Automation of Power System Reliability Challenges in Existing & Emerging Scenarios

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Agenda

- Industrial Automation in Context of Power System
- Quality Attributes in Context of Industrial Automation
- Architecture: Components, Interfaces, and Profile
  - Reliability – Power System Communication
  - Reliability – Satisfactory Performance & Recovery
- Example of Transmission/Distribution Automation Topology
- Emerging Context of Smart Grids
- Potential Areas of Standardization

Industrial Automation in Context of Power System

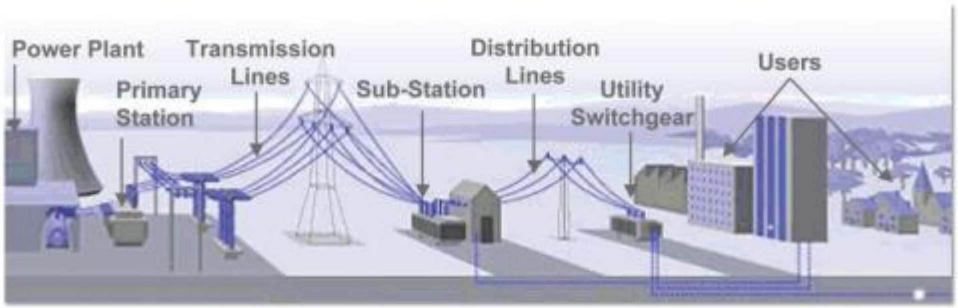
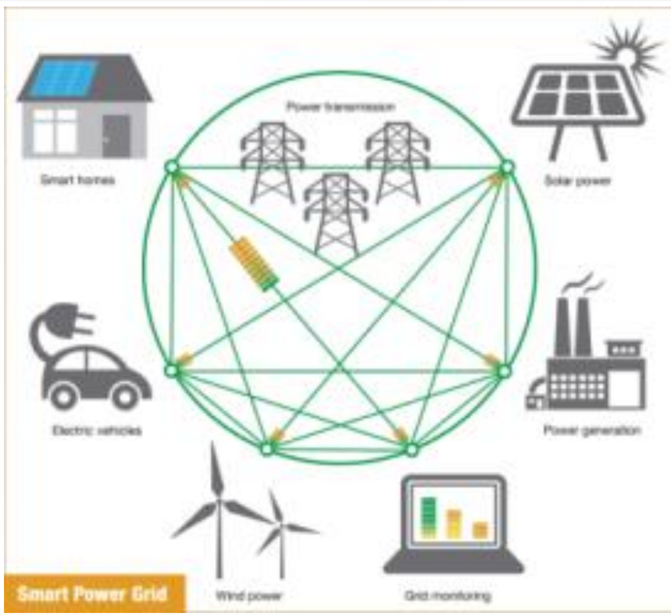


Fig.1: Traditional



Courtesy: rtcmagazine.com

Fig.2: Emerging

Generation → Transmission → Distribution

From Generation, Transmission, Distribution to reach consumers

- *Traditional*
- *Emerging Scenarios*

World Energy Outlook shows

- Nearly 1.3 billion people without access to electricity

- Renewable electricity generation grows from 21% in 2010 to 31 % in 2035

The emerging Industrial Control System (ICS) or otherwise called automation scenarios see communication as an integral part: open standards & mainstream technologies to be integrated

