

DETAILS

06:04:44
CURRENT TIME

09/22/15
CURRENT DATE

DATA STATUS

19/24
PMUS REPORTING

99.87%
% GOOD DATA

345ms
LATENCY

23,447
DATA PROCESSED
PER SECOND

SPACE WEATHER FORECAST

Kp 8
CURRENT CONDITIONS

Kp 7
1-DAY
FORECAST

Kp 5
2-DAY
FORECAST

-0.4
dH/dt

-0.1
dF/dt

0.0
dZ/dt

0.1
dD/dt

GMD IMPACT ASSESSMENT

52 MVar

Instantaneous MVar from GIC for all Assets

4

MINOR
GIC

2

MODERATE
GIC

2

STRONG
GIC

2

SEVERE
GIC

0

EXTREME
GIC

Assets Impacted by Severity

0.42 MVar Hour

Total MVar hours from GIC

Unlocking the Value of PMU Data

By Sean Patrick Murphy and Jerry Schuman

CIGRE Grid of the Future, 2016

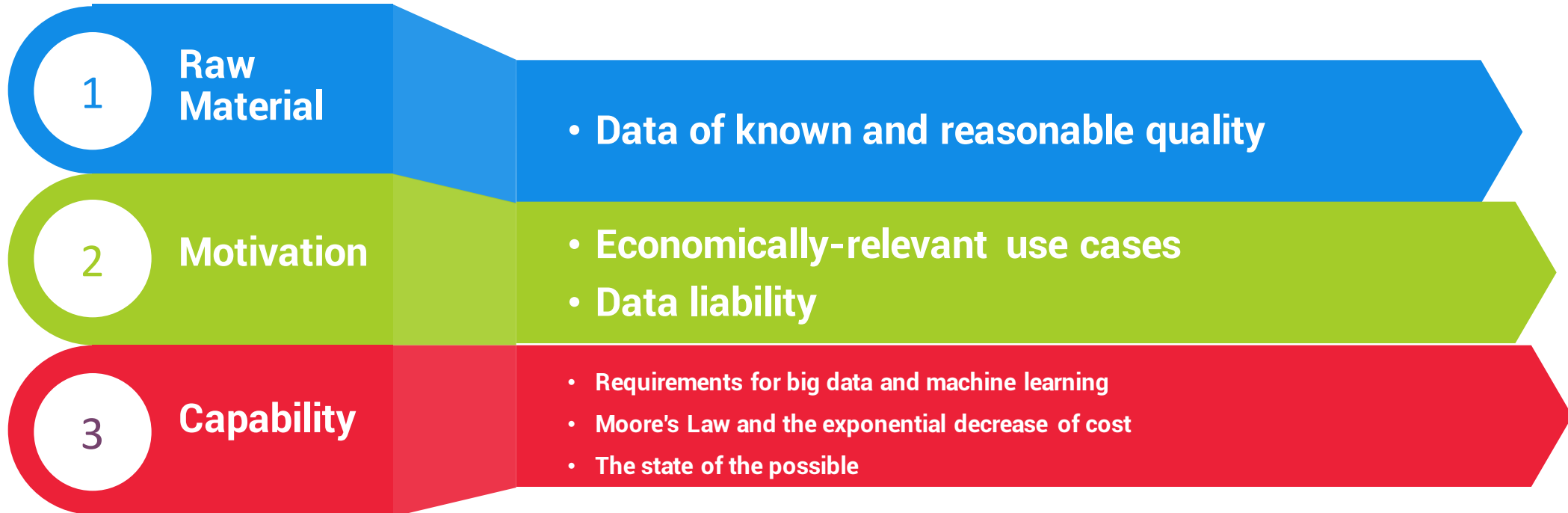
Philadelphia, PA

ABSTRACT

With the advent and subsequent deployment of synchrophasor technology across the transmission portion of the grid, the electric utility industry and federal government have made a significant and public investment toward a more data-oriented future over the last two decades. We will argue that all of the necessary ingredients are now available to leverage the data produced by these new sensors to generate far greater ROI than had originally been anticipated.

