Intelligent PMU

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from Data to Action

Premium Information Services

GRT

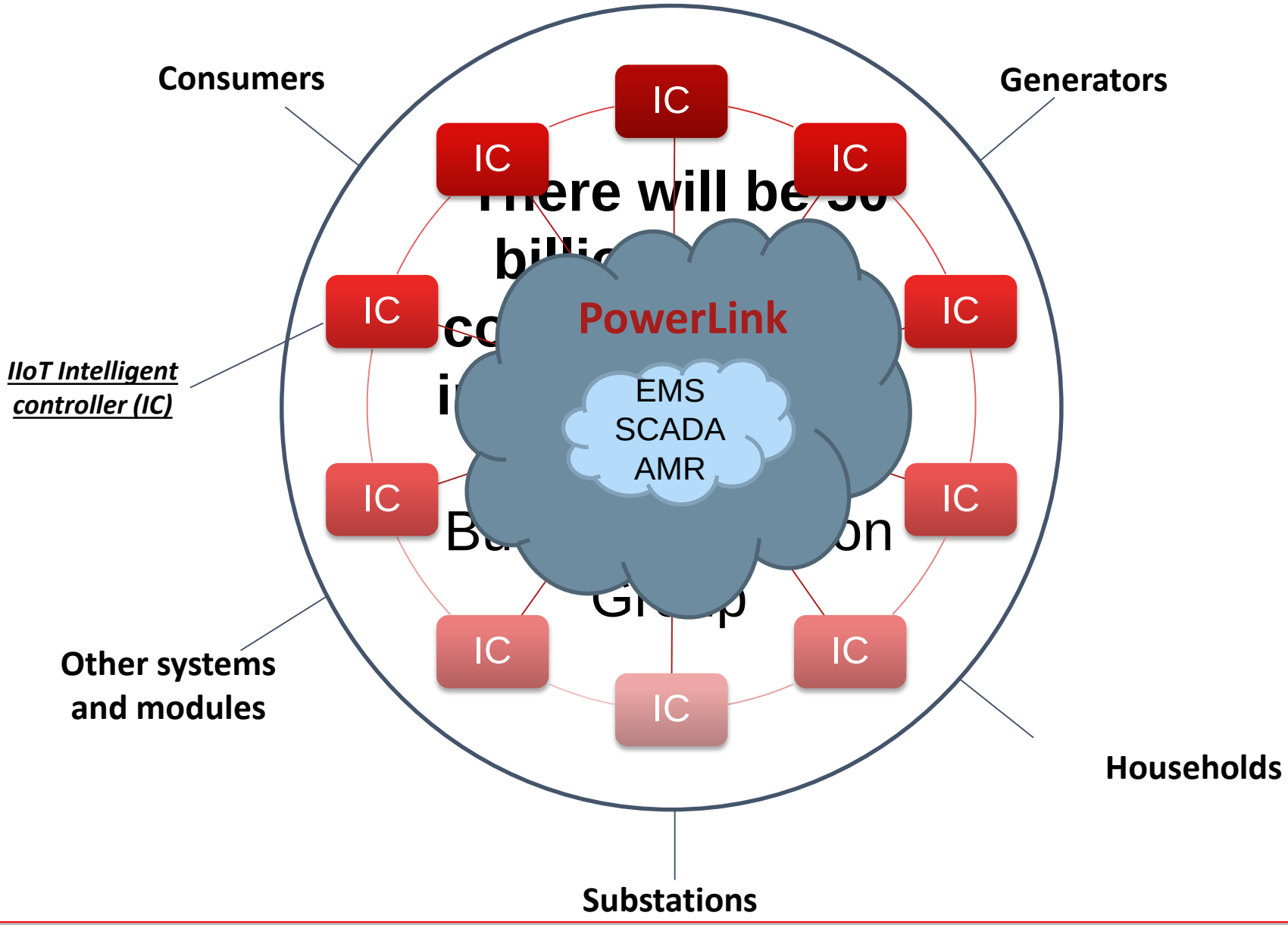
from Data to Action

Design, Develop and Deploy - digital transformation solutions for an Interconnected World.

