USING A COMMON INFRASTRUCTURE AND LANGUAGE TO INTEGRATE APPLICATIONS AT FLORIDA POWER & LIGHT

Don Brown, Florida Power and Light
Greg Robinson, Xtensible Solutions

Abstract

For integrating a Distribution Management System (DMS) of a new System Control Center (SCC) with a new Asset Management System (AMS), Florida Power and Light (FPL) is implementing an enterprise-wide integration infrastructure that is intended to lower life-cycle costs and improve business adaptability as more applications are integrated. This paper provides an overview of this infrastructure and describes two key elements of it: the technology being used for the inter-application "phone lines" and the utility industry standard semantics being used to describe the inter-application "common language" being carried through the phone lines.

The evolution and success of packaged applications has caused businesses to demand that disparate applications they have deployed work with each other. For resolving the plumbing issue, FPL has elected to use an Enterprise Application Integration (EAI) product. EAI solutions are application vendor neutral and allow business processes to be dynamically configurable and scaleable. The goal of an EAI solution is to semantically integrate application business processes. To do this, these tools address critical integration requirements such as communication integration, data integration, real-time analysis, and business process automation. Organizing the data in the plumbing is a more convoluted matter. Overlapping information requirements among functional organizations currently results in higher operating costs due to lack of integrity and operating efficiency caused by data duplication and data concurrency issues. Few attributes are used by all functional organizations, but most attributes are used by more than one organization. During the lifecycle of the asset, each organization 'touches' the asset at different times, business process requirements change, and technical requirements change.

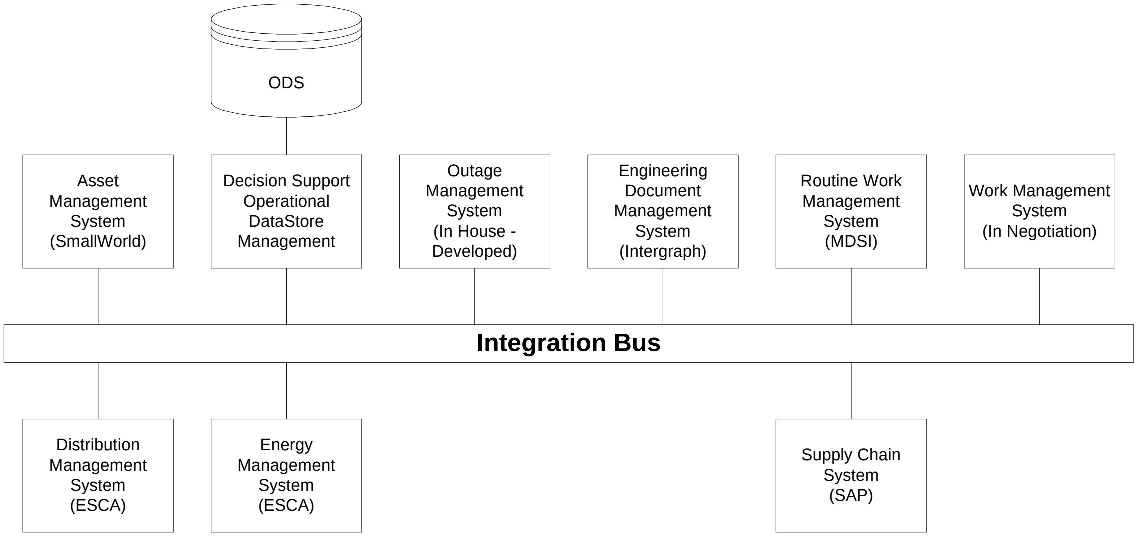
FPL's strategy for resolving this semantics issue is implementing a common language among applications that is based on a utility industry Common Information Model (CIM). In close cooperation with the Electric Power Research Institute (EPRI) Control Center Application Program Interface (CCAPI) Project, the CIM is being extended and standardized by IEC Technical Committee 57 (Working Group 13 for Energy Management Systems and Working Group14 for System Interfaces for Distribution Management). This paper describes how an in-progress project at FPL is implementing this strategy for maintaining a transmission and distribution network model among the AMS, DMS, and other systems.

