Technical Workshop Emerging IT, Communications and Analytics Technologies

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Real world network issues with synchrophasor data availability, tips and tricks

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Contents

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Data Quality

1. The term “Data Quality”, what is it good for?
   - Too vague to be useful
2. What is important?
   - Accuracy
   - Availability

Problem overview

1. Synchrophasor communication failures between the PMUs that measure the values and applications that use the data are creating a gap in data availability to track Synchrophasor metrics. There is a need for ongoing support to maintain communications between the PMUs that monitor the Synchrophasors and ensure communications are online and data is available.
   - Measurement accuracy is determined entirely by the PMU Availability is determined by the communications network.
   - Without maintenance procedures and policies, the deployed infrastructure fails.
   - PDQTracker application tracks data availability to aid network and equipment troubleshooting.
   - Notification Systems and Support Groups are essential to maintaining Synchrophasor communication availability

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Determine the value of the Data

1. Work with the end users of the data to develop availability SLAs
   - Protection and Control
   - Situational awareness
   - Post event analysis
   - Baselining

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Phasor Measurement Unit Application Data Requirements

	PMU Measurement Parameters					Delay/Quality Parameters				Other Information		
Application	*Amplitude, Angle, or Frequency Precision (p.u., degrees, mHz)*	*Amplitude, Angle, or Frequency Accuracy (%, absolute values)*	*ROCOF (Hz/s)*	*Frequency Range (Hz)*	*Time Accuracy (μs)*	*Measurement Transfer Time (ms)*	*Message Rate (Reports/sec)*	*Time Window (sec)*	*Data Loss Sensitivity (Reports or ms)*	*Performance Class (M/P/X/N)*	*Tools /Platforms*	*Comments*
Small-Signal Stability Monitoring	0.5 degrees 0.01 Hz	TVE	STD	0.1 - 1.0 Hz	STD	50 ms	60 Reports/sec	600 seconds	10000 ms	M	EPG RTDMS, Allstom eTerra Vision	Even in real-time applications, small-signal stability often requires a long analysis window (unless event-based). Data drop outs can be tolerated and "burst data" packets can be handled by many algorithms.
Voltage Stability Monitoring/Assessment	0.01 p.u. mag 0.5 degrees	TVE	STD	0.1 - 10.0 Hz	STD	500 ms	30 Reports/sec	300 seconds	10000 ms	X	EPG RTDMS, Allstom eTerra Vision	Even in real-time applications,voltage stability often requires a long analysis window. Data drop outs can be tolerated and "burst data" packets can be handled by many algorithms.
Thermal Monitoring (Overload)	0.5 degrees 0.1 p.u. mag	TVE	STD	0 - 0.2 Hz	STD	1000 ms	1 Report/sec	300 seconds	30 Reports	X		Significant data drop outs can be tolerated and "burst data" packets can be handled by many algorithms. Thermal Monitoring (Overload) is primarily a function of fundamental frequency current and voltages.
Frequency Stability/Islanding	0.5 degrees 0.01 Hz	TVE	STD	1.0 - 30.0 Hz	STD	50 ms	60 Reports/sec	5 seconds	1 Report	P		
Remedial Action Schemes: Automatic Arming	0.01 p.u. mag 0.5 degrees 0.01 Hz	TVE	STD	0.02 - 30.0 Hz	STD	20 ms or 50-70 ms	1 Report/sec	300 seconds	1 Report	P		RAS Arming is a low latency, steady state phenomina. The response is based on the overal required timing of the RAS to protect the system from instability.
