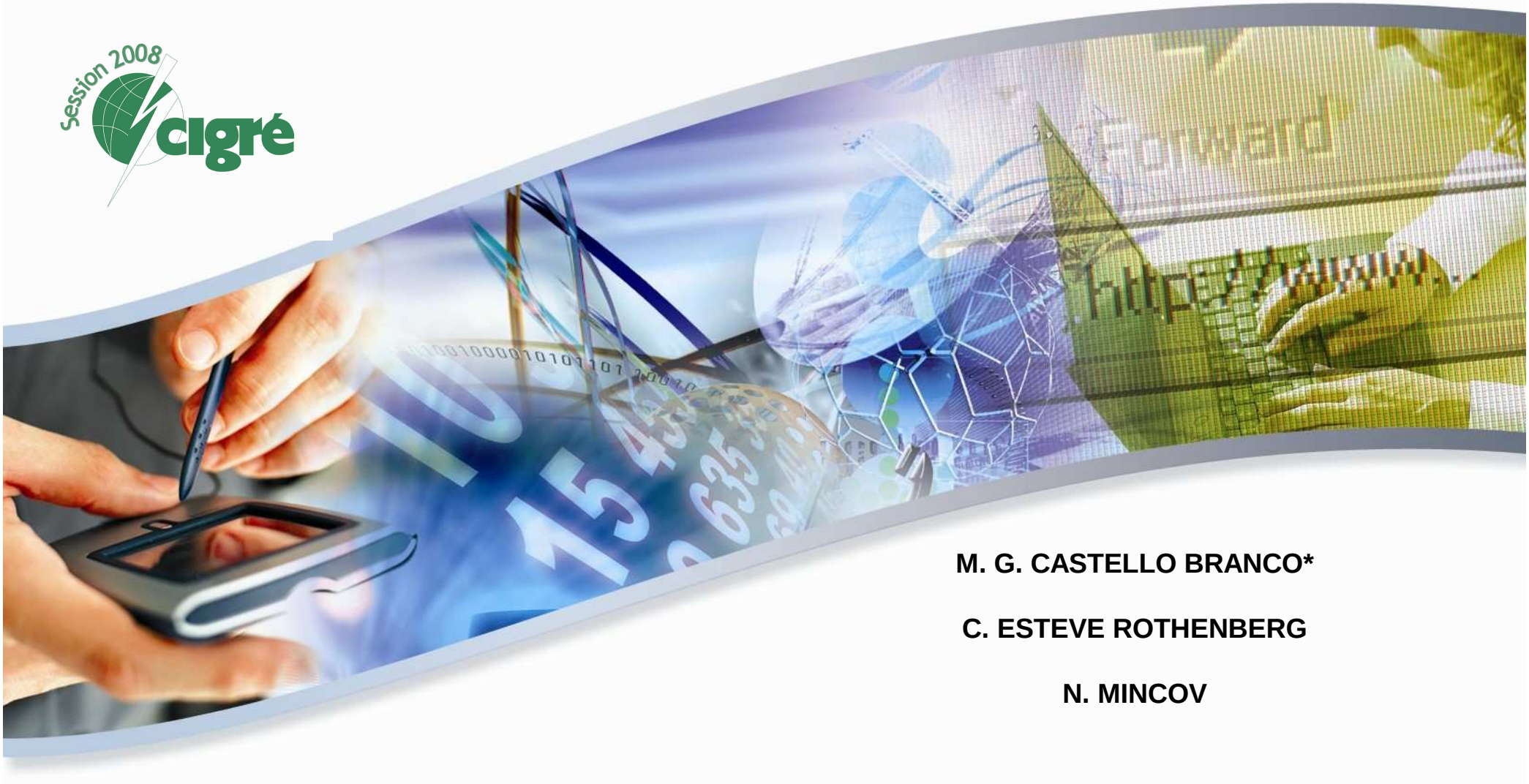
New Challenges in Electric Substation Telecommunication and IT Networks



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Summary

- Introduction
- Electric Plant Technology Convergence;
- Modern Multimedia IP Networks;
- Main Challenges for Electric Plant IP Networks;
- Network Evolution to a Converged Scenario;
- Conclusion

Introduction

- **Up to now:**
  - **Networks for SE ´s telecom and IT developed separately;**
  - **Differentiated services or business units;**
  - **Not expected or designed to integrate with each other;**
- **Convergence:**
  - **A key trend of the telecom market today;**
  - **Brings financial and business benefits - integration of networks and applications increasing productivity;**
  - **Lower total cost of network ownership;**
  - **Lower OPEX associated with equipment maintenance, network administration and data transport fees**
  - **Infrastructure able of scaling / new business applications;**
  - **Ability to new multi-vendor environment / SE IEDs components for automation and control processes**

Convergence drivers and consequences

- **Convergence Drivers**
  - **Ubiquitous development of the Internet Protocol (IP);**
  - **Performance enhancements in Ethernet technologies for industrial communications and processes;**
  - **Massive adoption of the IEC 61850 SE Communication System Standard;**
- **Convergence consequences**
  - **Utilities are augmenting their communication infrastructure;**
  - **With high-speed networking technologies**
  - **Opening a new series of challenges and applications in their communication processes**

Convergence – Why just now?

