Data Driving the Smart Grid

Network Model Management for Distribution Operations

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Topics

- Importance of Network Model for Distribution Operations
- Evolving Data Requirements
- Utility GIS Systems / Departments
- Data Readiness and Associated Challenges
- Defining Network Model Management
- Network Model Management Benefits
- Current Industry Status and a Glimpse into the Future

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Importance of the Network Model for Distribution Operations

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“Tools are only as good as the network models that support them, and network models are only as accurate as the data that feeds into them.”
- Robert Ito EPRI

Facts about Data Modeling for Distribution Operations

- Distribution operations systems are driven by data
- Split second decisions are made based on the accuracy of the network model
  - Erroneous data can impact reliability of electric service, inability to operate devices through supervisory control and lead to overall distrust in the systems
- Operators may be controlling the network in using various models
  - Advanced distribution system (ADMS)
    - Single database / data model
    - Separate data models by application
  - Separate, but tightly integrated DMS, SCADA and outage management (OMS)
- Smart grid operations systems require robust data
  - Connectivity, phasing, engineering parameters, etc.
- Maintenance and capital planning decisions are also based on grid analytics

GIS Systems and Evolving Data Requirements

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“We used to migrate data into our OMS once a month and into our engineering planning tools once a year and it was acceptable. Today that seems archaic.” - Planning Engineer Midwest IOU

Evolving Data Requirements

- Outage management is an example of an early IT system that required a network model
  - Data requirements were simplistic and mostly resided in an as-built GIS
  - Main interface for OMS was to CIS for outage call processing
  - Monthly data migrations were common
  - Errors simply impacted outage prediction
  - As operated OMS model was different than engineering planning model
- With the evolution to ADMS with advanced applications, data requirements have changed but for many the approach to build model did not
  - Most utilities believed that they could still build complex network models from GIS

GIS Departments and Systems

- Primary focus of utility GIS systems is not on operating the grid
- GIS departments often report to staff engineering / IT organization
  - Charged with facilities management, record keeping, design and map production
- GIS systems are meant to show the ***as-built*** network, whereas operational systems are intended to reflect the ***as-operated*** network
  - Tracking the installed date and manufacturer of an inline disconnect is not dependent upon if the switch is currently in the open or closed position
- Not all detailed attribute data resides in GIS
  - GIS was never designed to feature a smart grid ready data model
  - Limited in their ability to store, maintain all network data
  - Attribute data may be in static look up tables

Key ADMS Data Required

- Branch Data (Lines, Cables, Transformers, etc.)
  - Branch Z, R, X, or X/R values and units, tolerance, and temperature, if applicable
  - Cable and transmission line, length, and unit
  - Impedance base kV and base kVA/MVA
  - Zero sequence impedances
  - Transformer rated kV and kVA/MVA, tap, and LTC settings
  - Transformer winding connections, grounding types, and grounding parameters
- Feeder/Power Grid/Source Data
  - Operating mode (swing, voltage control, Mvar control, or PF control)
  - Nominal kV
  - %V and angle for swing mode
  - %V, MW loading, and Mvar limits (Qmax & Qmin) for voltage control mode
  - MW and Mvar loading for Mvar control mode
  - MW loading and PF for PF mode
  - Grounding types and parameters
  - Single-phase MVAsc and X/R
- Bus/Junction Data
  - Nominal kV
- Load Data
  - Rated kVA/MVA and kV
  - Power factor
  - Loading category ID and % loading
  - Equipment cable data
  - Phase type
  - Grounding types (when 3-phase)
- Capacitor Data
  - Rated kV, kvar/bank, and number of banks
  - Loading category ID and % loading
  - Equipment cable data
  - Phase type
  - Grounding types (when 3-phase)

Data Readiness and Challenges

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“Before we take the dive into ADMS, we are going to invest significant time with a readiness effort to ensure we have the data required to power the system.” - VP IT Central US

Questions to ask for Data Readiness

- Some utilities have been sold on the functionality of ADMS systems with little attention on the data required to power these systems.

