Wildfire Mitigation Data System (WMDS): Specific Data and Collection Methodologies

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I. Introduction

A. Internet of Things (IoT)

The Internet of Things (IoT), broadly defined, is a network of physical devices that communicate with each other via the internet [1]. Typically, this communication involves the processing of data by organizations from a variety of sources - ranging from small consumer electronics devices such as smart watches to large industrial processes such as concrete production. Any IoT application, regardless of the specific field, shares the following key characteristics [2], displayed visually in *Figure 1*.

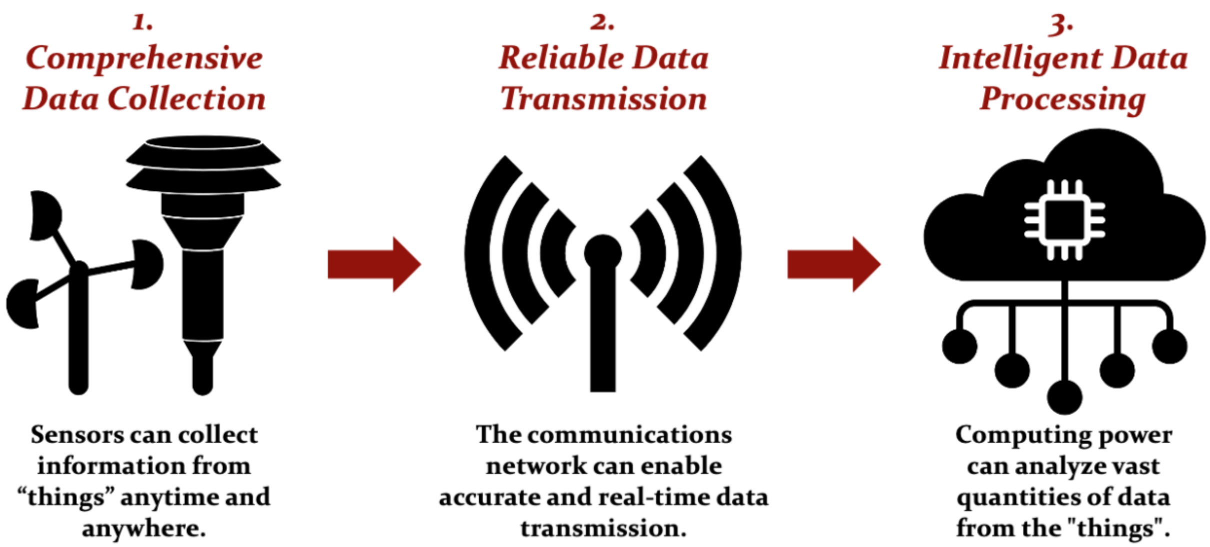

Figure 1: These three key characteristics of any IoT application will be applied to the field of wildfire mitigation for electric utilites.

B. The Smart Grid

The important features of IoT (comprehensive data collection, intelligent data processing, reliable data transmission) can be applied in the electricity grid to create the Smart Grid (SG) of a decarbonized future economy. For instance, the software company VMWare has a microgrid pilot project at its corporate campus in Palo Alto, CA that leverages IoT technology to optimize its electric vehicle (EV) charging facility [3]. The goal of this proof-of-concept installation is to use real-time sensing of renewable energy production, energy efficient consumption, and battery energy storage in the microgrid in order to precisely control EV charging and discharging. In addition to EV management, other IoT SG current or proposed uses include: fault monitoring in transmission lines, advanced metering infrastructure (AMI) to predict consumption patterns, and smart appliances enrolled in demand-response or load shifting programs [4].

C. Western Interconnection Data System to Inform Utility Wildfire Mitigation Efforts

A joint study by the Western Interstate Energy Board (WIEB) and the Precourt Institute for Energy at Stanford University recommends a regional data system, spanning the Western Interconnection, that aggregates information from electric utilities in order to inform wildfire mitigation efforts [5]. The student researchers analyzed probable ignition events for electric infrastructure, which are events that could have started a fire but did not. Their report includes the "why" component (the increasing threat of utility-caused wildfires in the Western United States and Canada) and the "what" component (collect and aggregate regional data on probable ignition events in order to improve wildfire mitigation efforts by electric utilities). This paper seeks to build on the concept of a Western Interconnection-wide "Wildfire Mitigation Data System" (WMDS), shown visually in *Figure 2*, by presenting the "how" component: how the specific inputs for the data system can be collected via IoT and SG concepts and technologies.

