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Telecommunication Network Management System Survey Report

First Edition

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EPRI Project Manager

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ABSTRACT

Utility telecommunication networks are very complex systems. They are made up of a variety of technologies for both wired and wireless networks. The management of telecommunication networks can therefore be a challenging mission. One way to accomplish this is with a network management system (NMS). However, as the number of different networks and network equipment begin to grow, the number of NMS systems required may also grow. This degrades the ability of an individual or IT group to successfully monitor and respond to various conditions in the network.

One solution to this problem is a single, overarching network management system that can interface with all the various network solutions being deployed. This provides the ability to monitor and manage the equipment, including the areas of fault, configuration, accounts, performance, and security. Several product offerings are commercially available, each having various strengths across these different functional areas of network management. However, the utility survey conducted for this project indicated that many of these solutions do not adequately incorporate support for all the network hardware solutions common to the utility industry, and multiple NMS platforms are often still necessary to provide the level of management required.

This report provides a list of NMS tools currently used by utilities, with a short description of the tool and its use. Future NMS system requirements and potential next steps are documented. Additional work is needed to consolidate the number of network management systems that utilities are required to use. A future state vision for NMS includes a goal of arriving at a single platform to provide a "single pane of glass" for situational awareness, with geo-spatial visualization of network elements, and integration with asset management, work management and IT ticketing systems.

Keywords

Network Management System
NMS
Telecommunications
Manager of managers

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1
OVERVIEW

Utility telecommunication networks are very complex systems. They are made up of a variety of technologies, for both wired and wireless networks. Whether it is due to the merging of companies, or a staged migration from one technology or vendor to another, these networks are often made up of a conglomeration of different vendors. Due to the rapid evolution of technology and anticipated in-service lifecycles for utility network infrastructure, it is not uncommon to be managing different vintages within the same vendor and product line.

The management of telecommunication networks can therefore be a challenging mission. One way to accomplish this is with a network management system (NMS). In most cases, vendors of network hardware will offer a NMS software platform as one approach to monitor and manage the deployed equipment.

Sometimes, the vendor's own NMS may provide options to configure, troubleshoot, and manage their network equipment using proprietary methods, or standards that are not widely used. This often forces a user to primarily rely on these tools, and not a more generic, vendor agnostic tool. However, as the number of different networks and network equipment begin to grow, the number of NMS systems required may also grow. This degrades the ability of an individual or IT group to successfully monitor and respond to various conditions in the network.

One solution to this problem is a single, overarching network management system that can interface with all the various network solutions being deployed. This provides the ability to monitor and manage the equipment, including the areas of fault, configuration, accounts, performance, and security. Several product offerings are commercially available, each having various strengths across these different functional areas of network management. However, the utility survey conducted for this project indicated that many of these solutions do not adequately support all the network hardware solutions common to the utility industry, and multiple NMS platforms are often still necessaryto provide the level of management required.

This report provides a lis of NMS tools currently used by utilities, with a short description of the tool and its use. Future NMS system requirements identified through the survey are documented. Finally, potential future areas of research are identified.

Additional work is needed to consolidate the number of network management systems that utilities are required to use. A future state vision for NMS includes a goal of arriving at a single platform to provide a "single pane of glass" for situational awareness, with geo-spatial visualization of network elements, and integration with asset management, work management and IT ticketing systems.

2
WHY NETWORK MANAGEMENT?

To understand the value and uses of network management systems, utilities were asked about different aspects of their IT and OT networks, and how they were currently being managed. Utilities were asked about areas that were identified as "gaps" and some of the features they would be seeking in a future system.

Utility organizations represented in the surveys included staff with the following in their titles:

> IT Infrastructure, Communications, Network Planning and Network Engineering, Information Security, Operations and Reliability compliance, EMS/DMS.

The Value of Utility NMS

When asked, "Why is NMS important to your organization?", utility members surveyed provided the following top responses:

The ideal telecommunications network management system would allow utilities to:

- Meet [electric] reliability standards / compliance by enabling us to operate the power grid
- Improve Operational Performance [for both telecom / OT networks]
- Bring Radio, Data and Voice networks together
- Perform correlations between connected network systems and identify system trends
- Provide a security operations center (SOC) with monitoring and alerts from the telecommunication systems.
- Share telecommunication network status between IT NOC and SCADA support groups.

Desired NMS platform features

Utilities were asked to describe an ideal NMS system and how these features could provide additional value and benefit to their organization. The desired features, system interfaces and subsequent values are listed below.

- Enable management and monitoring of all IT and OT networks and platforms through a centralized network operations center (NOC) (Depending on the organization, there may be multiple NOCs)
  - Accomplish system wide monitoring* in a single software package, and not require multiple software tools.
    - *Note: The ability to perform system wide monitoring vs. management is a subject that is discussed later in this report. It is reasonable that the first iteration would support monitoring, yet still rely on vendor tools for some of the advanced management functions.
    - Note: This concept has been described as a "single pane of glass" for improving situational awareness.

