APPENDIX G

Outage Management Systems (OMS)

A. OMS OVERVIEW

General Discussion

With the improvements in technology, Outage Management Systems (OMS) has become a sophisticated tool which can be valuable for improving the efficiency of restoration and communication with customers.[1] OMS integrates with systems that are normally installed for reasons other than outage management, but when working in conjunction with the OMS, they are able to provide information helpful to the restoration effort. Supervisory Control and Data Acquisition (SCADA) systems are an example. They are usually installed to give operators information about the condition of equipment, the status of switches and breakers, and to control the remote opening and closing of breakers. This same SCADA information can be invaluable to operators as they try to restore service after an outage. They can tell which breakers or reclosers have opened and may be able to attempt remotely closing some devices. The dual nature of the systems integrated into the OMS can at times make this integration difficult. The ease of integration into the OMS should be an important part of the utility's thinking when choosing any particular technology.

The modern OMS requires an accurate customer-to-electrical system model to provide accurate predictions of outage locations. It must gather, compile, and display information from a variety of sources including:

- Customer Information Systems (CIS)
- Interactive Voice Response (IVR) systems
- Call Over Flow (COF) systems
- SCADA status information
- Distribution Automation (DA) systems
- Automated Meter Reading (AMR) or Advanced Metering Infrastructure (AMI) systems
- Protective relay fault location information
- Geographic Information Systems (GIS)
- Damage assessment reports
- Automatic Vehicle Locator (AVL) systems

[1] Nielsen, T.D. (2007). Outage Management Systems Real-Time Dashboard Assessment Study. *Conference Proceeding IEEE/PES General Meeting June 2007*. (10.1109/PES.2007.385707).

- Crew reporting information[2]

Figure G-1 shows the architecture of a typical OMS. To manage the available data, the computing power and interface between the information gathering portions of the system and the OMS itself cannot be overwhelmed during a large area outage. This has been a problem historically with OMS. They have performed well with small scale outages, but have failed to operate correctly when large scale outages occur. Recently, newer systems have been shown to be more reliable under large outage conditions. However, the algorithms used might need modification for disaster scale conditions. The predictive algorithms incorporated in OMS try to use outage data to pinpoint a single location of trouble. During a large scale event, the predictive methods used may be inadequate and provide misleading or useless information. With this knowledge, the operators can still obtain useful information with the understanding that some of the conclusions reached by the system will be incorrect. Rather than merely leaving the system algorithms in place to identify trouble locations, human intervention and decision making may be necessary. Newer systems continue to improve in their ability to handle large outages, and several manufacturers claim their systems can handle multiple system outages simultaneously.

The different parts that may be integrated into the OMS are as follows:

- **Customer Information System (CIS):** A computerized system used to track customer information, generate bills, issue service requests, and “manage” customer relationships by providing the utility information about each customer’s needs and preferences.
- **Interactive Voice Response System (IVR):** Interactive computer system which can answer telephone calls, route information, compile data, return calls, and call back customers as programmed. It can be linked to record customers' locations and link these with locations in the distribution system.
- **Call Over Flow System (COF):** A system that redirects telephone calls from one answering location to another when volume exceeds capacity. It allows overflow calls to be answered and information tabulated.
- **Supervisory Control and Data Acquisition system (SCADA):** A computer system that gathers data from devices such as protective relays, provides breaker, switch, and re-closer statuses and a means to control these devices remotely, and displays the status of this monitored equipment graphically.

[2] Nielsen, T.D. (2002). “Improving Outage Restoration Efforts Using Rule-Based Prediction and Advanced Analysis.” *IEEE Power Engineering Society Winter Meeting 2002*, Vol. 2, January, pp. 866-860.

