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Consolidating Operations, Planning and Protection Model Management Using a Network Model Manager Approach

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SUMMARY

Multiple applications within a utility rely on electrical system network models. In today's utility, these models are typically maintained independently for each application, with data manually supplied for each application's database. Engineers often spend significant amounts of time entering, synchronizing, validating, and correcting duplicate information. The current maintenance approach leads to process inefficiencies and data inconsistencies that can have adverse effects both in terms of reliability and cost.

The Common Information Model (CIM) provides a basis on which a coordinated network model maintenance strategy can be built. The CIM is mature and field-tested in the areas of network equipment, connectivity, topology, and power flow solution exchange. However, its use to-date in supporting network model exchange has been primarily for sharing information between utilities and/or regional authorities, not for the exchange of model information between applications inside a utility. The growing reliance on network analysis, the advent of new regulatory requirements related to

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model validation and the need for network model sharing between Transmission and Distribution, has made better management of Transmission and Distribution network models a topic of growing interest.

This paper describes recent work done by a number of utilities and vendors, in collaboration with EPRI, which defined the high-level requirements for a Network Model Manager (NMM) tool. The work focused on a CIM-based consolidated network model management approach to facilitate internal network model management inside the utility as well as the exchange of models between utilities. The goal of describing NMM requirements was two-fold:

- to provide guidance to utilities in understanding and internally promoting standards-based, consolidated network model and case management
- to help vendors gain an enterprise-wide view of required NMM functionality and to help them understand the universality and potential of demand for NMM tools.

During the course of the work, a conceptual Network Model Manager-based solution architecture to facilitate the organization and management of network model information from multiple sources and its provision to multiple consuming applications was proposed. Using the NMM architecture a number of common use cases were developed to explore how such an architecture might function at various types of utilities, to identify potential benefits of NMM-based solutions and to derive fundamental requirements for an NMM tool. Identified NMM tool requirements included functionality related to physical network model management, object registry, model and case assembly, user workspaces and interfaces, model validation and CIM-based interface support.

KEYWORDS

Network model management
Common Information Model
CIM
Operations and Planning models
Network Model Manager
IEC 61970

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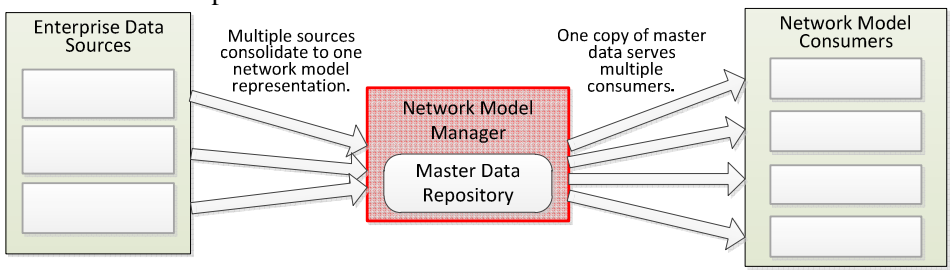
Network Model Information Management Today

The network model management practices typical at today's utilities have evolved 'ad-hoc' over many decades. They are a consequence of a continually increasing deployment of more sophisticated, more specialized and more critical network analysis functions (power flow, state estimator, contingency analysis, short circuit, dynamics, transients, etc.) in more domains (operations, operations planning, long-term planning, protection).

As more and more network applications came into use at utilities, silos developed: each application had its independent users, its independent model maintenance group and its individual modeling processes and assumptions. The resulting silos were, and continue to be, both technical and organizational, with the resulting lack of coordination reflected in a typical network model data management picture where network model information flows come from a variety of sources in a variety of forms, go to a number of target systems and are inconsistently triggered by a variety of events. Lacking an overarching or unifying data management architecture, the creation of accurate models relies on the experience, thoroughness and energy of modeling engineers.

Network Model Manager Vision

As articulated in the work of a recent project, led by EPRI with active participation by multiple utilities and vendors, the technical vision for improved model management is based around the architectural concept illustrated below.



Network Model Manager vision

Enterprise data sources (like station engineering drawings, asset databases and load forecasting systems for example) from which network model data is drawn are represented on the left side. On the right side are consumers of network models, such as an Energy Management System, a suite of planning applications or protection software. Between the sources and consumers a Network Model Manager (NMM) function is introduced. The role of the NMM is to maintain a master repository of network model data that is shared by different network model consumers.

The NMM provides an environment for maintaining master source information in a form that enables efficient maintenance, sound quality control procedures and construction of the network base cases needed by the various analytical processes. Master data is created once, but used many times.