- **Up to now: Network capabilities were not mature enough to perform the convergence process cost-effectively;**
- **Today: Network convergence is a viable technology trend that can be implemented today in high power electric plants, meeting expectations with regards to:**
  - **Quality**
  - **Resiliency**
  - **Scalability**
  - **Simplified network management**

Electric Plant Technology Convergence

- **IP converging networks are:**
  - **becoming faster and flexible enough to accommodate a different set of applications with differentiated Quality of Service (QoS) (e.g. IEEE 802.1p);**
  - **incorporating real-time characteristics (e.g. Real Time Ethernet – RTE);**
  - **taking benefits from virtual network topologies (e.g. 802.1q VLAN);**
  - **allowing electric plant designers and manufacturers to insert new elements and features to increase substation automation and control capabilities through LAN and WAN;**
  - **enhancing the efficiency of traditional station and process buses;**
  - **offering more flexibility for fully integrated substation designs and sophisticated management and control systems with progressively increasing number of new IEDs and associated logical functions (e.g. IEC 61850)**

Electric Plant Technology Convergence

- **IP network elements are :**
  - **facing new challenges to provide performance and quality behaviors compatible with the requirements usually stated for the electric plant operation. Currently network elements were used just for non critical communications;**
  - **becoming the focus of technological development and evolution (servers, switches and routers) in order to satisfy the more stringent requirements of operational plants;**

Electric Plant Technology Convergence

The role of IEC-61850 in the converging scenario :

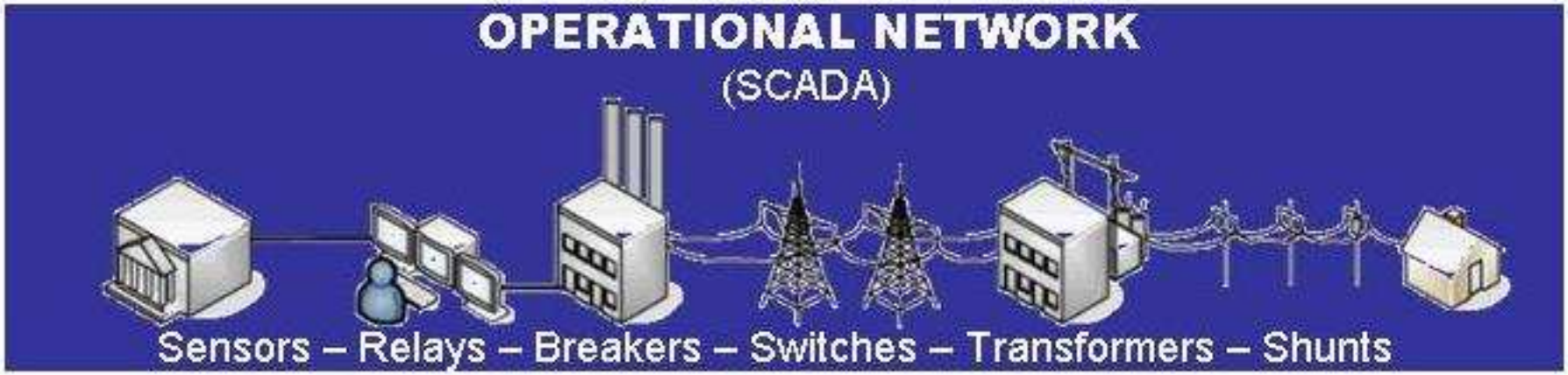
- IEC 61850 defines the next generation of standardized high-speed substation communications for control and protection processes;
- With its object–oriented data model and formal description language IEC 61850 offers high potentials in terms of reusability, data interoperability and seamless engineering;
- IEC 61850 communication services provide multiple methods for information exchange:
  - reporting and logging of events
  - control of switches and functions
  - polling of data-model information
  - real-time peer-to-peer communication (eg. GOOSE messages)
  - sampled value exchange
  - file transfer for disturbance recordings