Remedial Action Schemes: Event Detection	0.01 p.u. mag 0.5 degrees 0.01 Hz	TVE	STD	0.02 - 30.0 Hz	STD	20 ms	60-120 Reports/sec	300 seconds	1 Report	P		RAS Event Detection is a low latency, low delay event. Typically it would use a report by exception rather than a polling mechanism. This is only included as a reference NOT a recommended method. RAS event action would be a command action.
Out of step protection	0.5 degrees 0.01 Hz	TVE	STD	5.0 - 30.0 Hz	STD	10 ms	60 Reports/sec	5 seconds	0 Reports	P		
Short-term stability control	0.01 p.u. mag 0.5 degrees 0.01 Hz	TVE	STD	0.5 - 30.0 Hz	STD	16 ms	60 Reports/sec	60 seconds	10 ms	P		
Long-term stability control	0.01 p.u. mag 0.5 degrees	TVE	STD	0 - 10.0 Hz	STD	1000 ms	30 Reports/sec	600 seconds	1000 ms	X		
FACTS feedback control, Smart switch-able networks	0.01 p.u. mag 0.5 degrees 0.01 Hz	TVE	STD	1.0 - 30.0 Hz	STD	16 ms	60 Reports/sec	300 seconds	50 ms	X		This is very dependent on the control application. Different objectives would lead to different data reauirements. Voltage Stability would be different the Subsychronus Resonance control.
State Estimation	0.5 degrees 0.01 Hz	TVE	STD	0 - 1.0 Hz	STD	1000 ms	5 Reports/sec	300 seconds	1000 ms	M		Assumes traditional static state estimation. Dynamic state estimation would obviously have more stringingent requirements
Disturbance Analysis Compliance	0.01 p.u. mag 0.5 degrees 0.01 Hz	TVE	STD	0 - 30.0 Hz	STD	1000 ms	60 Reports/sec	Length of event	100 ms	M		
Frequency Response Analysis	0.5 degrees 0.01 Hz	TVE	STD	0 - 1.0 Hz	STD	1000 ms	5 Reports/sec	300 seconds	25 Reports	M		
Model Validation	0.01 p.u. mag 0.5 degrees 0.01 Hz	TVE	STD	0 - 30.0 Hz	STD	1000 ms	60 Reports/sec	Time frame of model	1000 ms	M		
Phasor Network performance monitoring & data quality	N/A	TVE	STD	0 - 30.0 Hz	STD	Measured	60 Reports/sec	86400 seconds	60 Reports	X		General evaluation of the phasor communication network, including delays and drop out sensitivities. This application itself is insensitive to drop outs and delays (it is evaluating them), but the results may tie directly into other application requirements.
Baseline Normal Phase Angle Trends	0.5 degrees	TVE	STD	0 - 10.0 Hz	STD	1000 ms	15 Reports/sec	86400 seconds	150 Reports	M		
Pattern Recognition/Correlation Analysis	0.01 p.u. mag 0.5 degrees 0.01 Hz	TVE	STD	0 - 0.2 Hz	STD	1000 ms	1 Report/sec	3600 seconds	20 Reports	M		
Situational Awareness Dashboard	0.01 p.u. mag 0.5 degrees 0.01 Hz	TVE	STD	0 - 1.0 Hz	STD	100 ms	30 Reports/sec	300 seconds	10 Reports	M		The data displayed on a trend or visualization may only be updated at 5 times a second or so, but if it is a trend the data should be displayed at scan rate updated at the slower rate.
Real Time Compliance Monitoring with Reliability Standards	0.01 p.u. mag 0.5 degrees 0.01 Hz	TVE	STD	0 - 1.0 Hz	STD	1000 ms	5 Reports/sec	1800 seconds	10 Reports	M		Reports/Second could vary dependent upon the Reliablity standard in question
Real Time Performance Monitoring and Trending	0.01 p.u. mag 0.5 degrees 0.01 Hz	TVE	STD	0 - 0.2 Hz	STD	1000 ms	1 Report/sec	3600 seconds	30 Reports	X		Not sure what this one means. Are you refering to the Electrical system or the data collection system. Different information would be needed for the different systems.
Anomaly Characterization and Alarming	0.01 p.u. mag 0.5 degrees 0.01 Hz	TVE	STD	1.0 - 30.0 Hz	STD	100 ms	60 Reports/sec	3600 seconds	120 Reports	M		

