

REAL-TIME PERFORMANCE MANAGEMENT FOR THE ENTERPRISE

RtPM



REAL-TIME PERFORMANCE MANAGEMENT FOR THE ENTERPRISE

RtPM



Herbert Falk

Systems Integration Specialists Company, Inc.



Project Manager

Using RtPM/PI and IEC standards to create a distributed architecture for phasor acquisition and analysis

- The motivation of phasor measurement
- What are phasors/synchro-phasors
- IEC Reference Architecture
- What is happening in the United States
- How RtPM/PI is being used
- Future Innovations



The Initial Motivation



August 14, 2003 Blackout*

Results (for Southeast Michigan):

Power lost for 1-3 days

No gasoline available


No cell phones

No credit cards/banking

10's of billions of dollars of lost production.

Manufacturing equipment damage

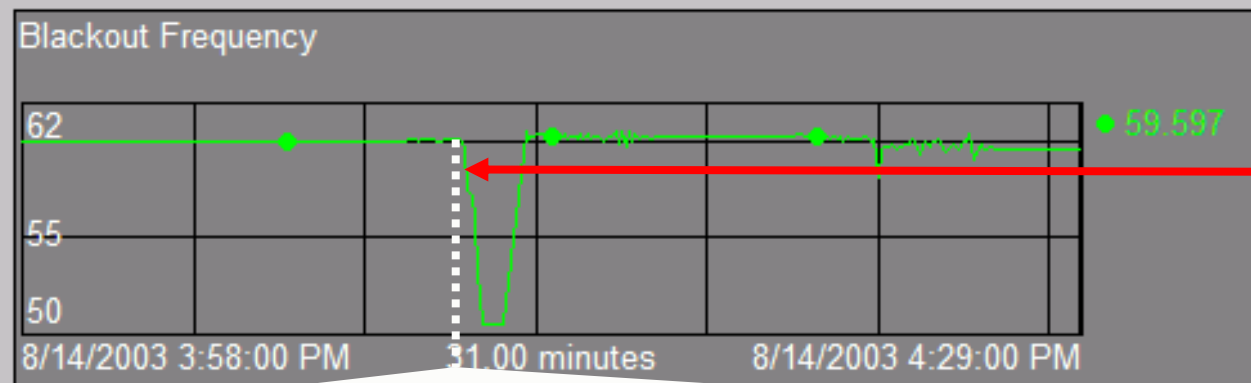
Water supply disrupted for one week.

 - where I live.

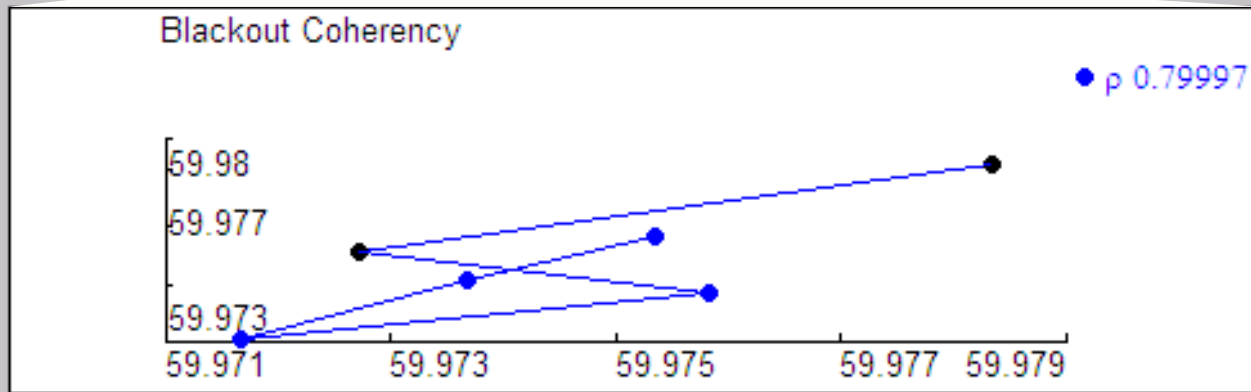
* Courtesy of National Oceanic and Atmospheric Administration



What caused the problem?



At this point,
GRID was
unrecoverable.



