Data science for smarter optical networks and Wi-Fi

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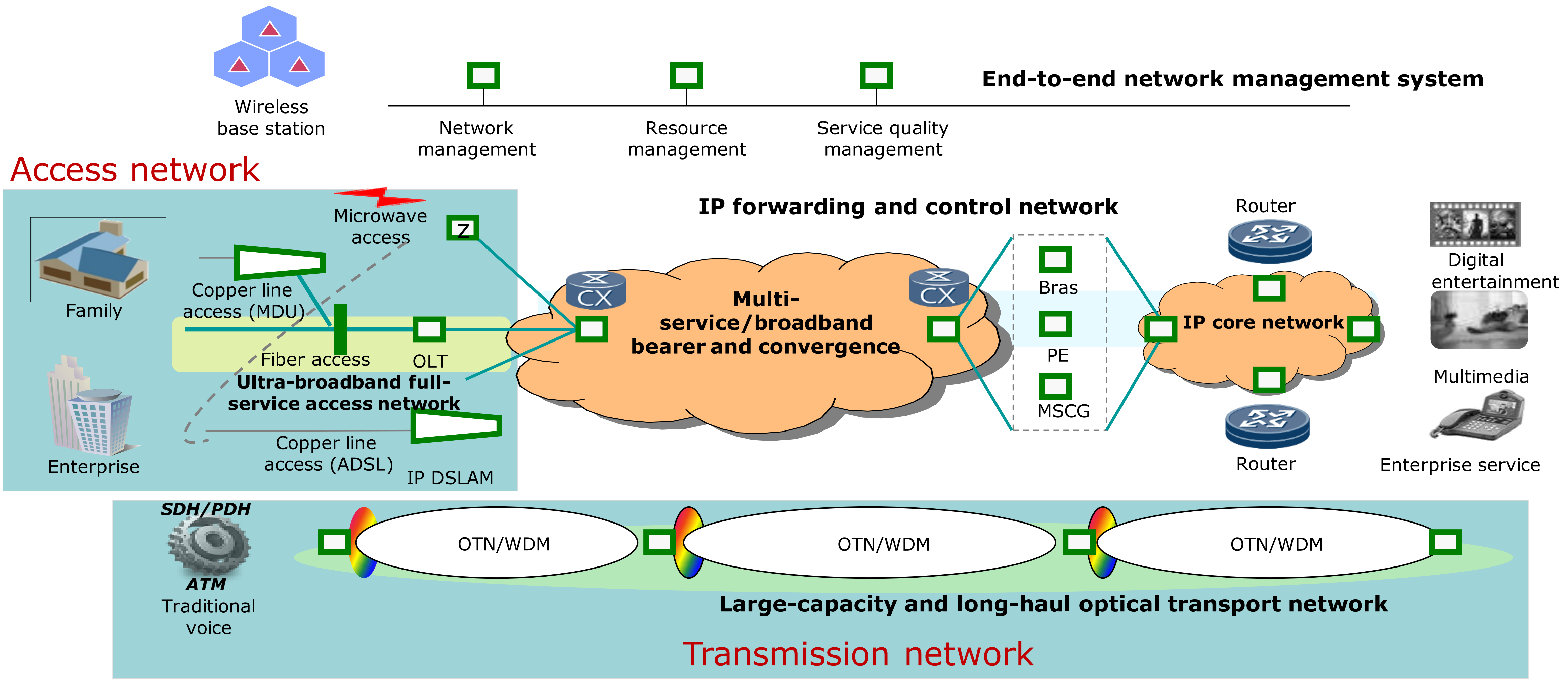
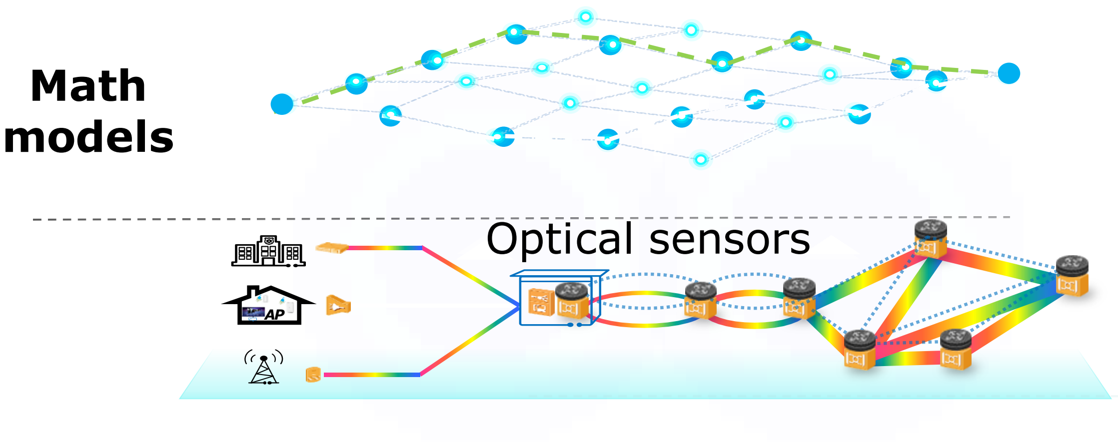
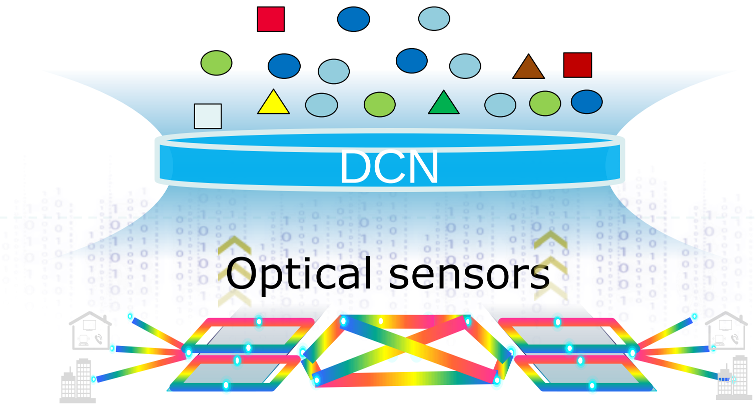
Transmission and Access Networks

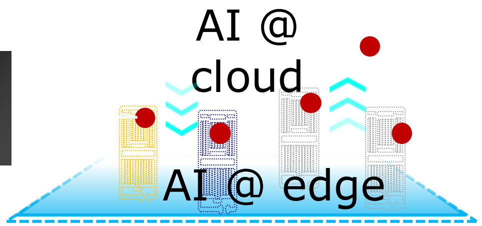


Data and computational resources





Edge intelligence – real-time
Huawei's Ascend 310 AI chips based acceleration boards: 10+ times of computing power



Cloud intelligence
Huawei's Ascend 910, a single AI chip with the highest computing density

Case 1: Forecasting critical damage of optical fiber

Various abnormalities causing frequent fiber damages





Fiber cuts cause losses to users and carriers.

