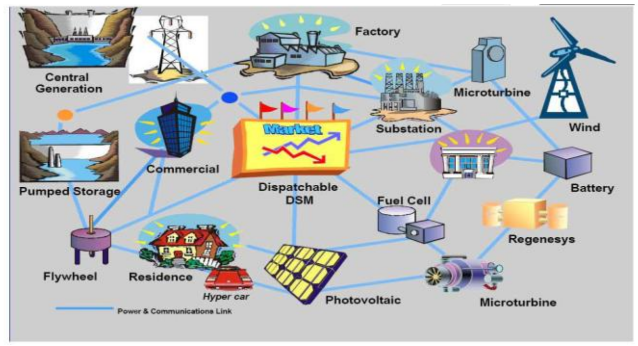
QT e-News™
Quanta Technology's Online Newsletter
QUANTA TECHNOLOGY
Volume 2, Issue 3 Summer 2011

Planning of Smart Distribution Systems:
Trends and Emerging Needs

By
Dr. Julio Romero Agüero



Economic, political, environmental, social and technical factors have prompted the emergence of the smart grid concept. Power distribution systems are arguably the element of power delivery infrastructures where smart grid technologies are likely to have the most significant impacts. The smart grid concept has driven the coordinated and integrated application of existing power, communications, control, and information technologies at distribution system level. Furthermore, it has encouraged the development and implementation of new technologies, tools and approaches for optimizing the operation of distribution systems, empowering customers, and creating new products and services. Expectedly, all these factors have also contributed to the emergence of new issues, challenges, and changes in distribution operations and planning. From a planning perspective, the criteria, guidelines, methodologies and tools to plan the transition from the existing (conventional) to the smart power distribution system is an area where there is an increasing need for solutions. This article discusses some of trends and emerging needs in this area. A broader discussion of this subject will be presented in an upcoming article to be published in the September issue of IEEE Power and Energy Magazine.

Multiobjective optimization

An important aspect of distribution

Continued on page 3

Communications Network Errors and Their Influence on Current Differential Relaying

By
Dr. Solveig Ward

The same physical fiber pair that carries a single channel 64 kbps relaying data could be used for up to OC-192 (10 Gbps) or GigaBit Ethernet.

To use an available communications network for relaying makes sense from an economical standpoint. However, even with digital communications, the network is not error free. While many links are optical fiber which are immune to electrical interference, most networks incorporate wired links or microwave paths in their design. Attenuation on long fibers, synchronous clock inaccuracies causing frame slips, etc., contributes to the errors. For evaluation, protective relays are subjected to extensive bench or simulator testing with injected currents and voltages but the vital communications link that is integral to the operation of a current differential relay is excluded by connecting the relays back-to-back. The results are thus valid for a direct fiber application but not necessarily so over networked communications.

Continued on page 6

INSIDE THIS ISSUE

Letter from the President

Dear Colleague,

As the Quanta Technology staff continues to grow, we are pleased to provide you with an increasing array of thoughtful and timely subjects. In this issue, we share several issues being learned during smart grid initiatives implementation:

- *Planning of Smart Distribution Systems: Trends and Emerging Needs* discusses the need for more comprehensive planning tools that include capabilities for effectively dealing with the challenges introduced by the evolution of the power distribution system and the implementation of smart grid technologies. This topic will be discussed in further detail in an upcoming article that will appear in the *IEEE Power and Energy Magazine*, September/October 2011 issue.

- *Communication Network Errors and Their Influence on Current Differential Relaying* focuses on handling critical protective relaying signals in utility communication infrastructures designed to facilitate increasing volume and diversity of information.

- *Utility Communication Networks: Not just an afterthought anymore*! explores the process for evaluating current capabilities and preparing a strategic plan for serving evolving communication needs.

An additional article, *Economic Benefits of Energized Work on Electric Power Facilities,* explores a methodology to assess the cost/benefit potential of performing transmission live-line maintenance and construction work. This is becoming an increasingly important issue for needed transmission maintenance and upgrades while keeping critical lines in service. This article is based on a discussion panel at the IEEE ESMO Conference & Exhibition held in May, 2011 at Providence, RI.

Included is an update of Quanta Technology's international activities and industry experts who have joined our team.

On a lighter note, Quanta Technology celebrates its 5th anniversary. See page 5 for the announcement!

As always, we look forward to receiving suggestions for future topics and discussing any subject with you.

Sincerely,
Damir Novosel - President

Utility Communications Networks:

Not just an afterthought anymore!

By
David Boroughs

Telecommunications networks in electric utilities have undergone a tremendous transition over the last few years. Networks have evolved from multiple independent single purpose (i.e. SCADA-only or Corporate specific networks), to more of a single platform network, supporting different data types (core operational vs corporate admin data), each type with its own performance requirements. Historically, operational networks were based on point-to-point Time-Division Multiplexing (TDM), with corporate networks based on packet-based technologies, more recently including Ethernet and Internet Protocol (IP). Now in the new age of "convergence", managed Ethernet and IP are viewed as the platform of the future, evidenced by a wide variety of vendor offerings. To accommodate protocols associated with more time critical applications, Multi-Protocol Label Switching (MPLS) is being introduced as a way to accommodate connection-oriented "pseudo-wire" transport to better meet latency and performance requirements. Now, with overlay requirements for Smart Grid on top of the telecommunications infrastructure, the utility has communications challenges that have never before been encountered—what to do!

Problems to Solve

The utility needs a telecommunications strategy that can answer some key questions:

- Can the existing network infrastructure support present and future requirements?
- If not, what will it take to rehabilitate/enhance the network to meet the requirements in terms of technology, cost, and resources?

If rehabilitation and/or enhancements are needed, a reasonable goal is to develop a five-year telecom-

Continued on page 9

Continued from Page 1

Planning of Smart Distribution cont.

planning in a smart grid world is the decision making process for selecting the locations of the numerous new equipment and technologies that are expected to be deployed in the distribution system and the variables that should be taken into account during this process. Methodologies and tools are required, for instance, for determining the optimal location of equipment such as Distribution Automation (DA) switches and reclosers. It is worth noting that the location of this equipment has a direct impact on reliability, distribution feeder losses and voltage profiles. At the same time new switched capacitor banks and modern line voltage regulators are being installed on distribution systems to reduce losses, control voltage profiles and implement approaches such as Volt-VAr Optimization (VVO) and Conservation Voltage Reduction (CVR). If Distributed Generation (DG) and Distributed Storage (DS) are also considered the problem grows in complexity since the effects of all these equipments are interrelated. Therefore, location selection must consider all the aforementioned variables (reliability, losses, voltage profiles, etc); this can be done via multiobjective optimization techniques, which have the goal of achieving solutions that satisfy a series of objectives instead of a single one.

Computational models

A limiting aspect of modeling and simulating the benefits and challenges introduced by smart grid technologies is the fact that the computational models of some of these technologies are still not available in commercial tools or simplified models are used instead. Examples of these are dynamic models of some (DG) technologies, stochastic-based reliability models, and models of DA and self-healing schemes.

For instance, in the specific case of dynamic models for DG impact analysis, conventional distribution analysis software includes standard tools such as power flow and short-circuit analysis, however, for intermittent DG impact studies is necessary to conduct specialized power flow analyses to estimate the impact of DG output fluctuations on feeder voltages. This type of analyses is difficult to conduct using conventional distribution system software. For instance, since DG output variations can be faster than the delay time of Load Tap Changers (LTC), line voltage regulators, and voltage-controlled capacitor banks, it is possible that feeder voltage violations occur before the operation of these devices. Unfortunately, several distribution analysis software do not have this type of capability and those that have it require specialized skills and rather complex and time-consuming script language programming work to conduct this type of analyses.

Another area where further work is required is the development of models for implementation and estimation of benefits of advanced DA schemes. Existing distribution reliability assessment tools allow estimating the spatial distribution of reliability, modeling DA equipment in full-loops and half-loops, and considering capacity constraints during upstream and downstream restoration. Figure 1 shows an example of this type of analysis, the diagrams show estimated system reliability before (left) and after (right) implementing a portfolio of improvement projects that include this type of equipment, areas colored in tones of red have poor reliability and those in tones of blue have good reliability. Improvement is evident.

