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Grid Analytics to Enhance Feeder Performance

Leveraging grid data for real-time operational intelligence and enhanced situational awareness

Abstract

- With the advent of smart grid and proliferation of networked sensors and Intelligent Electronic Devices (IEDs) throughout the T&D system, grid data become abundant. The abundance of raw data provides unprecedented opportunities to fulfill the promise of smart grids but at the same time poses significant challenges in the midst of rising data volumes across various levels of the grid control hierarchy. To achieve a resilient and self-healing grid of the 21st century, the data must be converted to actionable information at all levels through the application of analytics.
- This presentation focuses on the grid side of the utility analytics and presents the process by which analytics are applied to substation IED data to enhance feeder performance and situational awareness in a cost-effective manner. Real world scenarios and use cases will be presented along with a review of end-to-end automation system requirements to deliver the value in incorporating grid analytics in real-time operations.

Outline

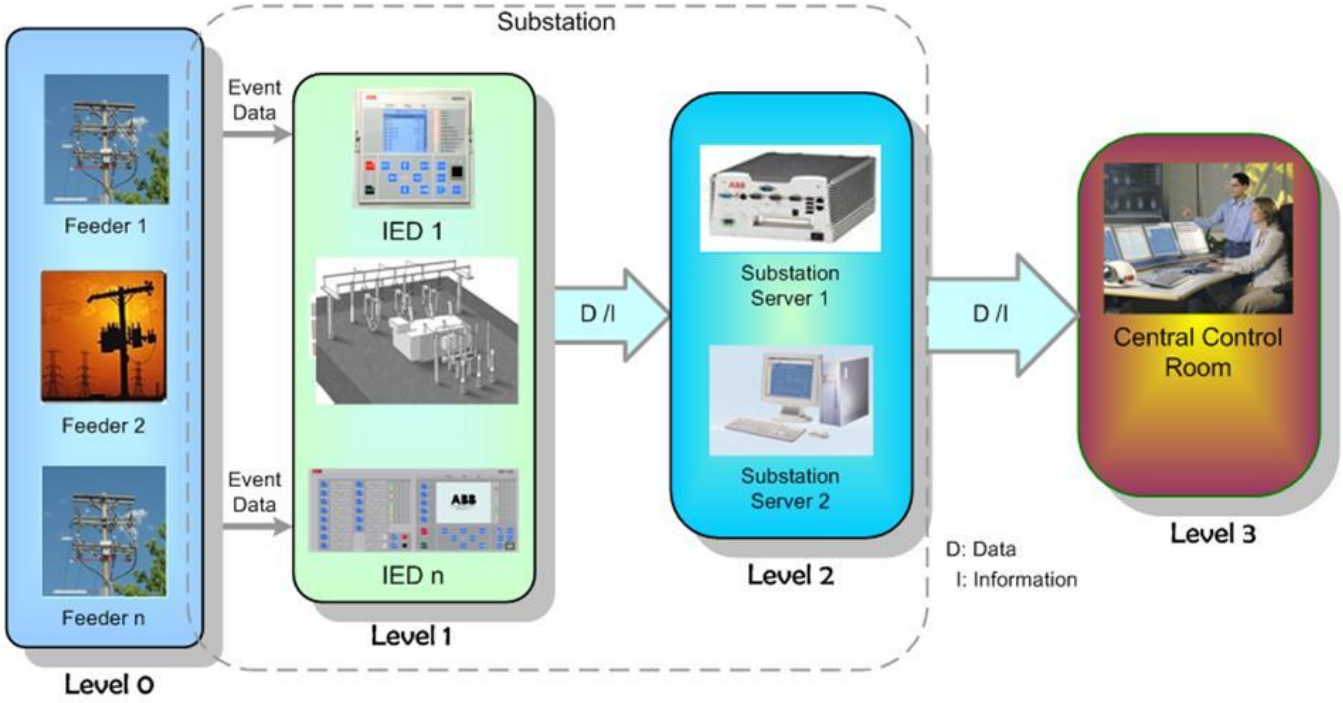
- Grid Analytics: why and why now
- Methodology
- Use Cases
- Take Aways