Losses (per hour) caused by faults to users

Gartner

$ 42,000

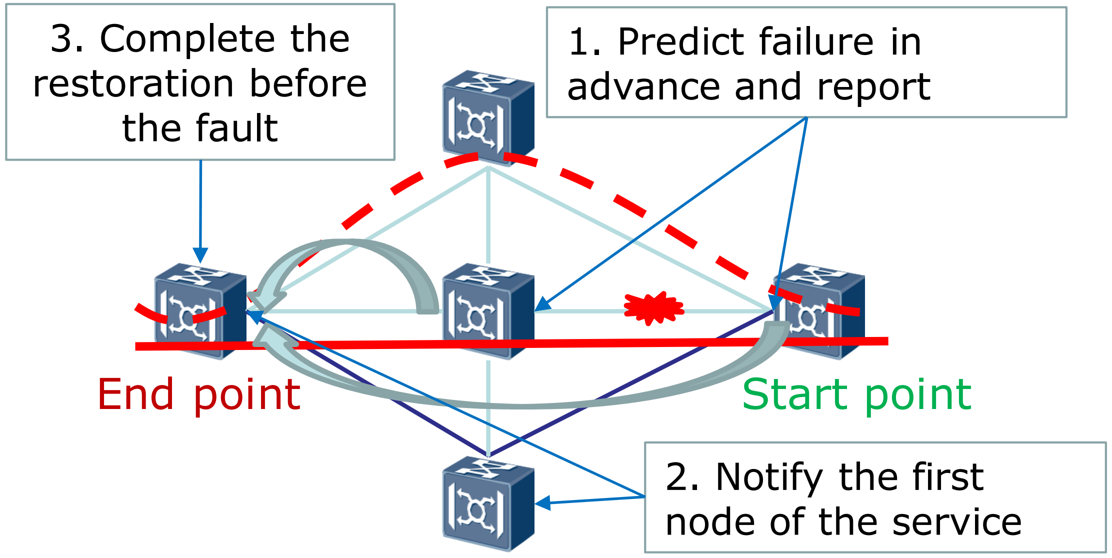
The losses to financial enterprises reach **million dollars per hour**.

China: A typical carrier backbone network undergoes 50 fiber cuts on average each year.

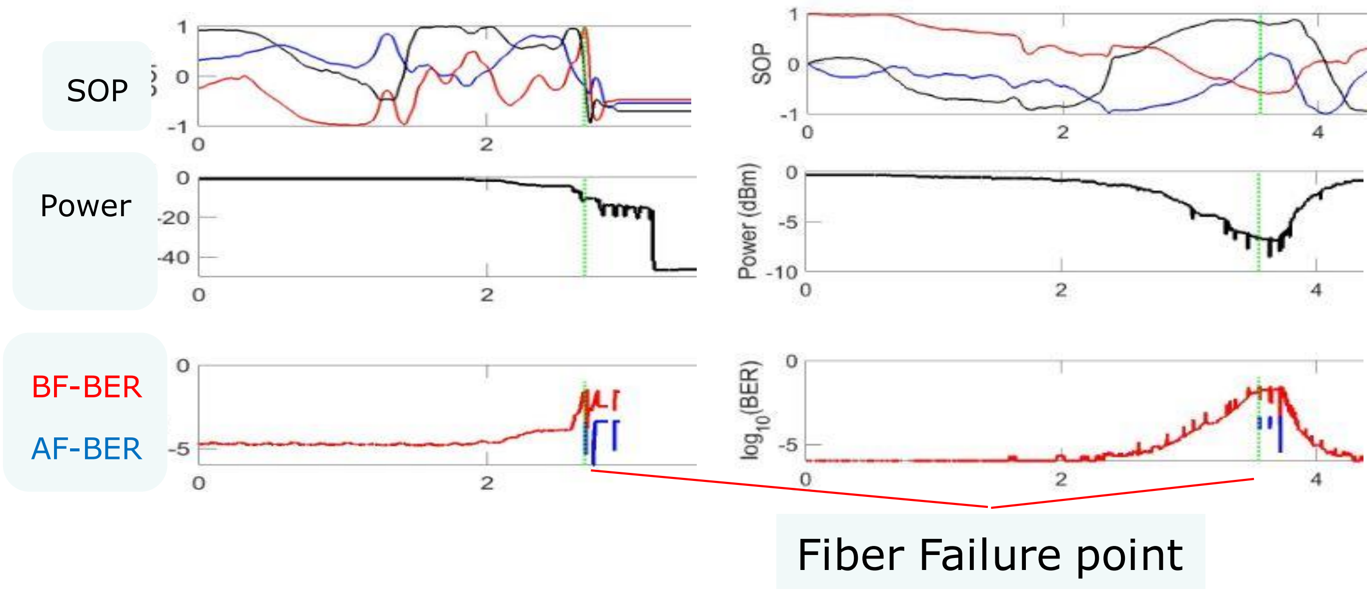
India: More than 30 fiber cuts occur every day.