Electric Plant Technology Convergence

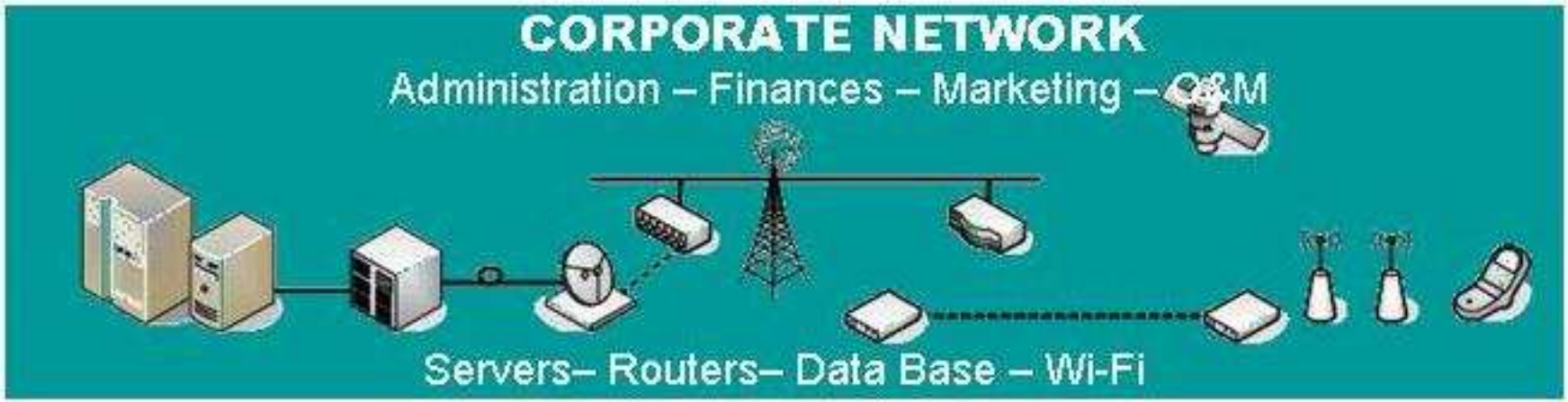
Why IEC-61850 over Ethernet?

- Improvements of Ethernet networks features of transmission bandwidth and network span support new communication profiles.
- Today, the Ethernet profile of IEC-61850 requires:
  - 100 Mbit/s bandwidth
  - flexibility to adapt for underlying transport technology changes
  - priority-based QoS traffic differentiation
  - synchronization capabilities.

