DAT 300: Paper presentation

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Keywords:

- Distributed generation, Electric vehicules, Grid planning
- Cyber-Physical System, Data analysis, Pattern clustering

List of papers

The future of the Electric grid
Chap.5 : The Impact of Distributed Generation and Electric Vehicles
2011
An interdisciplinary MIT study
(Two pages of smart people)

Multidimensional Analysis of Atypical Events in Cyber-Physical Data
2012
Lu-An Tang, Xiao Yu, Sangkyum Kim, Jiawei Han, Wen-Chih Peng, Yizhou Sun, Hector Gonzalez, Sebastian Seith
From University of Illinois at Urbana-Champaign
& National Chiao Tung University
& Google Research
& Morningstar Inc.

The Impact of Distributed Generation and Electric Vehicles

2011

An interdisciplinary MIT study

Keywords: Distributed generation, Electric vehicules, Grid planning

The Impact of **Distributed Generation** and Electric Vehicles

1kW < Small-scale generators < 10MW

Connected to the grid at distribution or substation level.

Solar photovoltaics, wind turbines, …

Owned by customers or industries.

The Impact of **Distributed Generation** and Electric Vehicles

Reliability and Security Benefits	Economic Benefits	Emission Benefits	Power Quality Benefits
• Increased security for critical loads • Relieved transmission and distribution congestion • Reduced impacts from physical or cyberattacks • Increased generation diversity	• Reduced costs associated with power losses • Deferred investments for generation, transmission, or distribution upgrades • Lower operating costs due to peak shaving • Reduced fuel costs due to increased overall efficiency • Reduced land use for generation	• Reduced line losses • Reduced pollutant emissions	• Voltage profile improvement • Reduced flicker • Reduced harmonic distortion

Source: U.S. Department of Energy, *The Potential Benefits of Distributed Generation and Rate-Related Issues that May Impede Their Expansion: A Study Pursuant to Section 1817 of the Energy Policy Act of 2005* (Washington, DC, 2007); and P. Chiradeja and R. Ramakumar, "An Approach to Quantify the Technical Benefits of Distributed Generation," *IEEE Transactions on Energy Conversion* 19, no. 4 (2004): 764–773.

The Impact of **Distributed Generation** and Electric Vehicles

<u>Photovoltaic (PV)</u>

1998-2007: 1 PV installation < 10kW

2009 : 1 PV installation > 14 MW

93k residential PV installations (2009) for 450MW capacity

Huge price drop, $10,50/Wdc (1998) to $3,70 (2011)

Not yet competitive, will come soon!

The Impact of **Distributed Generation** and Electric Vehicles

A lot of potential benefits… what about adverse impacts?

The Impact of **Distributed Generation** and Electric Vehicles

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☹ Voltage waveform distortion
☹ Flicker (rapid voltage variations)
☹ Workers safety

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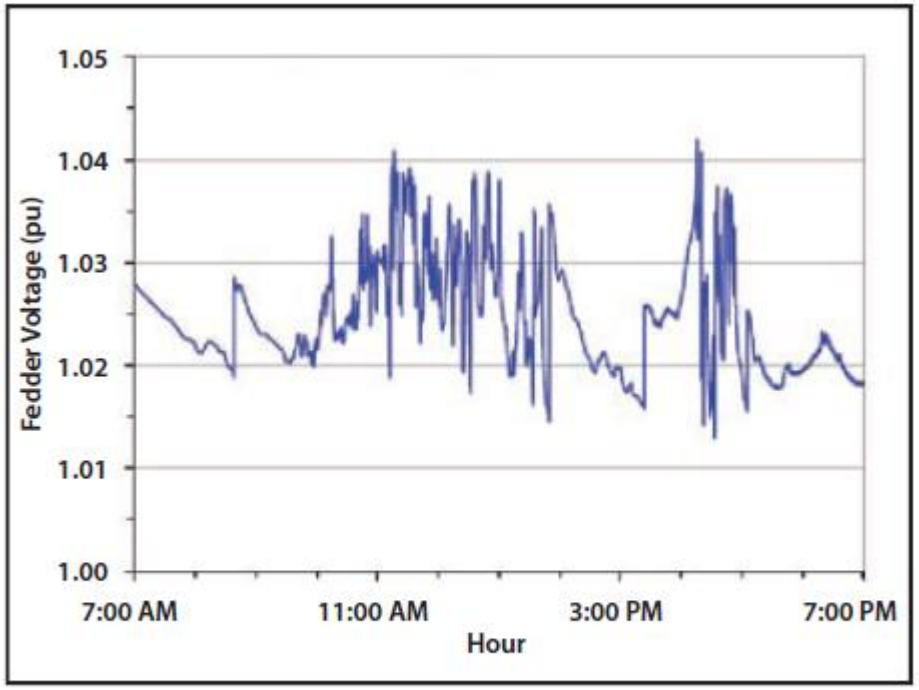
Example: Feeder Voltage at the Point of Interconnection of a Solar PV System



(a) Without Voltage Regulation Capability

Source: © 2010 IEEE. Reprinted, with permission, from R. A. Walling and K. Clark, "Grid Support Functions Implemented in Utility-Scale PV Systems," paper presented at the Transmission and Distribution Conference and Exposition, 2010 IEEE Power & Energy Society, New Orleans, LA, April 19–22, 2010.

The Impact of **Distributed Generation** and Electric Vehicles

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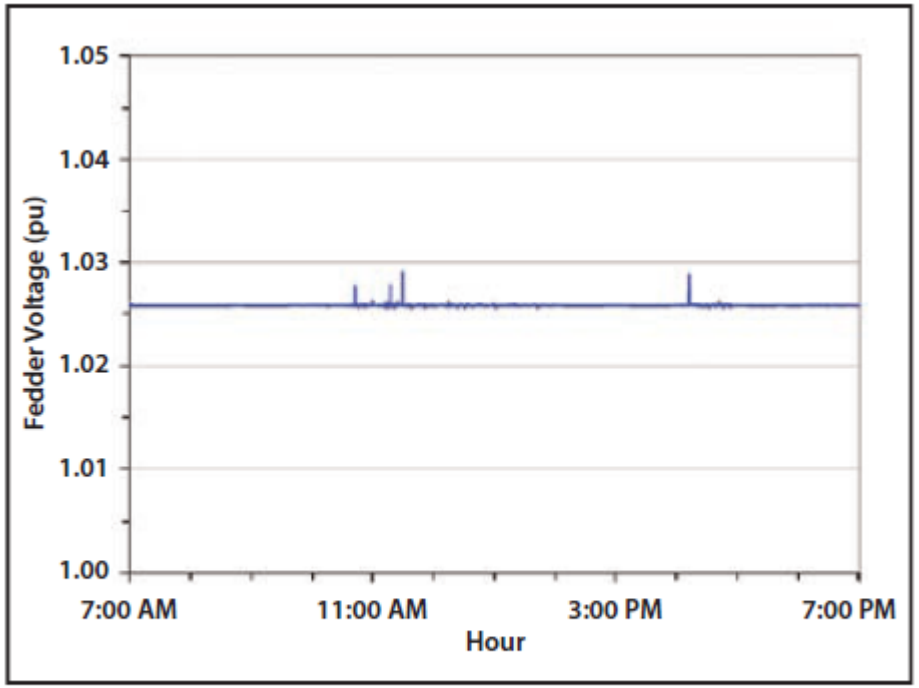