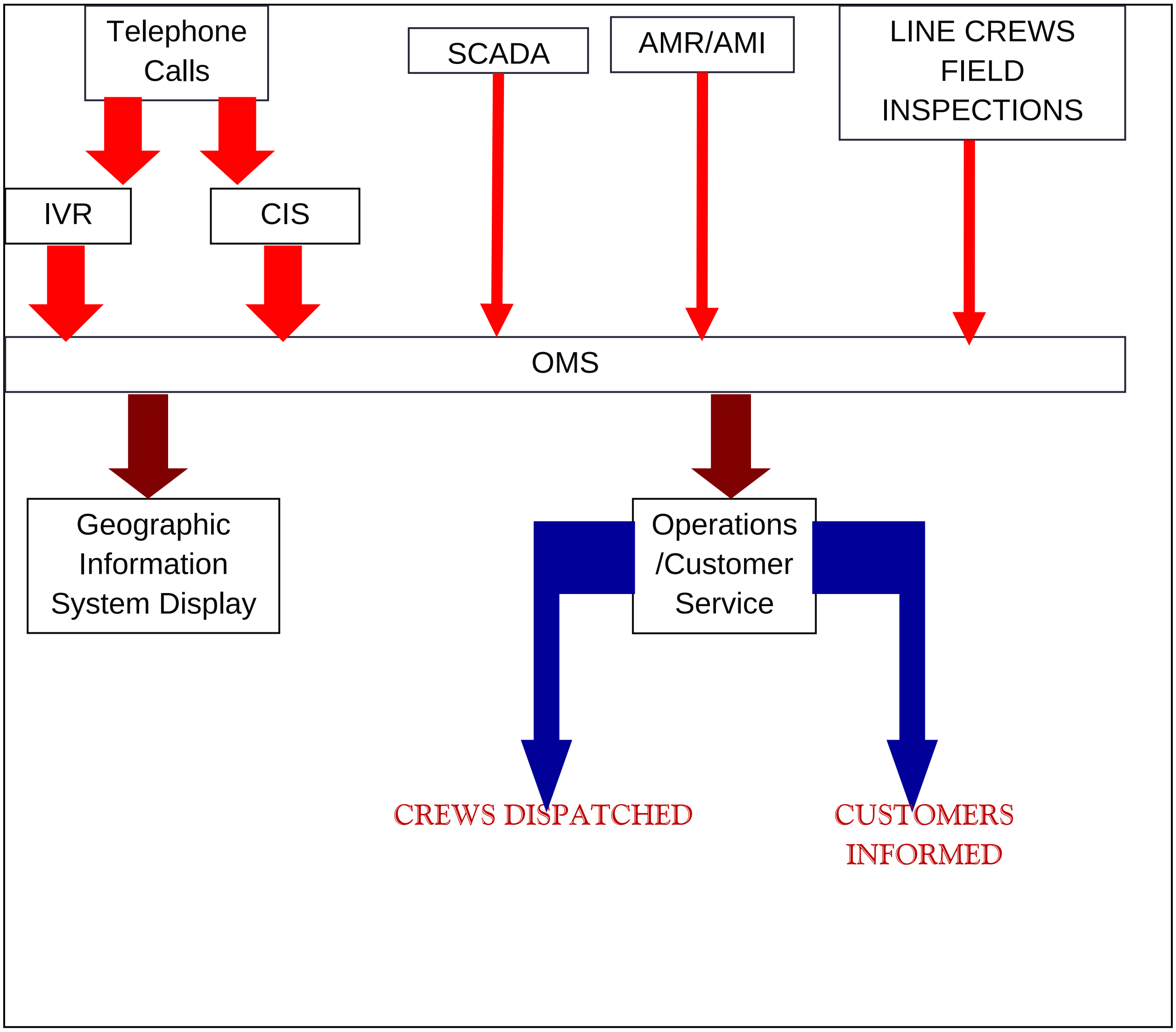

Figure G-1: OMS architecture.

- **Distribution Automation (DA) system:** Computer system which monitors and controls devices on the distribution system. May include monitoring and controlling breakers, re-closers, and distributed generators.
- **Automatic Meter Reading (AMR):** Systems which can remotely read kWh from meters and automatically record the values in a computer data base. Some systems can also send instantaneous values to the system reading the meter. Meter data can be transferred via radio, telephone, or power line carrier.
- **Advanced Metering Infrastructure (AMI):** Includes the same hardware, software, communications, and customer associated systems that are used by AMR systems, but also includes two-way communication to make possible remotely disconnecting customers or in other ways manage demand.

- **Geographic Information System (GIS):** A computer based technology to collect, record, and display geographically referenced or spatially oriented information. Can record the exact locations of utility infrastructure and attach to those records construction information, life, or repair data. Can produce graphic displays which compile and usefully display data concerning components in a power system.
- **Automatic Vehicle Locator (AVL):** Uses global positioning system information to automatically record in near real time the location of vehicles in a utility's fleet. Can display on a GIS based system the location of all line trucks or other vehicles so dispatchers can determine the truck located nearest an outage.
- **Protective Relaying:** Devices on the power system which trip breakers to disconnect parts of the system experiencing malfunctions, such as short circuits or open conductors. The OMS may be informed if a relay has detected a problem on part of the system and has tripped a breaker. This will help the OMS characterize the reason for an outage.