Actual data from August 14th Blackout

Displays generated using actual data in Processbook 3.0

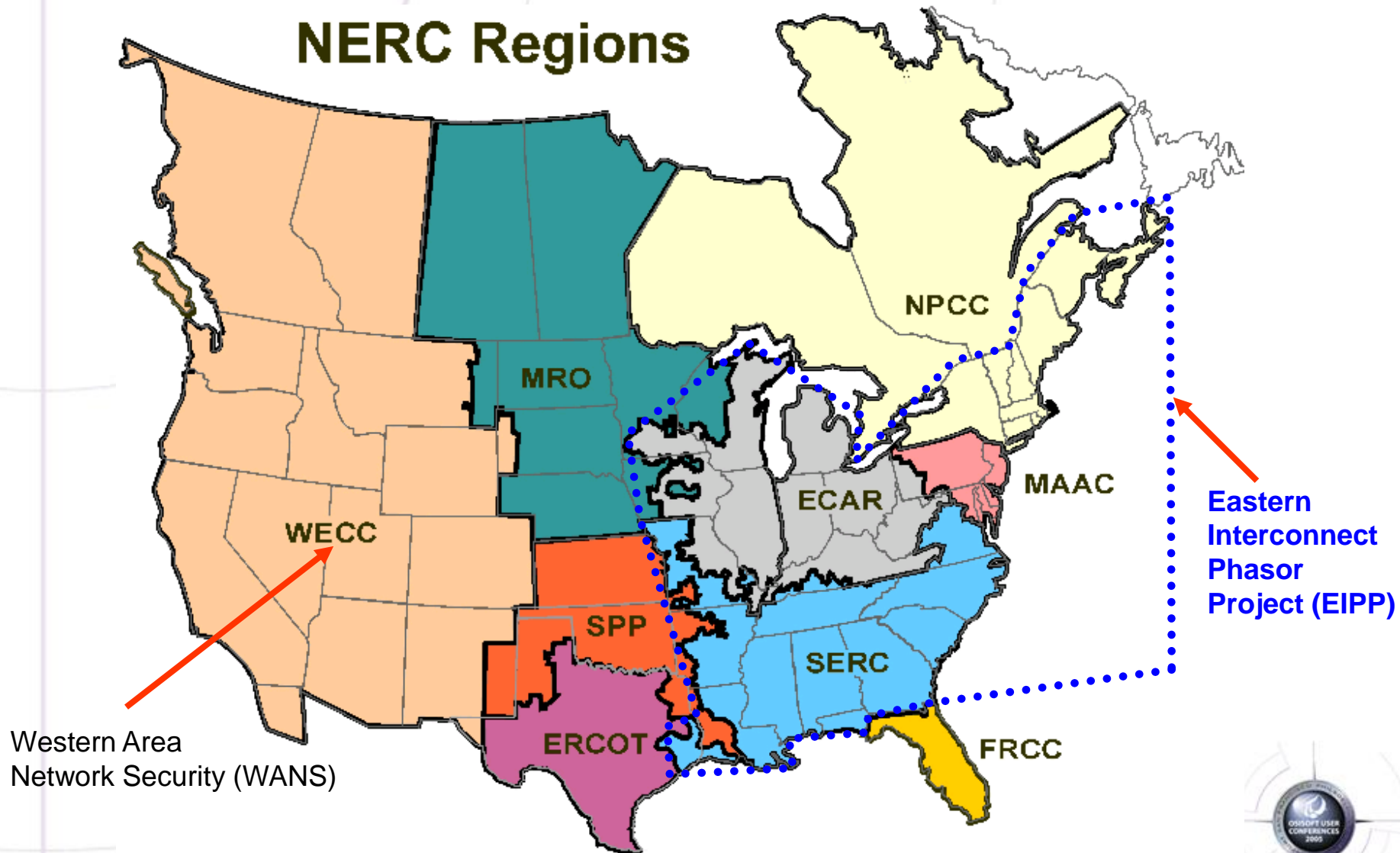


Blackout Report

- Trees and transmission lines (a bad combination)
- Human error
- Lack of procedures
- Forensics took time since there was no common way of measuring.
 - Time stamping
 - Types of measurements (need for synchrophasor)



Three major initiatives

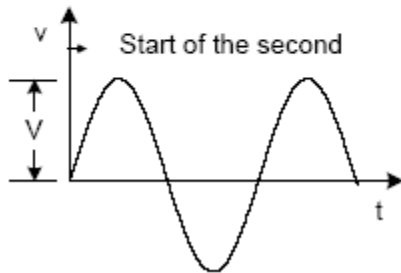
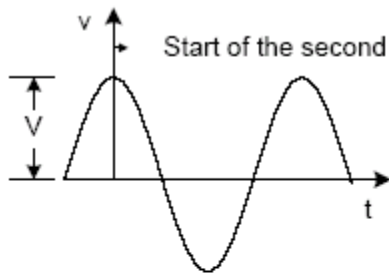
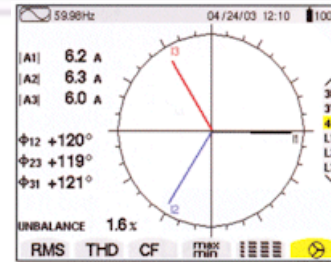


Third Initiative

- Develop a standard (IEEE C37.118)
 - Vendor Driven (initially)
 - No systematic approach
 - Sponsored in IEEE
 - No coordination with IEC



What is a Phasor?



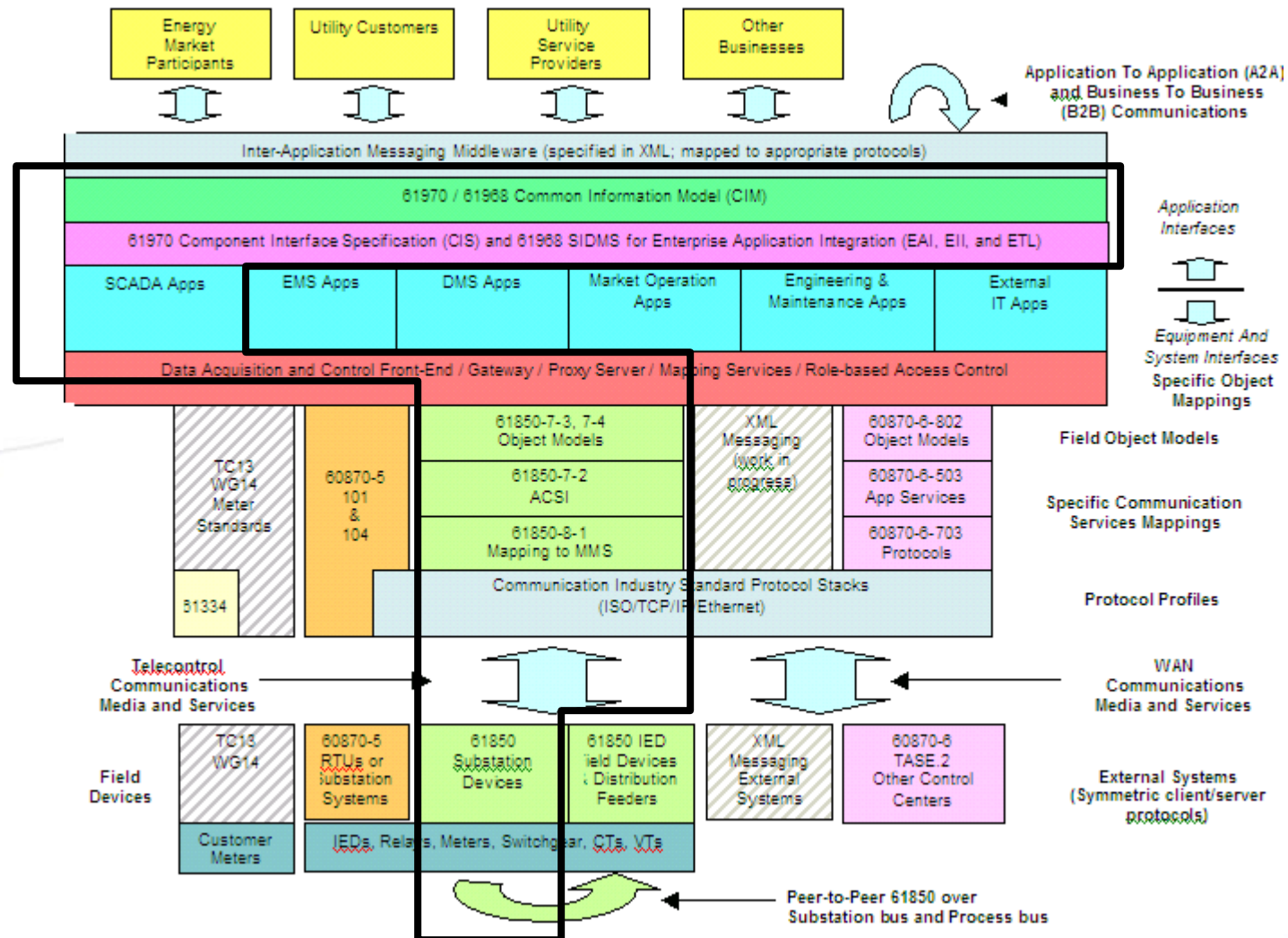
Measurement vs. Time
generates an angle/offset
vs. known point in time.