- Interface with a Geospatial Information System (GIS) system, or have an API to a mapping platform.
  - Visualize entire network, and relationships between network components (upstream and downstream devices)
  - Allows "layers" of network infrastructure to be turned on and off.
  - Allows overlay of telecommunications network with electrical grid (Ability to display Transmission and Distribution system components)
  - Several products discussed with utilities were reported to have a mapping system within the product or an API to Google Maps.
  - ESRI ArcGIS was reported to be capable of displaying NMS location, status and alerting in the same GIS system that presents SCADA (EMS or DMS) information.
    - Note: Other utility GIS platforms may also have this ability. This is not meant as an exhaustive list, so absence from this list does not mean an interface is not available. This solution was mentioned in more than one survey, and is the reason for including it here. Where information was available for GIS capability, it will be included in the table in Chapter 4.
- Interface with an IT Inventory / Asset Management System
  - Provides single listing of assets for accounting, tracking and maintenance.
- Interface with a Work Management System (WMS) / IT Ticketing system
  - When an issue is identified that cannot be resolved remotely, a field technician, with the right training, needs to be assigned.
  - (Secondary) The WMS / IT Ticketing system should interface with the GIS system to identify the location of available Telecom field technicians.
- Interface with the security operations center (SOC) by providing monitoring and alerts.
  - The SOC can move towards the model of an Integrated Security Operations Center (ISOC) by integrating telecommunication NMS information with related information from cyber security and physical security systems.
- Assist in troubleshooting and problem resolution; countering a lack of alarm correlation
  - In the case where there is minimal or nonexistent network monitoring, provide the ability to quickly determine if the problem is with the network component vs. the device behind the network. Currently, a lack of formal NMS tools for OT causes the utility to rely on a "secondary indication", such as SCADA.
  - Consider a system that could predict, based on historical trends or other methods of ranking, which is the "more likely" component to have failed.
  - With a product having a basic knowledge of system topology, and knowing which devices are "upstream" or "downstream", alarms could be correlated.

Additional NMS Benefits

Benefits and efficiencies gained from a system with these features may include:

- Improved situational awareness
- Reduced troubleshooting time

- Improved coordination between network response groups
- Improved communication to affected customers (internal or external)
- Faster restoration times and
- Reduced outage durations

3
THE MANAGERS OF MANAGERS CONCEPT

This section will describe the basic architectural concept of vendor specific NMS systems, and moving towards NMS systems that can monitor several different device makes and models.

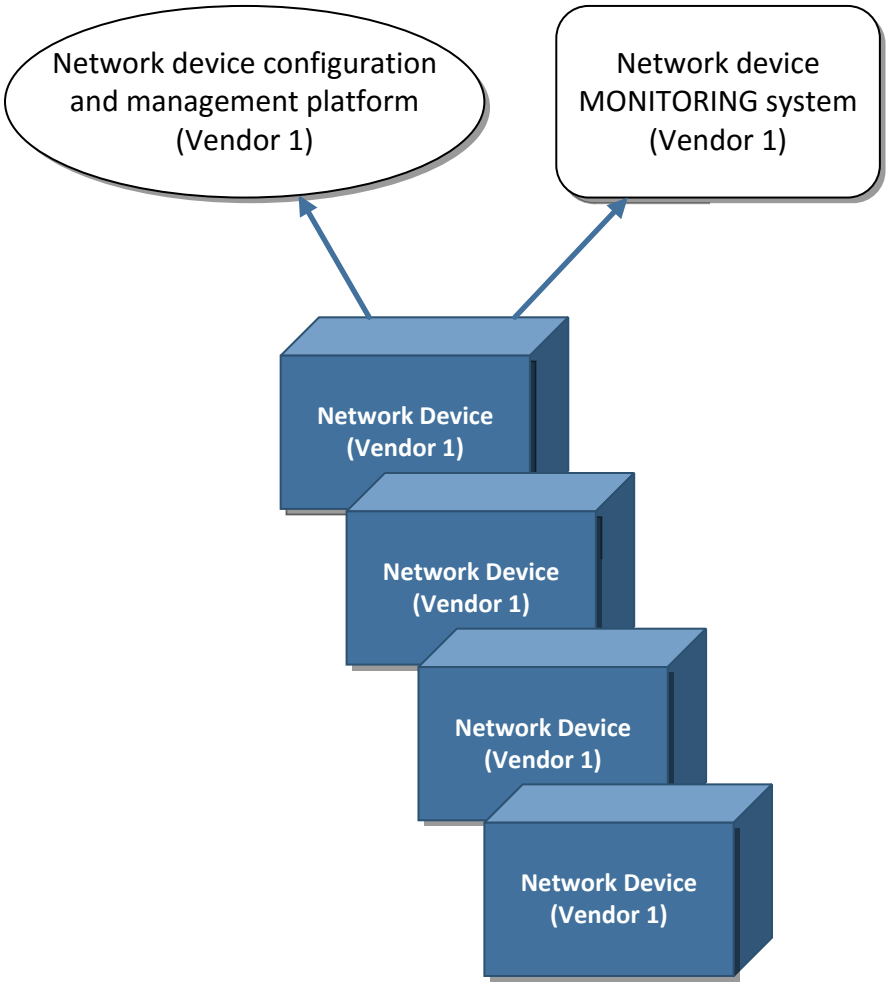

Figure 3-1
Network monitoring and management platforms for devices from a single vendor

A single vendor product and NMS system is shown in Figure 3-1. Multiple instances of the same device from Vendor 1 can be monitored by Vendor 1's "monitoring platform", while the device configuration and management tasks can be performed also using Vendor 1's platform.

One potential source of confusion in this topic is that these are often referred to jointly as an "NMS", even though some products provide more of a Network *Monitoring* System, and others a Network *Management* System. The monitoring and management platforms may be the same product, but for purposes of illustration, they are shown as separate entities.

In the example in Figure 3-1, the individual or group responsible for maintaining these devices only has one tool to interface with. This is described as the “1-to-1” scenario: For every one network vendor, one NMS system will be needed. Consequently, as the number of vendor platforms grows, the number of NMS platforms will grow. This case is represented in Figure 3-2, with one through ‘n’ vendors needing to be monitored separately and managed separately.

This case assumes that there is no correlation of abnormal conditions being performed, and the only way to resolve the condition is for the user to rely on troubleshooting techniques to pinpoint and resolve the problem. As the number of platforms grow, this becomes a tough and challenging task. One way to handle the growing network is through a Network Operations Center, or NOC. But even a network specialist with the appropriate training and skills would find this to be a very inefficient way of managing the network.