Analytics
”The science of data analysis”

- Not a brand new process/concept but a new emphasis in power systems with the advent of smart grids as data quantity, variety, and velocity challenges start to materialize.
- Already a norm in the business world for decision support e.g. in risk management
- Utility Analytics
  - **Grid Analytics**
    - data-driven recommendations and conclusions that benefit grid reliability, efficiency, performance, and sustainability.
    - could be in real-time for operations or off-line (data mining) for planning, maintenance, etc.
  - **Customer Analytics**: knowledge and insights that empower consumers to make informed energy decisions e.g. participate in demand response
  - Other Analytics: used in business decision support systems e.g. business intelligence (BI)
- Here the focus is on Grid Analytics for real-time operations

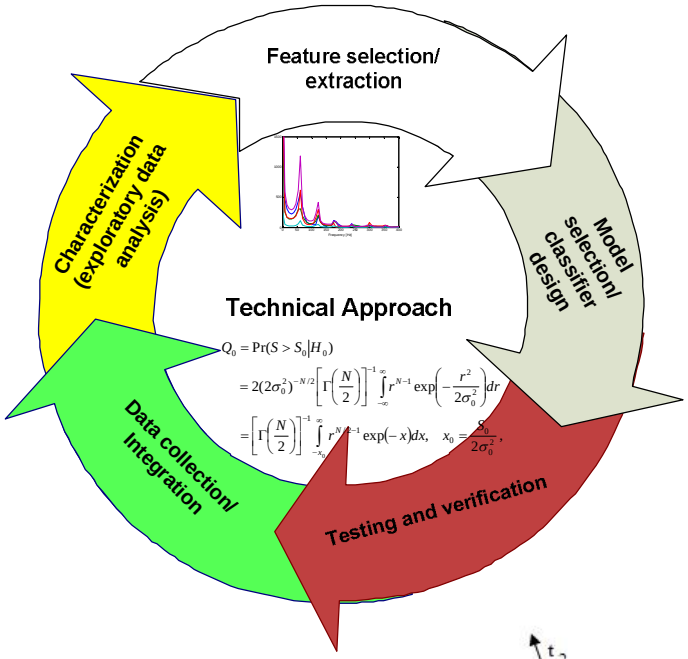
Grid Analytics (GA)
Sources of Data

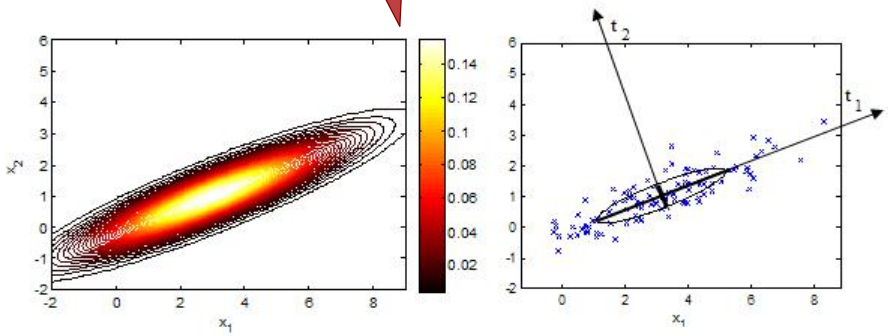
- Data streams from source to socket: PMUs on the HV grid, AMI/AMR on the LV circuits, and IEDs/Sensors everywhere in between
- Data to information/intelligence conversion through analytics takes place in every level of the control hierarchy.