Enterprise-Wide Integration

The wires division of FPL (Power Systems) has embarked on a mission to replace most of its core business systems by 2004. The current suite of applications, most of which were developed internally, are very difficult to maintain. They may also make it more difficult to operate in the modes required by the emerging changes in regulations. The replacement applications will be Commercial Off The Shelf (COTS) packages with little or no customization. However, it is probable that functions coded within a single one of FPL's custom applications will be divided across a number of the purchased packages. In order to provide seamless functionality to a given business process, a high level of integration will be required between the packaged applications.

The integration approaches used with FPL's custom applications may not differ much from those used in other companies where applications have grown to a high level of functionality over a long period of time. For the most part, every integration problem has been treated as a new development opportunity, with little inheritance from work done in the past. Even interfaces very similar in information transferred and systems connected were developed with totally different designs, and the older interfaces remain in place in parallel with the newer ones. In each case, only one or two developers may be familiar with the design of the interface, and this knowledge is seldom transferred, since any new interface is developed with a different design. As the original developers leave, the interface designs fade into obscurity until the interfaces break, and then there is a scramble to discover any documentation that can be used to restore operation. It is highly desirable to reduce the cost of operation and improve the reliability of interfaces as we implement the new replacement applications.

The first core systems to be implemented and integrated are FPL's Power Systems Asset Management System (AMS), Distribution Management System (DMS) and Energy Management System (EMS). Early in 2000, FPL contracted with SmallWorld for the AMS, and with ESCA for the DMS and EMS. More recently, a contract was put in place with STC for Enterprise Application Integration technology. The first integration deliverable for the projects, due at the end of November of 2000, will support transfer of the Distribution power system model from the AMS to the DMS. Subsequent deliverables will handle transfers of operational information from the DMS to the AMS, improved interface automation, and exception handling. The interface is to be substantially complete in March of 2001, and will go into production with the DMS implementation in November of 2001.



During the final stages of negotiation of the contracts for the AMS and the EMS/ DMS, a group was formed to conduct the selection process for the EAI technology. The members of this group were selected from: the central Information Management Operations and Architecture departments, the Power Systems Information Management department, the EMS/DMS operations and development departments, and from the AMS and DMS project teams. Consulting support was provided by Andersen Consulting and Xtensible Solutions. A field of about seven suppliers was narrowed to three for the final evaluation process. The evaluation criteria were developed to ensure that the selected product would meet the overall corporate requirements for application integration. However, special attention was given to the requirements for the AMS/DMS integration, which included a very aggressive schedule for the first deliverable, unique platforms, high performance and high availability. Throughout the selection process, the management personnel within the different areas involved in approving the selection were kept well informed of the progress. Also, all parties involved in development and operation of integration solutions were invited to be a part of the selection process. Although this resulted in a rather large group of participants, it resulted in rapid buy-in for the selected solution. During final contract negotiations, some simple integrations were demonstrated using FPL's existing systems and the selected STC product. These demonstrations proved that the products could deliver on the promise of easier integration.

The Inter-Application “Phone Lines”
Interface Architecture

In the past, applications have been selected primarily on the basis of business features and functionality. Many utilities are recognizing that selection criteria must place a higher value on factors affecting lifecycle costs. The ability to integrate applications with other packaged, built, and legacy applications is one of the most important criteria. Implementing a message-based infrastructure provides the means for utilities to lower their integration effort without giving up their ability to use COTS applications. The major steps required for this are to establish the following:

- Message-based interface architecture;
- Application interface specifications;
- Information Exchange Models
- Migration plan.

Once an interface architecture and associated interface specifications are defined, interfaces to new and existing applications may be implemented progressively. The interfaces hide the implementation from the user, making internal design irrelevant. Communication among application components is managed through the defined interfaces. When existing applications are changed, the impact on other applications is minimal because the interface structure remains unchanged. New functionality can be implemented on a progressive basis without causing major problems to other applications. Upgrades and maintenance becomes easier as more applications become managed at the component level.

Interfaces are developed for existing applications by using a technique known as “wrapping.” This has immediate benefit because it provides open interfaces that enable application functionality to be extended. This approach provides FPL with a framework on which a migration plans can be developed for solving some major problems: legacy applications that can not be rewritten; monolithic code that has not been built for easy maintenance; multiple design and execution technologies that need to be integrated; demand for new technology support.