As frequency changes so
does offset.

Offset and rate of offset change are
indicators of system stability.

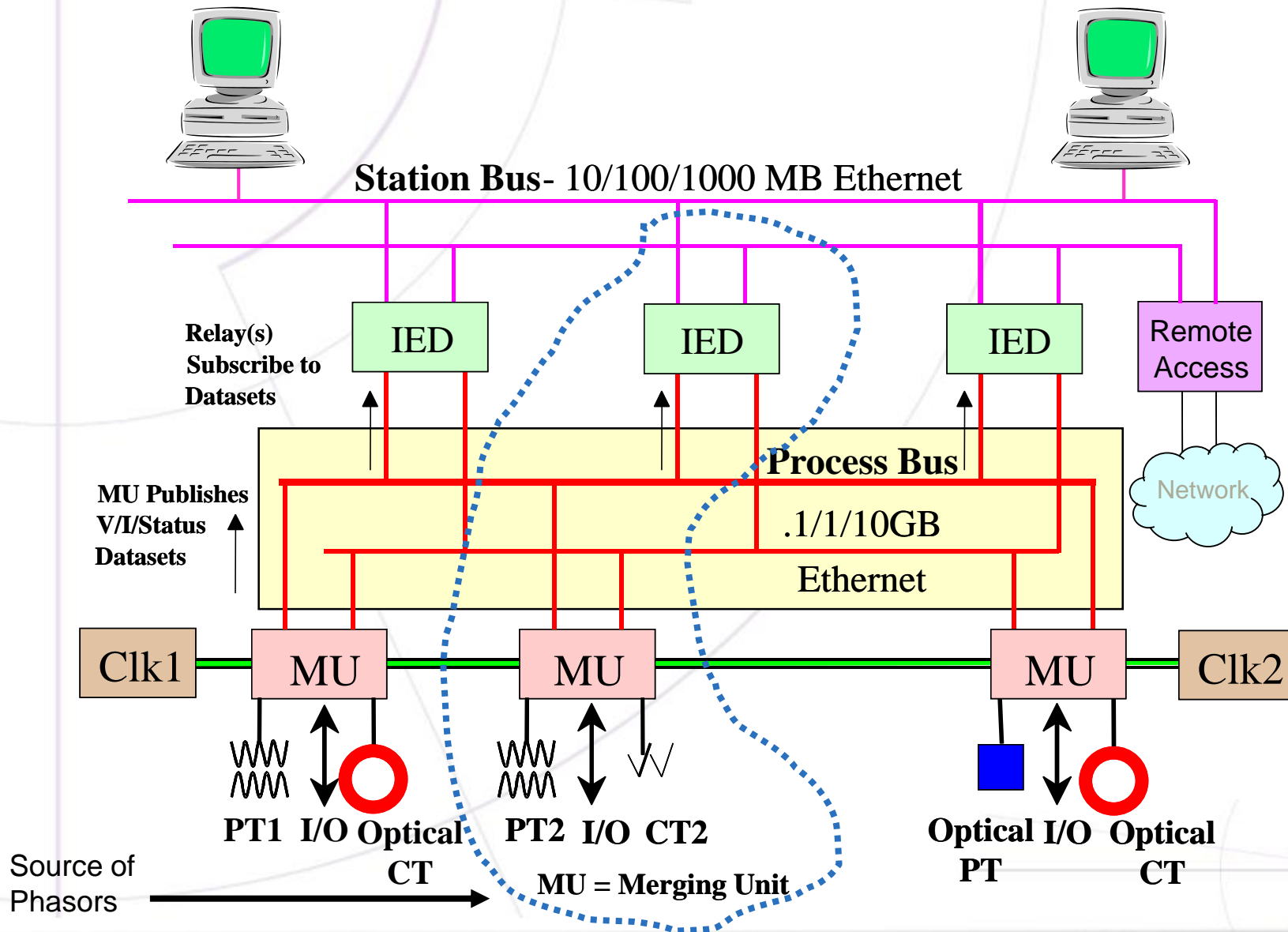
In a perfect world, what would the
offset be?