(b) With Voltage Regulation Capability

Source: © 2010 IEEE. Reprinted, with permission, from R. A. Walling and K. Clark, "Grid Support Functions Implemented in Utility-Scale PV Systems," paper presented at the Transmission and Distribution Conference and Exposition, 2010 IEEE Power & Energy Society, New Orleans, LA, April 19–22, 2010.

The Impact of **Distributed Generation** and Electric Vehicles

IEEE Standard 1547

First release 2003.

Prevent negative impacts from DG units.

Several addendums, evolving with the technology.

The Impact of **Distributed Generation** and Electric Vehicles

Now, « fit & forget » protection schemes: circuit breakers, fuses,…

Calibrated once on local distribution characteristics.

Next, Active System Management

Use real-time information!

Dynamically change protective relay setting.

The Impact of Distributed Generation and **Electric Vehicles**

4kWh (PHEV) < Electric Vehicule battery < 53kWh (BEV)

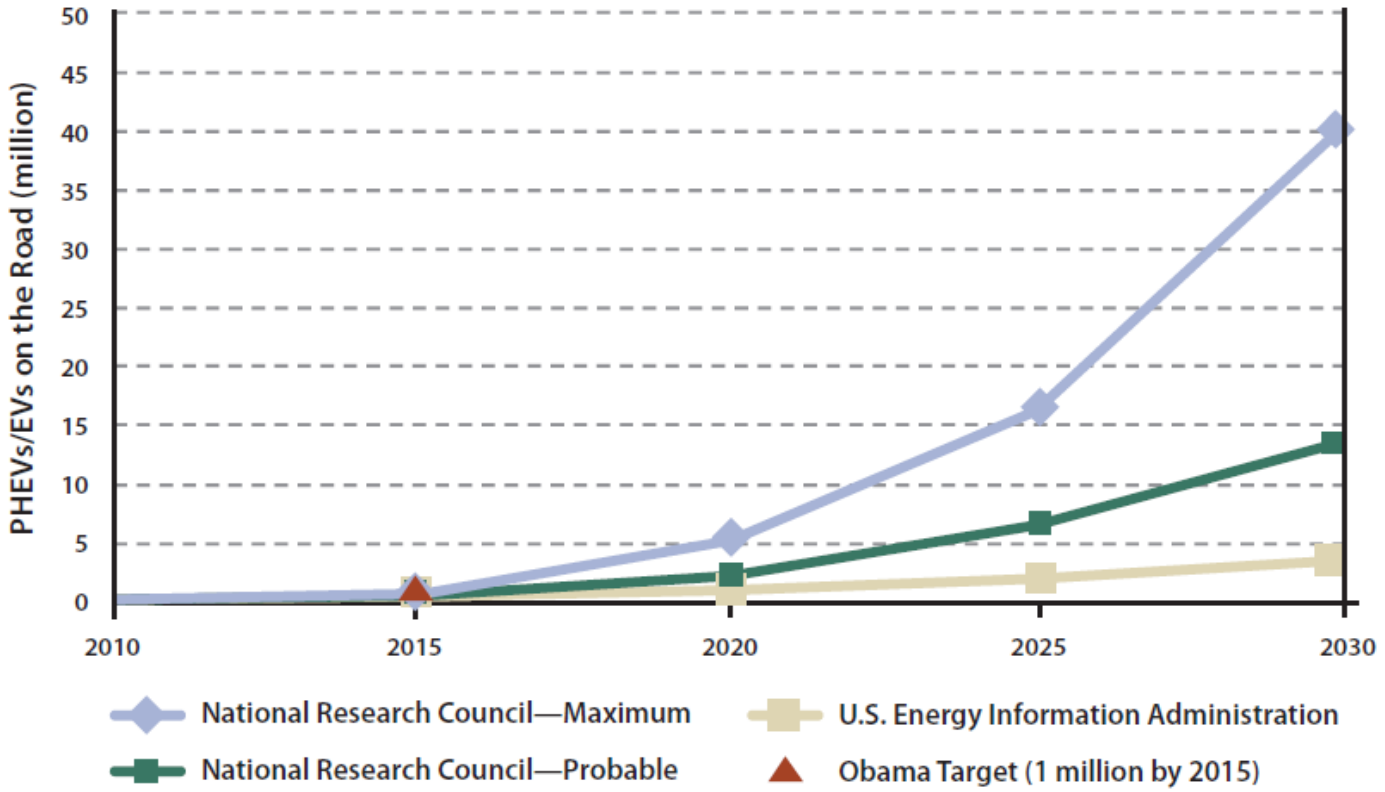
Load can be higher than a house.

Impact will depend on market penetration.

The Impact of Distributed Generation and **Electric Vehicles**

National projections with highly variations.

The Impact of Distributed Generation and **Electric Vehicles**



Source: Projection data from Committee on Assessment of Resource Needs for Fuel Cell and Hydrogen Technologies and National Research Council, *Transitions to Alternative Transportation Technologies—Plug-in Hybrid Electric Vehicles* (Washington, DC: National Academies Press, 2010); Daily Compilation of Presidential Documents 2011 DCPD No. 00047, p. 3 (January 25, 2011); and U.S. Energy Information Administration, *Annual Energy Outlook 2011* (Washington, DC: U.S. Department of Energy, 2011).