Case 1: Forecasting critical damage of optical fiber

Goal: Forecast fiber failures based on real-time data



Data Example

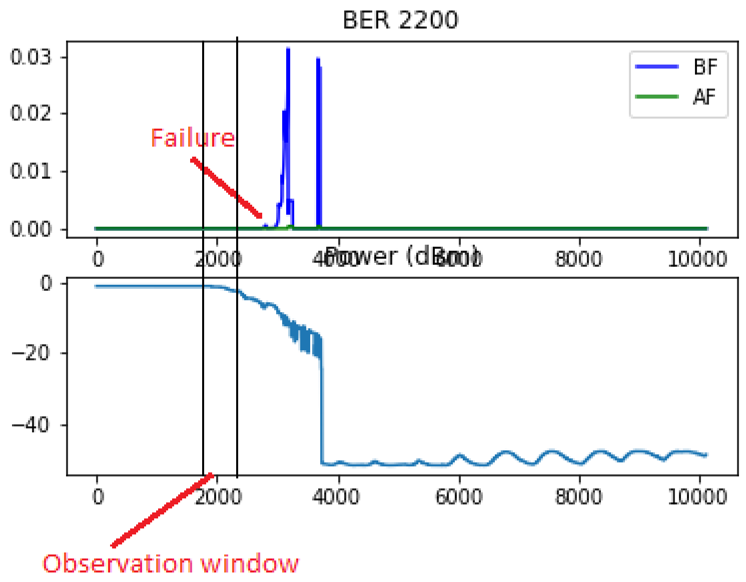


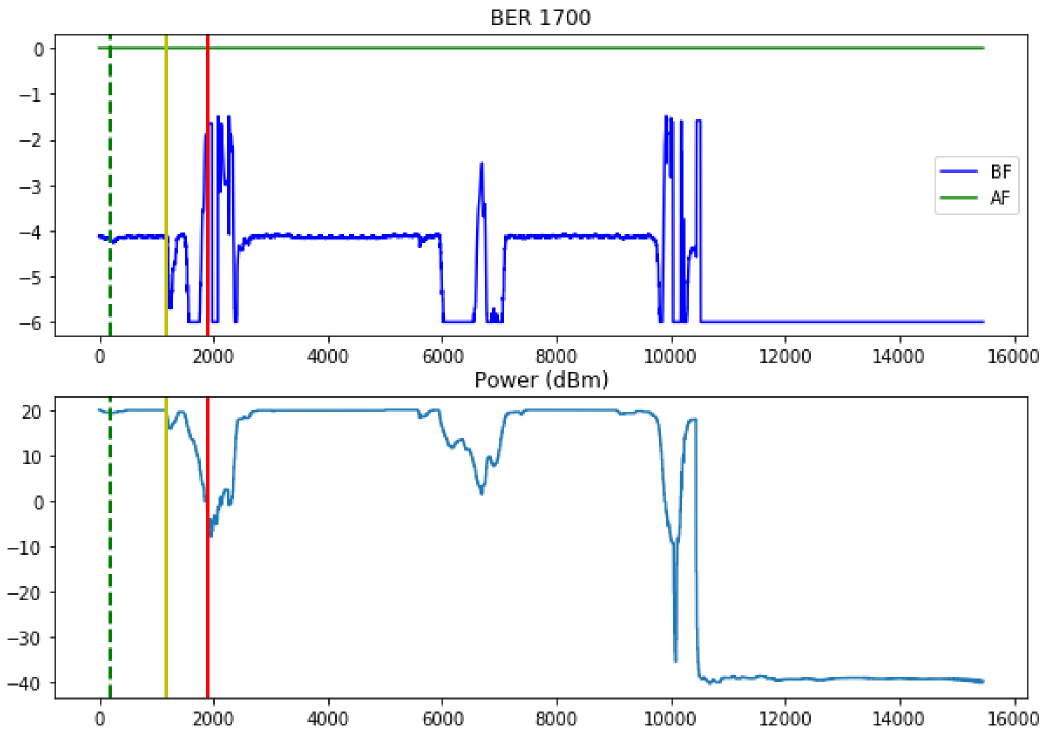
General problem statement

- Build a model for predicting in advance the failures based on given laboratory multivariate time series
- Requirement: model well generalizable to real-world data

