

A decorative graphic on the left side of the slide, consisting of a dense cluster of small, multi-colored squares (red, blue, orange, black, white) that tapers off into a few scattered squares as they move towards the right. The background is a light gray gradient with a subtle, wavy pattern.

Analytics Architecture for PMU data

Viktor Litvinov



from DATA to ACTION

Design, Develop and Deploy digital transformation solutions for the InterConnected World.

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





- PMU based Analytics demands
- Data Driven Analytics - Realtime vs operational vs analytical
- Architecture for expansion - Microservices – data ingestion, cleansing, harmonization, and storage
- EDGE Computing – intelligent PMU
- Infonomics - Data as a Service

Data Driven Analytics



Data sources

Phasor measurement units (PMUs)

Phasor data concentrators (PDCs)

IEDs and protective relays

Frequency disturbance recorders (FDRs)

Supervisory control and data acquisition (SCADA) systems

Smart meters

Geographic information systems

Weather forecast data
Electricity market information

Analytics – Real-time vs Operational

- Power Plant monitoring
- Substation monitoring
- Low frequency oscillations monitoring

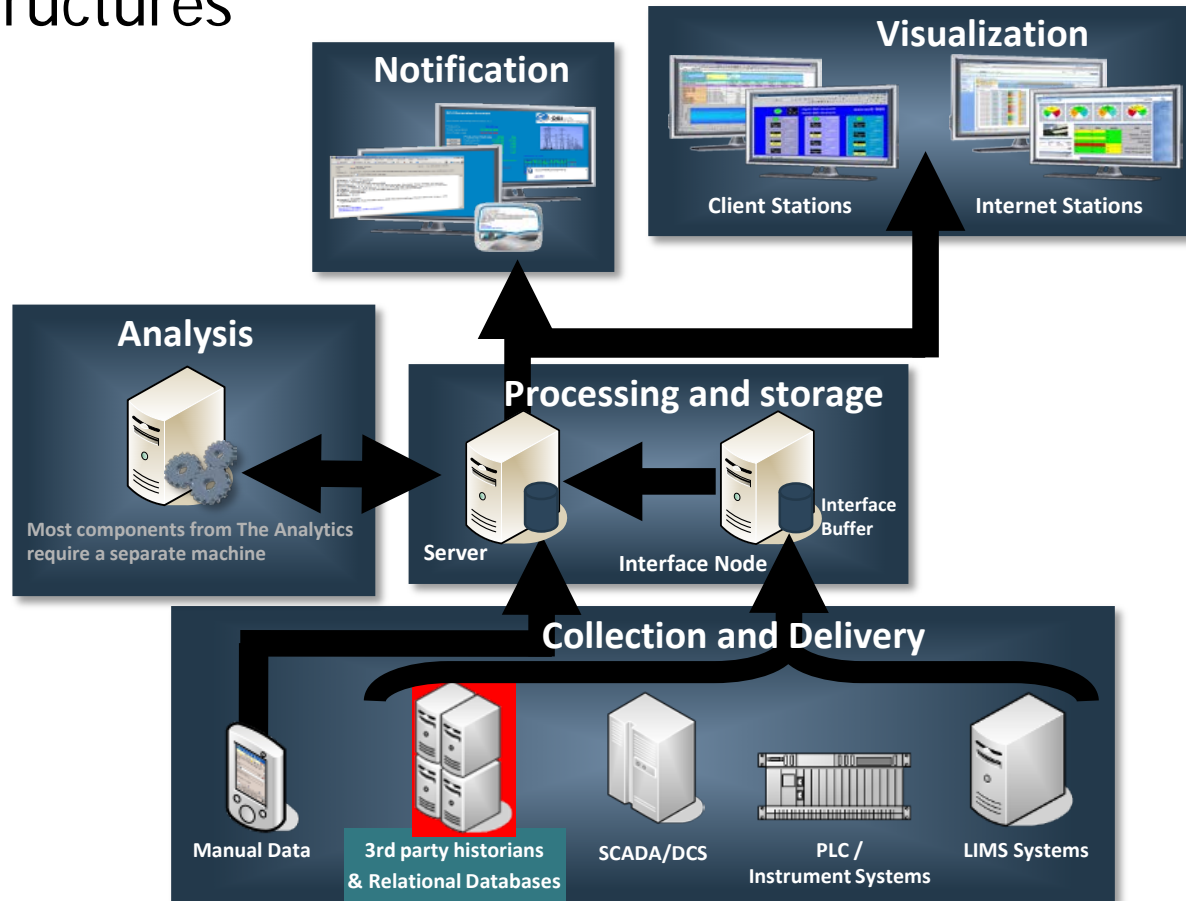
- System Stability monitoring
- Fault system restoration
- Real Time Recovery