To unlock the latent value in this data, utilities need the (1) appropriate raw material in the form of high quality data, (2) suitable financial motivation to use the data to solve known and unknown problems, and (3) capability to realize the use cases in a scalable and cost effective fashion. This paper will show that data quality is a readily solvable issue despite having not been adequately addressed. It is neither a technology nor an algorithm problem, but appears to be one of organizational will. Significant incentive to use PMU and other next generation sensor data exists in many forms. PMU data can be leveraged to reduce unnecessary costs for utilities and enhance operational visibility without the need for additional investment in equipment and systems. We also note that other industry sectors have evolved the state of the art in big data storage and analysis and that the utility industry could capitalize on the value that those investments have produced.

3 Components to Unlocking the Value of Data



Synchrophasor Data Quality

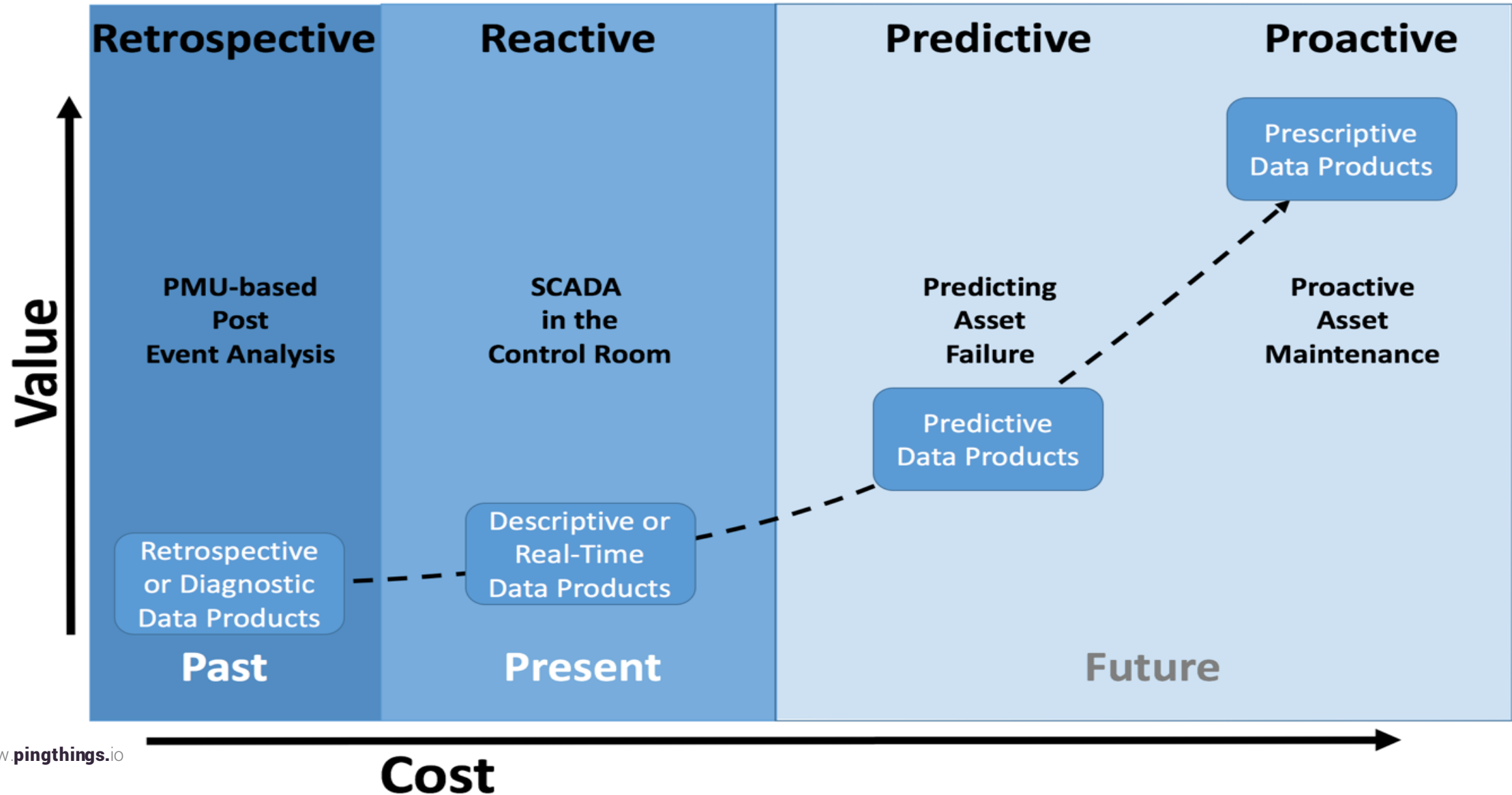
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Data is just like crude. It's valuable, but if unrefined it cannot really be used. It has to be changed into gas, plastic, chemicals, etc. to create a valuable entity that drives profitable activity; so must data be broken down, analyzed for it to have value.

