iVIC

RCBD

Computing Issues for Big Data
Theory, Systems, and Applications

Beihang University

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Big Data Summit, with CyberC 2013
October 10, 2013. Beijing, China.

Bio of Myself

- ## Chunming Hu
  - Got my Ph.D in 2006, Beihang University
  - Associate Professor at Institute of Advanced Computing Technology (ACT), School of Computer Science, Beihang University

- ## Research Interests
  - Service Computing（2001-2008）
  - Grid Computing（2005-2009）
  - Cloud Infrastructure and System Virtualization (2008-)
    - Network System Virtualization
    - Cloud-Client Computing
    - Distributed Systems for Data Processing

Agenda

- **Understanding the Big Data**
  - Background
  - Computing Issues (4V → 3I)
- Big Data Research at Beihang University
  - RCBD, lead by Wenfei Fan
  - 973 Project on Big Data, lead by Beihang University
- Early Experience on Big Data
  - BD-Tractable by Preprocessing
  - Performance Model for Hadoop
  - Distributed Graph Pattern Matching
  - Event Early Detection via Social Data
- Summary
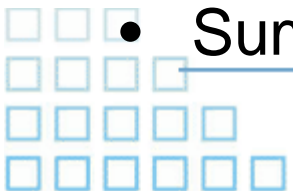
Big Data in Cyberspace

- ## Large Scale with Rapid Updates

1PB data in DVD:
~25km
$1ZB = 1PB \times 10^6$

Social Networks

- **4 Micro-blogger Provider in China:**
- 800M Users, 200M tweets everyday, 20M+ Photos.

Internet Search

- **Baidu**：1PB log data per Day. Handling 1000PB
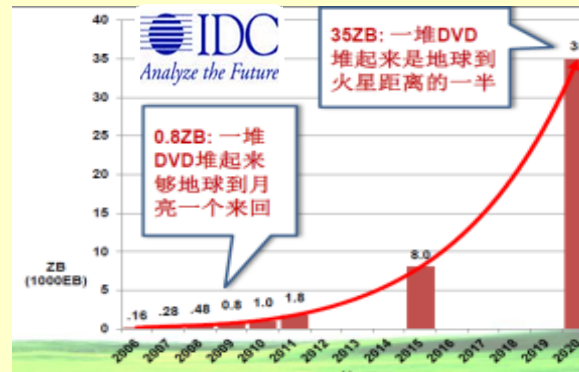- **Google**：Processing 20PB data everyday

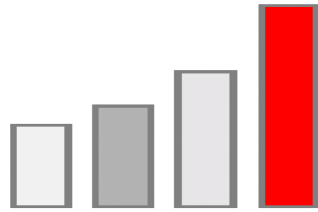Airplane 15,000m

IDC Report

- **Data doubled every 18 months**
- **Data in Cyberspace**

- **IDC Report :**
  - **2009: 0.8ZB**
  - **2012: 2.7 ZB**
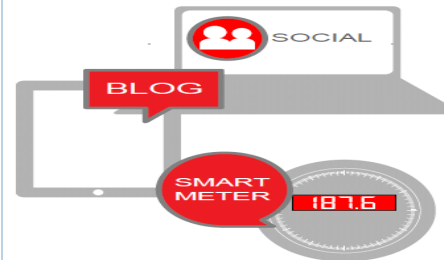 - **2020(E): 35ZB**

Chomolungma 8,800m

4V Features in Big Data
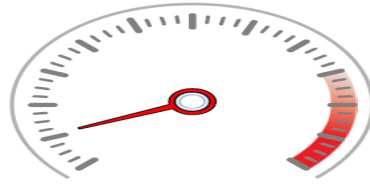
VOLUME	VELOCITY	VARIETY	VALUE
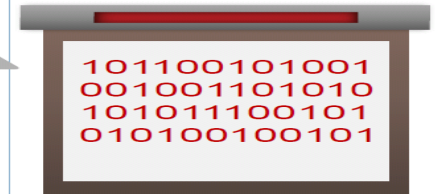
Volume	Velocity	Variety	Value
•In PB or EB •Distributed data	•Dynamic Changes •Updated constantly	•Heterogeneous •Semi-structured or unstructured	• Biz opportunity • Sensitive Data

