SMART GRID Technologies

PE/PE/HT/324C

Professional Elective Course

Smart Grid Technologies

- Automatic Voltage Regulation (AVR)
- Automatic Generation Control (AGC)
- Energy Management System (EMS)
- Distribution Management Systems (DMS)
- Demand Side Management (DSM)
- **Outage Management System (OMS)**
- Wide Area Management System (WAMS)
- Advanced Metering Infrastructure (AMI)
- Meter Data Management (MDM)
- Geographical Information System (GIS)

Outage Management System (OMS)

In addition to catastrophic failures, utilities and their customers are subjected to small scale outages on a much more frequent basis

Trees fall, cars knock down utility poles and animals short out feeders

Utilities are measured by their regulators on both the number and duration of outages. They may face penalties for poor performance on these metrics

While some outages can't be avoided, their length and scope – the number of affected customers – can be minimized

For decades, utilities have relied on customer phone calls and dispatching crews to the field to identify outage areas

They often received delayed and imprecise outage information, slowing power restoration

Their reactive response and long outage durations are often viewed negatively by customers

Outage Management System (OMS)

Electricity outages create significant damage for utility companies such as lost revenue, lower customer satisfaction levels, and more difficult compliance processes

To help manage and prevent future outages, Outage Management Systems (OMS) are being employed in smart grid infrastructure

Outage management systems or OMS are a variety of computer-aided systems which are used by electrical distribution systems

They are primarily used by the grid and distributed system supervisors to return power to the grid following a fault/outage

By using the OMS, dispatchers could easily view the network behavior in near real time and validate outages by simply pinging the smart meters to validate and identify the cause of the outage without having to send truck rolls to visually validate possible outages points.

Outage Management System (OMS)

Utilities can improve customer satisfaction by deploying software, intelligent devices and network communications to implement a state-of-the-art outage management system

These technologies can minimize the scope and duration of outages and enable proactive engagement with affected customers

A key element enabling proactive outage management is real-time, bidirectional communication with utility devices in the field.

Communications permit OMS and other utility software systems to collect up-to-the second information from the distribution system, adjust system operation and provide information to customer service systems and personnel for proactive customer engagement

Even better, the OMS could predict impending failures, enabling scheduled preventative maintenance and reducing unscheduled maintenance under outage conditions

Outage Management System (OMS)

OMSs identify outages and provide instant alerts

They also record the history of outages throughout the operations and provide real-time insight into the systems

OMS systems also provide customer assistance by alerting them about outages and status of repairs

OMS systems usually work in tandem with geographical information systems (GIS) or customer information systems (CIS) and call handling systems such as IVR (interactive voice response)

Outage Management System (OMS)

Major Functions of OMS:

- Facility planning of systems such as transformer, fuse, recloser, breakers and other kinds of safety devices
- Efficient planning of maintenance and remedial efforts along with the prioritization of grid restoration activities depending upon emergency devices, location, and scale of outages
- Collecting and communicating accurate records of outages, and their consequences to the affected customers
- Estimating maintenance times and schedules
- Assigning crews and deciding number of members in each kind of crew

Outage Management System (OMS)

How OMS works?

- The OMS receives the load profile channels prior to the outage to analyze and diagnose the probable cause of the outage, such as loss of phase, overload, or drop in frequency
- This provides important data in real-time to quickly detect a potential power outage event of a transformer, feeders and substations
- It provides instant information about the size and location of the outage and pinpointing affected service points for both predictive and post-incident analysis to identify likely upstream incident devices

Outage Management System (OMS)

How OMS works?

- The OMS automatically identifies equipment and customers affected by outages; monitors levels of service affected by outages and provides reports to relevant stakeholders on the state of the restoration process
- The OMS provides accurate information on the behavior of the network in near real time eliminating costly and time-consuming network analysis and predictions, field validation, etc.
- Once the power is restored and the event is closed, the system will send a notification to the Area Managers responsible for outages

Outage Management System (OMS)

Requirements for Implementing OMS

- The main foundation of typical OMS lies in having efficient networking of distributed systems
- Having a robust network model is vital to having strong outage management systems
- GIS is fundamental in establishing this model network
- By recording the location of all the support calls made for outages, analysis engines of OMS can predict future outages more efficiently

Outage Management System (OMS)

Requirements for Implementing OMS

- Having strong CIS is also a prerequisite for having OMSs
- Since most outage service calls are handled by the consumer support department, it makes complete sense to establish an automated CIS in conjunction with OMS
- For such systems to work, it is important to keep track of all the customers and also hoax customers
- Having automated consumer handling technologies such as IVR as mentioned above can be established in order to streamline the operations of OMS by automating the process of consumer-end communication and real-time alert generation

Outage Management System (OMS)

Requirements for Implementing OMS

- For efficient and advanced outage management systems, one can install advanced automatic meter reading systems which are equipped with outage detection and safety capabilities
- It is a common practice to combine outage management systems with other computer-aided systems such as SCADA which provide automated monitoring and management of electrical systems

Outage Management System (OMS)

