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April 29, 2010

Hyatt Regency Phoenix

Phoenix, Arizona USA

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Parag Parikh

Dan Kuklov

CURRENT Group

Kerry D. McBee

Xcel Energy

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Unified Real-Time Network Topology Management Using Oracle Spatial

Xcel Energy SmartGridCity

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Overview

- Managing Dynamic Distribution Grid & IP Network
- Unified Electrical and IP Network Topology Management – Overview
- Oracle Spatial & CURRENT OpenGrid Solution
- Unified Network Building Blocks

Smart Grid for the Middle Mile

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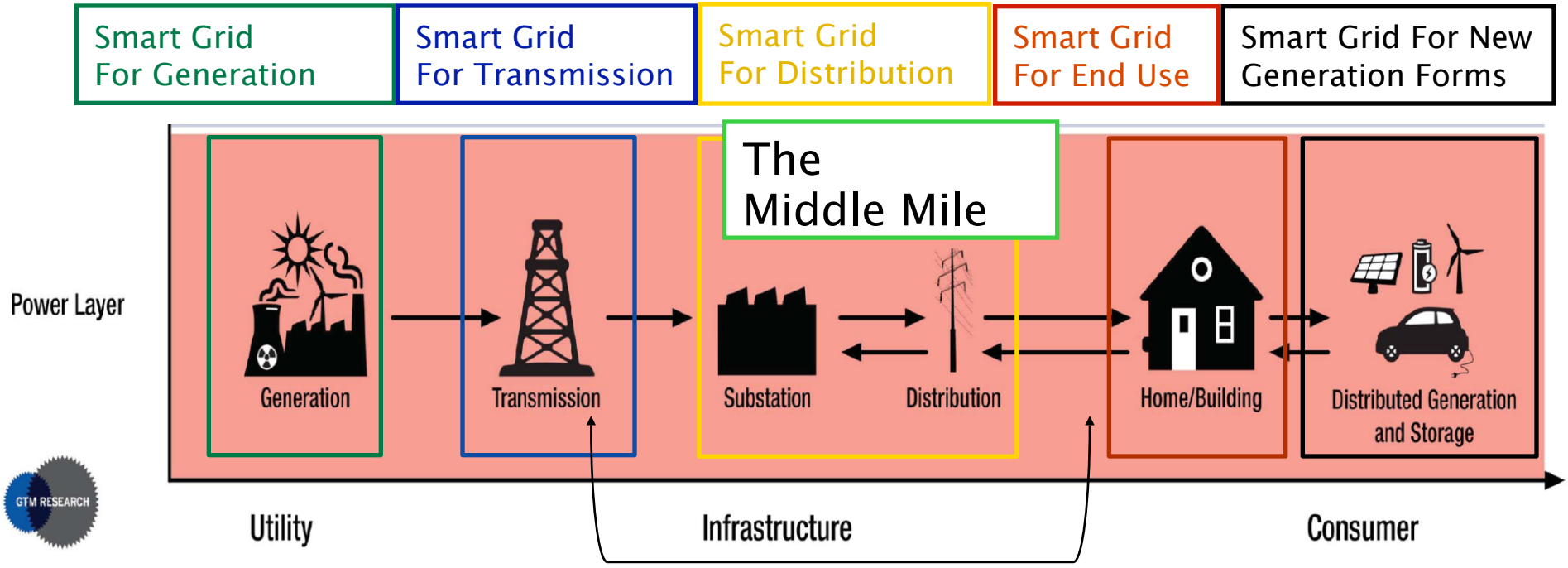

- Convergence of Electrical and Communication Networks
  - *Two distinct set of users with common goal requires both networks to be fully integrated*
  - *Widespread deployment of smart sensor with actionable intelligence and communication requires robust Network Management System*

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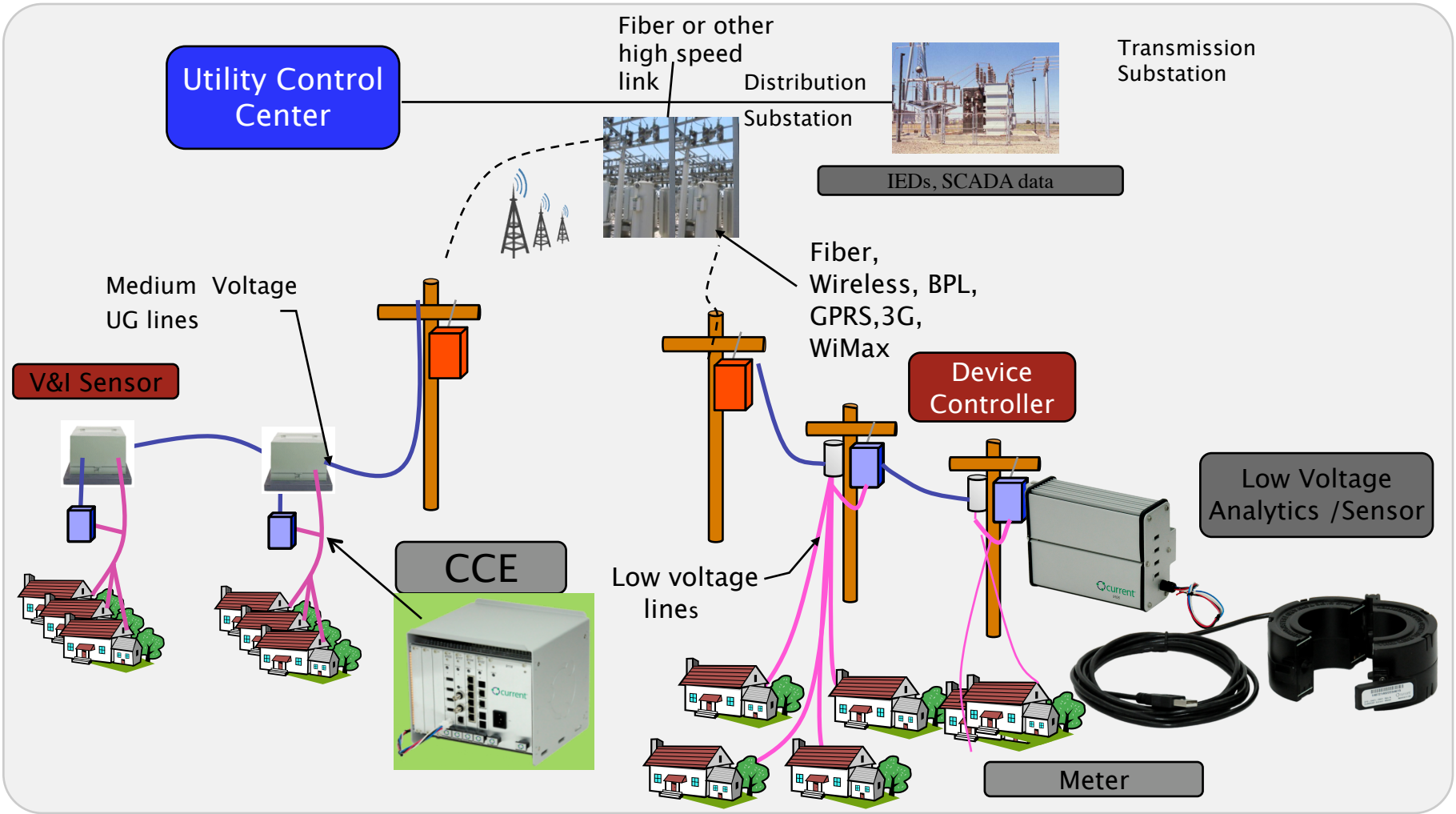
Smart Grid Infrastructure