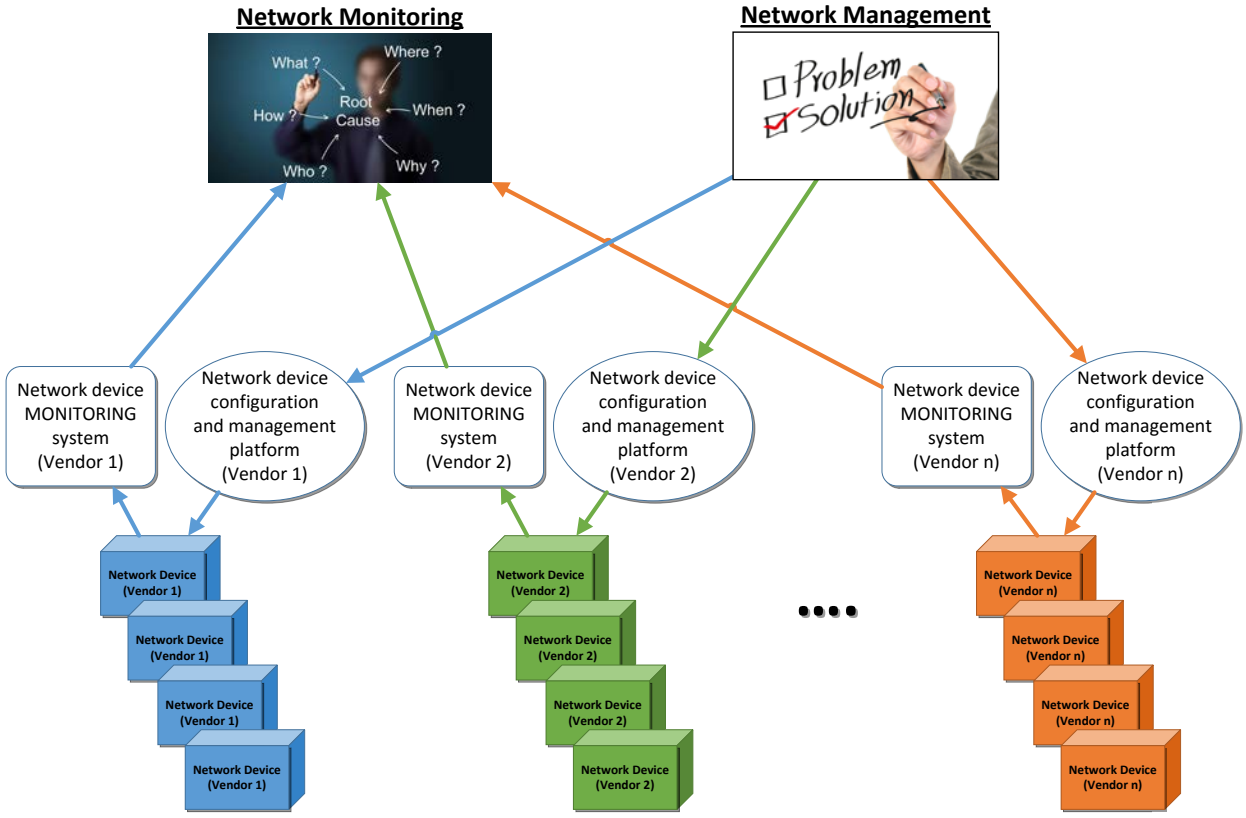

Figure 3-2
Network Monitoring and management platforms for device vendors 1 through ‘n’

Figure 3-3 illustrates a shift from the “1-to-1” model to a “many-to-1” model. This is shown by the aggregation of multiple vendor monitoring platforms into a single “Manager of Monitors” platform, and similarly, the aggregation of the various management platforms into a “Manager of Managers” platform.