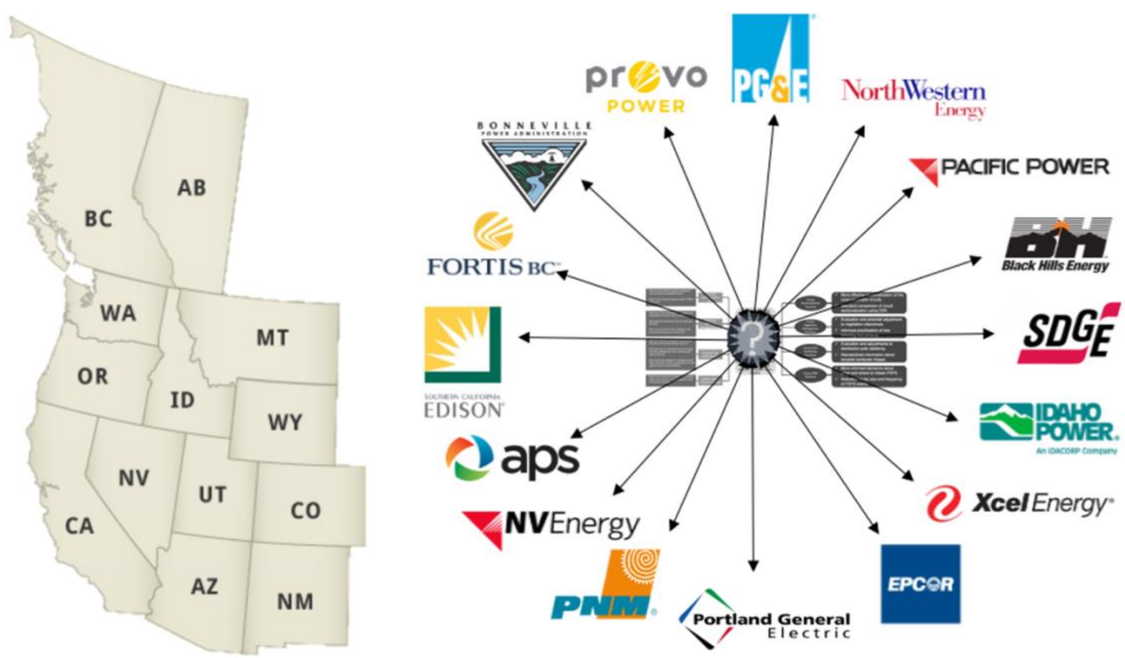

Figure 2: A "Wildfire Mitigation Data System" (WMDS) can allow utilities throughout the Western Interconnection to submit their data in exchange for access to a broader dataset that will help them improve operations, reduce costs, and manage wildfire risks.

II. Data System

A. Inputs

There are two main categories of inputs for the WMDS:

1. **Probable Ignition Events**: Events that could have started a fire but did not.
    a. *PSPS Damage*: Damage during a Public Safety Power Shutoff (PSPS) that could have started a fire had those lines been energized.
    b. *Other Near Misses*: Near miss events that could have started a fire during the course of normal utility operations (non-PSPS related).
2. **Ignition Events**: Fires caused by electric utility infrastructure.

Each input is associated with at least twenty-six variables, which can be divided into the following categories: sectionalization, vegetation management, grid hardening, and weather. Each variable pertains to the circuit at which the ignition or probable ignition event occurred.

B. Sectionalization Variables

Table 1 contains information on the customer impacts avoided per each individual sectionalized circuit, as opposed to aggregate data on the impacts of sectionalization. Additionally, it contains the Customer Exposure Ratio (CER) for each sectionalized circuit, which is a measure of the "extent of sectionalization" beyond a binary "Yes or No" answer [6]. There is also a need to incorporate wildfire risk into this metric.

