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Modern Grid Architecture - Requirements for Advanced Distribution Management Systems

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Introduction

Over the past several years, a set of powerful, global market drivers—climate change, increased customer expectation, severe economic pressure, aging infrastructure, affordability of data-intensive technology, and an aging workforce—have been profoundly affecting electric utilities. These drivers are causing changes within the industry on a scale not experienced since the creation of the grid more than 100 years ago. Utilities are being forced to manage these changes at the most fundamental levels of their business: operational processes, customer relationships, technology systems, and economic models.

In many parts of the world, historic storms are leading regulators to demand improved restoration management while satisfying customer expectations for more timely and accurate information. At the same time, distributed energy resources (DER) are being purchased and deployed by customers much faster than expected. As well, utilities are adding interconnected “smart” devices to the grid at a staggering rate. The resulting proliferation of data is increasing the need for the integration, management, and efficient utilization of ever more real-time information.

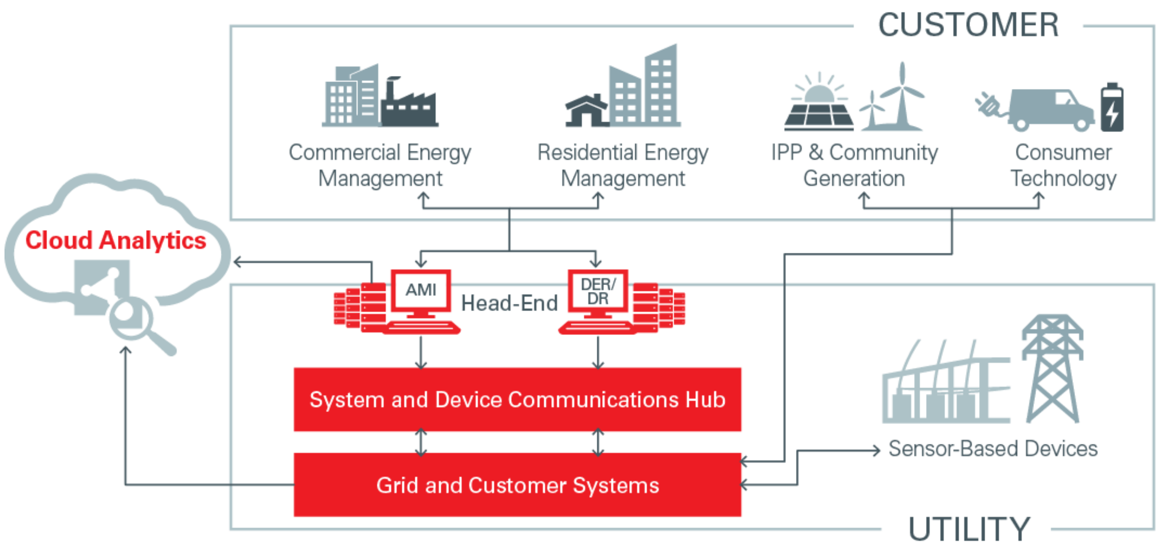
Grid modernization initiatives are being undertaken to address these challenges, with utilities around the world taking very different, evolutionary approaches to meet this mix of complex business, regulatory, and customer realities. The capabilities gained through these initiatives are expected to include better situational awareness, more integrated work processes and control of grid equipment. The expected benefits are delivery of exceptional and affordable reliability, new consumption choices, new revenue possibilities, and improved customer service.

Electric utilities are challenged with establishing a manageable system architecture that supports integration of the technologies needed to achieve grid modernization goals. This paper will discuss the requirements of this architecture, providing insight into key grid management issues encountered in modern distribution, such as data management, system model, grid edge devices, security, and mobile strategies.

Qualifying Considerations for ADMS

At the forefront of many grid modernization initiatives are capabilities provided by an advanced distribution management system (ADMS). With its ability to deliver grid control, hard and soft efficiency cost-savings, as well as its ability to directly support current and anticipated enterprise processes, an ADMS is quickly becoming a mission-critical system.