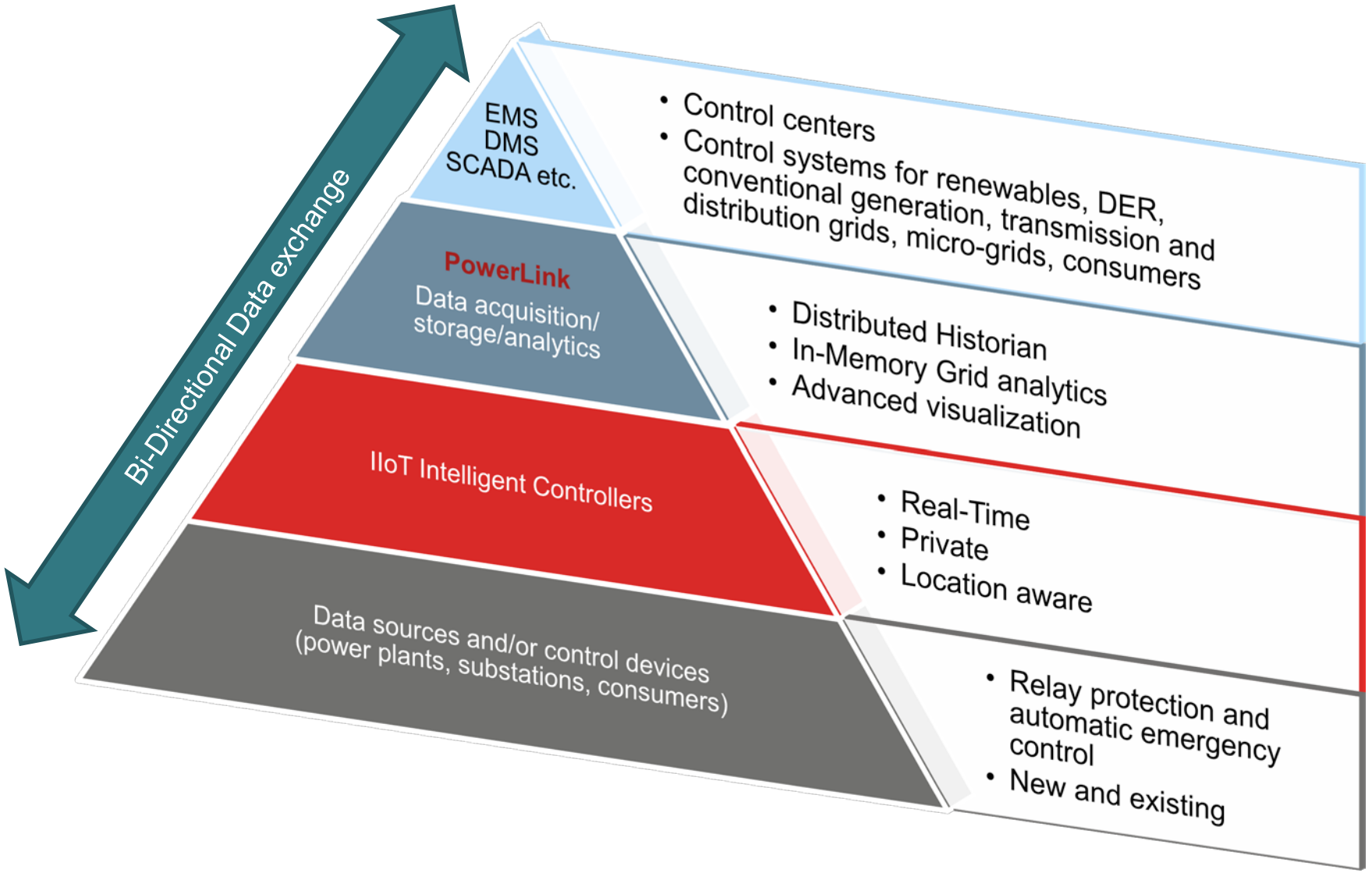
- Power system and industrial automation
- Business Analytics, Data Warehousing and Big Data
- Information Security and Compliance