Synchrophasor Data Quality



Value Creation as a Function of Cost and Time Period



Known Use Cases

"BPA used synchrophasor data to recalibrate the 1,100 MW Columbia Nuclear Generating Station without needing to take the unit off line, **providing \$100,000 to \$700,000 in estimated savings for this type of generator outage.**"

"ISO-NE event analysis applications automatically collect and analyze synchrophasor data from PMUs all across New England, enabling engineers to quickly identify and analyze disturbances. **With the improved efficiency, ISO-NE is able to analyze two or three events per week – up from two events per year – using the same resources.**"

Retrospective



Operator Training and
Event Simulation



Forensic Event
Analysis

Reactive



Wide Area Situational
Awareness



Oscillation Detection



Phase Angle
Monitoring



Voltage Stability Monitoring
and Management

Unexpected Use Cases from Data

NETFLIX

Netfix Prize

COMPLETED

HomeRulesLeaderboardUpdate

NETFLIX

BrowseRecommendationsFriendsQueueBuy DVDs

HomeGamesNew ReleasesPreviewsNetflix Top 100

Movies For You

Netflix Prize

Completed

Congratulations!

The Netflix Prize sought to substantially improve the accuracy of predictions about how much someone is going to enjoy a movie based on their movie preferences.

On September 21, 2009 we awarded the \$1M Grand Prize to team "BellKor's Pragmatic Chaos". Read about [their algorithm](#), checkout team scores on the [Leaderboard](#), and join the discussions on the [Forum](#).

We applaud all the contributors to this quest, which improves our ability to connect people to the movies they love.