The Impact of Distributed Generation and **Electric Vehicles**

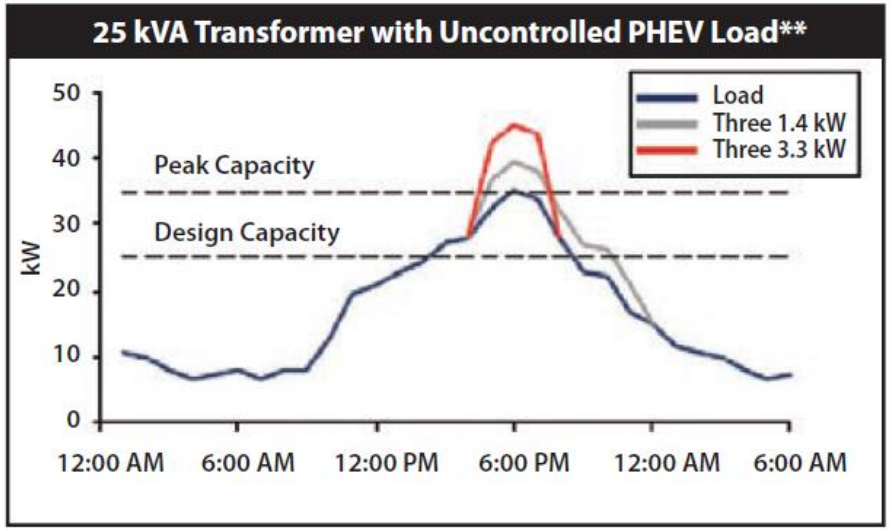
EV expected to cluster in local regions.

Select high-income and eco-conscious neighborhoods.

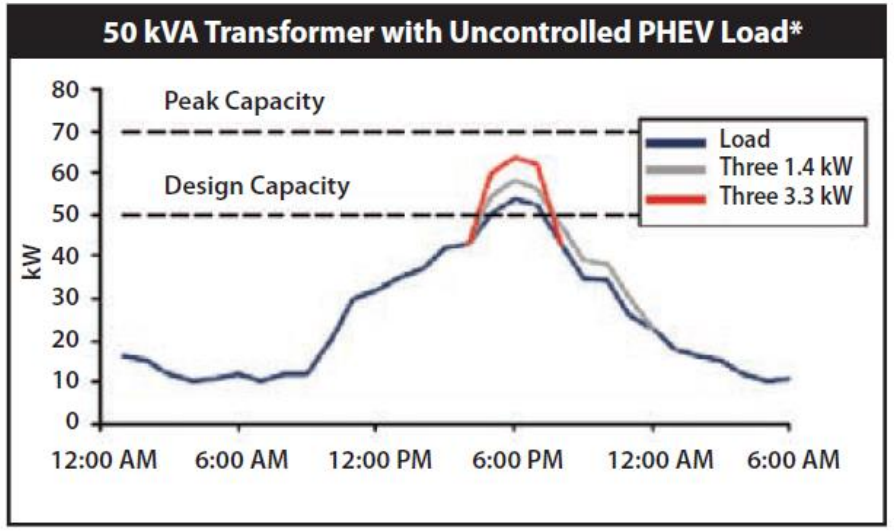
Major threat for local distribution network.

The Impact of Distributed Generation and **Electric Vehicles**

Major threat for local distribution network.



(a) 25 kVA Transformer



(b) 50 kVA Transformer

Source: J. LeBrun, DTE Energy, "Plug-in Electric Vehicle Overview," presentation at A Tale of Three Cities, webcast hosted by Intelligent Utility, January 6, 2011.

The Impact of Distributed Generation and **Electric Vehicles**

Major threat for local distribution network.

Level II charger is a bigger load than a house.

Same charging pattern accross population.

Potentially lot of EV in some neighbourhoods.

The Impact of Distributed Generation and **Electric Vehicles**

How to solve this overload threat?

Influencing the timing of vehicle charging.

Policy or controls to produce a flat load between 6 p.m. and 6 a.m.

- ❑ Time-differentiated tariffs
- ❑ Centralized charging control structures

The Impact of Distributed Generation and Electric Vehicles

Summary:

- Distributed Generation (DG) & Electric Vehicules (EV)
- Expected increase in next 10+ years
- Systemic changes in electric grid planning and operations.
- Concern of industry engineers.

Multidimensional Analysis of Atypical Events in Cyber-Physical Data

2012

Lu-An Tang, Xiao Yu, Sangkyum Kim, Jiawei Han,
Wen-Chih Peng, Yizhou Sun, Hector Gonzalez and Sebastian Seith
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Keywords: Cyber-Physical System, Data analysis, Pattern clustering

Multidimensional Analysis of Atypical Events in Cyber-Physical Data

Cyber-Physical System (CPS)

- ❑ Large number of sensors
- ❑ Huge amount of data
- ❑ Monitoring

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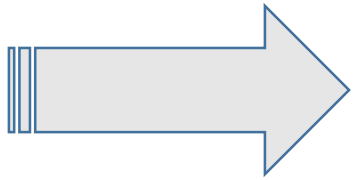


Example: Road network

- ✓ Thousands sensors
- ✓ 24 hours x 7 days
- ✓ Terabytes data records

Multidimensional Analysis of Atypical Events in Cyber-Physical Data

Data collected:

Locations, time, weather, temperature…

Multi-dimensional information.

Normal behavior most of the time!

Multidimensional Analysis of Atypical Events in Cyber-Physical Data

Complex events:

- ❑ Fondamental change in monitored objects
- ❑ Expanding spatial range
- ❑ Moving time window

If something happen, atypical data!

Multidimensional Analysis of Atypical Events in Cyber-Physical Data

What information do users want?

Not 1000 database records.

Few significant results.

Summarized data.

Multidimensional Analysis of Atypical Events in Cyber-Physical Data

The paper is introducing a new technique:

- ❑ To discover atypical events
- ❑ To summarize them as atypical clusters

Claims:

