Wide Area System Islanding Contingency Detecting and Warning Scheme with the Implementation of Synchrophasor Measurements

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The Principle: Islanding Detection using Decision Tree

Major Procedures:

1. System Islanding Detecting Strategy
   • Concept level, distinguish islanding & non-islanding

2. Dynamic Simulation
   • Create isolation randomly, then apply modified enumeration method for island region selection
   • Create also normal operation cases with different load conditions; other fault/contingency cases

3. Simulation Data Analysis
   • Decision tree & Severity Index (ISI)
The Principle: Islanding Detection using Decision Tree

Decision Tree Algorithm:

- A decision tree is a decision support tool that uses a tree-like graph or model of decisions and their possible consequences, including chance event outcomes, resource costs, and utility. (From WIKI)

- Program used: CART (Classification And Regression Trees)

- Input: State variables at different operating conditions

- Output: Analysis results: splitting points, variable importance and prediction success

- Three questions are expected to be answered:
  1. The functions of the tree: what the tree can solve;
  2. The critical PMU implementation locations;
  3. How many PMUs (locations) needed to form a highly accurate tree;
The Principle: Islanding Detection using Decision Tree

The flowchart of the islanding analysis strategy using DT.
The islanding analysis is part of the PMU measurements application study.

This project is sponsored by the Dominion Virginia Power & U.S. Department of Energy.

By the Year 2014, there will be 20 substations in the DVP system have PMUs implemented and all 500kV network in the DVP will be monitored under synchrophasors real-timely.
Islanding Analysis Approach in the DVP system

The Decision tree based analysis procedures:

Step 1: Determine regions with potential islanding risk in DVP system

| Region 1: Newtont station | Region 2: Einstein and Dirac station | Region 3: Franklin and Raphson station |

Step 2: Create geographical/system one-line diagrams at selected regions and set up cut-off locations for potential islanding criteria

| Newton | Geo/1-line | Einstein | Geo/1-line | Franklin | Geo/1-line |

Step 3: PSS\(e\) simulations on potential islanding cases with DVP load-shedding schemes applied

Step 4: Islanding contingency identification and ranking through Decision tree algorithm and severity index method based on simulation results
Islanding Analysis Approach in the DVP system

The detailed DT and ISI calculator functions

**INPUT**

- State Estimator Component
  - Input channel: Voltage and current phasor variables from PMUs and the estimator; update rate: 30 times per second.

- DT 1: Full DVP area
  - DT 1: Full DVP area decision tree
  - 1) Determines whether system is under islanding condition;
  - 2) If islands occur in the system, estimates its probable location (Newton, Einstein or Franklin).

- DT 2-4: vary locations
  - DT 2-4: Sub-system decision trees
  - 1) Estimate the islanding event is stable or not based on the database for further use;
  - 2) Estimate the probable islanded region (isolated GEN capacity).

- Islanding Severity Ranking Component
  - ISI computation program: using the analysis from DT 2-4, compute the islanding severity.

**OUTPUT**

- Output channel: Data 1-Islanding identification (1/0); Data 2-Islanding severity ranking (1-5); update rate: event driven.
## Decision tree specifics:

- **DT name DT1:** Full DVP
- **DT2:** Newton
- **DT3:** Einstein
- **DT4:** Franklin

### Total cases

<table>
<thead>
<tr>
<th>DT name</th>
<th>Islanding cases</th>
<th>Stable cases</th>
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### Channel #

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### Specific features

- **Location determination:**
  - Newton
  - Einstein
  - Franklin

### Min Generation involvement:

- **G1:** 1140MW
- **G2:** 980MW
- **G3:** 1020MW
- **G5:** 860MW
- **G6:** 813MW

### Max Generation involvement:

- **G1:** 1141.8MW
- **G2:** 1026.8MW

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## Result / Conclusion

### Decision tree prediction success rate:

<table>
<thead>
<tr>
<th>DT name</th>
<th>Covariance method</th>
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<tbody>
<tr>
<td></td>
<td>DT1: Full DVP</td>
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<tr>
<td></td>
<td>DT2: Newton</td>
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<tr>
<td></td>
<td>DT3: Einstein</td>
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<tr>
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<td>DT4: Franklin</td>
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<table>
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<th>Islanding identification</th>
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Result / Conclusion

The proposed islanding detection and strategy is

1. Online, real time updating with synchronized phasor measurements;

2. Accurate with high prediction success;

3. Updatable, the database is capable to increase and modify with historical events and simulation results;

4. Compatible with other application modules (i.e. state estimation, unbalanced current analysis).
References