As utilities consider an ADMS deployment, it is imperative they establish guiding selection principles and identify they architecture they are working toward. No longer is distribution characterized by linear, one-way energy delivery and consumption. As a result, the system must efficiently scale and assimilate a broad range of evolving inputs into practical distribution operations, as seen in the visual below:



Modern distribution requires a system-of-systems supporting a range of integrated processes, customer types, and service models.

Given the complexity of components and inputs, as well as the rapidly changing nature of them (rooftop solar growth, as an example), a modern ADMS needs to have baseline capabilities well beyond its historical precedents. Utilities seeking to implement ADMS must find a solution capable of answering key questions, such as:

- Can the ADMS successfully and efficiently converge data from all necessary sources?
- Can the system model these data accurately and at the speed required for grid modernization, particularly at the grid edge?
- Can it ensure security?
- Does it enable mobility of processes and people?

A Platform for Network Convergence

In order to provide a reasonably complete decision-support system for monitoring and control of the electrical grid, an advanced ADMS must encompass or integrate to systems and equipment both within the utility infrastructure and at the customer premises. As well, in order to minimize outages and better manage power quality, an ADMS must also be able to effectively control appropriate field devices. These complex tasks invariably require some level of multi-vendor component integration.

When evaluating ADMS vendors in regard to their overall solution and technology footprint, the capacity to support and integrate best-of-breed solutions is a significant factor. Below is a list of grid and system components an effective ADMS must be capable of considering. Those considerations include:

Process Area	Systems and Equipment	
Grid management	» *Outage management* » *Distribution management* » *AMI*	» *Field sensors* » *Utility-scale renewables* » *Communications and control, including SCADA*
Operational processes	» *Billing system* » *Customer account management* » *Forecasting* » *IVR and self service*	» *Asset management* » *Work management* » *Mobility*
Distributed resources	» *Solar rooftop panels* » *Wind and microturbines* » *Electric vehicles* » *Smart homes and buildings*	» *Demand response* » *Microgrids* » *Distributed storage*

Integration points an ADMS must be capable of considering for modern distribution

Enterprise Information Management Architecture

The limits of SCADA-centric systems

To capture the full benefits from ADMS investments, enterprise architects must pay close attention to enterprise information management architecture. Supervisory control and data acquisition (SCADA) technology is well-known and proven within the electric utility and other asset intensive industries. However, over time, most of these SCADA-centric systems evolved beyond their original intended purpose to include a set of market-specific applications that rely on some aspect of basic SCADA functionality. This evolution has been in progress for decades, resulting in the majority of grid technology innovations concentrated on peripheral systems and equipment rather than SCADA itself.

Energy management systems (EMS) that monitor and control high-voltage generation and transmission are a good example of a system that has evolved beyond its SCADA core. While EMS uses SCADA to closely monitor/control grid frequency, system load, tie points and generation controls, it uses advanced applications to intelligently interpret SCADA-reported data. EMS then generates grid-stabilizing control signals to send to the field equipment.

Modern distribution grid management is rendering ineffective many traditional SCADA-centric architectures.

Today's network must deal with many different data sources—not just from SCADA-controlled devices but also from advanced metering infrastructures (AMI), smart sensors, trouble calls, weather feeds, demand response , and many more. An outage management system (OMS), for instance, often models two orders of magnitude more field devices than a typical SCADA and must model many inputs beyond SCADA – generally at much higher volumes—and may be entirely SCADA-independent.

Similarly, many distribution management system (DMS) applications—fault location analysis (FLA), power flow, feeder load management (FLM), suggested switching, etc. —are all common DMS applications that fit this SCADA-independent rule. These DMS applications require input from the field for current load and fault conditions, but they do not require remote control. As well the outage management component of ADMS does not necessarily need to include SCADA or SCADA controls.

Consequently, it makes less and less sense to build outage and distribution management as SCADA-dependent systems. In terms of architecture, SCADA and/or SCADA initiated controls need to be viewed and managed as enabling technologies, similar to GIS, rather than a centerpiece component.