Case 1: Forecasting critical damage of optical fiber

Use machine learning to observe sliding windows



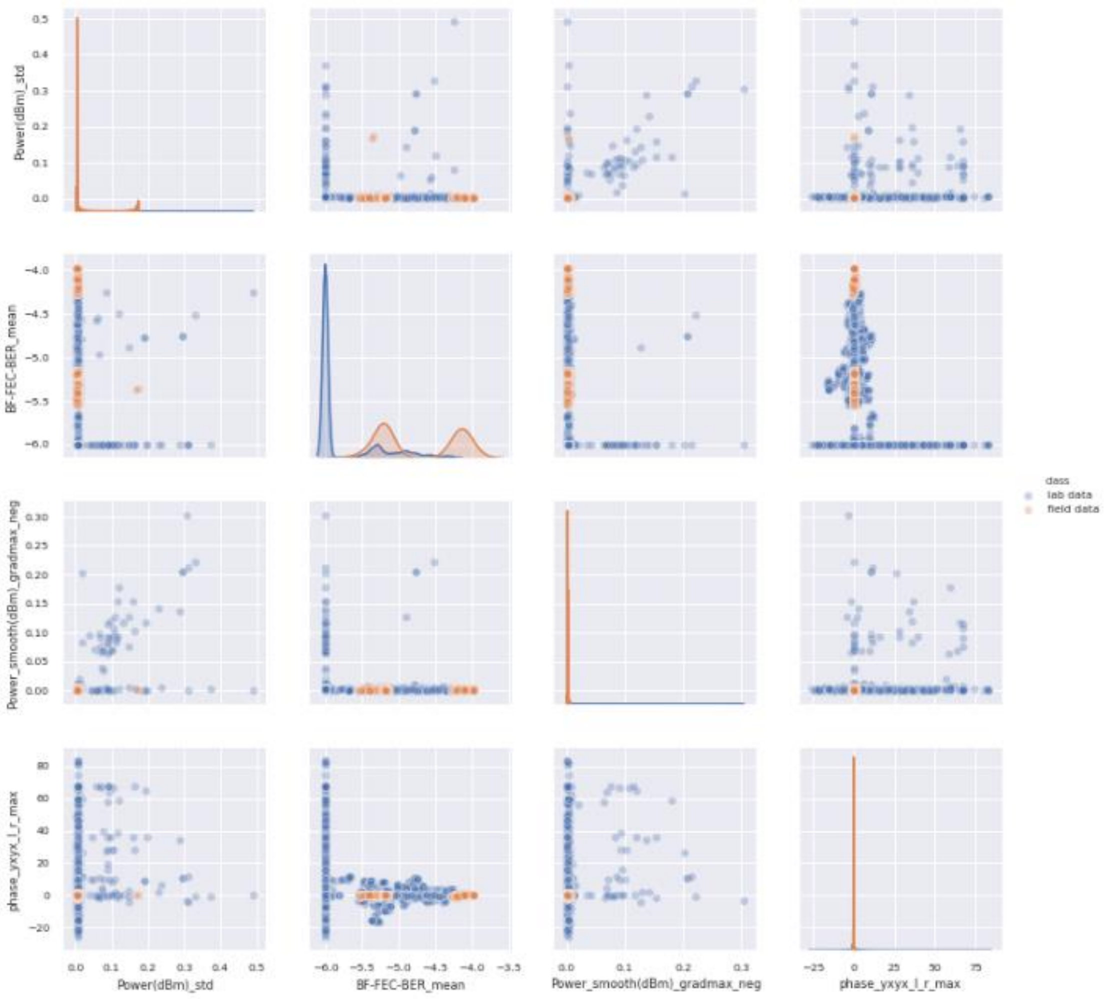


- Train the model in a way that it inherently tries to predict the future behavior
- Make sure is does not overfit on non-relevant features

Case 1: Forecasting critical damage of optical fiber

Challenges

- Extremely **high recall** needed to avoid large costs
- **Hard to obtain the data** for training
  - Damages are rare and different
  - Simulation in laboratory conditions is expensive, slow and restrictive
- **Generalization** on very few samples of field data



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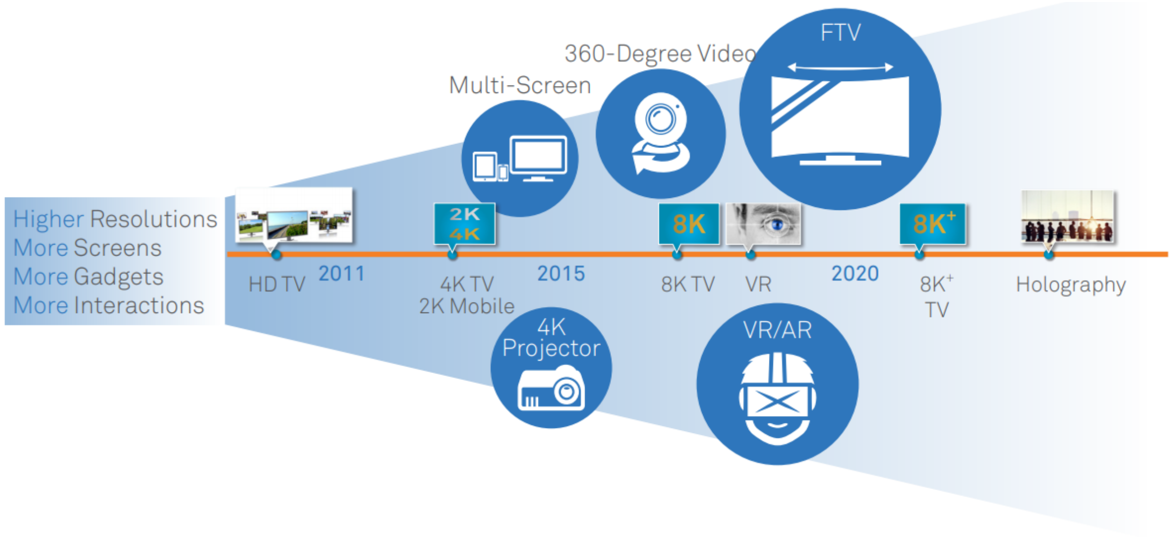
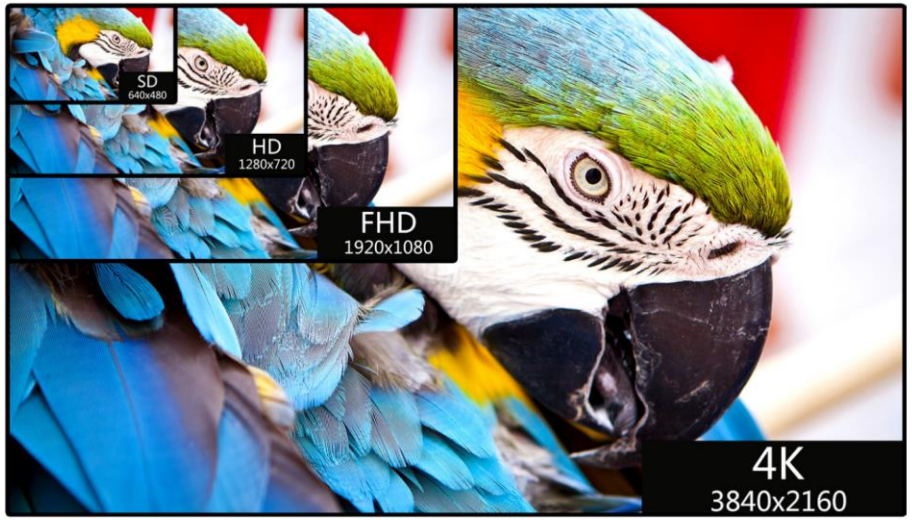
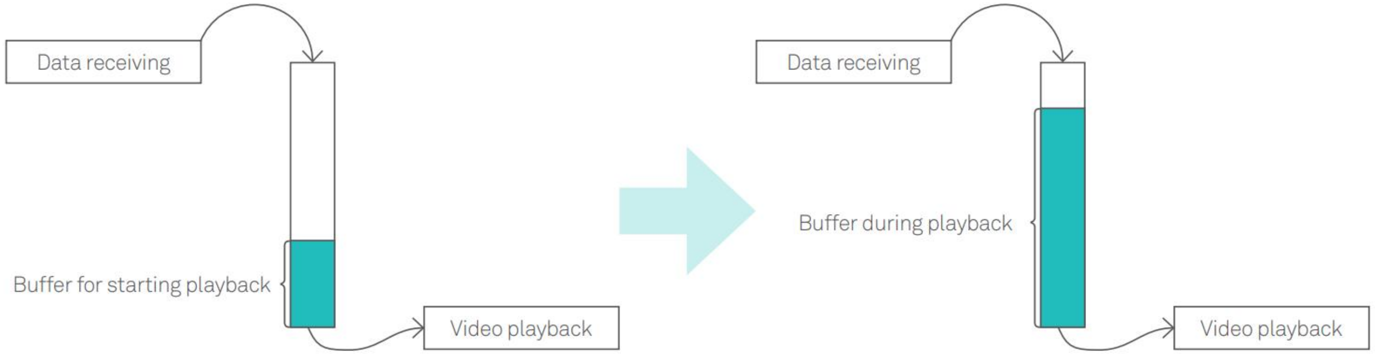
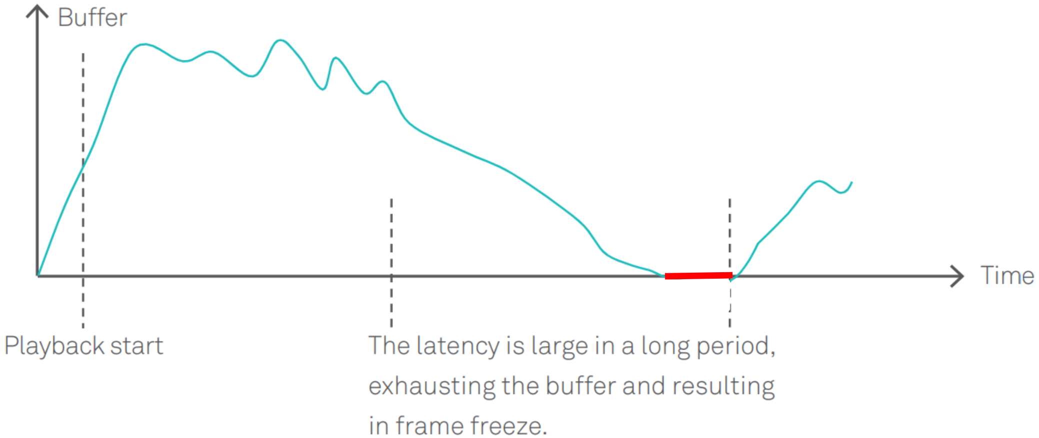
Case 2: Video quality evaluation







