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An Integrated Approach to Electric Utility Processes

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Abstract - **Every electric utility has similar processes. In most utilities productivity and efficiency suffer when each of those processes remain isolated. In addition to lost opportunity costs, system efficiency could be enhanced through connectivity with other utility processes. Line design (staking), Geographic Information System (GIS), Outage Management System (OMS), Interactive Voice Response (IVR), Customer Information Systems (CIS), Engineering Analysis (EA), and Advanced Metering Infrastructure (AMI) could all benefit from both a methodology to share information, as well as a process that makes that information sharing more seamless. This document will explain one method of leveraging many processes already utilized in every electric utility, and using those processes to make a system that both updates and creates a basis to enhance the engineering and operational efficiency of a utility.**

Index Terms – **Advanced metering infrastructure, customer information systems, electric utilities, engineering analysis, Geographic information system, interactive voice response, interfacing, MultiSpeak®, outage management system, Smart Grid Interoperability Panel**

I. INTRODUCTION

Electric utilities today are undergoing the merging of information and operation technology along with the process changes that go hand in hand with technological advances. The process changes that occur with fast paced advances in technology present both a challenge and an opportunity for electric utilities. The technology and process advances, when implemented properly, have a significant impact on the cost of operating the electrical distribution grid, improved situational awareness, and improved customer service. Historically many power utility engineers and employees have spent a significant amount of time dealing with a dichotomy of issues, utilizing multiple processes that were often operated in isolation. These engineers and employees found themselves fighting fires and wishing there was more time to think about the situation they were in at that point in time, wondering why no one had an actual plan and a delineated long term goal. Every electric utility has implemented some form of processes, whether the process is for system planning, management, accounting, or something else. How effective are these processes and the systems that support the processes is often an ongoing discussion at most utilities. Currently, there are processes, system design tools, and methodologies that help improve electric utilities. These processes along with new systems can create a base for other practices and business improvements for the utilities. This paper will specifically discuss a methodology where systems and processes are designed and improved through connectivity with other utility systems and processes. The systems and processes discussed will include Line Design (staking), Geographic Information System (GIS), Outage Management System (OMS), Interactive Voice Response (IVR), Customer Information Systems (CIS), Engineering Analysis (EA), and Advanced Metering Infrastructure (AMI). By implementing a methodology that seamlessly shares information between systems and processes, the electric utility benefits from improved operational efficiency that helps lower operational costs, improves employee productivity, and increases customer service.

II. PROCESS AND SYSTEM DESIGN

Beginning in the late 1990's, **W**estern **IN**diana Energy Rural Electric Membership Corporation (WIN Energy) began working toward a state of mapping automation that would ultimately be the model on how the cooperative improved its systems and processes. One of the many reasons most utilities have not tackled the issue of leveraging processes into an integrated system were due to process definition. What variables are required for each process, and how best to gather, store, and share those data fields required for each process? Who are the stakeholders? Who is the "owner of the data"? How should the data be edited? How should updates to the data be posted?

Stepping back and evaluating the entire process first aids in gaining insight on what changes can be made in a process to make it more useful to another process. Creating connectivity between the different processes not only saves money and supports long and short term planning, but

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process connectivity will ultimately enhance customer service. This line of thought was the driving influence in defining the work flow. Doing a 'mini-impact study' allowed WIN Energy to see if enhancing one process significantly helped, or harmed, another part of the work flow.

The result of the 'mini-impact study' showed that staking was the logical starting point for this integrated approach. Staking would also act as the correction method for those same processes. Furthermore, staking would be done electronically, and both Facilities Management data and GPS data would be gathered at the time of staking. Staking would then feed into a Geographic Information System (GIS), which would then pass required information to Engineering Analysis (EA), Outage Management Systems (OMS), Customer Information System (CIS), Automated Metering Infrastructure (AMI), and Interactive Voice Response (IVR). All of the data would then be exported back to staking to act as the new starting point for the process previously described.