- Remotely configured and managed sensors
- Remotely configured and controlled electrical device



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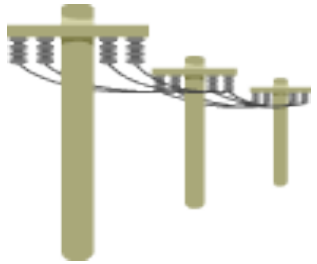
Unified Networks



- **IP Network Management** –
  Centralized management of Network Elements (NE) and model network topology
  - Provisioning, activation, health check, data acquisition and control
  - Utilize spatial data for problem detection and Resolution
  - Acquire data from sensors and controllers associated with NE using IEC 61850, DNP3, IP and SNMP
- **Device Data Management** –
  Centralized management of sensor provided measurements and correlate data with related electrical device
  - Single repository with temporal element to maintain real-time and historic measurement data of electrical devices
  - Receive and processes events and alarm

Oracle Spatial NDM Enabled NE - Device Correlation

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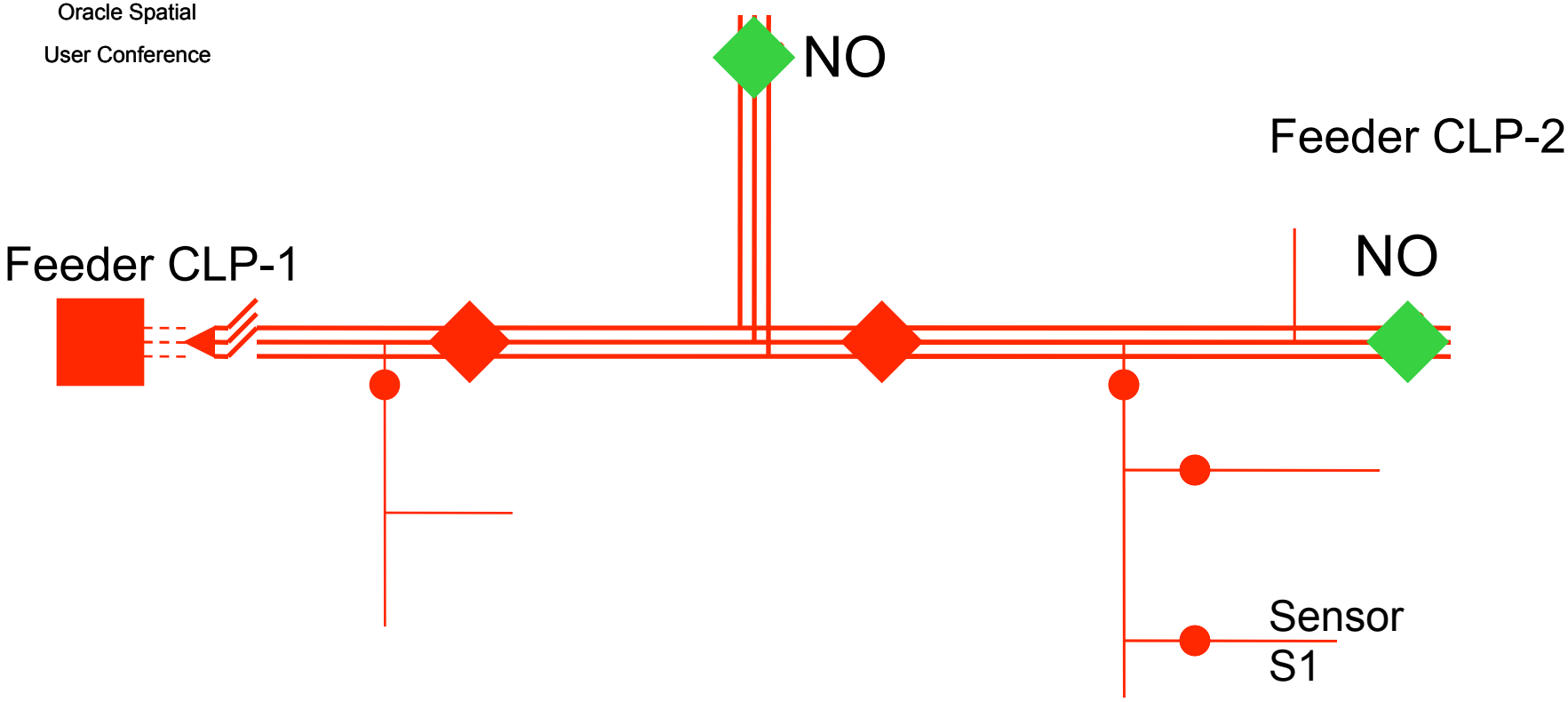

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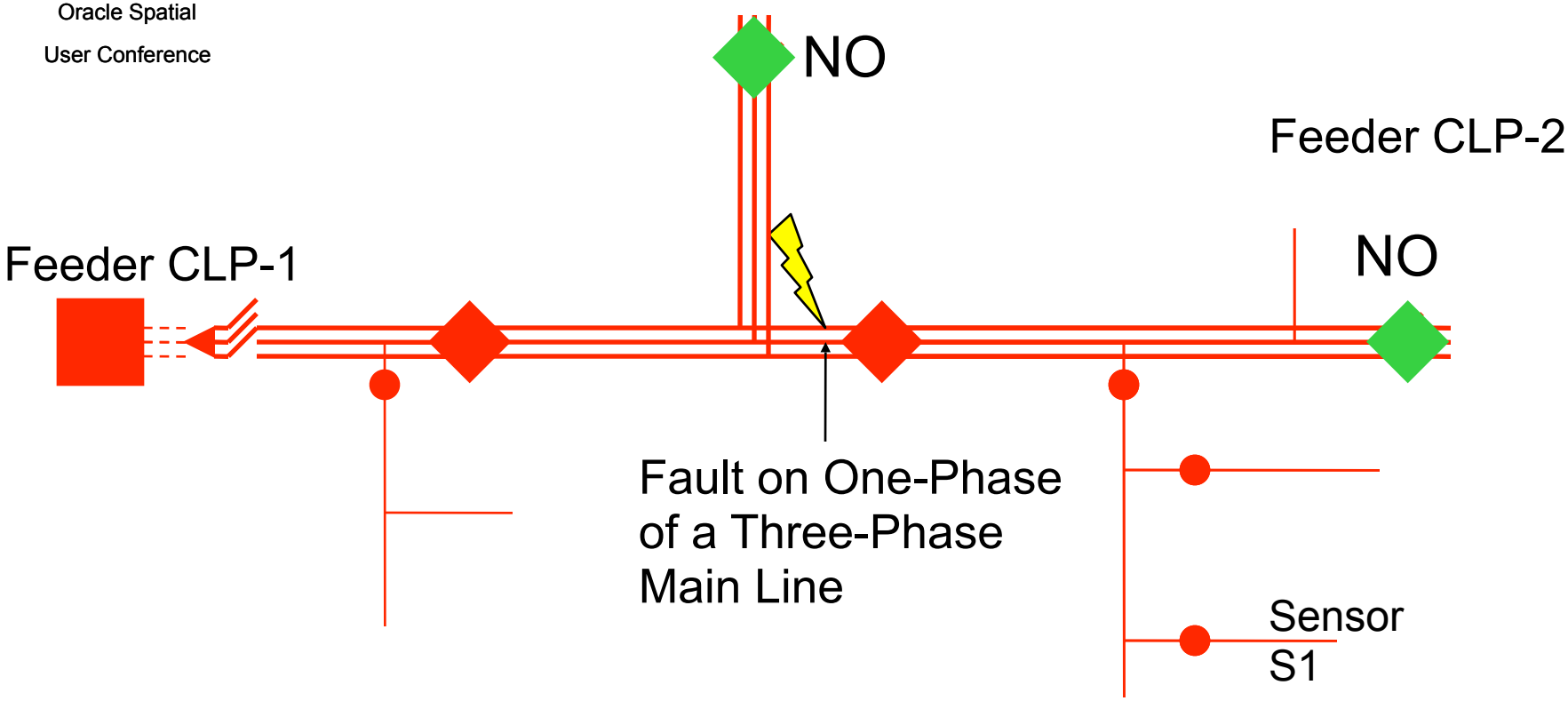

