Using Artificial Intelligence to Automate Distribution Feeder Restoration

By Warren B. Causey
Vice President
Sierra Energy Group

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Market Intelligence and Research Solutions

Beset by political, regulatory, and economic storms, utilities increasingly are turning to artificial intelligence (AI) to improve efficiency, reduce outage time, and generate cost savings. Many utilities are moving toward becoming more efficient by automating everything that can be automated. The results will enable them deal not only with their aging workforces, generation constraints, distributed generation, demand response, etc., but also with what are sure to be ever-increasing cost constraints in the future. Artificial Intelligence is coming to the fore in these efforts and will be a vital technique in the "Smart Grids" and "Intelligent Utility Enterprises" of the future.

Pepco, Washington, DC, and Pacific Gas & Electric Co., San Francisco, are two major utilities that have used AI from D.C. Systems, Pleasanton, CA, to make their grids more automated and self-healing . The Pepco project won an Apex Award from the UTC (Utilities Telecom Council) in 2007.

pepco

According to Mark Gray, manager of substation protection and communications engineering, at Pepco, in 2004 PHI, parent company of the utility, was looking for ways to improve the reliability of its Washington DC based electric operations, Although the utility had been retrofitting manual operated disconnect switches with motor operators for a number of years, anticipated improvements had not been realized. It was determined that the problem was largely due to the System Operator's inability to react quickly enough to distribution system problems. This was particularly true during storm conditions when operators can often become overwhelmed with a multitude of issues demanding their immediate attention. Furthermore, expanding the SCADA systems in a traditional way to field installed distribution equipment would be costly, would increase the burden on the system operators, and would overwhelm the legacy EMS system.

For this reason, Gray says, it was determined that an intelligent approach would be needed.

To address the problem, PHI's SPT Engineering Group & Pepco's Control Center Systems Group worked together to begin developing a scope document which ultimately detailed an innovative automation approach that:• Utilized Pepco's core fiber optic network

- Developed a next generation distributed RTU & wireless gateway platform
- Developed a substation wide area network supporting high speed Ethernet communications
- Provided a flexible control system that utilized Artificial Intelligence in a creative way to automate its distribution network

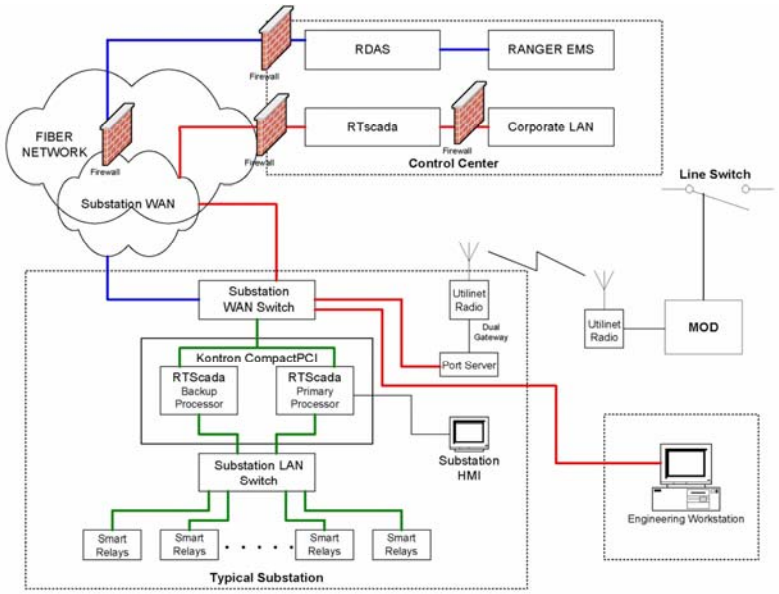
In early 2005, the engineering scope document was developed and in August 2005 DC Systems was selected to develop and deploy the control system software (**RTscada**) & algorithms.

