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2020 ITU AI/ML in 5G Challenge
China Region
Network Topology Optimization

China Mobile Research Institute

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Background

Since the development of 4G network technology, internet technology has achieved new breakthroughs. With various network services gradually impacting people’ s lives, more and more requirements have been put forward for the capacity guarantee of network links in the 5G technology.

However, market-growth brings forth the contradiction between the demand for equipment scaling to meet the increasing traffic and imbalanced and non-optimal capacity utilization.

The lack of consideration for the future growth trend of the traffic in the current network topology during the planning stage, leads to the imbalance in the utilization rate of the link capacity.

Therefore, we need to optimize the existing network topology structure, that is, to realize the global refined topology optimization of the network, and increase the capacity utilization efficiency through reorganizing the connection between the nodes of the link with imbalanced load.

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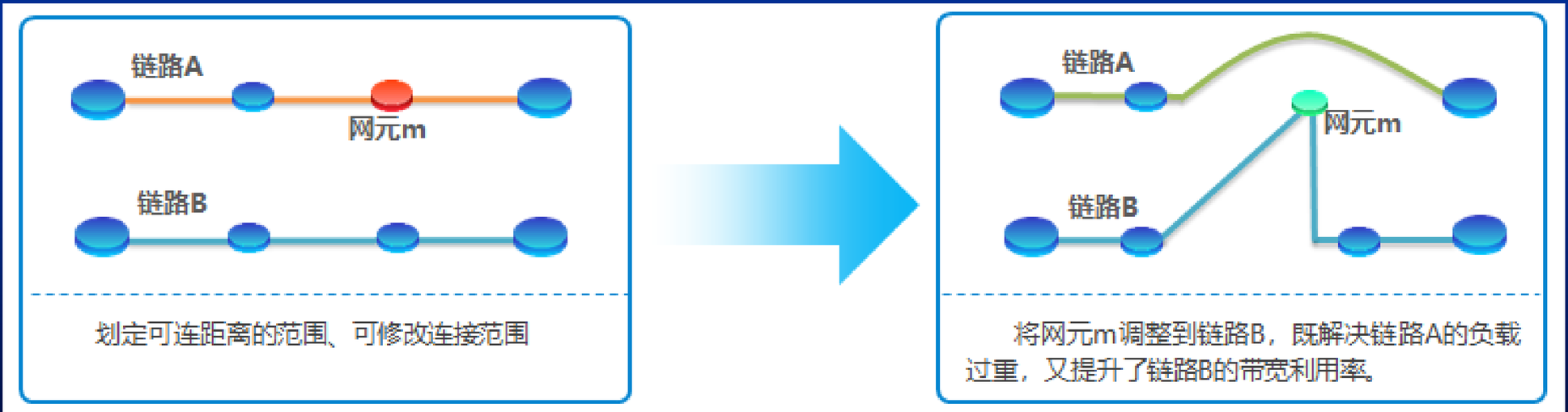
Problem Statement

Our goal is to dynamically optimize the network topology according to the node traffic and the current network topology for load balancing. This includes optimization of the topology through deleting some network connections and adding new network connections on a need basis. Thus the optimized topology achieves balanced load while meeting the future traffic changes in the existing network topology.



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Data

- The network topology connection and network element (NE) attributes data of three cities (A, B, C) are provided.
- The existing topology of each city was assumed to be unchanged, so each city has a copy of network topology connection data. Node A and node B are on the same line, indicating they are connected in the existing topology. In addition, there are also some attribute values of NE A and B, as well as the corresponding capacity value (A-value) of the connection.
- The NE attribute data contains hourly NE node traffic data (fx_val0-fx_val23) from March 1 to March 20, and the basic attributes such as the type of the NE, the capacity value (A-value) of the NE, the longitude and latitude.

网元连接关系样例数据如下:

NodeID_A	longitude_A	latitude_A	type_A	NodeID_B	longitude_B	latitude_B	type_B	A	NE
39848747	132.266962	388.658861	H	29357488	132.252856	388.645792	G	1	129771721
1590772	132.0867178	388.5658228	H	1589765	131.98258	388.52944	H	1	187732484
1590772	132.0867178	388.5658228	H	29357488	132.252856	388.645792	G	1	129771721
60429296	缺失值	缺失值	J	1589609	132.252856	388.645792	G	10	162240856
60429296	缺失值	缺失值	J	1590587	132.252856	388.645792	G	10	162240857
60509138	缺失值	缺失值	J	60429296	缺失值	缺失值	J	1	162434193

网元属性样例数据如下：

NodeID	type	A	longitude	latitude	D	fx_val0 (后23列数据与此列类似,不全列出)
1590587	G	1	127.1422373	387.67183507	0	2488.51
1847191	J	1	127.1396658	387.67420274	0	4.56
43365083	J	1	127.1469591	387.67889268	0	0.04
78665085	J	1	127.1373822	387.66159354	0	缺失值

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Data

- The optimization result data of the network topology connection structure of the three cities (ABC) in the next 10 days, that is, from March 21 to March 30, would be submitted in the format of CSV encoded in gbk (a CSV file for each city per day). The result file of topology optimization should be named as ‘Graph_topology_A/B/C_20200321/20200330.csv’ .
- The Circle ID refers to the link number. This link includes the host link, the auxiliary link and the hanging link.
- NodeID_A and NodeID_Z are similar to the previous topology, that is, A and Z are connected here, but they are distinct. For example, Z is hung on A, so A is written at the front and Z is written at the back, because the relationship of hanging between them determines their A-values.
- For Link class, there may be the host link or the auxiliary link in a link, so encoding is needed,1 for the node of the host link, 2 for that of the auxiliary one and 3 for that of the hanging link.