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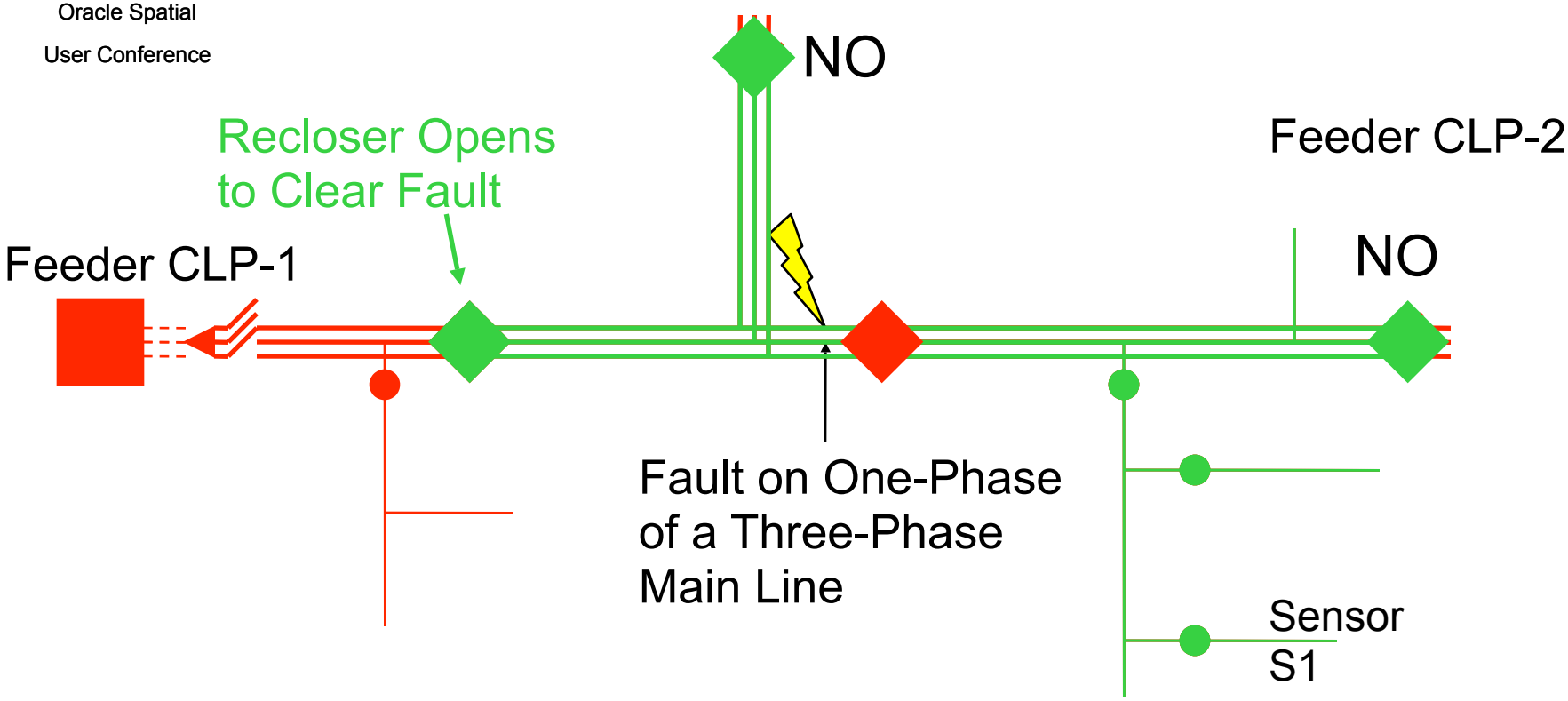

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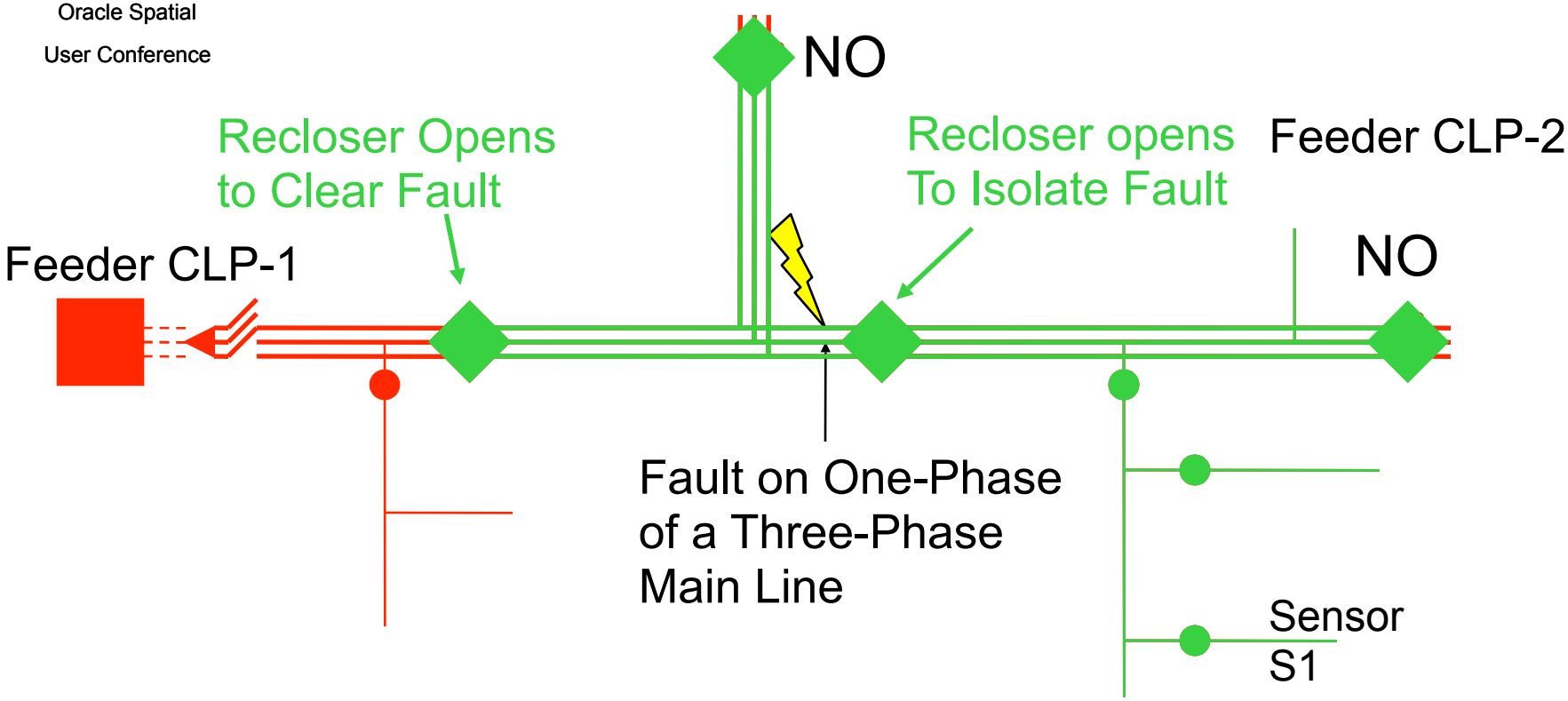

