Use CVAE in QoS Management

IRTF-NMRG-Session

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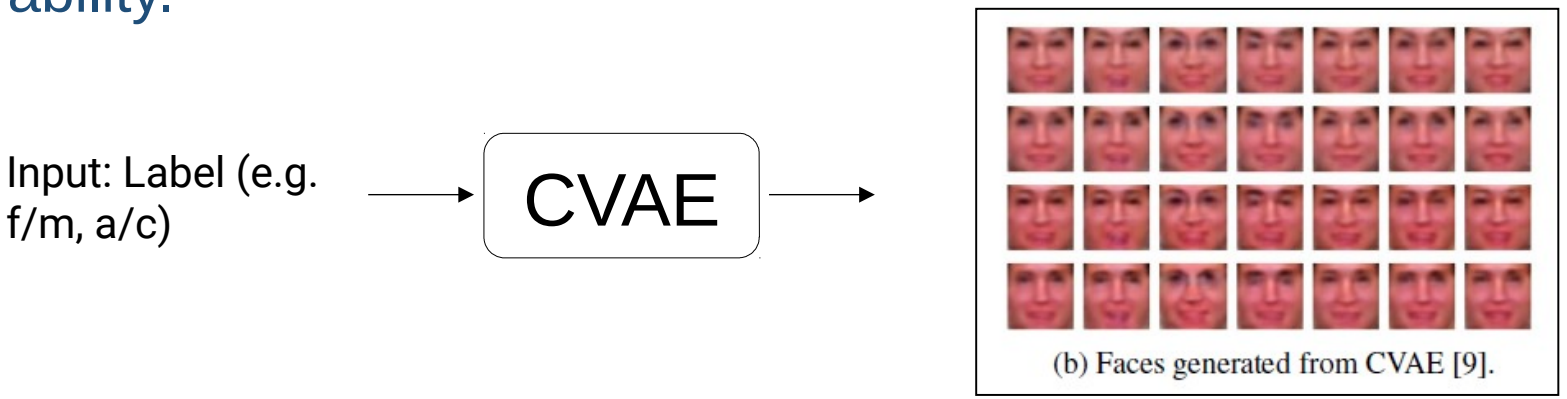
Motivation

CVAE is one of the popular generative models and has achieved a great success in AI area. It can extract the hidden feature from the training set data and reconstruct the distribution model of the focused object.

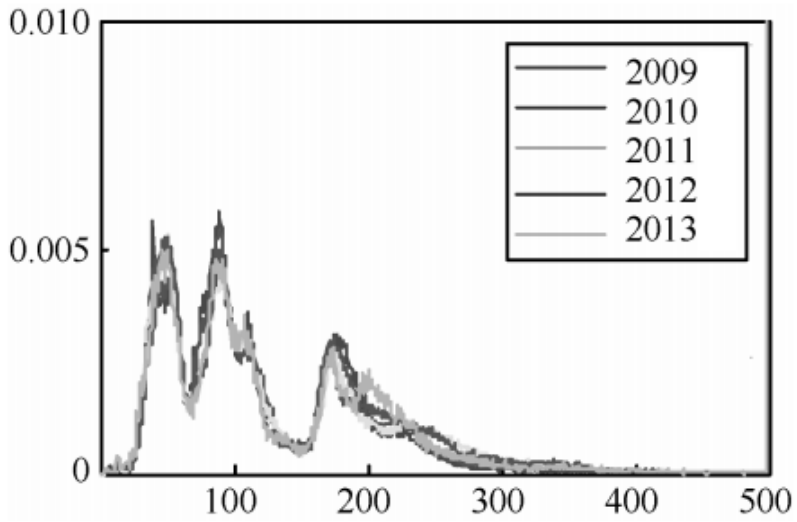
It can generate samples based on the trained model, which enable the inf erence ability.



Introduce **Conditional Variational Auto-Encoder** into network manage ment to provide an inference ability for QoS performance.

Motivation

We think the network is a complex system and the QoS parameters have some hidden statistic feature, which is hard to describe by simp le formulas. Therefore, we can use CVAE to model the network QoS then generate the samples from the trained model. Finally, we can re construct the QoS distribution according to the generated samples.

