ENI ISG PoC Report: PoC#12 Intelligent Transport Network Optimization

1 General

Submission of this ENI ISG PoC Report as a contribution to the ENI ISG does not imply any endorsement by the ENI ISG of the contents of this report, or of any aspect of the PoC activity to which it refers.

2 ENI ISG PoC Report

2.1 PoC Project Completion Status

- Overall PoC Project Completion Status: ___Completed___

2.2 ENI PoC Project Participants

Specify PoC Team; indicate any changes from the ENI ISG PoC Proposal:

- PoC Project Name: Intelligent Transport Network Optimization
- Network Operator/Service Provider: China Mobile Research Institute

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2.3 Confirmation of PoC Event Occurrence

- PoC Demonstration Event Details: The PoC was showcased during ETSI ENI#17 online meeting in the week of March 8th-11th. The following photo is the screenshot of the PoC#12 demo.

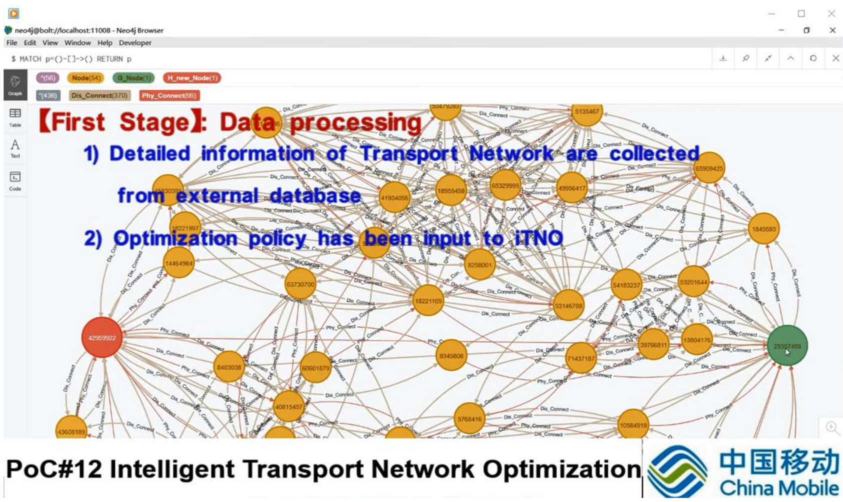

Figure 2-1: The PoC was shown in ENI #17 online meeting

2.4 PoC Goals Status Report

According to the proposal, these were the specific projects goals:
This PoC contributes to demonstrate the use case [#1-4: Intelligent Optimization for Transmission Network]. In particular, the proposed mechanisms are compliant with its triggering conditions, operational flow, and post-conditions, as defined in RGS/ENI 014 [1].

- **PoC Project Goal**: **Policy-based Transport Network Optimization**: Based on pre-determined optimization policy, demonstrate the use of AI/ML algorithms on the topology of transport network and detailed information of VNFs, the PoC platform shall be able to intelligent analyse and decide on a policy optimization scheme leading to a global optimum bandwidth utilization regarding the overall network capacity.