Real-time Network Model Accuracy

Of the major components an ADMS must integrate, the most complex interface is certainly between an outage management system (OMS) and a distribution management system. Some utilities have tried to keep these systems separate, but this poses significant construction and maintenance costs, complexity, and safety challenges. A common OMS/DMS system presents the most efficient, crew safety supporting, accurate and cost-effective network model.

From an operational perspective, there is merit in anchoring your ADMS with a proven OMS/switching platform. A quality OMS provides an effective mechanism to model, prioritize, communicate, and resolve customer outages. OMS provides the most complete and accurate representation of electrical field equipment conditions because it models all relevant field assets. Because OMS tracks current field device status and current outages it is also the logical platform to safely coordinate both planned and unplanned field switching operations.

OMS and DMS both have complex data models. Building the two models in parallel adds significant operational cost. Operators are typically limited to one system or the other, creating workforce constraints. As well, this separation not only limits the flow of information across the two systems, it can present worker safety issues due to data inaccuracies presented by time lags in model and/or integration updates.

Integrating outage and distribution management into one model solves these challenges and also presents a number of additional customer and operational benefits. For example, switching leverages the OMS model to safely coordinate outage restoration efforts. If the DMS model fails to track outage management switching activity, it could be using less accurate input data—making DMS-produced predictions that much less accurate.

A common OMS/DMS model system presents the most accurate network model and does so in real time.

The result is improved information flow and communication, heightened situational awareness, faster response time, and more effective decision making. The outcome is better reliability and service across the process lifecycle:

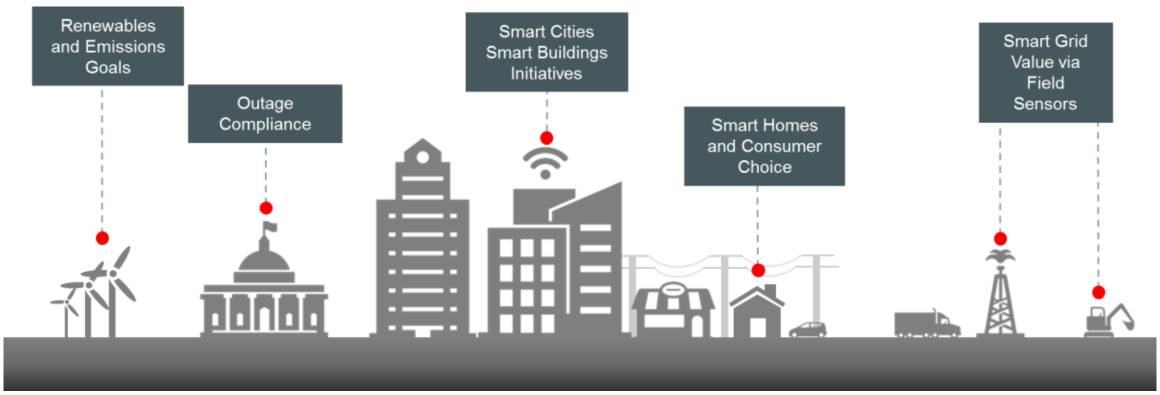
» Fewer overall resources are required to manage restoration operations because cross-trained DMS/OMS operator can be leveraged

» Outage duration is reduced as analysis and resource prioritizations are more accurate and timely.

» Customer satisfaction improves due to integrated workflow that provides more accurate restoration time estimates, more timely restorations, and ready access to real-time status updates.

Visibility to the Grid Edge

Utilities increasingly utilize automated metering infrastructure (AMI) to remotely monitor customer usage, automatically detect outage (and restoration) events identified by the AMI meter, and remotely connect/disconnect meters and even other field equipment. Some also use AMI to bring in near real-time meter voltage from the edge of the grid. The ability to effectively monitor and control edge of the grid devices means AMI (and other related line sensor technologies) must be considered legitimate data acquisition and field-control ADMS components.