Enterprise Application Integration (EAI) Technology's Role

The base technology often used to mesh applications together into one consistent framework is commonly referred to as Enterprise Application Integration (EAI). EAI solutions are application vendor neutral and allow business processes to be dynamically configurable and scaleable.

EAI tools typically address some or all of the following integration infrastructure requirements:

- Communication integration, whereby a fast and robust communication network provides services for various enterprise applications to securely exchange data.
- Data integration, whereby disparate applications use the communication services to exchange data with other applications.
- Real-time analysis, whereby business users are able to monitor and analyze key information flowing through their integration infrastructure. This allow problems and opportunities to be reported and acted upon as events occur.
- Business process automation, whereby business users are able to automate and coordinate the flow of information through their integration infrastructure through business process automation.

An overriding goal of EAI solutions is to semantically integrate application business processes. EAI systems do this be extending the semantic content of the business processes that existing applications have already implemented by providing business logic components that fill in the gaps among the applications.

FPL's Integration Bus will consist of adapters and message queues constructed using STC's tools, and a message architecture to be implemented as coding in adapters. The message architecture is determined during the analysis phase of individual projects. For the power systems development area, a team of consultants within a technical support area is responsible for working with the project teams to develop the message architecture. This facilitates reuse of the messages between different application areas, such as Asset Management and Work Management. Using STC's terminology, e*Ways (adapters) on each end of an interface exchange events through an Intelligent Queue. The message formats are reflected in the design of collaborations, which are implemented in the code of the adapter.

The Inter-Application "Common Language"
The Role of Industry Standards

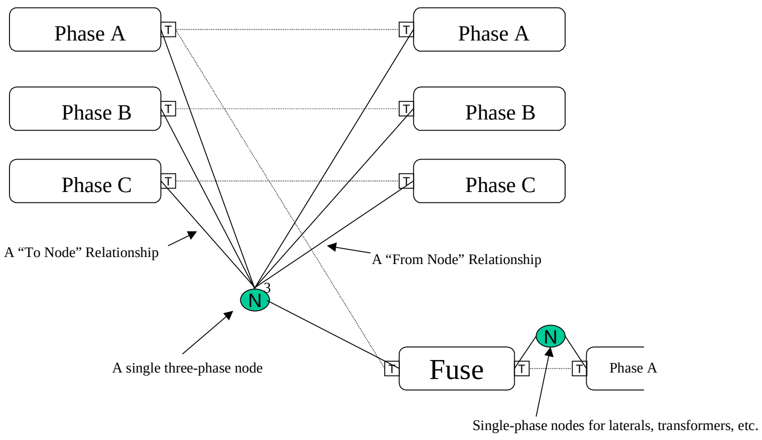
An information technology marketplace is needed that enables a utility to take advantage of the most appropriate application products and systems. This occurs as multiple utilities implement a similar enterprise-wide system architecture that organizes the use of independently procured application components. Standards play an important role in establishing markets. They reduce risk for suppliers and consumers of business automation solutions. An enterprise-wide architecture that is evolved into a standard will provide technology bridge between the commercially available component applications and utility application needs. The reusable interfaces allow utilities to migrate from one application to another without losing the information it created with the previous application. These standard interfaces insulate utility investments in application software from product specifics that will change as products evolve. From the vendor perspective, a consistent architecture deployed across utilities enlarges the market for its applications, reduces risks, and provides economy of scale. The resulting marketplace is a "win-win" for utilities and vendors.

IEC Technical Committee 57 (IEC TC57), in collaboration with the Electric Power Research Institute (EPRI) Control Center Application Program Interface (CCAPI) Project, is developing a Common Information Model (CIM) that represents all the major objects in an electric utility enterprise. The model includes public classes and attributes for these classes, as well as the relationships between them. A key purpose of the CIM is to provide a common language for describing exactly what data is being exchanged among Abstract Components of Business Functions. As opposed to using custom defined tags for information fields in message payloads, fields identification is based on class/attribute and association relationships defined in the CIM. Using an industry supported model thereby provides rich capabilities for various types of analysis as well as a certain degree of off-the-shelf support from product vendors.

