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Distribution System Low-Voltage Circuit Topology Estimation using Smart Metering Data

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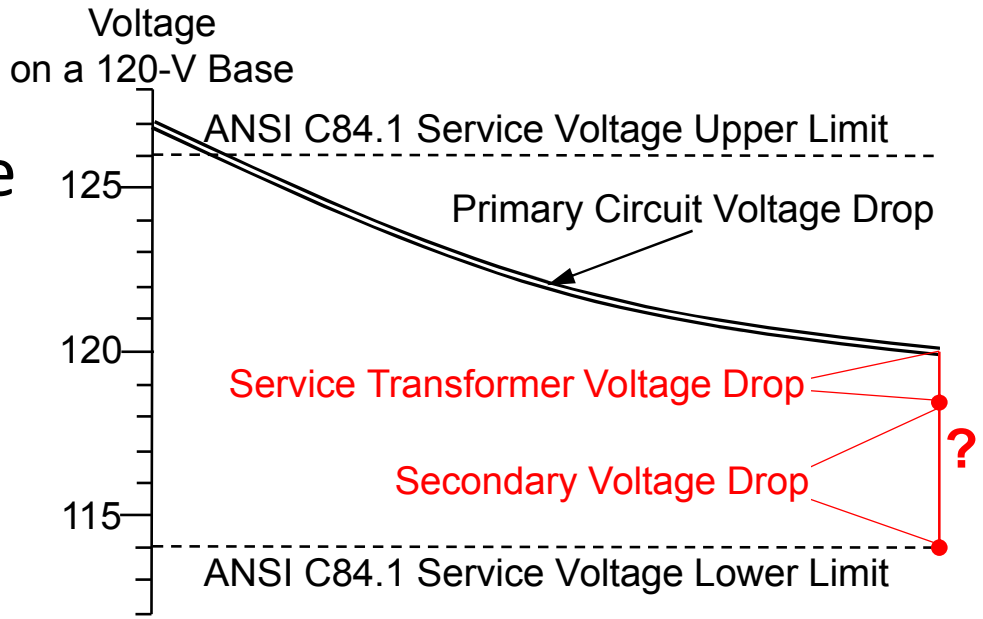
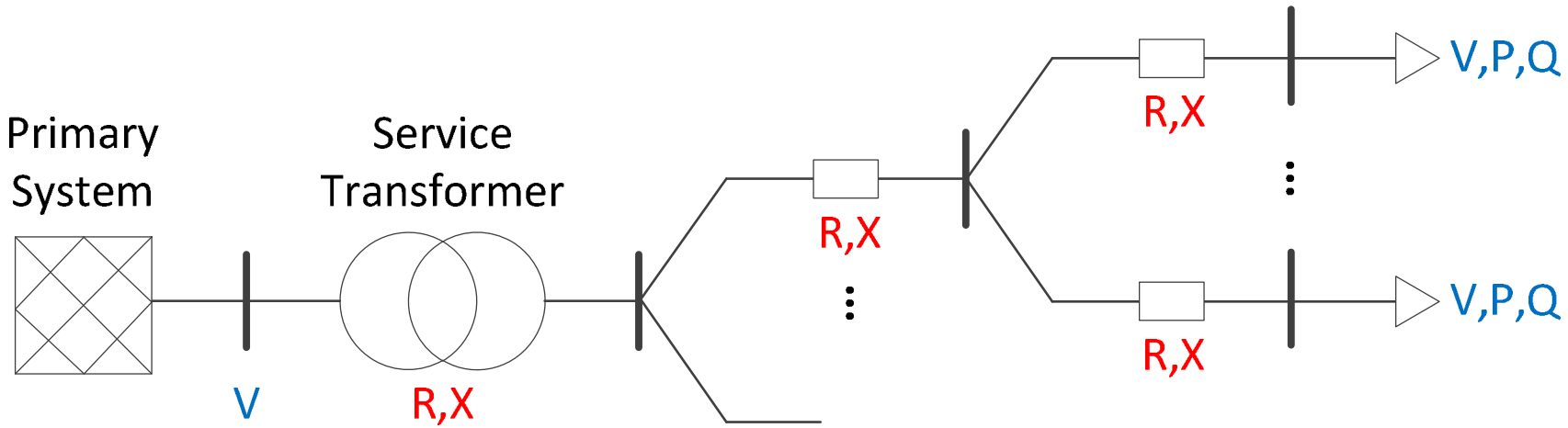
Need for Secondary Modeling

- Operating distribution systems with a growing number of distributed energy resources (DERs) requires accurate feeder models down to the point of interconnection
- Many DERs are located in the secondary low-voltage distribution circuits that typically are not modeled or modeled with low level of detail



The Objective

- Identify secondary circuit topology and series impedance parameters using the measurements from smart meters and DER



Infeasibility of Exhaustive Search

- It would be a computationally demanding task to evaluate all the possible topologies even with 5 to 7 meters
- This paper proposes a computationally efficient greedy-type joint topology and parameter estimation algorithm