From a technological point of view, the most quickly changing part of the system that can be integrated with the OMS is the metering system. Due to governmental initiatives seen in the last few years that mandate smart grid and smart metering technologies, metering technology and communications have improved dramatically. The trend has been for utilities to install Automatic Meter Reading (AMR) systems or Advanced Metering Infrastructure (AMI) systems.[3] The AMR/AMI technology is usually installed for reasons not relating to outage management since its principal benefits go beyond it. Significant benefits can be seen in customer service due to improved accuracy in meter reading. The increasingly detailed information available from AMR/AMI systems can be beneficial in system planning, load management, asset allocation, and load forecasting.

Integrating the AMR/AMI system with an OMS system, even a simple one, can have definite cost advantages. About 70-75% of outage reports received by a utility are single service outages, nearly a third of which are customer side problems. If the AMI system is integrated with the OMS, the meter can be queried instantly to determine if the problem is on the utility or customer side of the meter. This can avoid sending line crews or trouble-men to the site for a customer side problem. The improved speed and accuracy in response has been shown to decrease average outage durations from 6 to 4 minutes.[4]

One of the worst customer perception problems is caused when a customer reports an outage, the utility takes action to remedy the outage, believes the customer is restored, but the customer is still without power. An integrated AMI-OMS system allows the utility the ability to verify that

[3] Steklac, I. and Tram, H. (2005). "How to Maximize the Benefits of AMR Enterprise-Wide." *IEEE Rural Electric Power Conference 2005*. (10.1109/REPCON.2005.1436325).
[4] Tram, H. (2008). "Technical and Operational Considerations in Using Smart Metering for Outage Management." *IEEE Transmission and Distribution Conference and Exposition 2008-IEEE/PES Vol. 1*, Issue 21-24, April, Pgs 1-3. (10.1109/TDC.2008.4517273).

the meter is energized without a call to the customer. The OMS can also help identify problems with meters which could otherwise result in inaccurate or missing billing information.

AMR systems come in two basic types. The first requires in-field reading which means personnel must be dispatched to the vicinity of the meters being read and the metering data is transmitted over relatively short-range radio channels. The second type provides centralized meter reading which does not require that personnel be dispatched to the vicinity of the meter. This type may transmit its data via power line carrier to the substation or another point where it is compiled and transmitted to a central location using radio, telephone, or satellite communications channels. The second type can typically be "pinged" during an outage to determine if the meter is on-line. Some modern meters have the ability to be interrogated and can send back voltage and other data. Some AMR systems are limited in their response time, however, and if integration with the OMS is required, the AMR system must be chosen carefully to maximize its benefits to the OMS.

Operational Aspects of OMS

OMS, if integrated with all available systems, can be of great value during both large and small outages. It can provide call based and independently derived data, and in turn, display this data in useful forms to aide operators in making the proper decisions as to where resources can best be allocated. A properly used OMS can also track the restoration efforts by monitoring how many crews are allocated to each outage and where those crews are located. It can also record the time it takes to complete restoration, which can then help project restoration times for all customers as the restoration process progresses.

The OMS system may function in this way during a large area outage:

- Outage Notification
    - Customers call the call center to notify the utility their power is off.
    - The AMI detects the outages and transmits outage messages to AMI network.
    - The customer call is logged into the OMS system.
    - The AMI network sends its outage data to the OMS.
- Outage Verification
    - Damage assessment crews are dispatched and report damage to the call center.
    - Damage assessment crew reports logged into the OMS.
    - OMS orders AMI to periodically "ping" all the meters.
    - OMS provides a graphical display to show operators where outages exist.
    - OMS provides a graphical display of the status of breakers and switches.
    - SCADA system detects which breakers and relays have operated and transmits this information to the OMS.
- System Restoration

- Operators remotely close breakers/switches and reconfigure the system to restore power where possible using the SCADA and DA systems.
- Available crews are dispatched to areas where operators decide power can be most quickly restored.
- Crew locations are tracked with the AVL system.
- Crew information from AVL is relayed to the OMS network which displays current location and number of crews.
- Decisions are made to bring in additional repair crews if needed.
- AMI reports restored meters to the OMS.
- OMS graphically displays meters as they are restored.
- OMS system records restoration time for each meter. This information helps operators calculate estimated restoration times for meters still not restored.
- Estimated restoration times are logged into or calculated by the OMS.
- OMS sends graphical data to the web-based customer information system that indicates the size of the outage, the number of crews working in each area, and the estimated time for restoration for each customer.