A modern ADMS must be capable of serving as a platform for numerous grid-edge innovations

AMI and related smart grid and distribution automation solutions are becoming common and significant pieces of the ADMS puzzle, particularly as distributed energy resources (DER) proliferate at the edge of the grid. As DER continue to gain traction it will become more critical to capture near-real-time customer meter voltage for ADMS model feedback. This edge of the grid feedback provides utilities confidence they are providing proper service to their customers even as they minimize the cost of that service via advanced functions like conservation voltage reduction (CVR). AMI and related sensors become another input into the ADMS - another way to extend control of the network from the control center to the field – augmenting more traditional D-SCADA integration.

System Intelligence to Manage High Volumes of Data

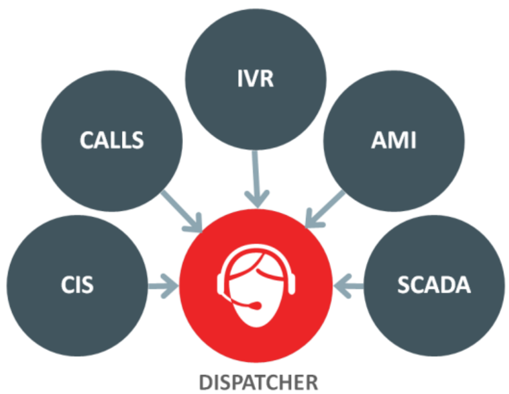
A modern ADMS at a large utility must deal with massive amounts of static and dynamic data. It must manage the ongoing data flow from the integration of GIS, CIS, planning and SCADA systems necessary to maintain a basic model. As conditions continuously change, trouble calls, AMI, SCADA, mobile and operator data input must be constantly updated and reconsidered. Depending on configuration, severe storms can prompt SCADA systems to generate hundreds of thousands of alarms – often not all that helpful to a typical ADMS operator.

As it stands, many utilities rely on the grouping capabilities of independent monitoring systems such as SCADA to manage the data overload. However, even systems using intelligent alarming typically disregard valuable network data and so only consider part of the picture.

To overcome this problem, an effective ADMS must provide two capabilities. First, it must improve the ability to draw correlations by sorting through massive amounts of information without eliminating sources of data from consideration. Second, it needs to present that data in a meaningful way so that the insight it provides is actionable for the operator.

Data distillation to improve correlation

To the first requirement mentioned above, the ADMS must be capable of viewing the entire distribution network model – all the way to the customer meter. To do so, ADMS must encompass an expanded breadth of data inputs—GIS, CIS, AMI, SCADA, mobile field crews, operators and more—to provide a more accurate representation of field conditions and primary concerns. Based on dynamic trouble calls, AMI and potentially SCADA data, an effective ADMS/OMS provides a list of predicted outage devices conveniently ordered by impact size and/or utility provided prioritization rules. This provides a practical task list that operators can use to efficiently manage limited restoration (crew) resources.



Expand the breadth of information that can be correlated, filter out extraneous input, and prioritize using context-based understanding

An ADMS/DMS can also automatically calculate distribution infrastructure overloads based on real-time SCADA measurement inputs, load profiles, and construction information already in the model. By presenting predicted distribution infrastructure overloads to the operator in degree of feeder overload order—with drill down to overloaded devices within the feeder—the ADMS/DMS yields a routinely updated display. Operators can use this information to easily see which feeders are predicted to be in the most trouble from a loading perspective. In contrast, ineffective solutions often generate bursts of limit-oriented alarms for an operator to sort through, often with no practical ability to reasonably correlate these alarms to a higher level root cause.

The broader use of data means more information can be used to draw correlations, leading to more accurate root cause analysis while also filtering out extraneous input. This distillation efficiently combines all relevant input to yield a clear and concise picture of current conditions and customer impact.

Context-based prioritization to make insight actionable

The second capability necessary to deal with high-volume data is information prioritization and presentation (touched on above). Without it, alarms can overwhelm operators, making them prone to error that can lead to safety, asset risk, and outage duration issues. An ADMS using exception-based management, combined with data distillation, pushes only the relevant information to the operator. This substantially reduces error, such as high-priority responses to low-priority alarms.