FAQForumNetflix Home

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NETFLIX

Netfix Prize

COMPLETED

HomeRulesLeaderboardUpdate

Leaderboard

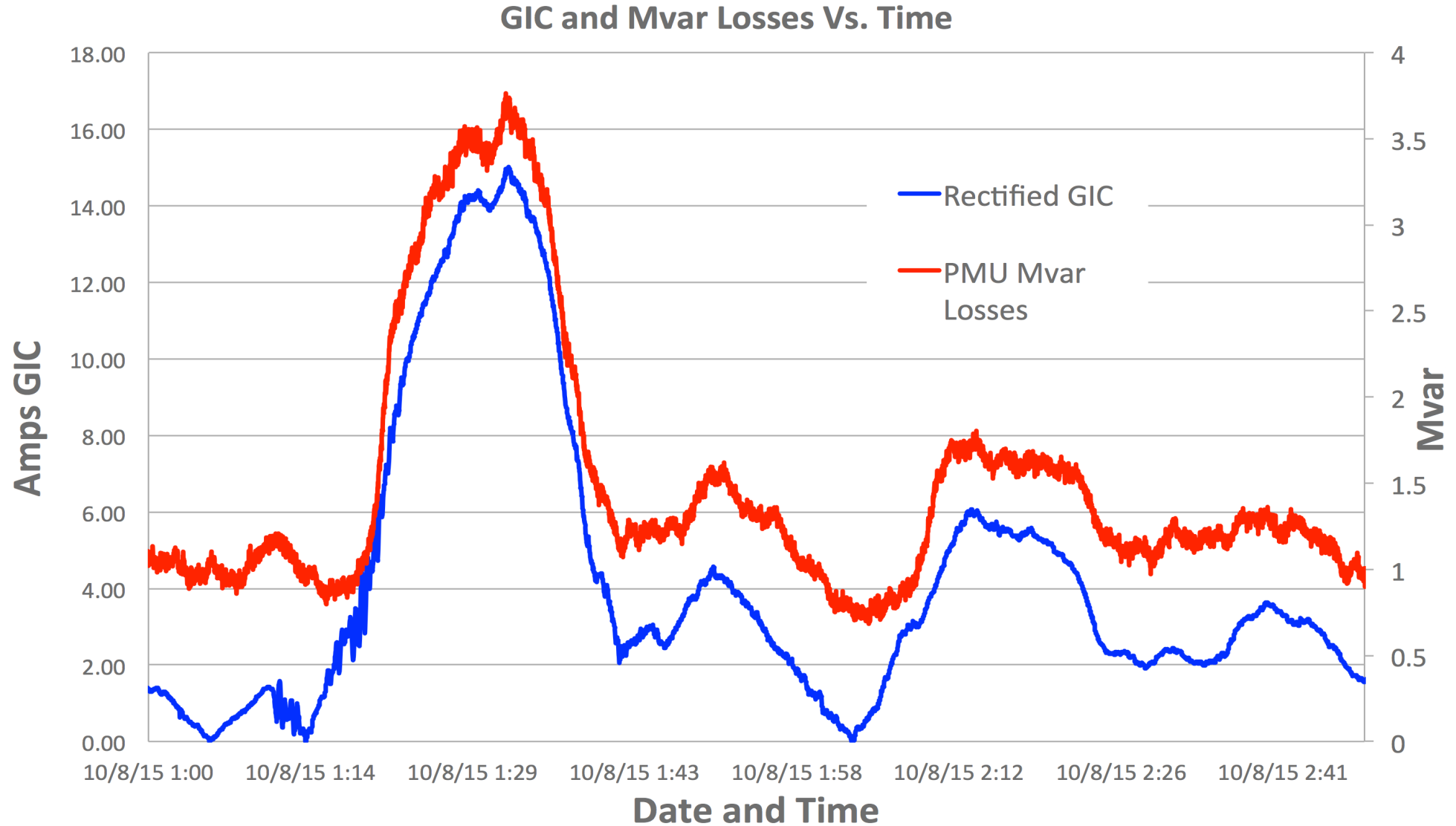
Showing Test Score. [Click here to show quiz score](#)