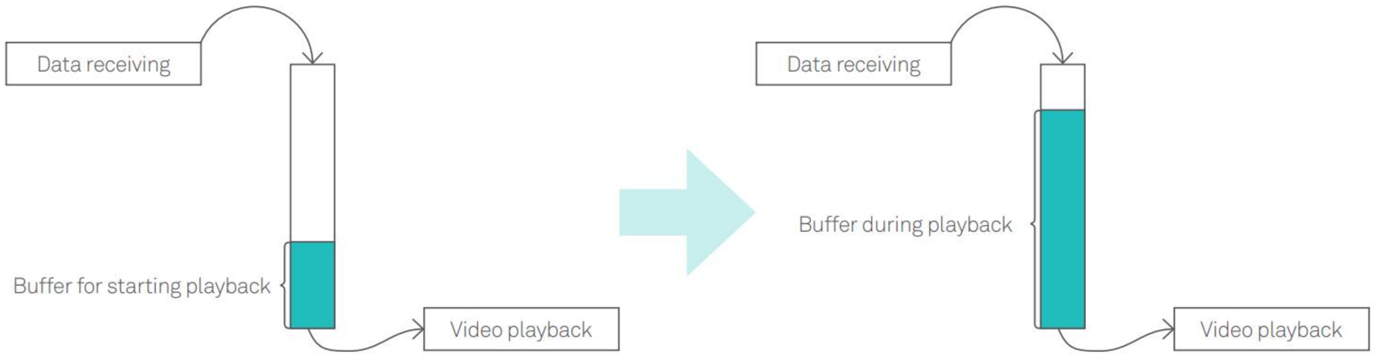
4K Video on Demand playback principle



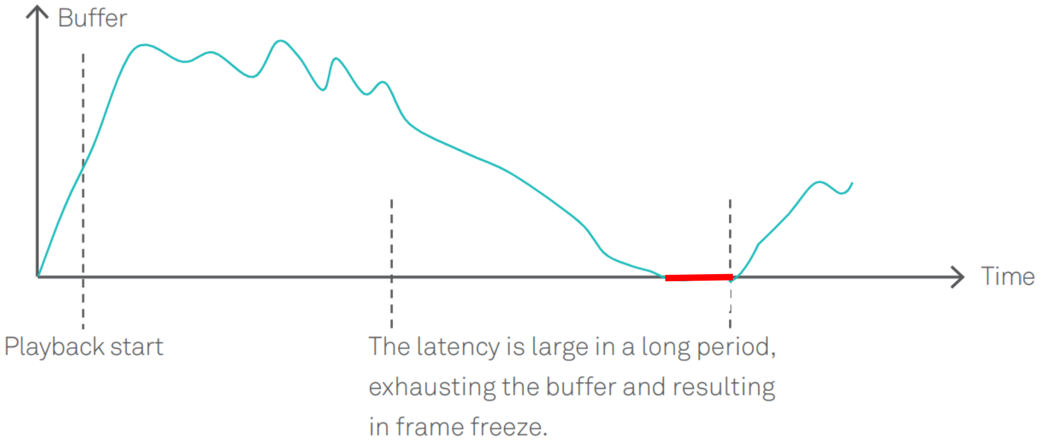
Causes of stalling during 4K Video on Demand playback

Image source: Technical White Paper on the Premium Wi-Fi 4K Video Transmission Solution