- ❑ More accurate
- ❑ Better detail level
- ❑ 20% time cost of the baseline

Multidimensional Analysis of Atypical Events in Cyber-Physical Data

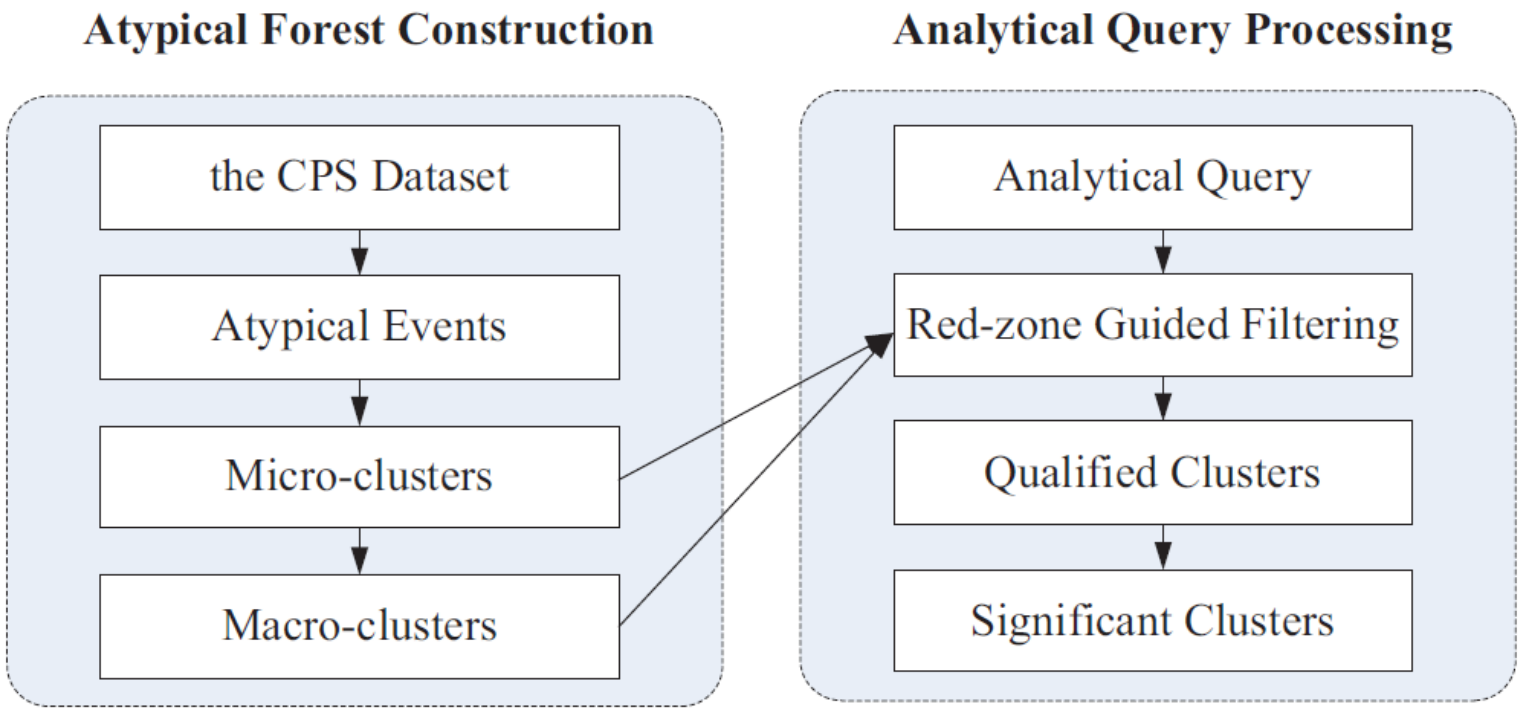
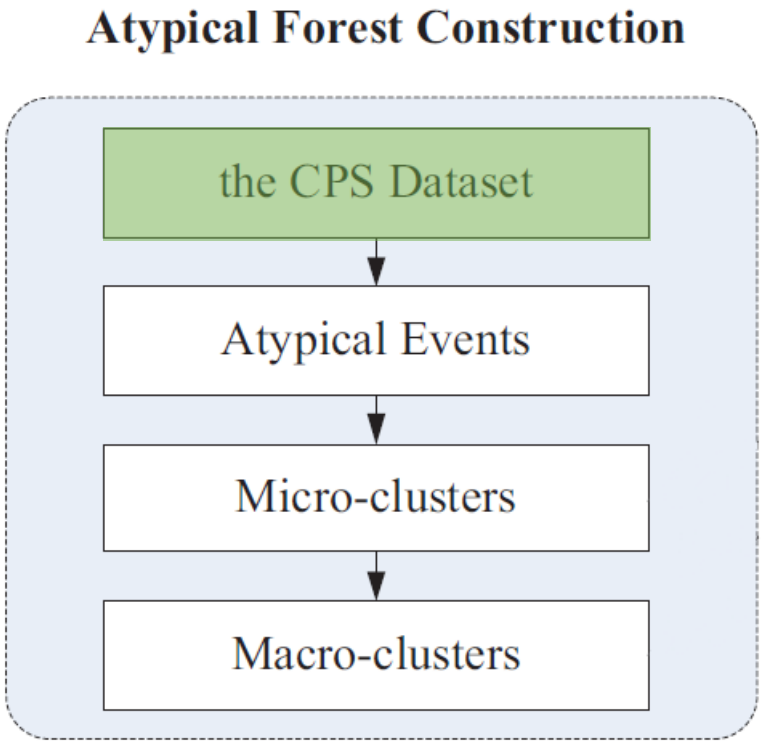


Fig. 2. The Overview of System Framework

Multidimensional Analysis of Atypical Events in Cyber-Physical Data

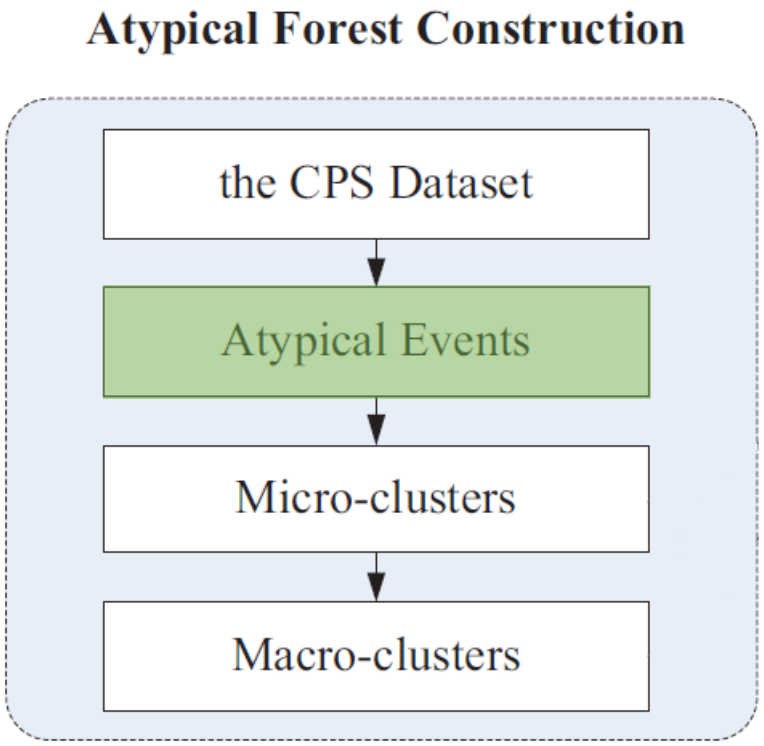


Extract data out of tresholds.