- Demand response
- Load Forecasting
- DER Forecasting
- DER Asset management

- Equipment life extension
- Predictive maintenance
- Optimal equipment placement

Classical Architecture

Monolithic centralized monitoring and control infrastructures

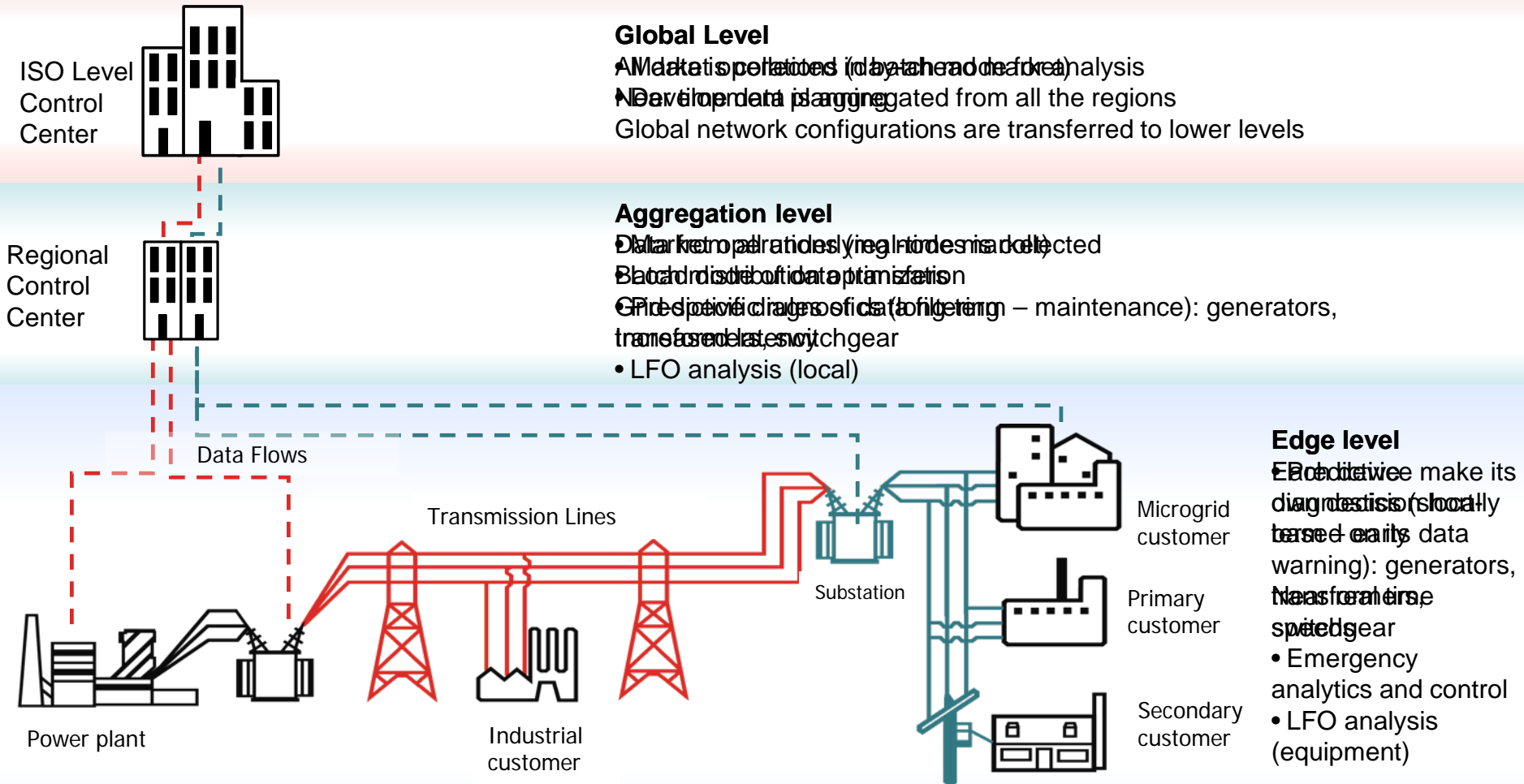




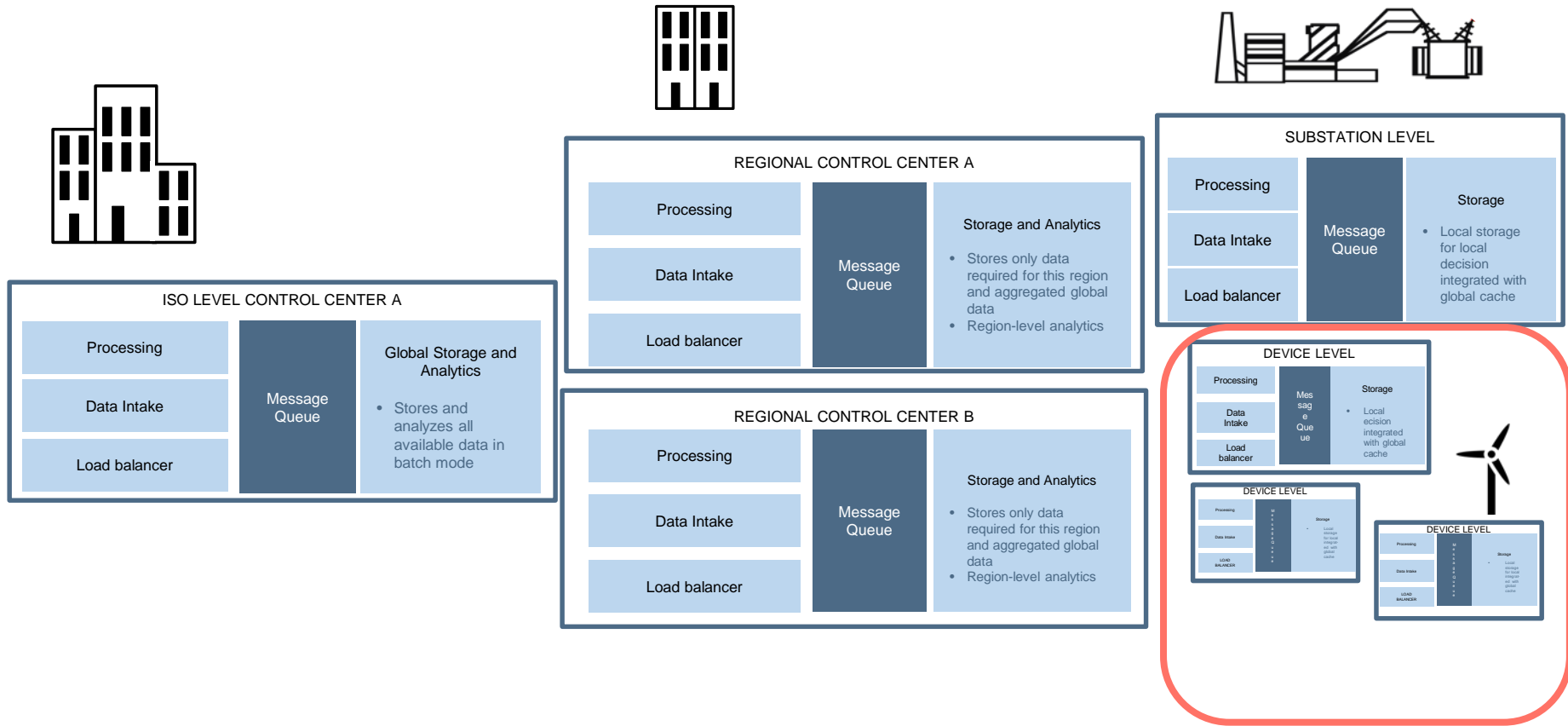
- Data propagation
 - Distributed sources of data
 - Multileveled PMU –PDC-Local-Region transmission
 - Time critical event detection
- No centralized repository for PMU data
 - Multiple bilateral data streams
- Data quality
 - accuracy
 - completeness
 - timeliness
- Data/Access security

Distributed Layered Decision Making

- At each level decisions are made on the basis of the data available at this level.
- Data required at higher levels is transmitted: only the minimal required amounts and granularity
- Higher levels distribute global updates to lower levels

