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Poster: K-anonymity Applied to the Energy Grid of Things Distributed Energy Resource Management System

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ABSTRACT

The violation of information privacy in Smart Grids can be a significant barrier to customers' participation. Employing privacy protection models such as K-anonymity in a Smart Grid implementation adds desirable privacy guarantees. This work provides an approach to applying the Mondrian algorithm to ensure data within the system excludes Personally Identifiable Information. Results suggest that a dynamically generated generalization hierarchy minimizes information loss incurred by the anonymization process.

CCS CONCEPTS

• **Security and privacy** → *Privacy protections.*

KEYWORDS

distributed energy resources, k-anaonymity, security, privacy

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1 INTRODUCTION

The success of any Smart Grid (SG) hinges on its customers. For instance, an increase in Distributed Energy Resources (DERs) participation within a system boosts its ability to counterbalance disruptive events. That is attributed to grid operators having greater control over the demand side of the grid. Similarly, one must ensure there are little to no discouraging factors that affect customers' participation. One very significant barrier to customers' participation is the prospect of violating their privacy. Any Demand Response (DR) program depends on a large amount of information exchange between its components. With that in mind, the problem this work attempts to address is how to preserve customers' privacy in an Energy Grid of Things Distributed Energy Resource Management System (EGoT DERMS) [3].

1.1 Common Smart Inverter Profile v2.0

SunSpec Alliance proposed the Common Smart Inverter Profile (CSIP) v2.0 standard to aid DER manufacturers and aggregators compliance with California Rule 21 (CA21) proceedings and IEEE 2030.5 [1]. Among the many propositions put forth in the CSIP standard is the topological grouping of DERs. Figure 1 illustrates the topological and non-topological groupings as described in CSIP. The figure depicts a topology tree on which several service points are located. The topological location of each node is the result of concatenating all its ancestors. It also represents the physical location of each node. Given that the EGoT DERMS adopts IEEE 2030.5, it is only natural to adopt the proposed grouping (the non-topological groups are not considered in this work).

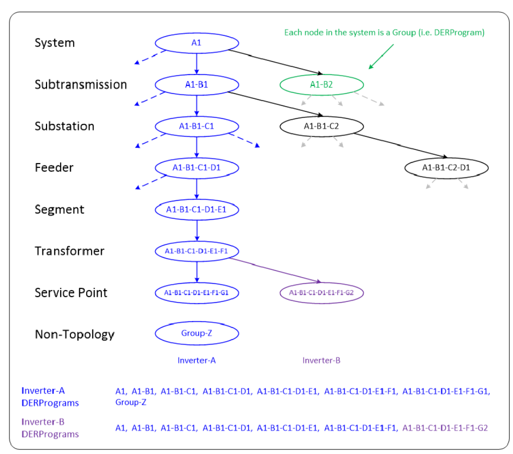

Figure 1: Topological grouping as described in CSIP v2.0 [1].

2 METHODOLOGY

The Mondrian algorithm is a greedy algorithm that aims at approximating the optimal K-anonymization [2]. Essentially, it finds a

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solution by partitioning the instances for all quasi-identifiers in a Mondrian manner. The proposed approach has a far better complexity than previously proposed methods for achieving K-anonymity. The fact that it relies on a greedy algorithm gives us the benefit of attaining anonymization in $O(nlogn)$ time complexity.

2.1 Generalization Hierarchy

The Mondrian algorithm utilizes a generalization hierarchy to generalize or suppress attribute values. This reliance on a generalization hierarchy aligns with the topological load groupings in distribution systems. For example, every load has a topological location that describes its associated substation, feeder, segment, transformer, and service point to which it is connected, as illustrated in Figure 1. This topological location is an identifying value for loads in an electrical distribution system. Only the distribution side of the grid is considered here, starting from the substation down to the service point. Such topology can be morphed and used as a generalization hierarchy for the Mondrian algorithm. Figure 2 portrays a generic scheme of the generalization hierarchy used for the EGoT DERMS.

