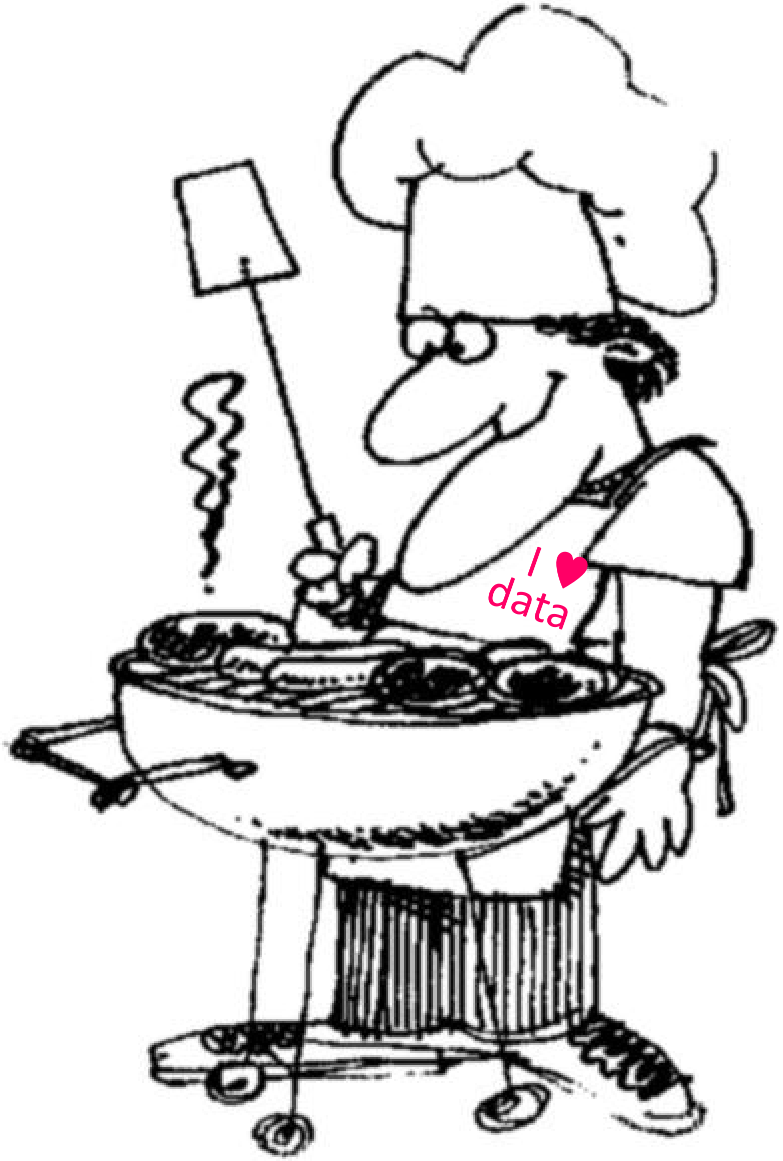
# What will we learn?

- **We will learn to solve real-world problems:**
  - Recommender systems
  - Market Basket Analysis
  - Spam detection
  - Duplicate document detection
- **We will learn various "tools":**
  - Linear algebra (SVD, Rec. Sys., Communities)
  - Dynamic programming (frequent itemsets)
  - Hashing (LSH, Bloom filters)

# How It All Fits Together



| High dim. data | Graph data | Infinite data | Apps |
|---|---|---|---|
| Locality sensitive hashing | PageRank, SimRank | Filtering data streams | Recommender systems |
| Clustering | Community Detection | Web advertising | Association Rules |
| Dimensionality reduction | Spam Detection | Queries on streams | Duplicate document detection |



# How do you want that data?

# Outline

☑ What is Data Mining?

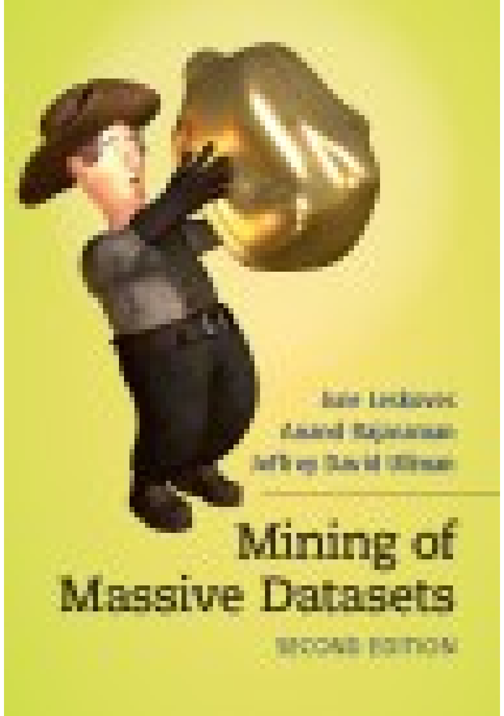
➡ □ **Course Information**

# M1522.000900, Spring 2016

- http://datalab.snu.ac.kr/~ukang/courses/16S-DM/
  - Lecture slide: at least 1 hour before the lecture
- TAs
  - Jinhong Jung (montecast9@gmail.com, 301-519)
  - Minsoo Jung (qtyp456987@gmail.com, 301-519)
- Office hour
  - (Prof) Mon. 11:00 – 12:00
  - (TAs) See the course homepage
- Class meets: Mon, Wed 9:30-10:45, 302-208

# Textbook

- Mining of Massive Data Sets (Jure Leskovec, Anand Rajaraman, Jeff Ullman)
- Available at http://www.mmds.org



# Prerequisites (?)

- **Algorithms**
  - Basic data structures
- **Basic probability**
  - Moments, typical distributions, MLE, …
- **Programming**
  - Your choice, but C++/Java will be very useful

# Grading

- 10% Attendance and Quiz (random)
- 25% Homework
- 30% Midterm
- 35% Final
- (+5% Participation)

# Late Policy

- For all deliverables (homework, code, …)
  - No delay penalties, for medical etc emergencies (bring doctor's note)
  - Each person has 4 'slip days' total, for the whole semes ter. 10% per day of delay, after that

# Questions?