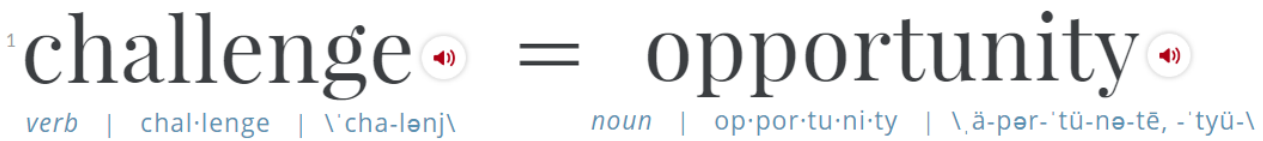
- Questions to ask to ensure data readiness ***BEFORE*** starting a system deployment
  1. What data is needed to support the operational systems?
  2. Is the data required currently available?
     - If so, where does it reside? Who owns it? Is it openly accessible?
     - If the data is not available, should default values be used? What defaults should be used?
  3. What are the gaps in completeness and quality of the data?
  4. What is the plan to collect and input the missing required data?
     - Physical inventory?
  5. What processes are in place to clean up erroneous data?
  6. How to determine when the data is ready to support operations?

Data Challenges Uncovered with Readiness

- Traditional GIS data model limited to network connectivity and inventory attributes
- Asset attributes and metadata key in network analysis calculations are not stored in GIS but in disparate repositories
- Required data may be stored in diverse formats
  - Spreadsheets, relational and non relational databases, flat files, etc.
- The data can be very ‘big”
- There may be gaps in the required data
- Accuracy issues are every present with a dynamic model
- Phase connectivity often unknown

Process Challenges Uncovered with Readiness

- Potential for hundreds of people updating the GIS each day
- Normal backlog to post as-builts after construction could be several months
- Organizational and management support of required processes to ensure quality data entry moving forward
- How can the operational systems receive updates in real time?
- How can we avoid duplication of data?



- Each utility has just a single, physical grid but there are various IT systems that house the data that describe the grid
- Engineers, operators, etc. all need a single source of the truth to perform their functions correctly… this is Network Model Management.

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“The truth is out there.”