Condition ▭ CVAE ▭ 

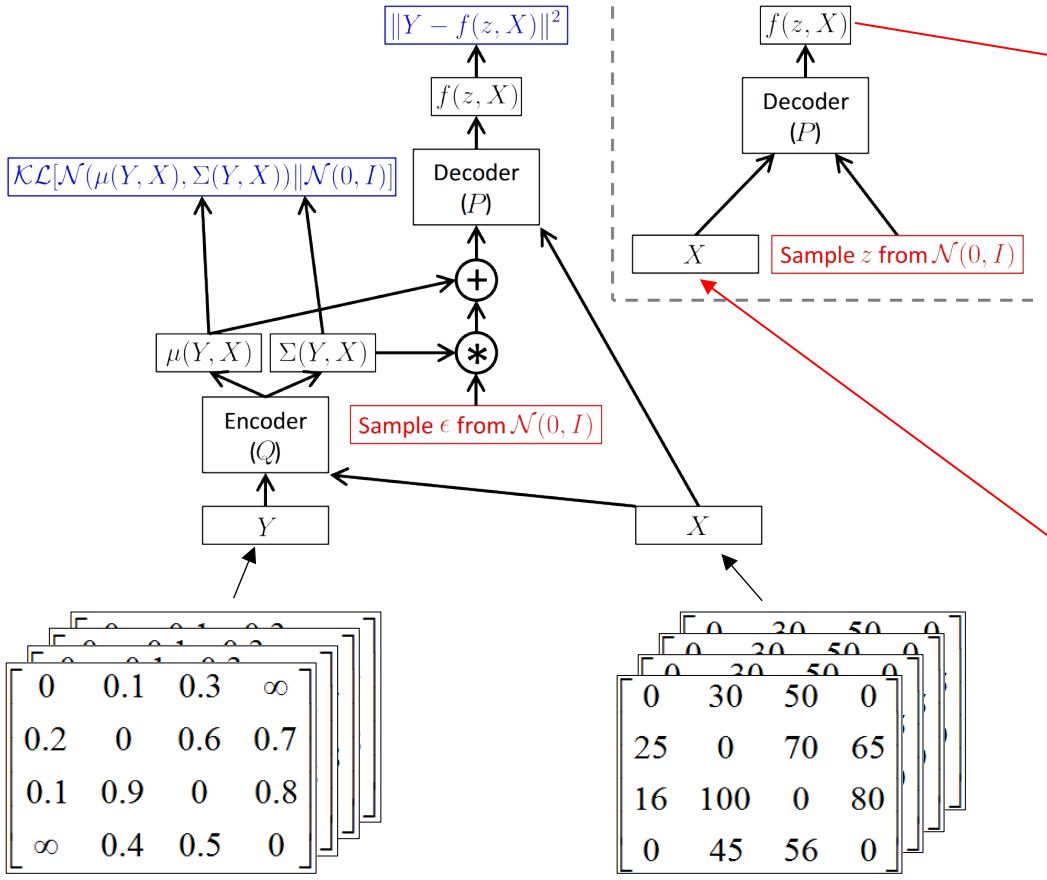
▭ Action

Action

CVAE’s result is a guideline of network management that

- Predict the QoS (by input the conditions, e.g. real-time traffic data) and t hen implement the proactive operations, such as bandwidth reservation, priority setting, flow migration, etc.
- Evaluate the action. E.g. if we migrate a flow / VPN to a new path, will it perform well enough?

CVAE Workflow Schematic Insight



Training Time

0	0.1	0.3	∞
0.2	0	0.6	0.7
0.1	0.9	0	0.8
∞	0.4	0.5	0

QoS Matrix
[Queuing Delay, ms]

0	30	50	0
25	0	70	65
16	100	0	80
0	45	56	0

Traffic Matrix
[(1,2)=traffic from R1 to R2, Mbit/s]