优化后网元拓扑连接关系样例数据如下：

ID	Circle_ID	NodeID_A	NodeID_Z	NE	Link_class
1	1	15286460	17796422	176704142	2
2	1	45093217	53588738	151339239	1
3	2	1589609	1847191	1	3
…	…	…	…	…	…

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Requirements

Hard conditions:

1. The submitted results must include three cities, one csv file for each per day
2. The number of nodes in each city after optimization must be consistent with the number of nodes in the existing topology of each city.
3. The optimized graph should be fully connected. All nodes in the graph are included in the link.
4. The newly added connections after the optimization need to meet the establishment conditions, that is, less than or equal to 500 meters.
5. Each J node in the optimized graph only exists in one link. The nodes of G and H can appear repeatedly in multiple links, because they can be the beginning and end nodes of the links.
6. The number of nodes in a link should be between 3~30. The link should not be too short or too long.

Soft conditions:

1. The optimized auxiliary link and the hanging link structure should be as few as possible.

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Requirements

- The requirement for the hardware is 8-Core and 256G memory and no GPU.
- The optimization convergence time for the graph of 20,000 nodes should be less than 20 minutes, so hopefully your algorithm time complexity will not increase with the number of nodes, and a linear or multi-box time complexity will be preferred.

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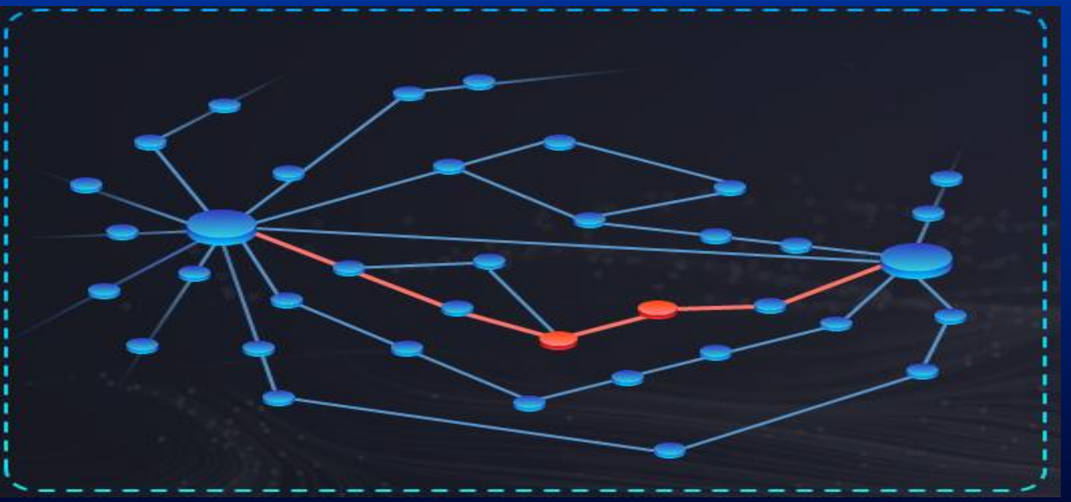
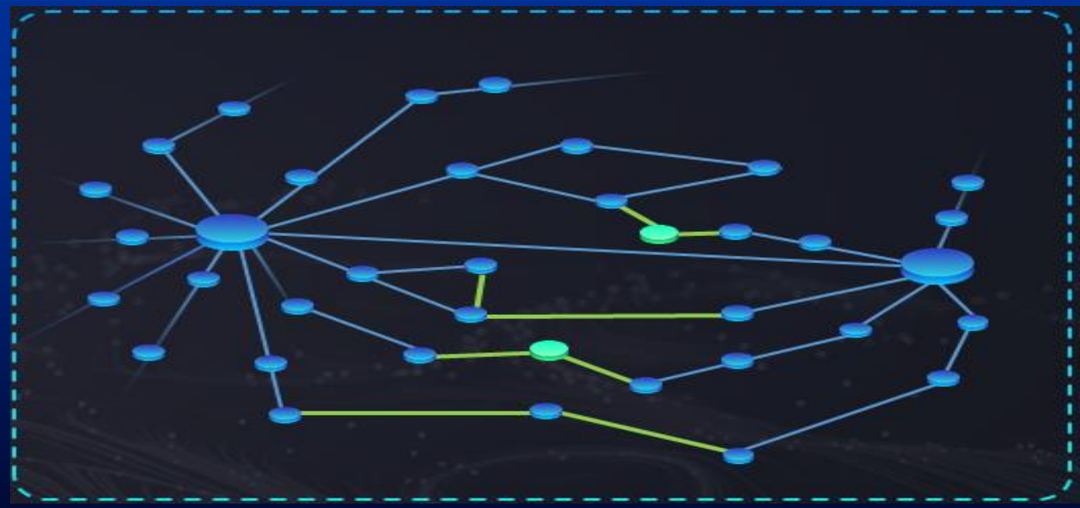
Methods

1. Generate a collection of existing links in each city based on the existing topology.
2. Conduct an hourly forecast for the traffic of each NE node in the subsequent 10 days in each city.
3. Optimize the daily topology structure of each city based on the result of the second-step traffic prediction and the existing topology of each city.

For the prediction method, consider LSTM and Prophet.

For the search method of the link collection, the methods of DFS and BFS are suggested.





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THANK YOU!