- Restoration Verification
  - AMI detects sustained voltage and transmits message to OMS.
  - IVR call-back system calls customer to notify that power is restored and confirm the customer's power is back on.

The OMS can be integrated with tools dedicated to informing the public of the status of restoration efforts. These would mainly be web based tools that could display the size of outages, allocation of crews to certain areas, and estimated restoration times. These values can be graphically attached to individual meters so customers can obtain up-to-date information on the estimated duration of the outage for their own home or business.

In Figure G-2 and Figure G-3, sample screenshots from an OMS display the way outage information is displayed for easy use by operators. A properly chosen OMS can update this information several times a day, and some of it can be updated in near real time. The OMS can also help prioritize the restoration effort by tracking and displaying critical locations such as 911 systems, fire departments, hospitals, police departments, shelters, etc. so operators can allocate resources to restore critical infrastructure first.

OMS is not a cure-all and does have limitations. Instantaneous information may not always be available since polling time of devices may not provide immediate feedback. Wide area outages may limit the value of the OMS algorithms. During these situations, the OMS may not achieve its real advantages for restoration until a few hours or days after the disaster, or until field information from damage analysts is available and entered into the system. Implementing the OMS is often necessary in stages and this might limit its usefulness in the areas where the infrastructure to support it is not yet in place. OMS is also a major expenditure for a utility and personnel must be dedicated to its implementation.[5] The system model must be kept up to date and the utility's personnel must be dedicated to maintaining the information inputs to the OMS. OMS are often limited in the speed at which they gather input data--40,000 calls per hour is often a limit. When an OMS system is selected, the utility must make sure that the chosen system can gather the quantity of information available from the systems connected to it and respond to the large amount of data available during a wide area outage.

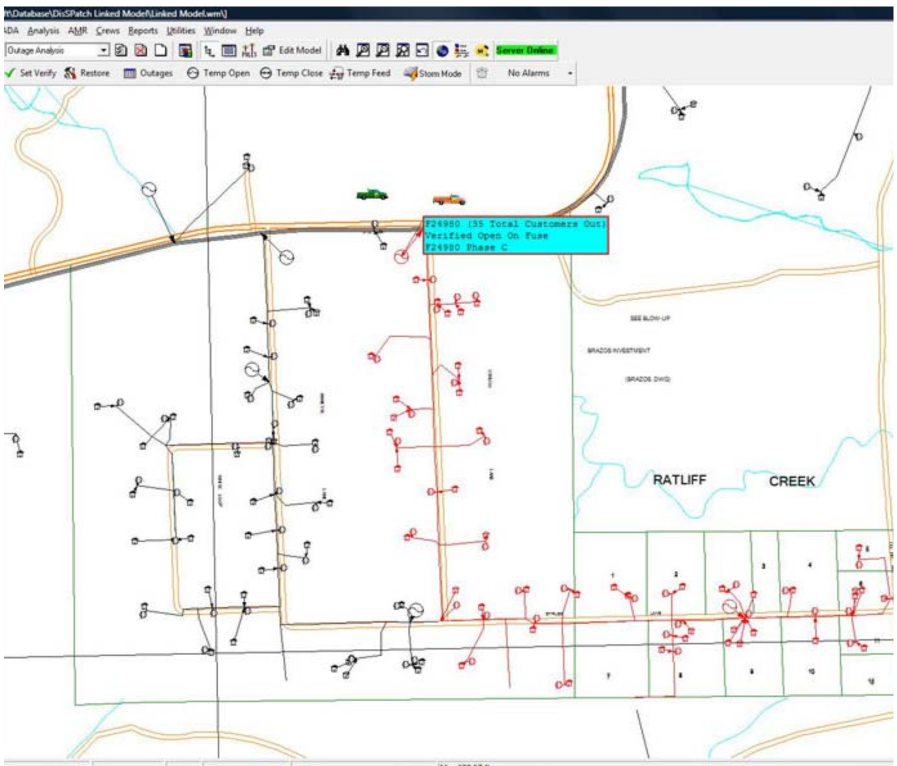

Figure G-2: Typical OMS screen showing customer outages. (Courtesy of Milsoft Utility Solutions)

A modern integrated OMS will require secure communications from the operations centers to the data gathering points. It may also require secure communications between operations centers if a utility has multiple centers. The communications infrastructure used must support a real-time, highly available information platform. The communications system could be the weak link during a disaster, and an OMS may be rendered useless if sufficient attention is not focused on maintaining good communications so data can be reliably sent to the OMS. There are two types of communications systems that a utility may use.[6] The first is an internal network, which is completely owned and controlled by the electric utility, and the second is an external network,

[5] Blew, D.S. (2001). "Outage Management System: Surviving the implementation." *IEEE Power Engineering Society Summer Meeting, 2001, Vol. 2*, Pgs 994, 995. (10.1109/PESS.2001.970193).