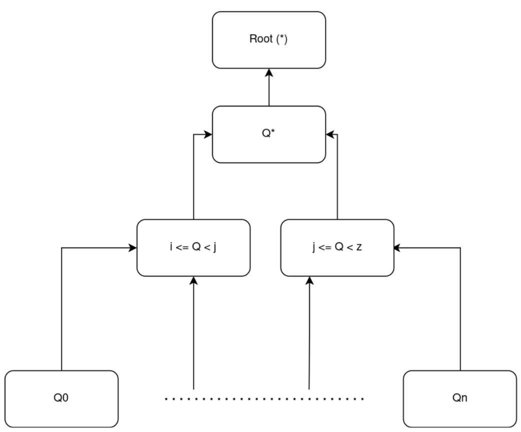

Figure 2: The generic scheme used as a generalization hierarchy in the system.

The i, j, and z shown in Figure 2 are calculated based on a value H that is derived from the value of K and the size of records present in the data set, whereas Q corresponds to the quasi-identifier value. H can be dynamically selected based on K or naively set to the value of K. The shown hierarchy in Figure 2 is constructed for each attribute, i.e., each part of the topological location.

3 RESULTS

The anonymization degree, which in this case is denoted by K, exerts influence on the information loss observed in the resulting data set. Figure 3 demonstrates the Normalized Certainty Penalty incurred when the algorithm is run on the test feeder data set with various K-values under two different heuristics for selecting H.

Figure 3 shows that when naively setting H to K, and as K grows in size, the penalty rises to approach 20% (blue plot). The penalty spikes to 100% once K reaches the size of the dataset, as there is no way of retaining information when K is equal to the total number of records. Only the substation information is maintained at this elbow point, and everything else ends up suppressed instead of generalized.

Note that there are recurring periodic dips up to the half-point when using this naive heuristic. These frequent dips are caused by the greedy algorithm finding and picking new, better partitions that result in less information loss. Such behavior indicates the existence of H values that produce optimal structure such that it minimizes information loss for the EGoT DERMS feeder topology.

Figure 3 also demonstrates the performance of a simple heuristic used to minimize the information loss for the used scheme and the generalization hierarchy used in this work (purple plot). This simple heuristic relies on finding such H in advance to pick the best H value for a given K. Finding H in advance requires one to empirically sample H values based on the results obtained by first naively setting H equal to K. The dependence on prior knowledge of the underlying is a significant limitation of the heuristic described here.

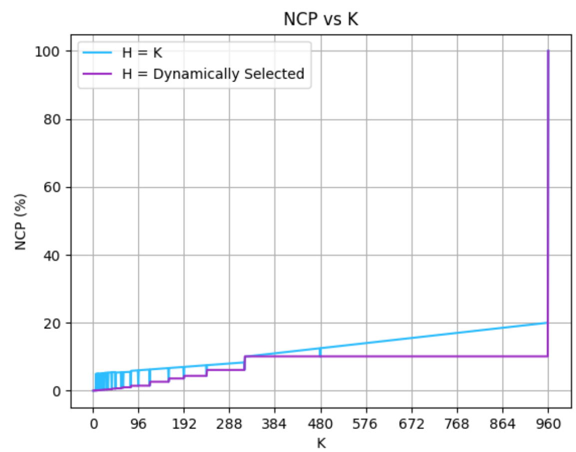

Figure 3: Plot of Normalized Certainty Penalty (NCP) against different K values using two different heuristics. Choosing H to equal K results in higher overall penalty incurrence than dynamically selecting H.

4 CONCLUSION

This work provides an approach to using the Mondrian algorithm in a Smart Grid implementation to preserve privacy. The generated generalization hierarchy for an EGoT DERMS topology affects the information loss. In this work, two different heuristics for generating the hierarchy were compared. Results suggest dynamically generation minimizes information loss.

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