GRT Sample Clients

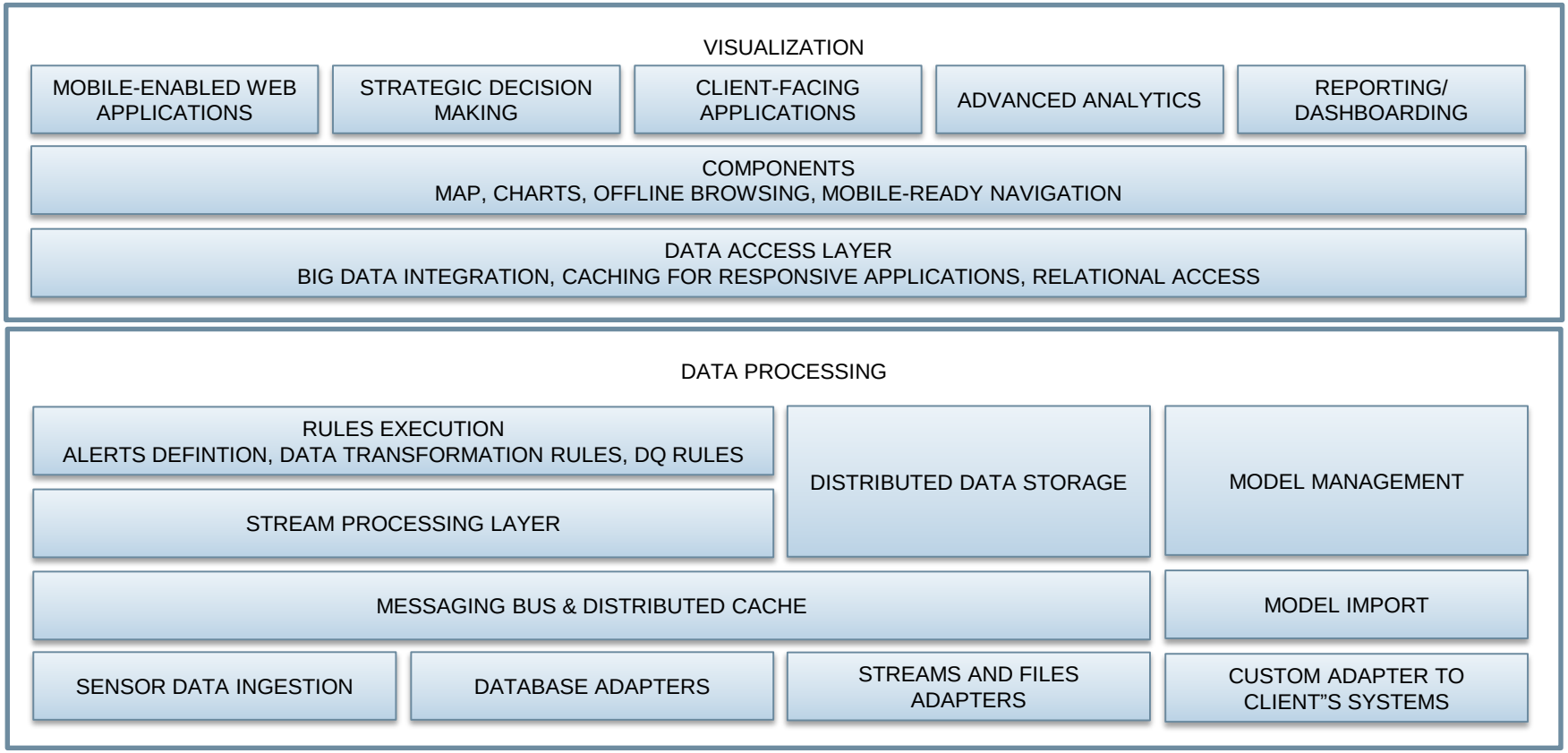
Edge Computing Paradigm



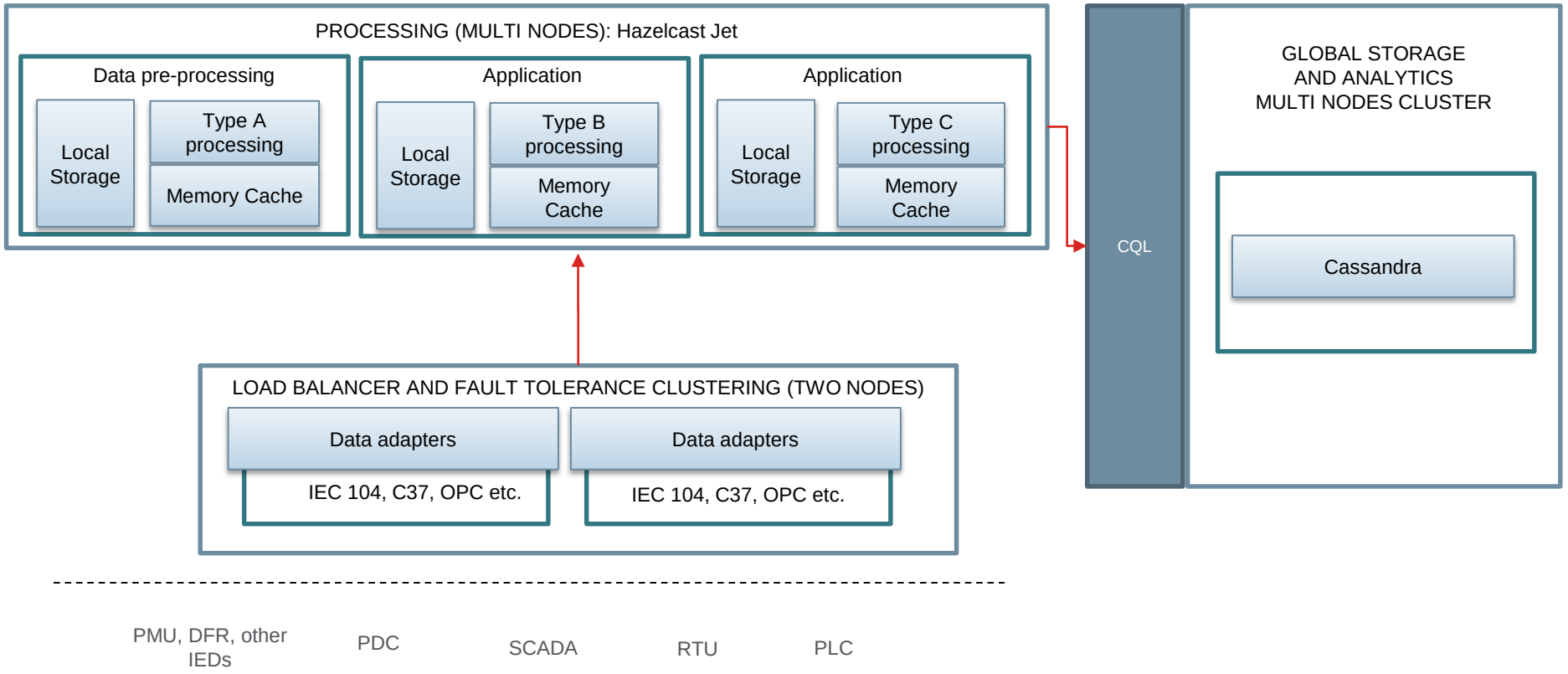
From Consumer to Control Center



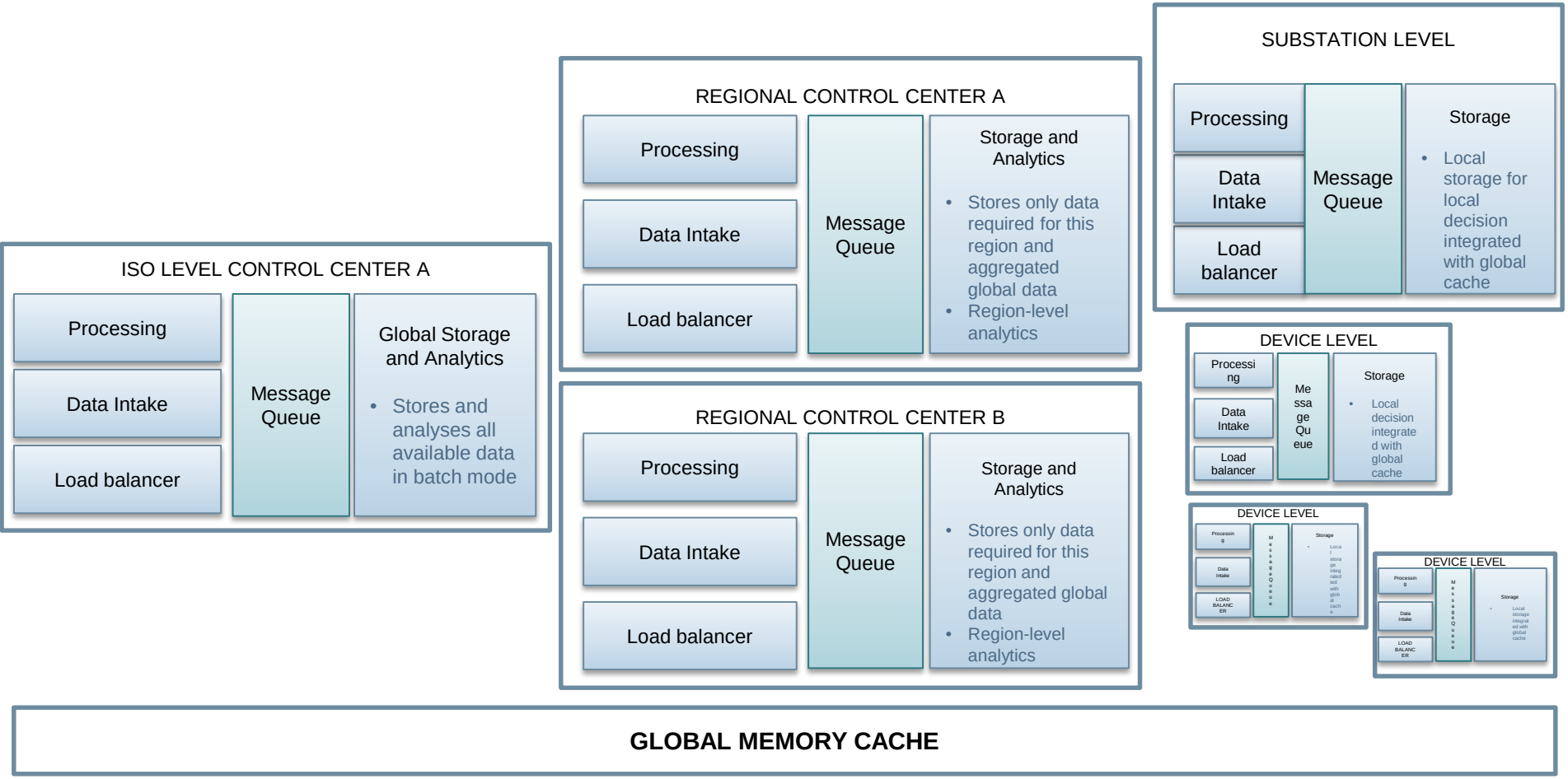
PowerLink – Logical Architecture



PowerLink – Node Structure



PowerLink – Distributed Multi-node



- Using new techniques of data exchange, optimized data flows
- Combining **JSON API (web-services), MQZero messaging middleware and Hazelcast in-memory-grid** for online and off-line data exchange between the network nodes

