ENI PoC #20: IP Network Congestion Prediction and Prevention Progress Update

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PoC Background and PoC member

Short Description： this PoC is meant to demonstrate the proposed network congestion prediction and prevention mechanisms based on Artificial Intelligence/Machine Learning (AI/ML) algorithms. In particular, these proposed mechanisms are aimed to control the data traffic entering the network, ensure that the communication subnet is not overwhelmed by the data flow sent by users, and make reasonable use of bottleneck resources.

Host/Team Leader:

Team members:

PoC Goals and Architecture

Main goals of this PoC : Show the feasibility and the benefits of network congestion control, especially before congestion occurs, and demonstrate in a testbed environment that how ENI system can support full closed-loop management of network congestion prediction and prevention.

Goal #1:

Demonstrate the use of ML algorithms to be able to predict network traffic for a period of time in the future, and anticipate the occurrence of network congestion. Determine whether to trigger congestion warning mechanism by combining traffic prediction and resource assessment results. If congestion warning is triggered, the automatic generation of congestion optimization strategy is completed.

Goal #2:

Deploy the system in an experimental IP backbone network to achieve a full closed-loop process from user demand intention analysis, traffic prediction, congestion control to user feedback, hoping to significantly improve the digital capabilities and operational efficiency of operators.

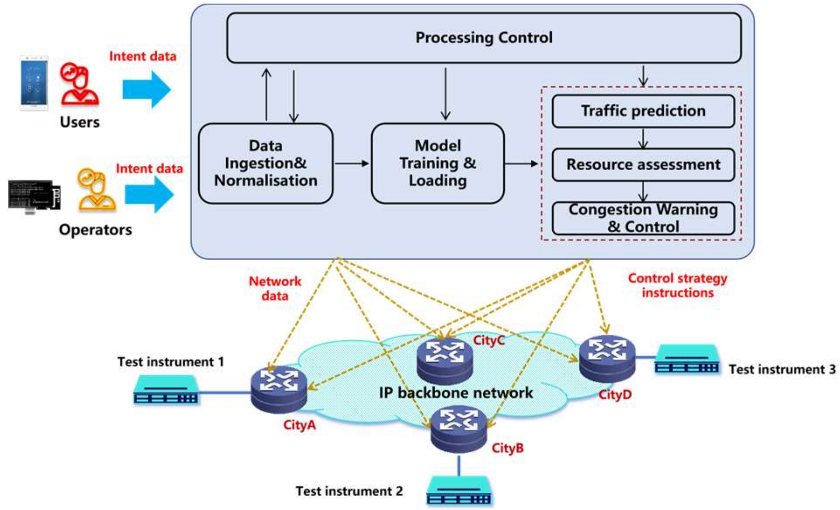

Figure 1 Scenario of this PoC

PoC Milestones and Current Status

PoC Milestone	Stages/Milestone description	Target Date	Additional Info
P.S	PoC project submission	04/2024	
P.TP.1	PoC user story finalization	06/2024	Finalization of the high-level description of the two scenarios described In Section 2.
P.TP.1	PoC Test Plan 1	09/2024	Initial algorithm testbed up and running
P.D1	PoC Demo 1	12/2024	Webinar demo at an ENI plenary meeting.
P.C1	PoC Expected Contribution 1	TBD	Contributions to ENI requirements.
P.C2	PoC Expected Contribution 2	TBD	Contributions to ENI reference architecture.
P.R	PoC Report	03/2025	PoC-Project-End Feedback
P.E	PoC Project End	04/2025	Presented to ISG ENI for information
NOTE: Milestones need to be entered in chronological order.			