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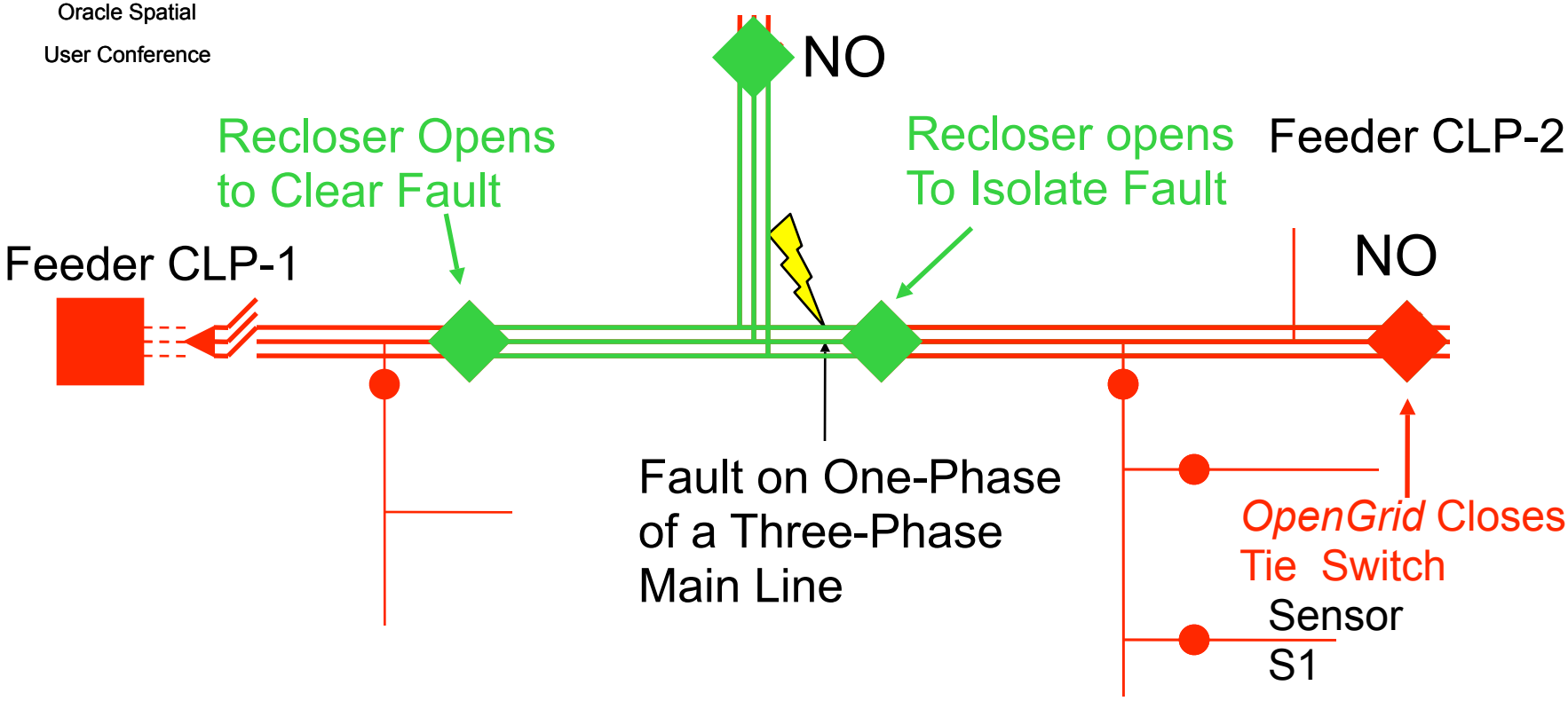