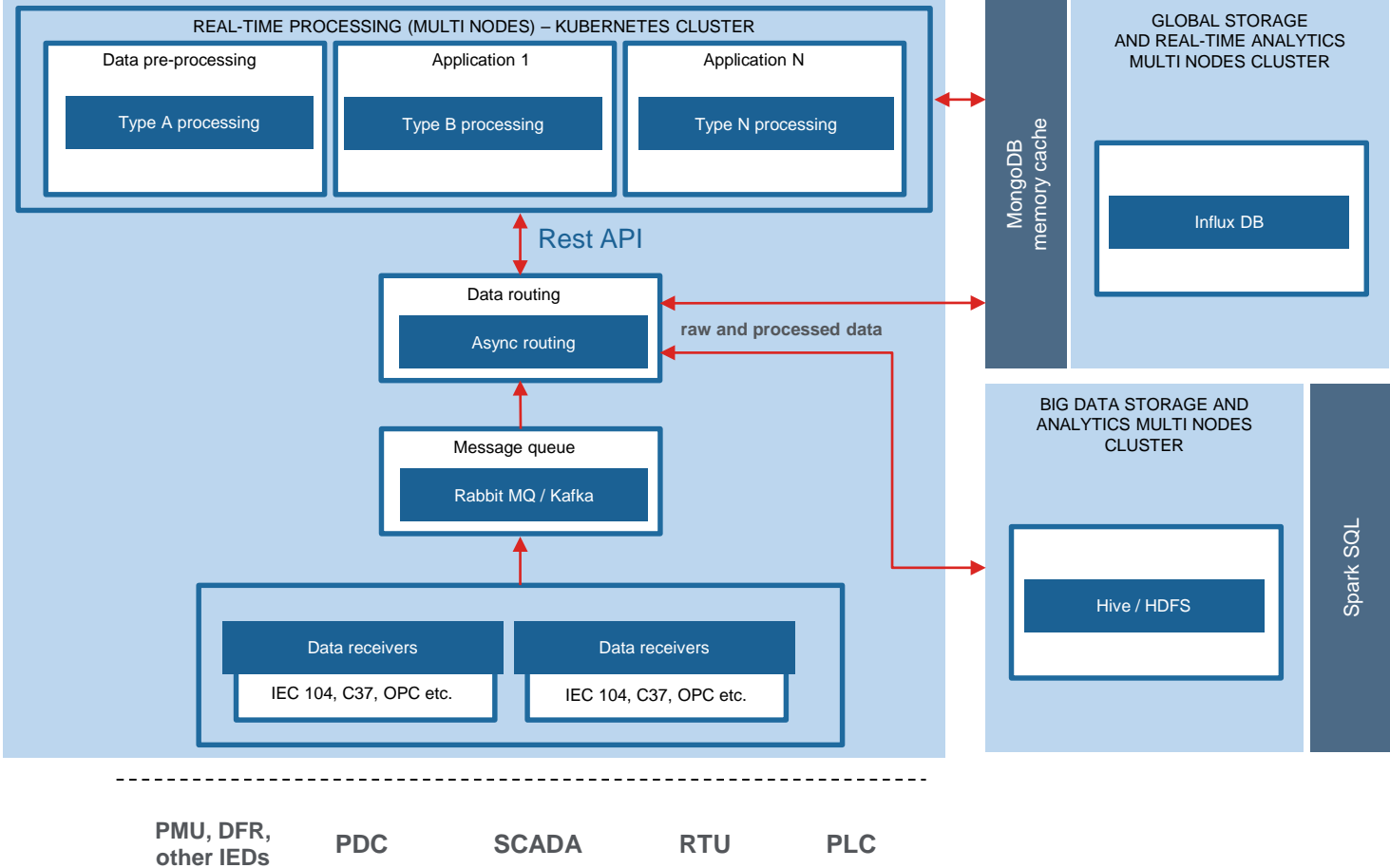


Data Partitioning – Distributed Multi-node

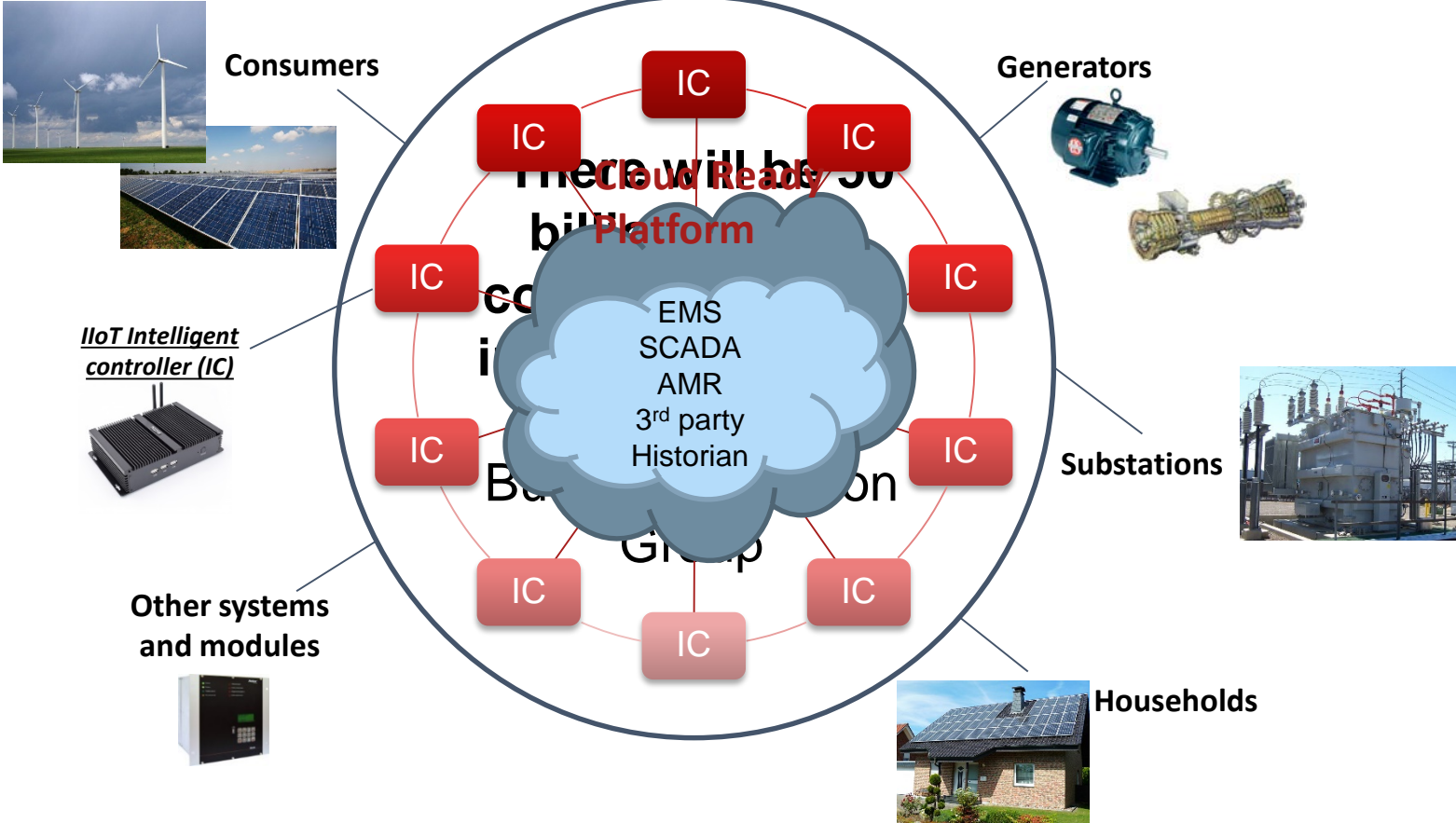


- Using new techniques of data exchange the data flows have been optimized more than 5 times
- Combining **REST API (web-services)** and **RabbitMQ messaging middleware** we provide on-line and off-line data exchange between PowerLink nodes