As an example, it is not required to use a computer and GPS to design a power line. Utilities have been doing this process for decades with employees using chains or measuring wheels, writing down the measured results, and then hand drawing sketches on paper to give to the warehouse and line construction personnel, as noted in Cooperative Research Network's *Simplified Staking Manual for Overhead Design* [2]. While this method accomplishes the initial goal, it is time consuming and redundant. If that data is captured electronically and measurements are geospatially stored, lost opportunity costs as well as greater accuracy in location of data and resources could be recaptured by the utility in material management, mapping, and staking. Material management would simply upload the staking file to the CIS where material would be charged out and inventories updated. Staking could capture the data for that location and store that information for geospatial queries (i.e. - how much copper-weld-copper on the system, how many 40 class 4 poles are on the system, what meters are in Washington Township…). Furthermore, this process reduces staking time the next instance line changes are required at that location by simply recalling the 'existing' data from the database. In the background of the computer aided approach information is stored as both a basis for a GIS system and a method for error correction. As far back as 1974, the Rural Electrification Administration (now the Rural Utility Services) recognized the level of detail necessary to create and maintain this type of database prior to the development of new technologies that are currently accessible: "Computerized pole-by-pole records, keyed to the maps, seem to offer great promise. However, results have not always fulfilled the promise because of problems in maintaining the large volume of records that are generated. Anyone considering such an application should proceed very carefully, learn from the experience of others and recognize in advance the high cost of introducing and maintaining this type of record" [1].

III. LINE DESIGN (STAKING)

In its base form, a Facilities Management Database (FMDB) would feed staking, staking would feed a GIS, and GIS would feed both EA and an OMS. Any Non-Work Order driven changes (usually special equipment: transformers, reclosers or meters, for example) would be fed back to the GIS from a CIS, or by manual input. At this point, the FMDB would be updated and exported back to the staking system for use by the staker as a base point for line design. This would close the loop and be the continuing update, as well as a method for corrections to the database for all the systems previously listed here.

Beginning in the late 1990's, WIN Energy began the first process of this approach, staking automation, that would eventually include all of the processes previously mentioned. Having many systems working together and sharing information, starting with creating and maintaining one database, appeared to be the logical starting point.

The process of updating a mapping system traditionally took a manual process focusing solely on data from line design and construction (staking), or from construction surveying (mapping after the fact). This one dimensional approach traditionally accomplished only one goal; an electronic map that could print a paper map that was generally years behind the actual field construction completion. Stepping back from this limited approach shows that there is an opportunity to incorporate other systems into this process to recoup lost opportunity costs. One goal can still be a paper map; however, this new process allows for more automation and leveraging this data to benefit the entire organization.

The staking process can now be done electronically to include GPS and laser offsets. The advantage of this is that the staked point is now geo-referenced, inclusive of distances between stations. In addition, any calculated line angles are now significantly more accurate. This accomplishes both an improved rules-based design process and a more accurate GIS representation.

Most utilities use short-hand on staking documents to represent a defined list of materials. Rural Utilities Services (RUS) electric cooperatives call these short-hand notations 'units'. In the normal staking process, the line designer (staker) has to complete an inventory on the existing stations involved in the line design. If the system has already been inventoried, or if the staking is stored in a system that has the ability to be electronically retrieved, there are lost opportunity costs realized on the line designer's time by recalling these units into the line design job. This unit database is called, for this discussion, the FMDB. This is the launching point for both the other systems to draw their data from, and a means of generating the error correction process.

While individually all of these systems have been in place at utilities, in some form, for decades problems arose because they were separate systems that did not integrate with other data collection and analysis systems. The challenge has been a means of accurately and reliably passing data back and forth between these silos of information. Additional information that needs to be passed from the staking system to the GIS software is a way to store and pass on specialty equipment sizes and ratings (i.e. sectionalizing, regulators, capacitors).