[6] Banks, D.R. (2005). "Telecomm Disaster Recovery Planning for Electric Utilities." *IEEE Rural Electric Power Conference 2005*. Pgs D3/1-D310. (10.1109/REPCON.2005.1436337).

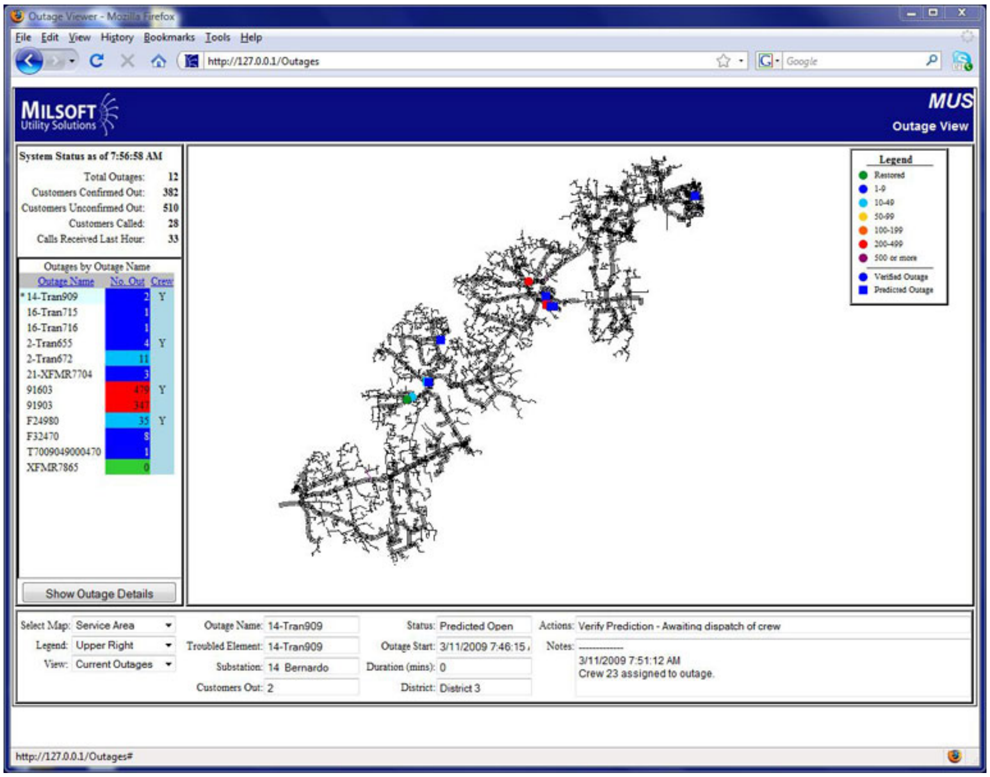

Figure G-3: Typical OMS screen summarizing area outages. (Courtesy of Milsoft Utility Solutions)

which is owned and operated by another company over which the electric utility has little or no control. In the case of the New Hampshire utilities, the communications systems are typically external and controlled by the telephone companies rather than the electric utilities. During the storm, the telephone companies were slow in restoring their systems. Where utilities were depending on information relayed from substations, their efforts were hampered by the lack of telephone communication to these substations.

The electric utilities should develop a telecomm disaster recovery plan that coordinates with their system restoration plan. Successful telecomm disaster recovery might include several options which either prepare for loss of communications by providing a secondary system, or provide for the restoration of the communications system in tandem with the electrical system. Considerations must also be given to supplying emergency power for critical telephone system components, or in other ways insure that critical telephone infrastructure can function for extended periods of time when the electric grid is inoperative. Suggestions which may be considered to improve communications from and to the OMS are:

- Supplying emergency generators to the telephone company to keep central offices, cell phone sites, or other critical systems operating during the outage.
- Providing expanded internal networks such as private optic networks or microwave facilities which can transmit data in the event of a loss of telephone service.
- Providing redundant telecomm service. This is an expensive option but might provide a secondary telephone network in the event the primary network fails.
- Provide telephone carrier diversity. Different companies or different services, such as a wired and wireless service, could both be used to provide redundant carriers and telephone mediums to minimize the possibility of outages.
- Coordinate restoration plans with the telephone company so the communications system can be restored at nearly the same time as the electrical system.