What is IEC TC57

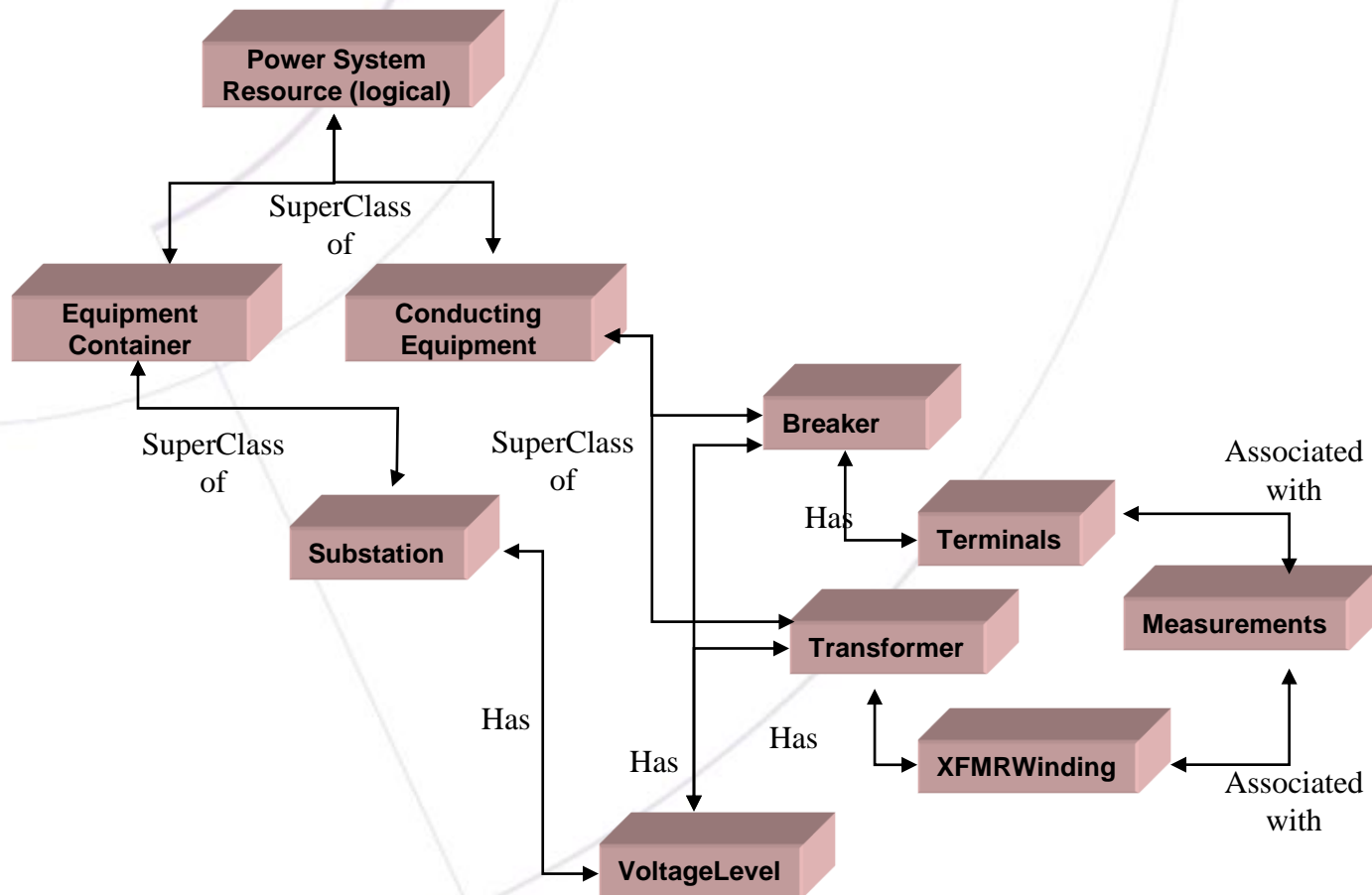


The integration solution to be discussed.