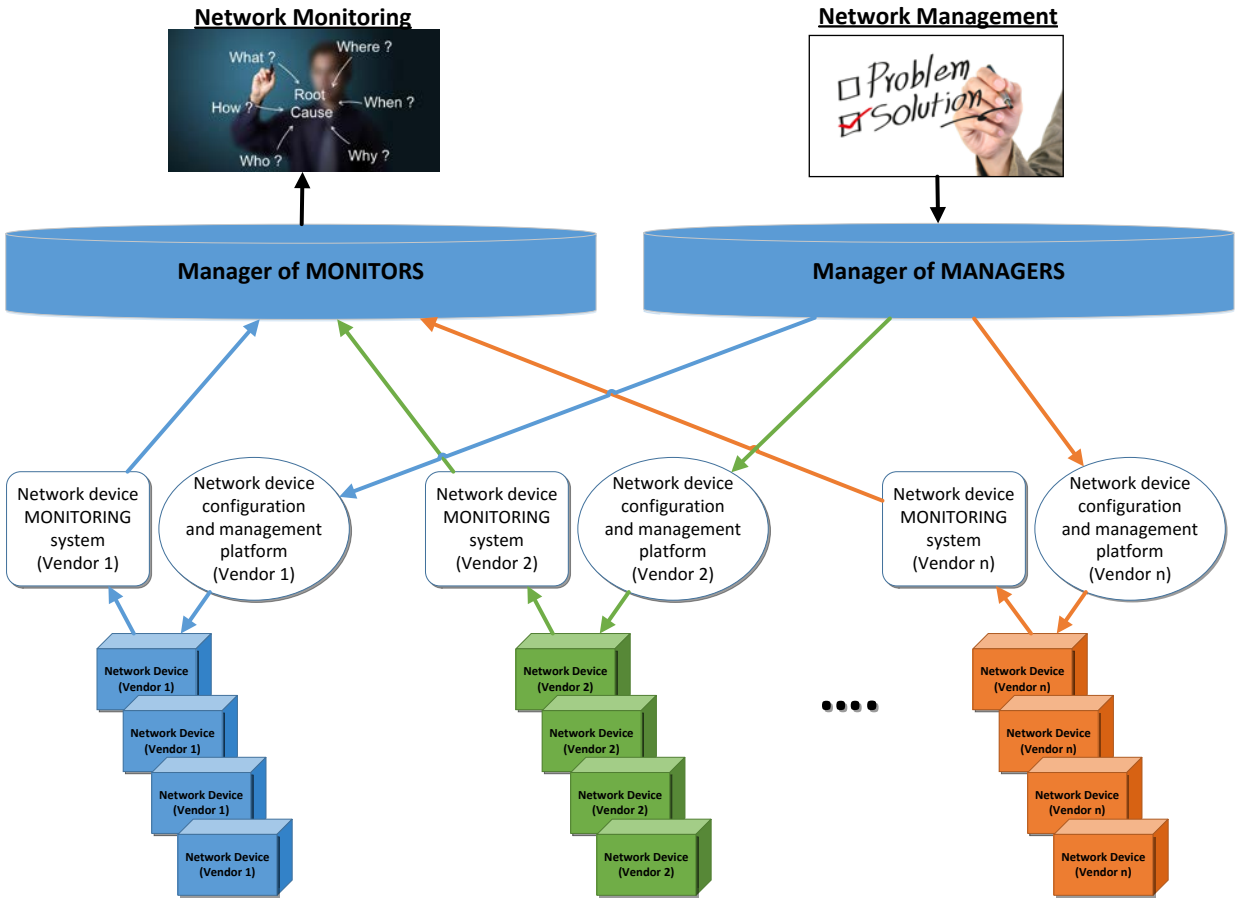

Figure 3-3
Manager of Monitors and Manager of Managers for device vendors 1 through ‘n’

Manager of Manager vs. Manager of Monitors

A “Manager of Monitors” would allow the staff to identify which systems require further attention, but is not capable of “managing”, or performing any actions on the device to resolve issues. Device actions may include changing a configuration or restarting an interface or device.

This is where the term “Manager of Managers” (typically referenced as MoM) comes in. These systems would provide not just the monitoring into the devices, but also allows the configurations to be changed during troubleshooting. Management of the device also includes provisioning to add additional circuits across a TDM device, or adding new services in a packet switch device.

A listing of some of these products being used by utilities are listed in Chapter 4.

4
SURVEY RESULTS

NMS Solutions at Utilities

NMS products identified by utilities were documented and researched. Due to mergers, acquisitions, and end of life products, many of the products and NMS names have evolved. To provide a cross-reference to common names that may still be used, older product names are also listed. The full list of products and brief descriptions can be found in Appendix D.

Manager of Monitor or Manager of Managers

Some of the vendor solutions being implemented by utilities in either the Manager of Monitors or Manager of Managers role include the following:

More likely to be used as the primary tool:

- Megasys Telenium
- Solarwinds
- HP OpenBridge (formerly OpenView)
- Splunk
- CA Spectrum

Less likely to be used as the primary tool:

- Proximetry AirSync
- NetBoss.Now Portfolio

Potential for future consideration:

- ESRI ArcGIS Telecom
  - GIS visualization using NMS / MoM data
  - May be complimentary to MoM, or provide the MoM dashboard
  - Has syslog and SNMP interfaces

Based on the number of utilities participating in the first edition of this survey, it was not possible to draw a conclusion that pointed to a single vendor as providing a complete solution for every need at a utility. In fact, some utilities used a combination of these tools to cover different aspects of their network.

The table showing MoM usage by utility can be found in Appendix A.

SIEM, Syslog or SNMP products

Some of the vendor solutions being implemented by utilities for collecting or aggregation of logs or device information include the following products. These products may be grouped into various categories, including security information and event management (SIEM). In some cases,

these products were primarily used by a security group, or the details of the monitoring paths were not known by the survey contributors. Specific utility information on how or where these products are used is provided where available. Multiple sub-bullets indicates information provided from different utilities.

- Splunk (see above)
  - Used for SNMP Trap and Syslog
  - Being used for enhancing the SOC, with a goal of using as a Manager of Manager
  - Currently using as Manager of Manager platform
- HP ArcSight Command Center
  - L&G logs are sent to HP ArcSight and then forwarded to HP OpenBridge
- IBM QRadar
- Kiwi Syslog
  - Used as a syslog collector for the OT network
- NetBrain Technologies
  - Network mapping / diagraming
- Statseeker
  - Proactive polling of devices using SNMP and ping. Status is then sent to Splunk
- Solarwinds
  - Used as a syslog collector for the IT network
- WhatsUpGold
- Megasys Telenium
  - Only used for SEL ICON SNMP v3 to v2 conversion to HPNA

The table showing SIEM, syslog or snmp logging usage by utility can be found in Appendix B.

NMS products

All of the vendor solutions mentioned being used for IT or OT network management are listed in Table 4-1 with the associated management platform. A brief product description for these tools can be found in Appendix B.

The table showing NMS usage by utility can be found in Appendix C.