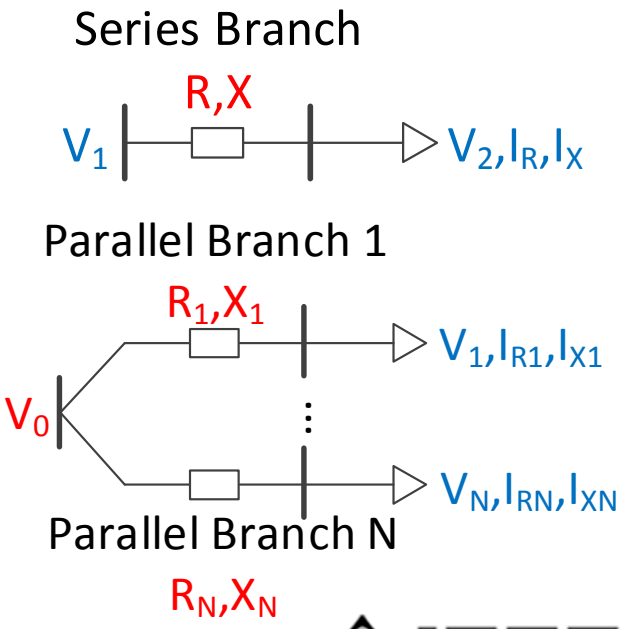
# Meters	1	2	3	4	5	6	7	8	9	10
# Topologies	1	3	22	262	4,336	91,984	2.38e6	72.8e6	2.57e9	1.03e11

Algorithm

- Based on linearized voltage drop approximation

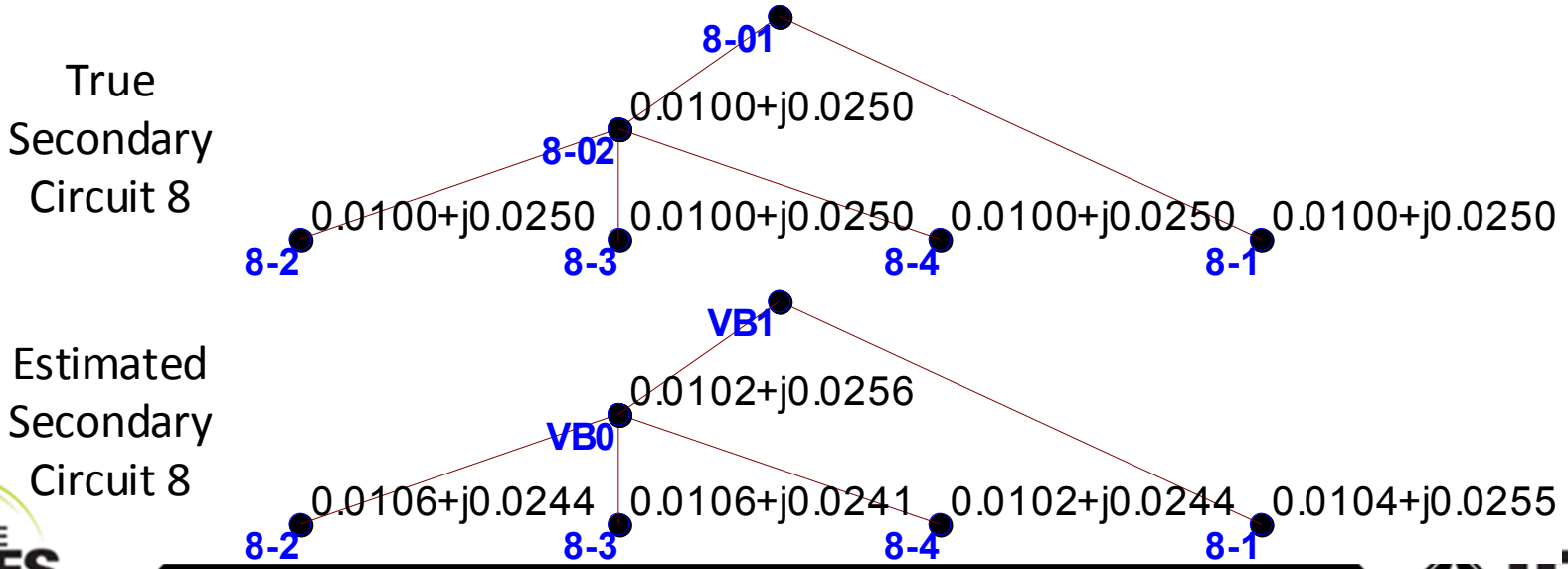
$$V_{drop} = V_1 - V_2 \approx (RP + XQ)/V_2 = RI_R + XI_X$$

- Build a linear regression models for each meter pair for the series and parallel circuit subsection types $\boldsymbol{y} = \boldsymbol{X\beta} + \boldsymbol{\epsilon}$
- At each iteration, select the meter pair and the circuit type with the best regression fit
- Stop with a circuit including all the meters



Results

- The paper shows results for the secondary circuits of a test circuit and of a Georgia Tech distribution feeder
- Practical challenges related to real measurement data are discussed



Summary

- The proposed algorithm does not require modifying any existing information systems
- The algorithm is executed within seconds for each secondary circuit even when thousands of measurement samples are used to counteract the accuracy, granularity, and time synchronization issues related to AMI and DER measurements