The Economist

Information has gone from scarce to superabundant. That brings huge new benefits, says Kenneth Cukier—but also big headaches
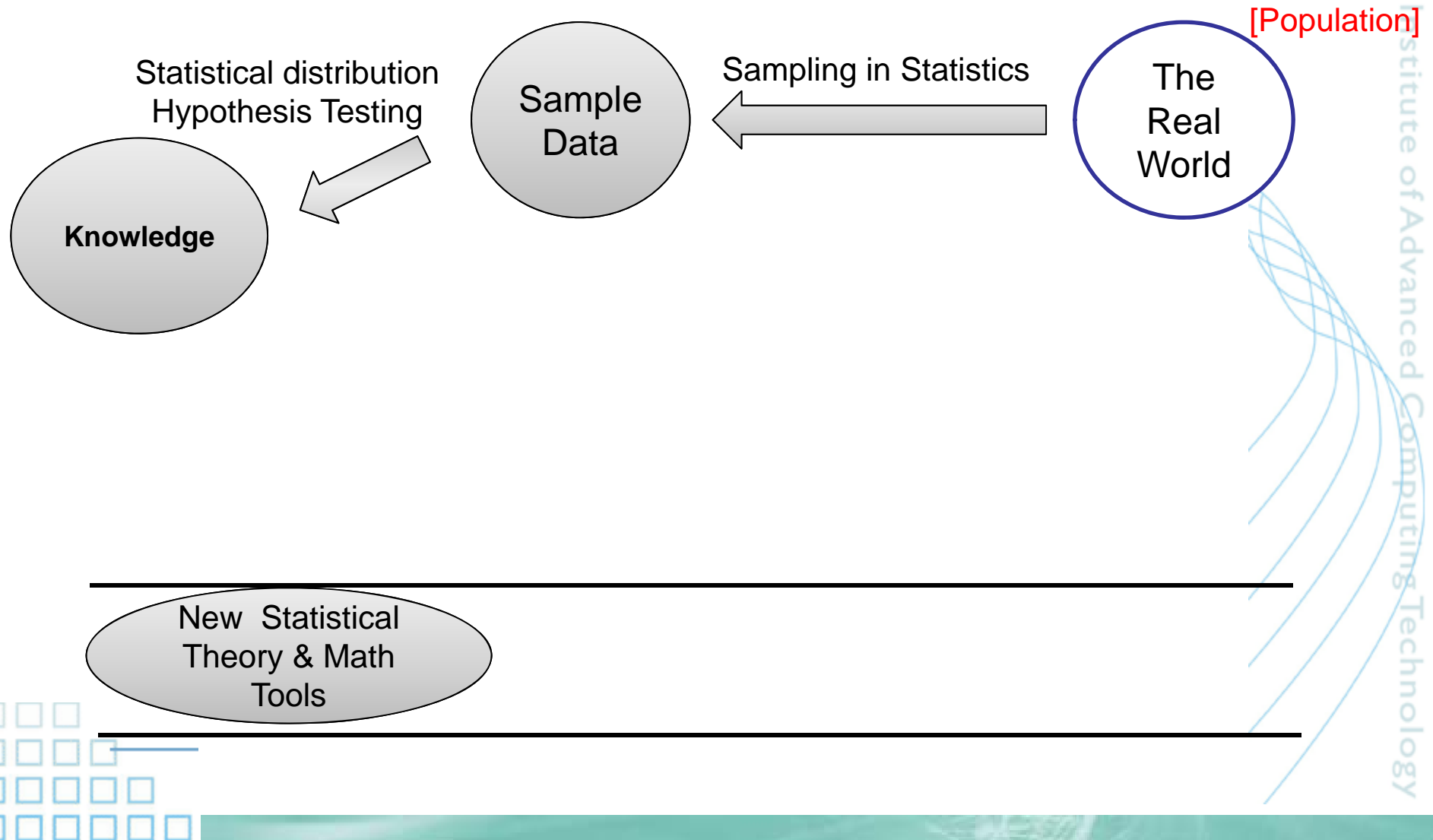
Data Deluge

Wikipedia
large and complex datasets, which is quite difficult to process using existing data management tools, and traditional data processing applications