IV. CUSTOMER INFORMATION SYSTEMS (CIS)

The first integration between processes started with staking to CIS. One of the challenges was standardizing what staking unit designations really meant. A computer does not interpret the meaning of a unit. If a unit 'X' is input into the computer, the output will be 'Y' material. Some staking technicians would designate a construction unit and know that was not the correct choice, but would go on the assumption that 'the guys know what I mean'. Cleaning up and standardizing that ALL units were the same every time gave WIN Energy the basis to build the foundation for a process driven system. According to the Rural Electrification Administration's Bulletin 40-4, "if a pole-by-pole method record system is adopted, make certain that it is a working tool with built-in procedures for updating. This will likely require….3. Incorporation into the property accounting (work order) procedure, to avoid wasteful duplication of the pole-by-pole detail" [1]. Other information typically stored in a CIS is equipment data such as manufacturer, transformer serial numbers, KVA sizes, transformer impedances, transformer high side and low side voltages as examples. Since most companies do not use a staking system to change or update this type of information, a link into the CIS database is essential to obtain engineering information needed for fault current and voltage drop calculations. CIS centric information is also needed by other processes in order for those processes to be timelier and by extension more effective. One such example would be if a consumer is disconnected due to non-payment, it would be undesirable to allow the OMS or IVR system to create an outage from a non-pay customer. WIN Energy's overall goal in integrating CIS information into the process was to leverage what a CIS system is originally designed to do: store information.

V. MULTISPEAK®

WIN Energy became involved in MultiSpeak® early on because one of the processes the rural electric cooperative was using, passing units between CIS and staking, broke every time there was a software update from either of two vendors. These interfaces were custom, and the cooperative had to pay the vendors every time the interfaces broke to restore the interface to its original functionality. Having a common standard for the vendors to write against helped both the vendor and the end consumer. This standardization also empowered the cooperative to now pick the vendors that best fit its business model, instead of a 'one size fits all' vendor that sells a suite containing some of what the cooperative wanted and a lot of other processes the cooperative did not want or need. This process has been coined as the 'Best of Breed' approach.

One of the many challenges of developing a system approach to this process was discovering how little each software system knew about the process and data needs of the other software systems, even in the 'suite' approach. Staking knew that an oil circuit recloser (OCR) was installed, but did not care about the ampere rating or frame type. Engineering required an ampere rating and frame type that was not being provided from staking. Staking gave support structure locations and non-electrical assemblies (overhead guy stub poles and anchors) that an engineering analysis software package did not include, because it was not part of the electrical model. Accounting did not save certain units, because it was not a taxable unit (A1, J10,…) or Continuing Property Record (CPR, for RUS cooperatives); however, staking needed that unit as part of the overall database because those non-CPR units still made up the structure in the field and still required material that needed to be charged out and accounted for in the inventory system. The list of issues could continuously expand. Each process was really a subset of the overall agenda. Getting each stakeholder to understand they were not the end product, but just a part of the process, was a large challenge in this project.

While this paper is about using data in a process that touched many different software systems, the discussion of MultiSpeak® is germane to this topic. Without a stable, defined, and consistent transport mechanism, the goal of information exchange and timeliness could not be achieved. This paper will only cover the MultiSpeak® process as it relates to the goals of this paper, and will not go into a dissertation of how MultiSpeak® works. For detailed information on MultiSpeak®, the reader should visit www.multispeak.org.

Early in the MultiSpeak® development, it was acknowledged that the process would not be effective and sustainable without both end user input and significant vendor buy in to the concept. To the latter, a technical committee was formed made up principally of vendors. The idea was each software process was a 'black box' that imported data from, and exported data to, another 'black box'. This way no individual vendor was giving proprietary information to rival vendors. Everyone agreed they needed 'X' data in 'Y' format every time, and then each vendor knew how they would receive the data and in what format they needed to export the data. Should one system define itself as 'unique' and need data outside of the defined process, MultiSpeak® was made extensible and the two vendors could enhance the data exchange process beyond the definition without major changes in the standard.

As was stated earlier, getting everyone to acknowledge the need for certain datasets in varying degrees of granularity was a significant challenge. Each vendor considered itself a subject matter expert. In a very limited definition, they were. The problem was utilities needed to pass what a vendor sometimes considered as insignificant data into and out of a vendor's system**,** because the vendor's system was a step in the overall goal. The granularity of the data had to be maintained, not for one vendor, but for any vendor in the overall process to have useful data.