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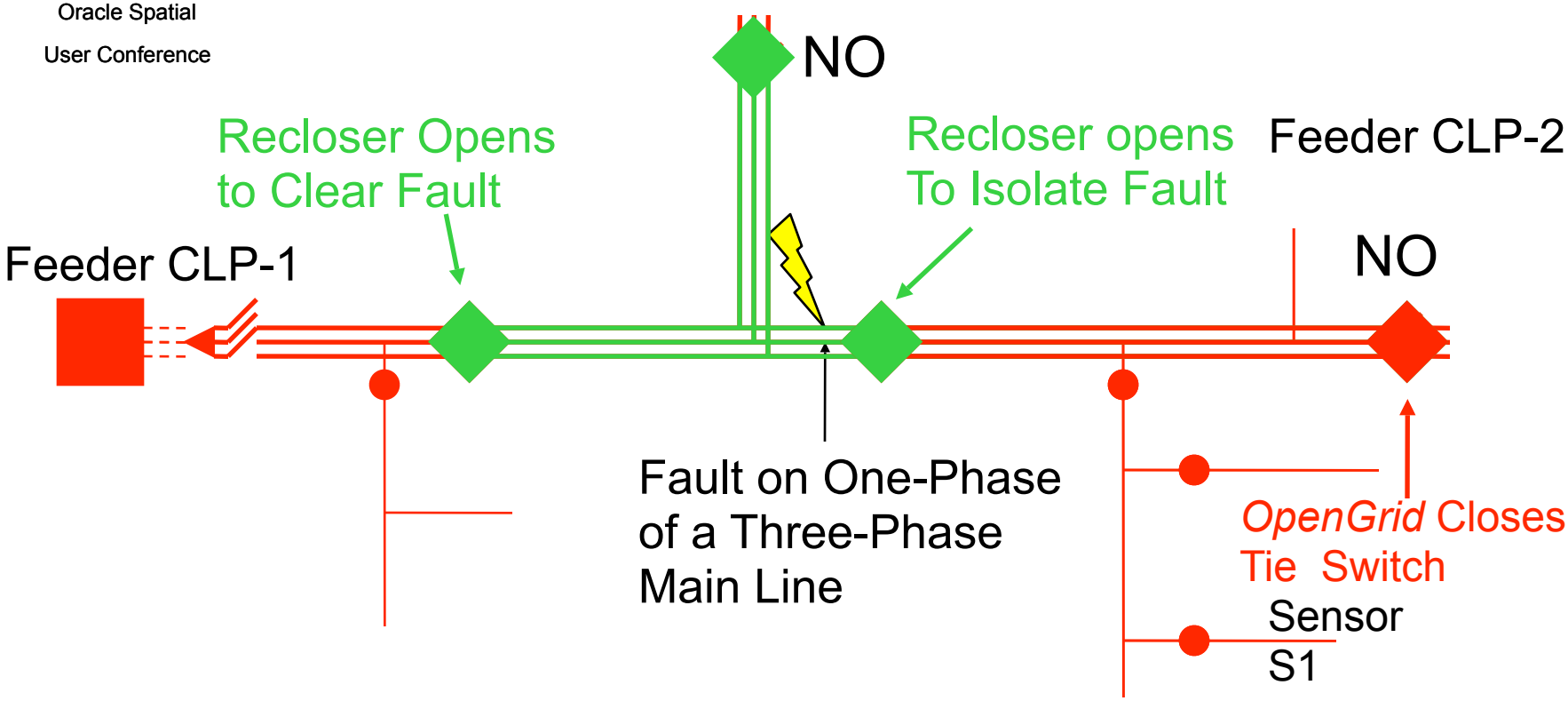

- Track and report Communication Network Element and sensor status using geographic and electrical feeder extent
- Maintain “As-built model” and “As-operated” network model
- Before fault, Sensor S1 reported voltage and current for Feeder CLP-1. After switching the same Sensor reports measurements for feeder CLP-2

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Spatial Powered Smart Grid

Legacy GIS

- Requires dual architecture to store data
- Proprietary API and spatial queries
- Isolated system requires extensive integration effort and data translation
- Often supports only single network
- Lacks built-in temporal features to take actionable intelligence using historic data

Oracle Spatial – CURRENT OpenGrid

- gIS – Unified data storage
- SQL based spatial query support
- Enterprise system enables ease of integration
- Build-in support for OGC and SQL
- Multiple Network Support to enable self-healing
- Unified network topology, real-time and historic data provide actionable intelligence to prevent faults

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Data Model Differences

Corporate GIS – As Built

- Complex, numerous objects & attributes
- Emphasis on asset detail, not speed
- Many update users, each with unique view
- Includes proposed facilities
- Static devices show nominal status
- New Smart Grid devices are yet to be modeled

Smart Grid – As Operated

- Simplified, essential objects & attributes
- Emphasis on speed
- Many operations users share one view
- Focus is on existing facilities
- Dynamic devices show current status
- Integrated Network models enables association between Smart Grid devices and grid

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Solution Approach

- Provide Smart Grid data management solution
- Geographic model based on Oracle Spatial without any proprietary abstraction
- Network Data Model based on standard Oracle NDM and API
- Configurable device rules to model network connectivity
- Schematic and Geographic Viewer
  - *Manages "as-operated" view of the distribution network*
  - *Node and Links populated using two-port modeling*
  - *Path and Path Link used to enable topology management*

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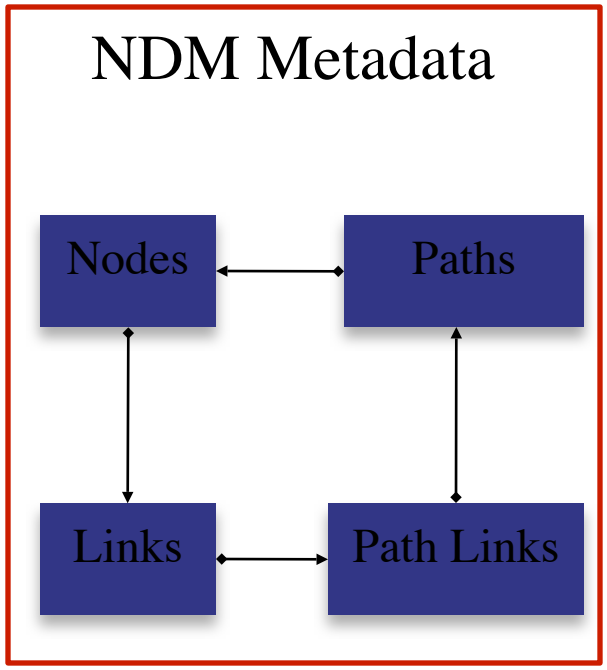
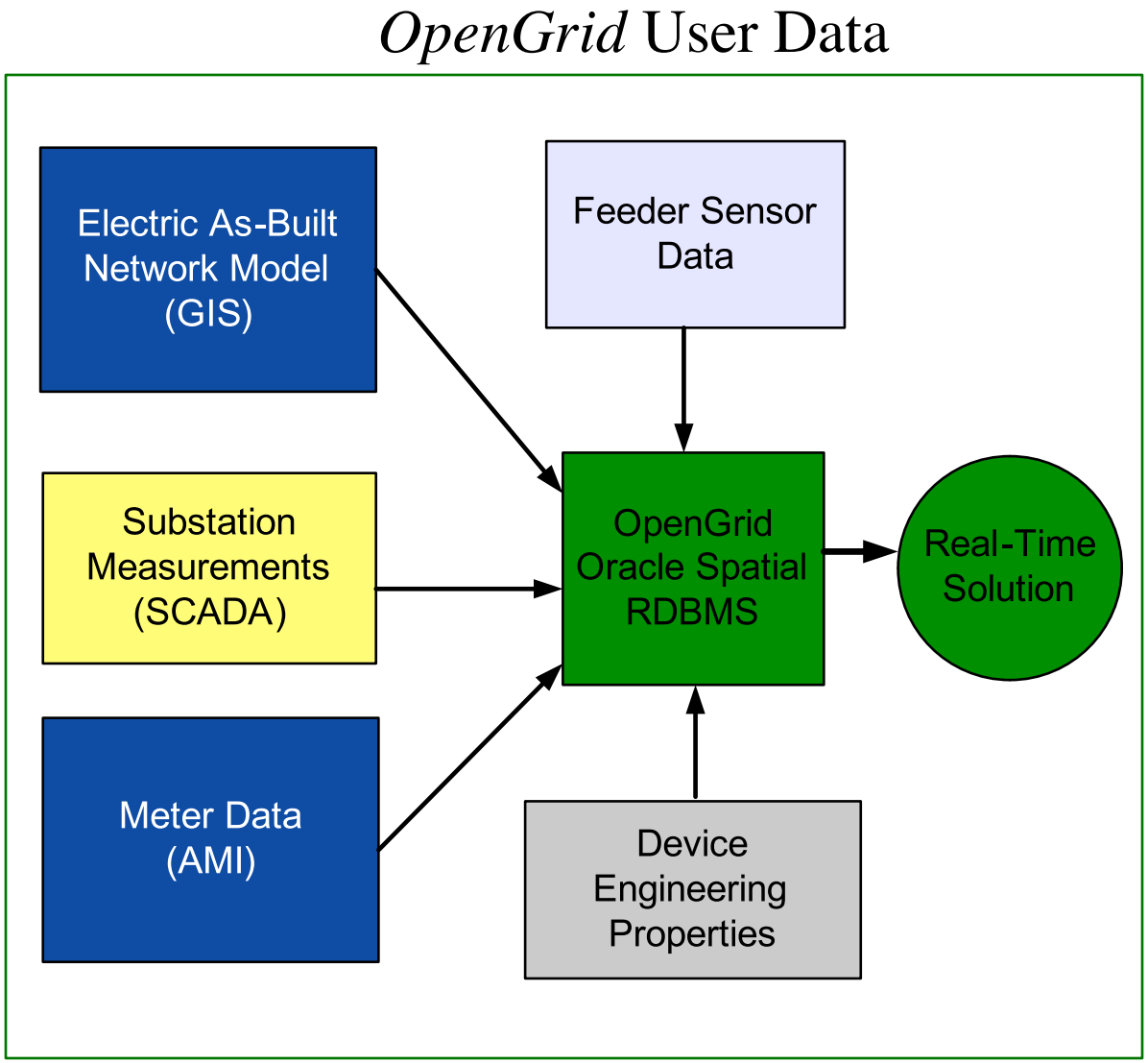
OpenGrid Data Sources