Advantages of OMS

- OMS is responsible for monitoring, analyzing and utilizing data related to power outages
- Together with other modules it helps provide constant power supply to its customers
- Reduction in duration of outages and maintenance
- Efficient prediction of outages and outage locations
- Improved consumer handling and customer satisfaction
- Better media relations through efficient outage data recording and clear visibility into restorative efforts
- Generates intuitive reporting, introducing reporting data visually in chart format with outage information
- Informs the relevant team in charge for relevant outage type by SMS/Email/mobile application and can notify the customers about the planned outages

Outage Management System (OMS)

Advantages of OMS

- A significant reduction in the number of complaints registered by end-users
- Additionally, the frequency of random outages can be reduced through the efficient setup of robust outage management systems
- Improved operations of regulators thanks to the planning and scheduling capabilities of restorative programs

OMS in Smart Grid

Smart grid devices can enhance outage management

Utilities can make use of the following smart grid installations to improve their outage response:

- AMI (advanced metering infrastructure)
- FCI (faulted circuit indicator)
- DA (distribution automation)

OMS in Smart Grid - AMI

Use of AMI to enhance outage management

- AMI can assist outage detection and isolation
- Smart meters with last gasp capabilities alert the OMS the moment an outage occurs
- Because all affected meters issue a last gasp message when an outage occurs, utilities get timely outage notification and an accurate picture of outage location
- Restoration notifications from smart meters can help avoid “OK on arrival” dispatch of line crews
- When time-stamped, they also help utilities accurately calculate Customer Average Interruption Duration Index (CAIDI)

OMS in Smart Grid - FCI

Use of automated FCI monitoring

- Traditional faulted circuit indicator (FCI) monitoring involved a lineman drive along a distribution feeder, visually inspecting each FCI to see if it has tripped
- By integrating communication capability with FCIs, the OMS can perform this task from a central location
- Automated FCI monitoring can hasten fault detection and location while eliminating the tedious task of driving power lines to look for tripped FCIs

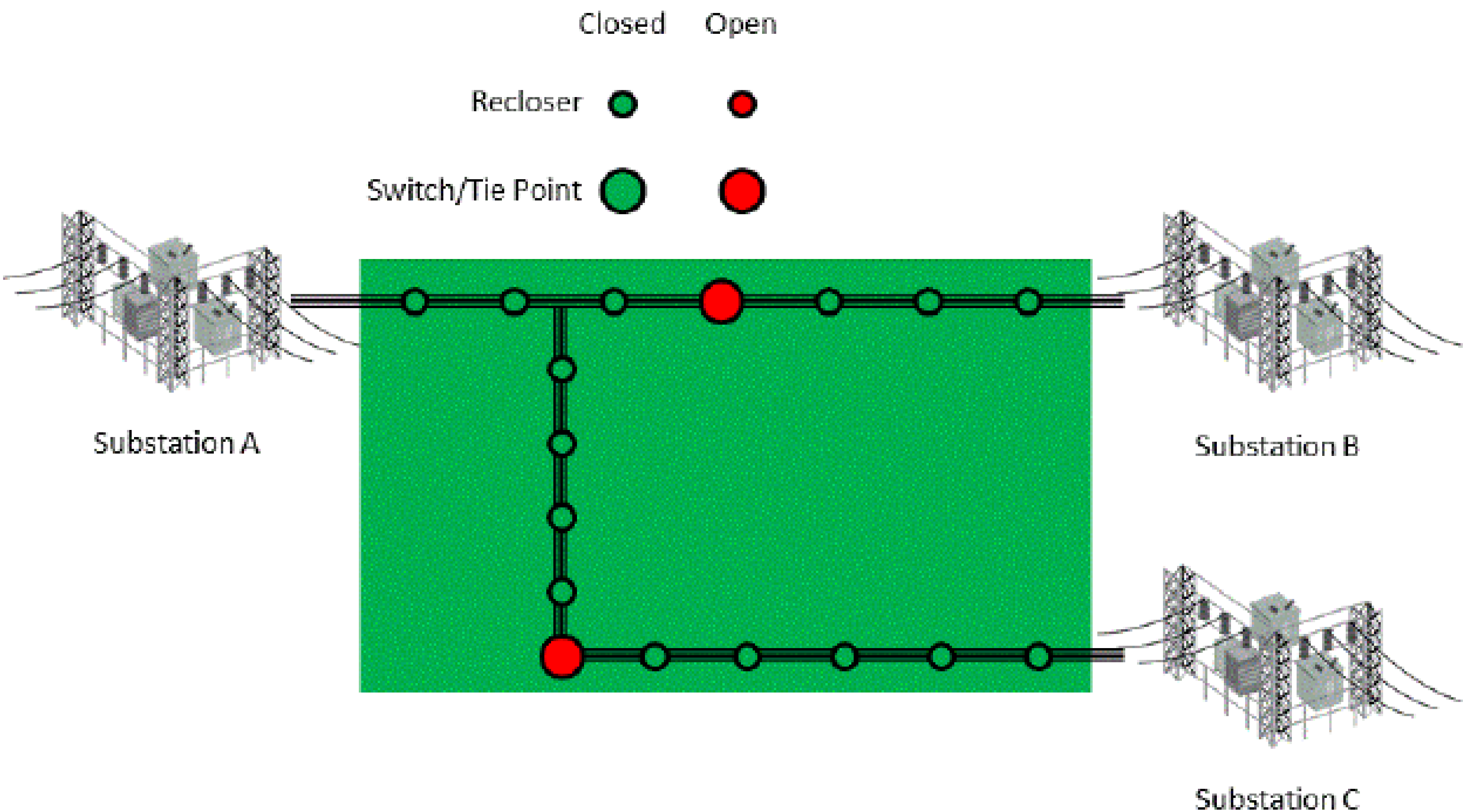
OMS in Smart Grid - DA

Use of automated smart distribution automation (DA)