Notifications

1. The more specific the better
   - Generic reports sent every day are soon ignored
   - Reports need to highlight problem areas
   - Avoid nuisance information

Information at a glance

1. Avoid sorting a report by PMU name
   - Sort by error condition
2. Dashboards give status at a glance
   - Something to indicate warnings
   - Need to show history
3. Automated detailed analysis helps the network engineers
   - Use the synchrophasor timestamp to help isolate issues

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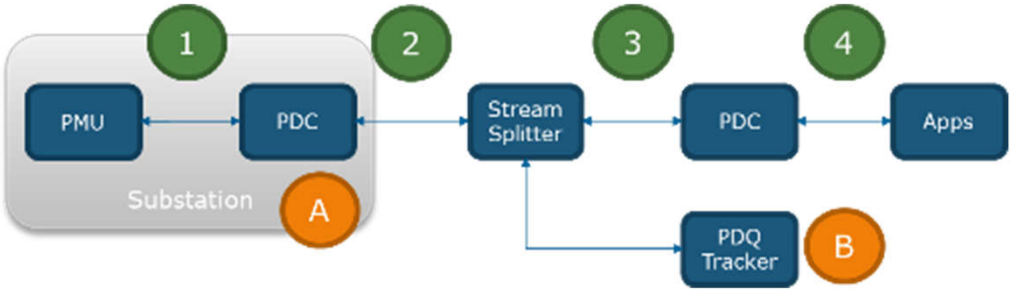
Understand your architecture



The PDC "hides" data availability problems

- Availability issues at location 1 appear as data errors at location 2
- Availability issues at location 2 are unchanged at location 3 but appear as data errors at location 4
- Availability issues at location 2 cause all the PMUs reporting to PDC A to have the same availability issues as seen by PDC B or the PDQTracker.

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Clarify your terminology

1. Don’t use the term Packet when you mean Data Frame
   - The term packet means a low level formatted unit of data on the network, it is not a C37.118 or 61850-90-5 data frame
2. Invalid Data Flag
   - Invalid Data flag as part of the C37.118 spec means nothing to the network engineer, understand how that flag gets set and what it means
3. Time Error
   - Some PDCs will set the time error bit when data does not arrive in time window
4. Data does not arrive late