Predictive Grid Analytics (PGA)
Technical Approach

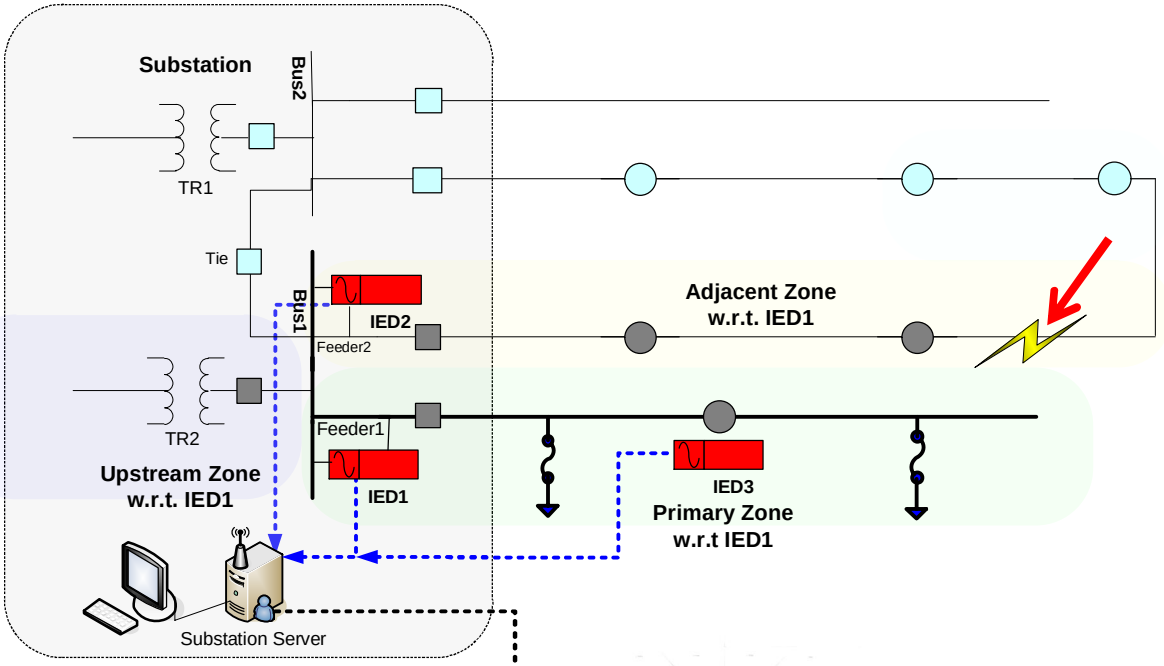
- Predictive Analytics: analyzing current and historical facts to make predictions about future events (used for forecasting/classification)
- Draws upon statistical decision theory, pattern analysis, and signal processing techniques, bridging the disciplines of computer science, statistics, and mathematics.
- Challenges are in the design of algorithms, data modeling, and discovering a few informative properties of data while optimizing for dimensionality (# of features)
- The process may involve all or some elements of a 5-step cyclical model to the right
- A trade-off exists between accuracy and complexity →leading to an optimized solution that must also meet the hardware (host platform) requirements.





Predictive Grid Analytics (PGA)