However, specialized tools and models are required for evaluating reliability improvements due to more

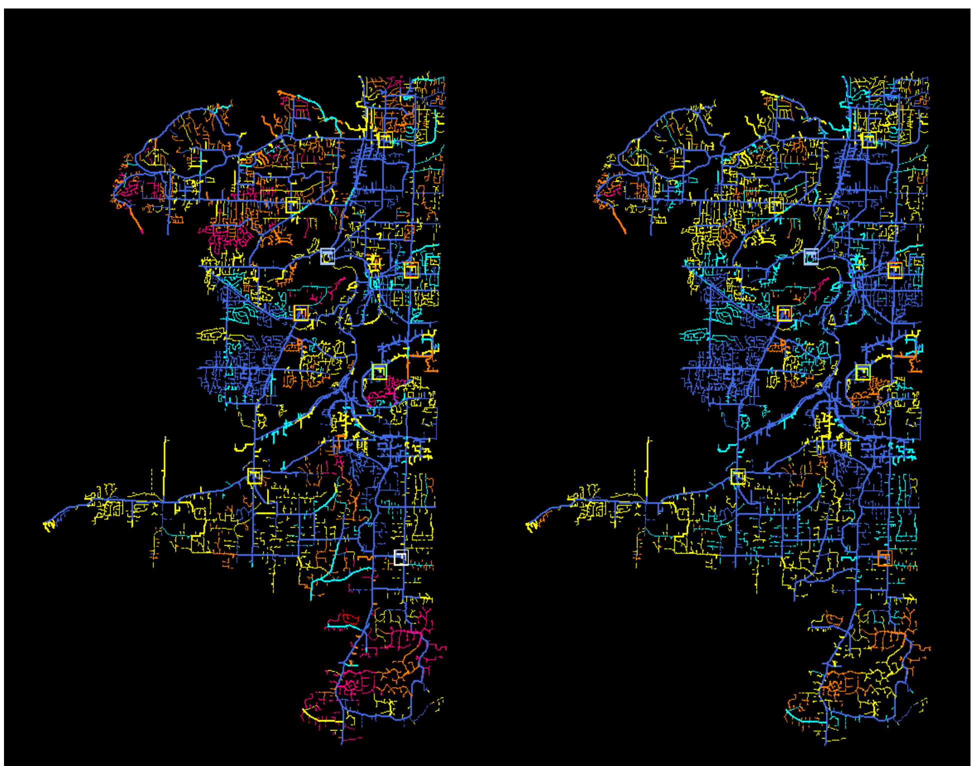


Figure 1 – Spatial distribution of reliability

Continued on Page 4

Cont from Page 2

Planning of Smart Distribution cont.

complex self-healing schemes. As using these types of devices and approaches becomes more common, it is necessary to incorporate these capabilities in standard tools. Furthermore, additional capabilities for stochastic-based reliability analysis that allows modeling failure rates and repair times of distribution system component using probability distribution functions are needed to conduct risk analyses. These capabilities allow a more detailed modeling of distribution reliability that is becoming increasingly popular for utility analysis, but still not available in most distribution analysis software.

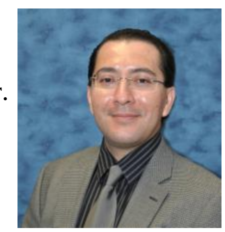
Batch processes

Finally, the implementation of smart grid technologies is giving distribution planners access to a variety of hourly and sub-hourly data and detailed computational models of distribution feeders that can be used to conduct more accurate distribution system studies, such as detailed hourly voltage profile, loading, and power and energy losses calculations. Since hourly data is becoming easier to obtain, the ability of conducting 8760-hour batch processes using distribution system analysis tools is becoming more important. Some of the benefits of using this type of approaches is increasing the accuracy of results and avoid using simplifications and "rules of thumb" (e.g., loss factors). An important aspect of 8760-hr batch studies is the need for processing the large amount of data obtained from the simulations and conduct risks analyses to draw conclusions that can lead to practical implementations. Other applications of batch processes are Plug-in Electric Vehicle and DG integration studies, which may require conducting thousand of power flow simulations to assess a combination of different market penetration rates, loading conditions and PEV and DG potential locations. Figure 2 shows an example of this type of application, the chart presents the voltage profiles of a real distribution feeder, for simplicity only 24 hours are plotted, each dot represents the voltage of a feeder node at a specific hour of the day. These results allow planners determine the range of voltage variations experienced by customers, and any potential voltage limit violations that they may experience. Similar analyses may be used to determine the range of annual or seasonal variations that they may experience, or to calculate annual feeder losses.

Conclusions

The modernization of power distribution systems is leading to the emergence of a series of challenges to the way distribution systems are planned and operated. Smart grid technologies are providing distribution engineers with abundant data to conduct detailed analyses. Some of the applications required for conducting these studies are available in commercial distribution analysis software. However, some of the key features, such as the ability of conducting batch processes, although available in some tools, generally demand of specialized skills and its utilization is complex and time-consuming. This is an area where further improvement is required and where collaboration between industry members (utilities, consultants, software developers, and academia) is decisive. Besides developing its own state-of-the-art tools that address some of these critical needs, Quanta Technology is contributing to this area by identifying gaps and recommending improvements to existing tools that facilitate the planning and analysis of the smart distribution grid.

For further information, please contact Dr. Julio Romero Agüero at julio@quanta-technology.com



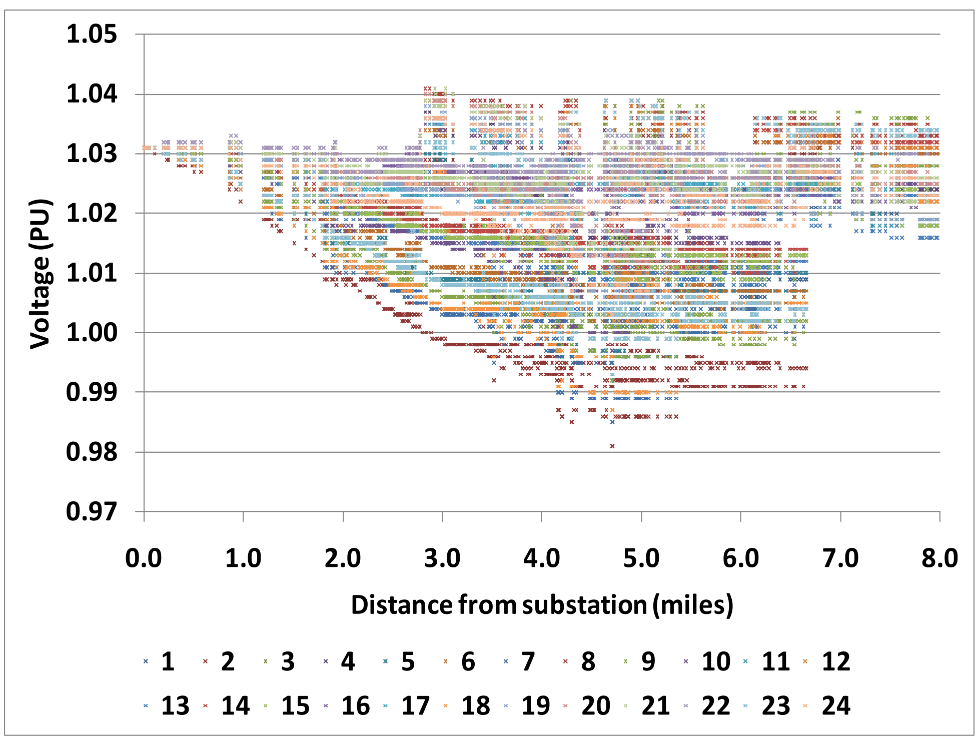


Figure 2 - 24 hr feeder voltage profile

Fun Facts about the Number 5

The number **5** is a most remarkable number! It has been used and incorporated into all facets of our lives:

Money	TV shows
Perfume	Celebrations
Movies	Songs

And it describes countless facts – like **5** fingers, **5** senses, **5** tastes. But this most important fact about the number **5** is that ...

There are 5 oceans in the world: Atlantic, Arctic, Indian, Pacific, and Southern

Quanta Technology is 5 years old!

On July 6th, 2006 Quanta Technology started out with three guys who believed that there were other engineers out there just as committed to expertise, research, and thought leadership as they were: And that there were people who would want to join in an organization dedicated to useful, innovative and game-changing projects that would help the power industry not just meet, but prevail against, the challenges of the 21st century.