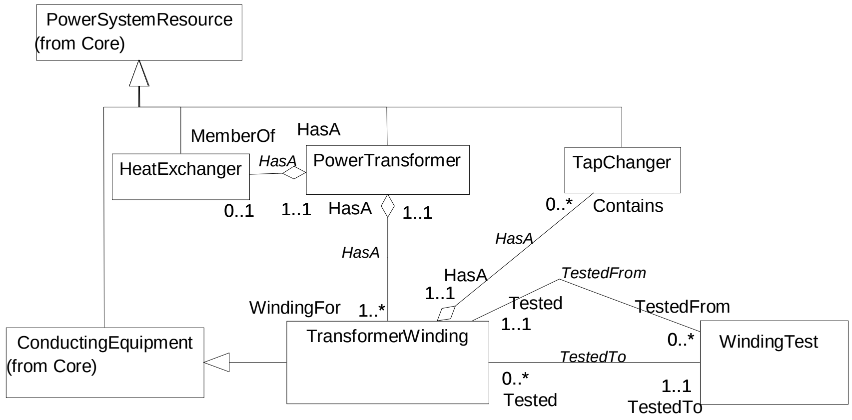
FPL's Use and Extension of the Common Information Model (CIM)

As the CIM is a large and multifaceted model, it has been partitioned into packages, each one emphasizing different aspects of the one underlying utility model. Two key package needed for the Distribution Management System (DMS) are the Wires Model Package and the Topology Package. An example of how topology is managed is shown in the following figure. "Break rules" for the AMS and DMS systems need to be consistent. Therefore, it was agreed that nodes will be introduced in accordance with the CIM philosophy, which is to insert a node anytime electrical characteristics change. This occurs at every power system device (e.g., switches, reclosers, breakers, capacitors, transformers) and at wire configuration changes (e.g., change in number of phases, conductor size, wire arrangement (framing)).

Terminals Connect To Other Terminals
Connectivity Nodes Are Associated With Conducting Equipment At The Terminal