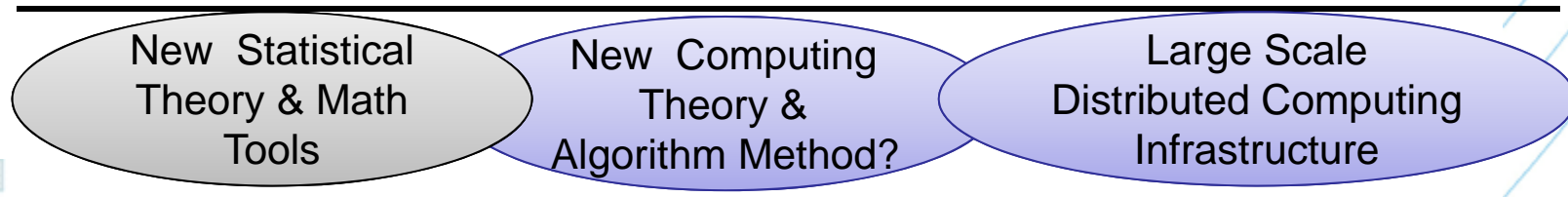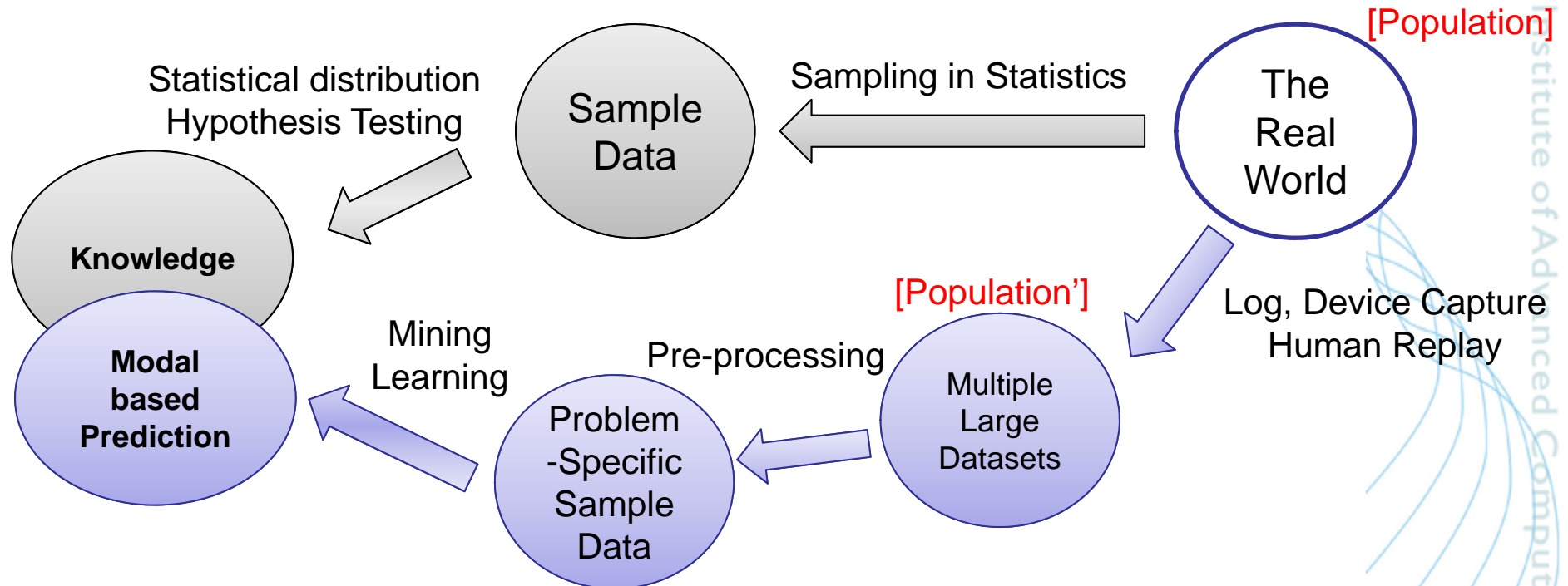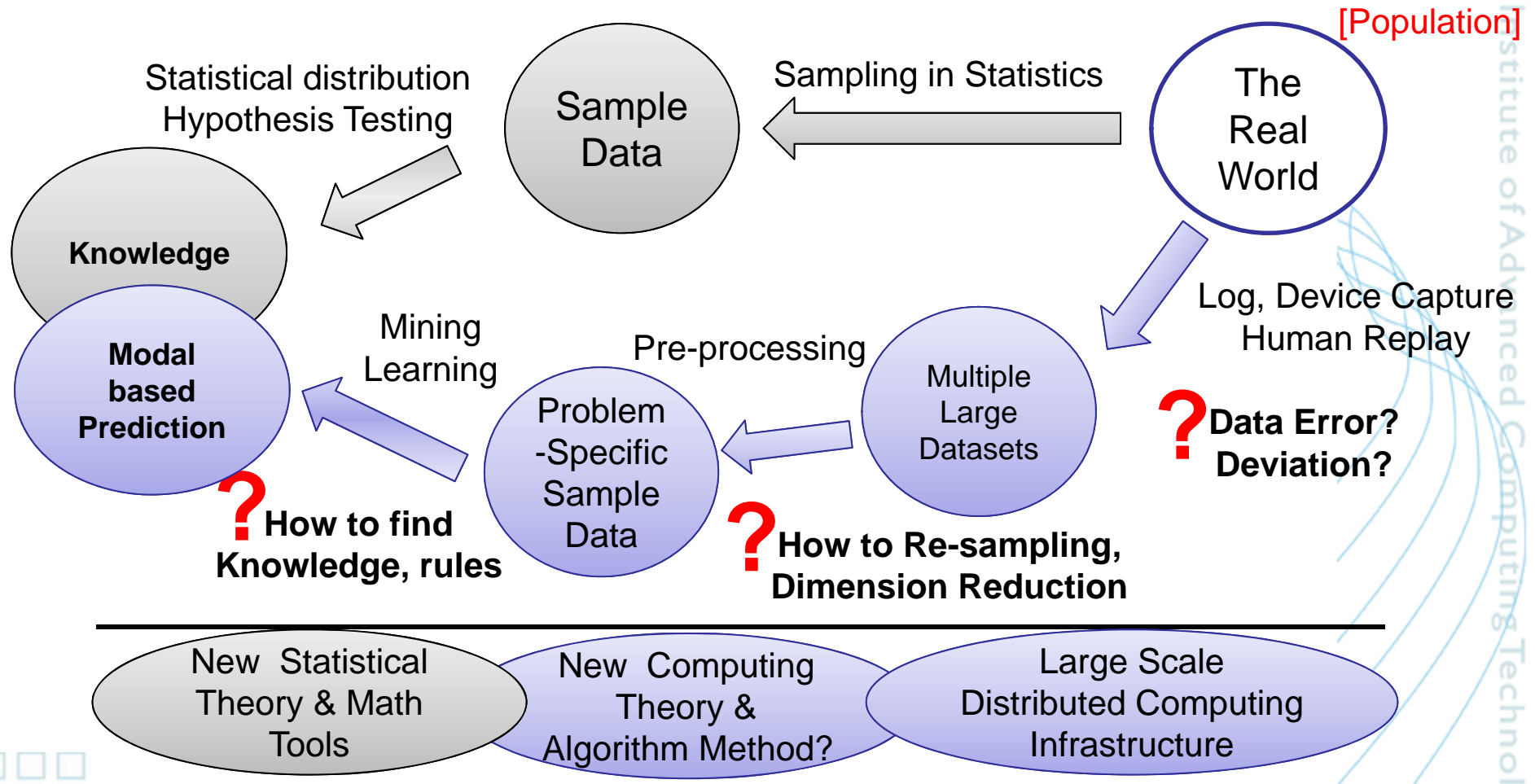# Big Data Changes

[Population]

Statistical distribution
Hypothesis Testing

Sampling in Statistics

Sample Data

The Real World

Knowledge

New Statistical Theory & Math Tools

The Institute of Advanced Computing Technology

Big Data Changes

Statistical distribution
Hypothesis Testing

Sampling in Statistics

[Population]

Sample Data

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Knowledge

[Population']

Log, Device Capture
Human Replay

Modal based Prediction

Mining Learning

Pre-processing

Problem-Specific Sample Data

Multiple Large Datasets

New Statistical Theory & Math Tools

New Computing Theory & Algorithm Method?

Large Scale Distributed Computing Infrastructure

Big Data Changes

[Population]

Statistical distribution
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Sample Data

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Multiple Large Datasets

? Data Error? Deviation?

Problem-Specific Sample Data

? How to find Knowledge, rules

? How to Re-sampling, Dimension Reduction

New Statistical Theory & Math Tools

New Computing Theory & Algorithm Method?

Large Scale Distributed Computing Infrastructure

Focusing on the Computing

4-V

VOLUME   VELOCITY

VARIETY   VALUE

Inexact

Datasets are inexact: Noisy, Erros.

Target are inexact. Eg. to find the macro trends.