- FBI Special Agent Fox Mulder

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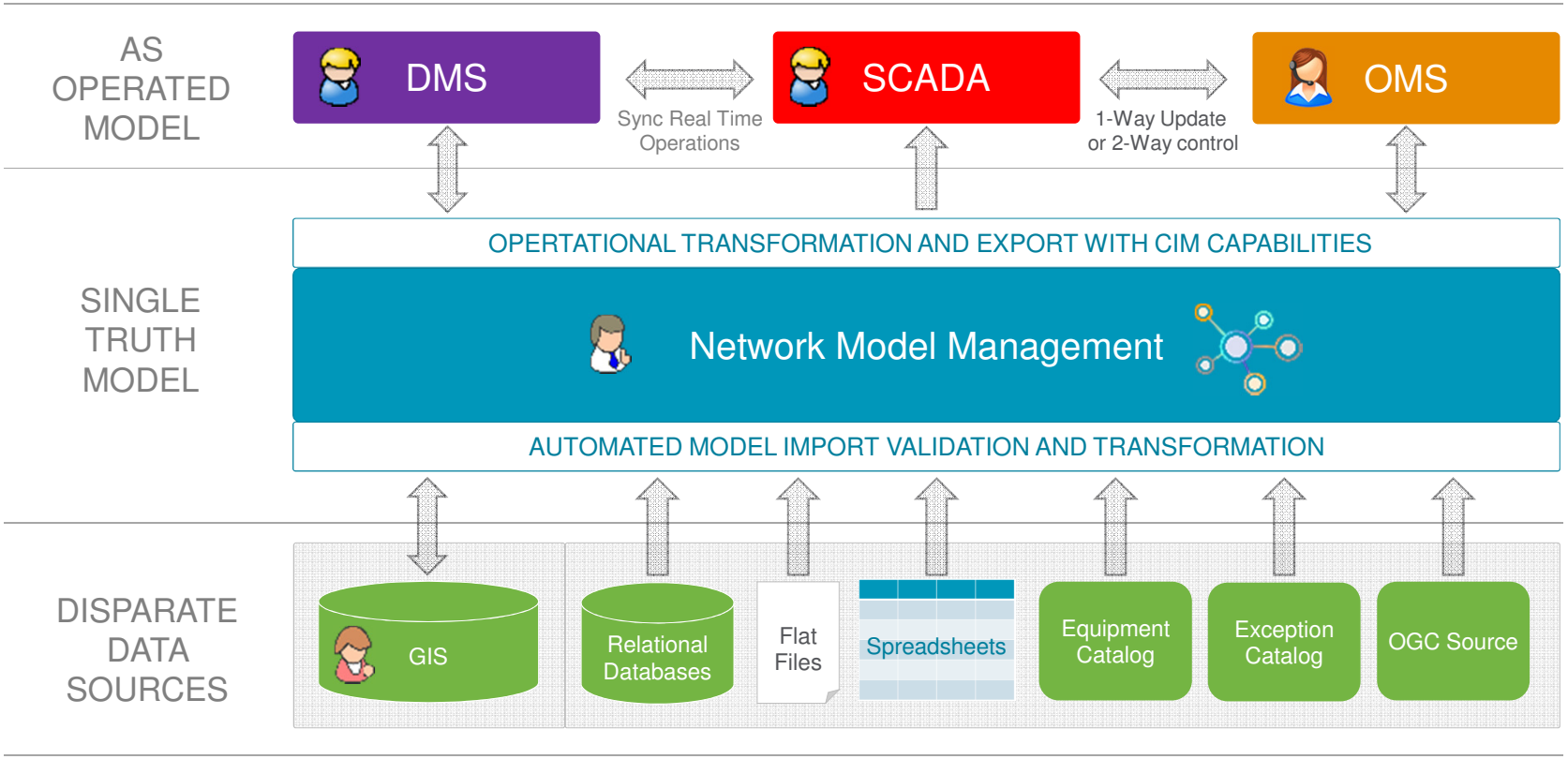

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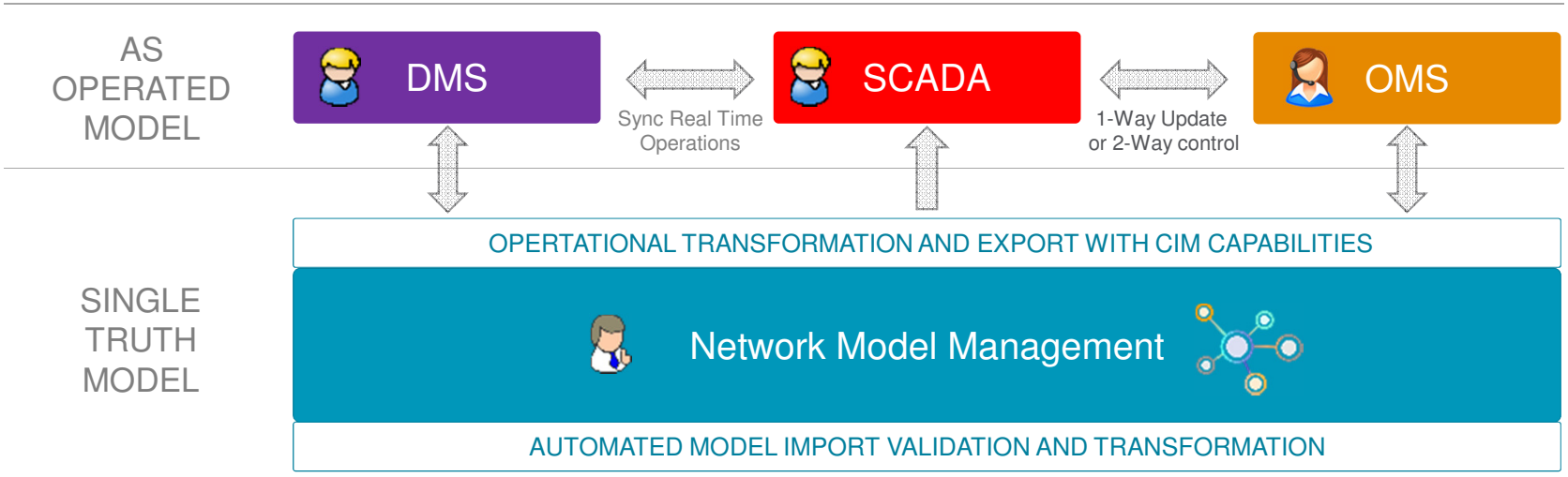