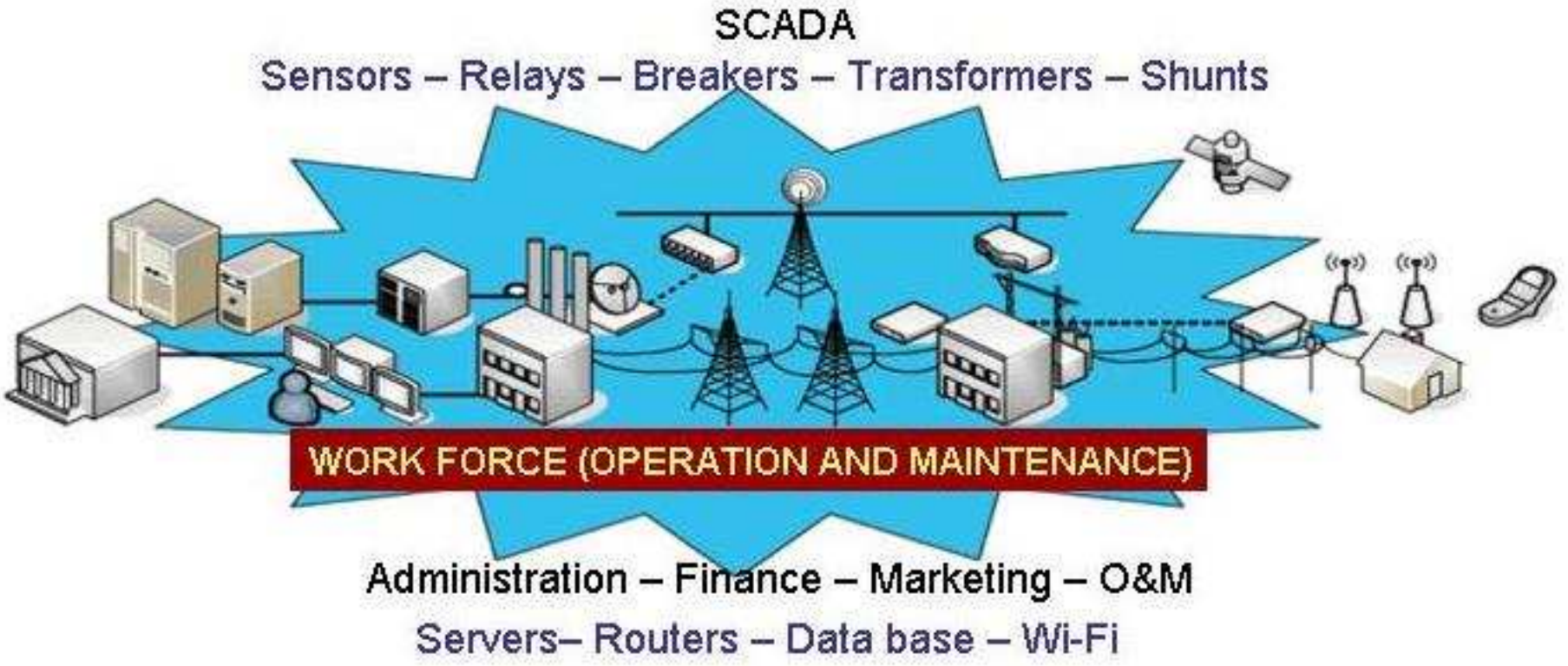
Electric Plant Present Architecture



WORK FORCE (OPERATION & MAINTENANCE)



Electric Plant Future Architecture



Converged Network Benefits

- **Improved connectivity:**
  - **Devices can be assigned specific tasks (e.g. peer-to-peer communication between IEDs);**
  - **The number of devices required is less which makes installation, and deployment easier tasks;**
  - **Simplified network management due to uniform setup in which the system resources operate.**
- **Single platform:**
  - **Allows interoperable devices running in innovative ways;**
  - **The openness of the communication standard helps in fostering interoperability and improving network efficiency.**

Converged Network Benefits

- **Business cost savings:**
  - **Through an uniform environment which requires fewer components in the network;**
  - **Smoother maintenance and management result from this and in turn lead to improved processes;**
  - **Affordable deployment results from the elimination of multiple networks operating in parallel and manageability improves;**
  - **In a converged environment, fewer platforms need to be tested and gateways between networks are eliminated.**
- **Flexibility:**
  - **in terms of molding utilities communication patterns to its management practices;**
  - **This is a dynamic process that can be continually improved with collaboration from inter-substation communications and across different utilities and partners resulting in the right information securely delivered to the right person at the right time which leads to improved decision making;**
  - **The on-going and cascading failures occurred during the 2003 blackouts after initial power equipment failures have been traced back to problems in providing the right information to the right place within the right time.**