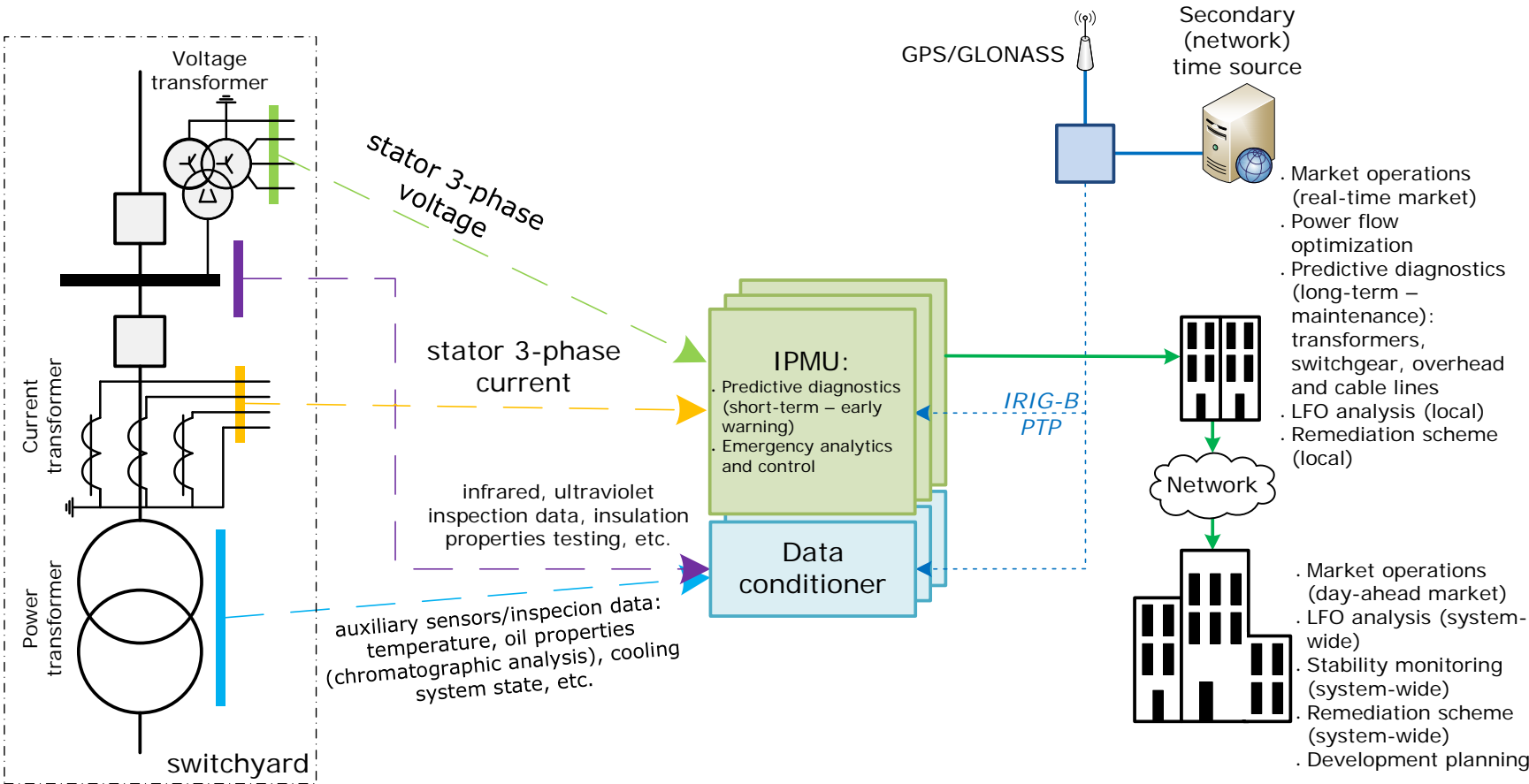
PowerLink – Node Structure



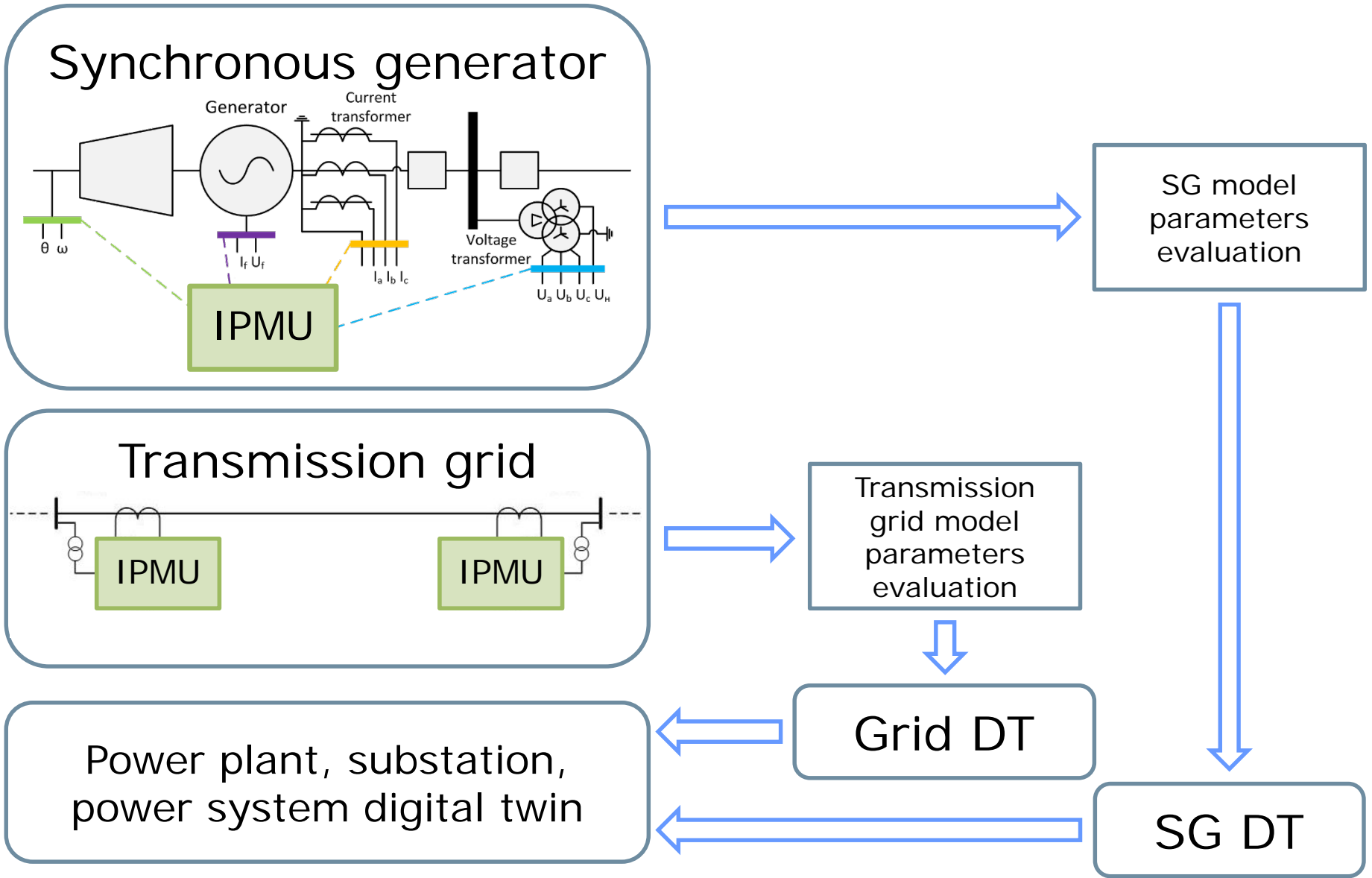
Edge Computing Paradigm



EDGE Analytics and diagnostics



Adaptive model / Digital twin





Generators

- Maintenance optimization through persistent condition monitoring
- Unexpected outage financial losses reduction
- Reduction of expenses induced by generators downtime and damage repair costs
- Long-term operation analysis for preventive alarming
- Real-time faults detection

Transformers

- Condition baselining
- Actual equivalent parameters evaluation
- Real-time and long-term insulation condition assessment
- Abnormal (accelerated) wear detection
- Possible cause identification
- Condition-based load optimization

Circuit breakers