- Goal Status (Demonstrated/Met?) **Demonstrated**

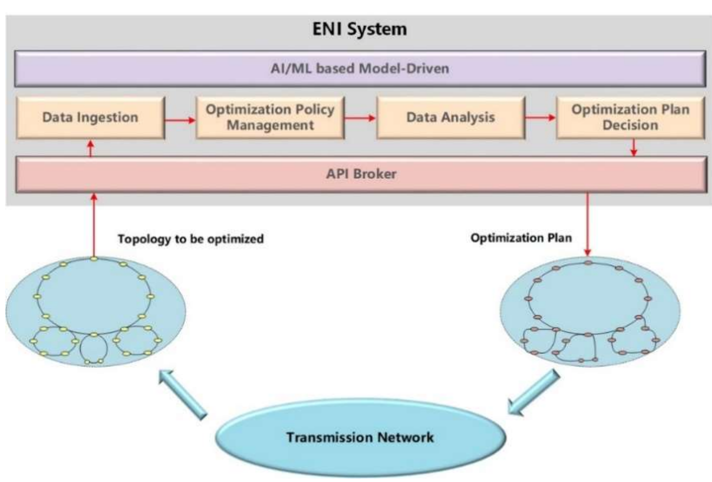

Figure 2-2 Scenario of this PoC

As shown in Fig.2-2, this PoC can be described in a scenario. This scenario is proposed to demonstrate the feasibility of transport network capacity optimization by applying AI/ML algorithms. The final system established to accomplish the intelligent is called iTNO.

The architecture of iTNO system is shown as Figure 2-3

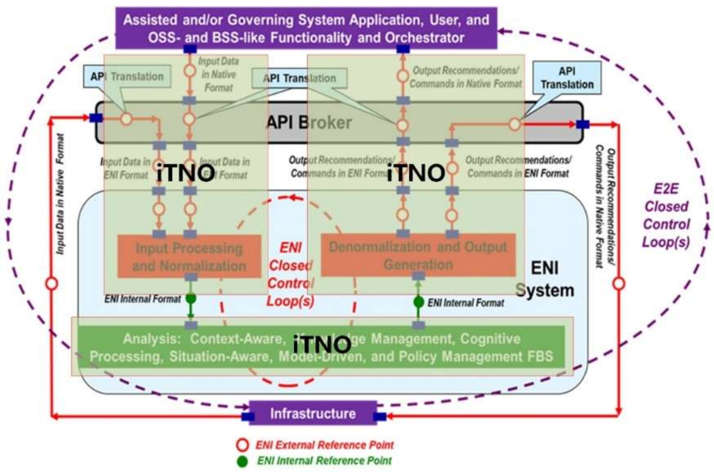

Figure 2-3 Architecture of iTNO System

iTNO system consists of following stages:

Stage-1: Data Processing

In this stage, the detailed information of transport network is collected. Moreover, parameters used for optimization will be also input to iTNO. These data are transformed into a common format based on normalisation algorithms and will be further processed by other FBs. This stage includes three steps.

- **Step-1: Data acquisition**

  In this step, iTNO obtains attribute data of VNFs among transmission rings (such as VNF type, VNF capacity, peak-hour capacity usage rate, etc) in each district/county unit

- **Step-2: Set Optimization Parameters**

  1) Set optimization restriction parameters: Considering the construction feasibility constraints, including the physical distance between VNF, construction cost and geological factors, in the optimization process, optimization restrictions, such as the maximum connection distance between VNFs, the maximum number of newly added connections between VNFs and whether two VNFs can be connected, are established. These restriction parameters are also input into iTNO.

  2) Set optimization objective parameters: Based on the capacity utilization rate of the current transmission ring and the actual running status, the optimization target parameter is determined. The detailed process involves following steps:

     a) Calculate the overall capacity usage rate η

     $$\eta = \frac{\sum_i^N \eta_i}{N}$$

     where η_i represents the capacity usage rate on each transmission ring, N represents the number of transmission rings in this district.

     $$\eta_i = \frac{Service\ load}{\sum_{m=1}^{m=n} A_m}$$

     where A_m represents the capacity of VNF, n represents the total number of VNFs among this transmission ring.

b) Based on the actual network running status and capacity usage rate calculated in above step, the optimization target parameter is established.

Global optimization objective function:

$$E = \sum_{j} (\eta_{P_j} - \varphi)^2$$

where φ is the target capacity utilization rate.

3) **Set iteration termination parameters**

Set the maximum number of iterations and the minimum change threshold of the objective function in each iteration

Stage-2：Data Analysis

In this stage, based on the network topology and pre-processed data, iTNO analyses the relation amongst capacity of transmission ring, topology of transmission ring and the capacity of VNF. Based on the global utilization rate of capacity, iTNO executes iterative optimization until meeting termination conditions. The analysis result is provided as the outputs of this stage.