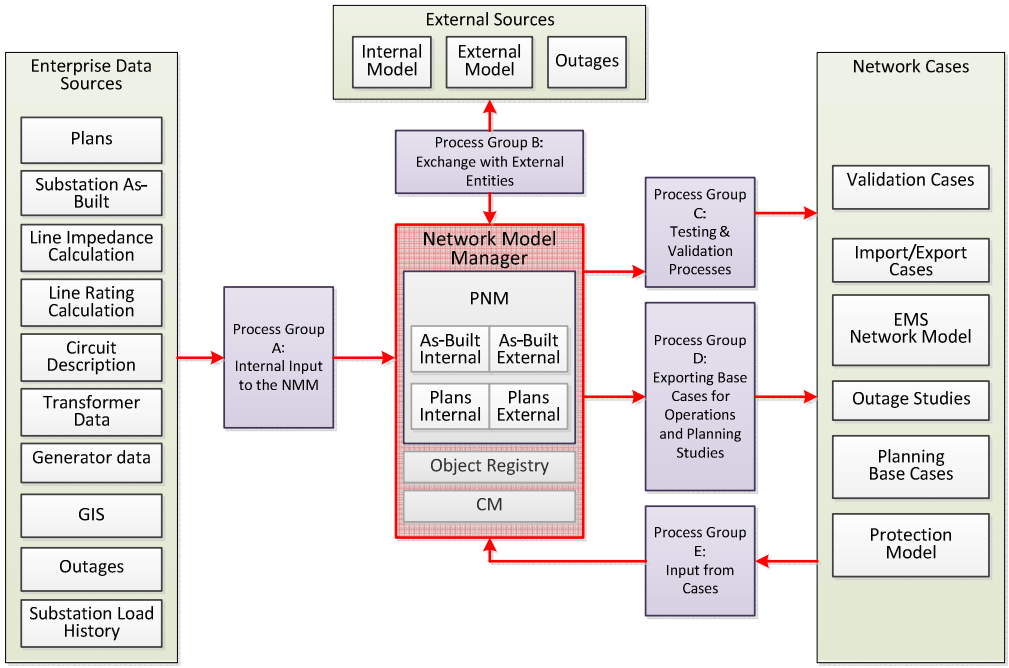
The NMM furthermore is designed as a vehicle for integrating systems and taking advantage of IEC CIM interoperability standards (IEC 61970, 61968, 62325) and more precisely of 61970-301 [2], 61968-11 [3], 62325-301 [4].

Use Case Exploration

In its role as an information management tool, an NMM relates to many other systems involved in network model management, both source systems and consumer systems. In the project, a number of use cases describing how an NMM could interact with other systems were explored and documented. These use cases were organized according to the following diagram, where Process Groups, shown in purple, allowed the organization of use cases into functional groups:

- Group A processes feed information from other enterprise sources into the NMM.
- Group B processes govern the exchange of information with external entities, such as regional entities or neighboring utilities.
- Group C encompasses the exchange of information with functions that assure the quality of the data in the NMM.

- Group D processes share the models or base cases created for operations, planning and protection analysis with various target systems.
- Group E processes reflect the fact that network cases themselves are sometimes sources of corrected network model information.



NMM role within network model management

A partial list of the use cases documented in the project includes:

Process Group A: Internal Input to the NMM

- Use Case A1 – Update a Project to As-It-Will-Be-Built
- Use Case A2 – Establish Identity of Public Objects
- Use Case A3 – Update the Physical Network Model (PNM) Baseline to Reflect Newly Commissioned Work
- Use Case A4 – Create a New Planned Project
- Use Case A5 – Update Content or Timing of a Planned Project

Process Group B: Exchange with External Entities

- Use Case B1 – TSO Updates its Footprint in ISO EMS Model
- Use Case B5 – TSO Receives EMS Model Update from ISO
- Use Case B4 – TSO Receives External Planned Project
- Use Case B6 – TSO Sends Contribution to a Regional Planning Case
- Use Case B7 – TSO Receives Complete Planning Base Case
- Use Case B9 – ISO Receives Generator Information from Generator Owner or Agent
- Use Case B11 – ISO Receives Planned Project from TSO
- Use Case B12 – ISO Receives Update to Planned Project from TSO

Process Group C: Testing & Validation Processes

- Use Case C1 – Validate Modeling of Newly Commissioned Work
- Use Case C3 – Validation of Future Projects

Process Group D: Exporting Base Cases for Operations and Planning Studies

- Use Case D1 – Update the EMS Model
- Use Case D2 – Build a New Planning Base Case of Type X
- Use Case D4 – Script New Case Assembly
- Use Case D5 – Configure Outage Scheduling Application
- Use Case D7 – Provide New, Updated or Baseline Project to Protection Software
- Use Case D8 – Update Market System Model