Current

Show demo at ENI #31

Testbed setup and data collection

- The testbed network consists of 6 city nodes (CityA, CityB, CityC, CityD, CityE, CityF). Each node deploys an SDN router to achieve interconnection and interoperability at the IP backbone network forwarding plane. Among them, four nodes(A,B,C,D)are responsible for simulating business access and connecting with the test instruments. E&F nodes act as P nodes responsible for traffic forwarding. All 6 node network devices are included in the scope of controller management, and a multi constraint and multi path network topology is constructed.
- The control plane introduces the ENI system to achieve SDN based topology management, centralized control, routing scheduling, and network programmability.

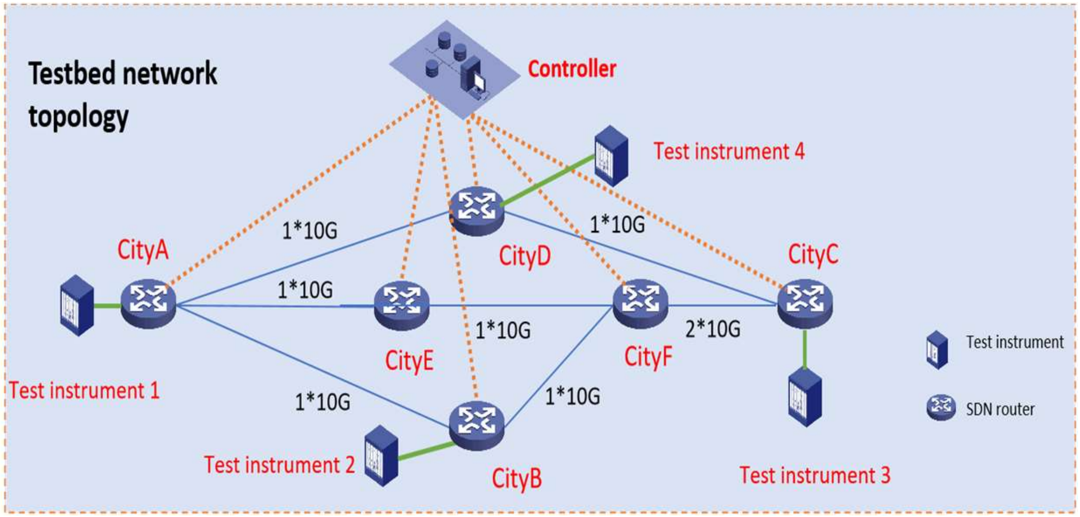

Figure 2 Networking scheme of testbed

Figure 3 Visualization of testbed network topology

Testbed setup and data collection

- Through the network traffic collection protocol, link traffic data is periodically collected and preprocessed for dimensionality reduction, noise reduction and deduplication before being stored in the database.
- The dynamic import cycle of traffic supports variable adjustment, introduces multi-source databases, supports long-term and short-term data storage:Long term storage takes a step size of 1 h as the minimum cycle granularity, and the data is stored in a long-term database; Short cycle storage is stored in short-term databases at a granularity of 10 s；
- It can support the data requirements of various application functions such as traffic prediction, achieve long-term and short-term traffic prediction, and meet the network planning requirements of different periods in the future.