Agregate records based on:

- ❑ Time relevance
- ❑ Close spatial relation

Multidimensional Analysis of Atypical Events in Cyber-Physical Data



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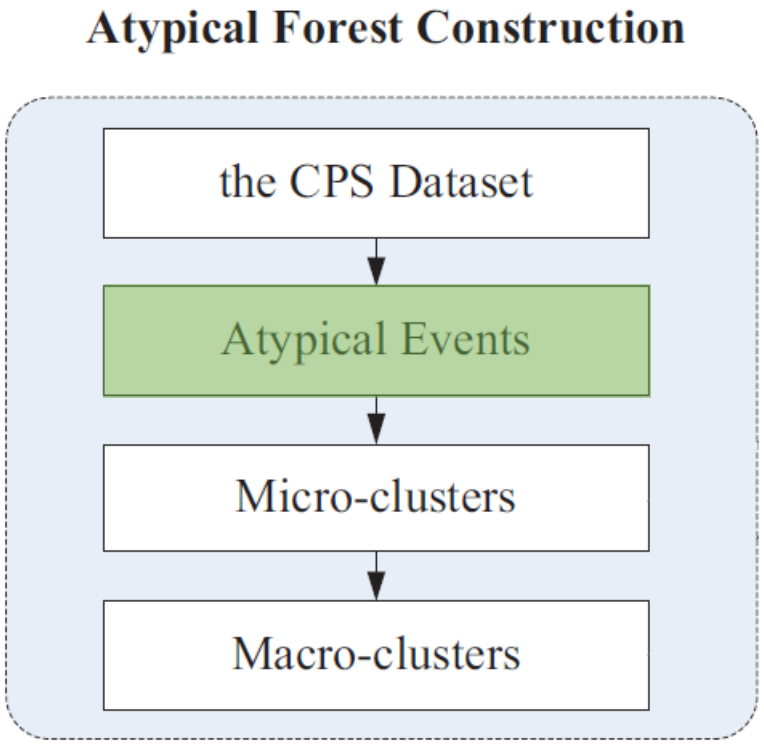
ID	Atypical Records
E_A	<s_1, 8:05am - 8:10am, 4 min>; <s_1, 8:10am - 8:15am, 5 min>; <s_2, 8:10am - 8:15am, 5 min>; <s_3, 8:15am - 8:20am, 5 min>; <s_4, 8:15am - 8:20am, 2 min>; . . .
E_B	<s_3, 6:20pm - 6:25pm, 2 min>; <s_4, 6:20pm - 6:25pm, 5 min>; <s_1, 6:25pm - 6:30pm, 5 min>; <s_4, 6:25pm - 6:30pm, 5 min>; <s_5, 6:30pm - 6:35pm, 5 min>; . . .
E_C	<s_1, 8:20am - 8:25am, 1 min>; <s_1, 8:25am - 8:30am, 5 min>; <s_9, 8:25am - 8:30am, 5 min>; <s_1, 8:30am - 8:35am, 5 min>; <s_7, 8:35am - 8:40am, 3 min>; . . .

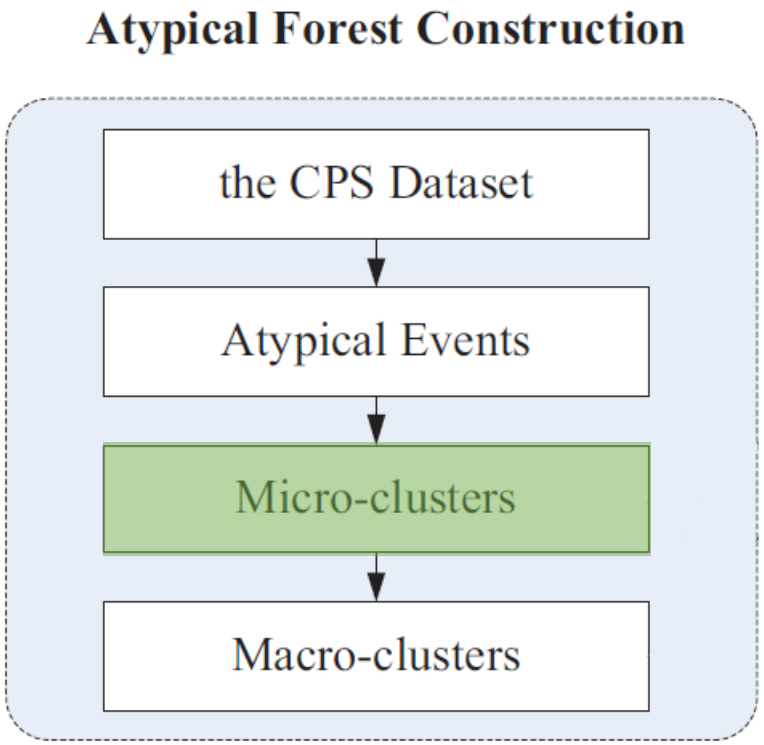
Multidimensional Analysis of Atypical Events in Cyber-Physical Data



Collection of atypical events.

Summary of event features.

Multidimensional Analysis of Atypical Events in Cyber-Physical Data

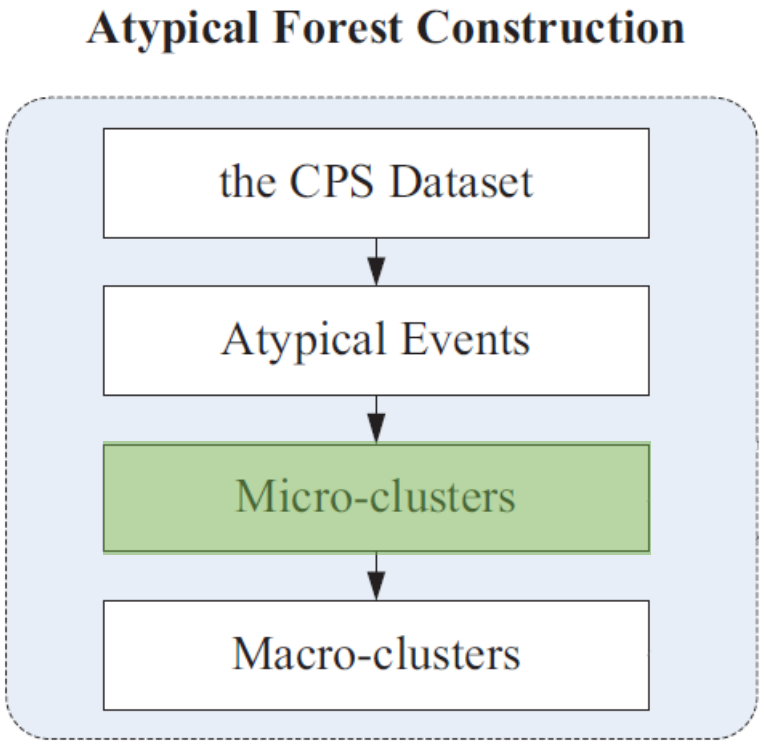


Collection of atypical events.