Enhancing outage management and situational awareness

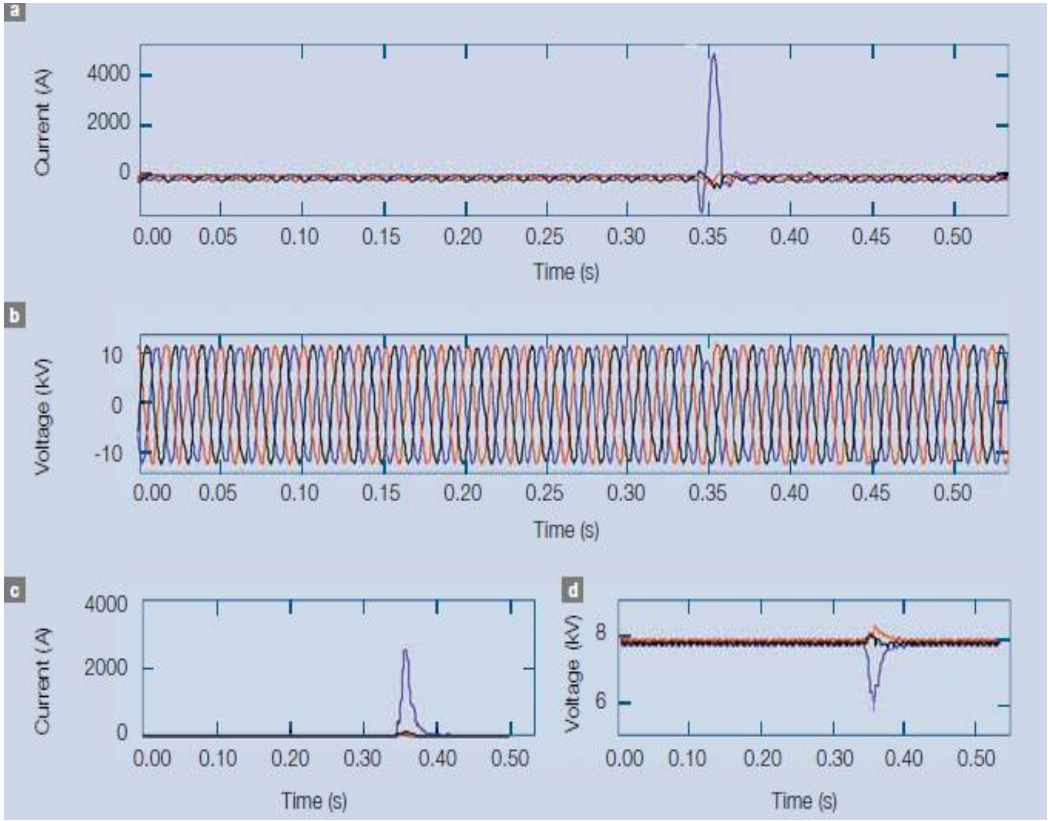


Network Operations and Control Center

- Primary value: Knowledge
- Event X-rays → Event MRI
- Dispatchers will know what they didn't previously know when a feeder fault/abnormality occurs that is either self-clearing, incipient, or are cleared by a non-communicative device, e.g., reclosers or switches, or unintelligent device, e.g., fuse
- Knowing beforehand assists utility in reducing "D"uration
- Will know substation, feeder, phase, magnitude, type, zone, date, and time information
- Able to detect 24/7/365 momentary, incipient, and permanent faults on overhead and underground lines
- Do it all from inside the substation taking advantage of the data infrastructure already in place and potentially reducing or eliminating feeder sensor installations

PGA Use Cases (1/3)
Feeder Performance

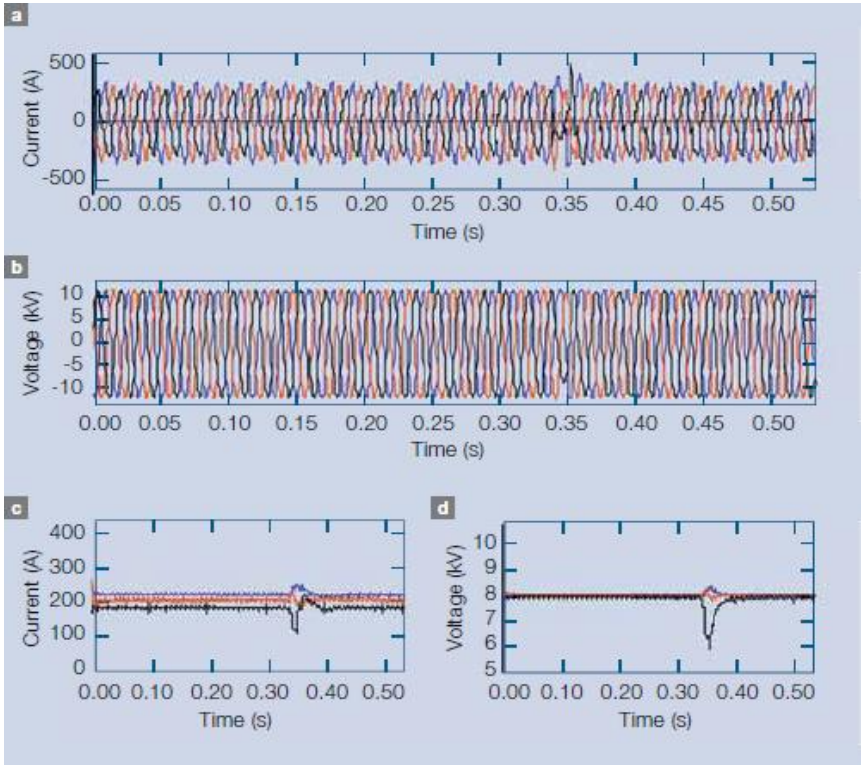
- **Situational Awareness and outage management**
- A “permanent” fault cleared by a 40A fuse
- Without PGA at-work
  - Everything “seems” to be just fine unless someone calls or AMI report is received.
  - Invisible in SCADA
  - No AMI/outage report for momentary, self-clearing or incipient faults, the majority class in OH lines
- With PGA, know and notify within seconds…
  - What/When/Where/How
  - Date/time/zone information
  - Phase(s) Impacted/event classification
  - Impact assessment/priority ranking