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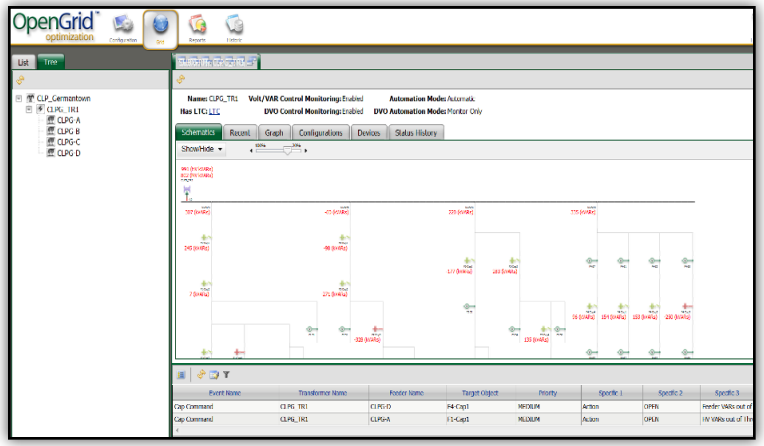
Technology

- Red Hat Enterprise Linux
- Oracle RDBMS
- JEE application server – Oracle App Server to provide browser based thin clients and external system interfaces
- IDE – Eclipse
- Hibernate to model spatial data in a standardized way by abstraction
- CURRENT DNP3/IP OSI Layer 7



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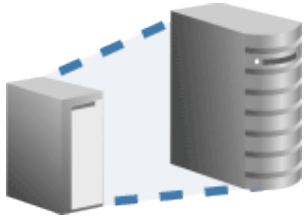
Architecture



- IEC 61968 CIM and OGC CIM inspired distribution data model
- Load-On-Demand Analysis to manage very large network analysis
  - *Web client utilizes LOD Java API for network applications*
  - *Spatial workspace for long term transaction and incremental import from the legacy GIS*
  - *Periodic versioning of network data model to maintain network operations history*

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Oracle Spatial Enabled Analysis in *OpenGrid*

- Geo-coding – Identify street location of sensors and network element reporting communication loss
- Geometry Processing – Analyze distribution asset performance by electrical and geographical boundaries
- Network Analysis generated schematics/ one-line diagram
- Network Modeling
  - *Discovering Reachability functions to transfer the load between substation*
  - *Tracing with direction and shortest path for the Fault Location Isolation & Restoration*
  - *Enable user define Search using various constraint*
    - *Cost, Depth, Distance, MBR*
    - *Constraints for Electric Network Contingency planning*

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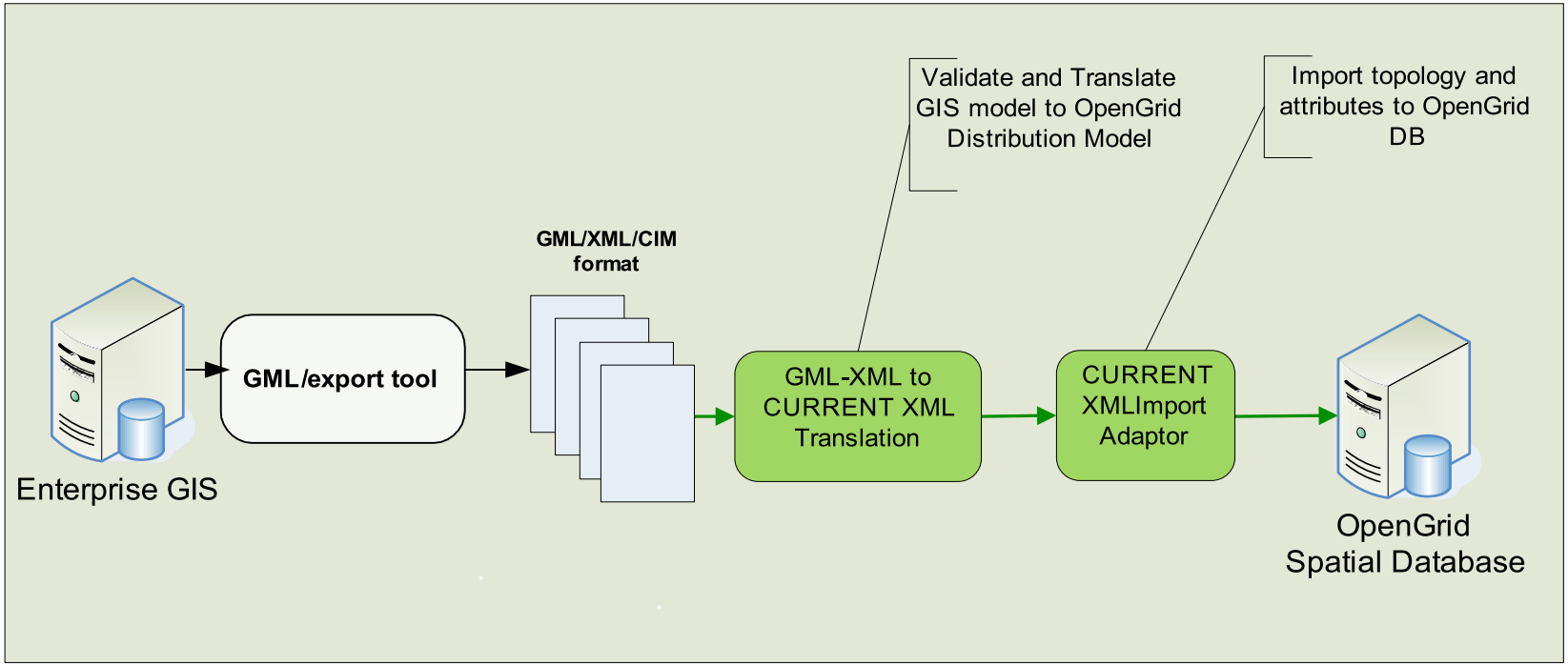
GIS Integration Process