0	10	80	0
35	0	60	15
45	120	0	85
0	40	17	0

Inference Time
Traffic Matrix

0	0.4	0.1	∞
0.7	0	0.2	0.3
0.8	0.3	0	0.4
∞	0.5	0.3	0

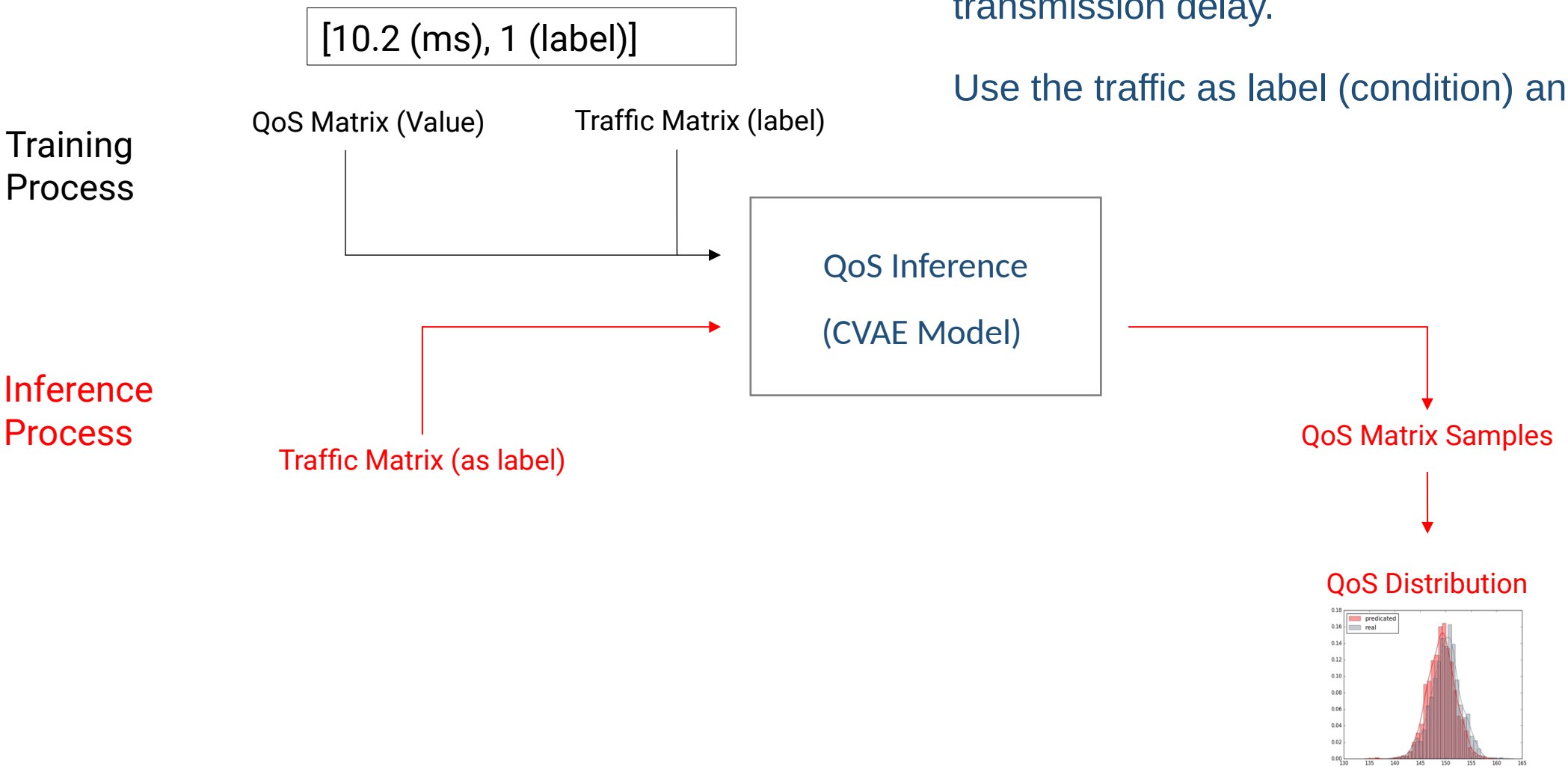
Predicted QoS
Matrix

+ Error

CVAE Workflow Outside

We focus on the QoS variation that caused by traffic, such as pay more attention on the queuing delay than transmission delay.

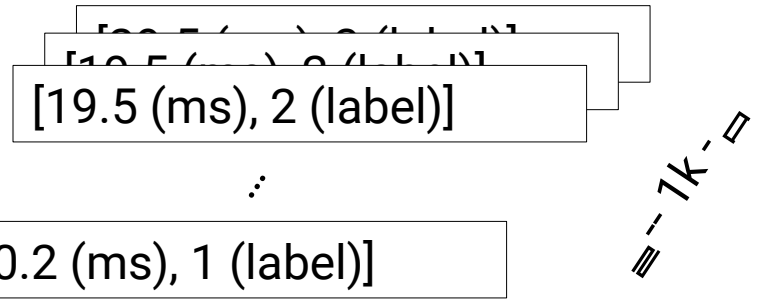
Use the traffic as label (condition) and QoS as value.