Case 2: Video quality evaluation



4K Video on Demand playback principle



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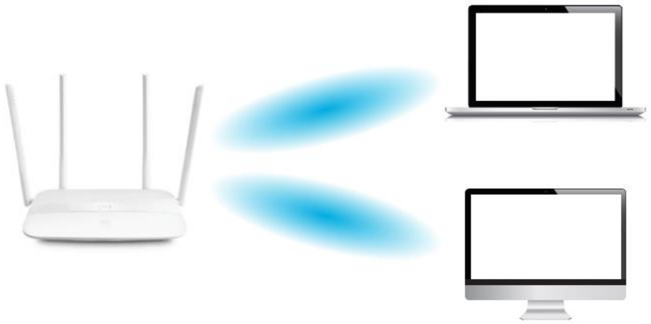


802.11ac Beamforming technology

Vision

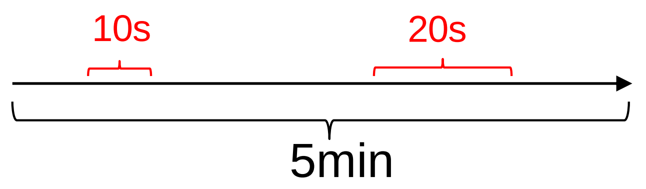
- Deliver the best user experience for watching videos by smart signal redistribution among multiple users
- Evaluate the video quality (**stalling** and **resolution**) based on TCP/IP packets data

Image source: Technical White Paper on the Premium Wi-Fi 4K Video Transmission Solution

Case 2: Video quality evaluation

Data

- Time series of TCP/IP packets measurements (number of packets, size of packets, some statistics, delivered and lost packets, etc.)
- Automatic labeling for specific scenarios



Frequency = (10+20)/300 = 10%

Task description

- Build a model for detecting stalling frequency and resolution of a given video data
- Requirement: deploy on AI edge device

Image source: Technical White Paper on the Premium Wi-Fi 4K Video Transmission Solution

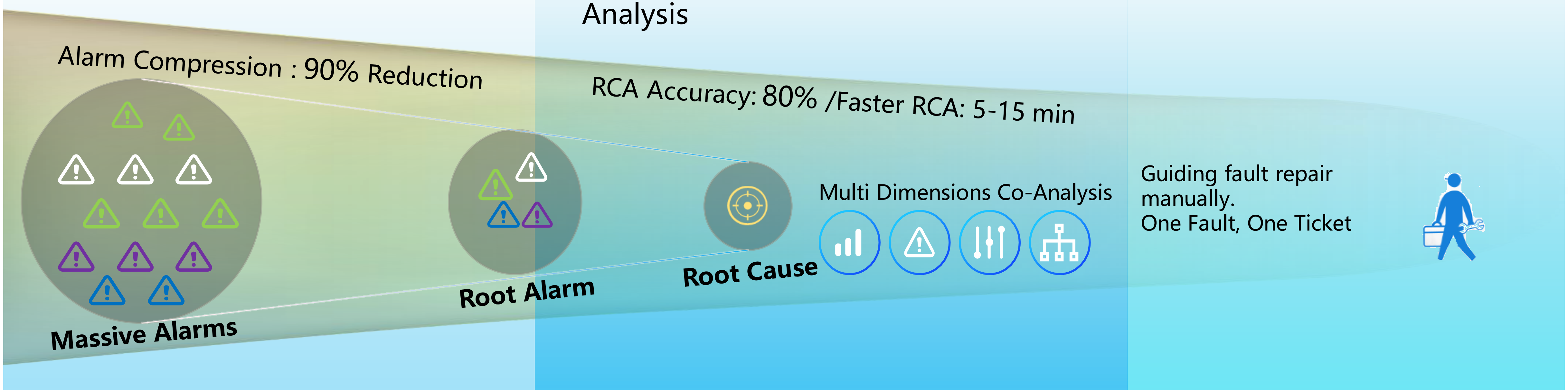
Case 3: Faults alarm compression and root cause identification

