CS 524: Project Proposal

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July 2019

1 Proposal: Smart Grid Energy Distribution

1.1 Problem Statement

Bryan, Saniya, and Tina are living with the Avengers in the new, progressive town called Kakariko Village. The town uses a smart grid to distribute its energy among its residents, as well as an optional connection to the main grid. The town has producers, via two wind turbines α, β, and three household solar panels owned by the Luu, Khullar, and Cho households. There is also a transformer γ that is connected to the main grid.

Each household has a demand for a given day given by Table 1. Each producer produces energy for a given day as seen in Table 2. The challenge is to meet the demand of every household for each day while minimizing usage of the grid.

Power is distributed via transmission cables as shown in Figure 1. Power lost along the cables is proportional to the distance, so that the power delivered to node j from node i is equal to: $P(x_{ij}) = (1 - 0.0005d_{ij})x_{ij}$, where d_{ij} is the length (in m) of the transmission line from i to j, and x_{ij} is the power being sent across the line originally. Note that this is an approximation only, not a reliable nor accurate model of transmission line power loss.

Node\Day	W	Th	Fr
Stark (S)	40.8	100	50.5
Parker (P)	28.8	30.3	28.8
Khullar (K)	27.3	27.3	27.3
Luu (L)	30.1	28.8	27.3
Cho (C)	30.0	25.5	31.2
Banner (B)	30.1	31.5	30.1
Odinson (O)	13.7	8.3	16.4
Maximoff (M)	27.3	21.9	24.6
Rogers (R)	19.2	20.5	20.5

Table 1: Energy Demand for each household per day (in kWh)

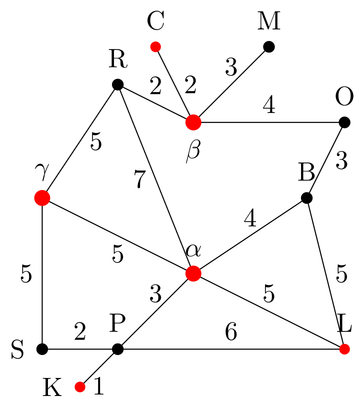

Figure 1: Network of Kakariko Village. Small nodes represent households, and large nodes represent generators. Red nodes are producer nodes, where α, β are wind-turbines, γ is a transformer connected with the main-grid, and red household nodes producing via solar. The transmission lines and their respective distances (in 100's of m) are shown.

Node\Day	W	Th	Fr
α turbine	1,500	300	7,000
β turbine	2,500	200	5,000
Luu solar-panel	1,500	2,000	1,500
Khullar solar-panel	2,000	1,500	1,000
Cho solar-panel	1,500	2,300	1,800

Table 2: Energy Production for each producer per day (in kWh)

1.2 Model Approach

We will approach this as a hybrid MCNF and Scheduling problem. First we will ignore the main-grid γ generator node and solve the simpler grid problem. We will effectively solve an MCNF problem that is indexed over days. We will need a variable $x_{ij,t}$ that indexes over edges $(i,j) \in E$ and days $t \in T = \{W, Th, Fr\}$. The set of (un-directed) edges involved are listed below:

$$E = \{(K,P),(S,P),(P,L),(P,\alpha),(\alpha,B),(\alpha,L),(\alpha,R),(L,B),(B,O),(O,\beta),(\beta,R),(\beta,C),(\beta,M)\}$$

Note that the full set includes both directions. The set of nodes are:

$$N = \{S,K,P,\alpha,L,B,O,\beta,C,M,R\}$$

and the set $N_P = \{\alpha,\beta,L,K,C\}$ are the set of producers, while the set $N_C = \{S,K,P,L,B,O,C,M,R\}$ is the set of consumers.

The main decision variable we have is the energy $x_{ij,t}$ being routed along path $i \to j$ during day t. The constraints are:

$$\sum_i P(x_{ij,t}) + p_{j,t} = \sum_k x_{jk,t} + c_{j,t} \qquad \text{Energy Balance for node } j$$

where $p_{j,t}$ is the energy produced by node j on day t, and $c_{j,t}$ is the energy consumed by node j on day t.

The objective function is to minimize the amount of energy lost through the transmission, so we effectively need to minimize the cost:

$$\min \sum_{(i,j)\in E, t\in T} 0.0005 d_{ij} x_{ij,t}$$