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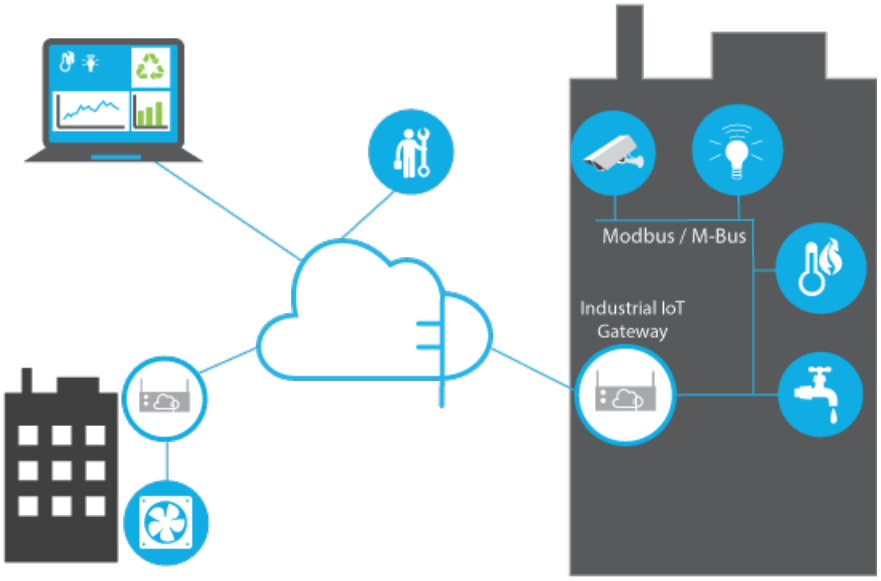
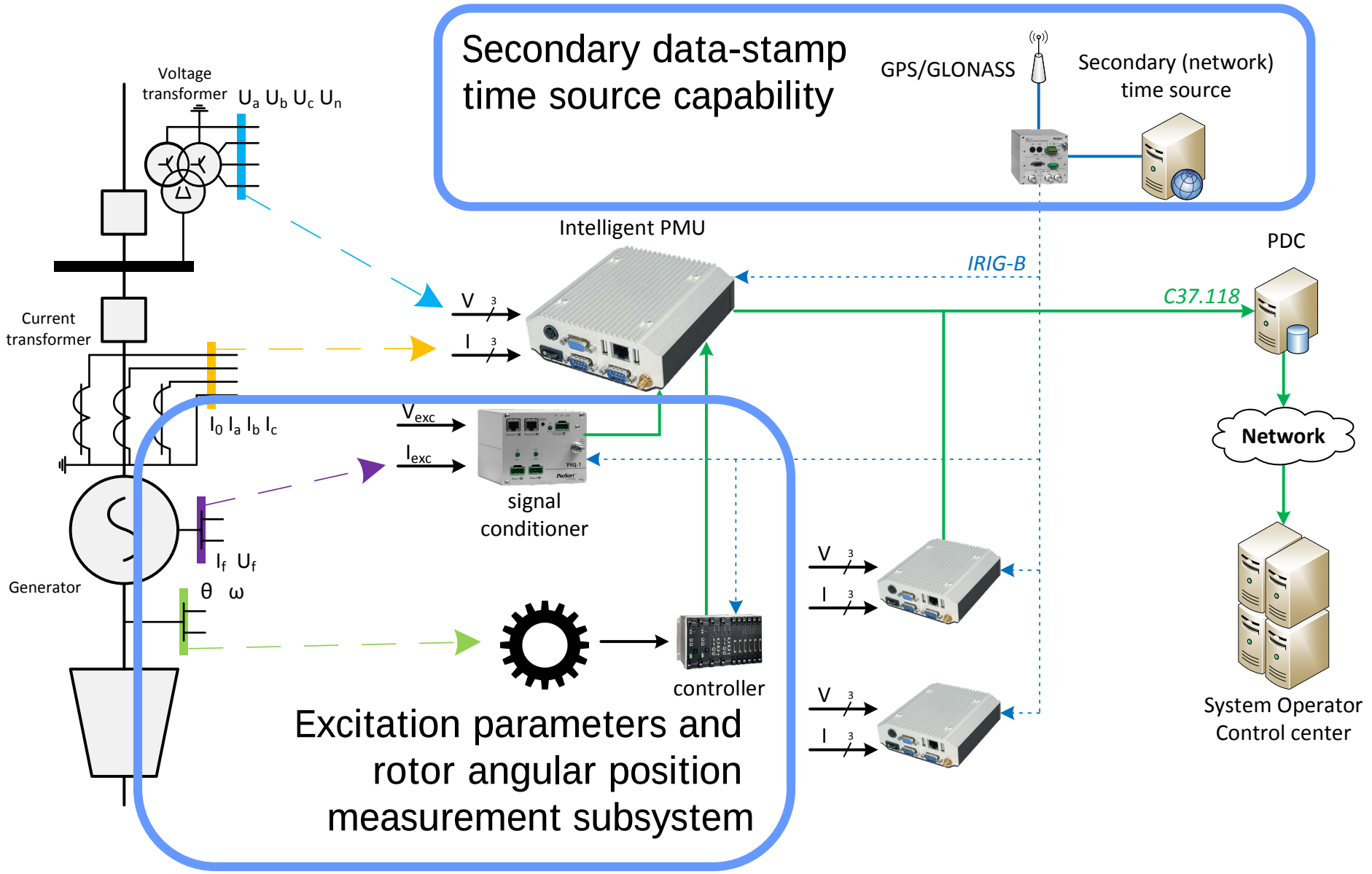
Intelligent PMU based on IIoT Intelligent Controller