Summary of event features.

ID	Spatial Features	Temporal Features
C_A	<s_1, 182 min>; <s_2, 97 min>; <s_3, 33 min>; <s_4, 12 min>; …	<8:05am - 8:10 am, 4 min>; <8:10 am - 8:15 am, 10 min>;…
C_B	<s_1, 12 min>; <s_2, 51 min>; <s_3, 34 min>; <s_4, 140 min>; …	<6:20 pm - 6:25 pm, 7 min>; <6:25 pm - 6:30 pm, 13 min>;…
C_C	<s_1, 103 min>; <s_2, 75 min>; <s_7, 54 min>; <s_9, 60 min>; …	<8:20am - 8:25 am, 1 min>; <8:25 am - 8:30 am, 15 min>;…

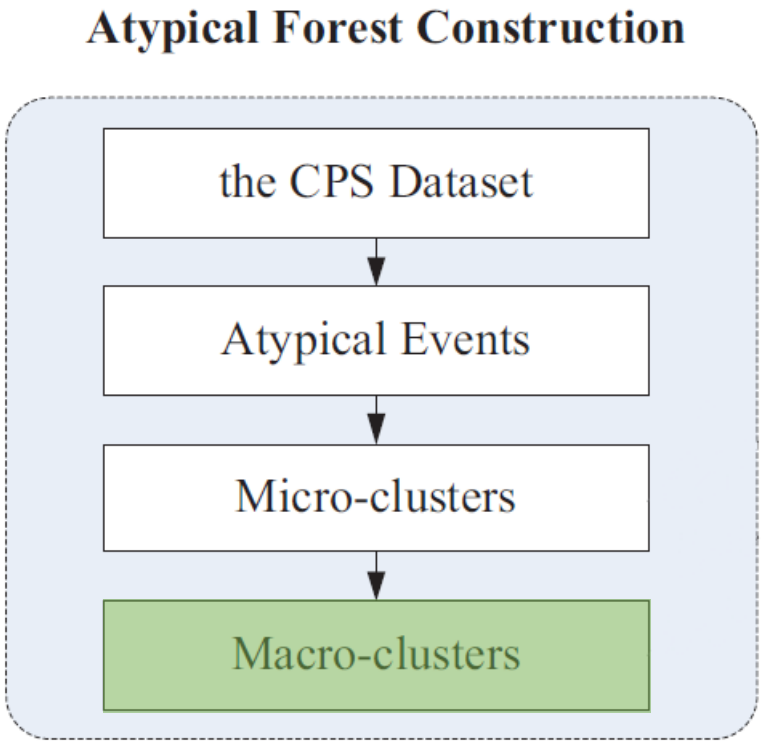
Multidimensional Analysis of Atypical Events in Cyber-Physical Data



Integrated information from multiple atypical events.

Summary of events over time or region.

Multidimensional Analysis of Atypical Events in Cyber-Physical Data



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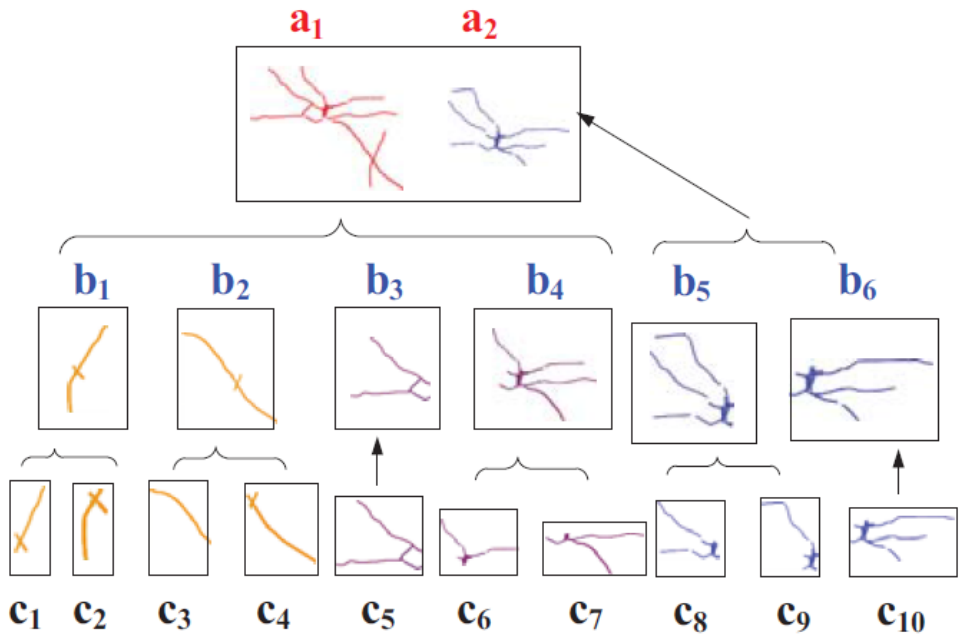