Today Quanta Technology is over 100 of the brightest and most committed experts in the power industry. We are a recognized industry leader - respected by our clients and competitors alike. And our success is due to the expertise, dedication, and particularly teamwork, not only amongst ourselves but with our clients and customers.

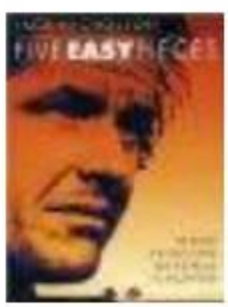
We look forward to many more years of service to the industry and our friends.

Damir Novosel, President

There are 5 rivers of Hades: Acheron, Cocytus, Phlegethon, Lethe, and

Famous TV Series

Famous movies



Celebrations

The 5th of May commemorates the victory of the Mexican militia over the French army at The Battle Of Puebla in 1862

The Fifth Dimension

The number 5 is the 5th Fibonacci number

Communication Network Errors cont.

Power Systems Communications

Protective relaying is one of many services provided over the utility communications network.

The requirement of high speed data transfer for relaying is recognized by utility telecoms specifications. Protective Relay service requires the shortest Process Response Time of all power system communication services and unlike most other communication requirements, requires short, deterministic, symmetrical latencies.

Communications Requirements

Data is intrinsically different from voice. By definition, data is information which originates in the form of digital representation (binary 1s and 0s) and therefore does not need to be converted to digital within the network, unlike voice that originates from the telephone microphone as an analog signal.

There are several key differences between the characteristics of voice and data and hence the different requirement for successful communications. To complicate matters, pilot protective relaying communications have requirements that are a mix of data and voice. By nature, pilot communications are data but have to operate in real-time, as does voice. However, the relatively high error tolerance and relatively moderate latency requirements for voice are not acceptable for pilot relaying. This poses a challenge for the telecom engineer as the typical configuration used for voice or data circuits may not meet the requirements of protective relaying.

Communications Considerations

A recent report by UTC Research identified reliability as the number one criteria for utility communications

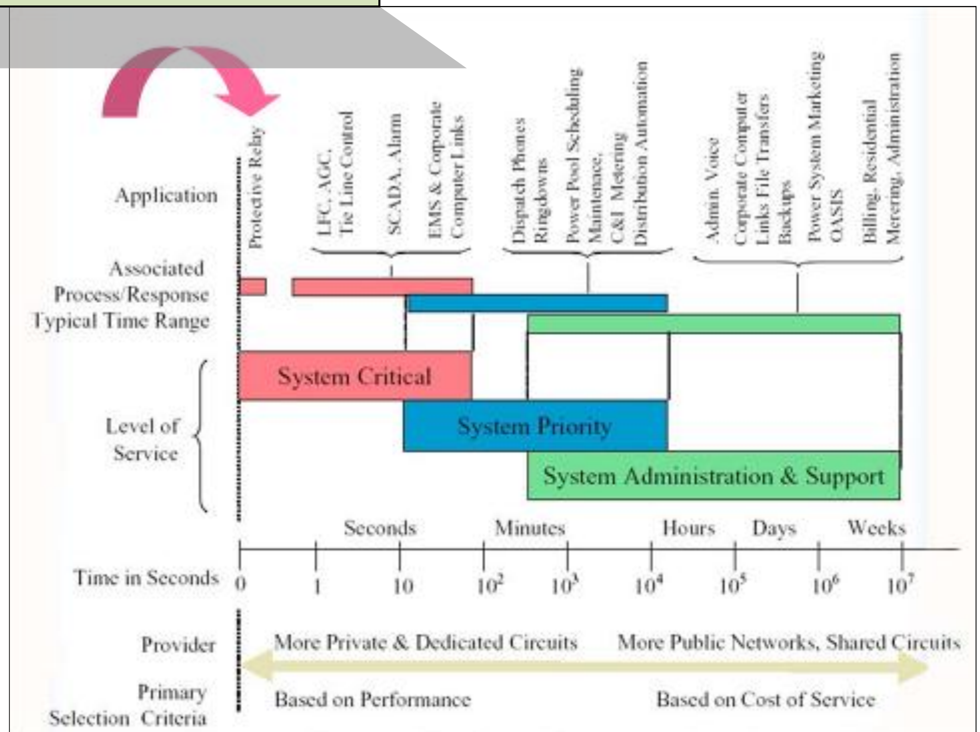


Fig 1. Power Systems Communications

	Data	Voice	Pilot Relay
Delay (latency) tolerance	High	Moderate/Low (50 - 100 ms)	Very low (<20 ms)
Asymmetry and variation in delay tolerance	High	Moderate	Very low
Stream/burst transmission	Bursts	Stream	Stream
Error tolerance	Low	High	Very low
Packet/data loss tolerance	Moderate, by the application requesting retransmission	Some data loss is acceptable until voice quality becomes too low	No
Interruption tolerance	Yes, by the application requesting retransmission	Moderate (100 ms)	None/very low
Protocol standard	Proprietary / standardized	Standardized	Proprietary

Table I. Communications Requirements

Continued on Page 7

Continued from page 6

Communication Network Errors cont.

networks. When a digital communications system is used for teleprotection or pilot protection, the dependability and security of the communications network has to be taken into account for overall protection system reliability.

Of particular concern for relay communications over digital channels are timing issues such as end-to-end delays, variable delays, asymmetry, and interruptions.

While a relay may work perfectly over a dedicated fiber, availability of the protection scheme when communicating over a network may not be as high. The reasons are often hard to pinpoint but are likely due to incorrect configuration of intermediate devices (multiplexers) or network errors and switching operations requiring re-synchronization of the protective relay device.

Network Errors

Digital communications networks are not error free. Errors are caused by transients induced in metallic wires (or devices), equipment failures (a faulty device may send out a garbled bit stream), temperature variations, changing atmospheric conditions of microwave links, excessive attenuation, clock inaccuracies, etc.

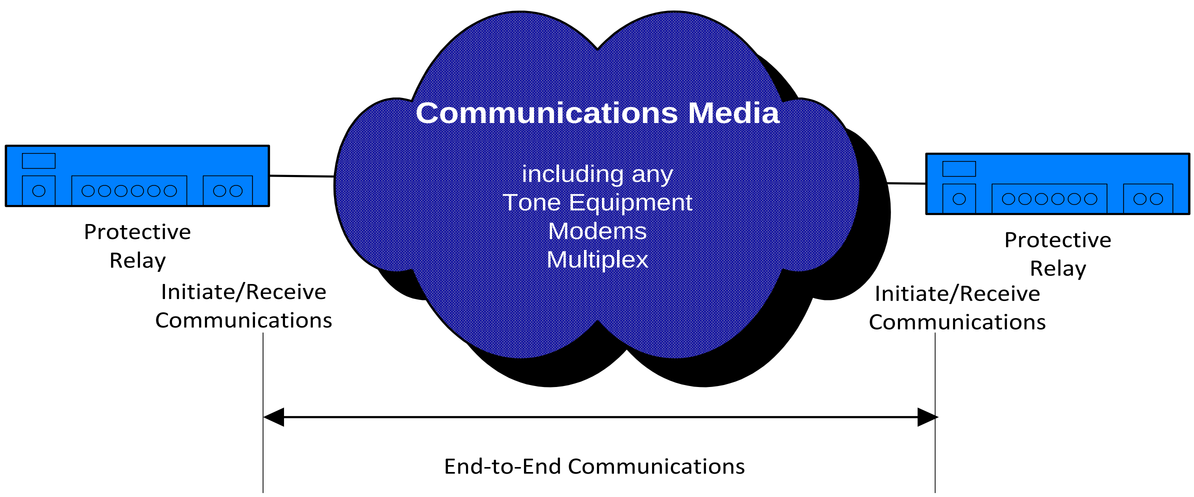


Fig 2. Protective relay communications

Current Differential Relaying Basics

Current differential relaying is a method of extending the benefits of differential protection as applied to transformers, buses or generators to the protection of transmission lines. Comparing current flowing into a line to the current flowing out of the same line allows for a simple protection scheme with high sensitivity and high speed simultaneous tripping of all line terminals.

A remote quantity containing the current information needs to be transferred to the local end for comparison to the local current. The quantities to be compared have to be time-coincident and the magnitude and angle information of the remote current must be preserved.

Referring to Figure 3, for an internal fault, the current will flow into the line from both line terminals, with the polarity of the current transformers as shown in the figure. The local current I_L will be practically in phase with the remote current I_R. For an external fault, the current will flow into the line in one terminal and out of the other. The local current I_L will be 180 degrees out of phase with the remote current I_R and they will be of equal magnitude.