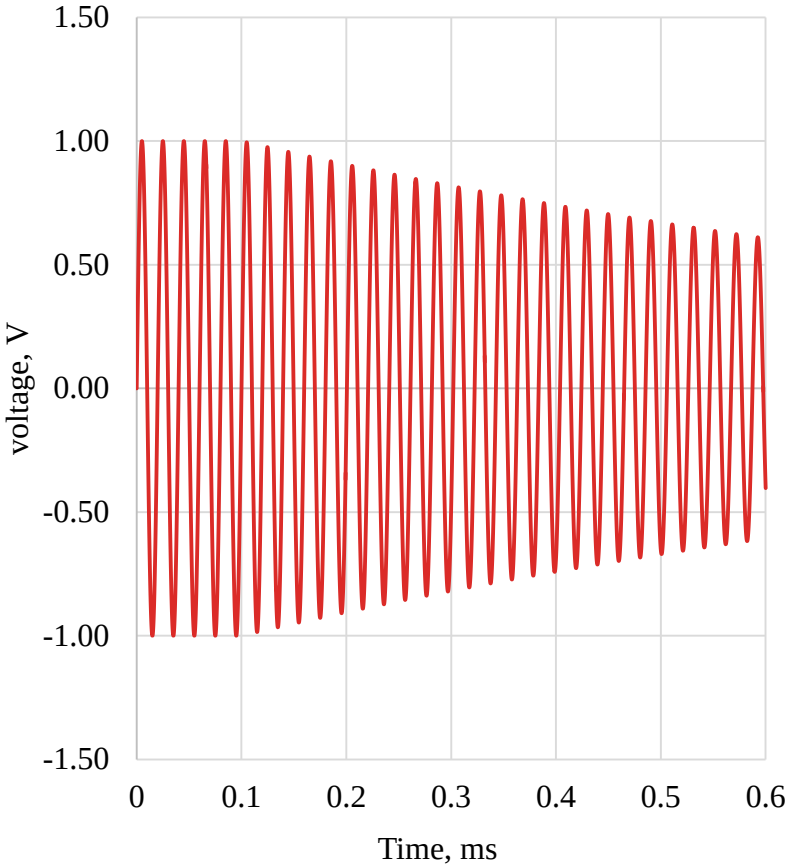
- Object control and sensors/actuators data acquisition/transmission
- Connection with an upper-level data acquisition and control system (e.g. PowerLink cloud platform)
- Advanced networking: interconnects with other ICs to form an IC network for load balancing and fault tolerance
- Enhanced built-in analytics