Rank	Team Name	Best Test Score	% Improvement	Best Submit Time
Grand Prize - RMSE = 0.8567 - Winning Team: BellKor's Pragmatic Chaos				
1	BellKor's Pragmatic Chaos	0.8567	10.06	2009-07-26 18:18:28
2	The Ensemble	0.8567	10.06	2009-07-26 18:38:22
3	Grand Prize Team	0.8582	9.90	2009-07-10 21:24:40
4	Opera Solutions and Vandelay United	0.8588	9.84	2009-07-10 01:12:31
5	Vandelay Industries I	0.8591	9.81	2009-07-10 00:32:20
6	PragmaticTheory	0.8594	9.77	2009-06-24 12:06:56
7	BellKor in BigChaos	0.8601	9.70	2009-05-13 08:14:09
8	Dace	0.8612	9.59	2009-07-24 17:18:43
9	Feeds2	0.8622	9.48	2009-07-12 13:11:51
10	BigChaos	0.8623	9.47	2009-04-07 12:33:59
11	Opera Solutions	0.8623	9.47	2009-07-24 00:34:07
12	BellKor	0.8624	9.46	2009-07-26 17:19:11
Progress Prize 2008 - RMSE = 0.8627 - Winning Team: BellKor in BigChaos				
13	xiangqiang	0.8642	9.27	2009-07-15 14:53:22
14	Gravity	0.8643	9.26	2009-04-22 18:31:32
15	Ces	0.8651	9.18	2009-06-21 19:24:53
16	Invisible Ideas	0.8653	9.15	2009-07-15 15:53:04
17	Just a guy in a garage	0.8662	9.06	2009-05-24 10:02:54
18	J Dennis Su	0.8666	9.02	2009-03-07 17:16:17
19	Craig Carmichael	0.8666	9.02	2009-07-25 16:00:54
20	acmehill	0.8668	9.00	2009-03-21 16:20:50
21	MonteCarlo	0.8669	8.99	2009-03-24 10:45:14
22	IDEA2	0.8669	8.99	2009-03-25 15:37:59
23	just_a_student	0.8675	8.92	2009-07-17 08:37:11
24	Howbert	0.8677	8.90	2009-07-26 07:13:00
25	My Brain and His Chain	0.8678	8.89	2008-09-30 02:19:47
26	Newman!	0.8681	8.86	2009-07-26 14:31:51
27	When Gravity and Dinosaurs Unite	0.8686	8.81	2008-02-29 06:48:56