- Advances in communications have enabled smart distribution automation
- Intelligent switches, reclosers, sectionalizes, capacitor banks and transformers can be actively monitored and remotely operated from substations and utilities’ data centers
- With smart DA devices, utilities can quickly and automatically pinpoint distribution network faults, reducing the scope and duration of outages and protecting critical assets
- Smart DA devices automatically isolate faults and reconfigure feeders to restore electricity with no operator intervention, reducing outage duration from hours to minutes

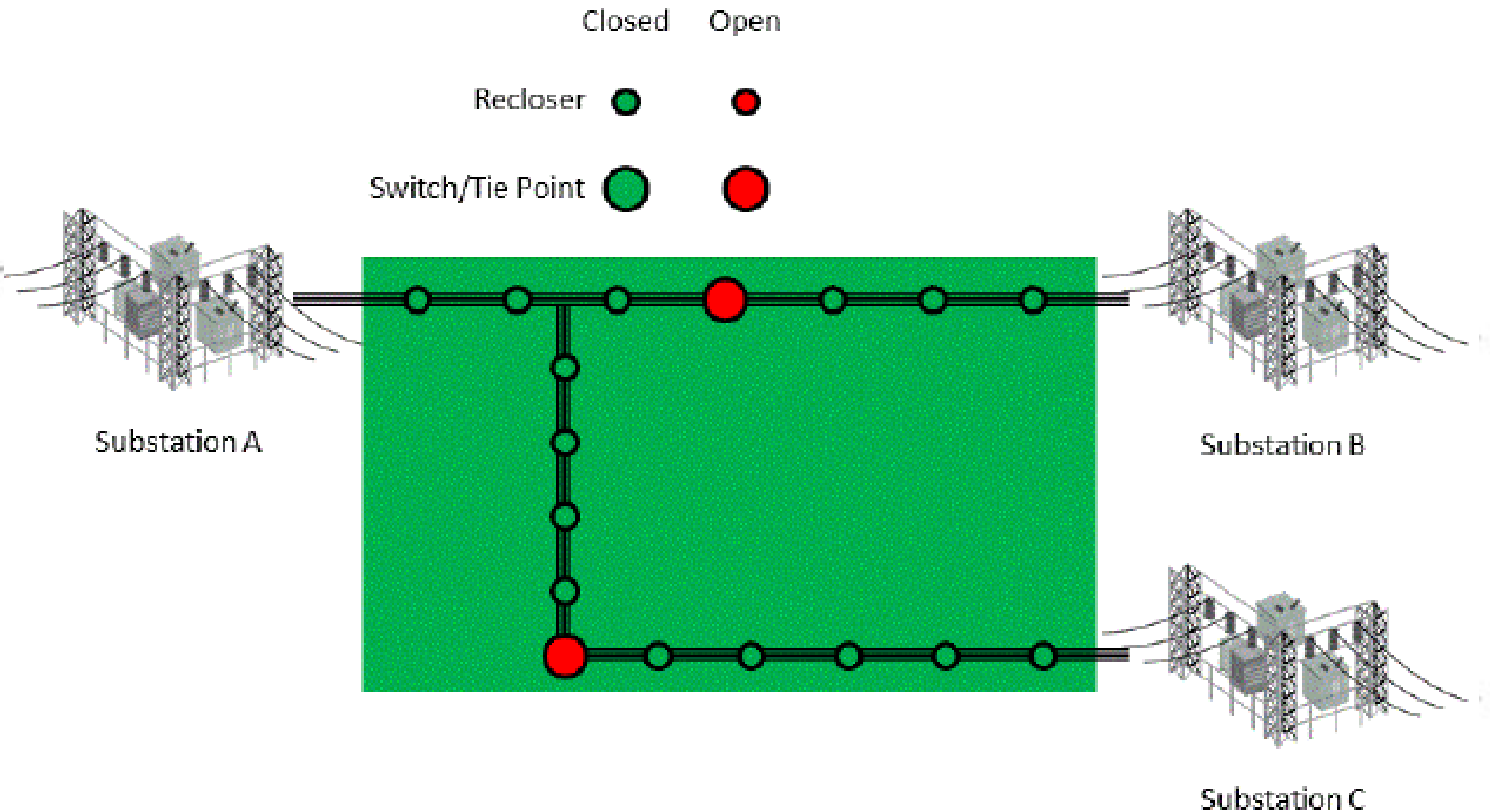
Example of OMS in Smart Grid

During normal operation, the neighborhood is served by distribution feeders from three substations, as shown