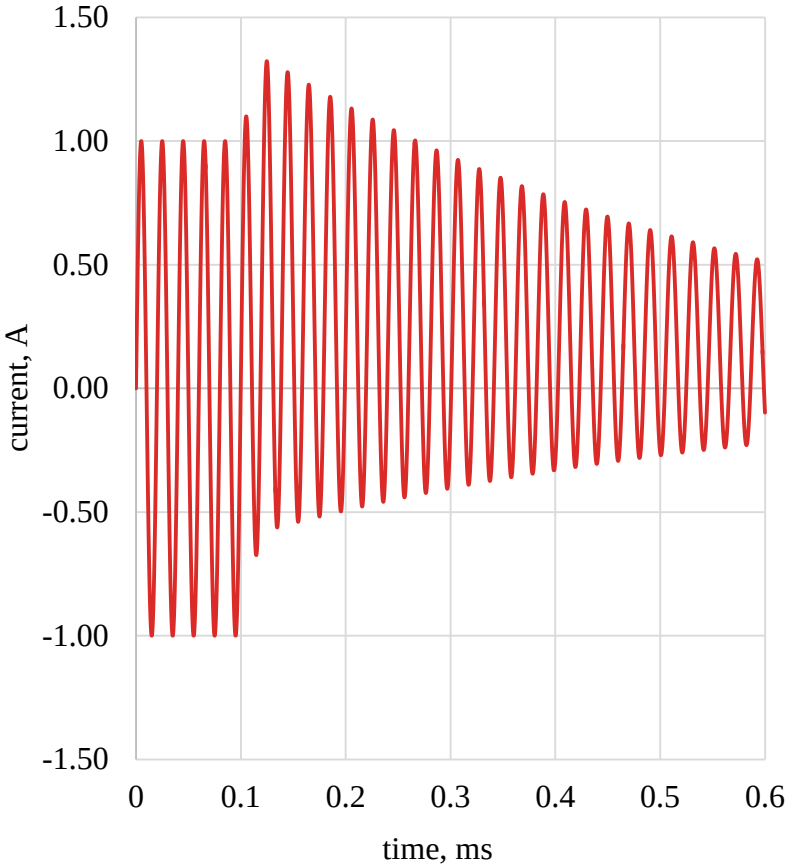


Direct measurements of the synchronous generator load angle



Initial data



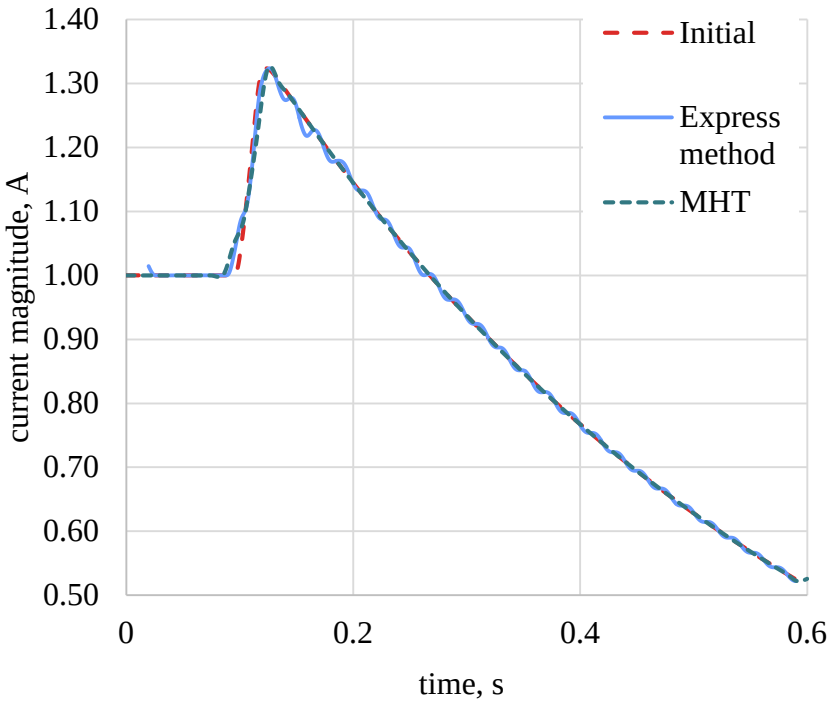


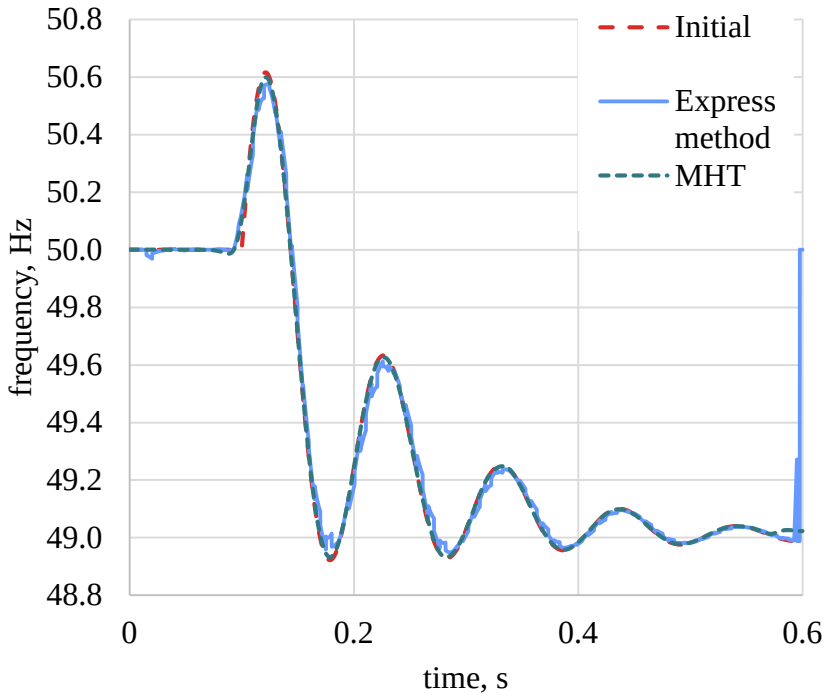
$$x(t) = a_0 + a_1 \cdot \sin(\omega t) + b_1 \cdot \cos(\omega t)$$

$$X_m = a_0 + \sqrt{{a_1}^2 + {b_1}^2}$$

$$\varphi = arctg\frac{a_1}{b_1}$$

Express evaluation technique vs Modified Hilbert transform





Parameter	Magnitude		Frequency		Phase	
	Express evaluation	Modified HT	**Express evaluation**	Modified HT	**Express evaluation**	Modified HT
Average deviation	0,04 %	-0,01 %	0,01 %	0,00 %	0,02 %	-0,66 %
RMS	0,87 %	0,95 %	0,11 %	0,02 %	1,87 %	0,80 %
Maximum deviation	2,81 %	5,37 %	0,49 %	0,21 %	0,19 %	0,71 %

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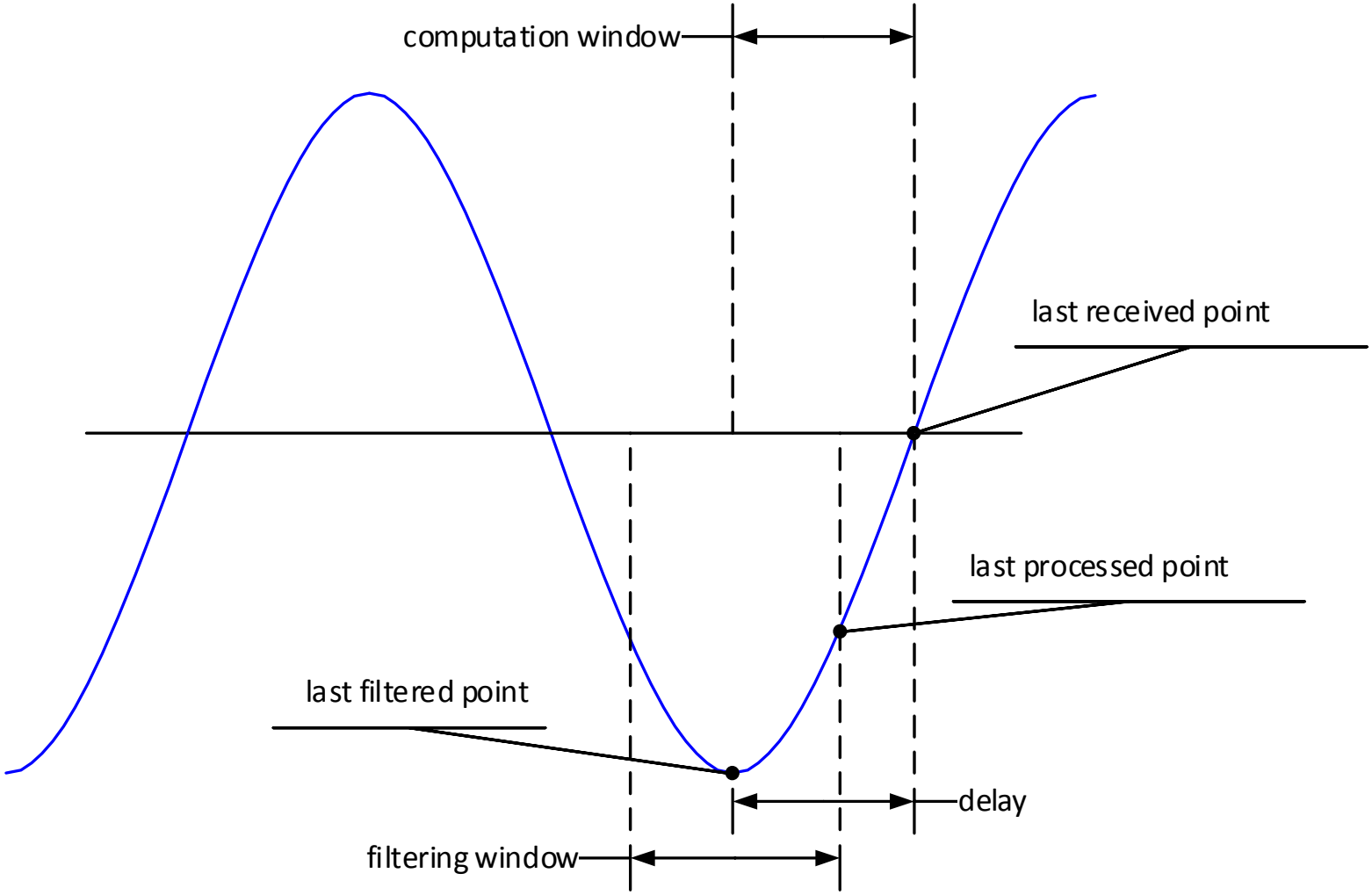
Express evaluation technique



