Synthetic Training of a Machine Learning Approach for Routing in PLC Networks

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Abstract

Power Line Communications (PLC) have shown to perform well in a variety of experimental applications, such as coexistence in a hybrid-infrastructure for sensing networks [1], fault detection in the smart grid [2] and front-hauling for Radio Access Networks [3],[4]. In this paper, we consider a PLC broadcast network consisting of multiple end-nodes and a data concentrator, alike the architecture of a power distribution and metering network as presented in [5] and shown in Fig. 1. The end-nodes share the resources of the network through a TDMA protocol.

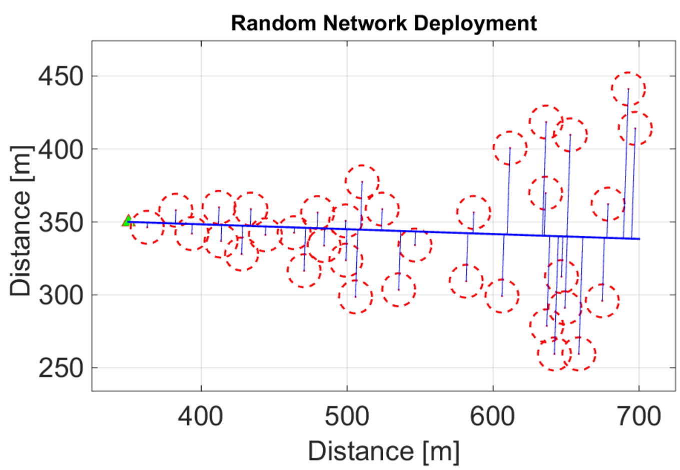

Fig. 1: Example of network topology realization.

To grant full coverage and reliable connectivity between end-nodes and the data concentrator, one or more nodes will act as routing devices (routers). Typically, optimal routing requires to identify a certain routing path for each given end-to-end link using a path metric based on the evaluation of capacity. This computationally intense task leads to the exchange of a great deal of overhead information and to delays, although the exhaustive bottom-up approach to solve this problem gives optimal results. To simplify such a task, we propose to use a limited number of routers whose position is fixed or infrequently changes. The position and number of the routers is determined from mostly topological information, namely the geometrical and physical properties of the power grid cables, the position and impedance behavior of the end-nodes and their density (which is typically available in LV/MV distribution grids) using a machine learning inspired inference approach.

The process here presented is endorsed by the observation that there is a certain level of determinism between link capacities and topology characteristics. Therefore, it is possible to infer from topology observations a globally good position for N routers in the network and the related routing paths for each end-to-end link, involving up to N+1 hops for each one of them. Specifically, the approach consists on first partitioning the links based on a constraint on minimum capacity and the achievable rate in a finite number of clusters, e.g., links that have a minimum required level of performance and links that do not have it: the latter group is the one of the nodes that require routing. Then, for the subset of end-nodes that require routing, we correlate the number and position of routers to distance, type of topology and load density. Finally, we infer the globally good routers position and required routing path based only on few topological information and distance between the end-node and the data concentrator. To train the overall algorithm, we use a synthetic data set obtained from the network simulator WACE ([6], [7]).

A comparison between optimal routing and the proposed machine learning routing approach is then made using a different data set. It is shown that the proposed approach can greatly improve performance w.r.t. no routing and it requires a significantly lower computational effort than optimal routing. In the final paper, several results will be reported to document such conclusions.

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