- **Step-1：Generate topology**

The topology of transmission rings is generated based on Random Walk Algorithm, and it consists of following elements:

1) Node: each node represents a VNF, containing following attributes

a) VNF type: Access Layer Node, Convergent Layer Node or Backbone Layer Node.

b) VNF capacity

c) VNF peak-hour capacity usage rate

2) Connection: represents the connection relationship between VNFs.

According to the optimization restrictions, if the physical distance between two VNFs is out of the pre-determined scope, these two VNFs cannot be connected in optimization process.

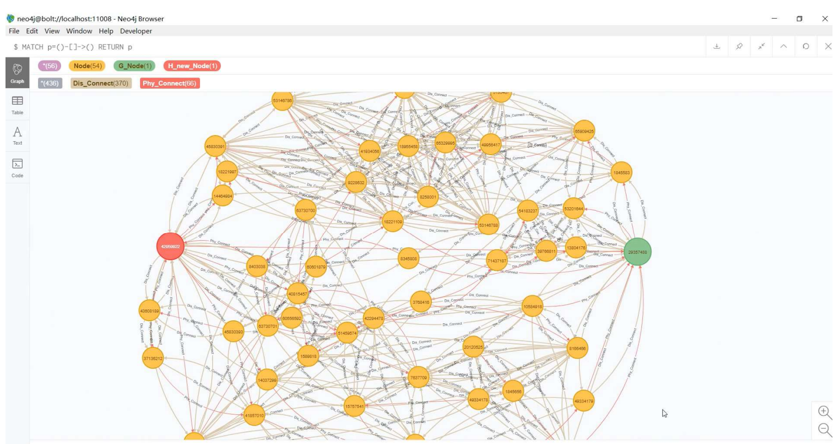

Figure 2-4 Topology Generation

- **Step-2：Iterative optimization**

Iteration process is based on GNN algorithm. In each iteration, according to the capacity usage rate and the connection restrictions between VNFs, iTNO adjusts the connections to form new transmission rings. When the iteration process meets the termination conditions, iterative optimization is finished.

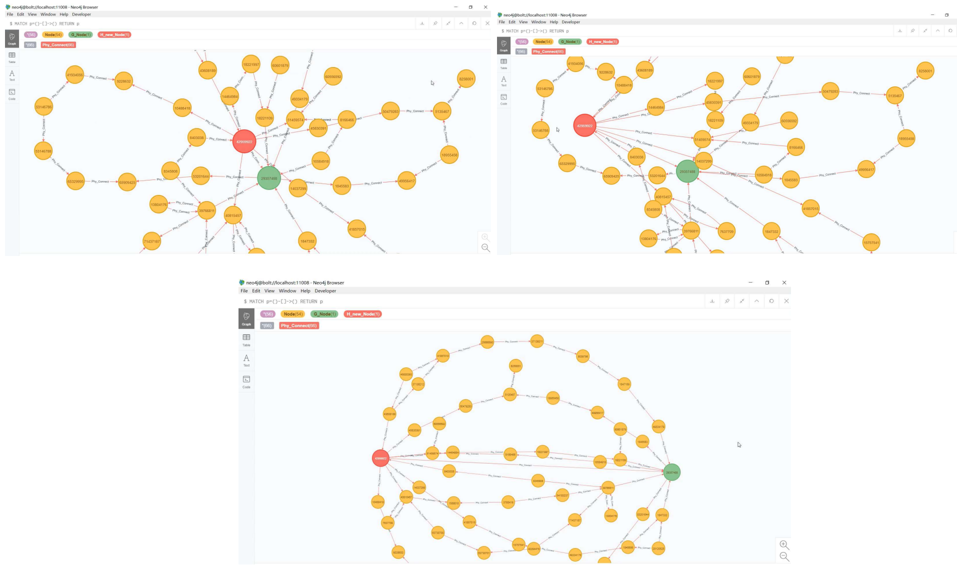

Figure 2-5 Iterative Optimization

Stage-3：Decision and Output

In this stage, according to analysis result of stage-2, iTNO decides the optimization plan. This plan will be used by the operator to optimize the transport network reaching globally optimum capacity utilization rate.