Computation window – 10 ms, filtering window – 5 ms

Computation delay – down to 5 ms

Intelligent PMU capabilities

- accelerated disturbance detection and analysis by instantaneous measurements processing;
- forming local control actions or adjusting local protection and automatic control systems on a 100 ms cycle basis;
- power quality monitoring on an object or an interconnection level: computation and analysis of power quality indicators inside the device with the sampling rate corresponding to the initial measurements (10 kHz or over) with the subsequent aggregation and transmission at the rated sampling frequency (60 Hz);
- data validation – platform for the 3-level data validation (1st level – an object, 2nd level – adjacent objects, 3rd level – interconnections);
- error detection and correction in energy metering;
- extended generating equipment monitoring, including excitation system parameters acquisition;
- proactive equipment condition monitoring with the maintenance/repair recommendations;
- advanced networking capabilities.

Conclusion

- Intelligent PMU network brings an extra layer to the cloud where sensor data can be stored, analyzed and act upon instantaneously.
- Intelligent PMU will become a backbone of DER systems due to
  - growing demand for Intelligent Grid from producers/consumers
  - increased interest from heat, water, utility gas, etc. providers
  - development of adaptive models for equipment and power system
- Foundation for the Demand Response and Demand Side Management approaches in the corresponding fields

Q&A

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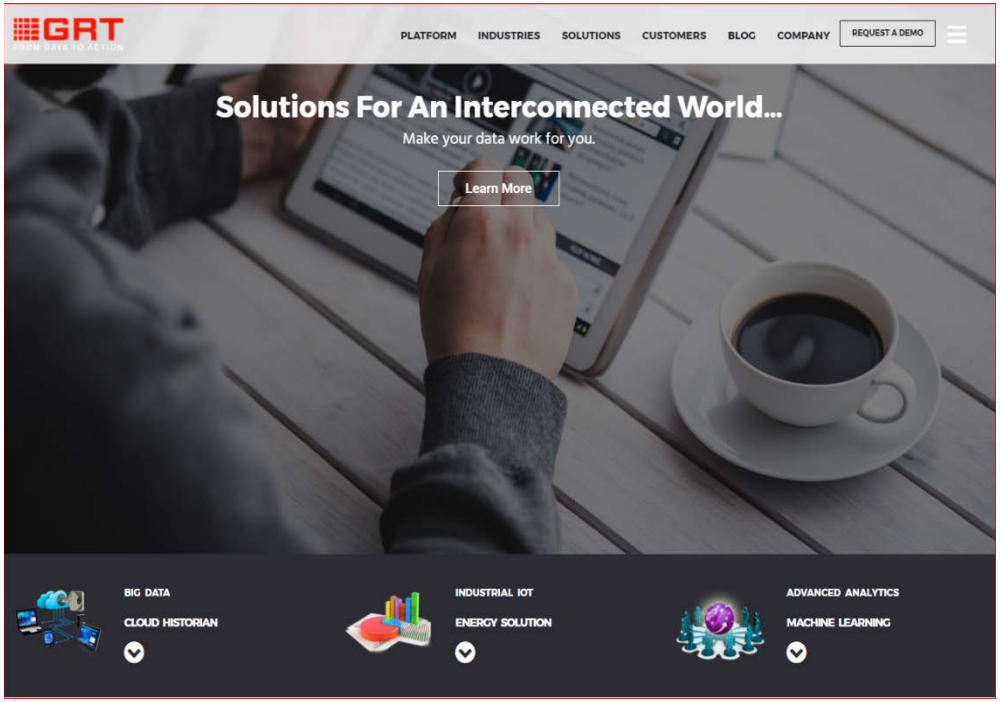

Thank You

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