- **GIS Integration Methodology**
  - Proven and standards based GIS integration process supports multiple GIS data sources and formats
  - Supported Data Standards: XML, GML, IEC 61968-11 CIM, NRECA MultiSpeak

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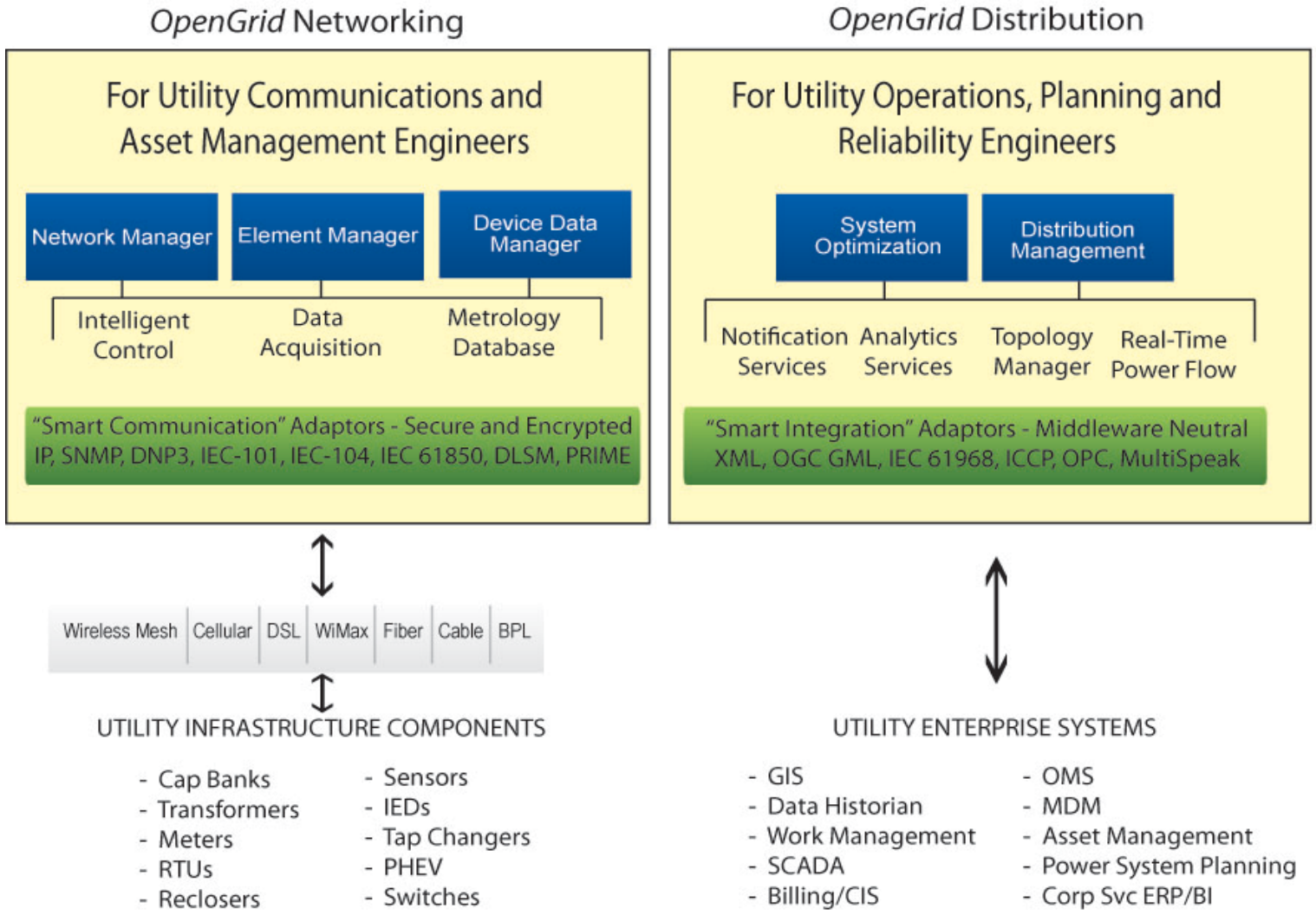
Infrastructure Data Management – *using Oracle Spatial*



Spatial Network User Interface

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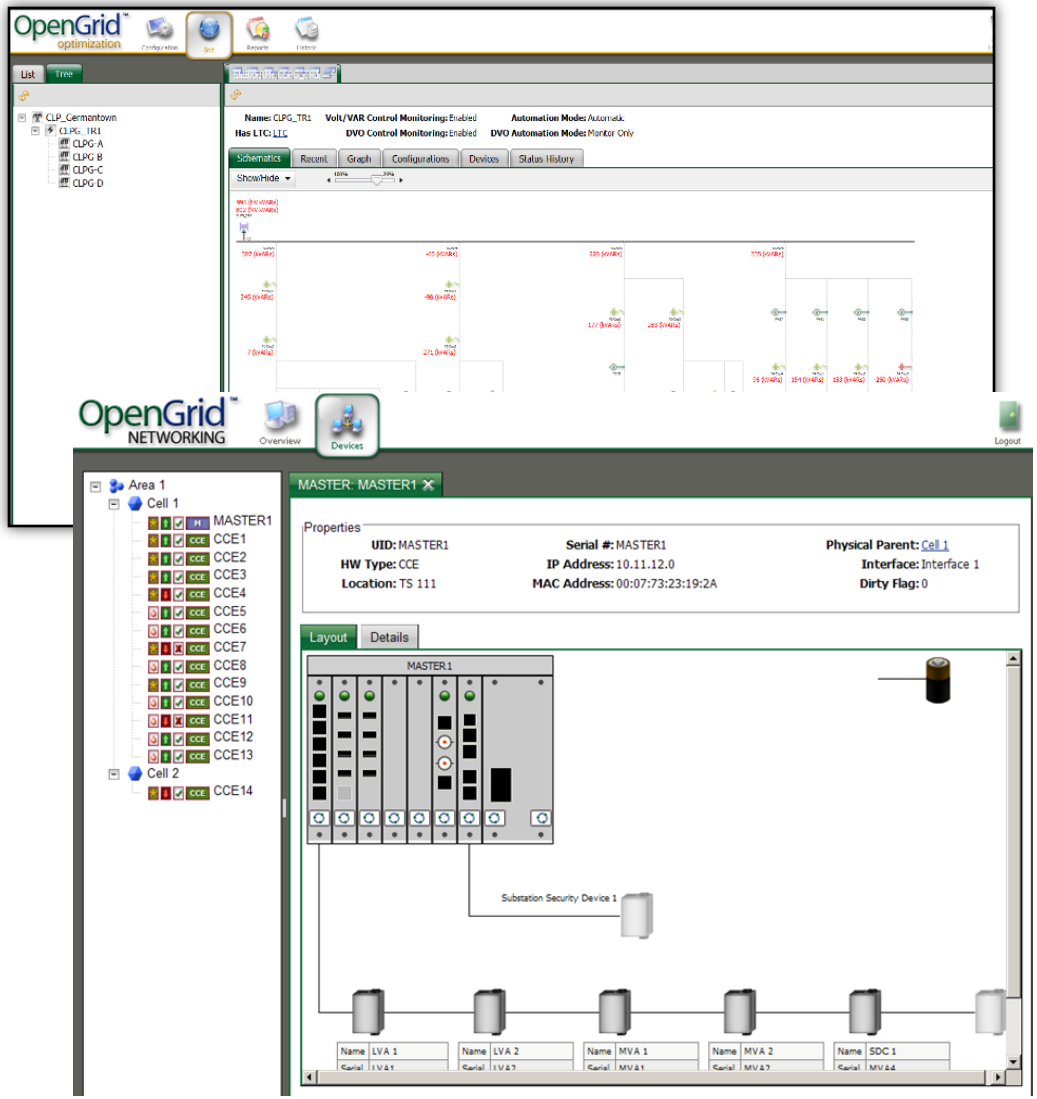
- Electric Grid View
  - *Provides access to real-time electric grid status*
  - *Historic data for analysis*
  - *Real-Time Distribution Power Flow Analysis to optimize the power delivery*
- Network View
  - *Provides access to communication network status and configuration*
  - *Root Cause Analysis of Network Elements*