Common to all current differential relays is the need of a reliable communications channel

Bit Error Testing of Current Differential Relays

The purpose of the test was to record availability of current differential relays when subjected to bit errors

Continued on page 8

Continued from page 7

Communication Network Errors cont.

The make and model of these relays are of no importance; they are all commercial products that are in wide use. The sole purpose of the test was not to compare brands but to answer the questions:

What requirements with regards to BER does current differential relaying put on telecommunications networks?
Should relay bit error rate testing be part of relay evaluation testing?

The three relays were equipped with C.37.94 interfaces, each of them using one 64 kbps channel over the E1/T1 substation multiplexer. The T1 communications link was routed via a noise generator, injecting an adjustable level of noise onto the T1 circuit. The average BER was measured with a BER tester, connected to a channel card on the multiplexer.

Testing was made with different average Bit Error Rates and the resulting availability recorded in Table II.

The tests show that all relay performed well for BER 10^{-6}.

Typical error rates for copper and optical transmissions are in the range 10^{-10} to 10^{-14} therefore a requirement of $<10^{-6}$ should be easily met during quiescent conditions. (As a comparison, cellular wireless networks can have BER as low as 10^{-3} to 10^{-6}.)

Differences between the relay designs started to show up for BER 10^{-5} and worse. The differences are likely due to differences in the design when it comes to the time required for recovery following a channel interruption.

However, the results show that there is not much difference in the availability for a BER that could be expected on a network which leads to the conclusion that network design is the dominating factor when it comes to protective relay scheme availability.

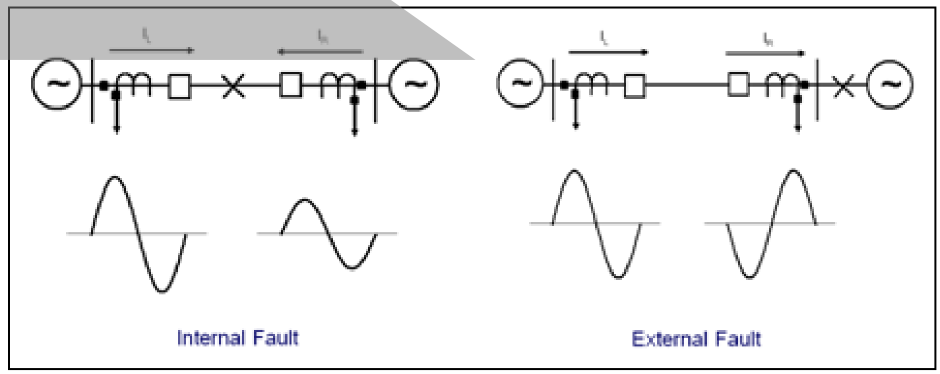


Fig. 3 Current differential relaying

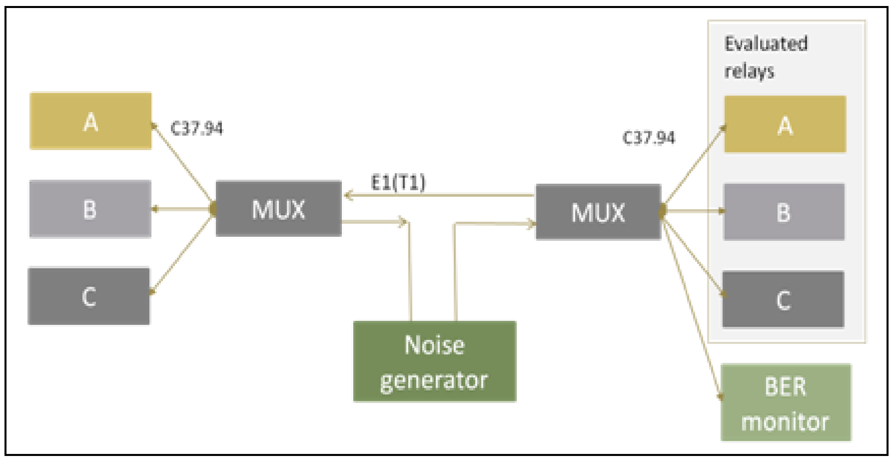


Fig. 4 Bit Error Rate Test

BER	Availability (%)		
	Relay A	Relay B	Relay C
10^{-6}	100	100	100
10^{-5}	72	96	100
10^{-4}	46	0	100
10^{-3}	50	0	51

Table II. Relay availability during Bit Errors

Continued on Page 14

Continued from page 2

Utility Communications Networks Cont.

munications strategy for the enterprise. This strategy should include an investment plan and associated justifications for recommended capital projects. The five-year timeframe is viewed as long enough to incorporate corporate strategies for long-range IT investment planning but short enough to allow flexibility to accommodate changing technology.

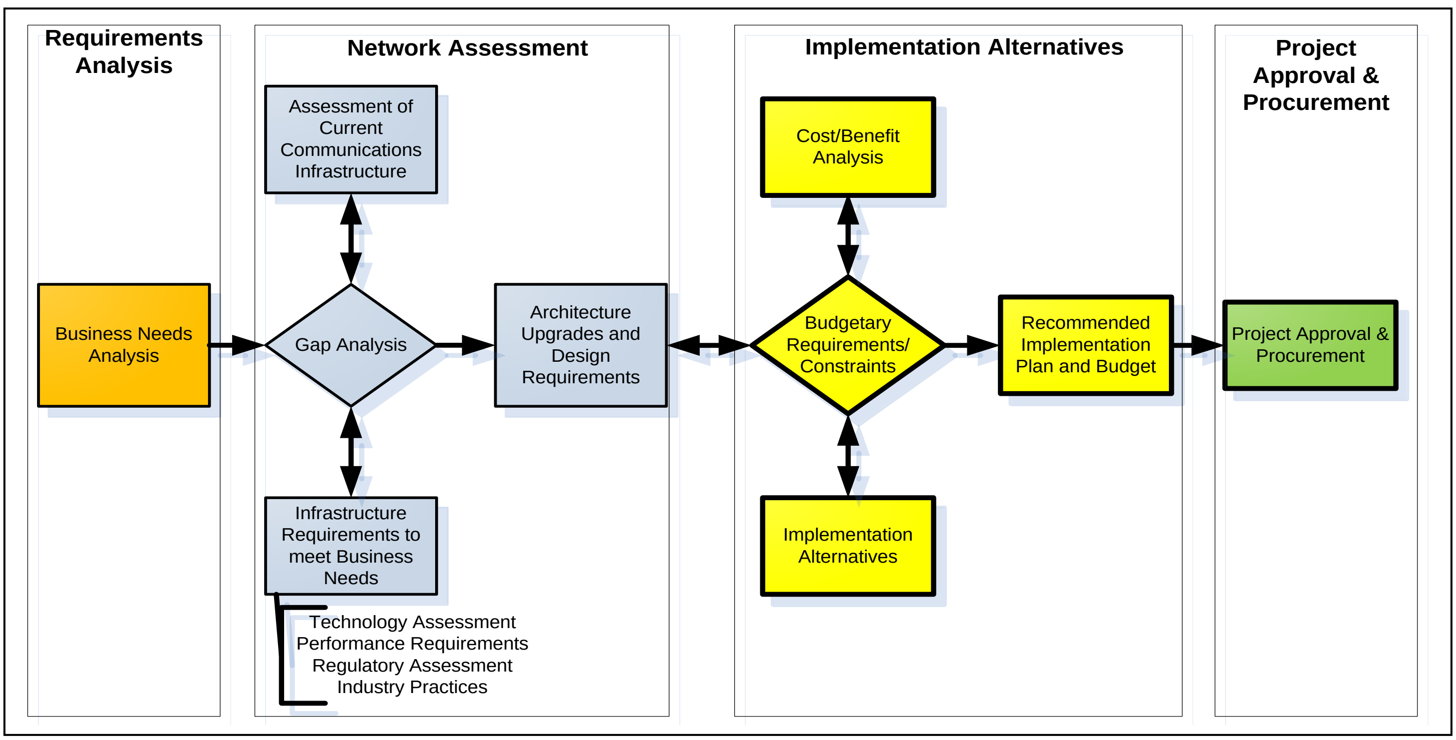
Required Outcomes/ Objectives

The objectives of the telecommunications strategy should:

- Identify the current state of the networks and technologies employed by the utility and evaluate the strengths and weaknesses of its present network implementations as compared to other enterprises in the energy services sector.
- Determine the networking needs of the utility going forward.
- Gather information on network technology trends and assess their applicability to the applications of interest.
- Develop architectural designs for implementation of new networks and/or migration of existing networks that will meet the needs of the utility.
- Recommend steps the utility should take to evolve the architecture.
- Estimate costs (including capital, operations and maintenance expenditures, etc.) of investment in network infrastructure over the next five years.