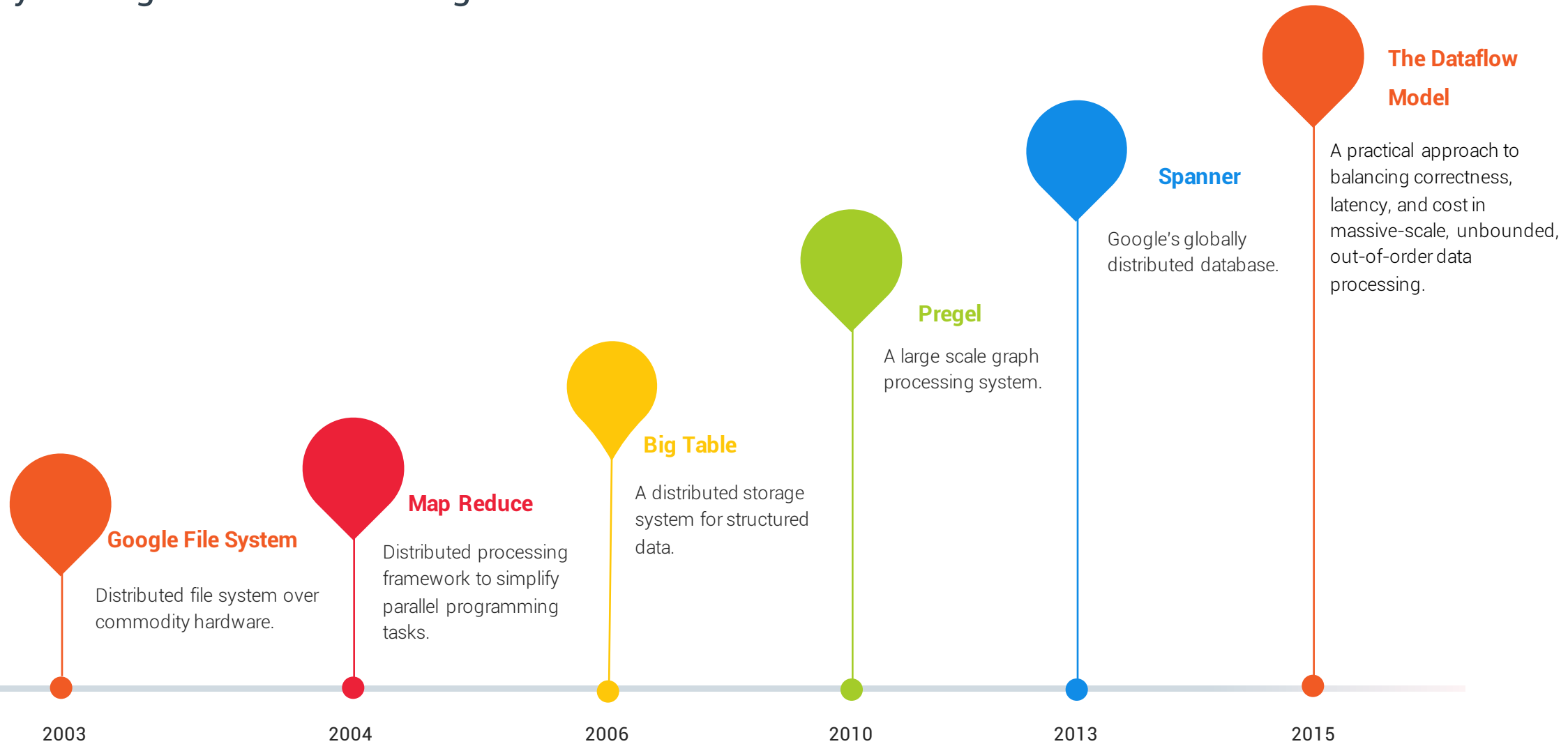
www.pingthings.io

7

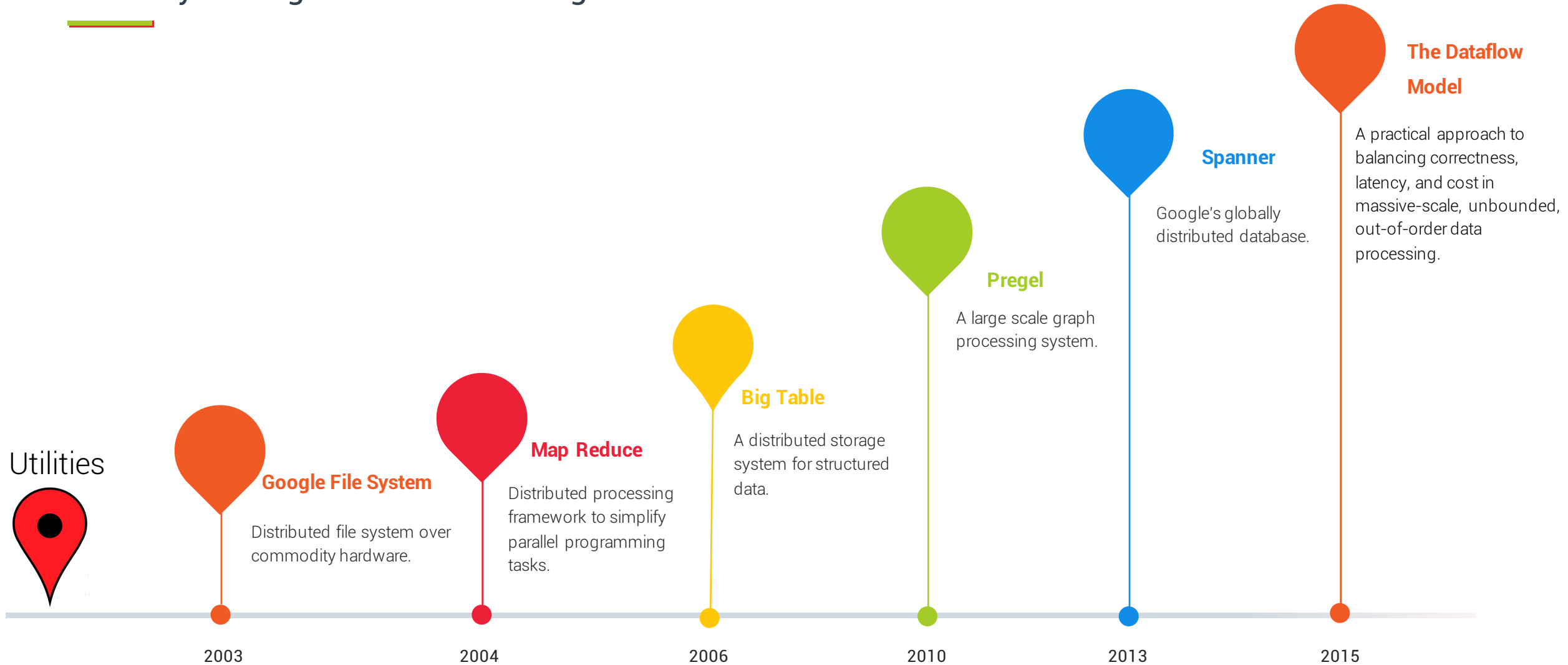
Unexpected Use Cases for PMU Data



History of Big Data from Google



History of Big Data from Google



A Paradigm Shift

Old Paradigm - Software Engineering

- Humans write the code
- Limited by ability to describe exactly what must be done without error

New Paradigm - Machine Learning

- Data teaches algorithms to perform function or task
- Limited by the amount of data and algorithms
- Algorithms need *****ALL***** available data



Deep Blue
beats Gary
Kasparov 1997



Watson beats
champions
2011



AlphaGo beats
Lee Sedol
2016

Cramming More Components onto Integrated Circuits

The experts look ahead

Cramming more components onto integrated circuits

With unit cost falling as the number of components per circuit rises, by 1975 economics may dictate squeezing many as 65,000 components on a single silicon chip

By Gordon E. Moore

Director, Research and Development Laboratories, Fairchild Semiconductor division of Fairchild Camera and Instrument Corp.

The future of integrated electronics is the future of electronics itself. The advantages of integration will bring about a proliferation of electronics, pushing this science into many new areas.

Integrated circuits will lead to such wonders as home computers—or at least terminals connected to a central computer—automatic controls for automobiles, and personal portable communications equipment. The electronic wrist-watch needs only a display to be feasible today.

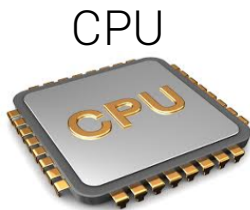
But the biggest potential lies in the production of large systems. In telephone communications, integrated circuits in digital filters will separate channels on multiplex equipment. Integrated circuits will also switch telephone circuits and perform data processing.