Table 4-1
NMS platforms by vendor

Hardware Vendor	Management Platforms
4RF	4RF SuperVisor
ABB TropOS	SuprOS
Alcatel-Lucent	TSM-8000
Aviat Networks	Provision, ProVision INM
Ciena / (Blueplanet division)	OneControl Unified Management System

Table 4-1 (continued)
NMS platforms by vendor

Hardware Vendor	Management Platforms
Cisco	Cisco Prime Infrastructure (was Cisco Works and other packages)
Elster	Energy Axis Mobile Solution (EAMS)
Fujitsu	NetSmart 1500
GE JungleMUX	Lentronics VistaNET Network Management System
Itron / Cisco Field Area Router	Cisco IoT Field Network Director (FND), replaces Connected Grid NMS (CGNMS)
Juniper	Junos Space
Landis & Gyr (L&G)	Command Center
MDS iNET and MDS Mercury Radios	MDS PulseNET, MDS PulseNET Enterprise. Older: MDS Element Manager, replaces MDS InSite
Nokia (5620 SAM)	Network Functions Manager – Packet (NFM-P), was Nokia 5620 Service Aware Manager (**SAM**), was Alcatel-Lucent 5620 SAM
Newbridge Networks (Discontinued)	Nokia 5620 Network Manager (NM), was Newbridge 4602 Mainstreet Intelligent Network Station NMS
Sensus Flexnet network	Regional Network Interface (RNI) software
Siemens Ruggedcom	RuggedcomNMS
Tait Radio	Tait Enable
Cellular	N/A

5
KEY FINDINGS

The most significant finding from this survey involved the differences in the ability to effectively manage IT networks with common NMS tools when compared to OT networks and their NMS tools. Additionally, due to the variety of telecommunication networks within utility identified IT networks, the ability to manage multiple platforms using only a few tools still was reported as an arduous, if not impossible task.

These challenges were consistently described in the interviews as "gaps" or "deficiencies" of current tools. For a few platforms, there was an identified lack of any management tools. Some work-arounds were considered or used in these situations, including relying on secondary indications, or using "in-band" monitoring, sometimes through an intermediate device.

Some of the other key findings are listed below

- A general lack of integration between an NMS system and network hardware from any other vendor. Also, different vendors and NMS toolsets was repeatedly identified.
  - This resulted in the current environment of requiring one NMS product for every one brand of vendor's hardware. This was referred to as the "1-to-1" situation.
- Many OT devices do not support common IT monitoring practices or tools. For example, many protective relays do not currently support SNMP or syslog. This makes it difficult to integrate OT devices in an overall network management strategy.
  - If the OT devices do generate monitoring data, it may be in a non-standard format. In some devices or SCADA gateways, it may be possible to map this data to a SCADA protocol (such as DNP3, Modbus or IEC 61850) to transmit to an RTU or other "master" device. If this upstream device can interface with a network management client, it may be possible to create a mapping from the SCADA protocol to a standard IT protocol that the NMS can interpret.
- Many of the NMS, SIEM, and "Manager or Manager" products that market themselves as multi-vendor solutions, were still identified as having only a "basic" level of support for monitoring. In these cases, the solutions were often not able to provide any kind of a "management" capacity, requiring the utilities to rely on the vendor's native tool for this. Some vendors had developed custom interfaces, but this still did not address many of the IT and OT network products still in use.
  - Where customizations can be produced, it was unclear if it was the policy or practice of the vendor to incorporate these drivers back into to core product in future releases.
  - The concept of developing an "Electric utility package" of device drivers and/or correlation rulesets could be of great value to electric utility customers.
- Many of the utilities surveyed expressed a need for geospatial correlation ("single pane of glass") across the different layers of network.
  - The added ability to exchange data with a GIS platform would allow the ability to visualize network and SCADA information at one time. The SCADA information might

include the location information for Transmission and Distribution lines, substations, and service crews.

- Lack of alarm correlation between network elements continues to be a significant problem to quickly identify the "source" of the problem.

  With a product having a basic knowledge of system topology, and knowing which devices are "upstream" or "downstream", alarms could be correlated. The remaining network elements that are not the "source" could then be "grouped" and "muted" pending successful resolution.
- Lack of direct correlation between SCADA (OT) and NOC (IT) networks poses a challenge for outage coordination between groups.
  - Does NOC monitor SCADA network for outages?
    - In some cases, the NOC would have a read-only view into the SCADA console to be aware of alarms or loss of data at sites.
  - Do SCADA operators get alerts from NOC regarding outages?
    - In many cases, this coordination occurred only via phone.
    - It is possible for NMS systems to utilize a SCADA protocol, such as DNP to send NMS status to SCADA system, while sending NMS status to NOC via SNMP.
    - Often, SCADA operators would recognize a network outage due to the sheer number of outages occurring at one time. However, this does not offer positive validation of the exact cause, or the extent of the network outage.
    - This situation was explained as "SCADA is my NMS".

6
NEXT STEPS

Additional work is needed to consolidate the number of network management systems utilities are required to use. A future state vision for NMS includes a goal of arriving at a single platform to provide a "single pane of glass" for situational awareness, with geo-spatial visualization of network elements. and integration with asset management, work management and IT ticketing systems.

Many of the desired features for a future NMS system were described in Section 2. These can be formalized and provided in greater detail to form an "NMS requirements" document that can be shared with vendors. Various score cards can be developed, potentially using the FCAPS or other models as appropriate.

This document could include the network hardware and NMS systems identified in this report, including manufacturer, make and model of equipment to be supported. Specific interfaces or protocols, where available could be specified.

A list of standards may be compiled to help steer solutions that fit the needs of the utilities. This list may also identify APIs to mapping systems, work management systems and asset management systems.

If the current standards do not sufficiently define the interfaces and the status information that is needed to achieve the stated goals, EPRI may seek to further explore the concept of a universal set of status objects to be implemented by each device. This concept was explored beginning in 2012 through 2014, with EPRI sponsoring the creation of the first official (registered) IEC management information base (MIB) document. This MIB can be used over SNMP, or mapped to other protocols, and it can describe the following: The health of the device, health of the protocol, and health of the network. It was based on the IEC 62351-7 standard, sponsored by IEC TC57 WG 15. After ratification, adoption natively by IT and OT vendors could push the translation layer down to the end devices, eliminating the need for the Manager of Managers products to support multiple vendor profiles.