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SmartGridCity™ – Boulder, CO

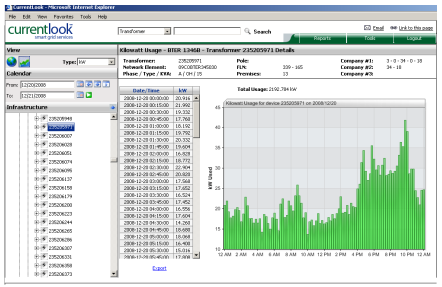
Smart Grid Deployed – The Xcel Energy Example

Installation of sensing equipments, two-way communication network for distribution grid automation and real-time AMI to provide:

- **Transformer Monitoring** - real-time decisions based on current grid conditions
- **Feeder Automation** - monitoring power flow, outages and asset device health to provide centralized Volt-VAR control and Dynamic Voltage Optimization
- **Smart Distribution System** – real-time data on power consumption, outages, restoration and fault locations

Utilizing

- **Advanced sensing** technology to monitor feeder condition
- Two-way, low latency **real-time communications**
- Unified Communication and Electrical grid topology management



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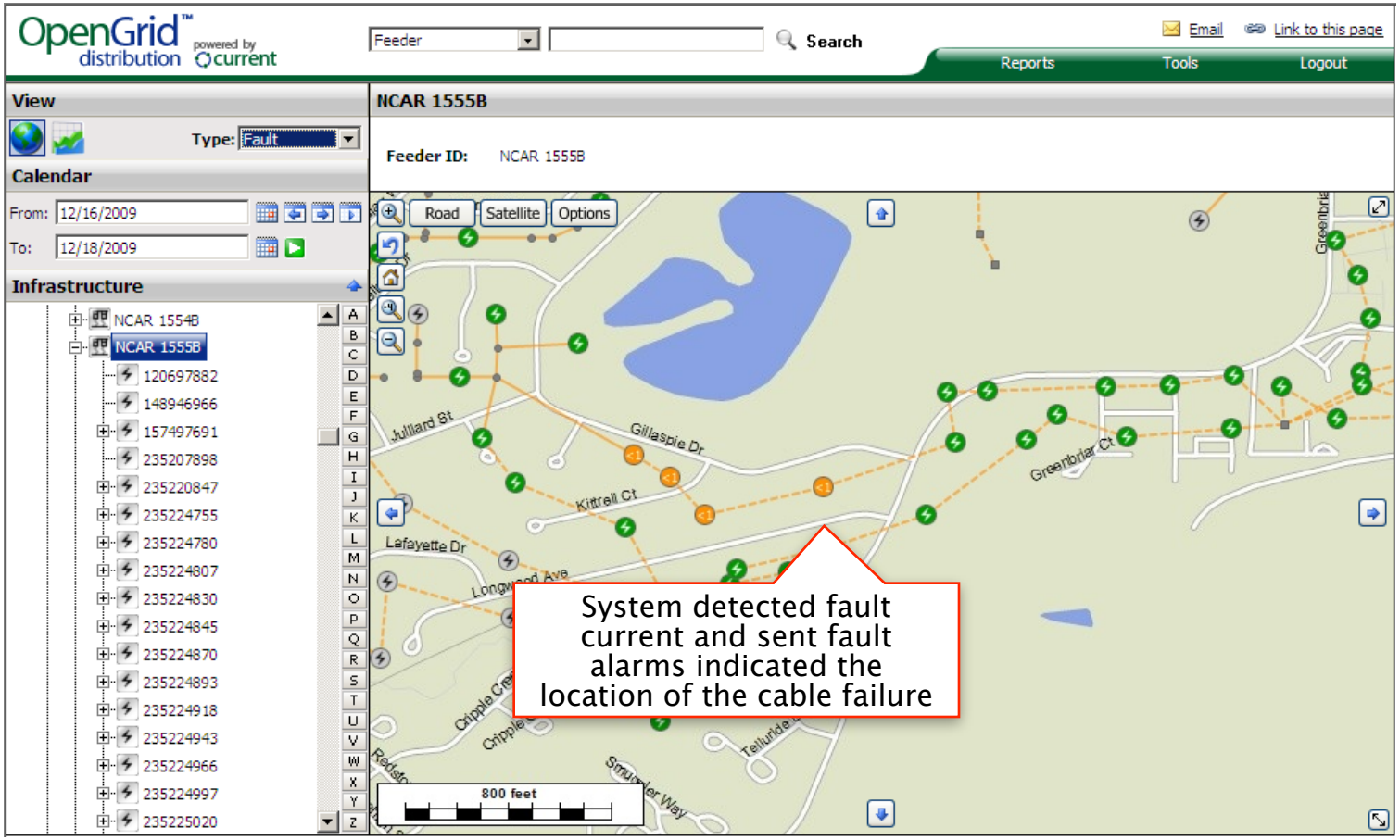
SGC– MV Fault Location Detection



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Spatial Feature Wish List

- Connectivity model import from proprietary GIS data models to Spatial Network Model
- Temporal support to track network model changes over the time

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Summary

- Oracle Spatial is a core component of OpenGrid's unified communication and electrical topology management to deploy the Smart Grid solution
- Unified networks enables self-healing and optimized distribution network operations Asset Management, Strategic Planning, Tactical deployment of sensors and visualization
- GML and CIM standards based GIS integration leads to
  - *Removes limits imposed by proprietary data model*
  - *Improves GIS data accessibility*

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Q&A