Converged Network Benefits

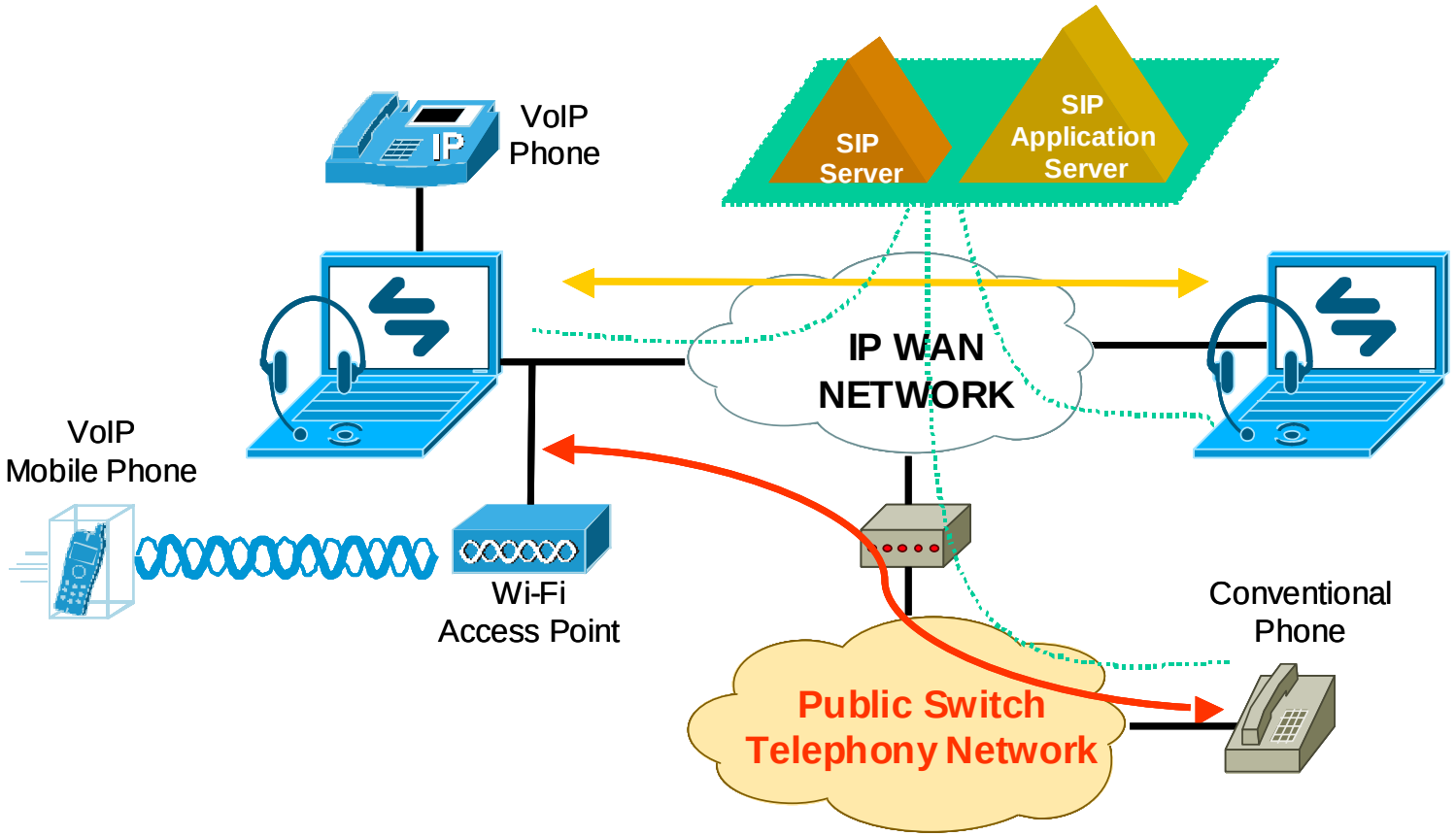
- **Data availability where and when needed;**
  - **Data should be able to go from all substation devices to any sink;**
  - **Some data may be needed in multiple locations, such as control centers (and their backups), regional security coordinators, neighboring control centers, ancillary service partners, or even in other substations in support of special protection schemes;**
  - **Allows the use of both operational and non-operational data across all corporate entities;**
- **Differentiation;**
  - **Convergence opens new communication paradigms, easies the introduction of new services, increases employee productivity and mobility, augmenting thus differentiation and competition because of faster information relay.**

Modern Multimedia IP Networks

- **Voice over IP (VoIP) scenario in a hybrid wired and wireless network environment ;**
  - **Session Initiation Protocol (SIP) servers allow the VoIP users access authentication and control;**
  - **Fixed Mobile Convergence (FMC) has a solid place in the enterprises;**
  - **Users with Dual-Mode Phones (e.g. supporting GSM and Wi-Fi) can roam between the public mobile network and the enterprise Wi-Fi network with seamless roaming and call handoff;**
  - **Field workers can attach to wireless access points installed at the electric utilities and get real time information from the management systems or directly from the process bus elements interfaces.**