DISPARATE DATA SOURCES

- Base layers of data
- Includes GIS as built data in any vendor format
- Supports multiple data types and formats
- Relational database independent

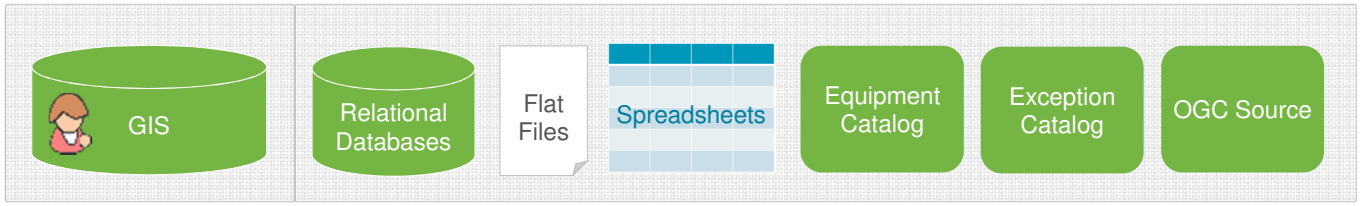
Network Model Management

AS OPERATED MODEL

SINGLE TRUTH MODEL

- Non relational database storing the model as a graph to handle big data with speed and scalability
- Cloud / web capable
- Process to extract data from multiple data sources
- Creation / definition of validation rules with model validation reporting
- Manual correction capabilities with notification or function to update source
- Capable of correction for missing catalog data
- Time based model for historical view of the network

DISPARATE DATA SOURCES



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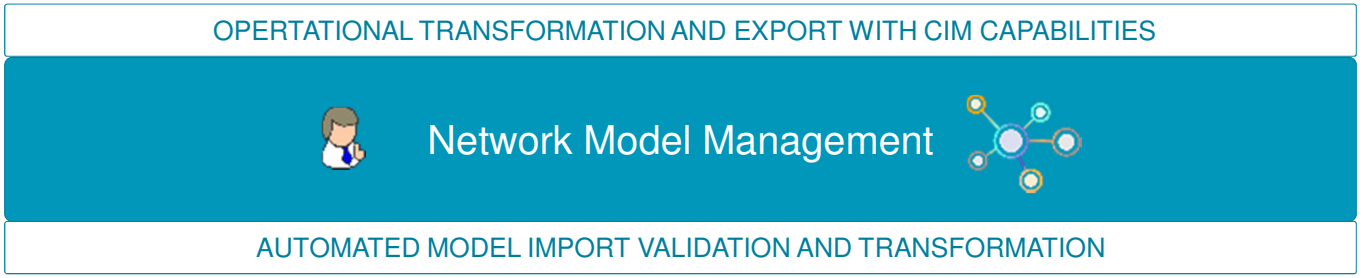
Network Model Management

AS OPERATED MODEL

- Export is CIM based but can be modified if destination system does not support CIM
- Permanent as operated changes can be sent back to single truth model
- Operational systems sync with each other based on real time operational changes