Architecture: Components, Interfaces & Profile

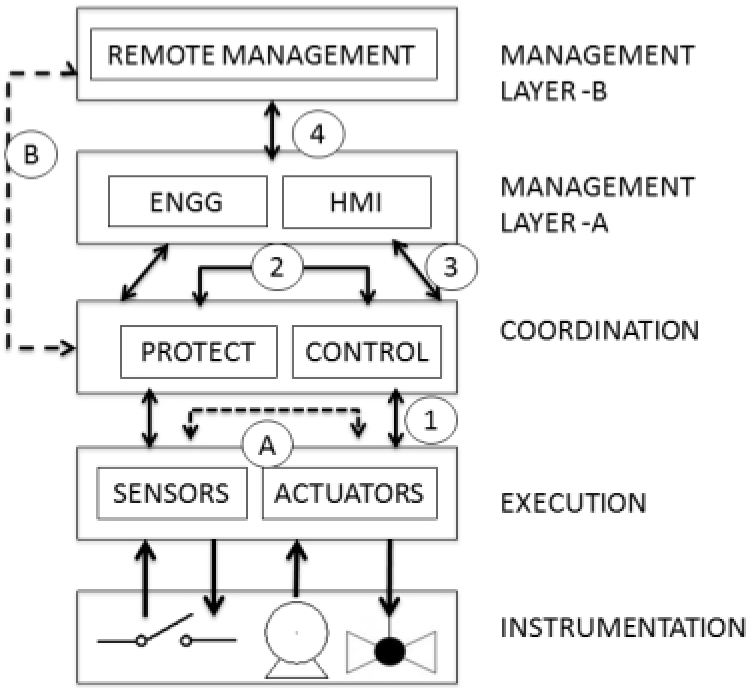


Fig.3: Components & Interfaces

The interfaces in Automation System with respect to communication or data exchange are described as:

- Interface between execution and coordination layer
- Interface within devices in coordination layer
- Interface between coordination & management layer
- Interface to management layers for remote management

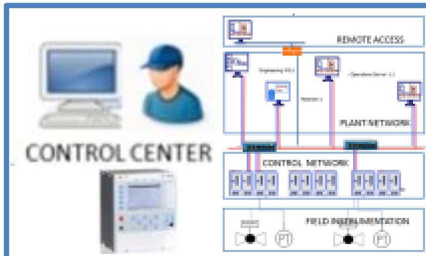
Table2: Traffic Analysis/Profile

APPLICATION CLASS	EXAMPLE APPLICATION	TRAFFIC PROPERTIES
REAL TIME	TRIP LIKE SIGNALS	IEC 61850 GOOSE
SIGNALING	HEALTH	IEC 61850 Quality Bit set
TRANSACTION	AUTHENTICATION	LDAP
INTERACTIVE	MANUAL CLOSE	IEC 61850 MMS
BULK	CONFIG	TFTP
BEST EFFORT MANAGAMENT	SYNCH, CONFIG, LOGGING	SNTP, IEEE 1588 (PTP), SysLog

Reliability: Power System Communication

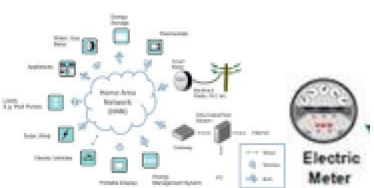
Wide Area Networks

Remote Control Center
to and from
Protection/Control Devices



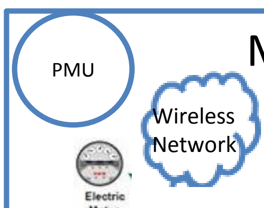
Field Area Networks

Distribution Management System
Devices for Control Commands,
Distributed Energy Resource
Electric charging stations.



Home Area Networks

Customer Premises functions
Eg. Automatic metering



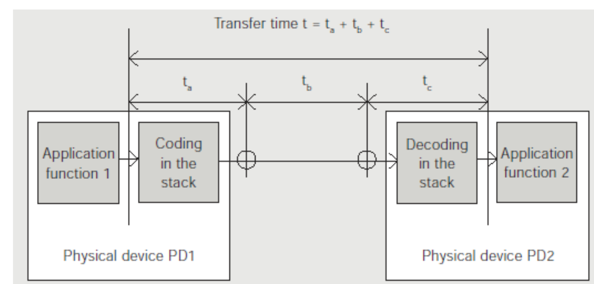
Measurement Systems & Networks

Wide Area Measurement Systems(WAMS)
Automated Metering Infrastructure (AMI)

Reliability as a measure of success has four important aspects : The device's or system's "intended function" ; "When the device is required to function" ; "Satisfactory performance" & "specified design limits" must be known.