Alarm Compression → **Root Cause Analysis** → **Fast Trouble-shooting**

Alarms Minimization
Based on
Intelligent Alarm Compression

Root Cause Analysis
Based on
Intelligent Multi-dimensional Data Analysis

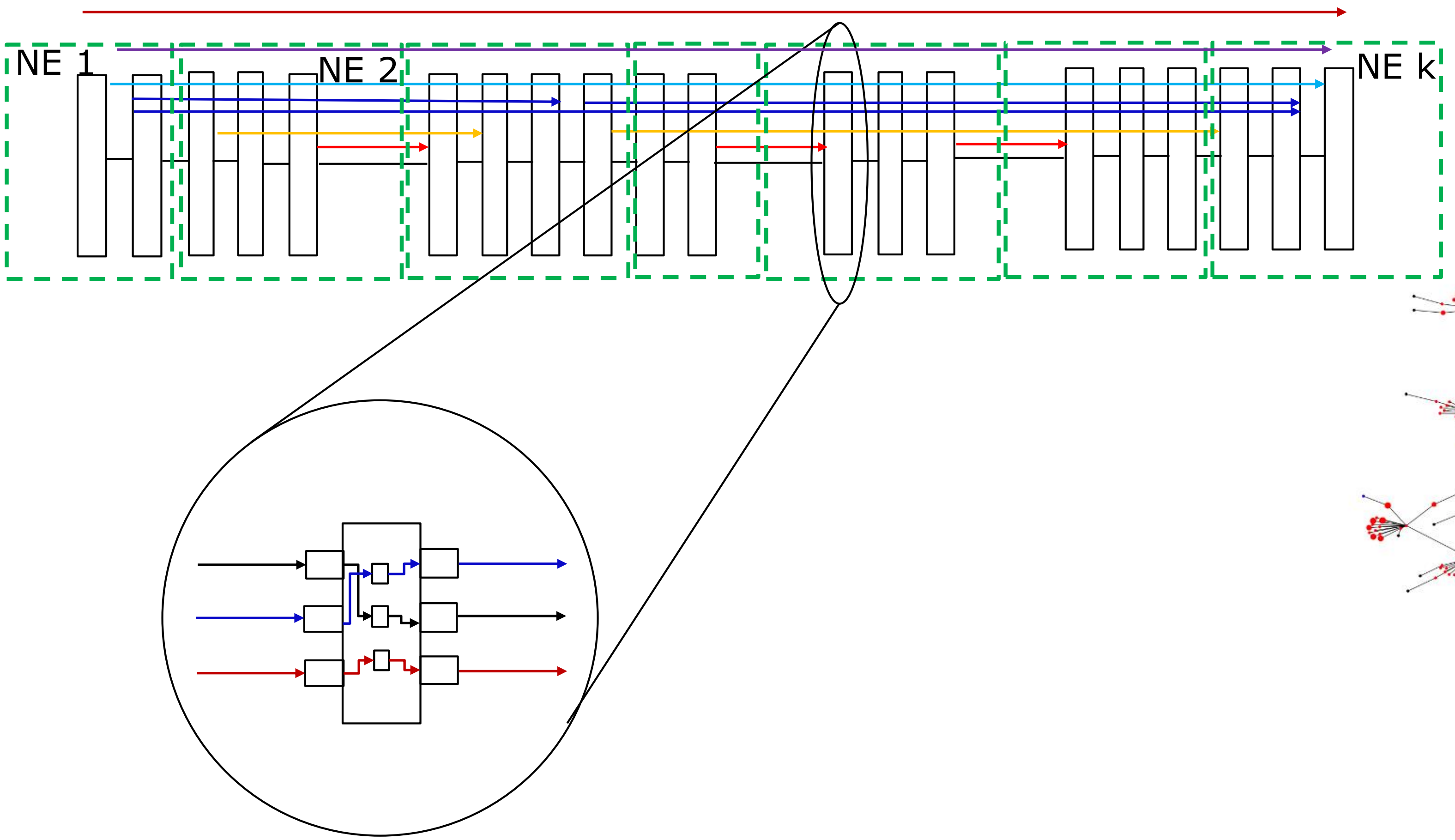
Fault Repairing suggestion



Vision: Automatically compress the amount of alarms caused by various failures in optical networks (e.g. fiber cut) by grouping them into clusters and finding the root alarm

Case 3: Faults alarm compression and root cause identification

Alarm and optical network topology data is organized highly non-trivially



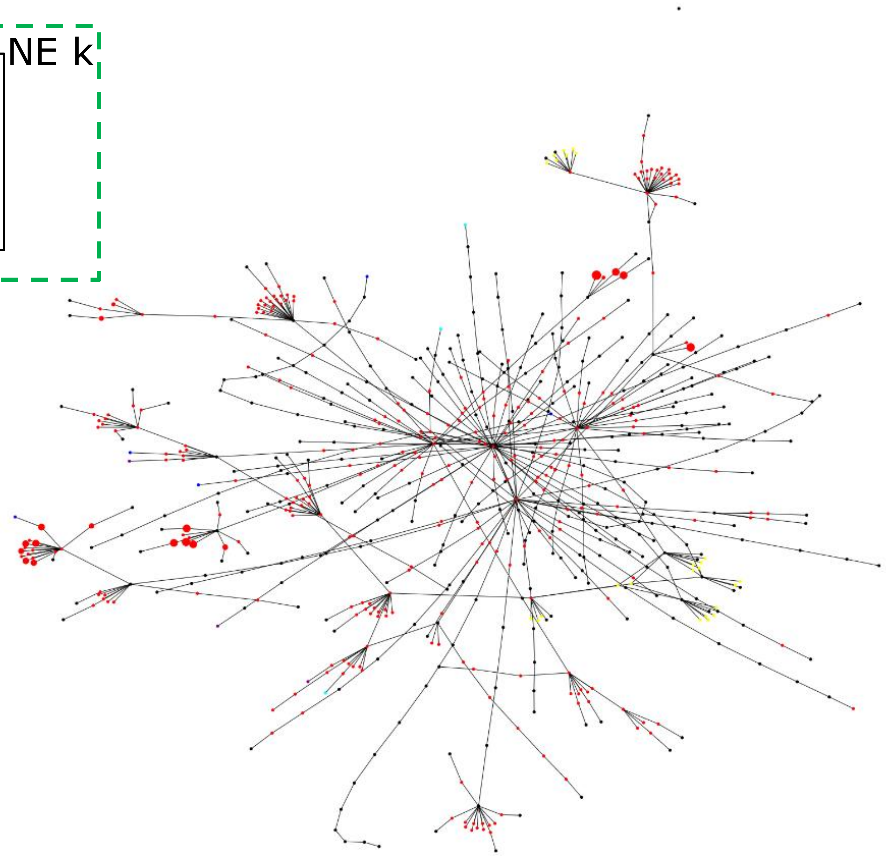
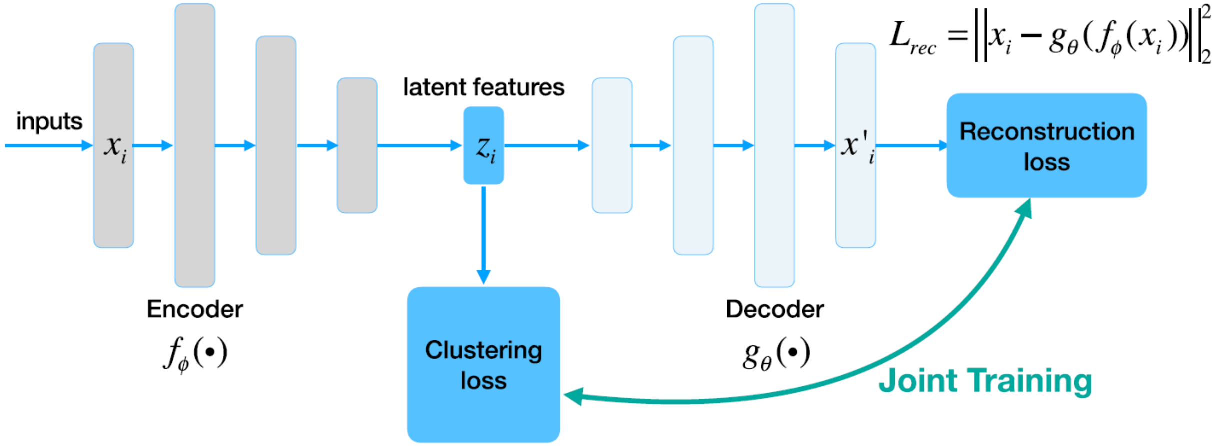