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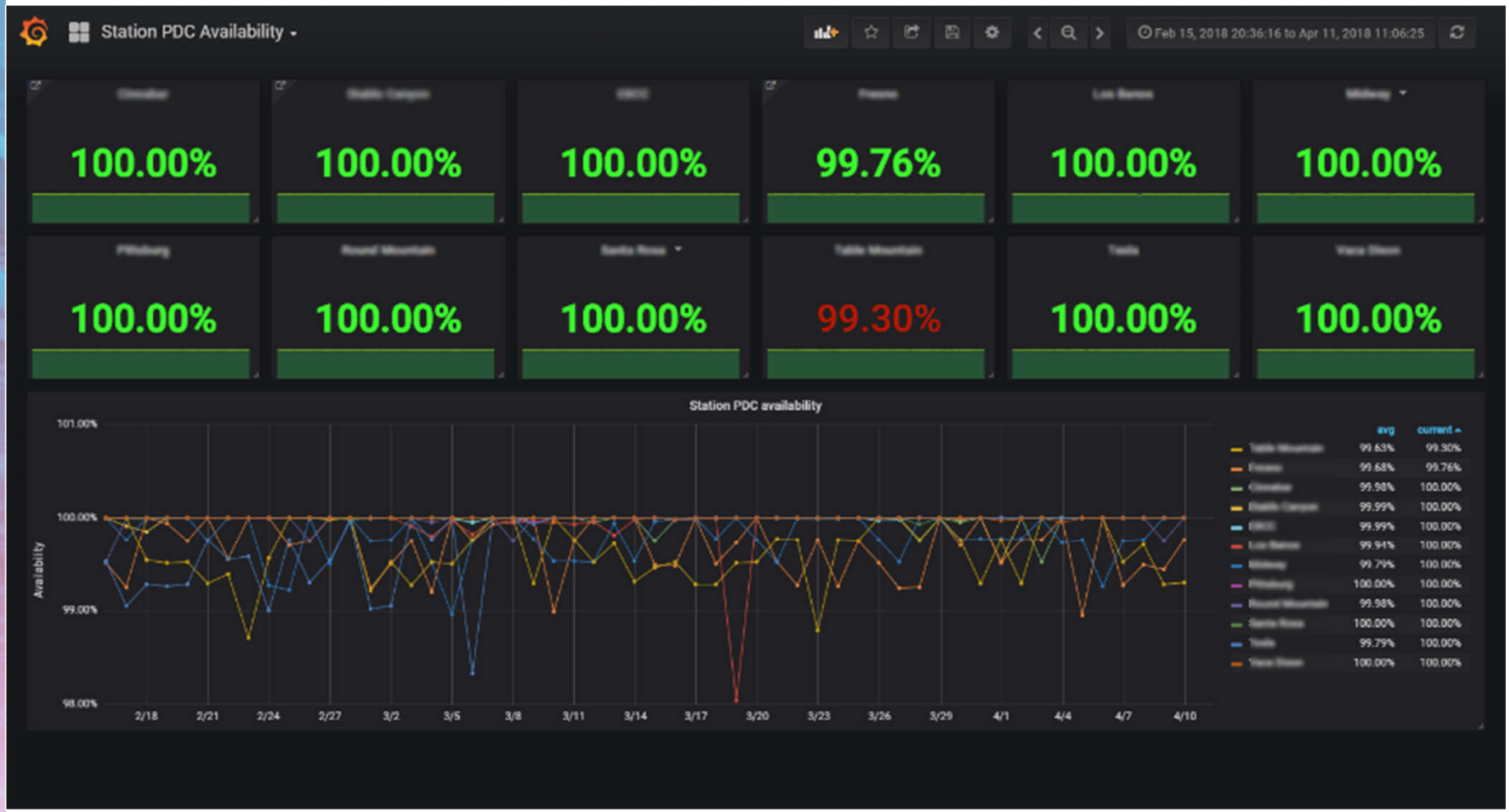
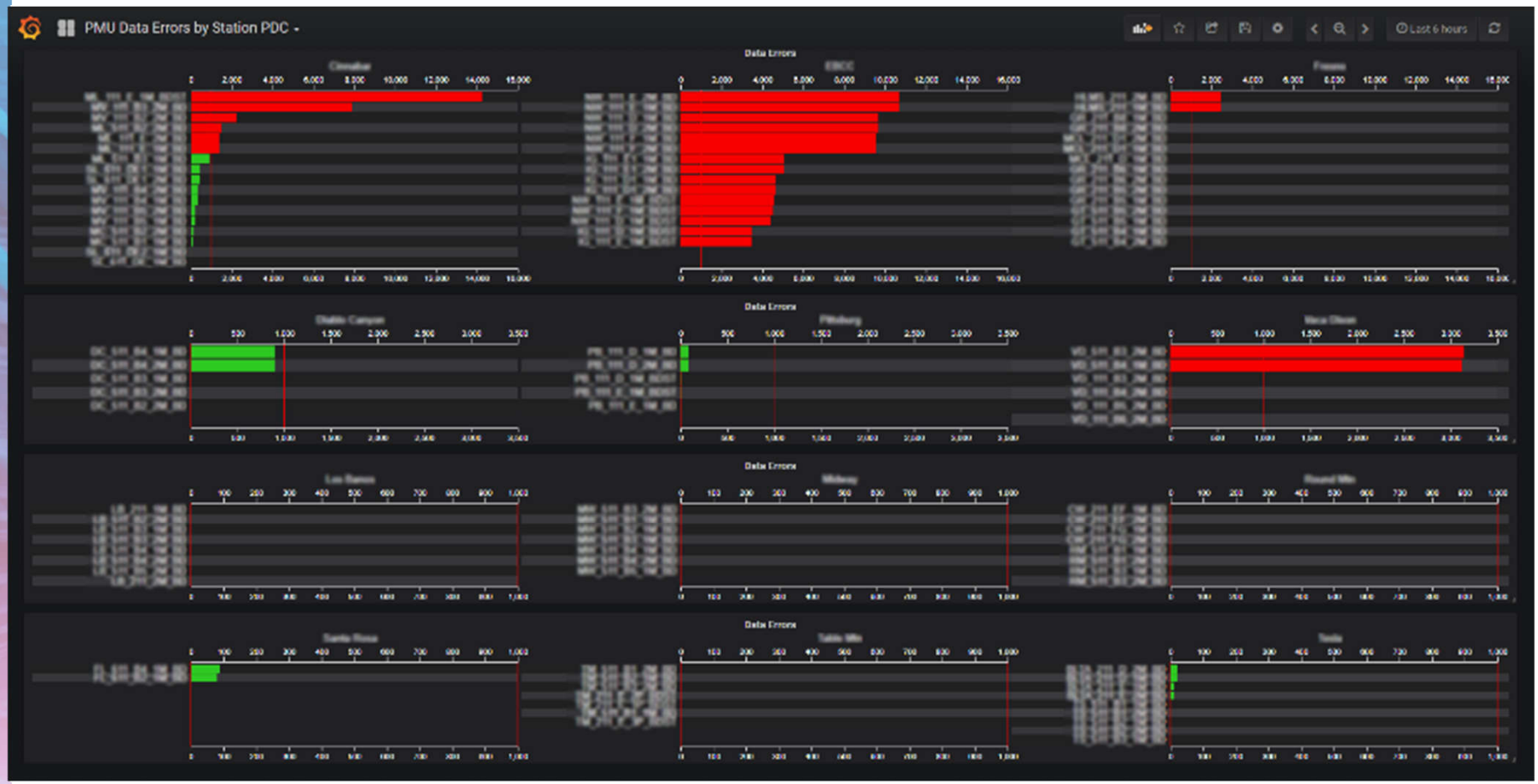