Table 1: Specific Data System Inputs for Sectionalization Variables

Variable	Description	Units
CER	Customer Exposure Ratio (CER) that calculates the extent of sectionalization for this particular circuit.	Unit-less number from 0-1
Avoided Impacts	The number of customers that did not experience an outage on this specific circuit due to sectionalization.	Number of Customers
Total Impacts	The total number of customers that experienced an outage on this specific circuit.	Number of Customers
Device Density	The number of sectionalizing devices (ex. inter-tie switches, reclosers) per mile on this specific circuit.	Device/Mile

C. Vegetation Management Variables

Table 2 contains information on the vegetation clearances, historical information on pruning, and information on the trees involved (if any).

Table 2: Specific Data System Inputs for Vegetation Management Variables

Variable	Description	Units
Clearance	Closest distance from branches to pole/lines.	Feet
Last Trim	Time since this section of the circuit was last trimmed by an arborist.	Days
Clearance at Trim	Closest distance from branches to pole/lines at time of last trim.	Feet
Next Trim	Time until this section of the circuit is scheduled to be re-trimmed by arborist.	Days
Tree: Damage	Whether the ignition or probable ignition event occurred via tree damage (If Yes, collect the following tree-related data).	Yes/No
Tree: Hazard	Whether the tree was classified as a hazard tree (tree at risk of falling onto line or pole due to particular species, physical condition, or proximity etc.).	Yes/No/NA
Tree: Removal	Whether the tree was previously identified for removal, due to classification, proximity, or physical condition etc.	Yes/No/NA
Tree: Distance	Closest distance from tree to pole/lines.	Feet
Tree: Age	Age of tree.	Years/NA
Tree: Species	Species of tree.	Species/NA

D. Grid Hardening Variables

Table 3 contains information on whether the conductors were covered, what was done to remediate the circuit, and information on the equipment if there was an equipment failure.

Table 3: Specific Data System Inputs for Grid Hardening Variables

Variable	Description	Units
Covered Conductors	Whether the lines at that section of the circuit were covered with an abrasion resistant insulating material.	Yes/No
Remediation	Whether remediation occurred at that section of the circuit (If Yes, collect the following remediation-related data).	Yes/No
Remediation: Pole	Whether the pole was replaced or repaired.	Yes/No/NA
Remediation: Conductors	Whether the lines were subsequently insulated.	Yes/No/NA
Remediation: Undergrounding	Whether that section of the overhead circuit was moved underground or will be moved underground.	Yes/No/NA
Remediation: Removal	Whether that section of the circuit was removed or will be removed entirely.	Yes/No/NA
Equipment: Failure	Whether equipment failure occurred at that section of the circuit (If Yes, collect the following equipment-related data).	Yes/No
Equipment: Type	Name the type of equipment that failed and the manufacturer.	Type, Manufacturer
Equipment: Age	Time since the equipment was first installed.	Days
Equipment: Service	Time since the equipment was last serviced.	Days

E. Weather Variables

Table 4 contains information on the data system inputs for the weather-specific variables associated with each ignition or probable ignition event. This primarily consists of wind-related data, as high winds are the most likely culprit of circuit damage and related fire risk.

Table 4: Specific Data System Inputs for Weather Variables

Variable	Description	Units
Wind Gust	Speed of maximum wind gust recorded at closest weather station.	MPH
Weather Station Distance	Distance from point of damage to closest weather station.	Miles
Wind Speed	Average wind speed recorded over 24-hr period encompassing time of damage at closest weather station.	MPH

III. Data System

A. IoT Devices

IoT devices are already used for a variety of wildfire mitigation purposes, both by utilities and other entities. Sensors can be installed by line workers to alert utilities about downed wires, vegetation contact, equipment failure, and other line disturbances that pose a fire threat. These products can provide data for the vegetation management and grid hardening variables [7]. SCADA-enabled (supervisory control and data acquisition) reclosers can also provide the necessary sectionalization data. During high fire threat conditions, situational awareness is also important. Utilities throughout California, for instance, have deployed cameras and weather stations throughout their networks. These stations capture real-time data for temperature, humidity, and wind speeds [8]. Therefore, it is clear that all inputs for the WMDS can be collected automatically and transmitted to the centralized data system via IoT and SG technologies.