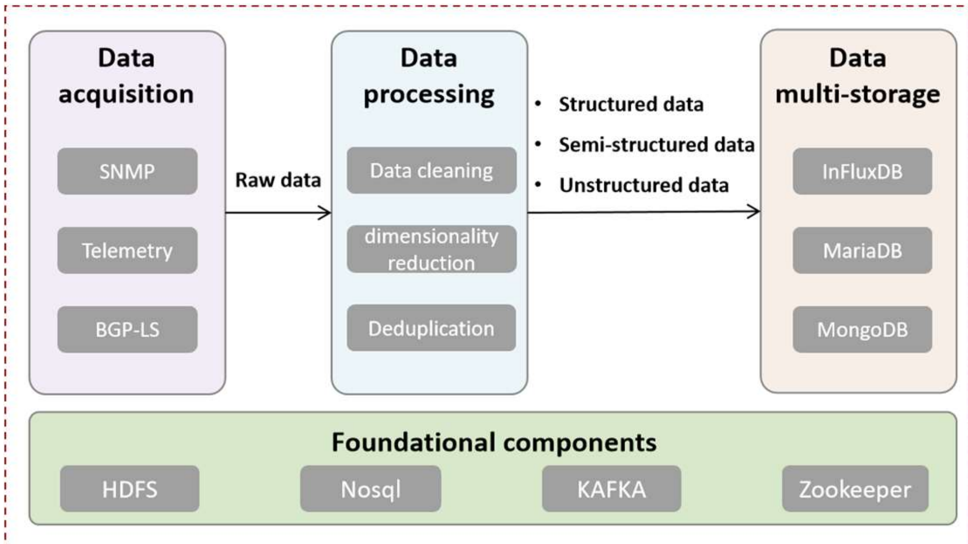

Figure 4 Framework of data collection and processing

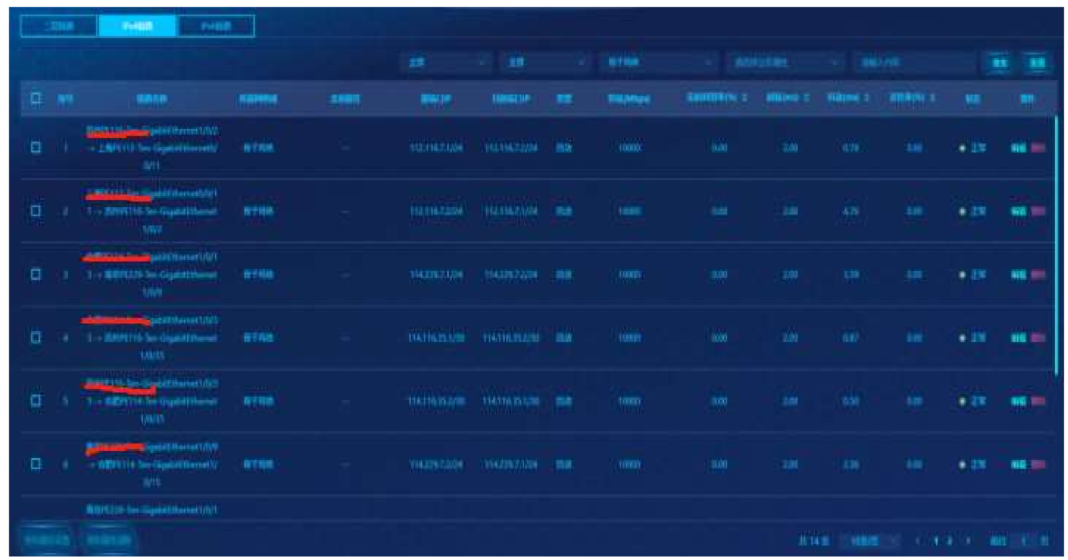

Figure 5 Data collection and processing visualization interface

Traffic prediction algorithm model

- In response to the nonlinear, dynamic, and uncertain data characteristics of traffic data in communication networks, technical breakthroughs and research experiments have been carried out from two directions: traffic prediction methods based on deep temporal dependencies and traffic prediction methods based on deep spatiotemporal dependencies.
- Currently achieved second and hour level traffic prediction.

