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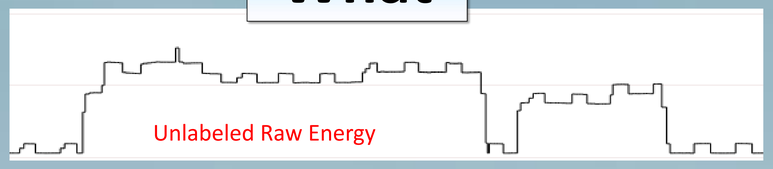
Graphical Closure Rules for Unsupervised Load Classification in NILM Systems

What



Energy Disaggregation can help save money and resources through load labeling. Whereas supervised methods require a bevy of widely characteristic data to learn from, unsupervised approaches are given more freedom to explore a domain that lacks significantly representative training data.

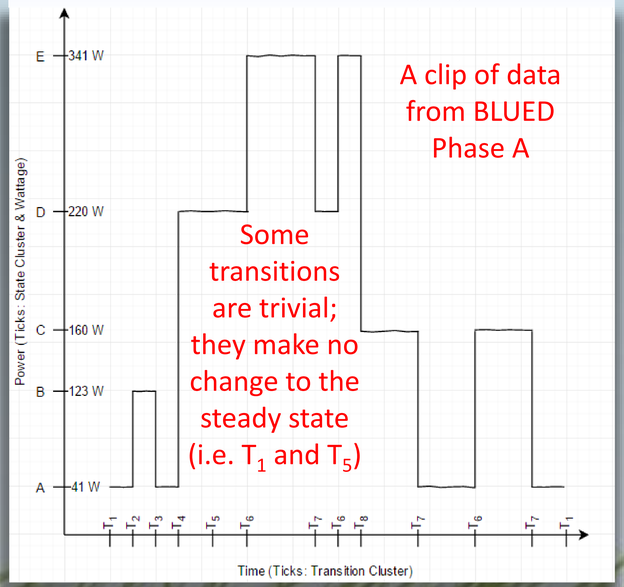
How

1) Cluster the raw energy data, using a fixed-radius nearest neighbor process (for a BLUED phase A dataset, we used 48W).
2) Construct a graph; steady states of power are vertices and transitions between states are edges; this defines many STEC (start-transition-end-count) edges, with dimensionless weights that characterize the reliability of each edge.
3) Perform cycle detection, which defines closure rules using the transitions of each cycle. Each rule is given a weight which defines its reliability/strength.
4) Simplify closure rules to eliminate redundant cycles and reduce longer rules into smaller rules to reveal rules of two transitions (one on, one off). These basic rules indicate loads, which can then be used to define combination transitions in longer rules.
5) Map loads to steady states with a simple map traversal technique, spanning from a minimum-power reference node.

Results

#Non Trivial Events	904
#Steady State Clusters	35
#Transition Clusters	49
#Unique STEC Edges	155
#Unique Cycles	27
#Loads	5
%Solved Non-Trivial Transitions	98.4%
%Solved Sum Abs Transition Power	94.2%

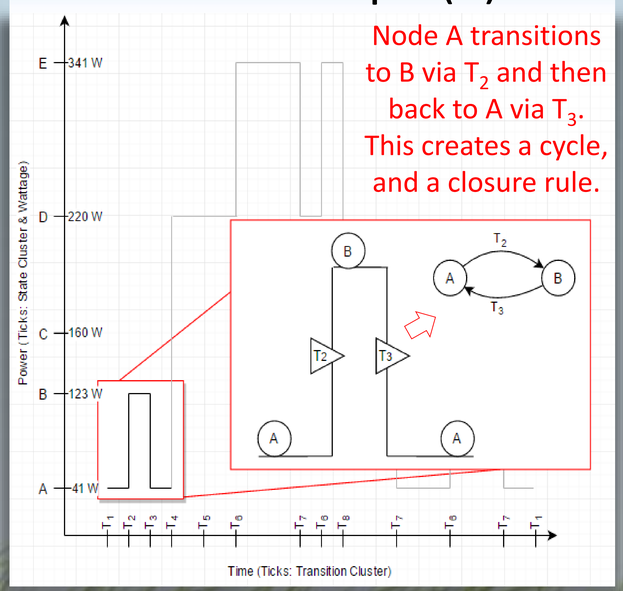
Initial Data (1)



A clip of data from BLUED Phase A

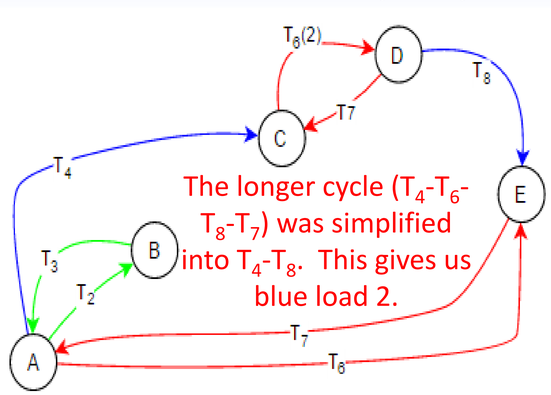
Some transitions are trivial; they make no change to the steady state (i.e. T_1 and T_5)

Build a Graph (2)



Node A transitions to B via T_2 and then back to A via T_3. This creates a cycle, and a closure rule.

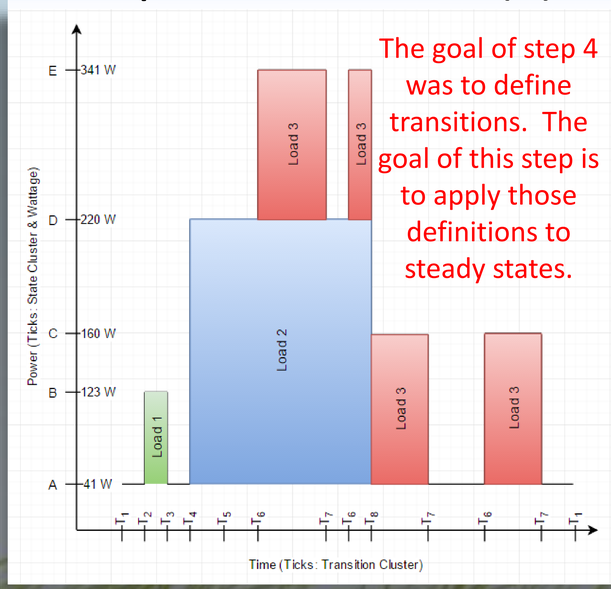
Closure Rules (3,4)



The longer cycle (T_4-T_6-T_8-T_7) was simplified into T_4-T_8. This gives us blue load 2.

Cycles:	Closure Rules:	Simplified Closure Rules:	Loads:
AB	T_2-T_3	T_2-T_3	L_1
CD	T_6-T_7	T_6-T_7	L_2
AE	T_6-T_7		
ACD	T_4-T_6-T_8-T_7	T_4-T_8	L_3

Map Loads to Data (5)



The goal of step 4 was to define transitions. The goal of this step is to apply those definitions to steady states.

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