- Actual performance parameters evaluation
- Remaining service life assessment
- Parameters deterioration forecast
- Early fault warning



Information

- Granular
- Timely
- Spatial
- Accurate
- Consistent
- Complete
- Relevant
- Secured

Data as a Services

- Grid visualization
- Building energy management
- Demand/Respond
- Substation automation
- Distribution automation
- AMI
- DERMS

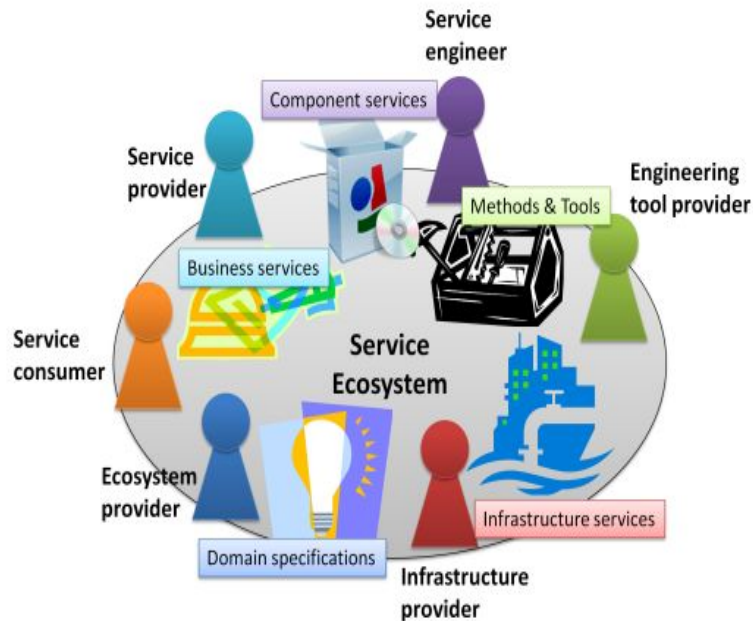
Supporting Technology

Event Processing tools
Streaming analytics
Blockchain

In-Memory Databases
Distributed system
Edge computing



Service Centric Ecosystem



- Consumers-Producers exchange roles
- Instant Settlement and Verifiable Contracts
- Counterparty identity
- Trusted data that eliminates the paper trail