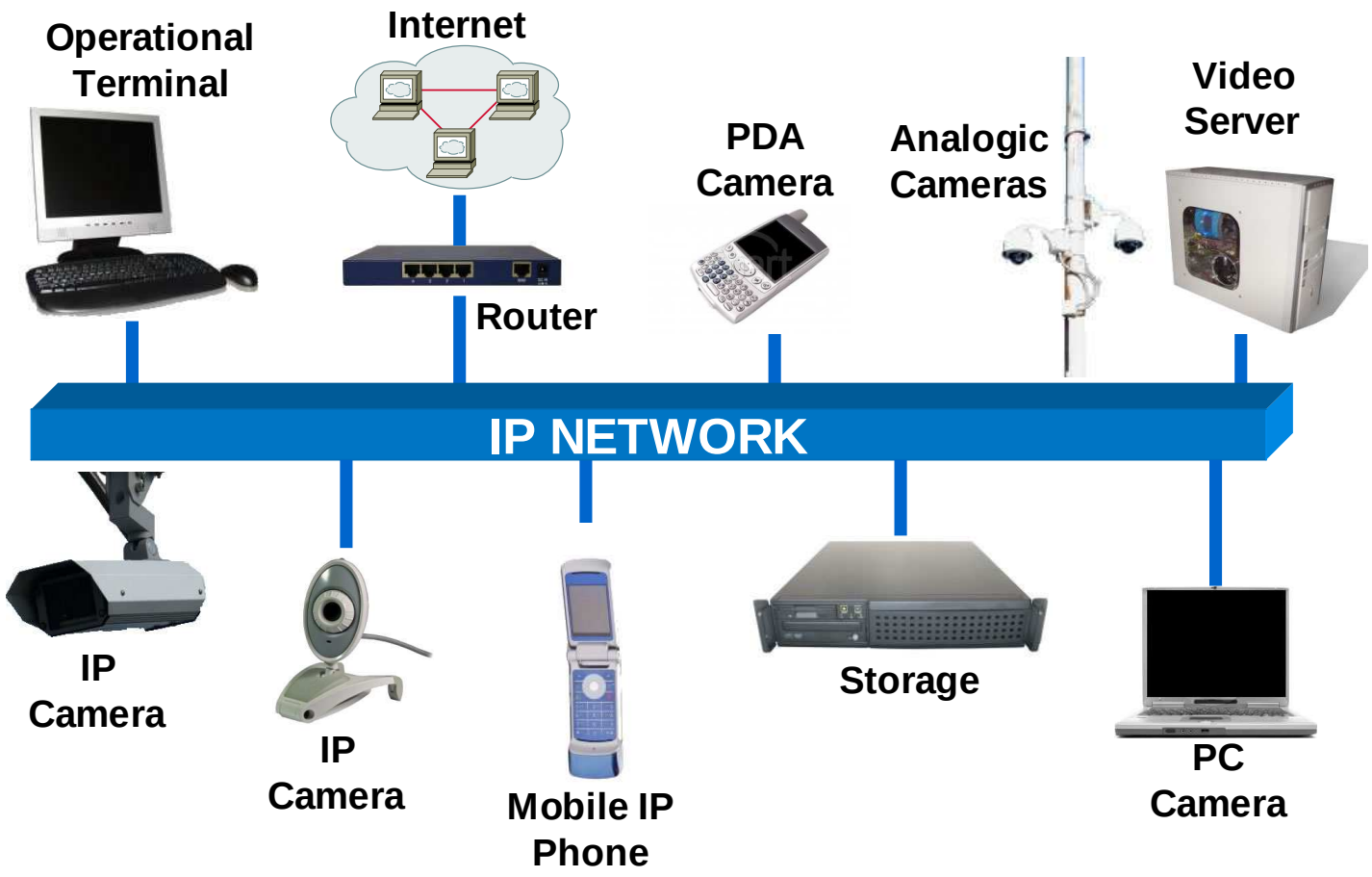
Modern Multimedia IP Networks

Voice over IP (VoIP) scenario in a hybrid wired and wireless network environment



Modern Multimedia IP Networks

Video network scenario

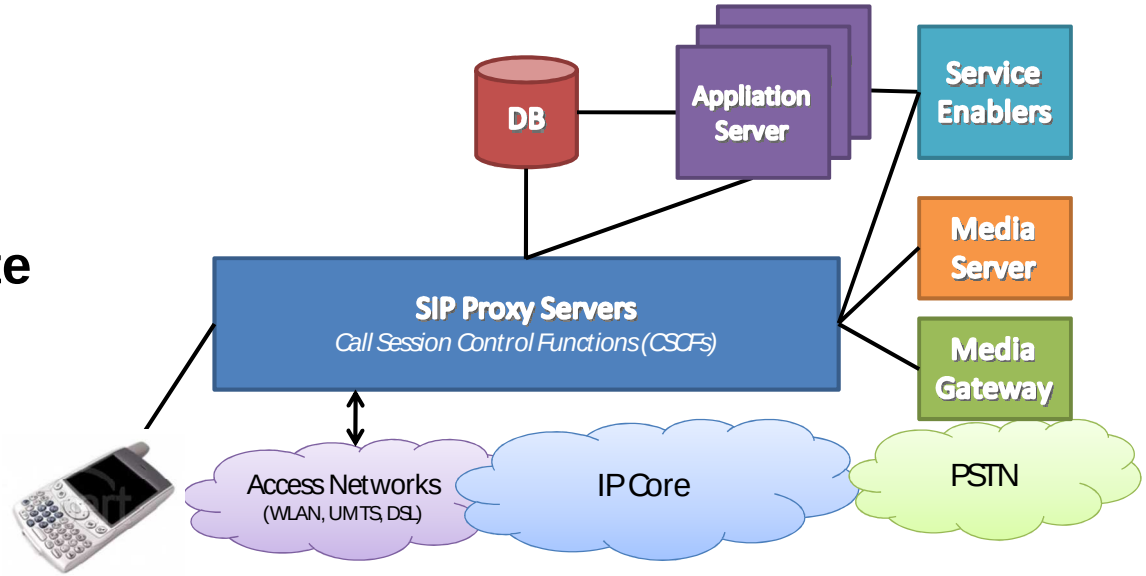


“All over IP” worldwide avalanche

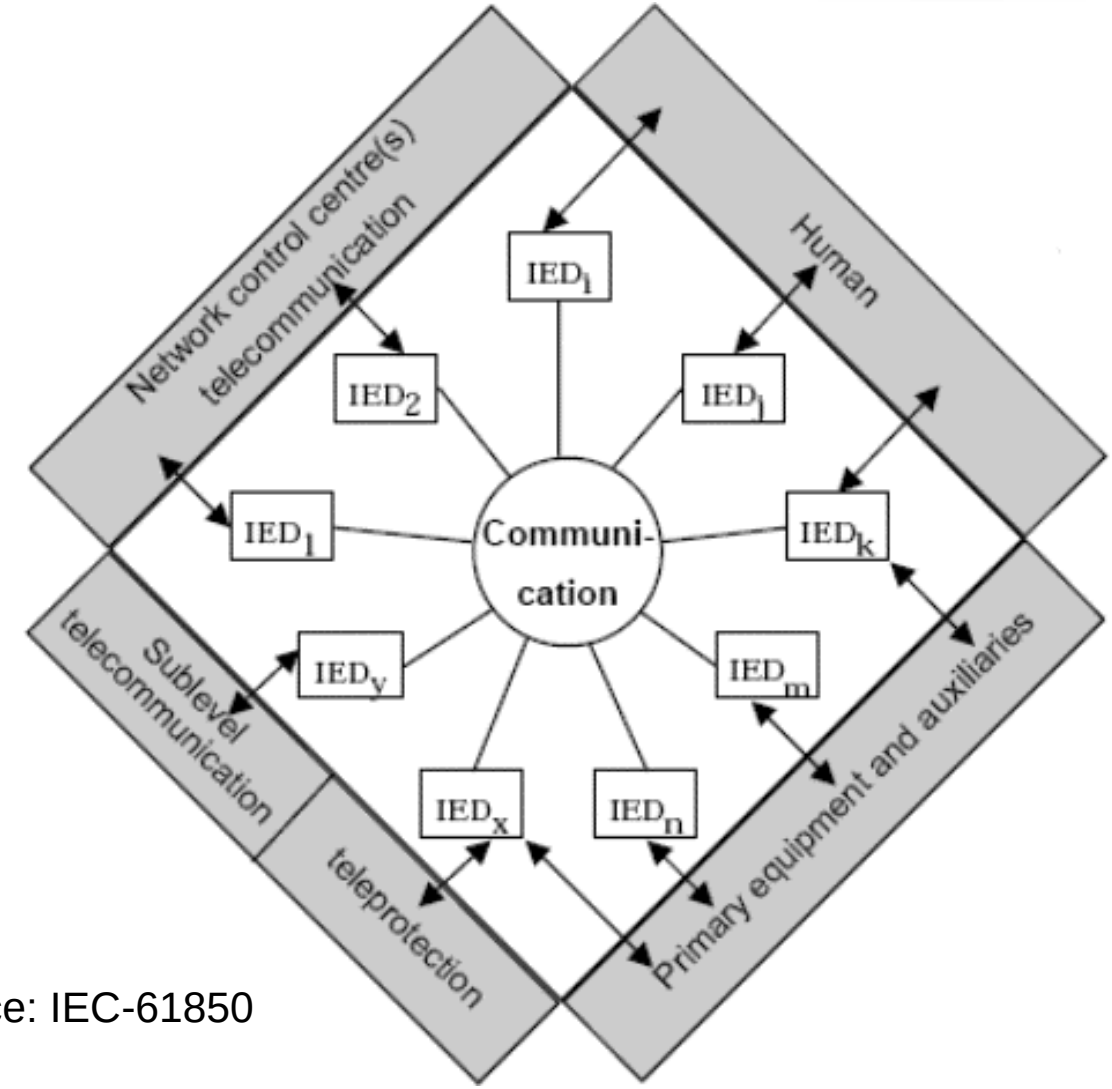
- Enterprises increasingly use IP to converge and transform their communication networks adding capabilities that greatly enhance their ability to reduce costs and increase functionality;
- The way employees communicate is evolving and now incorporates a wide range of video and voice communications like:
  - Desk phones in the office;
  - Mobile phones in their pockets;
  - IP phone services like GoogleTalk, X-Lite or Skype on their laptops;
  - Voicemail, E-mail, text messaging (SMS), as well as presence-enabled instant messaging and community based communications;
  - They access Web content and private intranet information from multiple end-points through different access technologies within an enterprise, at home, or remotely;
  - Typically, an application server (AS) handles the advanced enterprise communications services such as:
    - call forwarding, voicemail and integration with the enterprise IT infrastructure