Substation: IEC 61850

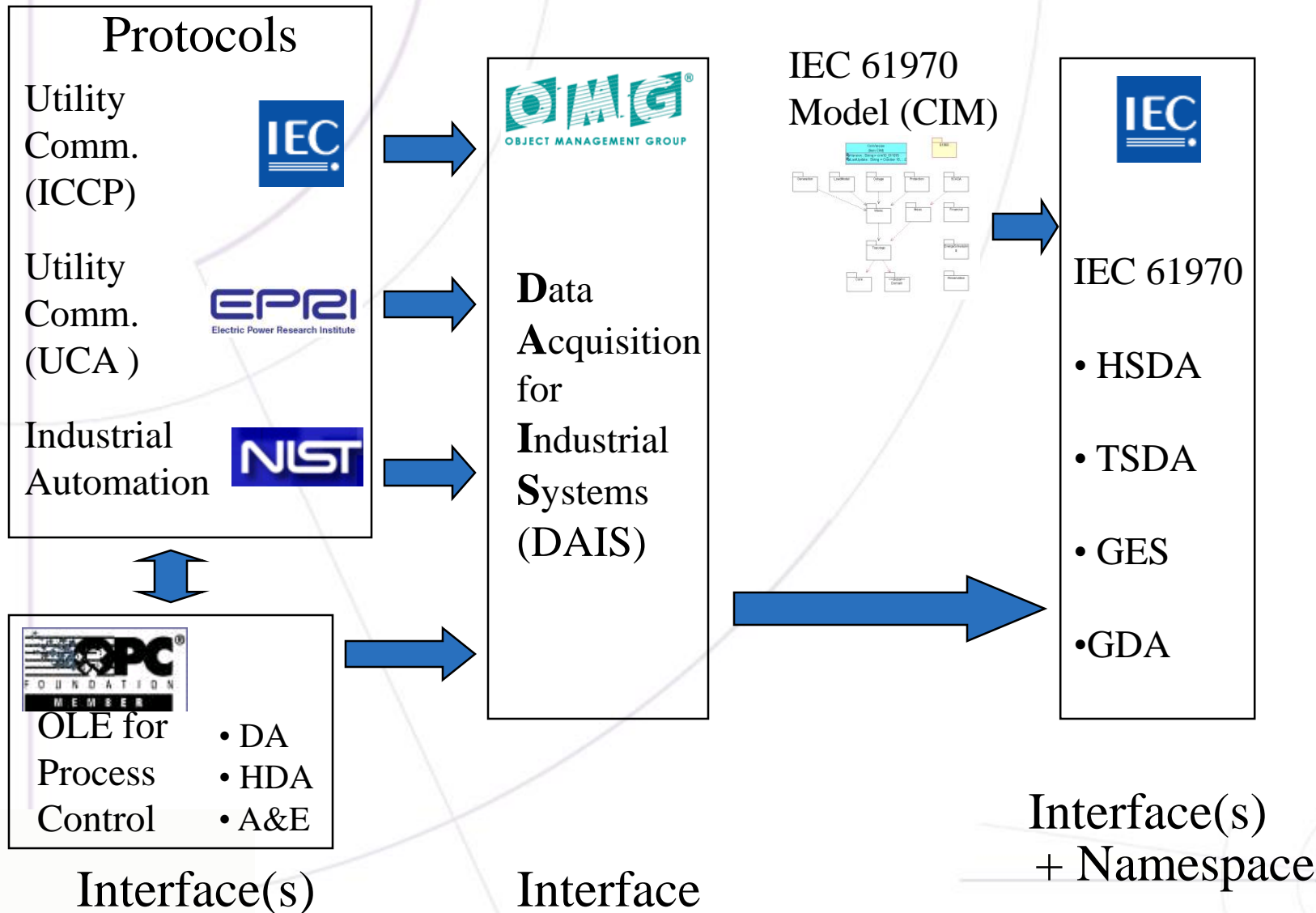


Analytics Standard: IEC 61970

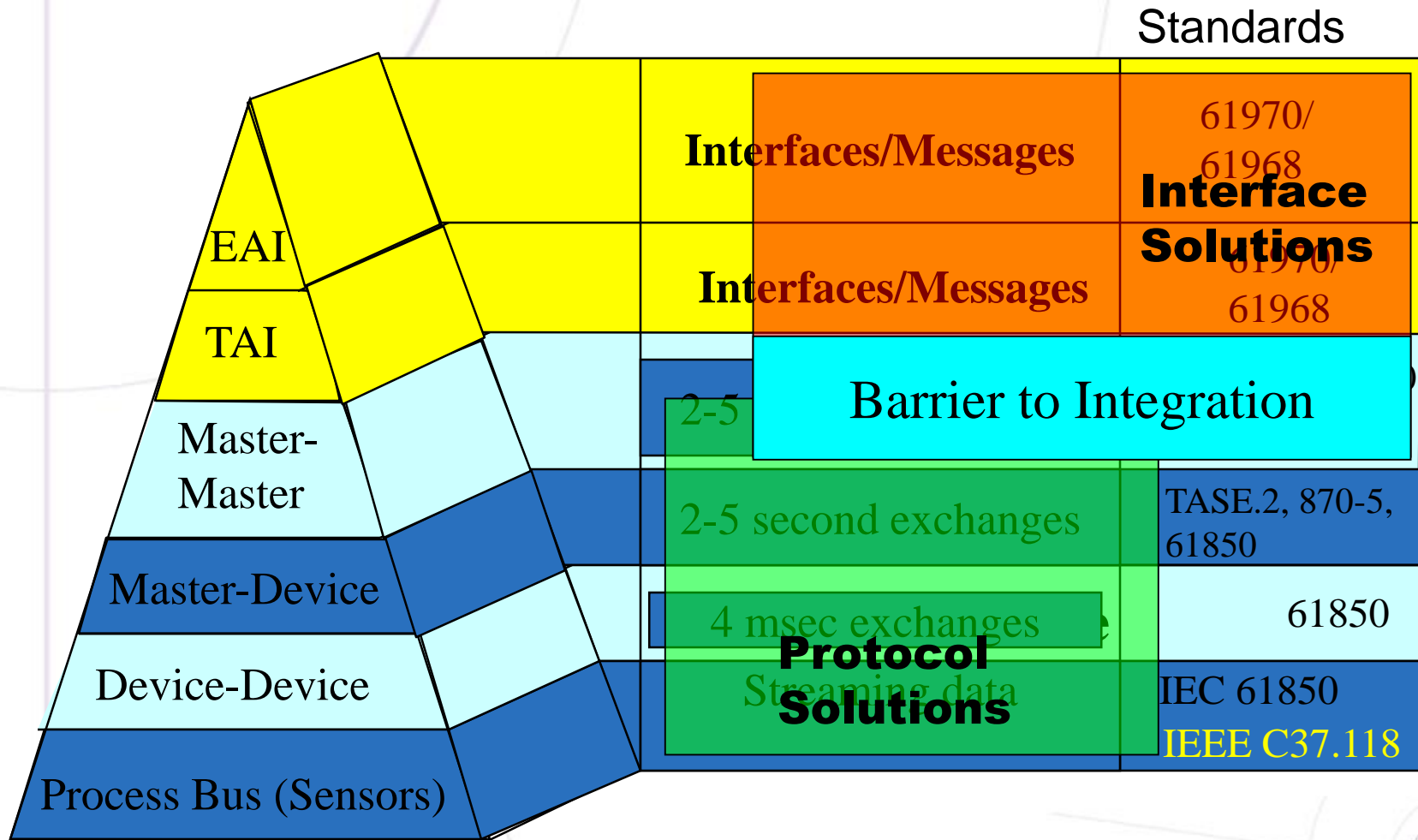


CIM: What data is exchanged

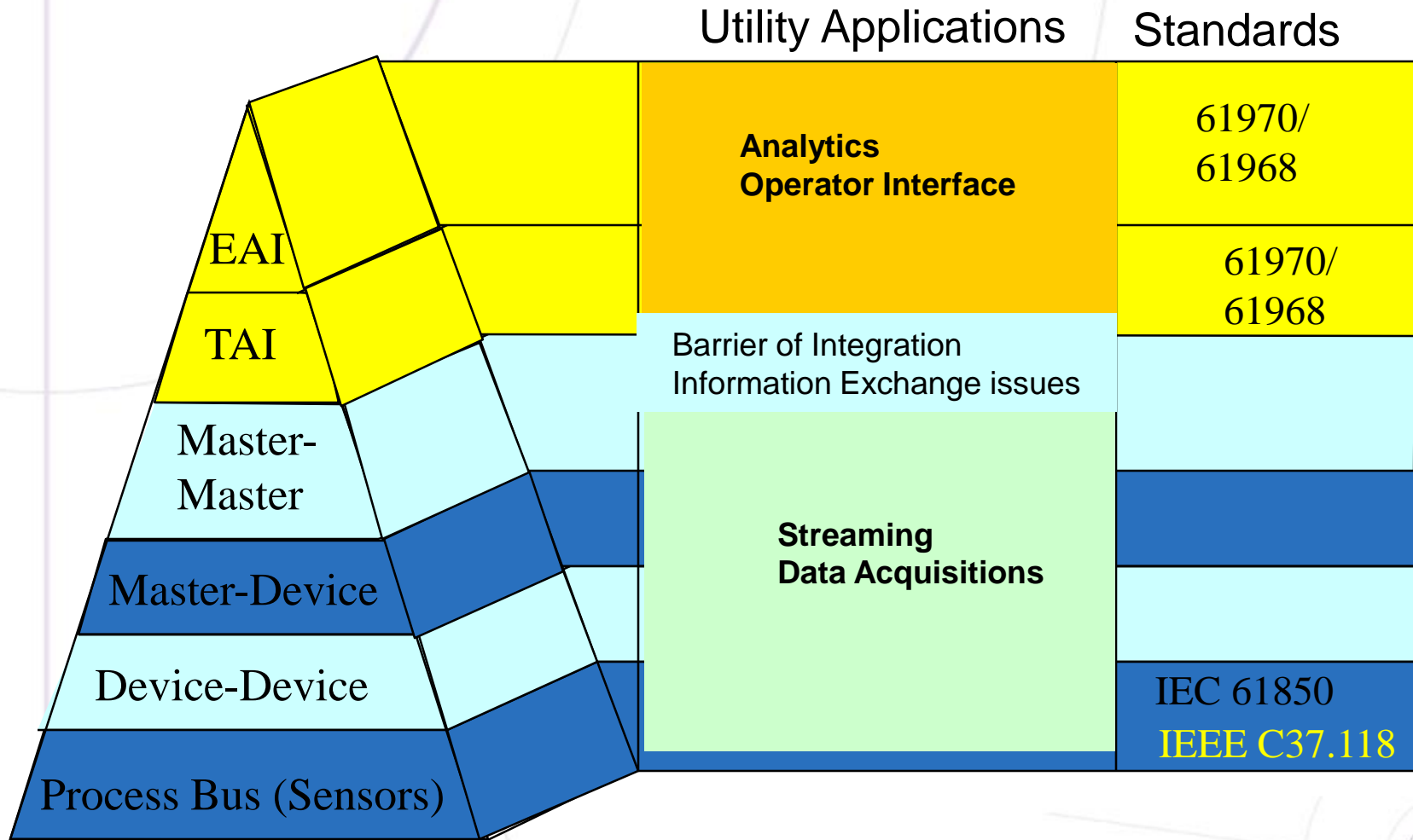
Standard: IEC 61970 GID



IEC, phasors, and C37.118



Another slice of the problem

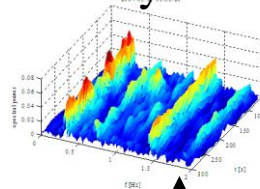


Initial deployment concept

Real-time

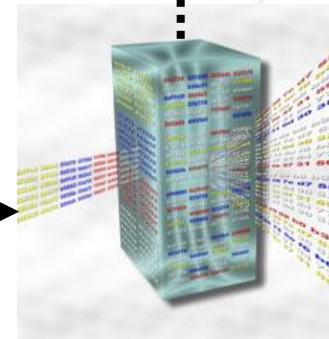


Analysis

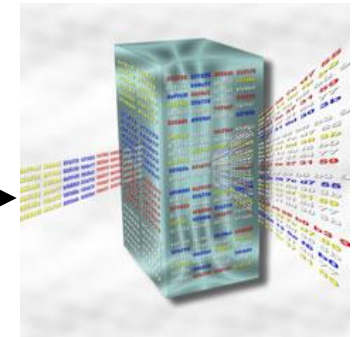


Analytical/PDC	
#PMUs	Values/sec
5	2,500
12	6,000
30	15,000
60	30,000
300	150,000

Per PMU/second		
Messages	Bits	Value
20	7,360	200
30	11,040	300
50	18,400	500
80	29,440	800
240	88,320	2,400



PDC



PDC (different location)

C37.118
IEEE 1344
IEC 61850-9-2

Protocol Choices:

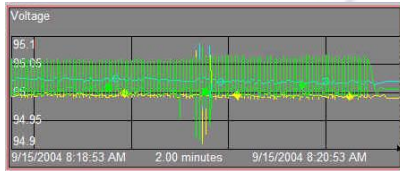
Approximately
 368 bits/report
 10 values/report

PMU(s)

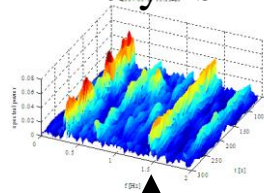


Revised deployment concept

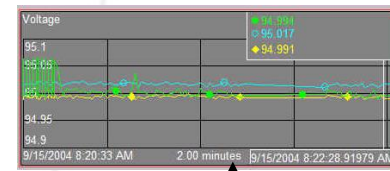
Real-time



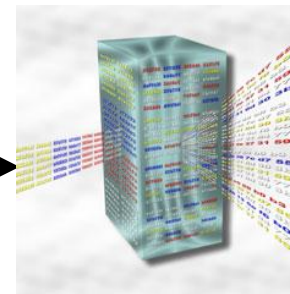
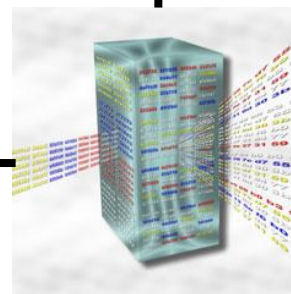
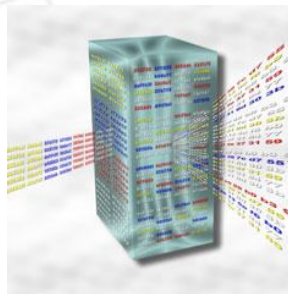
Analysis



Historical



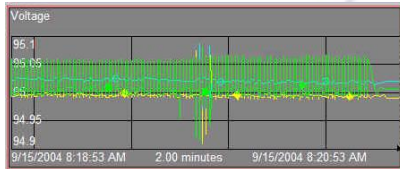
Standardized Interfaces from IEC 61970



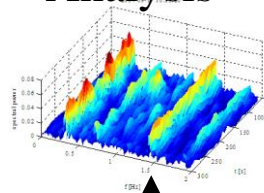
Looks like a job for PI



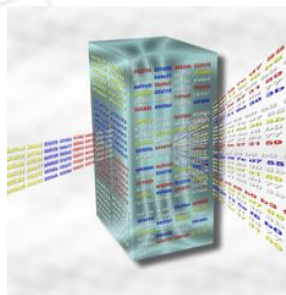
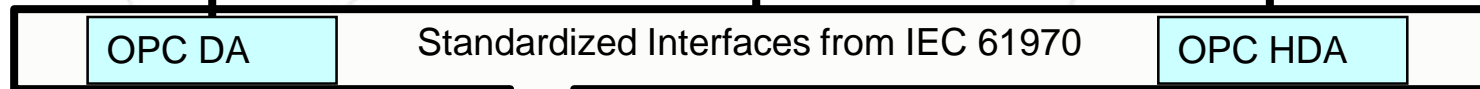
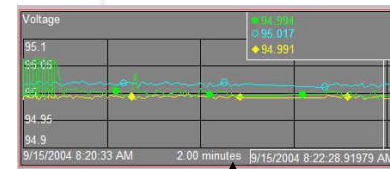
Real-time



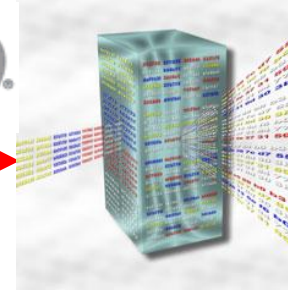
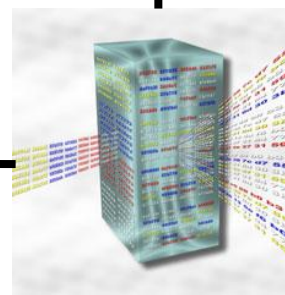
Analysis