- Avoid exact result to reduce cost
- Inexact but acceptable Results

Focusing on the Computing

4-V

VOLUME   VELOCITY

SOCIAL
BLOG
101100101001
001001101010
101011100101
010100100101
SMART METER

VARIETY   VALUE

Inexact   **Incremental**

Data arrives continuesly

Online/Realtime processing

- Hard to get an Static View of Data
- Batch/Full data is not enough

Focusing on the Computing

4-V

VOLUME VELOCITY

SOCIAL
BLOG
101100101001
001001101010
101011100101
010100100101
SMART METER 187.5
VARIETY VALUE

Features of Big Data Computing

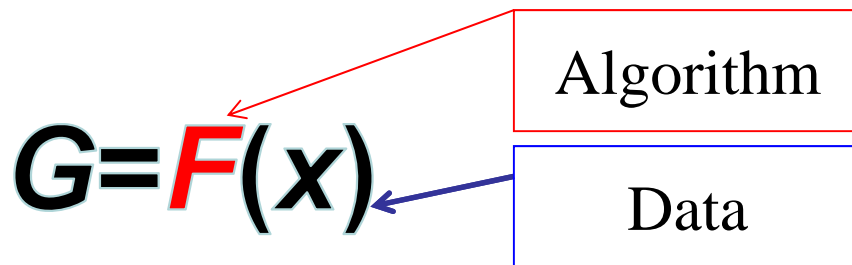**Inexact** **Incremental**

Inductive
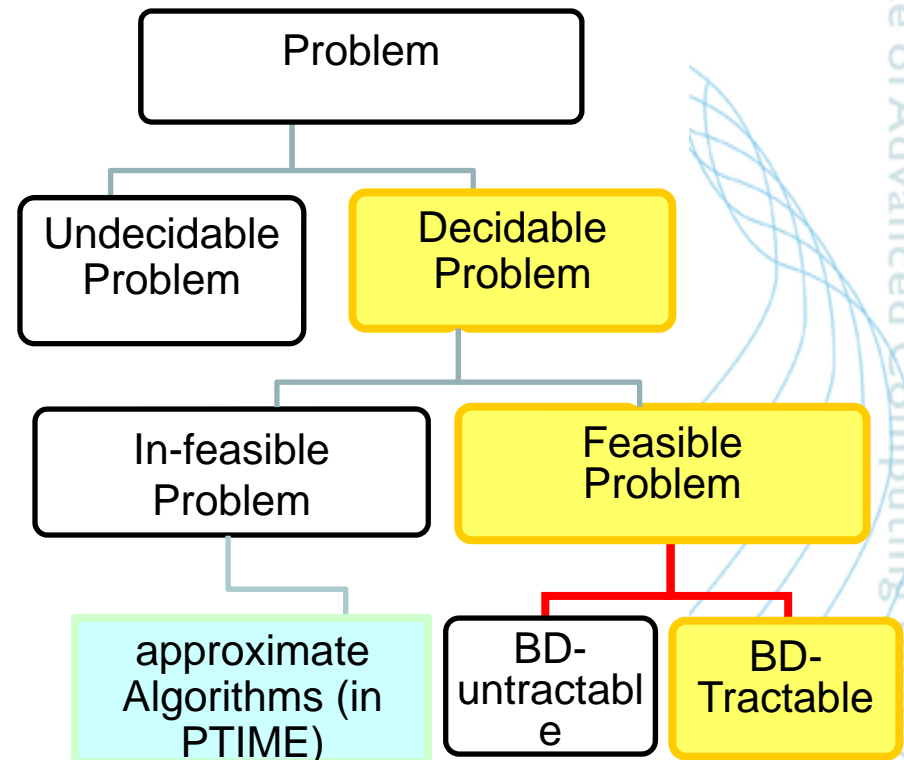
Multi-source Datasets

References between Datasets

- Use the data correlations to adjust the errors
- Transfer Learning

Questions on Big Data Computing

- Question 1: Is there new Theory for Big Data Computing?

$$G = F(x)$$

Algorithm

Data

- – **Good**: PTIME
- – **Bad**: NP-Hard
- – **Ugly**: PSPACE-hard, or EXPTIME-hard, undecidable

Problem

Undecidable Problem

Decidable Problem

In-feasible Problem

Feasible Problem

approximate Algorithms (in PTIME)

BD-untractable

BD-Tractable

Questions on Big Data Computing

- Question 2: Is Hadoop a must to data processing?
  - Different Computing requirements, User Scenarios
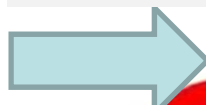 - Different Algorithm Design methods

•MapReduce (OSDI 2004)

$$x \rightarrow x_1, x_2, x_3 \ldots x_n$$
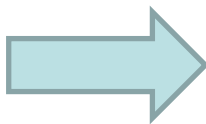
•Handling All Data in a Distributed way
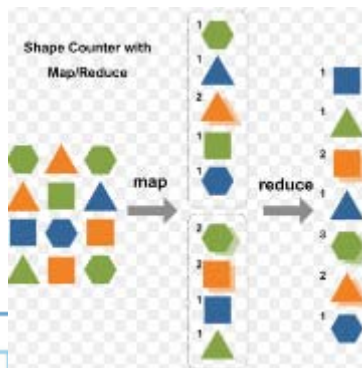
Increm ental

MR is not the only solution
  •Incremental Computing: Percolator by Google (OSDI 2010)

3I

New Algorithm Methods
  • Resampling
  • Query preserving data compression
  • Partial evaluation and distributed processing
  •Top-k query and terminating… …

Questions on Big Data Computing

- Question 3: How to handle the data computing algorithms in an operatable manner?