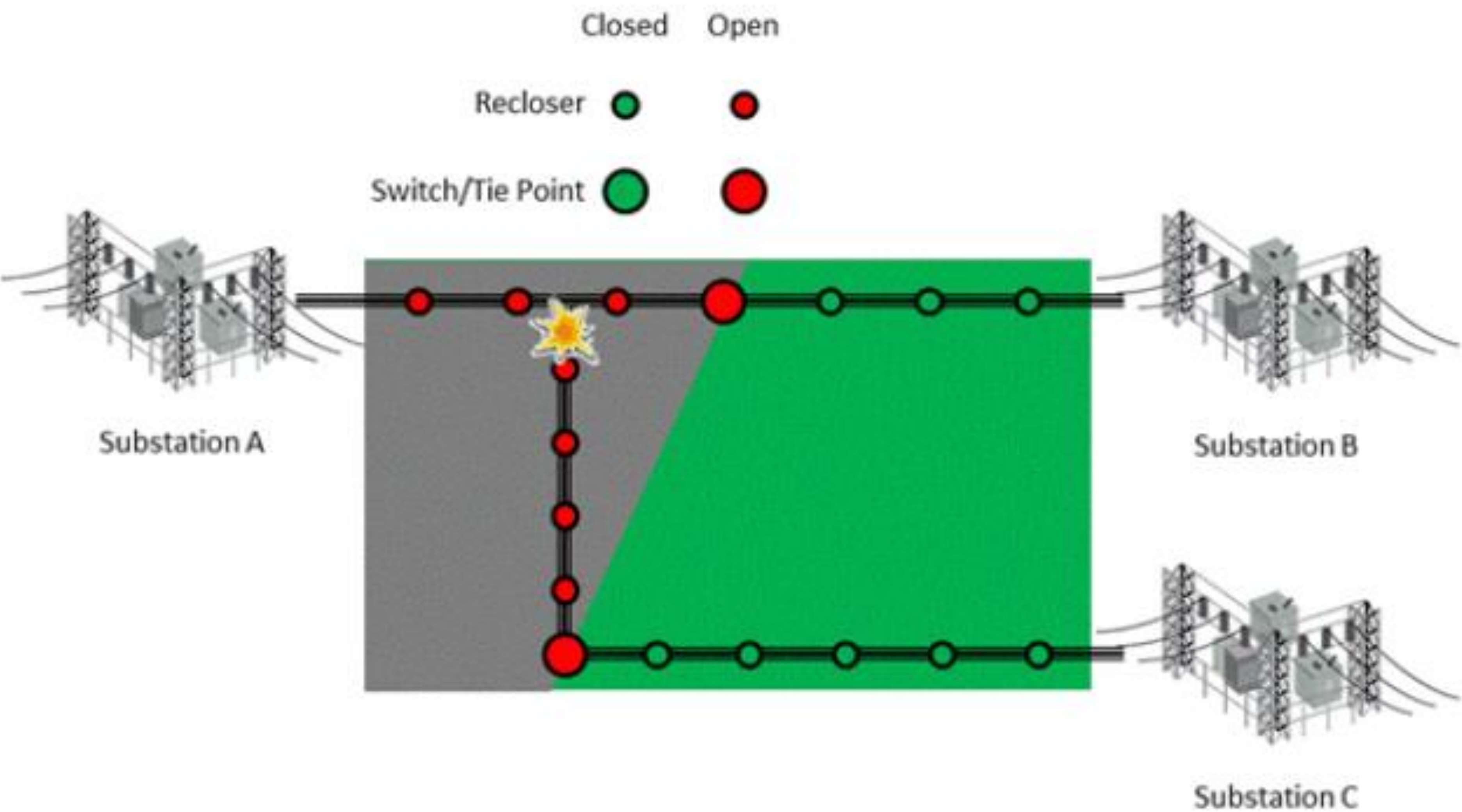
Example of OMS in Smart Grid

When a fault occurs, it causes all customers normally served by Substation A to lose power