SINGLE TRUTH MODEL



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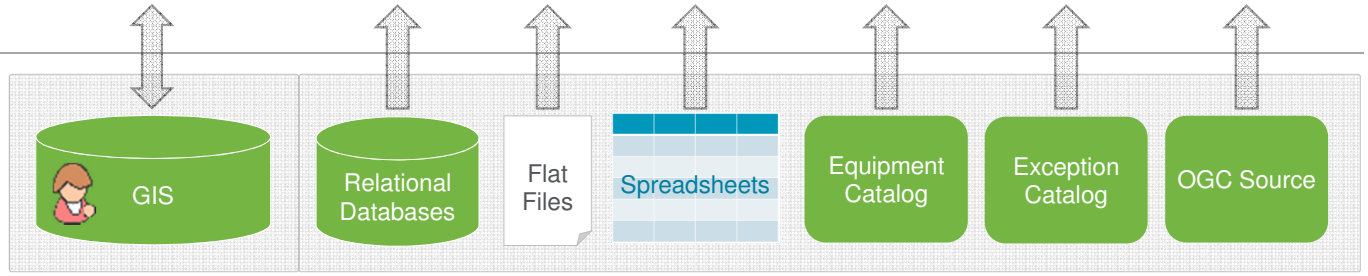

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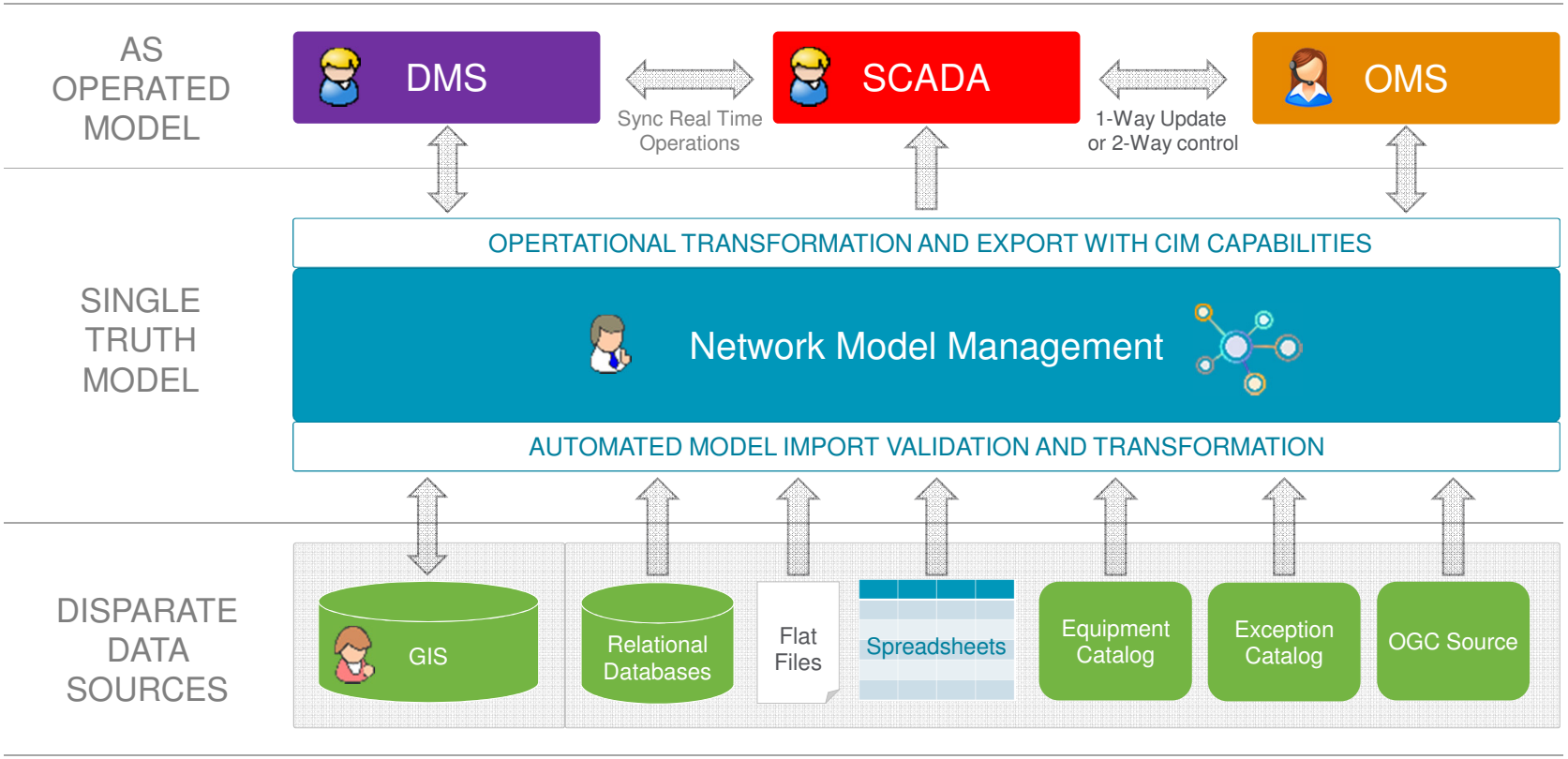