Distributed Ledger Technology

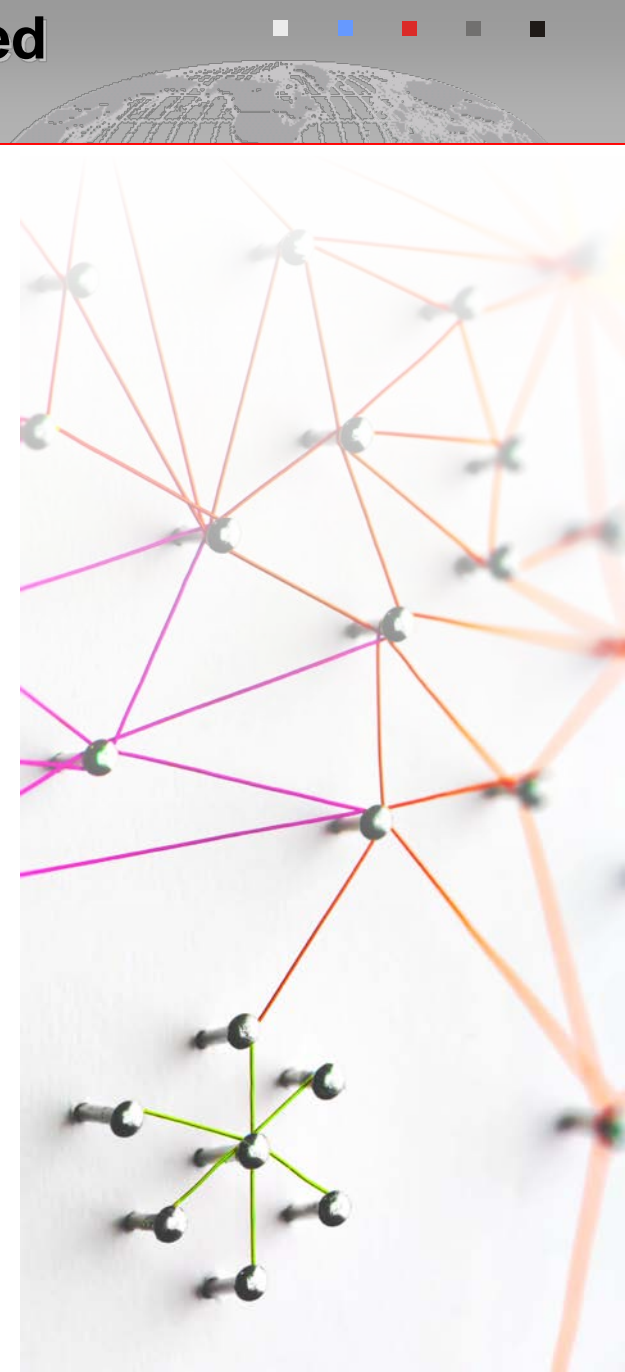
Energy Trading
Building management
Demand Response

Grid management
DER Generation
Equipment maintenance

Distributed Ledger Technology for distributed economies

Solutions will be built in a **distributed** manner with **no centralized governance** using Blockchain/DLT supporting key aspects of new digital economy:

- Frictionless/instant settlement with smart contract
- Financing of new ventures and projects with ICO or similar
- Secure Identity management
- Trusted data that eliminates the paper trail





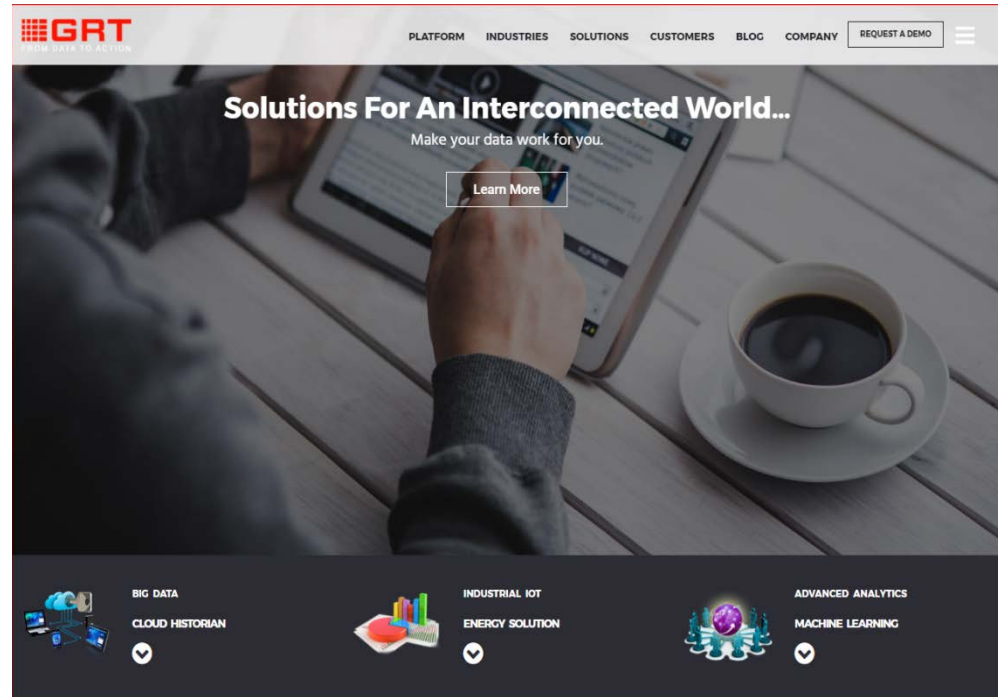
- Data Driven Architecture
- EDGE computing
- Adaptive Modeling
- Data-as-a-Service



Q & A

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