Network Strategy Development Model

The network planning and optimization methodology is depicted in the figure below.



The first step in the development of the design required is a ***Business Needs Assessment/Analysis***. This is accomplished by interviewing various Business Units within the utility, including transmission, distribution, operations, as well as IT and corporate, and defining current and future requirements in terms of communications traffic load. In the second step, the findings and requirements of the Business Needs Assessment are overlaid on the existing network infrastructure. A ***gap analysis*** is then performed to identify to what extent the existing networks may not meet the needs of the business units. Finally, based on a ***cost/benefit analysis*** and taking into account ***budgetary requirements and constraints*** of architecture upgrade requirements, ***implementation alternatives*** are developed to guide the network's migration towards the target

Continued on Page 10

Continued from page 9

Utility Communications Networks Cont..

architecture, i.e., "where it ultimately needs to be". A recommended plan with all the necessary justification is presented to receive ***project approval*** and advancement to the ***Procurement*** phase.

Gap Analysis

A gap analysis determines what is deficient and the cost to resolve what is required, so priorities and budgets can be set. The overall results can be depicted in a "dashboard" summary matrix (shown below)

NETWORK		DESIGN ENGINEERING ACTIVITY												
Pri. Assn	Sub-Network / Element / Technology / Application	Assessment Conclusions							Design Activity			*Investment Plan*		
		Maturity Assmnt	Congest Anal	SPF Anal	Wrkld Proj	Tech Assmnt	Pltfrm Assmnt	Futures Assmnt	Arch Design	Migration Path	Comparison Analysis	Invstmnt Anal	Benefit Anal	Prjct Recom
Voice														
Network	VoIP vs Circuit Switched Voice architecture					(green)	(green)	(green)	x (cyan)	x (cyan)		(green)	(green)	(green)
	Region 1 WAN Upgrade Design	(yellow)	(green)	(yellow)	(red)	(red)	(red)	(red)	x (cyan)	x (cyan)		(red)	(red)	(red)
	Region 2 WAN Upgrade Design			(red)	(yellow)	(yellow)	(red)	(red)	x (cyan)	x (cyan)		(red)	(red)	(red)
Wide	Core Operation TDM (Multiplexer, DACS)	x	x	x		x	(red)	(red)	x (cyan)	x (cyan)		(red)	(red)	(red)
Area	MPLS Backbone Feasibility	(red)	(yellow)	(yellow)	(yellow)	(red)	(red)	(red)	x (cyan)	x (cyan)		(red)	(red)	(red)
Network	Enterprise Telephone Network	(green)		(yellow)		(green)	(green)	(green)	x (cyan)	x (cyan)		(green)	(green)	(green)
	Enterprise Voice-Mail Network	(red)		(yellow)		(yellow)	(yellow)	(yellow)	x (cyan)	x (cyan)		(yellow)	(yellow)	(red)
	Traditional V-Mail vs. Unified Messaging					x		x	x (cyan)	x (cyan)	x (cyan)	x	x	x
	OTN vs. SONET in the Transport					x		x	x (cyan)	x (cyan)	x (cyan)	x	x	x
	GigE vs. MPLS in the Backbone					x		x	x (cyan)	x (cyan)	x (cyan)	x	x	x
Local	DA/AMI Infrastructure Assessment					x		x	x (cyan)	x (cyan)	x (cyan)	x	x	x
Area	LAN Wireless vs Wireline										x (cyan)			
Network														

LEGEND		
SIGNIFICANT INVESTMENT REQ'D	(red)	deficiencies noted that contribute to significant investment needed to meet Five-Year Planning Requirements
MODERATE INVESTMENT REQ'D	(yellow)	requirements marginally met, a moderate level of investment required to meet Five-Year Planning Requirements
MINIMAL INVESTMENT REQ'D	(green)	requirements can be met with minimal routine investment over the Five-year Planning period
STRATEGIC PLAN DEVELOPED	x (cyan)	designs and migration plans developed and included in the design document and capital investment plan
TECHNOLOGY & INVESTMENT ROADMAP DEVELOPED	x	assessments that influenced architecture designs and migration pathing, and likewise corresponding capital investment requirements

New Technologies Have to Show Cost-Effectiveness

With any new technology, the die-hard technologist can be like a kid in a candy store. But realistically, requirements drive the technology, not vice versa. Features of a new infrastructure should be weighed with a cost/benefit analysis and quantified to the greatest possible extent. This will enable the needed investment to be put in a context best understood by management.

Two Considerations: Cyber Security, Integrated Network Management

A cyber security plan and vulnerability analysis should be part of any telecommunications strategy and to ensure compliance with NERC CIP requirements for data and infrastructure protection. Cyber Security policy involves electronic security perimeter monitoring, interactive multi-point video monitoring, and alarm and event archiving systems. The plan may include the use of video-monitoring

Continued on page 17

Smart Maintenance/Construction and the Economic Benefits of Energized Work on Electric Power Facilities

By
Dr. David Elizondo

Introduction

The demand for availability and reliability of electrical power service has resulted in increased use of energized work. For particular maintenance and construction activities in electric power facilities, energized work has become the preferred alternative over de-energized work. A significant number of maintenance and construction activities for high voltage transmission lines, typically 115 kV and above, are nowadays performed energized and without the need to take the transmission line out of service. This is also the case to avoid shutdowns of large base load generation units. An increasing number of maintenance and construction activities at the power plant electrical switchyard, which connects generating units to different circuits into the transmission grid, are performed energized and without the need to shutting down the generating units and disconnecting them from the transmission grid.

In general, high voltage transmission lines, particularly 220-230 kV and above, contribute considerably to the reliability and economic operation of a power system. There is a significant impact of taking these key facilities out of service (even if at all possible) on power system reliability and economics. This condition has driven electric power utilities and the industry to analyze and include the alternative of performing the maintenance and/or construction activities using live work techniques.

There are particular maintenance and construction activities for electric power facilities and power system components that have proven to be more economically viable using energized work techniques, in particular, maintenance and upgrade of key existing facilities.

Based on the experience from multiple field projects in which energized work has been applied for more than 15 years and a recent internal research and development effort by Quanta Services, this article presents economic and social benefits of energized work for maintenance and construction of electric power facilities.

2-Drivers and Benefits of Energized Work

Energized work is related to all maintenance and construction activities performed on electric power facilities while they remain in service and supplying energy maintaining reliability and asset owner revenues.

Personnel safety has always been the biggest concern when performing energized line work. To assure safety, energized transmission work has been traditionally performed on a very limited basis by specially trained and qualified crews who receive meticulous and ongoing training. Each work assignment is rigorously planned and “tail–boarded”, so that each member of an energized work crew knows exactly what the tasks are and when each task is to be performed by each crew.

Traditional energized work has been performed over the years as direct “bare-hand” by crew members in insulated bucket trucks, via crew member held insulated “hot sticks”, or by installing temporary towers/poles. While traditional energized work is still in wide use in the electric power industry, it has major limitations such as: (1) the apparatus weights are limited to those that can be manually handled and (2) the approach to lines and apparatus from adjacent energized equipment is constrained to OSHA specified safety distances [1].

An innovative solution to resolve these limitations, which has been developed by Quanta Energized Services field lineman and patented, is the use of ground-based, insulated, heavy-lift robotic arms that are mounted on boom trucks or cranes. These robotic arms are able to capture and remove energized conductors from their structures, continue to support the energized conductors, and assure safe working areas for lineman while the lines remain energized during the execution of the projects. Detailed descriptions about ground based robots and field projects in which they have been utilized can be found in [2].

Continued on page 12

Continued from page 11

Smart Maintenance/Construction cont..