Current a and voltage b waveforms and the corresponding current c and voltage d phasor-magnitude plots

PGA Use Cases (2/3)
Feeder Performance

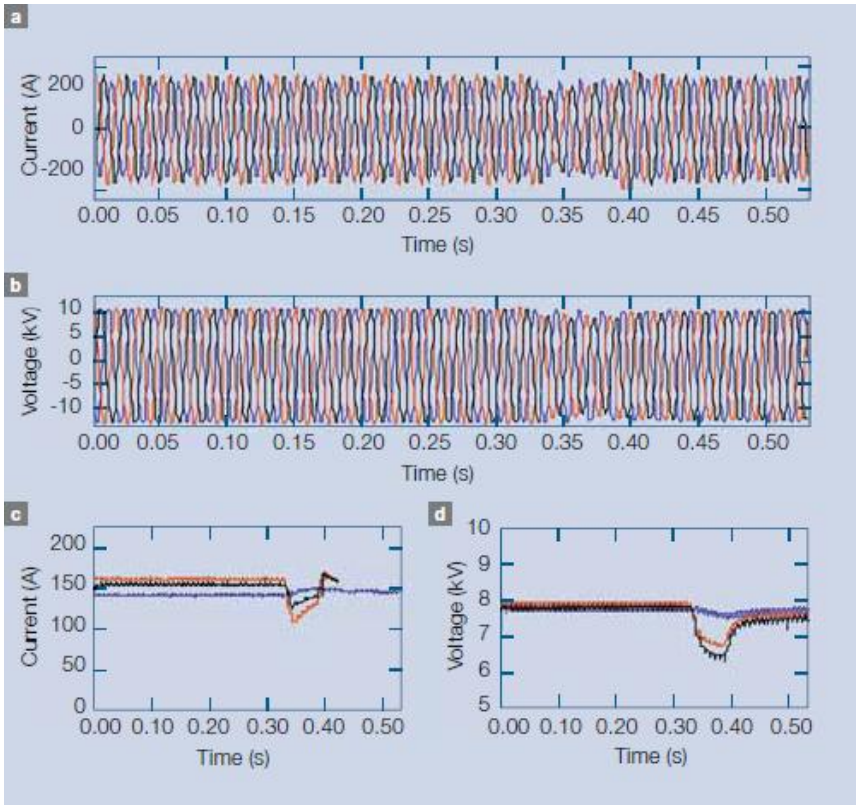
- **Impact analysis and monitoring of events on adjacent feeders**
- A “self-clearing” cable fault on an adjacent feeder on the same bank
- Voltage sags across the bank including the feeder provisioned with PGA
- Without PGA
  - Everything would “seem” to be just fine including the faulted feeder!
- With PGA, the “bonus” insight is there…
- Opportunities for asset optimization and health-check