B. IoT Architecture

A variety of IoT-SG architectures have been proposed in the literature or implemented in electricity grids. For the WMDS, a three-layer structure that contains a device layer, a network layer, and an application layer is most suitable [9]. Layer 1 (device layer) consists of the aforementioned devices: sensors, reclosers, and weather stations etc. Layer 2 (network layer) consists of the necessary communications networks such as 5G and the internet, which transmit the device-collected data to the application layer. Layer 3 (application layer) processes the raw data and in this example is the WMDS. A schematic of this structure is shown in *Figure* 3. Outputs of the data system can include improved practices for vegetation management, grid hardening, sectionalization, and public safety power shutoffs (PSPS).

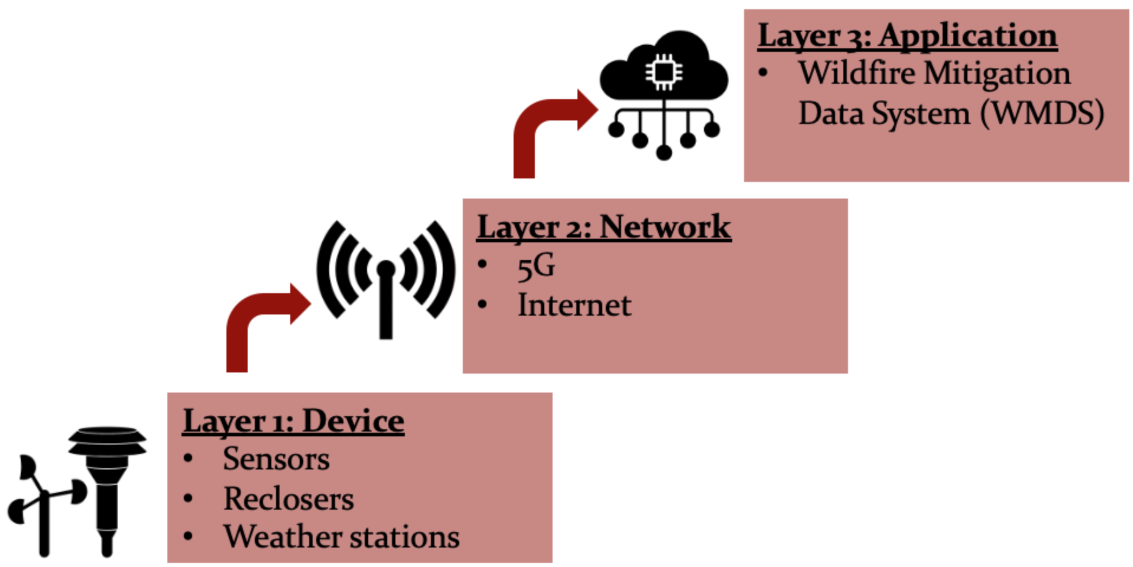

Figure 3: The device layer, network layer, and application layer for a Wildfire Mitigation Data System (WMDS) for the Western Interconnection

IV. Conclusion

In order to collect the necessary data for the proposed Wildfire Mitigation Data System (WMDS), Smart Grid (SG) strategies and Internet of Things (IoT) technologies need to be harnessed. The key principle of comprehensive data collection will be achieved through the strategic deployment of sensors, weather stations, and reclosers. These devices can remotely gather data related to sectionalization, vegetation management, grid hardening, and weather for ignition and probable ignition events. This information can be reliably transmitted via 5G networks and the internet to the WMDS, which can utilize intelligent data processing techniques to extract wildfire mitigation best practices for electric utilities. These adjustments in utility practices can result in changes to IoT device settings or sensitivities, thereby completing an information feedback loop.

V. References

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