  - Application specific Features Analysis
    - Data Pattern, Arriving Rate, Query, …
    - General Purpose vs. Specific Purpose
    - Domain-specific Knowledges
  - Data Mining and ML Methods
  - Distributed system
    - Offline/Online
    - Batch/Incremental/Streaming
    - In-memory Computing

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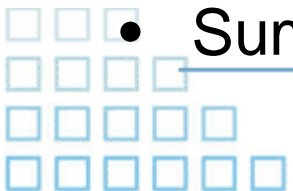
RCBD: International Research Centre on Big Data

International Research Centre on Big Data (Founded in Sept 2012)

RCBD
大数据科学与工程国际研究中心
International Research Center on Big Data

Beihang U.

U. Edinburgh

HKUST

U.Pennsylvania

Baidu

广州市香港科大
霍英东研究院

HKUST Fok Ying Tung
Graduate School

ISCAS

HUAWEI
NOAH'S ARK LAB
From Big Data to Deep Knowledge

973 Project on Big Data

- **Computing Theory on Big Data (2014-2018)**
  - a 973 Project Funding from Ministry of Science & Technology, with 8 institutional organization

- **Focusing on the Computing Issue of Big Data Processing**

973 Project on Big Data
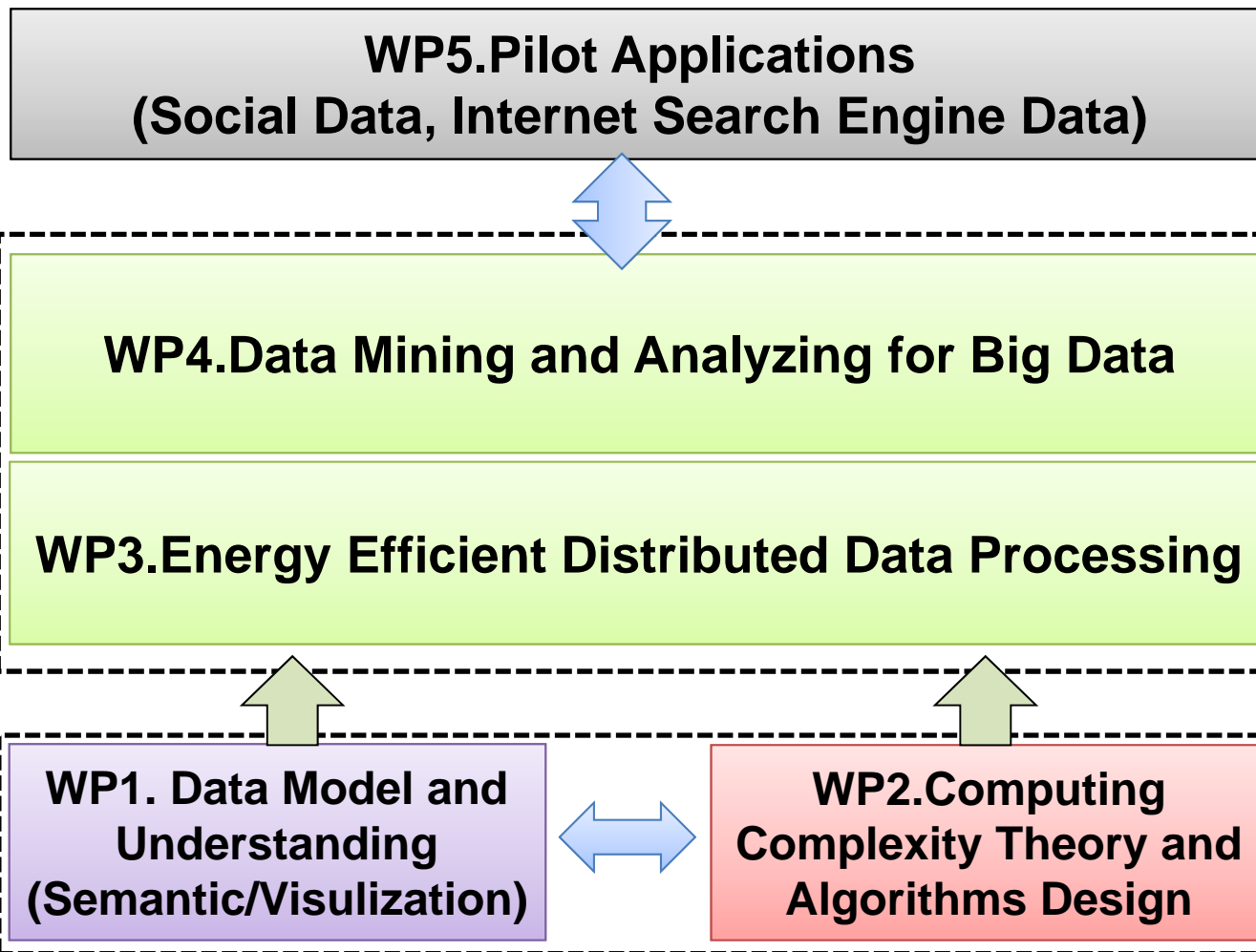
**WP5.Pilot Applications
(Social Data, Internet Search Engine Data)**

WP4.Data Mining and Analyzing for Big Data

WP3.Energy Efficient Distributed Data Processing

WP1. Data Model and Understanding (Semantic/Visulization)

WP2.Computing Complexity Theory and Algorithms Design

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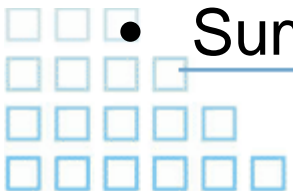
Some Early Experiences

- ## Theory
  - BD-Tractable via Data Preprocessing

- ## Systems
  - Performance Model for Hadoop
  - Graph Pattern Matching

- ## Applications
  - Using Mood to Detect Sudden Occurrence (Early Event Detection via Social Data)

BD-Tractable with Preprocessing

- *Polynomial time queries become **intractable** on big data*
- We want to be able to tell what queries are feasible on big data

