CRE2 : a CP application for reconfiguring a power distribution network for power losses reduction ⋆

Juan Francisco Díaz[2], Gustavo Gutierrez[1], Carlos Alberto Olarte[1], and Camilo Rueda[1]

[1] Pontificia Universidad Javeriana, Cali, Colombia,
`{crueda,caolarteggutierrez}@atlas.puj.edu.co`
[2] Universidad del Valle, Cali, Colombia
`jdiaz@univalle.edu.co`

CRE2 is a CP application written in *MOzArt* (www.mozart-oz.org) for reconfiguring power distribution networks for power losses reduction. This includes two distinct interacting processes: load flow computation and selecting switches to open or close. Load flow is computed for each *radial* network obtained from switching operations. We developed a real intervals constraint system (XRI) and integrated it to *MOzArt* . *CRE2* uses XRI for load flow and the *MOzArt* finite domain constraint system for switch state changes.

An electric distribution network consists of four main components: (1) Power Transformers, that supply the energy to the system; (2) Feeders, that are nodes attached to the power transformers; (3) Internal nodes, some with (active (P) and reactive (Q)) customer loads; (4) Branches, connecting feeders and nodes in the network, each having a resistance (R), a reactance (X) and (optionally) a Switch.

The *load flow problem* consists of finding values for the current in each branch (I), the voltage (V) in each node, load currents in nodes (I_q) having customer loads and, with these, compute active and reactive losses (L_p, L_q). Input data includes impedance ($Z = R + iX$) and active and reactive loads (P, Q). Values found must satisfy fundamental electrical laws:the Ohm law equations on each branch (relating node voltages, current in branches, and resistance and reactance), Kirchoff laws (relating input and output currents in nodes) and an equation relating load current $w.r.t$ P, Q and node voltage.

On the other hand, the target configuration (network topology) must satisfy the following additional constraints: (1) Node voltage cannot drop below a fixed limit; (2) Current in branches cannot exceed a given limit; (3) The number of branches supplying current into a given node must be equal to one (Radiality); (4) Current must flow to all nodes in the new configuration(Service Continuity); (5) The number of switches that can be changed is limited; (6) Power losses in the reconfigured network must be a given percentage lower than in the original network.

A user interacts with *CRE2* via a graphic interface. It contains a power distribution network editor offering widgets to represent electrical components. Properties of each component can be entered (and visualized) by clicking on it. Edited networks can be saved or processed launching load flow or reconfiguration tasks by choosing appropriate options in a menu. Large networks can be defined in an XML file and then loaded into the GUI.

Our model has been tested successfully in canonical reconfiguration problems of networks up to 60 nodes. While our approach is arguably less efficient than some existing approximation schemes, we think using CP provides definite advantages: (1) all electrical and operational power system constraints are always satisfied, (2) provides a simpler computational model, directly related to fundamental electric laws of the system, (3) allows more flexible parameter control, such as maximum number of switching operations and (4) leaves more room to introduction of additional operational constraints or search control strategies.

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