Station PDC Availability
Feb 15, 2018 20:36:16 to Apr 11, 2018 11:06:25
100.00%
100.00%
100.00%
99.76%
100.00%
100.00%
100.00%
100.00%
100.00%
99.30%
100.00%
100.00%
Station PDC availability
Availability
101.00%
100.00%
99.00%
98.00%
2/18
2/21
2/24
2/27
3/2
3/5
3/8
3/11
3/14
3/17
3/20
3/23
3/26
3/29
4/1
4/4
4/7
4/10
avg
current

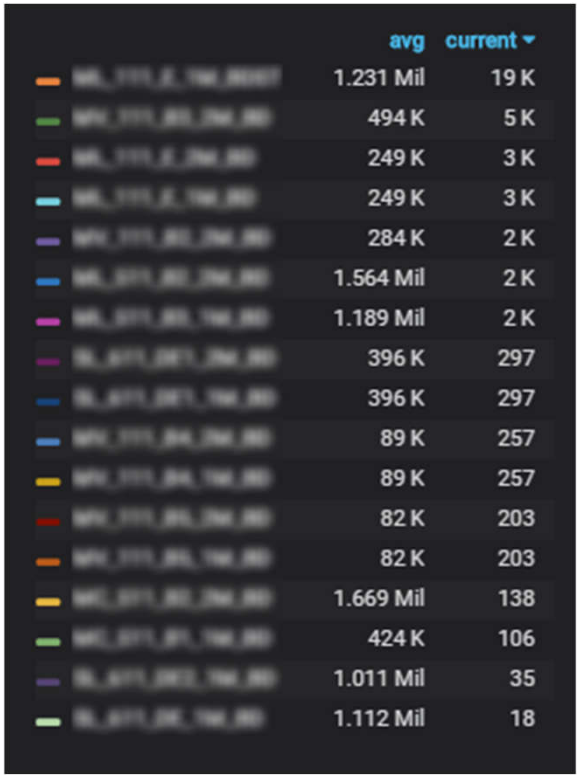

B Side Data Errors
Feb 13, 2018 10:12:14 to a few seconds ago
Data Errors
2/15
2/22
3/1
3/8
3/16
3/24
4/1
4/8
4/16

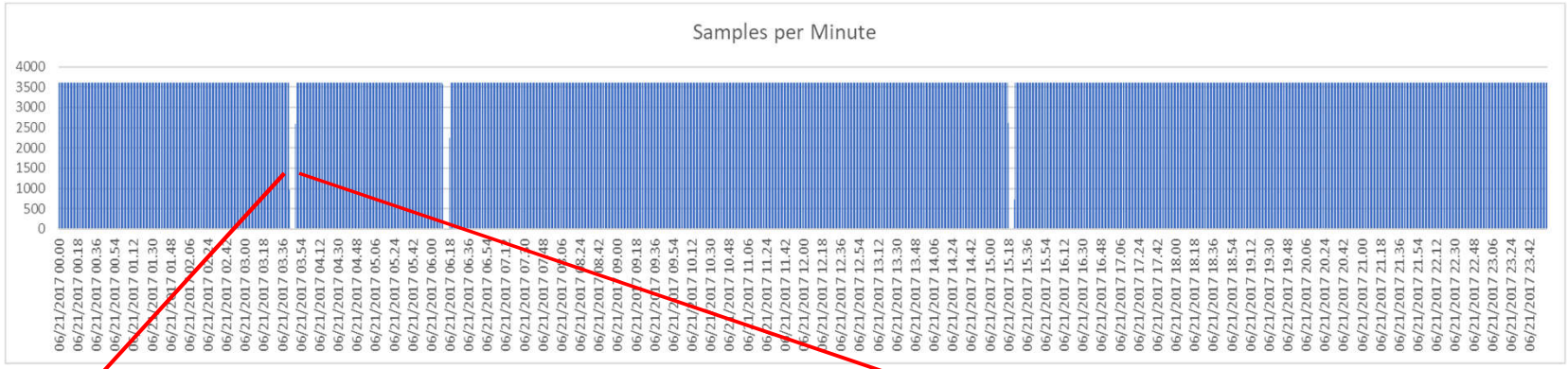

B Side Data Errors
Feb 13, 2018 10:12:14 to a few seconds ago
Data Errors
4.5 Mil
4.0 Mil
3.5 Mil
3.0 Mil
2.5 Mil
2.0 Mil
1.5 Mil
1.0 Mil
500 K
0
2/16
2/19
2/22
2/25
2/28
3/3
3/6
3/9
3/12
3/15
3/18
3/21
3/24
3/27
3/30
4/2
4/5
4/8
4/11
4/14
what happened here?