Current a and voltage b waveforms and the corresponding current c and voltage d phasor-magnitude plots

PGA Use Cases (3/3)
Feeder Performance

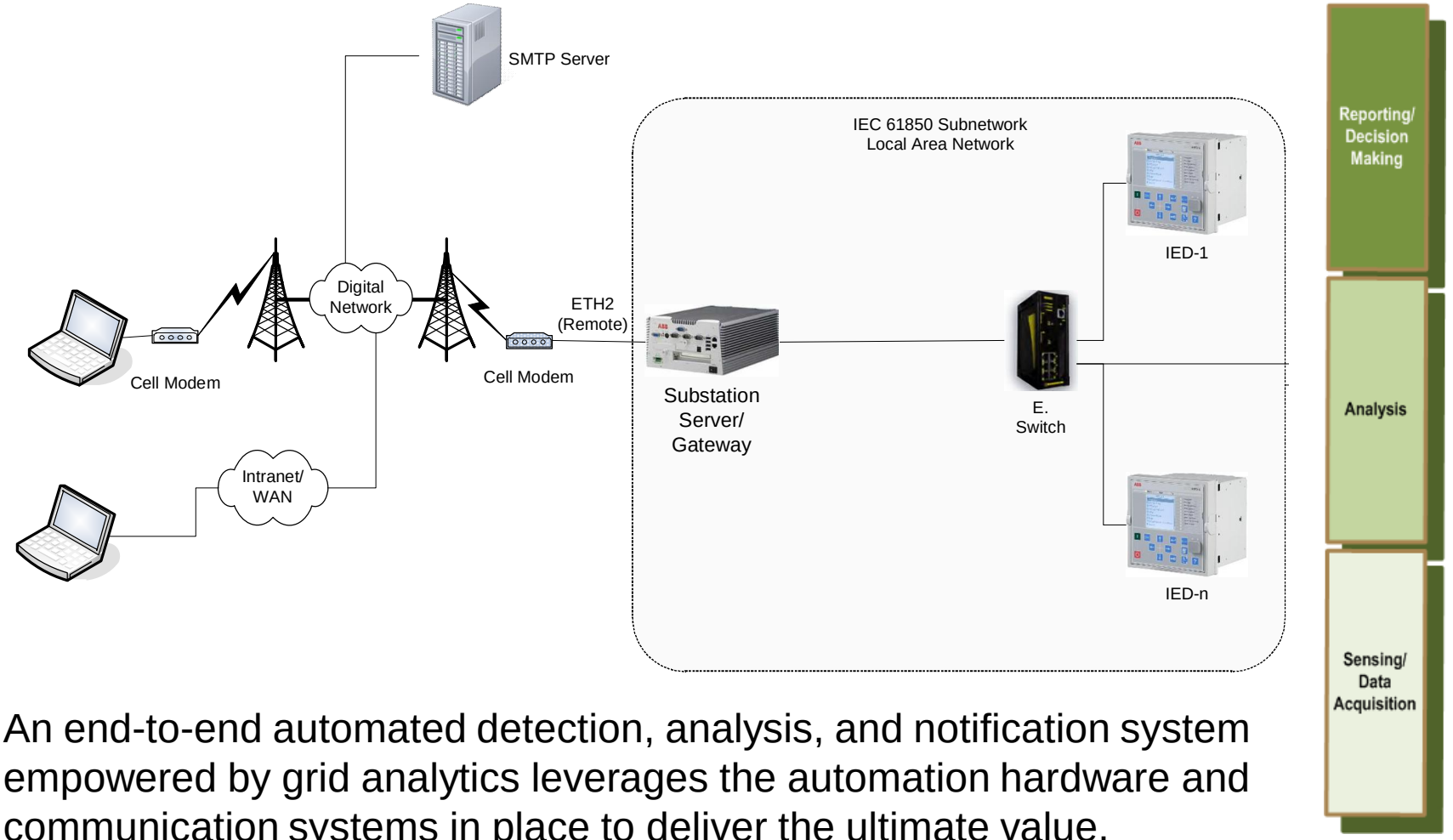
- **Indirect analysis and monitoring of transmission events**
- A Trip and Reclose (T&R) at the transmission level
- Voltage sags across the system including the MV feeder
  - Customer complaints
  - PQ issues
- Without PGA
  - Dismiss the case
  - Always blame others!
  - Resort to expensive investigations
- With PGA, the insight is there…