An example is shown in in Fig.2-6, the top figure shows the original topology of transport network, and the bottom one illustrates the optimized topology of transport network. Comparing these two topologies, the connections B-C, C-D, W-R and R-T have been changed into B-R, C-T, W-C, R-D, respectively.

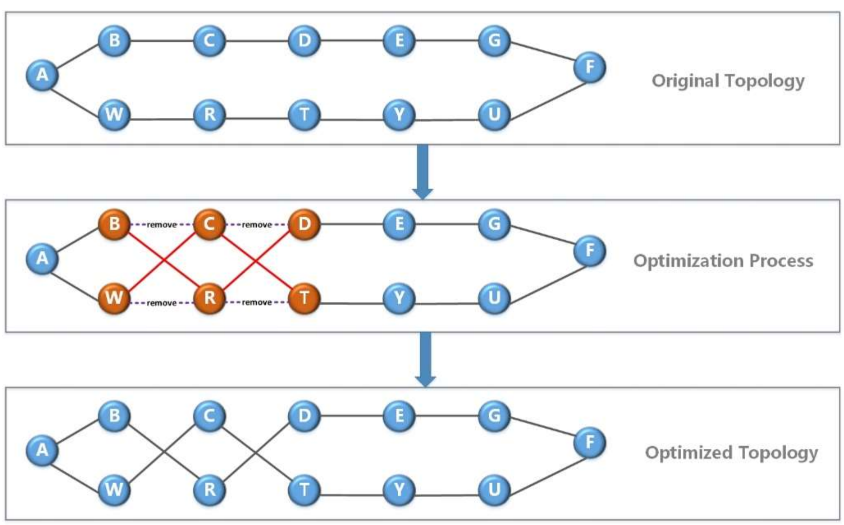

Figure 2-6 Optimization Process

iTNO system provides the following effects:

- The time taken to formulate the final optimization plan has been shortened from 48 hours to 2 hours with approximate 1000 nodes, saving 95% time-cost;
- The capacity expansion cost has been reduced from 50-million RMB per year to 40-million RMB per year by applying the intelligent optimization system, saving 20% investment-cost;
- The labor cost has decreased to 960 person-hour, saving 1500 person-hour compared to the traditional approach, saving 60% labor-cost.

Figure 2-7 Optimization Effect

2.5 PoC Feedback Received from Third Parties (Optional)

None

3 ENI PoC Technical Report (Optional)

3.1 General

PoC Teams are encouraged to provide technical details on the results of their PoC using the PoC Scenario Report template below.

3.2 PoC Contribution to ENI ISG

Table B.1

Contribution	WG	WI/Document Ref	Comments
ENI(20)000_082r1 CR_for_Adding_New_Use_Case_into_ENI-014_v3_0_6		ETSI RGS/ENI-014 (GS ENI 001)	This contribution adds a new use case "Intelligent Optimization for Transport network" into ENI-014

3.3 Gaps identified in ENI standardization

None.

3.4 PoC Suggested Action Items

None.

3.5 Additional messages to ENI

None.

3.6 Additional messages to Network Operators and Service Providers

None.

References

[1] RGS/ENI-014 (GS ENI 001), "Experiential Networked Intelligence (ENI); ENI use cases", v3.1.1

[2] RGS/ENI-015 (GS ENI 002), "Experiential Networked Intelligence (ENI); ENI requirements", v3.1.1.

[3] RGS/ENI-016 (GS ENI 005), "Experiential Networked Intelligence (ENI); System Architecture", v2.0.23.