Backbone communications for the system were through PHI's utility fiber optic network. A substation WAN was developed to enable networked communications between the Operations Center and associated substations. Eight 13kV circuits served from four different substations were selected for the pilot project. Field switching for the project included twenty (20) existing automated motor-operated disconnect (MOD) installations comprised of 19 S&C gang operated switches and one SF6 gas insulated switch from Yaskawa. Communications to all field devices is controlled by **RTscada** software through the Utilinet wireless network with dual gateways at each substation.

The (**RTscada**) system is designed to operate automatically, it's not designed to produce switching orders," says Douglass Campbell, president of DC Systems. "It is an automated system that takes the same actions an operator would given the same circumstances. The system takes into account pre-fault load, line capacity, protection settings on feeders, etc. Since it has access to the substation (where it typically is located), it takes a look at transformer loading so a switching operation doesn't cause an overload."

According to Pepco's Gray, **RTscada** was selected for the project for the following reasons:

- Proven track record of efficiently controlling Utilinet radio networks
- SCADA solution built using standard, commercially available tools
  - o Microsoft Visual C++
  - o Microsoft Access
  - o InstallShieldo TIBCO
  - o SmartSocket Inference Engine
  - o GE Fanuc Dataviews (HMI)
- Multiple levels of security (including Machine IDs)
- Off-the-shelf historian
- Field proven Rules-based Artifical Intelligance Engine



As eventually configured, three Pepco substations use Ethernet over fiber while one substation was connected to the network through the use of Motorola Canopy radios, all ensuring high speed updates over an Ethernet data network. At each of the four

substations, a hardened computer runs the RTscada applications and serves as a distributed Pseudo RTU. The system gathers critical information from Substation Smart Relays (GE, F60s) via LAN connections and field devices (MODs) through the Utilinet wireless network.

MODs used in the pilot project are outfitted with Fisher Pierce fault indicators. These fault indicators provide input to the **RTscada** control algorithms to facilitate the identification of the faulted feeder section(s) and for restoration of feeder sections not under fault conditions. (The SF6 switch operates similarly but has many additional advantages/features which will be used in any system wide automation deployment), Gray says.

The DC System automatic sectionalizer/restorer uses logical models to determine the best switching configuration to handle an outage. The system uses those models to make decisions. The logical models are based on "The Best of Breed Operators" rules ensuring these are not lost as the Work Forces changes.

"If the utility has an existing SCADA system, we can bolt on the **RTscada** automatic restoration as a side-by-side system," Campbell said. "The Pepco system has had several outages where the system did exactly what it was supposed to do.

Advanced SCADA systems enable utility operations personnel, and even executives, to see what is happening on the grid. Advanced AI systems will enable them to see it in action, but with less concern about what must be done when something fails. This process is described by Randall L. Smith, information systems and technical support SCADA, at PG&E:

"We started implementation of automated sectionalizing restoration in July and have several of the configurations operational now," says Smith. "What sectionalized restoration does is when one part of the grid goes down, intelligent systems automatically reroute power to as many homes and business as possible without human intervention. In the past, all this had to be done by hand, crews drove to the field and threw switches, or later they could be remotely thrown by system operators in control rooms. In the new automatic systems, computer systems with built-in rules and semi-artificial intelligence determine what needs to be done and throws the switches. This allows the utility to dispatch crews only to the specific points where human intervention is needed.

Automated restoration is one of the aspects of what has been called variously the "Smart Grid," or the "Intelligent Utility." Most utility experts believe today that the grid will have to become increasingly "intelligent" in the future to meet those increasing demands being placed on utilities in the current environment.

Artificial Intelligence systems, such as that built by DC Systems, is one of the major hopes utility executives have for dealing with the increasing demands being placed on them for efficiency, cost cutting by regulation and legislation, and for improved customer service—another major concern of regulators and legislators.

DC SYSTEMS

RTscada

6900 Koll Center Parkway
Suite 414
Pleasanton, CA 94566

925-485-0200
www.dcsystems.com
sales@dcsystems.com