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This and other concepts can be tested and in a future EPRI Telecom "Test Bed". The goals of which would include:

- Enable the ability to aid utilities in investigation of various vendor tools, and at the same time educate vendors about utility needs
- Exploration of NMS and MoM tools; and allow future integration with the integrated security operations center (ISOC) test bed
- Use of the EPRI lab for utilities to conduct objective comparisons of solutions. Vendors would then attempt to demonstrate their ability to meet or exceed specific pass/fail criteria requirements as outlined in a request for proposal (RFP). EPRI's test bed would provide a common platform for each of the vendors to conduct their tests.

Other topics that were discussed during this project:

Utilities wished to gain a better understanding of approaches towards NMS from other industries. For telecommunication carriers, the carrier NOC to utility NOC interface is one where steps to improve coordination could be made. For example:

- Carrier NOC providing value to the utility NOC:
  - The utility could subscribe to notifications about major (and minor) carrier work
  - The utilities would like to obtain more detailed statistics on cellular circuits
- Utility NOC providing value to the carrier NOC:
  - The carrier NOC could subscribe to outage notifications from the utility.

Finally, a discussion of maintaining NERC CIP compliance while having NMS networks was expressed as a topic of interest. This may be due to utilities deploying NMS networks that cut across various electronic security perimeters (ESPs). Utilities would like to learn from their peers how these networks are addressed for compliance purposes, and if it is possible to achieve the desired level of monitoring without the monitoring network "floating high" and automatically included in the highest level of reporting, equal to other networks with compliance regulations.

A
MANAGER OF MANAGER USAGE

Table A-1
Manager of Manager use by utility

Vendor Product	Notes / Network products supported or integrated by utilities	Utility 1	Utility 2	Utility 3	Utility 4	Utility 5	Utility 6	Utility 7	Utility 8
Megasys Telenium	In general, more support for OT devices		Interested			X (Radio, incl M/W)			X (Legacy, non-IP Telecom - TL1)
Solarwinds	In general, more support for IT devices and less support for Legacy OT/Non-IP devices		X (But considering other solutions)			X (Data)			
HP OpenBridge (formerly OpenView)		X HPOV, HPNA, NNMI		X (But considering other solutions)					
Splunk								X (MoM)	
CA Spectrum									X (MoM - anything IP, incl Cap Banks)

Table A-1 (continued)
Manager of Manager use by utility

Vendor Product	Notes / Network products supported or integrated by utilities	Utility 1	Utility 2	Utility 3	Utility 4	Utility 5	Utility 6	Utility 7	Utility 8
Proximetry AirSync								X (Radios)	
NetBoss.Now Portfolio						O Former user, now Telenium			
ESRI ArcGIS Telecom	GIS visualization using NMS / MoM data. May be complimentary to MoM, or provide the MoM dashboard. Has syslog and SNMP interfaces		Interested			Interested			

B
SIEM, SYSLOG AND SNMP TOOLS USED

Table B-1
SIEM, syslog and SNMP tools used by Utility

Vendor Product	Notes / Network products supported or integrated by utilities	Utility 1	Utility 2	Utility 3	Utility 4	Utility 5	Utility 6	Utility 7	Utility 8
Splunk (see above)	Used for SNMP Trap and Syslog		X						
	Enhancing SOC, goal of using this as Mgr of Mgr		X						
	Using as Mgr of Mgr platform							X	
HP ArcSight Command Center	L&G logs sent to HP ArcSight and then forwarded to HP OpenBridge			X					
IBM QRadar									
Kiwi Syslog	Used as a syslog collector for the OT networ						X (OT Syslog)		
Solarwinds (See above)	Used as a syslog collector for the IT networ						X (IT Syslog)		
Statseeker	Proactive SNMP and ping polling of devices, then goes to Splunk (real time polling)							X	
NetBrain Technologies	Network mapping / diagraming						X		

Table B-1 (continued)
SIEM, syslog and SNMP tools used by Utility

Vendor Product	Notes / Network products supported or integrated by utilities	Utility 1	Utility 2	Utility 3	Utility 4	Utility 5	Utility 6	Utility 7	Utility 8
WhatsUpGold									X (Currently eliminating)
Megasys Telenium (see above)		X (Only used for SEL ICON SNMPv3 to v2 conversion to HPNA)							
LogLogic	Syslog	X							
BitStew	Data Analytics platform. Potential to provide correlation between product logs.	Interested							

C
NMS USAGE

Table C-1
NMS usage by Utility

Hardware Vendor	Management Platforms	Utility 1	Utility 2	Utility 3	Utility 4	Utility 5	Utility 6	Utility 7	Utility 8
4RF	4RF SuperVisor				X			X	
ABB TropOS	SuprOS	X						X	
Alcatel-Lucent	TSM-8000					X (Telenium)		X	
Aviat Networks	Provision, ProVision INM			X	X				
Ciena / (Blueplanet division)	OneControl Unified Management System								X
Cisco	Cisco Prime Infrastructure (was Cisco Works and other packages)	X	X	X			X		X
Elster	Energy Axis Mobile Solution (EAMS)			X					X
Fujitsu	NetSmart 1500							X	
GE JungleMUX	Lentronics VistaNET Network Management System					X			X
Juniper	Junos Space							X	
Landis & Gyr (L&G)	Command Center			X		X Outsourced to L&G			X