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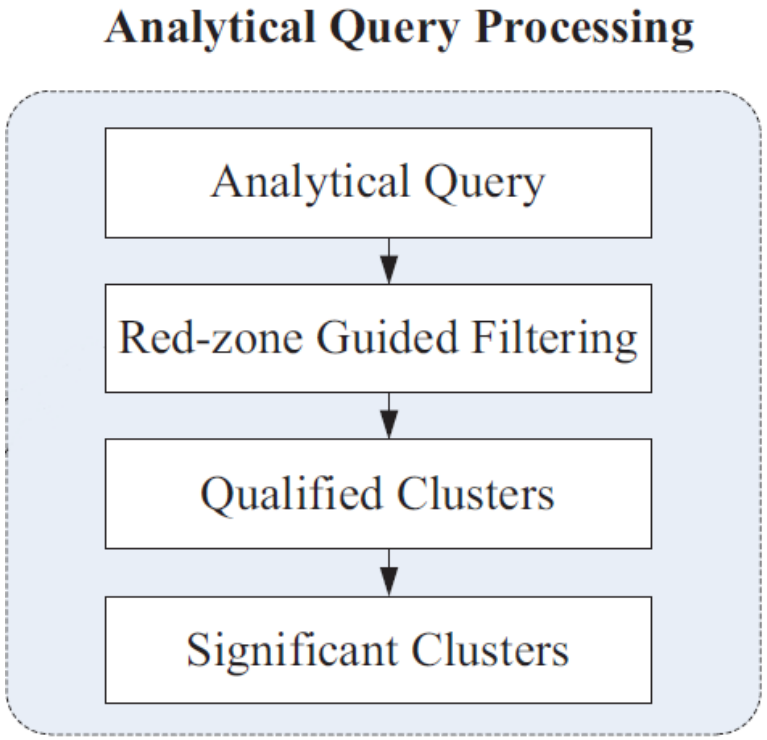
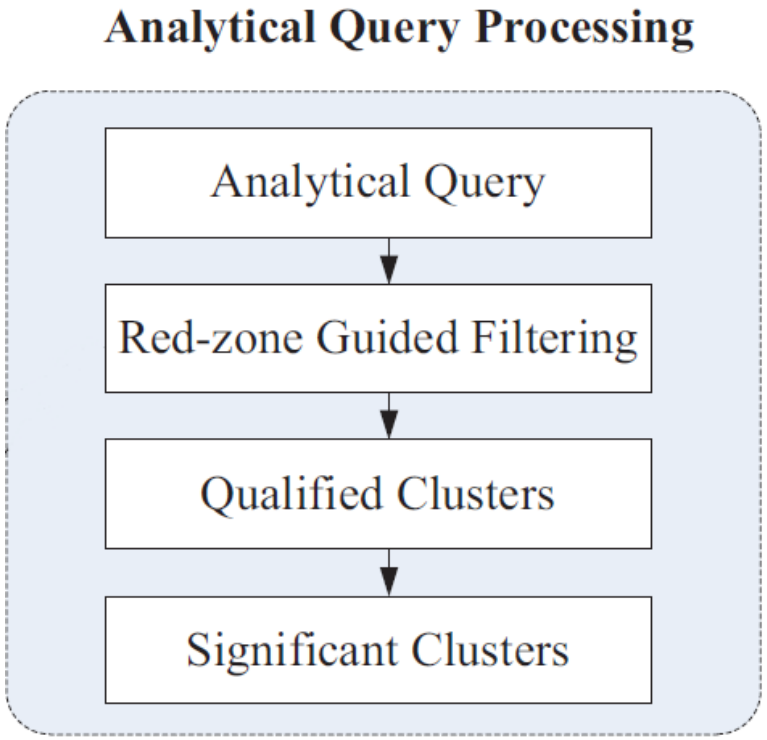


Problems: Efficiency & Effectiveness

☹ Quadratic time complexity

Multidimensional Analysis of Atypical Events in Cyber-Physical Data



Problems: Efficiency & Effectiveness

☹ Quadratic time complexity

Solutions:

☺ Prune irrelevant clusters

Multidimensional Analysis of Atypical Events in Cyber-Physical Data

Performance evaluation:

- ✓ CubeView, bottom-up method
- ✓ Atypical Cluster method

Multidimensional Analysis of Atypical Events in Cyber-Physical Data

- Evaluation of model construction

Multidimensional Analysis of Atypical Events in Cyber-Physical Data

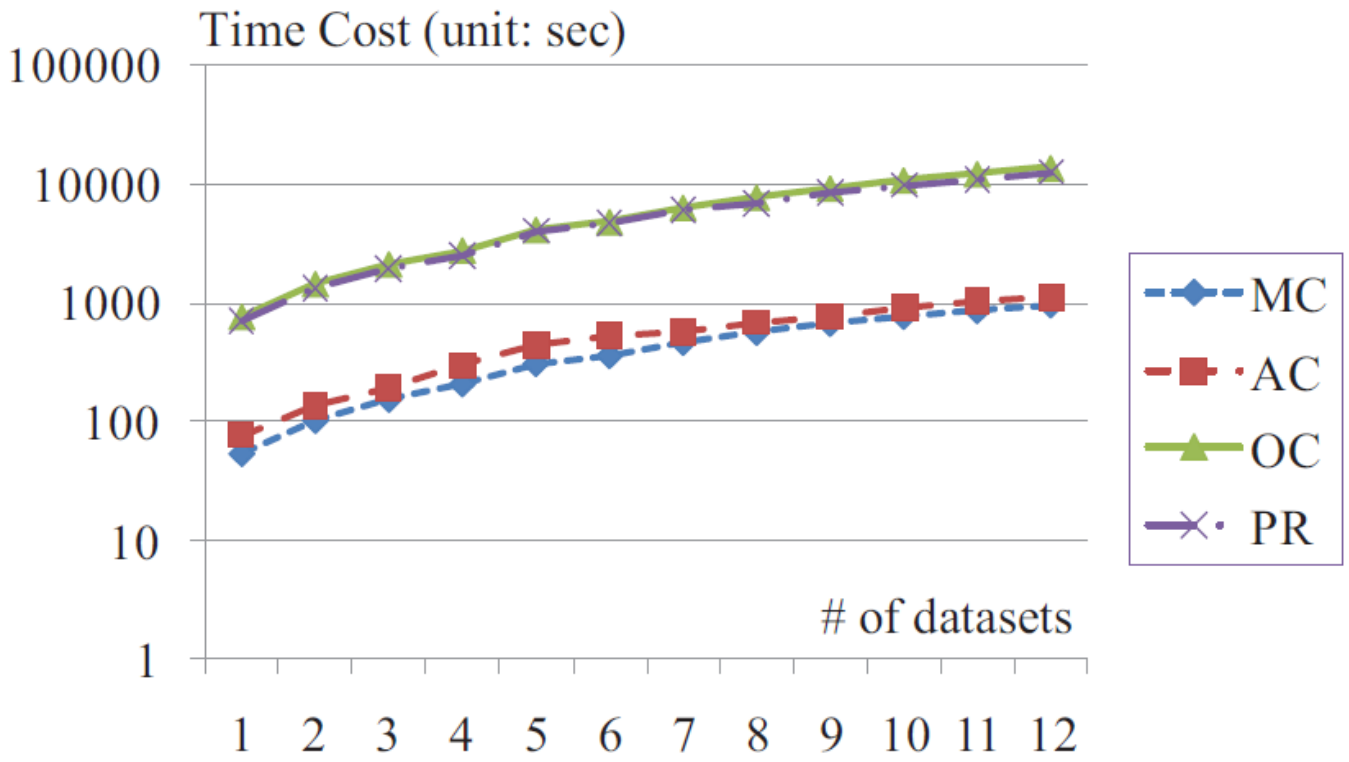


Fig. 15. Efficiency: Construction Time Cost vs. # of Datasets

Multidimensional Analysis of Atypical Events in Cyber-Physical Data

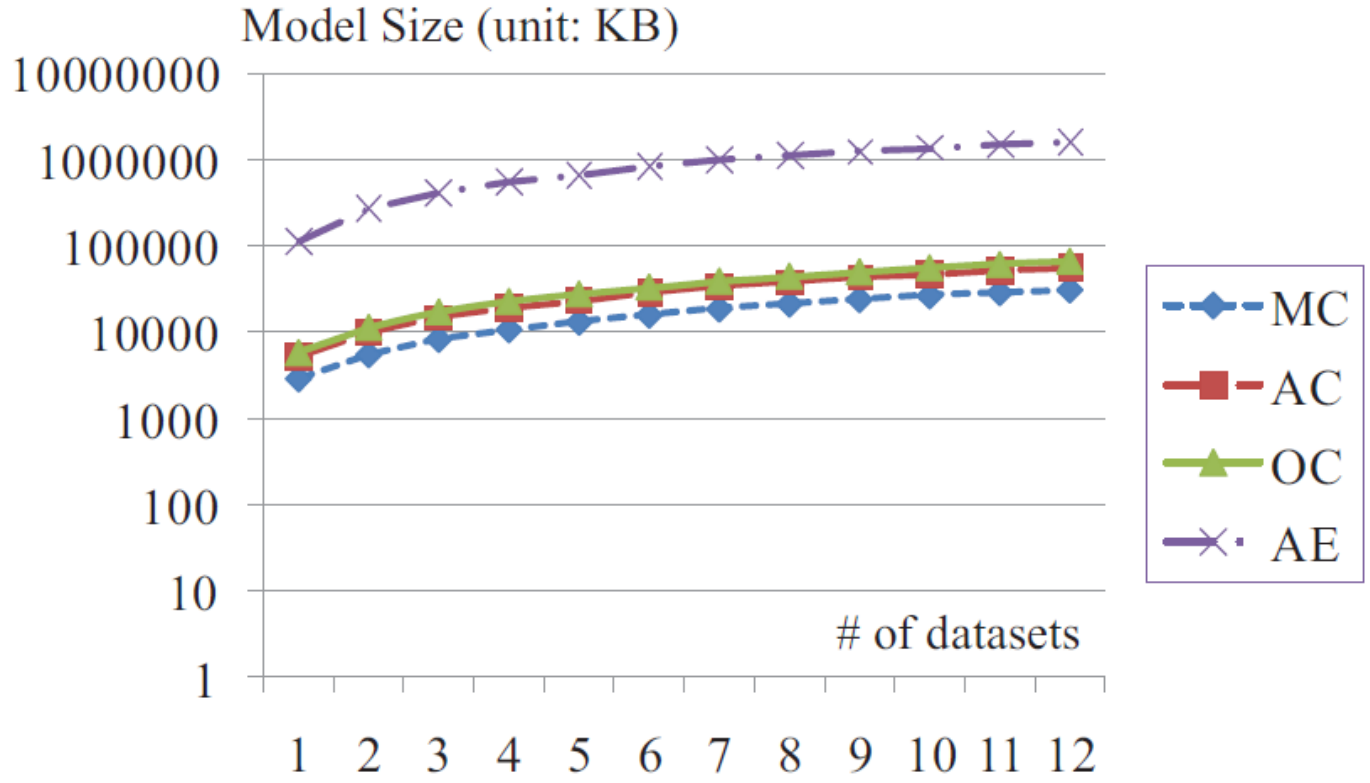
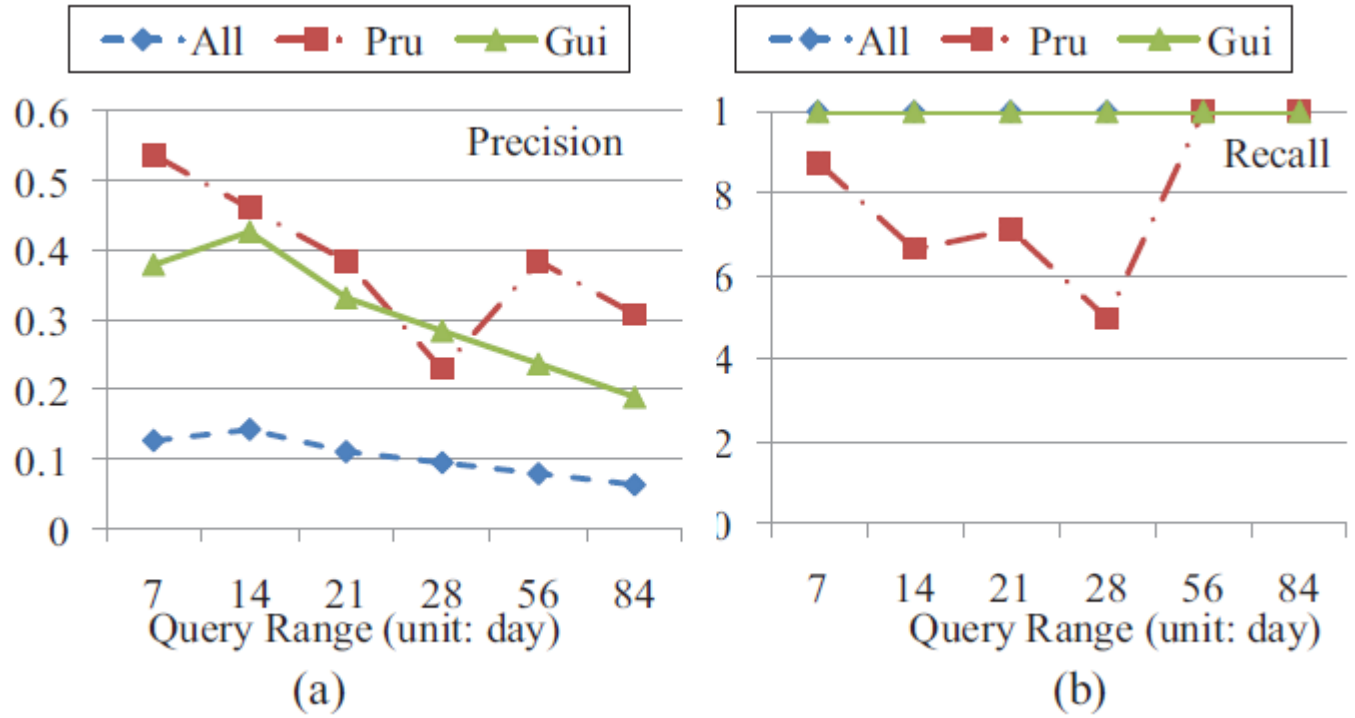


Fig. 16. Size: Constructed Model Size vs. # of Datasets

Multidimensional Analysis of Atypical Events in Cyber-Physical Data

- Comparison in analytical query processing



Multidimensional Analysis of Atypical Events in Cyber-Physical Data

Conclusions:

- ✓ Clustering data is hard.
- ✓ Multi-dimentional considerations.
- ✓ Atypical events don’t fit a model.

Thank you for listening!

Do you have any questions?