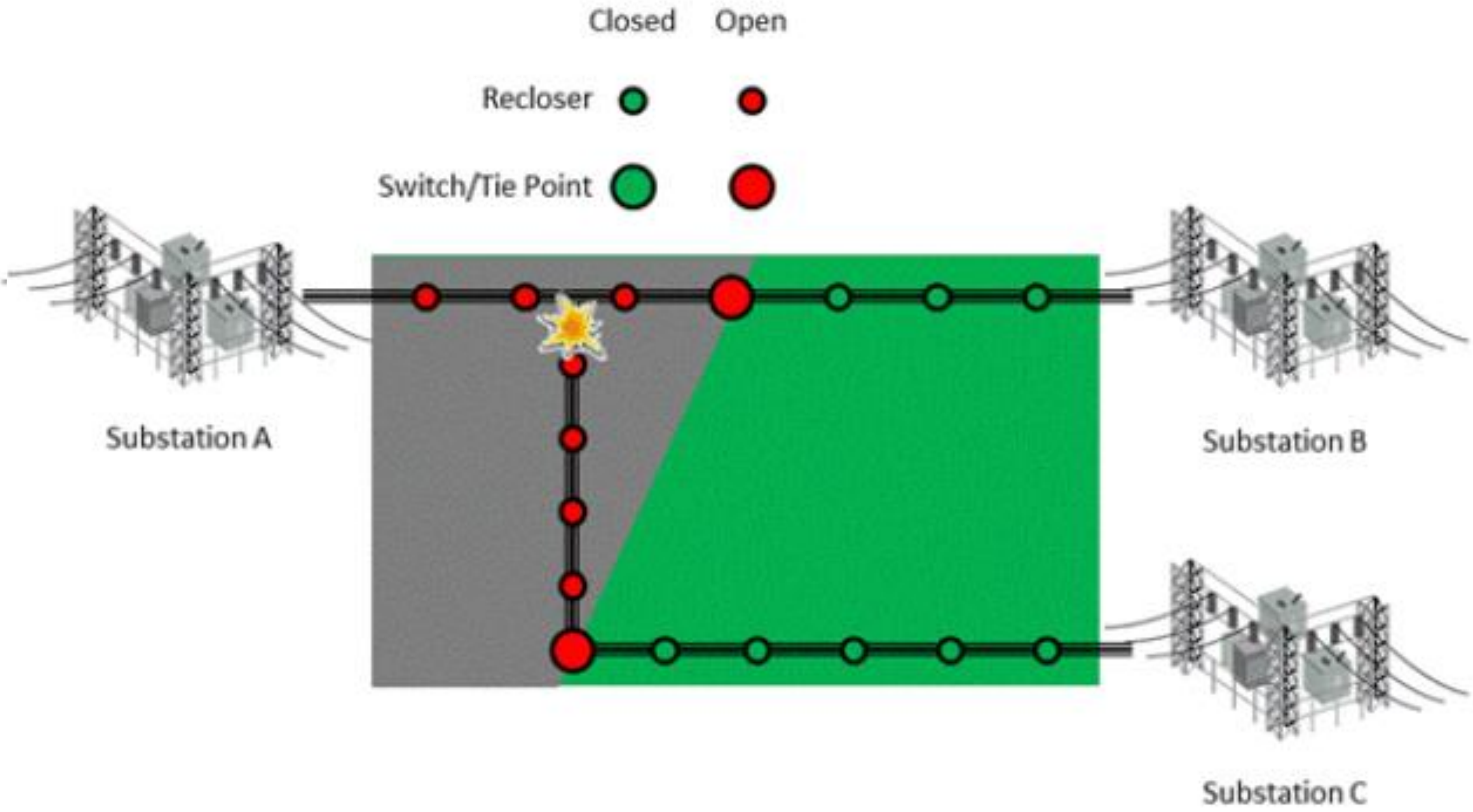
Example of OMS in Smart Grid

Without smart reclosers and switches, this condition would remain until service people come into the area to restore power