Table C-1 (continued)
NMS usage by Utility

Hardware Vendor	Management Platforms	Utility 1	Utility 2	Utility 3	Utility 4	Utility 5	Utility 6	Utility 7	Utility 8
MDS iNET and MDS Mercury Radios	MDS PulseNET, MDS PulseNET Enterprise. Older: MDS Element Manager, replaces MDS InSite	X	Not using NMS	X				O Being retired	
Nokia (5620 SAM)	Network Functions Manager – Packet (NFM-P), was Nokia 5620 Service Aware Manager (SAM), was Alcatel-Lucent 5620 SAM	X	X	X		X			X
Newbridge Networks (Discontinued)	Nokia 5620 Network Manager (NM), was Newbridge 4602 Mainstreet Intelligent Network Station NMS					X			
Sensus Flexnet network	Regional Network Interface (RNI) software		X			X			
Siemens Ruggedcom	RuggedcomNMS		Not using NMS					X	
Tait Radio			X						
Cellular		No NMS	No NMS						

D
NMS PRODUCT DESCRIPTIONS

NMS and MoM products and information is provided below for reference. The format includes the hardware vendor, their management platform, and a short product summary with key or unique features.

NOTE: Content from manufacturer websites has been used verbatim in this section to support clearer interpretations of the product or its prospective value.

Table D-1
NMS and MoM products and information

Hardware Vendor	Management Platform	Product Summary / Key or unique features Content from manufacturer websites has been used verbatim in this section to support clearer interpretations of the product or its prospective value.
4RF	4RF SuperVisor	SuperVisor enables you to manage and configure your network on a local, remote or network-wide level, from a central point, and remote units can be managed without interrupting primary port traffic. Local element management enables you to view and set all types of standard configuration parameters – frequencies, power, time and date, port settings – along with security parameters. Detailed access is provided to inventory management data such as serial numbers, alarm status and software and hardware revisions. Performance information is visibly displayed, including RSSI. Remote units can be managed over the air for control, diagnostics and firmware upgrades.For network-wide management, SuperVisor provides data for network utilisation and performance over time, allowing operators to produce standard and custom reports as required. It also supports SNMP for integration with third party network management systems.
ABB TropOS	SuprOS	SuprOS is a comprehensive wired and wireless network management system that provides the functionality and tools required to manage ABB communication networks as a single system – including TropOS broadband wireless mesh routers, MicrOS broadband wireless client nodes, TeleOS unlicensed narrowband PTP/PTMP radios and ArcheOS licensed narrowband PTP/PTMP radios plus selected broadband PTP/PTMP radios from Cambium and Redline. SuprOS also manages AFS Ethernet switches and AFR Ethernet routers from ABB. SuprOS streamlines and minimizes costs of deployment, optimization, operation, and maintenance of ABB communication networks.

Table D-1 (continued)
NMS and MoM products and information

Hardware Vendor	Management Platform	Product Summary / Key or unique features Content from manufacturer websites has been used verbatim in this section to support clearer interpretations of the product or its prospective value.
Alcatel-Lucent	TSM-8000	The Alcatel-Lucent TSM-8000 Fault Management System is a graphically oriented element management system. It automatically collects and stores alarm, status, and performance data from the monitored transmission equipment. As an option, the TSM-8000 provides SNMP fault reporting and controls to and from a higher-level Manager of Managers (MoM). The TSM-8000 supports SNMP (V1, V2 and V3), TL1, and MCS-11 protocols for fault management
Aviat Networks	ProVision INM	The Provision INM is a powerful network, element and service management system for microwave and fiber-based networks built using the Aviat CTR 8611 Microwave Router.
Aviat Networks	Provision	ProVision delivers an efficient, seamless end-to-end network management solution for TDM, Ethernet, and hybrid microwave networks across Aviat's complete product portfolio, including many key partner products. ProVision automates time consuming and error prone processes, such as the provisioning of end-to-end TDM and Ethernet services, bulk upgrading network firmware, and diagnosing network clock distribution problems. ProVision provides the following Aviat Networks and third-party device support: • Eclipse and Eclipse Packet Node Platform; Aviat WTM series microwave systems • Generic Device Support fault management for a wide range of third party SNMP devices; 50+ third-party device packages currently available • Application Integration including craft tools, PCR collector, PCR viewer, MSUU. Automated network health reports detect performance degradation before outages. Advanced end-to-end diagnostics including Ethernet OA&M (ITU-T Y.1731 and IEEE 802.1ag). Smartphone and tablet client option, enabling effective out-of-NOC fault management. Ethernet clock distribution and clock synchronization related faults across Eclipse networks. ERPS, EVC/VLAN and protection/diversity technologies.