To achieve this context-based understanding of alarms, ADMS adds to the system a data analysis intelligence layer between field signals and operators. The system automates the aggregation of relevant data and determines what activities are of the highest priority and benefit. Using an integrated model, it then delivers only information to the operator that enables effectively responses to customer interruption events.

Options to support mobile strategies

Mobility of people, information, and systems has become ubiquitous in the utility work environment. Nowhere is this more evident than during outage management, where mobile solutions can extend the visibility of the control room into the field. A more effective information flow between field crews and the control center ensures adherence to key performance metrics, such as accurate estimated time of restoration (ETR). As well, in the event of large weather-related events, accurate and fast information flow helps integrate temporary and mutual aid crews into workflow.

For this reason, ADMS must support mobility as a core feature. However, mobility needs often vary greatly across utilities, depending on factors like weather severity, the prevalence of contractors, and differing regulatory compliance requirements. As a result, the ADMS/OMS must include breadth of options for supporting mobile strategies. These options must include enterprise approaches, where the ADMS and an enterprise mobile system are integrated. Additionally, it also must support mobile device applications ("mobile apps"), which enable the utilities to use technology to quickly address more fluid field conditions.

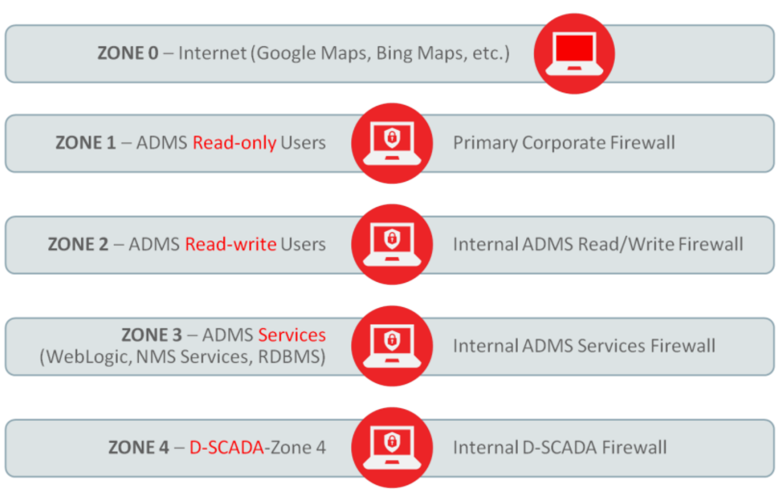
Ensuring security via modularity

An ADMS model typically ties together current information from GIS, CIS, planning, IVR, AMI, D-SCADA, mobile and many other systems. Due to that breadth of system and information integration, an ADMS attracts a broad range of end users who access the model for many different purposes. From a security perspective, it is often necessary to significantly limit which users have the ability to send control signals to distribution field equipment.

An ADMS that is an extension to an existing D-SCADA creates a tightly coupled integration, exposing more users to raw D-SCADA control functionality. This tight integration creates a significant security weakness, providing a larger "attack surface" for one of the most security sensitive components of an ADMS.

In contrast, a modular ADMS prevents this security risk by enabling the utility, in effect, to create user security zones. There is but a single path for field control requests to pass from ADMS to the D-SCADA, and access can be closely monitored and controlled to help eliminate security risk. However, this single path enables access into the modular security zones. The result is that the larger user base can access functionality for broader purposes without access to outbound D-SCADA control functionality. The relatively few ADMS end users that actually need full control of D-SCADA can then access it – minimizing any potential security concerns.

Example Security Zone Modules



Ease of system deployment and management

The rapid evolution of ADMS means that, today, there are few widely accepted industry definitions of modern distribution management. While that is slowly changing, undertaking deployment of ADMS and implementing modernization functions such as Volt VAR Optimization (VVO), Fault Location Isolation, and Service Restoration (FLISR) occurs, in many instances, in operational whitespace.