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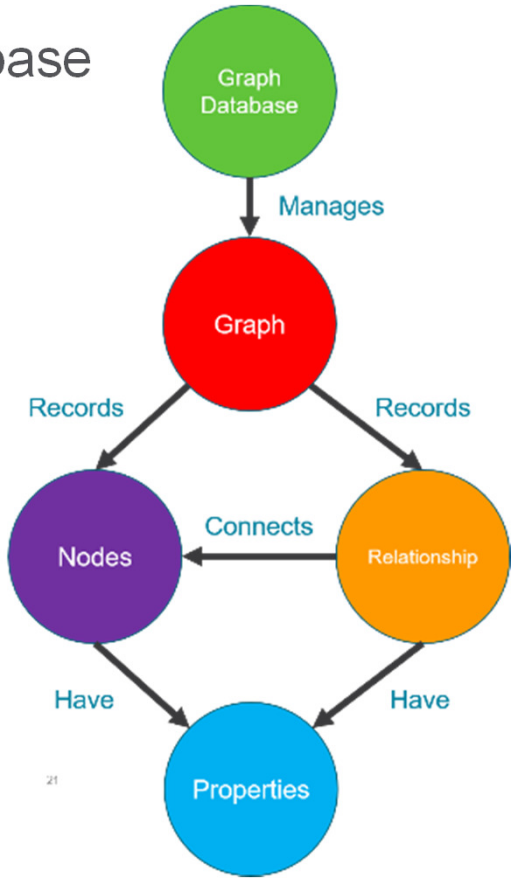
Network Model Management

AS OPERATED MODEL	▪ Export is CIM / XML based but can be modified if destination system does not support CIM ▪ Permanent as operated changes can be sent back to single truth model ▪ Operational systems sync with each other based on real time operational changes
SINGLE TRUTH MODEL	▪ Non relational database storing the model as a graph to handle big data with speed and scalability ▪ Cloud / web capable ▪ Process to extract data from multiple data sources ▪ Creation / definition of validation rules with model validation reporting ▪ Manual correction capabilities with notification or function to update source ▪ Capable of correction for missing catalog data ▪ Time based model for historical view of the network
DISPARATE DATA SOURCES	▪ Base layers of data ▪ Includes GIS as built data in any vendor format ▪ Supports multiple data types and formats ▪ Relational database independent

Non relational databases (NoSQL)

- NoSQL ("non SQL", "non relational" or "not only SQL") database
  - Designed to handle large volumes of structured, semi-structured, and unstructured data
- There are 4 basic types of NoSQL databases
  - Key-Value, Document-based, Column-based, Graphs
  - Graphs are made up of nodes (entities), relationships (connect nodes), properties (attributes) and labels
- Benefits include
  - More scalable / elastic, flexible, cost effective, higher availability, more modern
- Disadvantages
  - Open source, security concerns, data consistency, standardization