Computers will be more powerful, and will be organized in completely different ways. For example, memories built of integrated electronics may be distributed throughout the

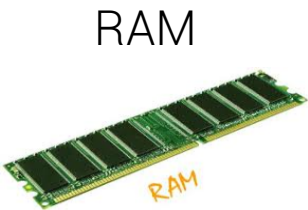
machine instead of in a central unit. In addition, the improved circuits will allow for more complex machines similar to those of today.

Present and future

By integrating technologies which as well as any additions supplied to technologies were first subject was to miniaturize increasingly complex minimum weight microstructures and film structures and each approach to the problem of miniaturization.



Cost per Gigaflop



Cost per Gigabyte



Cost per Gigabyte



Enterprise Data Systems

	CPU	RAM	Storage	Software
1995	\$42,000	\$32,000	\$60,000	Million\$
2015	\$0.03	\$5	\$0.05	Free, Open source

The RAM required to hold a month's worth of PMU data for the entire North American continent costs approximately \$10K

Conclusions

- Data quality is a solvable issue.
- Data liability is a looming issue for the industry.
- Vast motivation exists to pursue synchrophasor data applications.
- Moore's law and open source software have provided the capabilities to handle PMU data.

CURRENT SYSTEM DATE AND TIME

06:04:22

10/13/16

DATA STATUS

19/24
PMUS REPORTING

94.27%
% GOOD DATA

344ms
AVERAGE LATENCY

557ms
MAX LATENCY

13,176
DATA POINTS
PROCESSED PER SECOND

DATA QUALITY - SYSTEM LEVEL

94.27% Good Data

1.67% Missing Values

0.97% Null Values

1.00% Zero Values

0.95% Out of Range Values

1.16% Repeated Values

Show Table View

0%
20%
40%
60%
80%
100%

Questions?



PingThings
Chief Data Scientist
Sean Murphy
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