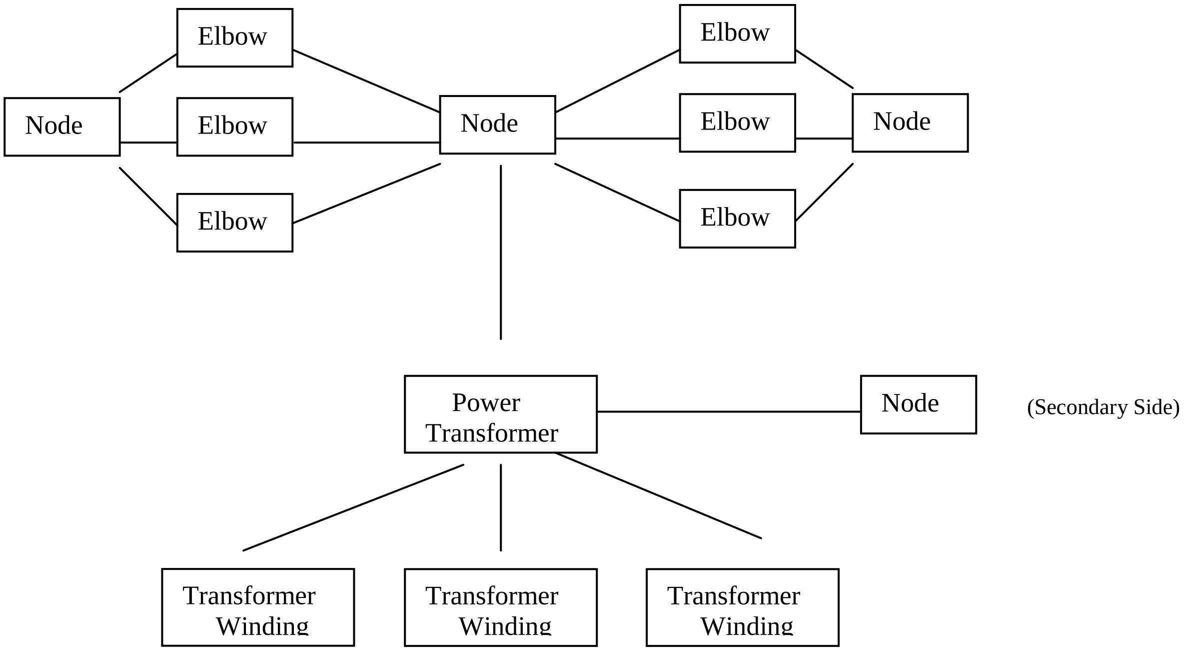


The Wires Package models physical equipment and the definition of how they are connected to each other. It includes information for Transmission, Sub-transmission, Substation, and Distribution Feeder equipment. An example of how a transformer is modeled in Unified Modeling Language (UML) notation in the CIM is shown below (attributes of classes are not shown).

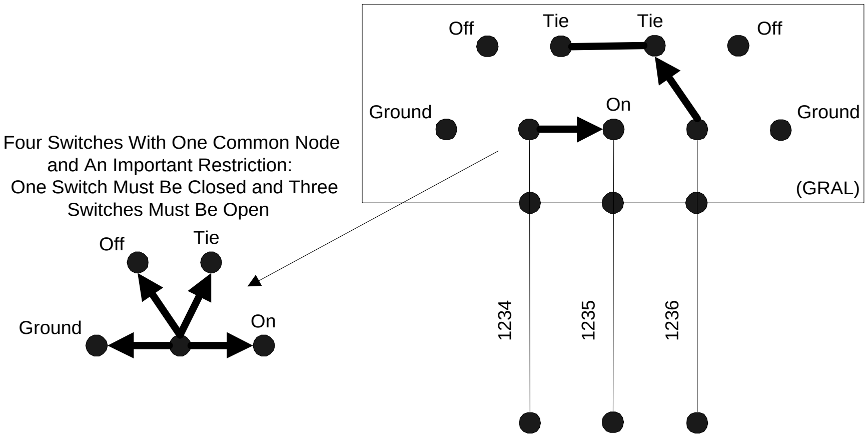


From an electrical behavior point of view, this sufficiently models all known types of overhead and underground transformers, as well as voltage regulators. The diagram indicates that a "PowerTransformer" object always consists of one or more "TransformerWinding" objects, which are themselves a type of "ConductingEquipment" object. The "ConductingEquipment" object is where the aforementioned terminal and node relationships are inherited for power system devices like capacitors, switches, etc. Note that not all objects are used for each instance of a transformer. For example, a tap changer does not typically exist on a residential transformer. These information based on these two packages is used by Network Status, State Estimation, Power Flow, Contingency Analysis, and Optimal Power Flow applications. The Wires Model has recently been modified so that it can support concepts that are important to distribution network management. Examples include three phase, unbalanced networks; distribution feeders; modeling of lines and cables; customer modeling. This part of the CIM is now a draft standard of IEC TC57 WG13 (Energy Management Systems), referred to as IEC 61970-301 [1].

While terminals are explicitly specified in the model, it is sufficient for existing applications to pass only nodal information for topology processing. As the number of objects in the distribution system is an order of magnitude larger than the transmission system, this “short cut” makes the volume of data much more manageable without losing necessary information. For the transformer, terminals and their associated conductivity nodes occur at the “TransformerWinding” class in the CIM, which is therefore the case with FPL’s CIM-based model. However, for information exchange purposes, this relationship can be assumed and information passed as shown in the following diagram for an underground transformer.



Most underground distribution switches can be modeled with the existing CIM switch object being associated with a cabinet. However, as can be seen in the following diagram, FPL found some cases where this does not work well. In this example, this GRAL type switch cabinet allows the three phase circuit 1234 to be tied to circuit 1235, 1236, both 1235 and 1236, or no other circuit.



