The Maximum Transmission Switching Flow Problem
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Operation of Power Grids [2]

Challenges
- Shift towards renewable distributed energy production,
- Changing energy flow patterns,
- Independent power producers,
- Volatile power flows and flow directions,
- Operation of the power grid becomes more demanding.

Strategies to cope with the challenges
1. Extend the grid with additional transmission lines,
2. Install control units like circuit breakers (switches) to enhance grid utilization (our approach).

Problem Statement [2, 3]

Goal
- Maximize the throughput of the network.

Input
- Network \( N = (V, E, V_0, E_0, \text{cap}, b) \) representing power grid with buses, lines, generators \( s \in V_0 \), loads \( t \in V_0 \), capacities and susceptances,
- Set \( S \subseteq E \) of switched edges (circuit breakers),
- Braess’ Paradox meaning adding a line might increase the cost.

Models
- **MAXIMUM POWER FLOW (MPF)** assumes \( S = \emptyset \) and requires an electrically feasible flow obeying the conservation of flow, feasible thermal line limits, and voltage laws [2]. Latter is defined by
  \[ b(u, v) \cdot (\theta(u) - \theta(v) - \text{thmin}(v, r)) = f(u, v), \]
  \[ \theta_{\text{max}}(u) \leq \theta(u) \leq \theta_{\text{min}}(u), \]
  \[ \forall (u, v) \in E, \forall u \in V. \]
- **MAXIMUM TRANSMISSION SWITCHING FLOW (MTSF)** assumes \( S \subseteq E \) and requires an electrically feasible flow on \( N = (V, E, V_0, E_0, \text{cap}, b) \) with
  \[ b(u, v) \cdot (\theta(u) - \theta(v) - \text{thmin}(v, r)) = f(u, v), \]
  \[ |f(u, v)| \leq \text{cap}(u, v) \cdot z(u, v) \leq |f(u, v)| \leq \text{cap}(u, v) \cdot z(u, v), \]
  \[ \forall (u, v) \in E, \forall u \in V. \]

Find
- The lines to be switched and the voltage angles.

Future Work
- Can the DTP be computed in polynomial time?
- Is there a PTAS on cacti?
- What happens if we minimize the number of switches or fix a set of non-switchable edges?

Source-Sink-Network

On general networks the switching centrality \( c_{\text{OPT}}(x, t) \) is defined by
\[ c_{\text{OPT}}(x, t) = \sum_{i \in N} c_{\text{OPT}}(x, i, t), \]
where \( c_{\text{OPT}}(x, i, t) \) is the total number of DTP-paths from \( x \) to \( t \) that use line \( i \).

Simulations on General Networks

- Simulations on NESTA benchmark sets that are more realistic than the IEEE benchmark sets, e.g., with regards to thermal line limits.

Literature