In addition to the interoperability features of MultiSpeak® interfaces, the MultiSpeak® Initiative has adopted a detailed standard to secure such interfaces. This is the only standard in the utility industry for securing interoperable interfaces that has been adopted by the Smart Grid Interoperability Panel for inclusion in its Catalog of Standards. Secured MultiSpeak® interfaces may use one of three security profiles, each of which must conform to well-defined and testable requirements that are defined in the standard. Utilities may define which security profile meets their security policy and then applications may be configured to meet the requirements of the security profile selected. A testing and certification program is under development to ensure that products designed to meet the requirements of the security standard do indeed work together securely when appropriately configured. This was very important in WIN Energy's decision to use MultiSpeak® in its processes. The basic links between processes are shown in Fig. 1 below.

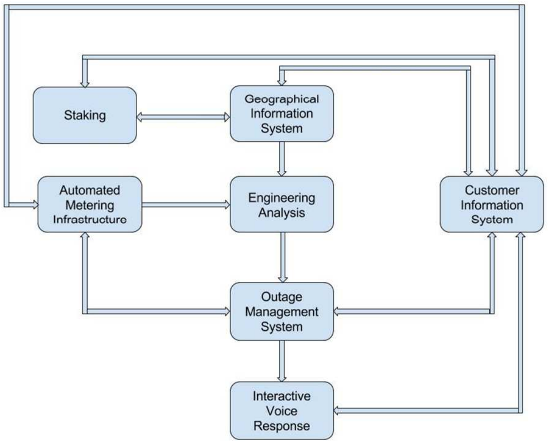

Fig. 1. Information flow between data processes

VI. GEOGRAPHIC INFORMATION SYSTEMS (GIS)

A GIS can accomplish many utility desirable functions. Not only can the utility produce accurate paper or electronic representations of the system, but the GIS can be a basis for both an EA, and an OMS. Simultaneously, the GIS can be the repository for detail information exchange, such as transformer KVA size, transformer impedance, and other data. The GIS system becomes the hub for a majority of the information interchanges. While a GIS system does not require wire, transformer and sectionalizing device sizes, other processes that interface to the GIS do require this information to function correctly. If GIS is the main repository for the FMDB, many useful queries can be made against that database. Feeding staking connectivity to the GIS makes a much better model for EA to apply AMI spot loading.

Using electronic staking to pass georeferenced staking information into the GIS also allows for more timely updates to the model. This model can then be passed back to staking and OMS for more accurate outage detection as well as stations used in the staking process. Deciding when the appropriate time to post this information (when facilities are completed in the field, when facilities are field inspected after completion, or when facilities are posted to the accounting system) then becomes a choice based on utility process decisions instead of information that is not available for, in many cases, years.

VII. OUTAGE MANAGEMENT SYSTEMS (OMS)

Every utility wants to take the guessing out of outages. While numerous electric utilities incorporate a section-based model (miles of lines and consumers lumped together and modeled as one section), benefits can be seen in implementing a good detailed connectivity model (span by span). Combining this with the ability to take advantage of a technologically advanced, computer integrated framework that maintains system connectivity allows the utility to improve outage management and decreases outage hours. Integrating detection devices, such as IVR, AMI, and SCADA, enhances the accuracy of outage predictions from a detailed connectivity model. Integrated data allows the OMS dispatchers to make better decisions on where assets need to be deployed during an outage. By incorporating an integrated OMS system, a utility can see significant consumer outage hour's reduction, as well as positively impacting consumer satisfaction and future rate cases. The use of a staking system as the source into GIS and then to OMS helps not only to create an accurate connectivity model, but creates a way to maintain the accuracy of that system model.

VIII. ADVANCED METERING INFRASTRUCTURE (AMI)

Having an AMI system can go further than just billing parameters. Assume an AMI vendor can bring back 15 minute kWh values, or even 1 hour kWh values. **IF** the information can be brought back in a timely manner, near real time system analysis could be achieved and many 'what-if' scenarios could be run for both emergency load transfers and for system planning. Even if the information was not returned quickly, getting the data the next day, next week, or in monthly downloads would still be useful. If all metering metrics were brought back, analysis for Non-Coincident Peak (NCP) and Coincident Peak (CP) would create enhanced engineering data. This same data could be used for transformer loading and load factor analysis. This process is another tool for analyzing rate groups for correct cost allocations as well as contributions to an overall peak for engineering analysis studies. Having proper connectivity to all meters allows for a more accurate load allocation and**,** therefore**,** better engineering design analysis. Millions of dollars (US) are spent by utilities each year on 'best guess' engineering analysis. Looking at today's loading, projected loading, as well as line losses under the before and after system improvements are all engineering best practices. Having an outage alert that can be interfaced into an OMS system adds to the value of a process traditionally looked at as just a billing process. A value added service to billing, OMS and EA provides a better cost justification than a standalone AMI process typically offers.