NP and beyond

PTIME

BD-tractable

not
BD-tractable
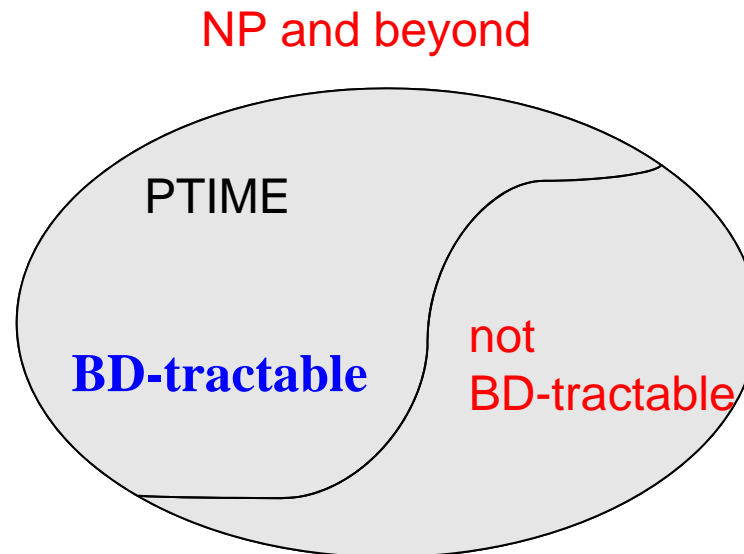
BD-tractable queries: queries feasible on big data

BD-Tractable with Preprocessing

- How do we dealing with SQL querys on a large DATABASE?
  - Scan through all the records? NO!!
  - Using Index to get better query performance!
    - B-Tree index, from $O(n)$ to $O(\log n)$
  - Query Optimizations!

- Two steps of computing
  - Set up the "index": preprocessing
  - Doing query on the "index"

BD-Tractable with Preprocessing

A class Q of queries is BD-tractable if there exists a PTIME preprocessing function Π such that

✓ for any database D on which queries of Q are defined,

　　D' = Π(D)

✓ fo~~r~~ *possible rewriting* ~~ned on D, Q(D) ca~~ ~~e computed by evaluating~~
Q on D' ~~in parallel polylog time (NC)~~

hence D' is of polynomial size

parallel log^k(|D|, |Q|)

$$Q_1(\Pi(D))$$
$$Q_2(\Pi(D))$$

D　　Π　　Π(D)
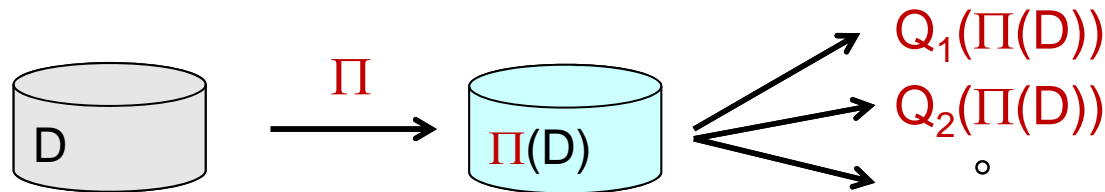
Does it work? If a linear scan of D could be done in log(|D|) time:

✓　15 seconds when D is of 1 PB instead of 1.99 days

✓　18 seconds when D is of 1 EB rather than 5.28 years

BD-tractable queries are feasible on big data

Performance Model for Hadoop

- Accurate performance prediction can help optimize the MR jobs
  - Cost-based scheduling strategies
  - Query Optimization
- Multi-processing steps in MR

- Basic Idea:
  - Benchmarking and Profiling on target machine
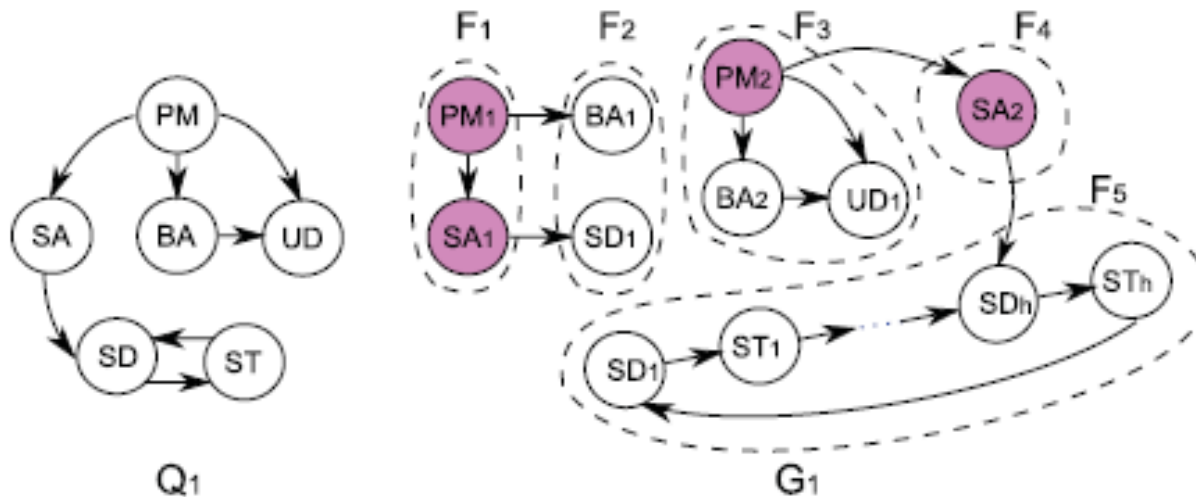 - Find out the parameters for the model

