Smart Meter Data Analytics for Distribution Network Connectivity Verification

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***Abstract*—Many utilities have the data quality problem with the geographical information system (GIS) records at distribution level. This affects many business functions of a utility, including asset management, outage response, and workforce safety. For correcting connectivity errors in the GIS representation of the distribution network topology, BC Hydro has developed an in-house algorithm. The algorithm leverages smart meter interval measurements and identifies the neighboring meters by voltage profile correlation analysis. It also predicts customers' upstream and downstream location relationship by voltage magnitude comparisons. The output of the algorithm is then compared with the existing GIS records to correct any errors in it. This paper presents in detail the algorithm and the promising testing results within the practical BC Hydro system. Challenges for underground services are demonstrated. The algorithm's potential use for phase detection by collectively leveraging smart meter and feeder meter data is explored. It shows encouraging results when applied in a downstream section of a large feeder.**

***Index Terms*—Advanced metering infrastructure (AMI), data analytics, distribution network topology, smart meters.**

I. Introduction

MANY utilities are implementing advanced metering infrastructure (AMI) programs as a part of their grid modernization efforts [1], [2]. The AMI automatically collects interval smart meter data from customer locations and sends them to the utility. This results in a large amount of data [3], [4], which can be analyzed for many different purposes. The data offers utilities many opportunities to apply data analytics to potentially enhance their operational efficiency [5], [6]. For instance, smart meter data can be used for enhancing and estimating voltage and var optimization benefits [7], evaluating distribution line losses [8], identifying and quantifying energy thefts [9], and enabling improved load forecast [10], [11], outage management, and distribution system analysis [12]. There are also data analytics which specifically address the distribution topology and connectivity problems, such as phase identification [13], transformer identification [14], and secondary modeling [15]. Some utilities also analyze the correlation between customer and feeder outage events in order to verify their connectivity relationship and improve the data quality of their geographical information system (GIS) records.

The GIS receives information inputs from many different sources and the problem of its poor data quality has been pervasive in power utilities. This has led different power companies to implement various programs aiming to reduce GIS errors. These programs include the introduction of standard operating procedures which require GIS records to be updated when asset changes are made in the field, as well as the introduction of line inspection patrols which are dedicated to correcting topology errors. An example of a more technologically driven program is the application of power line carrier technology to build feeder phase and device connectivity mappings.

The availability of AMI customer data has recently provided alternative approaches to the GIS accuracy improvement efforts. An example of this is the smart meter data analytic algorithm, which was developed and tested in house by BC Hydro. This algorithm aims to detect and correct connectivity errors in the GIS representation of the distribution network topology. Case studies conducted with this algorithm have shown very promising results [16]. The core principle of the algorithm is that customers' voltage profiles correlate the best when they have the shortest electrical distance. While the voltage profile correlation degrees identify the electrical distance between meters, voltage magnitudes further indicate the upstream or downstream position of the meters. The algorithm outputs a connectivity association of a customer meter with a transformer. This could be either the transformer indicated in GIS records or a neighboring transformer, indicating a potential topology error. The algorithm also outputs the order of customer meters along the branches stemming from the transformer, and compares with existing GIS records. In this way, mistakenly recorded customer meters are repositioned to a correct location within their original transformer, or to a correct location within the network of a neighboring transformer. This algorithm has been enhanced and applied to larger sets of customers since its introduction. The results are outlined in this paper. The algorithm is also tested for its phase detection capability by collectively using feeder meter and customer meter data. The results achieved show great potential for feeder phase detection in a downstream section of a large feeder.

This paper is structured so that the introduction is followed by the background and work motivation in Section II, the outline of the proposed analytic approach in Section III, details

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