The project team is proposing extension to the CIM to support the concept of "Composite Switches," a type of container object. In this example case, there would be two composite switches, each one containing (associating with) 4 simple switch objects. Both composite switches would be associated with the same "Cabinet" object in the CIM Asset Package. Composite switches would be required anytime there are certain inter-relationships among how simple switches operate in a cabinet (note restriction in diagram). The test is whether or not operational constraints exist. This is currently the case for the GRAL and RAM switch cabinets at FPL. In this example, the measurement value for the composite switch would reflect one of the following states: Ground ("ground" switch closed; others open); Off ("off" switch closed; others open); Tie ("tie" switch closed; others open); On ("on" switch closed; others open); Invalid (all other combinations). Connectivity processing is based on the simple switch (i.e., the composite switch is not to be used for topology processing).

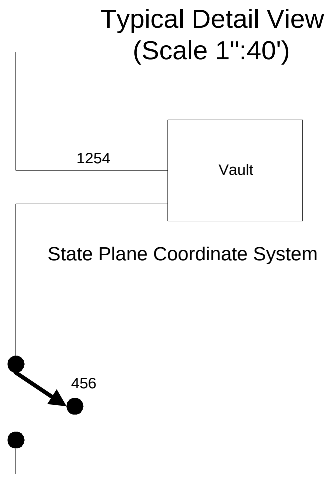
The aforementioned CIM packages are suitable for supporting most electric network analysis functions, but by themselves represent a limited view of how information is used at a utility. Extensions to the CIM have been needed to support records and asset management, outage management, construction and maintenance, work management, and other functions supporting the planning and operating of a electric distribution company. Various views of any given asset must be reconciled into the model: physical equipment, the logical connection of that equipment into the electrical network, the life-cycle of equipment, operating the equipment, protecting the equipment, and more. Along with these views comes the need to deal with different divisional and geographic boundaries for utility organizations assigned to any given asset. These areas have been have been under development by IEC TC57 WG14 (System Interfaces for Distribution Management Systems) and as part of the draft IEC 61968 series of standards [2]. WG14 encourages and welcomes participation by electric utilities that are interested in coordinating their integration projects with their standardization effort, thereby improving the quality of the resulting standard. As substantial progress has been made and a significant amount of market momentum around these standards has been achieved, FPL has decided to take advantage of existing work and to contribute to the development of these standards in areas needed by FPL's applications.

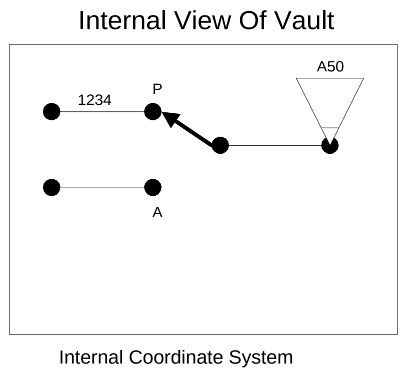
Key CIM extension for the Asset Management System (AMS) to be able to share information with the DMS and other systems are included in the IEC 61968 Asset Package and

Documentation Package. Whereas the Wires Model Package is concerned with the role a given object (e.g., a capacitor bank) has in the electrical network, the Asset Package is concerned with the equipment being used to fill that role. Asset package objects bring to light characteristics such as the equipment manufacturer's name, model number, data of installation, status of equipment, inspection data, etc. This is an example of how these additional CIM packages contain objects and relationships critical for information exchange among the many disparate systems supporting the planning, construction, operating, and maintenance functions of electric utilities.

The WG14 Documentation Package already handled the ability to pass portions of the network in the form of "Data Sets." This provides a standard mechanism to handle symbology and annotations, which includes, among other things, capability to specify x/y coordinates, rotation and size of symbols. For drawing conductors, line segment are associated with container objects that provide series of vertices between the beginning and ending nodes. FPL invokes this capability to pass network models for individual substations and feeders. These data sets contain all distribution network data for the DMS to populate its database and to render intelligent displays automatically. A manual check is performed at the System Control Center before displays are put on-line whenever substantial changes are made to the network.