2.1 Energized Work Drivers

The increasing single and fundamental driver that has spurred the demand of energized work is the inability to obtain a facility outage. For particular transmission lines, this is based on increasing difficulties in obtaining scheduled line outages to perform work de-energized and the lack of new rights-of-ways to add or upgrade transmission corridor capacity. For large generation plants, taking the generating unit out of service has direct and adverse impact on the economic operation of the system and revenue to the plant owner. A similar case applies for large industrial loads such as mines and other large industrial critical processes. In summary, a facility outage has many implications based on a wide range of factors as will be described in detailed in Section III of this article.

Energized work practices are increasingly used across the electric utility industry in many countries to accommodate needed transmission and generation switchyards infrastructure upgrades. These projects are designed to support maintenance and repair, aging infrastructure renewal, and additional line capacity to relieve congested corridors and accommodate additional generation interconnect-tion. In general, based on past project experience, energized work has been justified based on the following factors:

1. Increased difficulties to schedule a line outage as the lines most in need of relief are usually those difficult to schedule out of service
2. Avoids increasing congest-ion over already congested paths by scheduling line outages. In many cases, the customers are charged congestion fees on requested outages.
3. Avoids increase in opera-tional costs due to generation re-dispatch
4. Minimizes safety risks of equipment switching and grounding and associated delays
5. Minimizes capital invest-ments, such as new rights of way, while improving reliability
6. Potential for energized work to be safer than de-energized work based on more strict safety procedures

2.2 Energized Work Benefits

In general, based on the above drivers and past project experiences, energized work has been categorized into the following benefits:

1. Avoided congestion fees and minimization of revenue losses
2. Reduced manpower
3. Increased Safety
4. Avoided service interruptions to customers
5. Reduced or eliminated the need of new right of way and its environmental impacts
6. Avoided outage scheduling
7. Maintained power system reliability
8. Avoided possible reliability violation penalties from relevant regulatory bodies

To complement this information gathered through the years, a systematic methodology to classify, define, and quantify the economic benefits of energized work in monetary terms has been developed as part of an internal Quanta Services Research and Development effort which is presented in the next section.

3 Methodology to Evaluate the Benefits of Energized Work

This section presents the methodology intended to identify the most conceivable potential benefits that could be derived from energized work in electric facilities. The methodology is intended to be used by managers, maintenance planners and engineers who are working in the planning stages of a project in order to include energized work techniques as an option to execute maintenance and/or construction of electric facilities.

The methodology is intended to capture all potential benefits in a number of business units of the electric power industry including traditional regulated utilities and utilities which operate in unregulated electric markets administered by an ISO or RTO. Regardless of the electric utility structure, the business units to be impacted are planning, operations, wholesale power trading, reliability, maintenance, regulatory, public relations and customer service.

The benefits associated to the previously mentioned business units are quantifiable by mathematical equations and could be estimated using historical or forecasted operation, market, and trading data. Other benefits such as maintaining or improving reliability, public image, and customer satisfaction are subjective and are estimated based on judgment.

Continued on page 13

Continued from page 12

Smart Maintenance/Construction cont..

The data sources, such as cost of energy, to quantify and support the decision of energized work includes public information from government entities, regulated electric utilities, Independent System Operators (ISO) and Regional Transmission Organizations (RTO) in countries supporting unregulated electricity markets, and commercial third party electric market simulation ready databases.

In the methodology ten (10) metrics are defined to quantify the benefits of energized work in electric facilities. The metrics are classified in the following four areas: a) impact on power system operations, markets, contractual obligations; b) impact on utility crew operations; c) impact on reliability; and d) impact on public image and customer satisfaction.

3.1 Metrics related to Power System Operations, Markets, and Contractual Obligations

The following are five metrics related to power system operations, markets and contractual obligations.

1. Dispatch/production cost - Impact on utility or ISO generation commitment and dispatch scheduling. Change in commitment and dispatch will change the system incremental cost or Locational Marginal Prices (LMP) which in turn will change cost of serving load.
2. OASIS reservation, loss of revenue - Impact on the utility or RTO revenue from transmission capacity reservations on the transmission line in question.
3. Congestion/FTR revenue loss - Impact on congestion revenue for day-ahead and real-time on the path of which the transmission line in question is a part.
4. Import/Export penalties - Impact on revenue from sale of power for contractual and economy sales. Impact on saving due to purchase power for contractual and economy purchases.
5. Service Interruption Penalty - This penalty is imposed by local and state level governments for customer power interruption if the power interruption exceeds a certain time limit.

3.2 Metrics related to Utility Crew Operations

The following are three metrics related to utility crew operations.

6. Improved work safety - The more strict safety procedures and the fewer tasks make energized work in electric facilities to be potentially safer.
7. Manpower Cost - The difference in manpower cost when the work is performed energized vs. de-energized. This is related to maintenance coordination time, scheduling and preparation time, labor to perform the actual work and equipment usage.
8. Asset Owner Savings - Energized work enables the work to be performed when needed without an outage required, for an optimal use of mobilized equipment and crews as jobs could be done in succession. The normal maintenance and construction window is lengthened.

3.3 Metrics related to reliability

The following is the metric related to power system reliability.

9. Reliability - The monetary value of risk associated with reduction/degrading transmission system reliability caused by taking a line out of service to perform maintenance and or upgrades on a line. This metric provides the range of potential penalties that an ISO, RTO, or utility could be expected to pay if the line outage causes service interruption or a wide area disturbance.

3.4 Metrics related to Public Image and Customer Satisfaction

The following is the metric related to public image and customer satisfaction.

10. Public image and customer satisfaction - Outages may impact thousands of electricity end-users and affect the shares of the company in the stock market.

The applicable metrics are quantified based on the specific project details and the type of utility and ISO/RTO which administers the electric power facility. Some of the metrics provided may only be applicable to the US electric market and some may only be applicable to facilities administered by an unregulated ISO or RTO. The applicable metrics are quantified based on a spread sheet tool developed for this purpose.

4 Conclusions and Future Work

This article presented a methodology to define, classify, and quantify the benefits of energized work in economic terms was described in

Continued on page 14

Continued from page 8

Communication Network Errors cont.

Low availability over an extensive network is a factor of network design, equipment chosen, and maintenance practices.

In regards to the second question; whether BER testing should be part of relay evaluation, there is more than one answer. If the application will be over dedicated fiber, a back-to-back test without noise injection is sufficient. If the application will be over a network, perhaps it is a good idea to verify that the relay will handle BERs expected over that network.

The tested relays all performed well with a BER exceeding what can be expected on a digital communications network.

Conclusions

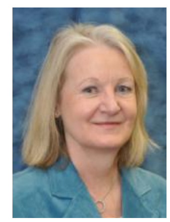
While a dedicated fiber pair is the preferred communications link for a relay engineer, this alternative is not always an option. There may be no direct point-to-point fiber available and it is also an inefficient use of capital investment as the fiber can carry much more data than just relaying, if multiplexed.

To ensure a reliable relay scheme with high availability, the network design needs to take into account and prioritize meeting the requirements by the relay scheme. This includes avoiding unnecessary intermediate devices, minimizing buffering delays, and minimizing switching operations on the network.

The tests performed verified that the relay interface is not the critical factor for availability. While the tested relays were all of different design the performance was comparable.

The tested relays all performed well with a BER exceeding what can be expected on a digital communications network.

For further information, please contact Solveig Ward at sward@quanta-technology.com



Smart Maintenance/Construction cont.

Continued from page 13

detail and for this purpose 10 (ten) metrics were defined. As the power system infrastructure experiences the stress of age, the author's intention with this article, is to stimulate conceptual ideas from maintenance or planning engineers/managers to identify energized work as a viable option for maintenance and/or construction activities in electric power facilities. As for every successful project, a multi-disciplinary team is required, the authors welcome opportunities to apply the methodology in different countries to evaluate the benefits of energized work and perform the upgrades needed to the power system infrastructure in order to maintain high levels of reliability and availability.

5 Acknowledgements

The authors of this article greatly appreciate the support from Quanta Energized Services staff.

6 References

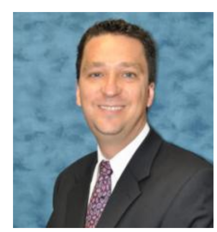
[1] Occupational Safety and Health Standards, part 1910, Standard No. 1910.269. Electric Power Generation, Transmission, and Distribution.

[2] David Elizondo, Thomas Gentile, Hans Candia and Greggory Bell. 2010. "Ground based robots for transmission line work–technology description, field projects and technical-economical justification of its application" IEEE PES Transmission and Distribution 2010 Latin America Conference.

