Disaster Resilience in Smart Cities

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Introduction

- As the name suggests, smart cities are cities that are smart
- There will be a high density of network connections in smart cities

Disaster Resilience in Smart Cities

- Depending on the size of the smart cities, when a disaster strikes, it is more likely to strike the entire city if the smart city is too small
- Unlike national or global networks, in smart cities, the lengths of links are in range of a few kilometers.
- In other words, disasters in smart cities look like a scaled down version of a national disaster problem
- Even in that case, there may be a few places (or the outskirts) which are relatively safe from disasters where we want to keep the backup

What can be done ?

- We propose duplicates of nodes like core nodes, metro access nodes etc.
- We define a quantity called as redundancy which accounts for duplicate copies of nodes
- As we know, reliability comes with redundancy
- However, redundancy comes with a cost
- We want to have the given reliability of service with the minimum amount of redundancy possible

Inputs and Constraints

- The inputs to our system are latency of the links, reliability and memory storage
- The constraints include latency requirement, memory constraints and the required reliability
- We need to minimize the redundancy which includes the number of data centers and the bandwidths of the links
- We also have flow constraints which are akin to KCL with different conditions for the source and the destination node

Problem Statement

Minimize the redundancy so that we have a certain quality of service given the constraints in each types of nodes like core nodes

Equations

- $\min \sum_i (a_i + \beta \omega_{ki})$
- $s.t. \sum_i l_{ki} \leq L_i$
- $0 \leq m_i \leq M_i$
- $r_i \geq 0.99999$
- Here, a_i is an indicator function which is 1 if the CO is active,
- β is a weight parameter, is the bandwidth of node i, l_{ki} is the latency of individual link and other factors in the path from data center to node i, is the latency tolerance for node i, m_i is the memory storage in node i, M_i is the maximum storage in node i, r_i is the reliability of node i.

Flow Constraints

- $\sum_{k \in A_i} (x_{k,i,c} - x_{i,k,c}) = \begin{cases} v_c \ \ if\ i = d_c \\ -v_c \ if\ i = s_c \\ 0\ otherwise \end{cases}$
- $\sum_c x_{i,k,c} \leq F_{i,k}\ \forall\ (l, k)$
- $x_{i,k,c}\ \ and\ F_{i,k} \in \mathbb{Z}_{\geq 0}$

Network Example