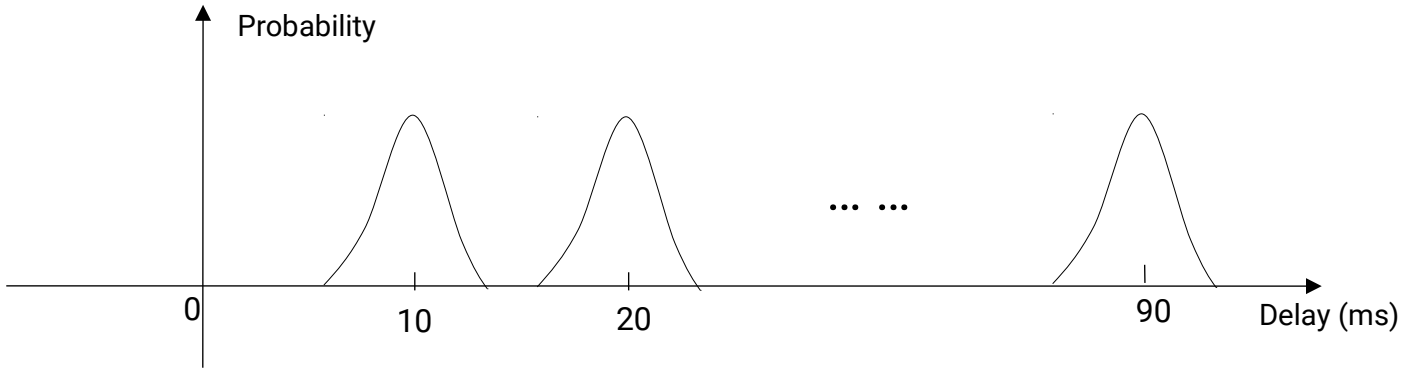


Rebuilding Train / Test

Training Sample：

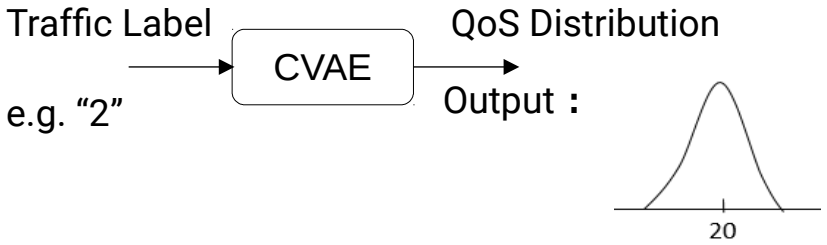
- QoS value, Traffic label = {1,2,3,4,5,6,7,8,9}
- **QoS(label) ~ N(label*10, 3)**
- Complexity:
  - 1k Samples for Training
  - 200s per training time





Test Sample：

- Traffic label={1,2,3,4,5,6,7,8,9}

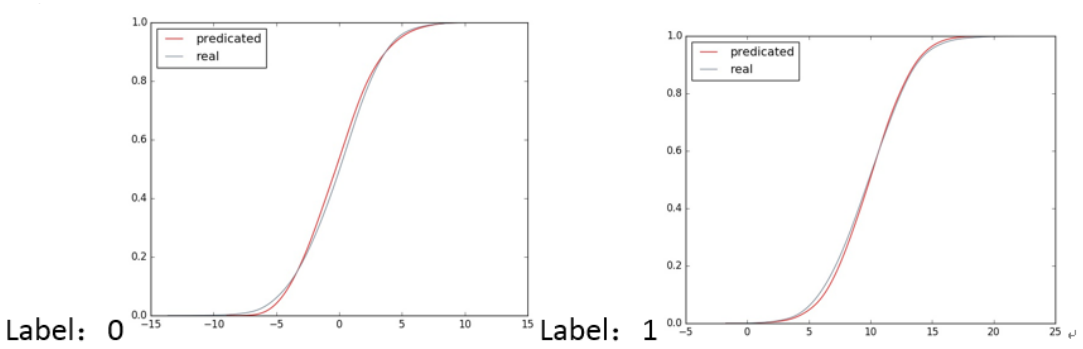


Experiment - Rebuilding Ability

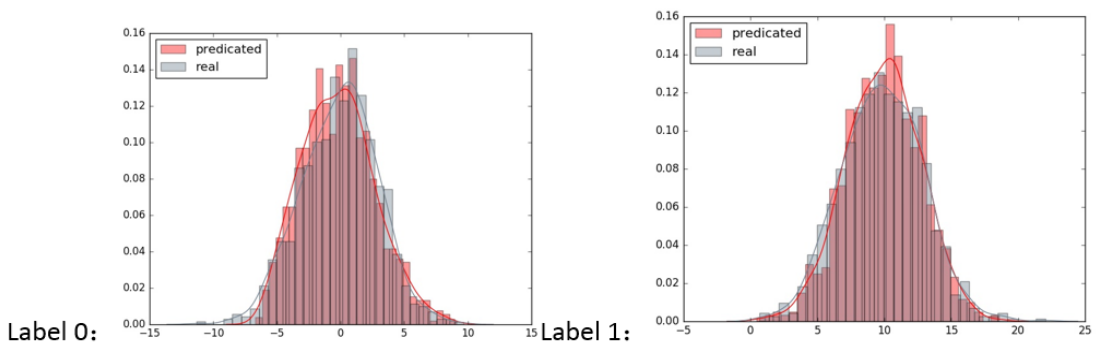
For **KNOWN** label, we can obtain the accurate distribution.