Historical



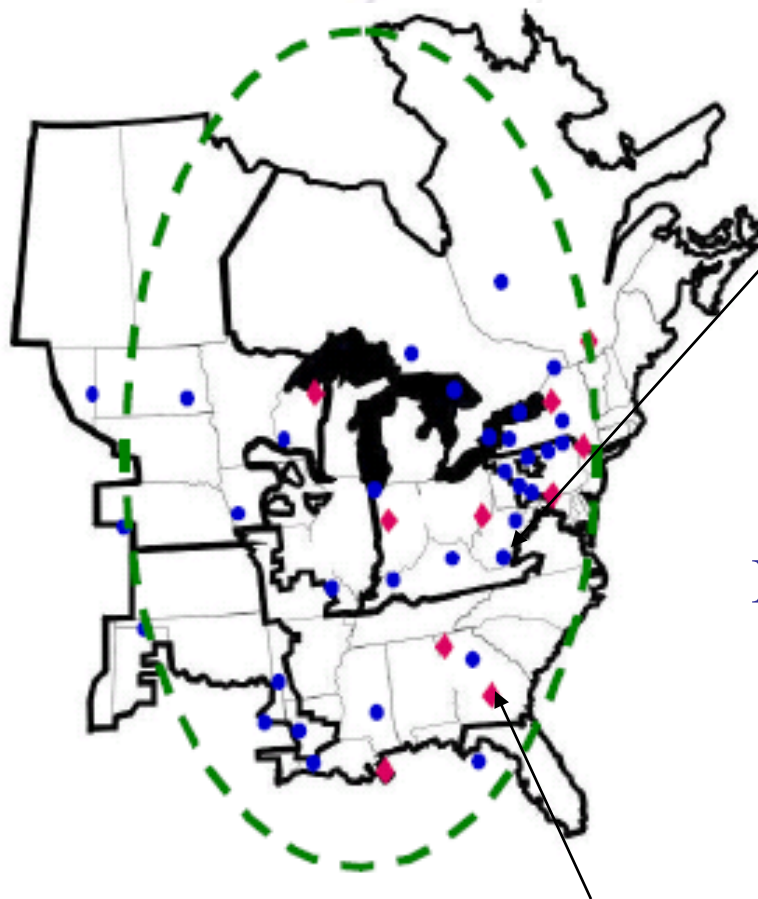
OSIsoft
Interfaces



PI-to-PI



PI solves: Sample Rate Issue



30 times a second

Time	20/sec	30/sec
------	--------	--------

x.033

m

x.05 n

?

Interpolation is needed.

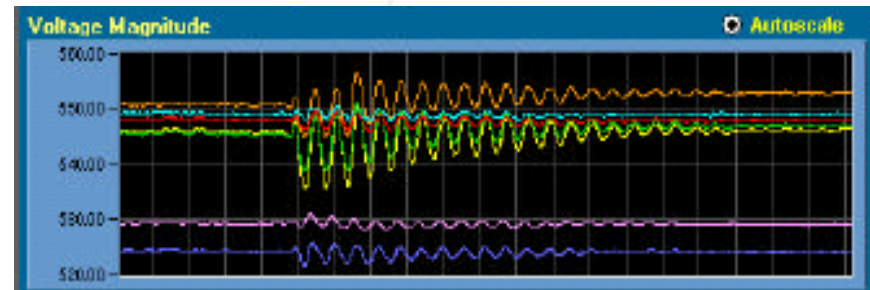
ServerSide or Application based?

Consistent analysis indicates
server side interpolation.

20 times a second

Possible Value Returned

- No Value
- Value from x.033
- Value from x.066
- A interpolated value



Most graphical systems
already interpolate.

Interpolation should be Storage Interface service.
Applications could augment.

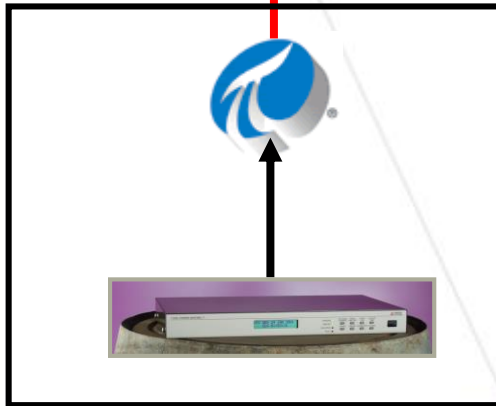
Loss of Data due to Comms?

Protection from Power outage
and days of communication outage



OPTION 1

PI-to-PI

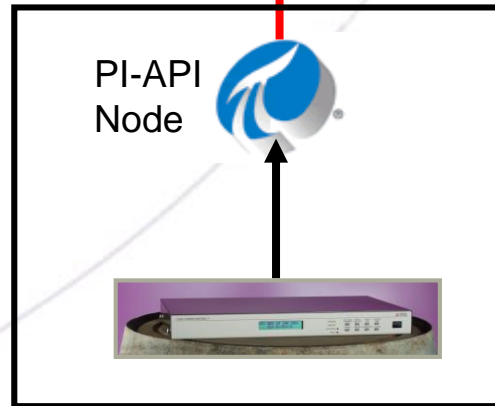


Protection from limited
communication outage



OPTION 2

PI-API
Node

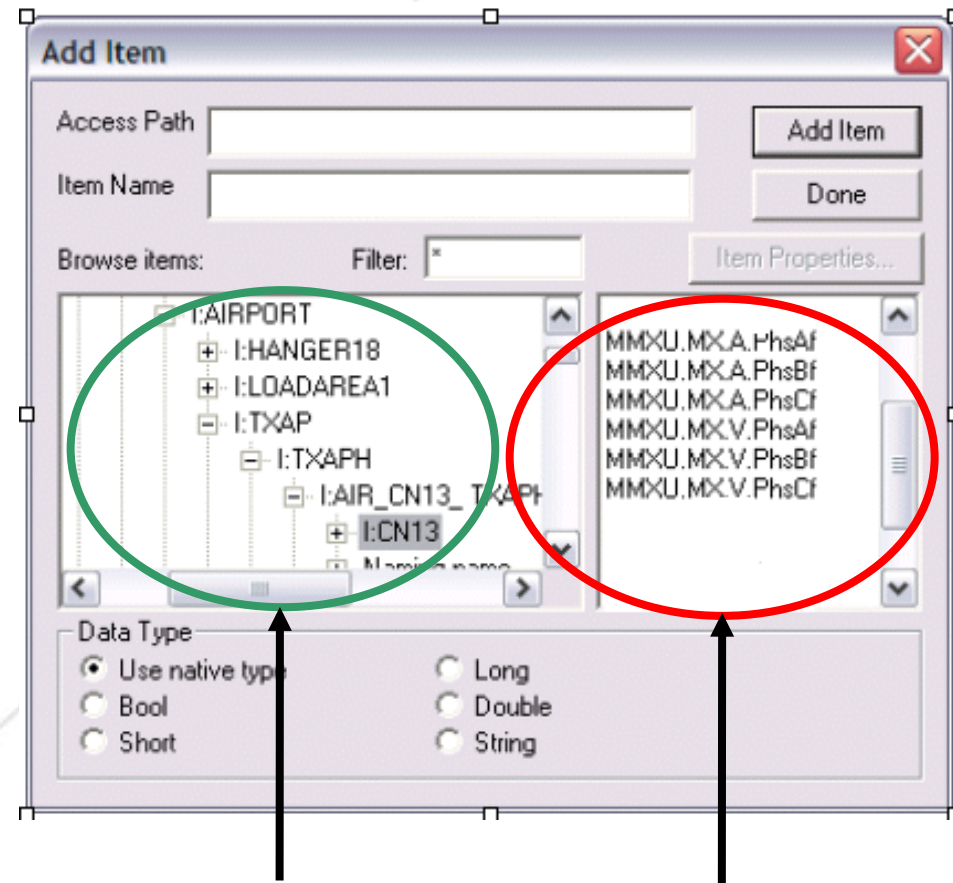


OPTION 1 also allows
for some analytics to
be executed at acquisition
site.