The systems and devices are oriented towards

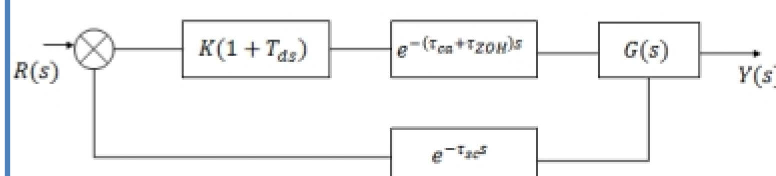
1. *Open Loop Control /Protection*



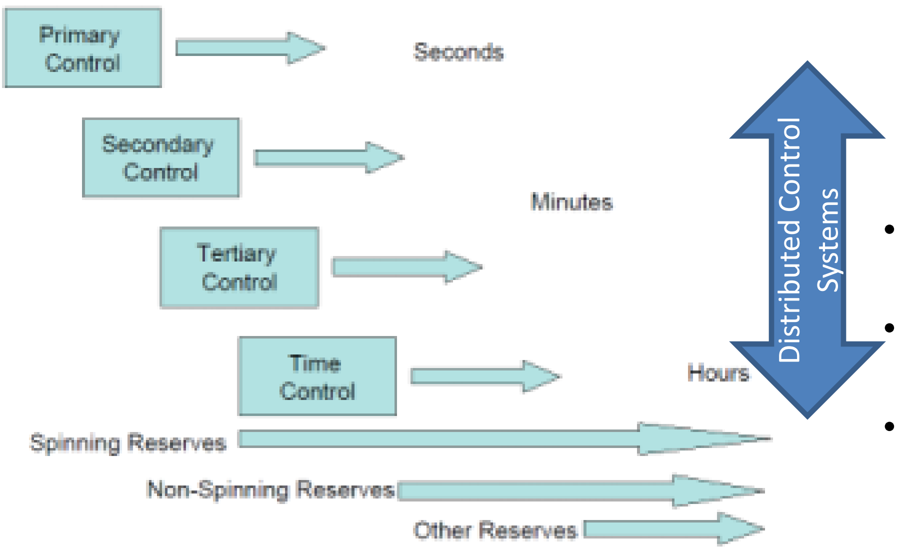
Electrical Protection - Trip Signals <3ms

2. *Closed Loop Control*

Round Trip Time >100ms



Reliability: Satisfactory Performance & Recovery



- Performance ranges across various types of control from Primary in range of seconds or less, Secondary in range of seconds –minutes and tertiary in terms of minutes to hours plus. Examples Turbine Control Total Reaction time <20ms, Trip Signals Application to Application Time is <=3ms
- Distributed Control Systems : International Society for Automation (ISA) Standards
- Communication Standards : OPC DA/AE -> OPC Unified Architecture (UA)
- Substation Automation: IEC 61850 –Part 5 , IEEE 1815 – Distributed Network Protocol (DNP)

ICS	*IT System*
Availability	Confidentiality
Integrity	Availability
Confidentiality	Integrity

PARTNERS	BUS	Recovery Time
SCADA to IED	Station bus	100ms
IED to IED Interlocking	Station bus	4ms
Busbar protection	Station bus	4ms
Sampled Values	Process Bus	0ms