Current a and voltage b waveforms and the corresponding current c and voltage d phasor-magnitude plots

Grid Analytics Solution

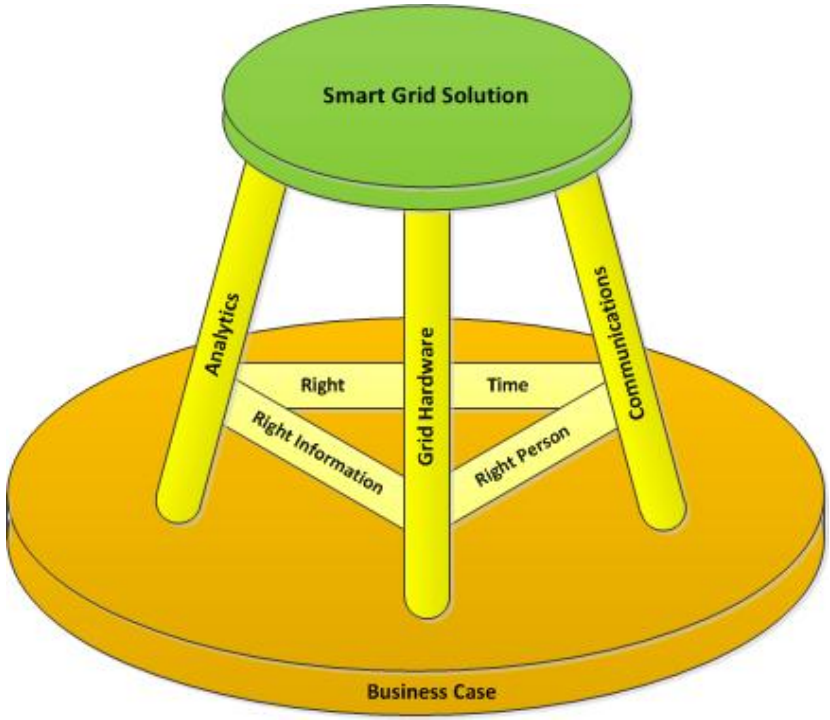
End-to-End System Requirements



- An end-to-end automated detection, analysis, and notification system empowered by grid analytics leverages the automation hardware and communication systems in place to deliver the ultimate value.

Remarks
Take Aways

- A successful analytics solution sits on the foundation of a solid business case with three supporting legs: analytics, communications, and grid automation hardware.
- Weaken the foundation or any of the legs and the solution starts to fail.
- Grid analytics solutions
  - Automated and real-time (as needed)
  - Able to bridge information silos
  - Important ingredient but not necessarily all that's needed to deliver the value
- A right step towards enabling the "auto-pilot" mode in the self-healing grids of the future



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Contacts

- Further reading:

  M. Mousavi, V. Donde, J. Stoupis, J. McGowan, and L. Tang, "*Information not data: real-time automated distribution event detection and notification for grid control*", ABB Review Journal, issue 3, 2009, pp. 38-44.

- Technical Questions:

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Glossary of Acronyms

Acronym	Description
GA	Grid Analytics
PGA	Predictive Grid Analytics
IED	Intelligent Electronic Device
PMU	Phasor Measurement Unit
AMI	Advanced Metering Infrastructure
AMR	Automatic Meter Reading
BI	Business Intelligence
MRI	Magnetic Resonance Imaging
HV/LV	High Voltage/Low Voltage