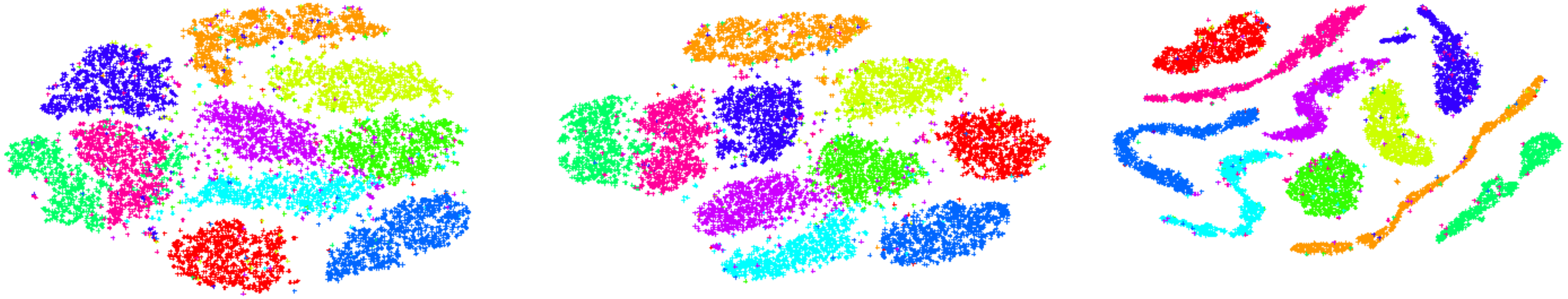
Image source: Wu, Zonghan, et al. "A comprehensive survey on graph neural networks." arXiv preprint arXiv:1901.00596 (2019).

Case 3: Faults alarm compression and root cause identification

General approach for deep learning clustering

- Find alarms representation
- Transform input into a low-dimensional latent space by minimizing a complex loss: alarm reconstruction + clustering (=topology)





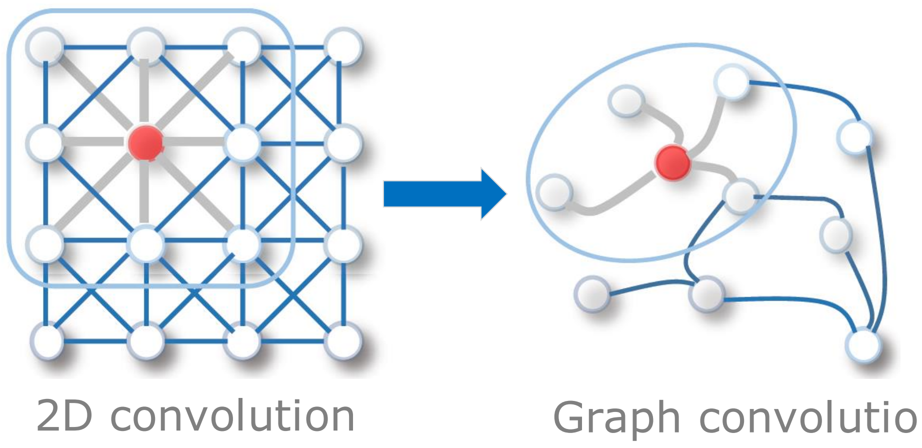
(a) Raw (b) SDAE (c) DCC

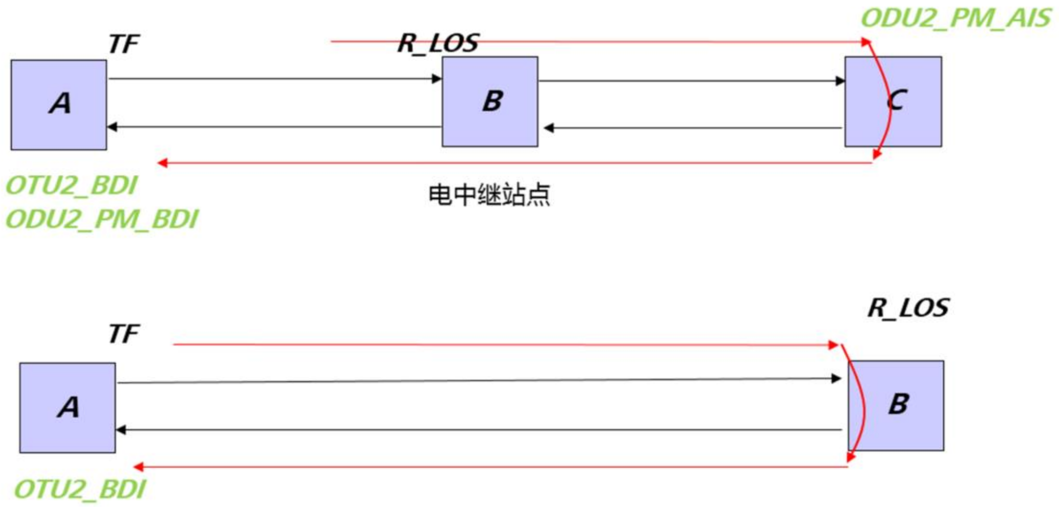
Specific implementation applied to MNIST dataset

Case 3: Faults alarm compression and root cause identification

Potential research directions:

- Graph Neural Networks
- Hybrid modeling: combining machine learning and empirical rules





Sample empirical rule

Image source: Wu, Zonghan, et al. "A comprehensive survey on graph neural networks." arXiv preprint arXiv:1901.00596 (2019).

Takeaways

- Transmission and Access optical networks: a broad range of challenging research problems in machine learning and optimization
- Multiple sources of data: physical processes, engineering systems, user behavior
- In some cases – data in simulators, in other — from lab experiments, accompanied with data “from the fields”

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Let significant breakthroughs come true by using mathematics!

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