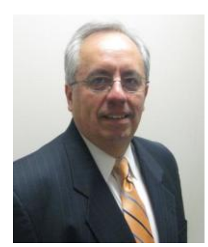
[3] David Elizondo, Thomas Gentile, Hans Candia and Greggory Bell. 2011. "Ground based robots for transmission line work–technology description, international field project applications and economic benefits" 10TH International Conference on Live Maintenance.

For further information, you may contact the authors:

David Elizondo at delizondo@quanta-technology.com



Hans Candia at hcandia@quanta-technology.com



Hamid Maghdan at hmaghdan@quanta-techology.com

We've Been Busy!

Achievements & Recognitions.

Congratulations to Damir Novosel and Solveig Ward! They were members of an elite team that were awarded the IEEE PES Prize Paper. The paper ***Performance of Relaying during Wide-Area Stressed Conditions,*** can be purchased from IEEE Transactions on PWRD, Vol. 25, No. 1, pp 3-16, January 2010.

Great job!

Congratulations to Dr. Julio Romero Aguero and Farid Katiraei for their article in the May /June issue of the IEEE Power and Energy Magazine To read the article, please use the following link: \\10.40.203.17\workgrps\Marketing\MKTG - Papers\Solar PV Integration Challenges - IEEE P&E.pdf

Congratulations go out to Bryan Gwyn and Solveig Ward on their **IEEE PES Working Group Recognition Award-Technical Report!**
This award recognizes achievements and contributions to electric power by duly constituted PESWorking Groups.

This award was for a Working Group report titled Redundancy Considerations for Protective Relaying Systems

Also available on the PSCR website www.pes-psrc.org under "Published Reports"

Upcoming Events

QUANTA TECHNOLOGY

Will again participate in
DistribuTECH 2012
in San Antonio, TX
January 24-26, 2012
Come see us at Booth #4323

EUCI

Managing Aging Transmission and Distribution Infrastructure
September 28-29, 2011, Chicago, IL

Quanta Technology is one of the major sponsors of this important event. This day-and-a-half seminar focuses on recent industry experience in managing the condition of aging electrical T&D equipment and systems. Keynote Address by: ComEd Executive VP, - Terry Donnelly, EVP, Operations. Other renowned speakers include H. Lee Willis, Founding Partner and Senior Vice President of Quanta Technology. For further information and registration, please use the following link http://www.euci.com/events/index.php?ci=1377&t=O

At the IEEE GM session in Detroit, MI, on-July 25 -26, 2011, Dr. Aty Edris has been chosen to deliver 2 papers

Damping Inter-Area Oscillations using Phase Imbalanced Series Compensation Schemes

And also

Impact of Imbalanced Phase Operation of SSSC on Damping Subsynchronous Resonance.

Promotions

Congratulations on Promotions earned by some of our outstanding Engineers

Farbod Jahanbakhsh has been promoted to Senior Advisor.

David Elizondo has been promoted to **Principal Advisor**

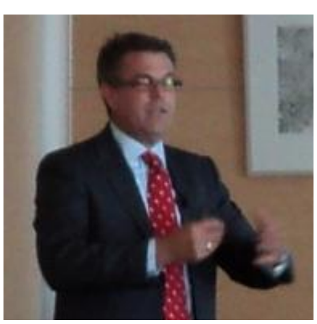
International Update

Technology Events and Trends –

Activities in Europe have been further developing during the past months. Our presentations and interaction at the ***Transmission & Distribution / Smart Grid Europe 2011*** conference in Copenhagen in April were very well received.

Copenhagen – The Little Mermaid

The key-note speech by our president Damir Novosel, the SMART-Transmission project by Tom Gentile and the Johannesburg City Power presentation on their live re-conductoring project with Quanta Energized Services were conference highlights.



Bas Kruimer at Smart Grid in Arnheim

In the Middle of May, Quanta Technology Europe gave a presentation at the ***UT Innovation Smart Grid Conference*** in Arnhem, NL, on grid evolution and phasor measurement.

Altea Spain

At the end of May, we presented at an international conference with utilities, suppliers, consultants and universities from all over the world at the ***11^{th} Electric Power Control Center Workshop*** in Altea, Spain. The presentation was on integration of phasor measurements into EMS/SCADA. At the ***CIRED 2011 Conference*** in Frankfurt, Germany, Quanta Technology presented a paper on battery storage and STATCOM with an emphasis on improving and facilitating integration of wind power into distribution grids.

Quanta Technology chaired a session at the ***PAC World Conference*** in Dublin, Ireland, at the end of June. And we are making preparation for our contributions to the ***Solar and Wind Integration Workshops*** in October in Aarhus, Denmark. At the ***IEEE-ISGT*** early December in Manchester, UK, we will be leading panel sessions on Demand Side Management and Distribution Automation as well as on Wide Area Measurement, Protection and Control.

Dublin Ireland

Aarhus, Denmark

Erasmus Bridge, Netherlands

Continued on Page 17

Continued from Page 16

integ

International Update cont.

Projects

In addition to the Marketing events outlined above, we are engaged in several projects in Europe.

The SCADA communication relocation project was finished successfully. In that project, QTE supported and structured the project management, and provided quality management while also taking the role as engineering lead.

Our market investigation on IEC 61850 Edition 2, process bus and communication performance, is well under way. It is a topic of high interest and it raises important questions within the utilities, which lead to good discussions on planning and deployment processes.

Meetings

Distribution

We are discussing self-healing grids with distribution operators, helping to improve the time that customers' power is interrupted. Also the discussions cover applying phasor measurements that will improve operations, stability, and how better to deal with congestion in distribution grids with the increasing renewable integration and CHP. This will alleviate congestion in distribution grids. These improvements would improve islanding and restoration, and serve as an early warning system that can significantly improve post mortem analysis.

Transmission

With the TSO's we are discussing deployment of phasor measurements and PM-Networks in transmission grids. The most important topics are:

- Roadmapping PM deployment
- PM locations and network design
- Supporting and improving dynamic modeling
- State estimation
- Voltage/angle stability
- Low – frequency oscillations

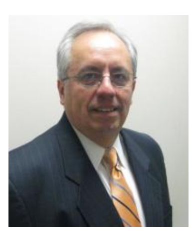
Also, we are following up with ENTSO-E (The European Network of Transmission System Operators) on their 10 year development plan for the European grid and the Modular Electricity Highway System. The leading topic is integration of large amounts of off-shore wind energy into the grid. In order to deal with all the increasing power flows in Europe, the following steps will be taken:

- Establish more interconnections
- Introduce more HVDC connections
- Better control voltage and angle stability

In other parts of the world we are pursuing business together with utilities as well. In the next newsletter we will address our activities in LAM, India and the Middle East. And we will report on the International Conference of Live Maintenance in Zagreb.

We are looking forward to a thrilling coming months in further developing our Quanta Technology business in Europe and internationally.

Bas Kruimer
QT Europe
bkruimer@quanta-technology.com



Hans Candia
QT International
hcandia@quanta-technology.com

Continued from page 10

Utility Communications cont..

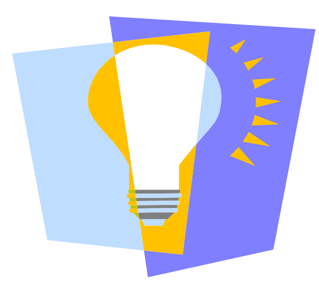
devices at all transmission substations and critical distribution substations, generation facilities, and eventually all critical facilities.

Coupled with the converged network that will support hundreds or thousands of disparate communications devices, an integrated network management system (INMS) may prove beneficial to support required maintenance response times and proactive network monitoring to ensure required service levels are adequately maintained.

Conclusion

The telecommunications strategy development provides a disciplined and rigorous approach to planning, budgeting, and implementing utility telecommunications systems which ensures reliable service and predictable budgeting and cost control.

For further information, please contact David Boroughs at dboroughs@quanta-technology.com



Quanta Technology welcomes David Boroughs

There has been a need at Quanta Technology to have a telecommunications expert. We now have one. In June 2011, David Boroughs joined the Quanta Technology family as an executive advisor in the Enterprise BA. He will be leading our consulting efforts and helping us grow our business in the telecom area.