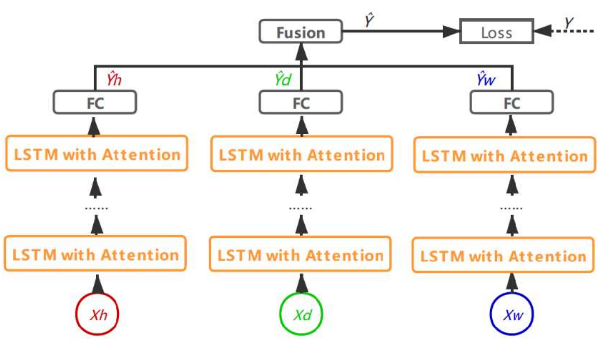

Figure 6 Deep temporal dependent traffic prediction based on LSTM

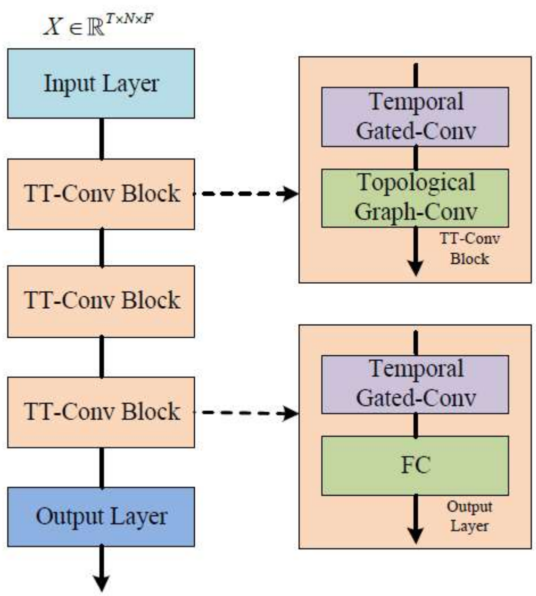

Figure 7 Deep spatiotemporal dependent traffic prediction based on GCN

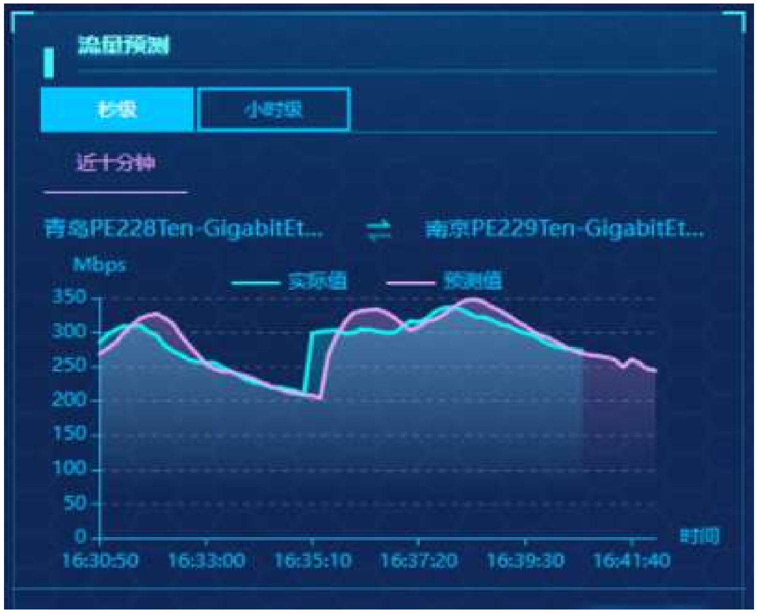

Figure 8 Second and hour level IP netwrok traffic prediction

PoC New Progress- Digital twin simulation and visualization interaction

- The system models the existing network data in multiple dimensions, completes the construction of basic and functional models in twin networks, and thus realizes the simulation and verification of intelligent routing calculation results in twin network elements or network topologies.
- By simulating traffic congestion scenarios, it was verified that intelligent routing algorithms based on more than 10 combinations of congestion control can achieve route optimization before congestion occurs, and the time from congestion prediction to path switching is less than 1 minute.
- Provide visual interactive services to users.

Figure 9 Digital twin simulation function interface

Figure 10 Visual interactive interface

PoC New Progress- System Demo

- **The demo demonstrated the set of automatic closed-loop management capabilities from user demand intent analysis, IP congestion prediction, congestion control to user feedback。**

This POC demo will be released and showcased at the technical seminar jointly organized by the CCSA T610 SDN/NFV/AI Standards and Industry Promotion Committee and ETSI .

Thanks!