IX. ENGINEERING ANALYSIS (EA)

EA takes the model created from GIS and pairs it to different defined engineering specific information. Information such as: a substation at X and Y coordinate is paired with the source impedances. The line conductor of 1/0 ACSR has this specific R+jX, the three phase spans in this defined area are made up of #2ACSR, #4ACSR**,** #6A CWC**,** and a #8A CWC neutral. The ability to take staking information to create more accurate fault current studies, motor start calculations, voltage drop studies, and construction work plan projections is a lost opportunity cost that most utilities do not realize. Linking this data to other databases – AMI for site specific loading at a specific date and time, source impedance tables, CIS systems to keep transformer information (KVA, transformer impedance, secondary voltage, etc.) up to date – are all processes that *can* be accomplished and have a meaningful impact on a utilities' operation and budget. Showing that the calculations are more accurate helps make an accounting case for targeted capital expenditures. Many times, engineers are fighting for resources to correct system issues both short term and longer term when the issue of 'predictive analysis accuracy' arise. Having the best data available is essential to making the case for better targeted budget money.

X. INTERACTIVE VOICE RESPONSE (IVR)

Integrating an IVR system into an OMS system, which maintains the detailed system connectivity, opens the door to giving site specific outage messages to accounts in that defined connectivity area. This can also be used to give specific announcements to a precise group of accounts, such as planned outages, detailed reasons for their specific outage, area tree trimming, and even estimated restoral times. Without the detailed model, only a broad overarching interaction with the consumer may be utilized and generally that message has to be so broad as to be close to useless, 'XYZ Utility is experiencing outages in your area'. Experience has shown that consumers that get specific and timely information on what is causing their specific issue and what the utility is doing about their specific issue are much happier consumers.

XI. CONCLUSION

The days of data silos can be over by integrating systems, such as the aforementioned. Figure 1 shows how the information interchange described in this paper flows between the various data processes. There are methods available and functioning today that share information between platforms. A security enhanced transport protocol has been developed and is now operational to securely pass information from each of the described platforms, even if they are from different manufacturers. Taking advantage of the information available in the described systems provides a significant lost opportunity cost savings for electric power utilities. These cost savings are both direct and indirect. The ability to take advantage of system interfaces can provide an immediate benefit, such as AMI to OMS outage detection, more accurate longer term system planning, staking to GIS for creating and maintaining the system connectivity model, more detailed system analysis for targeted spending of Construction Work Plan money, and the intangible benefits of more satisfied member/customers due to increased system reliability – cost/rate containment and outage communication. Using staking as the starting point leverages a process that is already required to build and modify power lines. Taking the data from staking and creating a GIS model from the data supplied from staking allows the user to edit, as opposed to re-creating from scratch, the required information that would build the GIS model. With the GIS model built, the connectivity model required for EA and OMS is seamlessly and effortlessly built as well as maintained. Since the OMS now has the connectivity of all meter locations, OMS metrics and predictions are now more accurate. IVR systems tied to these OMS models give better and more outage specific information to the member/consumers. Creating a more informed member/consumer typically makes them more forgiving about their power being unavailable. Since AMI data can be tied to the exact location in the system where it is used, existing and projected load flows can be significantly more accurate. This, in turn, has the potential to save significant dollars in system planning. Many other ideas can be spun off of this process. If AMI data is ‘near real-time’, load flows could be run on the system damaged by storms. The guesswork of whether or not the load can be switched from one substation to another can be more of a scientific process than one of assumed system knowledge.

The challenge of this system approach is whether or not the utility has a defined long term goal, and if that same utility is willing to put the effort into building the system the first time. While not every benefit delineated previously can be realized until the entire utility has been cataloged, even incremental benefits create large increases in both system performance and internal process performance during the build out.

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XII. AUTHOR

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