Performance Model for Hadoop
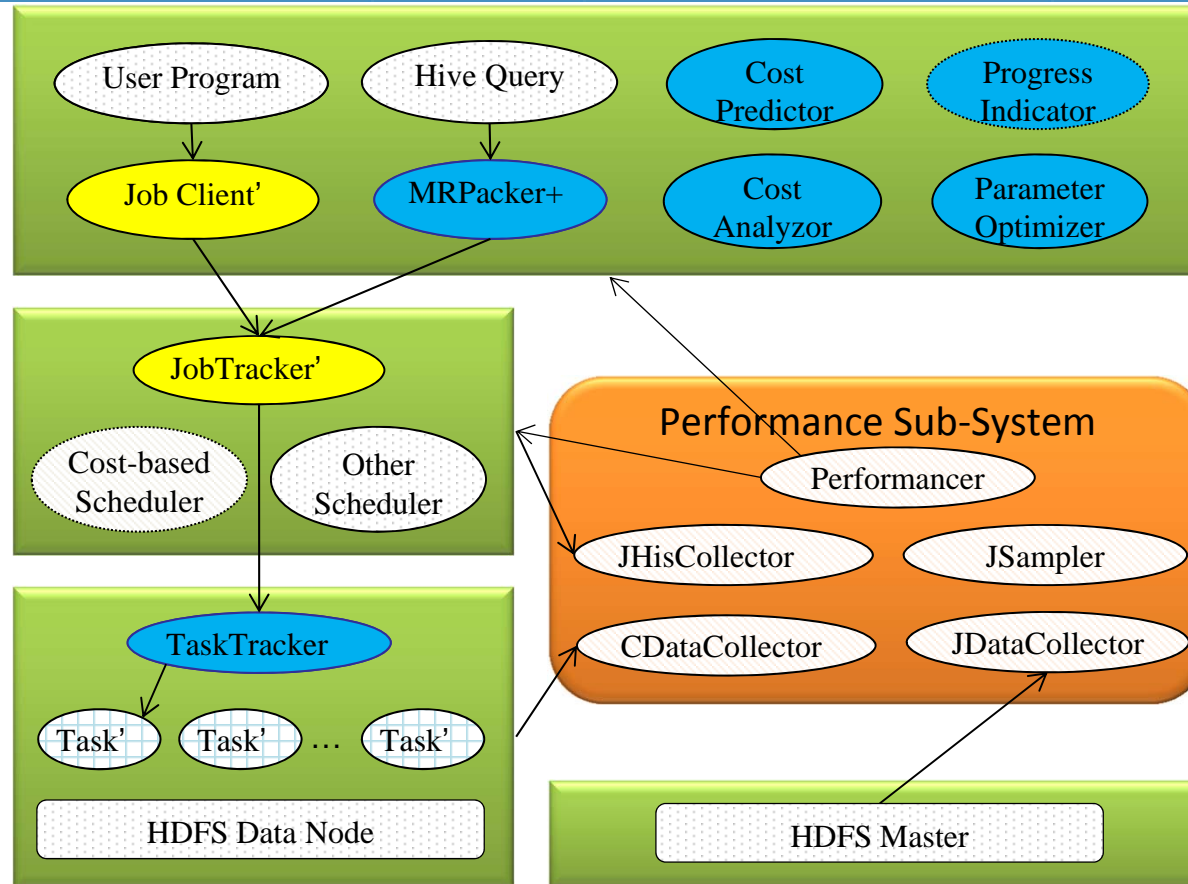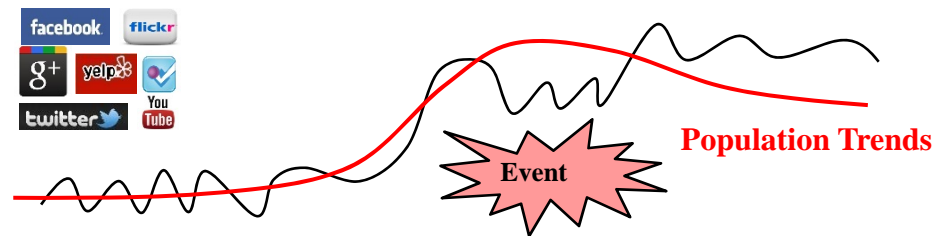
Distributed Graph Pattern Matching

- Graph patter matching

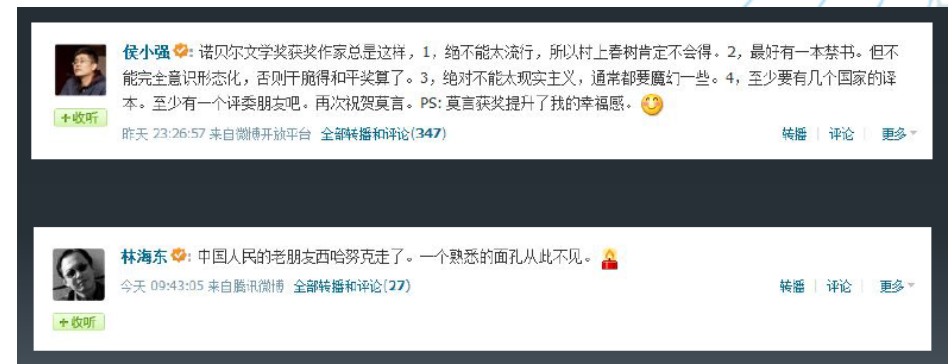- Providing evaluation algorithms and optimizations for graph simulation in a distributed setting

Early Event Detection via Social Data

- ## Social Data reflect the physical world
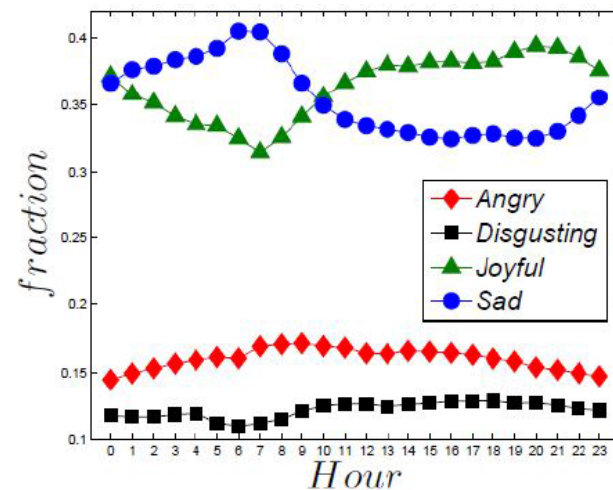 - – Event Detection via Social Data

Event   **Population Trends**

  - – Motion plays important role in social media

    - How to detect the user motion through the weibo text??