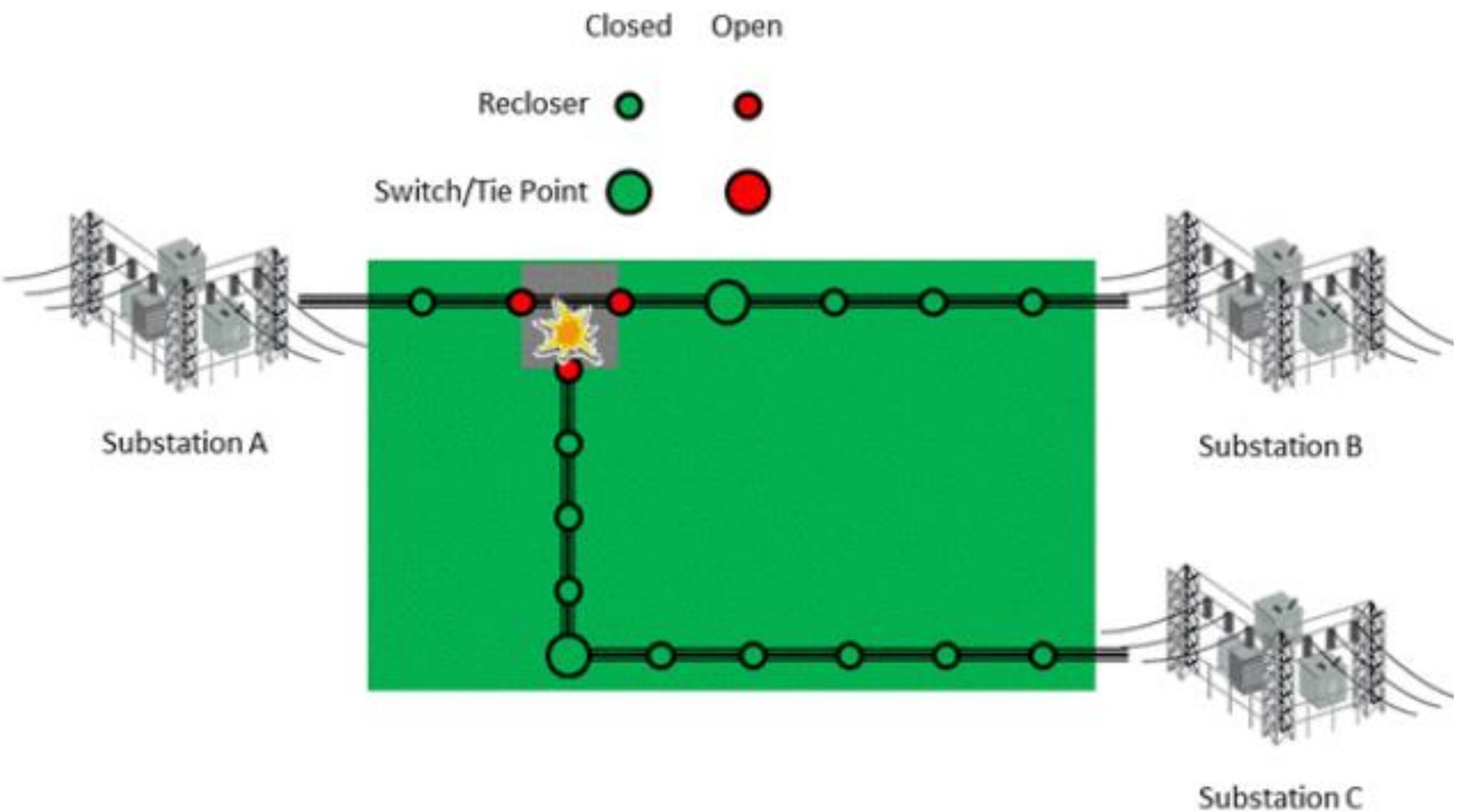
Example of OMS in Smart Grid

With smart reclosers and switches, service between the fault region and the various substations is restored by automatically closing the switches and the reclosers between the tie points and the fault



Example of OMS in Smart Grid

Now the outage is contained to the area between the accident site and the nearest recloser in the direction of each substation.

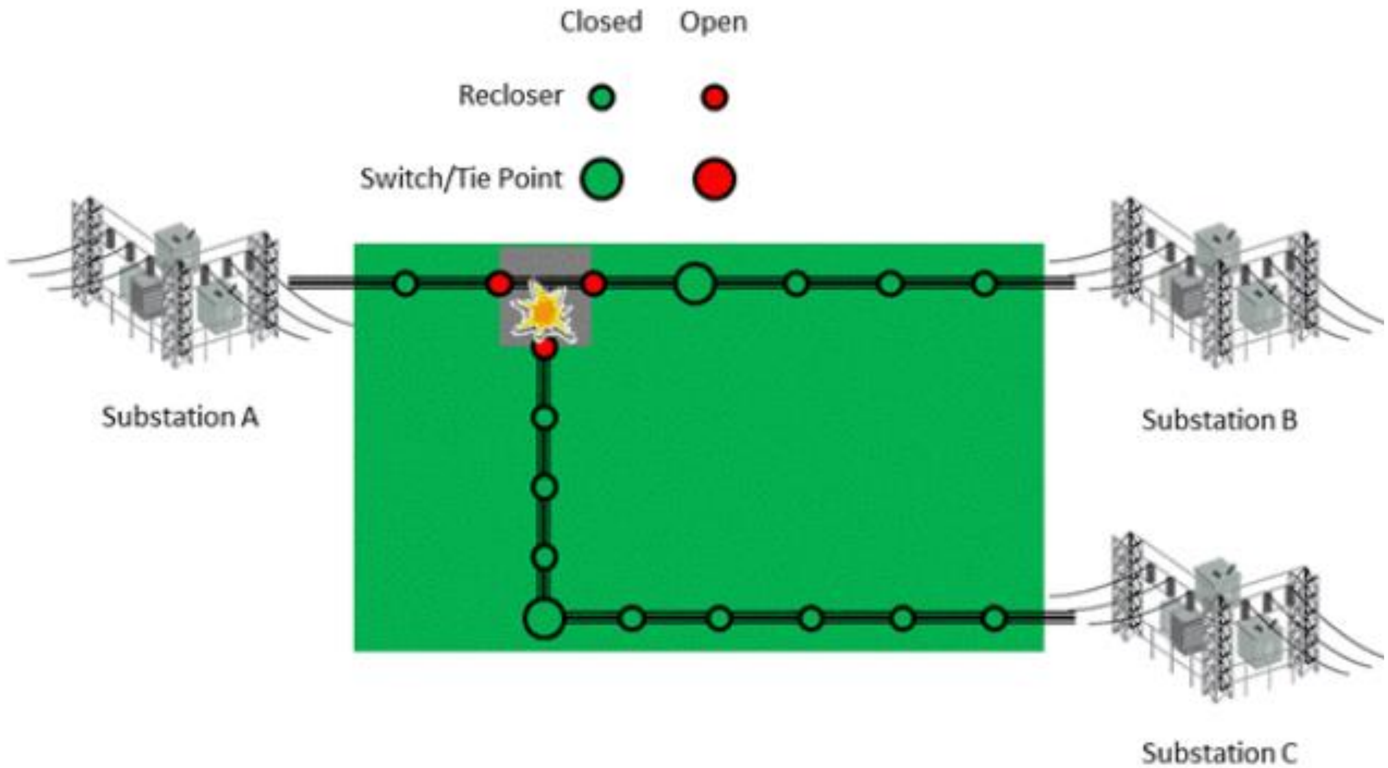


Example of OMS in Smart Grid

Without dynamic feeder reconfiguration, isolating the fault is a manual process

Manipulating switches requires truck rolls, which can take hours

With smart technology, the process is automated – requiring little or no manual intervention – and accomplished in minutes



Field worker communications in OMS

Outage management is further enhanced when the network used for machine-to-machine communications is also used for mobile workforce automation

Providing access for mobile workers enables them to access all information available in the data center without leaving the field

The practical utility of OMS will be the ability of the workers, during an outage event, to access real-time outage data from their vehicle in the field

Direct access to data ensures the utility crew will know that customers have power before leaving the area