Use Case D9 – Build a Post-Event Analysis Case

Process Group E: Input from Cases

Use Case E1 – Online EMS Changes/Corrections into NMM

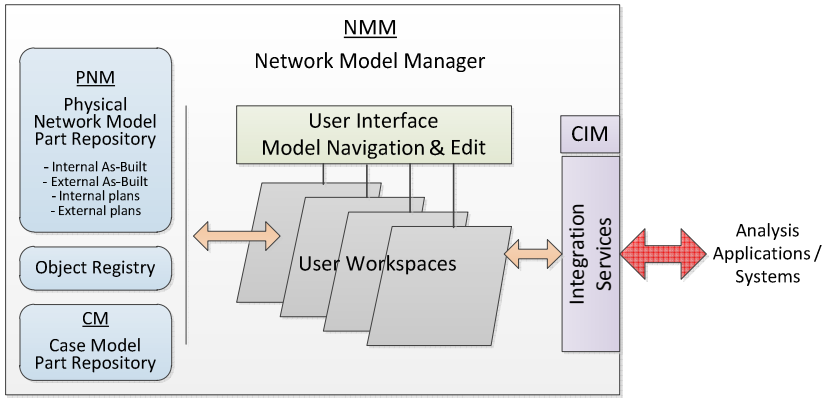
Potential Benefits

The benefits of fully-realized consolidated network model management can be substantial and far-reaching. The use cases explored in the project highlighted a number of main benefits, including:

- Existence of a generally-accessible, single source of model data. Modeling time can be cut substantially as changes are entered only once and all consumer applications receive the information they need.
- Model accuracy is improved for all applications. Quality of study results is improved and labor spent identifying/correcting problems is reduced.
- Accuracy can be validated quantitatively. Confidence in study results is improved.
- Model maintenance work flow processes are supported. Data completeness and quality are improved and labor spent correcting errors or oversights is reduced.
- Model and case information produced in CIM standard form. Implementation of a forward-looking solution positions utility to effectively deal with future process or application changes (both internal and external).
- History is maintained. Ability to support post-event analysis greatly increased. Labor to effectively manage model changes over time is significantly decreased.
- Documentation is improved. Labor spent communicating and managing changes is reduced.

Network Model Manager Functional Overview

As envisioned by the project, the NMM plays a central role in network model management. Its purpose is to maintain the master data components that are shared by network analysis analytical applications and other utility software requiring grid equipment and connectivity information. An NMM is the central vehicle for consolidating model data and automating network model management. A nominal functional overview of the NMM is given below (Note: this drawing is not intended as a design; it is simply a way to illustrate functionality visually.)



Nominal components of a PNM implementation

The most important part of the NMM is the master Physical Network Model Part Repository (PNM). The master PNM contains the data reflecting the inherent physical qualities and capabilities of the network as it is constructed (or as it is planned to be constructed). This data is both slowly changing (typically reflecting field construction activity) and critical to all network analysis studies. The Case Model Part Repository (CM) is the part of the NMM that defines the assumptions, rules and conditions that together allow the assembly of complete 'base cases' that can be supplied to analysis applications. The Object Registry is the part of the NMM that manages the identity of all objects shared across applications served by the NMM. User Workspaces and the User Interface allow users to view, navigate and edit network model data and to assemble network models and cases for export. CIM Integration Services are the means by which the NMM communicates with other systems, both sources of data and targets of data.

Network Model Manager Core Requirements

The project defined a core set of high-level requirements which a commercial NMM product would be expected to meet. These requirements included:

1. Physical Network Model (PNM) Requirements
   The PNM shall enable management of a set of core master Physical Network Model Parts, which represent the electrical capabilities of physical grid elements (as opposed to choices about how to operate the grid). The PNM shall assure that master data items have one source (their 'Model Authority') and that they are organized such that they may be assembled or manipulated to meet all of the important network analysis requirements for study models. The PNM shall support the definition of Projects expressing changes to the physical network model and baselining of model history.
2. Object Registry Requirements
   The NMM shall support object registry services to manage the names of network modeling Canonical Objects in different contexts.
3. Workspaces Requirements
   The NMM shall support multiple workspaces for carrying out NMM operations in parallel.
4. User Interface Requirements
   The NMM shall provide users the capability to browse and edit NMM content.
5. Model and Case Assembly Requirements
   The NMM shall support the CIM 61970 modular concept for assembling network models and network analysis base cases.
6. Validation Requirements
   The NMM shall support development of a testing and validation regimen.
7. Integration Requirements
   The NMM shall provide CIM-based integration services that will allow the NMM to be integrated with other systems without additional custom code.
8. Extensibility Requirements
   The data content of the NMM shall be model driven, definable by an information model and compatible with the idea that a utility may have a Canonical Data Model from which CIM Dataset Types may be derived for the NMM.

Conclusion

A Network Model Manager architecture, with its integrated and unified approach to network model management, has the potential of reducing engineering labor and increasing the accuracy of utility network models. The high-level Network Model Manager requirements developed by the recently completed EPRI project could help utilities recognize the feasibility and benefit of consolidated model management, could help vendors enhance their product offerings and could help the industry at large to move toward viewing network model management as an enterprise-, region- and interconnect-wide undertaking that calls for specifically designed model management software.

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