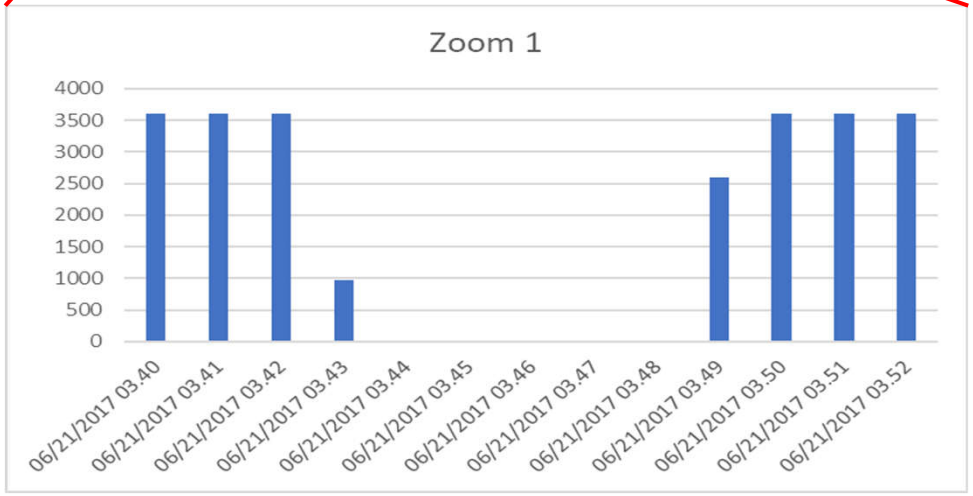

B Side Data Errors
Feb 13, 2018 10:12:14 to a few seconds ago
Data Errors
4.5 Mil
4.0 Mil
3.5 Mil
3.0 Mil
2.5 Mil
2.0 Mil
1.5 Mil
1.0 Mil
500 K
0
2/16
2/19
2/22
2/25
2/28
3/3
3/6
3/9
3/12
3/15
3/18
3/21
3/24
3/27
3/30
4/2
4/5
4/8
4/11
4/14
avg
current
1.231 Mil 19 K
494 K 5 K
249 K 3 K
249 K 3 K
284 K 2 K
1.564 Mil 2 K
1.189 Mil 2 K
396 K 297
396 K 297
89 K 257
89 K 257
82 K 203
82 K 203
1.669 Mil 138
424 K 106
1.011 Mil 35
1.112 Mil 18
add new information


PMU Data Errors by Station PDC
Last 6 hours
Data Errors
Data Errors
Data Errors
Data Errors

Simple additional details make the dashboard more informative



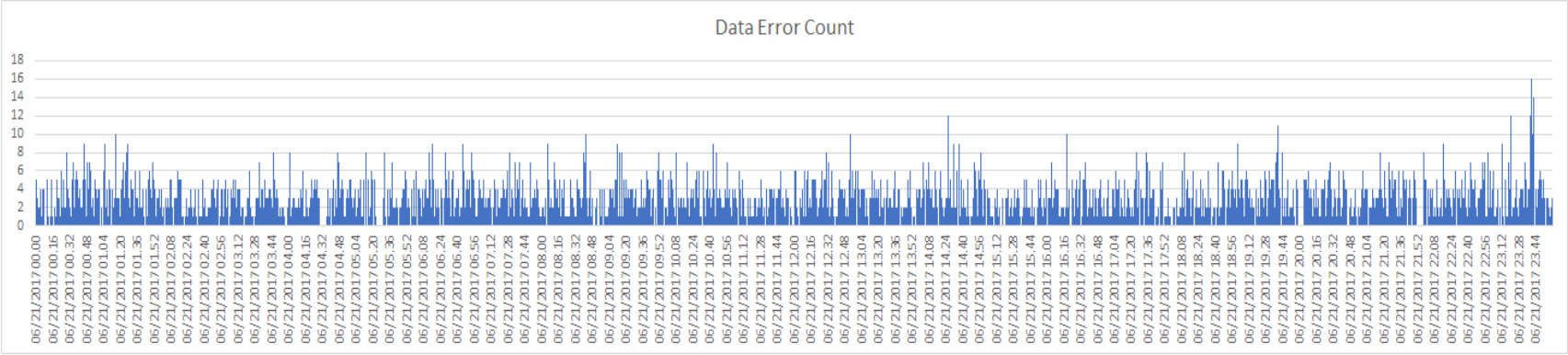




- Counting how many samples arrive every minute can help trouble shooting
- In this case it could indicate router issues or some timed process overloading the network

Data Dropouts

PMU to PDC communication errors as seen on the output of the PDC



Spread out over entire day (4407 data errors)

Questions?

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