Example - Transmission/Distribution Automation Topology

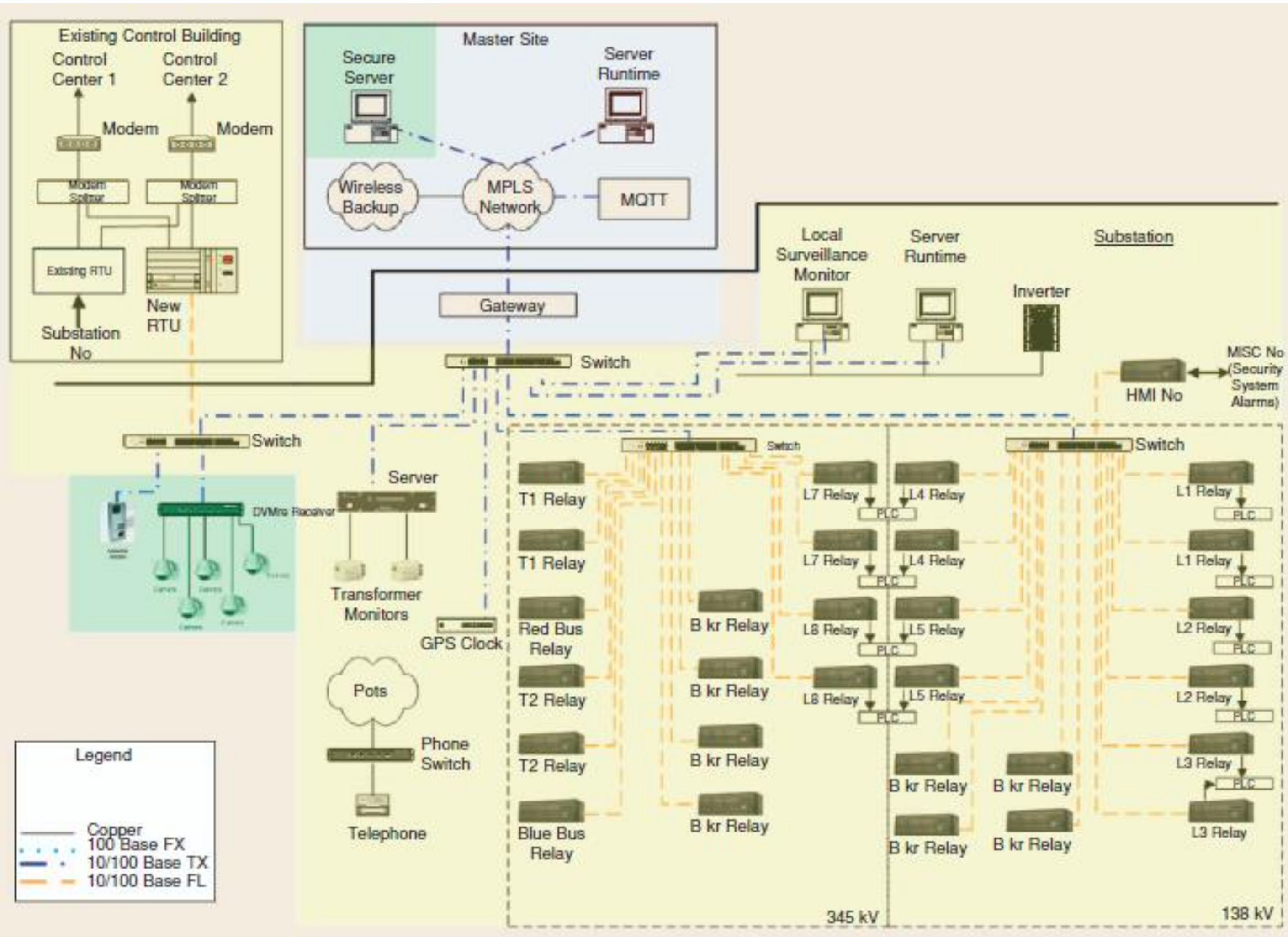


Fig.4: Substation Automation Topology Example : Based on IEC 61850/DNP [4]

- *Drivers Operability, Reliability , Redundancy and Visibility*
- *345KV Redundancy required; <138 KV Only backup Protection*
- *Ethernet 100 Mbit/s with IEEE 802.1 VLAN Priority Tagging for Trip signals GOOSE*
- *Time critical -Application to Application 3ms*
- *HSR and PRP for Communication redundancy*
- *Reaction times ranging from Microsecond to Milliseconds.*
- *Time synch using IEEE 1588 and SNTP*