David has 35 years of telecommunications experience, the last 8 of which has been primarily focused on the electric utility sector. At KEMA, David was involved with Telecommunications Architecture and Design projects for a number of utilities. The efforts range from development of a vision, benefit cost analysis and strategy for implementing a communications architecture solution, to infrastructure assessments including maturity assessment, technology assessment, platform assessment, and performance/vulnerability analysis. Strategy and design development included backbone transport, network management, substation and feeder automation, Smart Grid, and AMI communications architecture solutions that supports operational needs, as well as enterprise level related needs such as voice, video, IP, and back office networking requirements. He was also responsible for developing a study on substation communications for the Utilities Telecom Council (UTC) and a study on Fiber Trends for UTC. His client work includes Ameren, British Columbia Transmission Corporation (BCTC), Brookfield Power, CDEE Dominican Republic, CPS Energy, CenterPoint Energy, Consolidated Edison, Dominion, ENDESA Spain, ERCOT, Hydro Quebec, ISO New England, Imperial Irrigation District (IID), LG&E and KU Services, Lower Colorado River Authority (LCRA), National Grid, Newfoundland and Labrador Hydro (NLH), North Delhi Power Limited, Northern Indiana Public Service Company (NIPSCO), Pacific Gas & Electric (PG&E), PEPCO Holdings (PHI), Sacramento Municipal Utility District (SMUD), Southern California Edison (SCE), TeleTrans Romania, US Navy, and Utilities Telecom Council (UTC). Prior to joining KEMA, David's telecommunications career included work at GTE (now part of Verizon), Sprint, Telenet Communications, and PBS National Datacast, having increasing responsibilities in areas of engineering design, planning, implementation, and operation of wireless, copper, and fiber communications networks.

David holds a BS in Electrical Engineering from NC State University and an MBA from the Duke University Fuqua School of Business, and is a registered P.E. in North Carolina. He will be working from his home office in Burke, VA which is near the Washington, DC area.

Welcome, David!

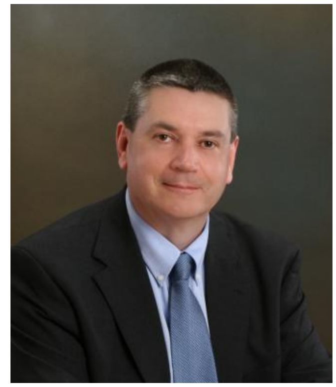
We're STILL Growing!

Andrew W. Gould, joined the Quanta Technology *Operations and Design group in June of 2011*. He recently finished his MSME at the University of Utah. He completed an internship for Puget Sound Energy(PSE) where he performed a condition assessment on a pumping station and developed a temperature predicting algorithm for a wind turbine gearbox.

John W.P. Bryant, joins Quanta Technology as a Senior Accountant. John has over 6 years of experience in the accounting field in many diverse roles. He has improved many manual accounting processes throughout his career, saving companies time and money while keeping the integrity of the data. John also has experience in SEC reporting and the detection and prevention of fraud. He is a NC CPA and a Certified Fraud Examiner and has his MBA is from Utica College

We're STILL Growing

Welcome, Bryan Gwyn



Bryan Gwyn has joined us as Senior Director in *Protection & Control Asset Management.* Bryan has 30 years experience in the Power Industry, working both in the UK and US, with extensive expertise in protection, telecommunications, control, asset management, and business management. Most recently, Bryan was the Director of Protection, Telecommunications, and Meter Engineering at National Grid USA. He has a BSEE and a PhD from City University, London, and is a chartered engineer in the UK.

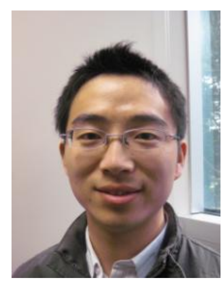
Bryan will be focusing on developing the new Business Area of Engineering Analytical Services. Due to the longer term nature of this work, we will be able to charge lower rates and will have higher billability. It will also include staff extension services. Initially, Bryan will work closely with Juergen and the Protection and Automation team while building this business. In addition, Bryan has extensive expertise in NERC compliance for protection systems, and will coordinate with Dave Hilt in this area. He will work out of his home in Massachusetts. Welcome, Bryan!

Quanta Technology welcomes Interns!

Even for the short time we have them, as they begin their careers, we are happy to welcome:

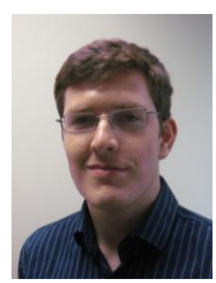
Kunal Dekhane is an intern in the Protection and Automation group. He is also a Graduate Research Assistant at the ECE Dept. at Virginia Tech. He is working in the PMU and PDC testing areas

Li Yu is a PhD candidate at Polytechnic Institute of NYU, where he is a research assistant. He is interning in the Distribution area. His area of expertise is in distribution networking with distributed generation



Vijay Sukhavasi is also an intern in the Protection and Automation gourp. And he is also from Virginia Tech. In addition to the Protection area, he is also familiar with Transmission and Distribution projects

Scott Wood is pursuing Bachelor's degree in Engineering Science at Trinity University. His studies will be completed in 2012.



William Hammett is a Student at the Charleston School of Law. His areas of Expertise are Accounting, Economics and Law. His legal contributions benefit QT as he learns about the energy industry

Heinrich Enslin has recently graduated from Southeast Raleigh High School. He is interning in the QT Human Resources Department. In addition to HR, he has had exposure to IT Technology and Engineering Design

Recent QT Publications

"A Framework for Assessing the Impact of Plug-in Electric Vehicles to Distribution Systems"
By L. Xu, M. Marshall, L. Dow

"A Novel Approach for Evaluating the Impact of Electric Vehicles on the Power Distribution System"
By L. Dow, M. Marshall, L. Xu, J. Romero Agüero, H. L. Willis

"Assessing the Impact of Electric Vehicles on the Electric Distribution System"
By L. Xu, J. Wang, M. Marshall, J. Romero Agüero, L. Dow, M. Montoya

"Dynamic Impact Studies for Integration of Large (Utility-Scale) Solar PhotoVoltaic Systems onto Distribution Systems"
By F. Katiraei, A. Yazdani, F. Jahanbakhsh, J. Romero Agüero,

"Steady State Impacts and Benefits of Solar Photovoltaic Distributed Generation on Power Distribution Systems"
By Julio Romero Agüero, L. Dow, L. Xu, M. Marshall, ML Chan

"Planning the Smart Distribution Grid"
By J. Romero Agüero, L. Dow

For a complete copy of these publications, please visit us at: www.quanta-technology.com

Please Join Us

Cigre, 2011
Sept 6-8, Halifax, Nova Scotia, Canada Julio Romero Agüero

Autovation
September 25-28, Washington DC Hahn Tram / Julio Romero Agüero

Managing Aging Transmission and Distribution Infrastructure
September 28-29, 2011, Chicago, IL Lee Willis.

Solar and Wind Integration Workshops
October 24-26, 2011, Aarhus, Denmark Bas Kruimer / Don Morrow / Tom Gentile

IEEE-ISGT Europe
December 5-7, 2011, Manchester, UK, Bas Kruimer / Damir Novosel / Edwin Liu

Utility University (at DistribuTECH)
January 22-23, 2012 San Antonio, TX

DistribuTECH
January 24-26, 2012 San Antonio, TX

Details to be posted at **www.quanta-technology.com**

Want to Receive Our Newsletter??

The QT e-News newsletter is published 4 times per year, in both electronic and printed form, and in special editions for important industry events. If you would like to receive your copy, please contact: Mary Cornwall at (919-334-3081) or at mcornwall@quanta-technology.com

About Quanta Technology

Quanta Technology, LLC, headquartered in Raleigh, NC, is the expertise-based, independent consulting arm of Quanta Services. We provide business and technical expertise to energy utilities and industry for deploying holistic and practical solutions that result in improved performance. We have grown to a client base of nearly 100 companies and to an exceptional staff – now over 100 persons – many of whom are foremost industry experts for serving client needs. **Quanta Services, Inc.**, headquartered in Houston, TX (NYSE:PWR), member of the S&P 500, with 2010 revenue of $3.9 Billion, is the largest specialty engineering constructor in North America serving energy companies and communication utilities, according to McGraw Hill's ECN. More information is available at www.quantaservices.com.

QUANTA TECHNOLOGY

4020 Westchase Blvd., Suite 300
Raleigh, North Carolina 27607
Phone: 919-334-3000

Mary Cornwall
Sales & Marketing Analyst
Managing Editor

mcornwall@quanta-technology.com