Predictive maintenance in OMS

Predictive maintenance as a part of OMS can largely eliminate outages

Intelligent distribution equipment with high speed communications can help the Distribution Management System (DMS) identify likely failures, allowing the utility to replace components before they cause an outage

Potential failures can be predicted using a variety of techniques

- For example, a transformer's temperature and kVA load are good predictors of pending failure
- Transformers with sensors and communication capability can provide temperature and loading data to the DMS which can, in turn, identify a potential failure point before an outage occurs

A more complex method requires intelligent electronic devices (IEDs) throughout the distribution system to collect large amounts of data and to send it to the data center to detect patterns that indicate impending failures

Wireless communication networks for OMS

Wireless Field Area Networks (FANs) provide the communications needed by OMS and other utility software systems to collect up-to-the second information from the distribution system, adjust system operation, proactively engage affected customers and predict pending failures

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The FAN links smart meters and IEDs in the distribution system to the data center

Wireless communication networks for OMS

IEDs usually connect directly to the FAN

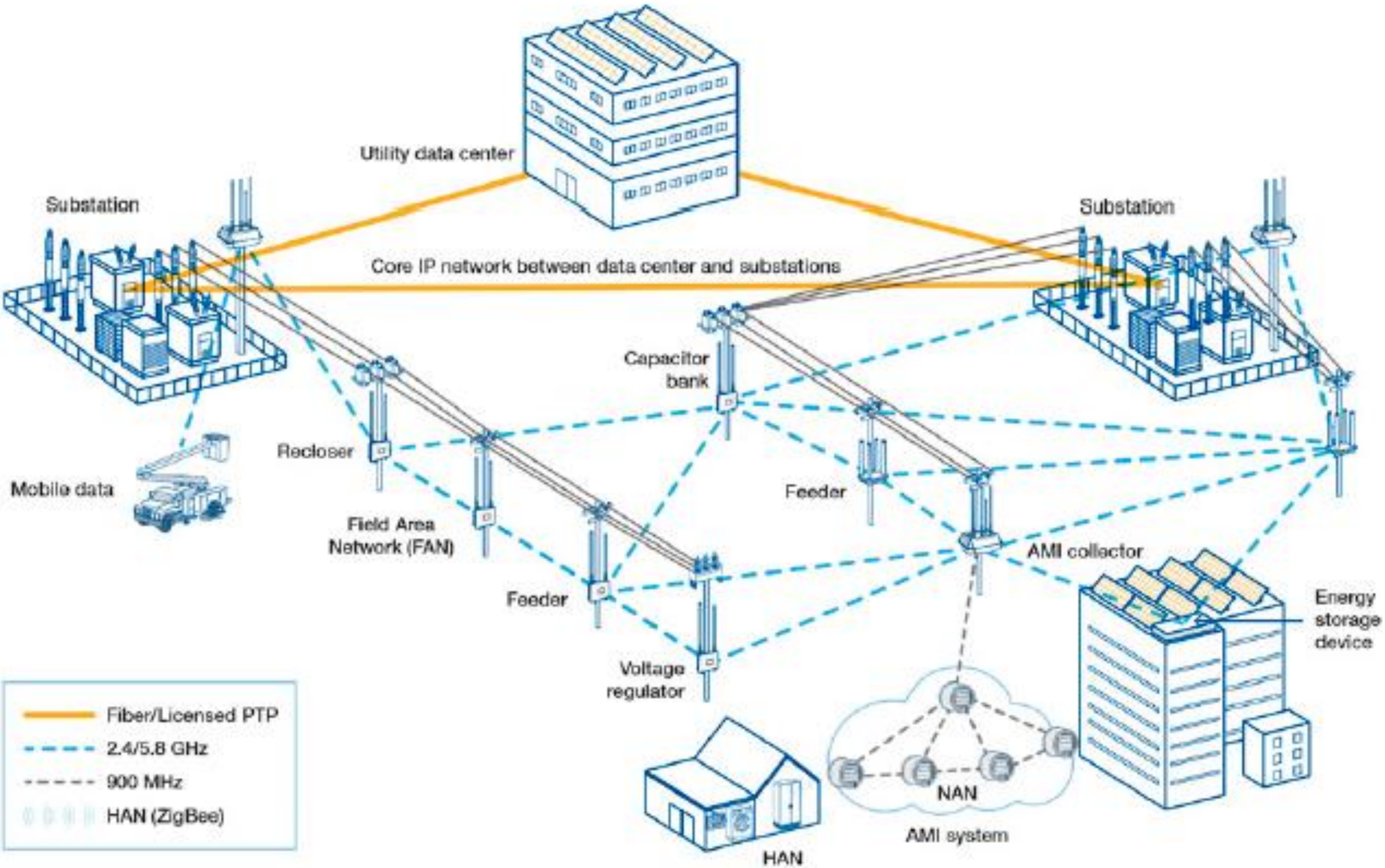
Smart meters generally use a lower bandwidth Neighborhood Area Network (NAN) to communicate with an AMI collector that aggregates data from a large number of smart meters

The collectors, in turn, connect to the FAN

The FAN transports information between NANs and IEDs and the utility's core IP network