Additional Details

- Begins with ownership of the process by GIS expert with operational focus
- Extensive validation is required on import and before transformation
- Equipment catalog used for attribute information
- Exception catalog for missing attributes with default values
- System identifies issues before export to avoid repetitive process
  - Validation should be looking for de-energized segments, loops, parallels, iso or missing loads.
- Full model or incremental (by circuit) updates possible and validated not to break non updated connectivity
- Process in place to handle permanent changes coming back from operations
  - Change in open points, transition from proposed to energized / in service

Benefits of Network Model Management

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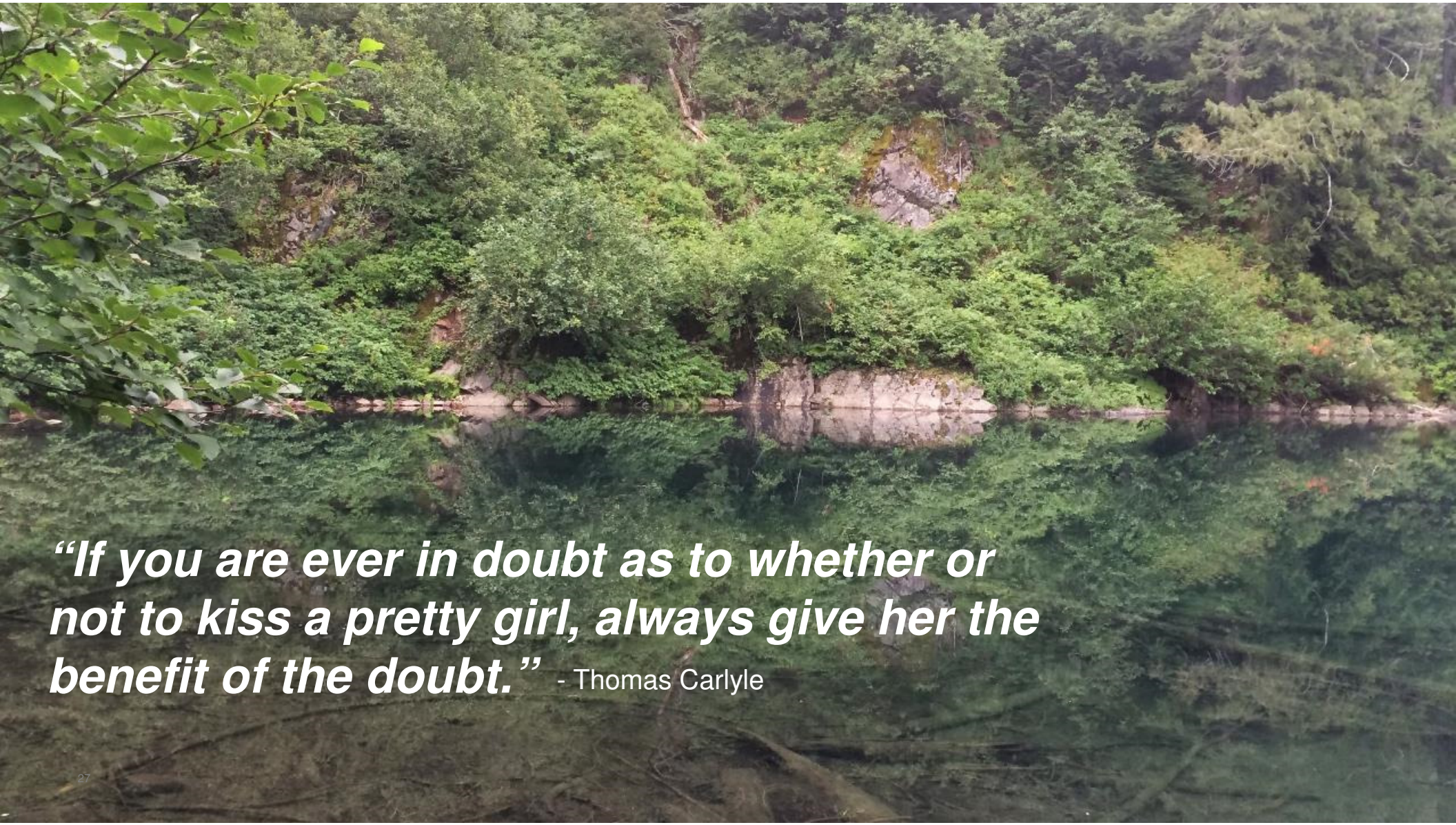
“If you are ever in doubt as to whether or not to kiss a pretty girl, always give her the benefit of the doubt.” - Thomas Carlyle