Answer: Distribute PI (SISCO GAP)

Power system knowledge?

- IEC 61970 defines standardized model (CIM)
- SISCO PI Adapter can impart CIM knowledge to Module Data Base and AF
 - Allows ACE, AF, and Processbook to reference model
 - Eases creation of analytics
- Exposes model through OSIsoft OPC Server that eases integration with other PDCs



CIM Namespace

PMU/Tag/IEC 61850
Naming

Have data, need information: Analytics

- State Estimation
- Stability Analysis
- Operator Information
- Portal
- Others...



State Estimation

$$v(\hat{P}_h) = \frac{n_h}{n_h - 1} \sum_{i=1}^{n_h} (Z_{hi} - \bar{Z}_h)^2$$

$$\text{where } Z_{hi} = \sum_{j=1}^{m_{hi}} Z_{hij} \text{ and } \bar{Z}_h = \sum_{i=1}^{n_h} \frac{1}{n_h} Z_{hi}$$

$$\text{and } Z_{hij} = \frac{w_{hij} y_{hij} - \hat{P}_h w_{hij} x_{hij}}{\hat{N}_h}$$

State
Estimation
Application

SCADA/EMS channels are not designed to handle 20 values/second for the same item.

SCADA/EMS channels are designed to handle one value/item every 1-2 seconds.

Means 97% of available PMU data would be discarded.

EMS
SCADA
System



20 values per
item/second

Data/Information is a terrible thing to waste!

Need another mechanism that preserves the PMU data.



State Estimation

$$v(\hat{P}_h) = \frac{n_h}{n_h - 1} \sum_{i=1}^{n_h} (Z_{hi} - \bar{Z}_h)^2$$

$$\text{where } Z_{hi} = \sum_{j=1}^{m_{hi}} Z_{hij} \text{ and } \bar{Z}_h = \sum_{i=1}^{n_h} \frac{1}{n_h} Z_{hi}$$

$$\text{and } Z_{hij} = \frac{w_{hij} y_{hij} - \hat{P}_h w_{hij} x_{hij}}{\hat{N}_h}$$

State
Estimation
Application

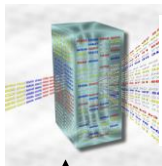
Selection of an appropriate PI interface allows PI to provide data to EMS/SCADA at an acceptable rate.

In the US, choice is typically IEC 60870-6 TASE.2 (ICCP)

EMS
SCADA
System



1 values per
item/second



Using PI and its interfaces allows preservation of 100% of the actual PMU data.

20 values per
item/second



Stability Analysis

- Purpose: Real-time detection of power system problems.
 - Frequency deviations from reference
 - Actual differences
 - Rate of change
 - Harmonic distribution of frequency shift
 - Area under FFT curve
 - Rate of change
 - Others...



Real-time stability analytics

- PI-ACE
- Custom

FFTs will be involved. SISCO and OSIsoft have worked to demonstrate “real-time” 4096 FFTs on PMU frequency data.

Means that the ability for distributed processing is key.



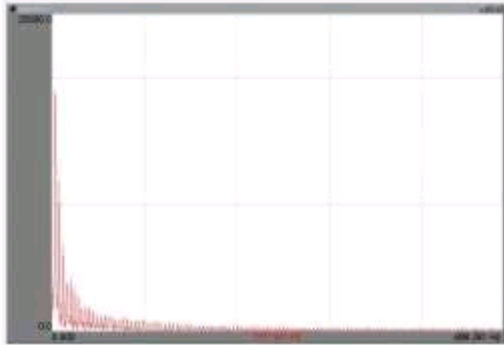
Operator information

- An art to be able to decide what to display
 - Information overload will frustrate operators
 - Information overload will delay operator response
- Deciding what to use for alarms is key
- Developing a procedure to use when an alarm happens is KEY.

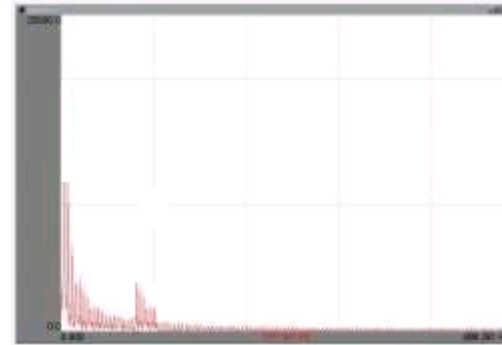


Possible simplifications

Good



Potential Problem



4096 FFT over 60Hz typically runs over 3 minute period



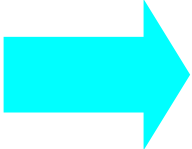
















Need to decide on alarm criteria

Need to alarm when criteria is reached

Need to decide on alarm criteria based upon time estimated to reach alarm criteria.

Waiting for the criteria to be reached may not leave enough time for operator intervention

Possible outcome in AF or PB

	Threshold	Time to reach threshold		Could be further simplified
State 1				
State 2				
State 3				
State 4				
State 5				
State 6				

Still might be too much for operators depending upon number of PMUs

Operators will need to be involved in deciding.

Similar mechanisms could be used by manufacturers to get advanced warning to put systems in a safe mode.

Portal

- Need ability to expose alarms and information to the appropriate people in the corporation.
 - RtPM/Rtportal



Summary

- PI technology allows some of the more difficult phasor measurement issues to be solved.
- Analytics are greatly enhanced through PI's server side analytical capability.
- Operator displays are still an “art”, but PB, AF, and RtPortal can handle the job.



Questions - Discussion



Thank You

Herbert Falk
SISCO, Inc.
6605 19½ Mile Road
Sterling Heights, MI 48314-1408 USA
Tel: +1-586-254-0020 x103
Fax: +1-586-254-0053
E-Mail: herb@sisconet.com