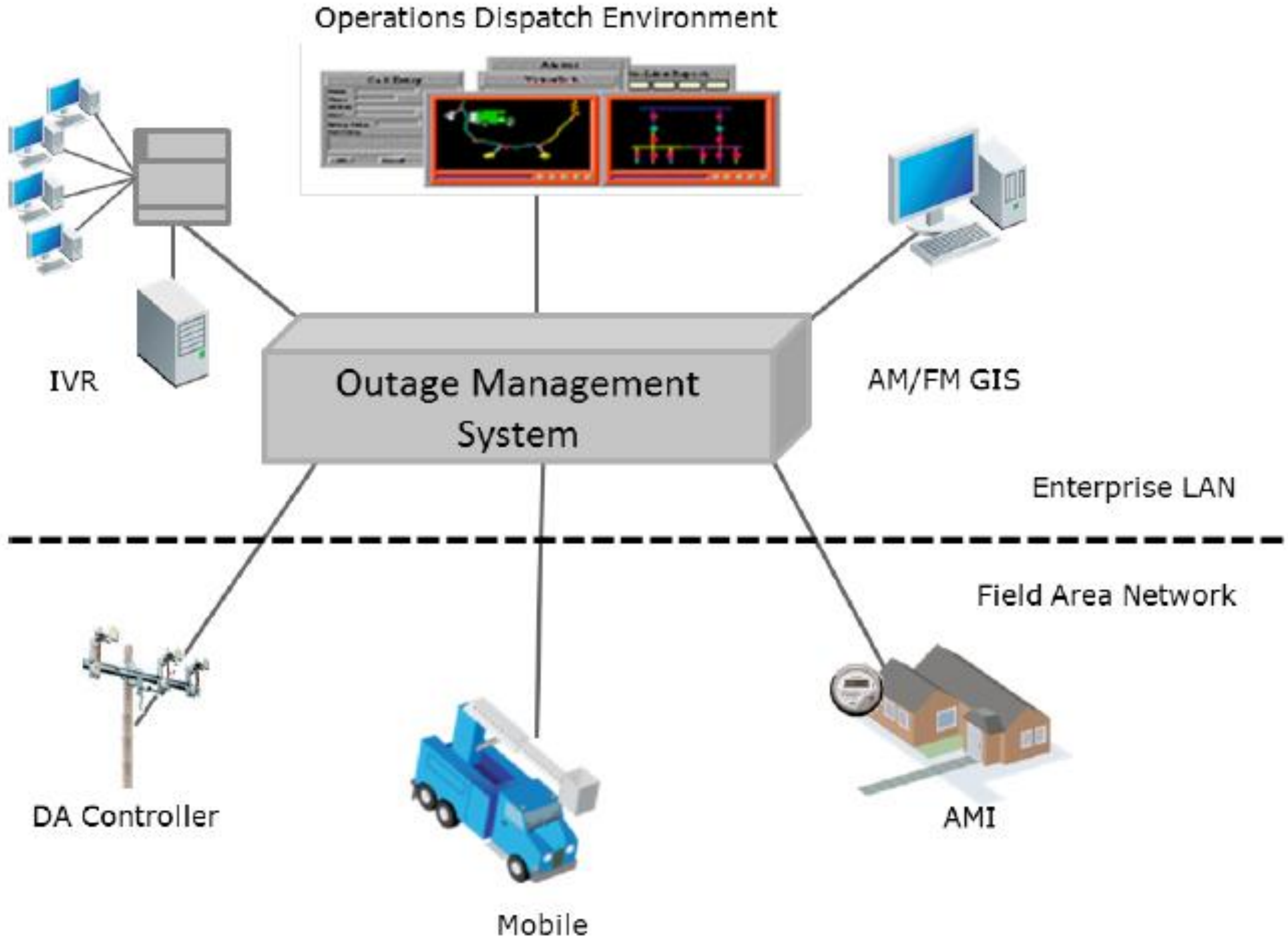
The core IP network connects to the data center, where the OMS and other smart grid software systems are located

Wireless communication networks for OMS



Wireless communication networks for OMS

The OMS shares information with systems such as the GIS and IVR via the utility's enterprise network with workers and systems in the field using the FAN



Field Area Network (FAN) requirements

High capacity

- As IEDs proliferate, become smarter and gather more information, capacity needs are changing
- High capacity networks are required because more applications and devices use the FAN and they send and receive more data

Application prioritization

- Application prioritization is required to ensure that delay-sensitive traffic gets to its destination in time

High availability

- Communications are most critical during outages
- FANs must operate even when events disable the electric grid
- Individual communication devices must be ruggedized, weatherized and supply battery backup

Field Area Network (FAN) requirements

Scalable

- Field area networks must scale to cover large geographic areas, potentially the utility's entire service territory
- They must also scale to support, directly or via NANs, millions of connected devices

Secure

- As utilities adopt IP in field area networks, fear of cyber-attacks increases
- However, IP-based architectures bring security advantages
- The tools used to thwart cyber-attacks in enterprise networks have been honed for years and are constantly being updated

Field Area Network (FAN) requirements

Flexible

- To support the widest variety of applications and devices, the FAN must be built on industry standards such as TCP/UDP/IP, 802.11 (Wi-Fi) and 802.3 (Ethernet)
- To best integrate IEDs, the FAN must also support secure network connections to devices that use serial RS-232 or RS-485 links and automation protocols such as DNP-3, Modbus, SEL Mirrored Bits and IEC 61850