Emerging Context of Smart Grids

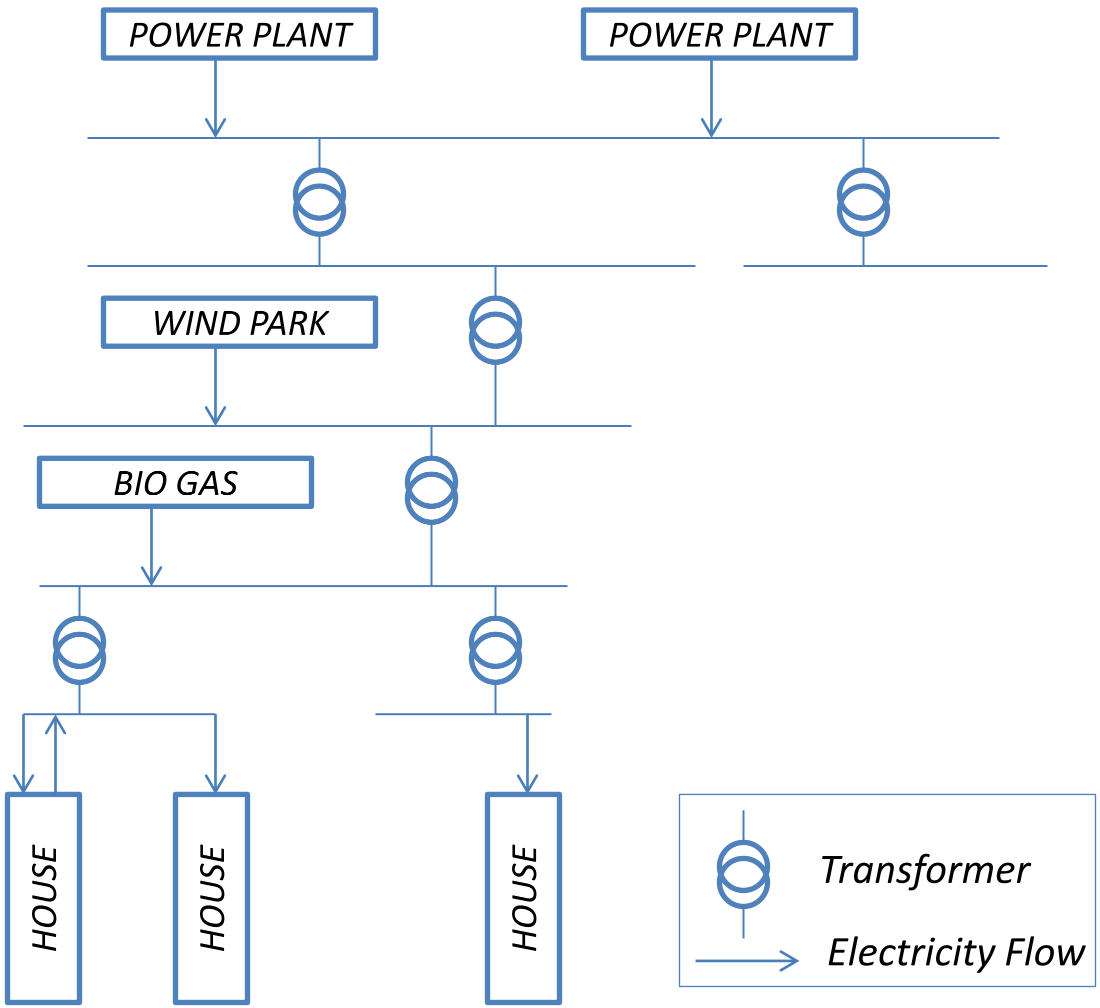


Fig.6: Smart Grid Integrating Multiple Generations and Consumer turns into Producer

"The Smart grid vision generally describes a power system that is more intelligent, more decentralized and resilient, more controllable and better protected than today's grid."

Integrated Communications becomes one of 5 key technologies for Smart Grid.

On domestic level there would be:

1. *Distributed Generation*
2. *Distributed Storage*
3. *Demand side Management*

More of decentralized and peer to peer communicating architectures. New fault detection, Isolation and Restoration Strategies required including methods like IEC 61850 GOOSE. Wide Area Early Warning Systems using Phasor Measurement Unit (PMU)

Potential Areas of Standardization - 1

Adoption of SDN/NFV/Similar Technologies in Industrial Automation is slow also due to the concerns discussed. Standardization could be accelerator. Some examples are:

1. ***SDN and Redundancy Support* –** Added support for redundancy of SDN Controllers is an important Contributor. Not sure this is standardized.
2. ***SDN Interfaces*** –Approach towards Northbound API is not known to be standardized. It is important to make sure SDN Networks work with existing Legacy Communication Networks.
3. ***Priority Tagging -****QoS* Strategies and Priority tagging and how the design for failure kind of approaches would make sure the QoS expected is delivered would be good to improve clarity at SDN and NFV fronts. Recovery plays a major role in ICS as well. Flows can be seen as critical flows and less critical flows. The critical flows need to be serviced. The QoS aspect more is aligned to Quality of Control.

Potential Areas of Standardization - 2

Resilience 4

- NFD and VNFD holding information about recovery and how this could be described in standard manner. The ability to stay tuned to millisecond time frames would make sure these virtualization approaches can be deployed in areas like secondary and tertiary control where the time frames are greater than millisecond.

In Operation Network Planning 5

- These systems undergo major testing phases (Factory Acceptance Testing) and today it is difficult to plan and easily commission with limited efforts on the site. Probably this is more to Management Plane. For example, Mininet like emulators and programmable simulators due to SDN it is possible could help diagnostics and planning before getting to site.
- NFV Update and Upgrade allowing new interfaces would enable Migration Paths to say newer interfaces like a new Time synchronization source.
- NFV Migrations to be supported at least partial and Live migrations would be important. This would help demonstrate the usage of NFV solutions and ability to substitution of existing solutions.

6 *Network/Virtual Network as a Service Use case*

- It brings in new and interesting usage scenarios like Network-As-a-Service in case of community micro grids, where pay-per-use is a much relevant option and business model.

7 *NFV - Deployment & Management*

With life time of ICS systems being from 15-20 or even 30 years, deployment and lifecycle is an important area. Customers want to protect investments.

- VNF Lifecycle Operations -Ability to Integrate Domain Specific Communication Stacks as VNF for example to play the role of demonstrators would be a possibility. This depends on the standard-ization of these interfaces and their description.

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Thank you!

Questions & Discussion