The appropriate display scale for operations is 1":600' that will be provided by the AMS for the primary view. However, other scales are also needed. Therefore, each object may have multiple geometries associated with it, which is a needed CIM extension that the FPL project team is collaboratively defining with WG14. The resulting capability is that the DMS, without using any of its database editing capability, is able to show the detail view (1":40') and internal views for cabinets, vaults, manholes, and other areas, as is depicted in the following diagram. In this example, minimal information shows up at the primary view, but when the vault is selected on a display, an internal view of the vault is displayed. This capability can be nested so internal view of cabinets inside vaults can be displayed. The AMS and DMS applications also support the ability to specify that certain attributes should be shown in one mode (e.g., primary view) for objects that only show up in the internal world. For example, the operational name label for a switch inside a cabinet could be shown at a X/Y coordinate, rotation, etc. outside the cabinet symbol on the primary view. The underlying electrical model is not impacted be having support for multiple geometries on a per object basis. However, the DMS is now able to render objects and labels for various display views, each being the correct size at the correct location that is appropriate for each view – with all of the data being supplied from another system through the use of industry standard semantics.





FPL is planning to take advantage of other aspects of the CIM as well. For example, Work Order includes recent CIM extensions that provide support for work design (using compatible units) and work closing. Activity records provide the means to associate events with various views of the model. This is an important design aspect as the association relationships in the CIM supports after-the-fact analysis, of historical events regarding a particular point on the network, the equipment that is filling that role on the network, and/or the customer attached to that point on the network. In other words, history can be maintained on the network location before and after a given transformer is moved from one site to another, history is maintained on the transformer itself throughout its life, and history is maintained on the affected customers before and after the transformer is moved.

Future Directions

Shortly after implementation of the integration between the DMS and the AMS, FPL will be developing an integration between the Outage Management System (Trouble Call Management System, TCMS) and the EMS/DMS. Through this integration effort, TCMS will do outage analysis based on the operational state of the network, as tracked by the EMS and DMS. Also, trouble ticket information will be passed to the EMS/DMS for display on the operations graphics displays. The first phase of this interface is to be operational in 2001 and the second phase is to be in production in 2002.

FPL is currently in negotiation with a potential supplier of the Work Management System (WMS). The new system will be in production by the end of 2001. This system will have interfaces with many of the new COTS applications, and with legacy systems which support General Accounting, Customer Information, and Personnel Information. The design of this integration was begun in the last quarter of 2000. The work begun in working group 14 of IEC TC57 may be used as a reference for the design of some of the WMS integration.

One dilemma associated with integration is the disparity among different applications regarding naming conventions. As it is difficult to adopt universal naming conventions, it would be helpful to have some sort of central naming service to allow each application's interface to use its local identification conventions. The application adapter invokes such a universal service that then translates from the local identification to a public identifier called an XID. This is a tag used for software coordination, not a new name for applications to be concerned with. In a future expansion of the Integration Bus, FPL will consider implementation of the central naming service so that each application connection will not have to handle creation and coordination of tables of correspondence.

FPL may add a history recording mechanism to save all events as they occur is needed. This event history would be an event sequence data structure based on the Information Exchange Model (IEM), which is referred to as an event store because it is a database for storing a sequence of state change events.

Conclusion

A complete enterprise-wide integration strategy requires that FPL implement an adaptable inter-application integration infrastructure that transcends the lifecycle of individual application systems and middleware technologies. A significant degree of this needed transcendence occurs when the infrastructure design is partitioned based on:

- Things that are stable; s*tandardized abstract application interfaces* represent stable technology elements.
- Things that can be controlled; component based applications and middleware can be changed relatively inexpensively.

The results to date and the direction of the EPRI CCAPI Project and IEC TC57 are in alignment with these objective. Therefore it is believed that implementation of an utility standards coordination strategy thereby improves investment protection, lower implementation risks, and will ultimately lower life-cycle costs as FPL positions itself to leverage products and services of growing marketplace. Over time, the benefits of this type of enterprise integration strategy will include:

- Improved ability to integrate business processes across commercial-off-the-shelf (COTS) applications (Work Flow)
- A simplified means for organizations to share information
- Less dependence on individual vendors
- Improved usefulness of existing applications
- Lower life-cycle costs of applications
- Support for event driven business processes
- Document and data congruence
- Increased use of Internet common tools on Intranet like browsers.

Acknowledgments

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References

[1] Committee drafts of IEC 61970, IEC TC57 Working Group 13, 2000.
[2] Committee drafts of IEC 61968, IEC TC57 Working Group 14, 2000.