Benefits of Network Model Management

1. Improved model accuracy leads to quality of data
2. Elimination of duplicate modeling work reduces effort
3. Automation of manual processes reduces time to produce the model
4. Validation of data leads to confidence in in the model
5. Improved data maintenance workflows leads to data completeness
6. Better data means reduced likelihood of grid operations errors
7. Temporal views of network state lead to easier post event analysis

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Current Industry Status and a Glimpse into the Future

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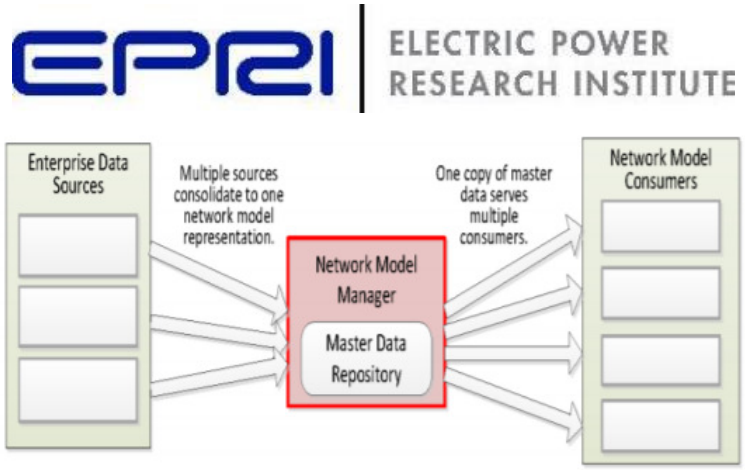
“The future is now.”
- Jim Carrey, The Cable Guy

Where is the industry at with NMM?

- EPRI driving the concept of Network Model Management (NMM) as a layer above GIS to serve as the single source of the truth
- Research began back in 2011 on best practices to manage “master” data and assemble it for use by network analysis tools
  - EPRI led a consortium of eight utilities and two vendors to define industry requirements
  - Focus was on the transmission network first
  - Findings were issued in a report released in Aug 2014
    - Intended to help utilities understand standards-based, consolidated network modeling
    - Help vendors gain an enterprise-wide view of required functionality and potential demand for NMM tools.
  - Report outlined how (CIM IEC 61970) provides basis for an industrywide strategy.



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Future of Network Model Management

- Complex problem driven by data, its accuracy, where it resides and how to bring it all together to feed all systems from a single data store
- Split second decisions are made based on the accuracy of the network model
- Traditional GIS was never meant to *directly* serve ADMS
  - Time to stop forcing a square peg into a round hole
- Clear that network model management is a “real” thing
  - A smart grid ready data model with ability to manage connectivity with perform extensive data validation with CIM export
- Market for network model management has not currently been established
  - Utilities slowly embracing the need for a system to manage the network
  - Vendors are still trying to determine the size of the market, opportunities
- Some standards still not complete, but centering on IEC CIM strategy is the start
- EPRI driving next step with a consortium of utilities focused on NMM for distribution
- Expect to see more vendor offerings by 2018

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