“All over IP” worldwide avalanche

- **IP Multimedia Subsystem (IMS) architecture**
  - **Being adopted by telecommunication service providers in order to adequate their networks to the most flexible structure for IP multimedia applications and services;**
  - **Allows applications to work across mobile and IP networks by deploying the mechanisms of the global mobile network in the IP network**



IEC-61850 Substation Converged Network Primary Architecture



Source: IEC-61850

Main Challenges for Electric Plant IP Networks

- To clearly define the requirements for each function and associated logical nodes to be implemented in the new converged network so that the data flow and network capacity can be optimized;
- To achieve the best model of a converged corporate and operational network based on an optimized architecture (optimized not only to support operational functions of the logical nodes but also accommodate extended IT corporate functionality) over all the utility plant;
- To specify the requirements for the core (WAN scenarios) and intermediate network elements (LAN scenarios) in order to properly deal with the functional requirements;
- To specify the edge elements (such as IEDs and user terminals) of the converged network so that their associated logical nodes can be adequately implemented according to the network functions requirements including reliability and time requirements ;
- To verify the adequate interoperability between the edge elements in order to assure the reliability and time requirements for data exchange over the entire network and associated corporate and operational functions.

Security aspects

- Security and priority policies should be implemented and verified during all steps of the network evolution and may also be provided through the network consultant / system integrator. Risk management plan should be part of the integration project;
- Disaster and fault recovery plans should be implemented in all the enterprise levels and network layers compatible with the required levels of redundancy, availability and time to recovery

Network Evolution to a Converged Scenario

- Cost-controlled roll out of the converged infrastructure (in parallel with each project stage);
- Choose network elements and architectures that are able to aggregate the highest flexibility to the increasing multimedia applications;
- Implement traffic classification and prioritization, and security policies in order to provide the required dynamic properties to the IP network;
- Network elements need to be adjustable with the traffic flow and user's profiles, even for human or devices "users":
  - The definition and enforcement of these policies at the network elements are the key factors to achieve QoS sensitive high data rate exchange over fixed, nomadic and mobile accesses in a standards based communication scenario;
- Provide the new required technical skills for the human task forces (operation and maintenance) and a customized process mapping of electrical corporations (in parallel with each project stage).

Network Evolution to a Converged Scenario

- Due to the inherent complexity of network evolution, utilities have to rethink the way they conduct their own business when it comes to business partnerships and vendor relationships towards the so-called IP transformation (Two possible ways depending on the specifics of the utility: OP1: First network transformation then rethink business model / OP2: First reposition in the value chain then consequently transform the network);
- Convergence increases the pressure to seek outside help for all aspects of secure end-to-end network integration, including:
  - Network design and engineering;
  - Installation and implementation;
  - System integration;
  - Network and operations management;
  - Disaster and fault recovery plans;
  - Project management;
  - Service delivery

Network Evolution to a Converged Scenario

- **Benefits from a Network integrator partnership:**
  - **Recommended as a trusted and experienced allied that understands the company needs, its communication processes and the underlying networks;**
  - **Can assist the adoption and implementation of the required network transformation;**
  - **Leveraging a comprehensive methodology with a full range of end-to-end network lifecycle capabilities;**
  - **Utilities are able to maximize their revenue opportunities in a cost-controlled manner;**
  - **By defining a proven set of benchmarked processes, a network integrator can manage organizational changes and deliver both the required network and IT expertise for a successful network transformation that supports the evolved business models and processes;**

Network Evolution to a Converged Scenario

- **Examples of converging network performance indicators :**
  - **Delivery time;**
  - **Number of end nodes;**
  - **Basic network topology;**
  - **Number of switches between end nodes;**
  - **RTE (Real Time Ethernet) throughput;**
  - **non-RTE bandwidth;**
  - **Synchronization accuracy;**
  - **Redundancy recovery**

Conclusions

- This paper raised some aspects to be considered in the upcoming converged network scenarios for the corporate and operational processes in an electric power substation plant.
- Some practical examples of modern IP multimedia network architectures have been presented to illustrate the present trend in telecommunication and IT cases.
- Convergence is a beneficial but challenging process and spans over technical, operational, cultural and organizational aspects.
- A network transition plan is therefore critical for utilities in order to benefit from the convergence trend.
- With these regards, relevant network related suggestions have been brought including network integration, performance indicators and requirements.

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Thank you!