As a result, defining precise requirements can be challenging, as ADMS benefits are often not just for meeting current objectives, but also for anticipated needs, many of which simply aren't readily apparent or quantifiable. The harsh reality of this dynamic is that many ADMS implementations, particularly highly touted and visible ones, have far exceeded anticipated budget, scope and timeframes. In fact, numerous of them have evolved into open-ended services engagements.

One of the overlooked benefits of a well-designed ADMS is the system's ability to limit these open-ended engagements and upgrades. It can do so by providing:

- Mature functionality out of the box, limiting the amount, cost, and time of customization needed to achieve deployment goals
- Training and knowledge management designed into system functionality to lower time-to-productivity cost
- Unified modularity so that new functionality can be released at the pace of business requirements, ensuring business improvement process remains manageable
- Grid edge management built in, eliminating the need for bolt-on system cost
- Application management to ensure the solution is capable of optimal performance at all times, particularly during major storms
- Proven scalability, so costly and lengthy re-architecture projects and performance compromises aren't required
- Unified platform, built-in standards, adjustable access and layouts, and other capabilities that limit IT involvement and source-code alterations and ensure straightforward upgradability
- Pre-integration to core utility processes, such as customer service (and self-service), metering, asset management, mobility, analytics, etc., to reduce complexity of tightly connecting grid operations to the enterprise and customers
- A consistent record of on-time and within budget projects, initially and with upgrades; while this isn't an aspect of system design, it's indicative of what to expect during deployment

Oracle Utilities Advanced Distribution Management

Modernize Distribution Performance All the Way to the Grid Edge

Oracle Utilities Network Management System (NMS) is recognized by industry analysts as a leading enterprise-class ADMS, delivered out of the box.

It combines world-class data management, predictive load and outage profiling, proven scalability, and grid optimization and automation to improve business performance and customer satisfaction.

With it, utilities can tie customer and operational processes together to meet demand at the lowest cost possible, deliver outage responsiveness needed to build regulatory and customer trust, and turn the challenges of a changing distribution grid into business opportunity.

Oracle Utilities Network Management System (NMS) is recognized by industry analysts as a leading enterprise-class ADMS, delivered out of the box.

Consisting of Oracle Utilities Distribution Management and Oracle Utilities Outage Management systems on a unified model platform, Oracle Utilities NMS enables utilities to realize powerful benefits:

» Bring new thinking to monitoring, control, and optimization of the grid to improve how you can safely meet demand at a lower cost

» Use the variability of distributed energy resources as a way to improve reliability

» When things do go wrong, more effectively respond to unplanned outages, integrate emergency and mutual-aid crews, and get accurate information to customers faster

Also, Oracle Utilities NMS is part of a complete suite of grid solutions. Via pre-integration and cloud services, these solutions deliver the industry’s most comprehensive network management capabilities that extend to the edge of the grid and into the customer premises.

Conclusion

For an effective business and technology strategy, utilities must establish guiding principles and a unifying architecture that allows diverse, evolving inputs to be efficiently integrated. The end result must scale into a unified distribution operation platform that enhances grid resilience, operational safety, and security. Decisions should be based on maximizing value from end-to-end solutions to solve present and future challenges, supported by a thorough and non-biased understanding of the most relevant technical and non-technical factors.

Utilities are best served by developing a holistic view involving all stakeholders. Technology should not be acquired based on a limited set of functional requirements designed to preclude viable options. Rather an understanding of fit within the context of a broader set of grid modernization technical and business process requirements.

When looking for an ADMS solution, potential customers have both current and future requirements to consider. Traditional grid systems weren’t built for the level of data-driven, complex processes needed for modern distribution management. ADMS is now more about how efficiently you can process and effectively present distilled data to your operators than it is about raw data acquisition.

Oracle Utilities NMS is purpose-built to support a modern utility, providing a data-centric approach to monitoring, control, and optimization of both traditional distribution and edge-of-grid needs.

Oracle Corporation, World Headquarters
500 Oracle Parkway
Redwood Shores, CA 94065, USA

Worldwide Inquiries
Phone: +1.650.506.7000
Fax: +1.650.506.7200

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Author: Michael Guilfoyle, Oracle Utilities