Table D-1 (continued)
NMS and MoM products and information

Hardware Vendor	Management Platform	Product Summary / Key or unique features Content from manufacturer websites has been used verbatim in this section to support clearer interpretations of the product or its prospective value.
Ciena (Blueplanet division)	OneControl Unified Management System	OneControl unites the management of Ciena's Packet Networking, Converged Packet Optical, and Optical Transport product portfolios under a single solution. With its unique toolset of comprehensive management features, OneControl puts the control of critical networks at the operator's fingertips. Through a unified GUI and common management model, NOC operators can rapidly deploy new service offerings that cut across domains (access, metro, and core) and coordinate across network protocol layers to ensure efficient use of critical network assets and bandwidth optimization.
Cisco	Cisco Prime Infrastructure (was Cisco Works and other packages)	This single, unified solution provides wired and wireless lifecycle management, and application visibility and control. It also offers policy monitoring and troubleshooting with the Cisco Identity Services Engine (ISE) and location-based tracking of mobility devices with the Cisco Mobility Services Engine (MSE). You can manage the network, devices, applications, and users – all from one place.
Elster	Energy Axis Mobile Solution (EAMS)	Elster now offers a mobile data collection system for reading these endpoints. Because these endpoints include full AMI capabilities, this mobile data collection system allows the utility complete flexibility in scheduling a full AMI fixed network deployment while protecting the more expensive sector of the automation process — the meters. EA_Mobile uses Elster's Route Manager software for creating and managing accounts, routes, and devices.
Fujitsu	NetSmart 1500	The powerful, scalable NETSMART 1500 Management System is a carrier-class system that simplifies management, provisioning and surveillance of the Fujitsu FLASHWAVE® family of SONET/SDH, WDM and packet optical networking solutions, as well as legacy Fujitsu NEs.
GE JungleMUX	Lentronics VistaNET Network Management System	Lentronics VistaNET Network Management System (NMS) Lentronics™ VistaNET is a complete suite of software tools to securely manage the GE Lentronics family of telecommunications products, consisting of JungleMUX SONET and T1 Multiplexers, TN1U and TN1Ue SDH Multiplexers and E1 Multiplexers.
Itron / Cisco Field Area Router	Cisco IoT Field Network Director (FND)	"Device Manager is a Windows-based application that field technicians can use to manage the CGR 1000 running Cisco IOS over WiFi or Ethernet. Beginning with Release 4.1, Device Manager also supports management of the IR500, which supplies RF mesh connectivity to IPv4 and serial Internet of Things (IoT) devices (for example, recloser controls, capacitor bank controls, voltage regulator controls, and other remote terminal units).

Table D-1 (continued)
NMS and MoM products and information

Hardware Vendor	Management Platform	Product Summary / Key or unique features Content from manufacturer websites has been used verbatim in this section to support clearer interpretations of the product or its prospective value.
Juniper	Junos Space	"Junos Space Network Management Platform works with our management applications to simplify and automate management of Juniper's switching, routing, and security devices. As part of a complete solution, the platform provides broad fault, configuration, accounting, performance, and security management (FCAPS) capability, same day support for new devices and Junos OS releases, a task-specific user interface, and northbound APIs for integration with existing network management systems (NMS) or operations/business support systems (OSS/BSS).
Landis & Gyr (L&G)	Command Center	Command Center™ software is the gateway for all Gridstream® metering technologies and the control point for grid management network sensors. Command Center brings data from any communication technology—including RF Mesh, PLC and Cellular—into a single application.
MDS iNET and MDS Mercury Radios	MDS PulseNET, MDS PulseNET Enterprise	PulseNET Base is intended for small-scale operations with a need to monitor up to 500 devices, while PulseNET Enterprise is intended for large-scale operations with a need to monitor up to 25,000 devices. Optimized for MDS Communication Products, MDS PulseNET provides easy to review radio device performance screens showing the critical radio parameters such as: RSSI, SNR BER, Throughput, and Availability. Network-wide Diagnostics – current and most legacy MDS devices: Built-in support for GE MDS proprietary communication protocol, Allows customers to manage non MDS devices GE will continue to incorporate additional Out-Of-The-Box 3rd party device as requested by customers, Customers can opt to incorporate non-MDS devices as a generic devices type for collections and reporting
MDS Radio	MDS Element Manager, replaces MDS InSite	The MDS Field Network Manager is a simple field monitoring and configuration tool that connects to supported radio networks via serial RS232 or IP Ethernet. FNM provides facilities to collect information on one or more radio networks, as well as providing radio read/write configuration data. FNM serves as a replacement for MDS InSite, providing a modern version of that tool's capabilitie
Nokia (5620 SAM)	Network Functions Manager – Packet (NFM-P), was Nokia 5620 Service Aware Manager (**SAM**), was Alcatel-Lucent 5620 SAM	The Nokia 5620 Service Aware Manager (SAM) enables end-to-end network and service management of Nokia's Network Elements (NEs), and limited management of third-party NEs.

Table D-1 (continued)
NMS and MoM products and information

Hardware Vendor	Management Platform	Product Summary / Key or unique features Content from manufacturer websites has been used verbatim in this section to support clearer interpretations of the product or its prospective value.
Newbridge Networks (Discontinued)	Nokia 5620 Network Manager (NM), was Newbridge 4602 Mainstreet Intelligent Network Station NMS	(Discontinued) The Nokia 5620 Network Manager (NM), formerly the Newbridge 4602 MainStreet Intelligent NetworkStation NMS, is a reliable and scalable network management solution. It provides network operators with a full range of configuration capabilities on multi-technology networks. Traffic and service parameters on frame relay, ATM, X.25, SONET/SDH and ISDN links and paths can be configured through a point-and-click graphical user interface.
Sensus Flexnet network	Regional Network Interface (RNI) software	The RNI communicates with endpoints and provides status updates. It continuously gathers and processes network data, storing or sending it to customer information and billing systems. Priority alarms are delivered immediately for fast response. And on-board diagnostic tools optimize performance by monitoring and managing network health.
Siemens Ruggedcom	RuggedcomNMS	RNMS extends the functionality of OpenNMS to provide enhanced support for RUGGEDCOM networking devices, including: • ROS-based Ethernet switches and serial servers • ROX-based network routers • ROX II-based network routers • • RuggedMAX WiMAX wireless network equipment
Tait Radio	Tait Enable	EnableMonitor delivers: • Real-time system health status that helps you diagnose issues early, and reduce your network downtime • Proof that your network is operating efficiently • Reporting on your IT network availability and infrastructure • Alerts and alarms when there is an issue • Automatic discovery and configuration for simplified setup • Standards-based technology for interoperability • Secure access to performance data anywhere, anytime • Redundancy options for guaranteed performance
Cellular	N/A	

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