Early Event Detection via Social Data

- ## Classification
  - 95 motion icons selected from 1000 icons
  - Use the text with motion icons as the training sets

Sentiment	#Emoticons	Typical emoticons
Angry	9	
Disgusting	14	
Joyful	50	
Sad	22	

(a) Hourly pattern.

Early Event Detection via Social Data

- Abnormal event detection

- Mood Search

http://xinqings.nlsde.buaa.edu.cn
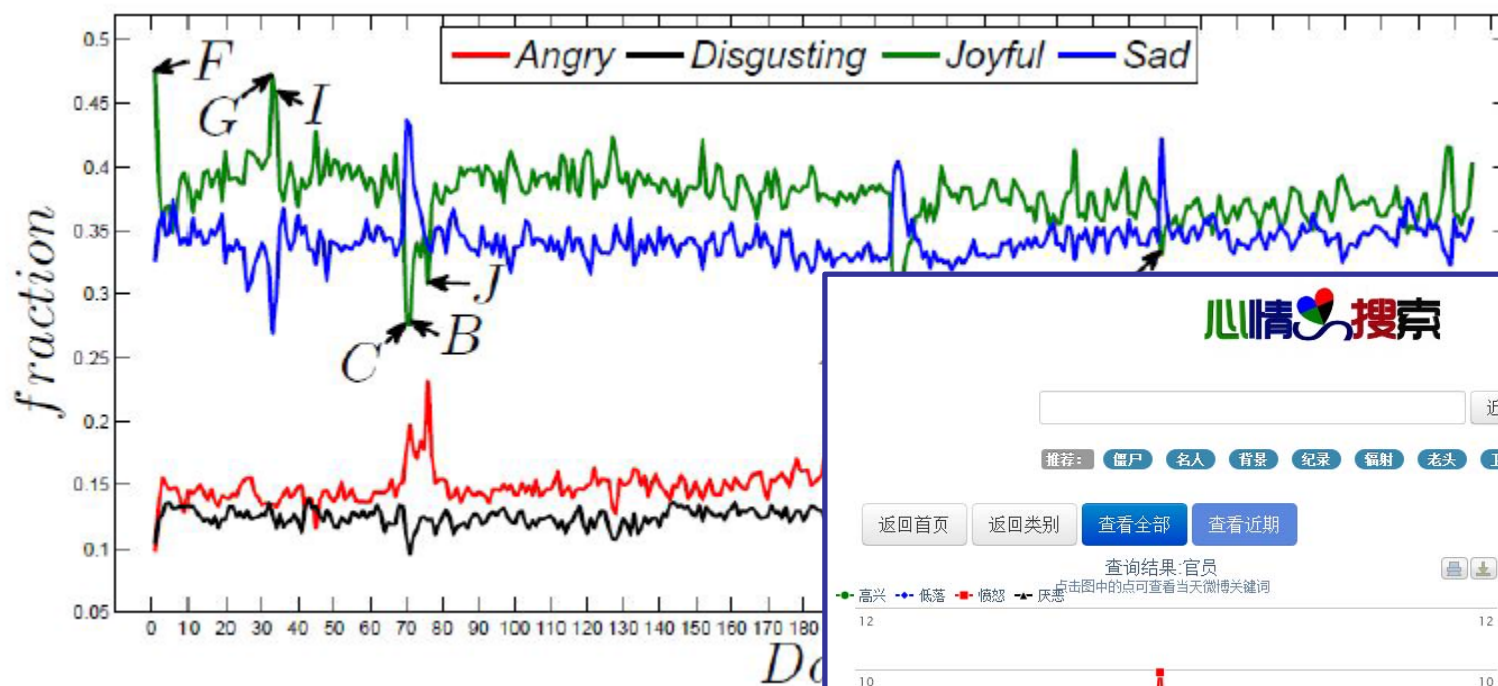
iCOME: a Competition for Big Data

http://www.icome.org.cn

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Summary

- **Big Data: from 4V to 3I**
  - Inexact
  - Incremental
  - Inductive

- **Application-Driven Vertical Integration**
  - Theory, Algorithm, Distributed Systems, Mining & ML Methods

- **Open Data Community**
  - Get more data from industry/government
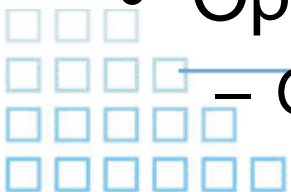
Acknowledgement

- **Part of the slides borrowed from**
  - Prof. Wenfei Fan at RCBD,
  - Prof. Ke Xu at NLSDE, Beihang University
  - Prof. Shuai Ma, Dr. Xuelian Lin at ACT, Beihang University

- **References**
  - Wenfei Fan, FlorisGeerts, Frank Neven. Making Queries Tractable on Big Data with Preprocessing, VLDB 2013.
  - Lin Xuelian, MengZide, XuChuan and Wang Meng.A Practical Performance Model for HadoopMapReduce. IEEE International Conference on Cluster Computing Workshops (ClusterW), 2012
  - Shuai Ma, Yang Cao, JinpengHuai, Tianyu Wo. Distributed Graph Pattern Matching, WWW 2012.
  - Shuai Ma, Yang Cao, Wenfei Fan, JinpengHuai, Tianyu Wo. Capturing Topology in Graph Pattern Matching, VLDB 2012.
  - Jichang Zhao, Li Dong, Junjie Wu, KeXu: MoodLens: an emoticon-based sentiment analysis system for chinese tweets. KDD 2012.

Thank You!

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