err_mean=0.659%, err_std=-7.677%, err_90p=-1.379%

90p: CDF (pred − real)/real



Cumulative Distribution Function (CDF)

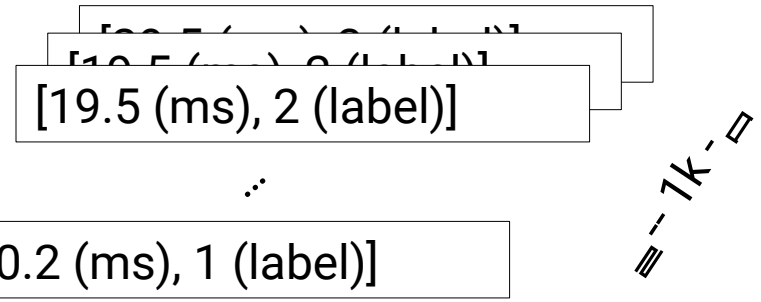


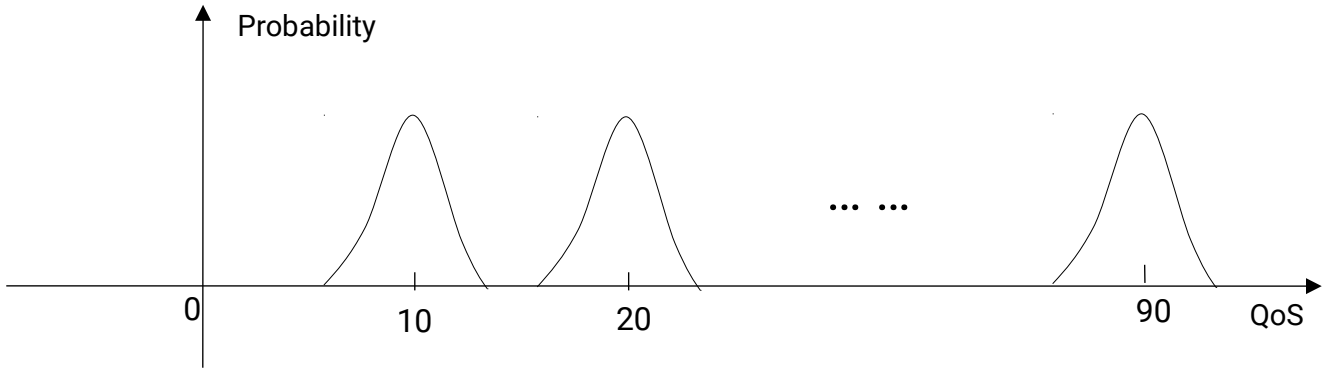
Probability Distribution Function (PDF)

Generalization Train / Test

Training Sample :

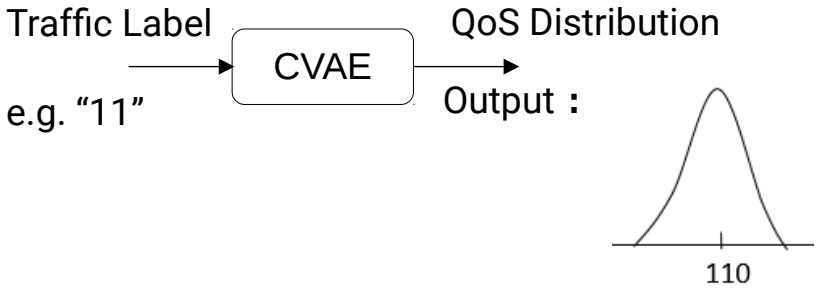
- QoS vector, Traffic label = {1,2,3,4,5,6,7,8,9}
- **QoS(label) ~ N(label*10, 3)**
- Complexity:
  - 1k Samples for Training
  - 200s per training time





Test Sample :

- **Traffic label={10,11,12,13,14,15}**



Experiment - Generalizing Ability

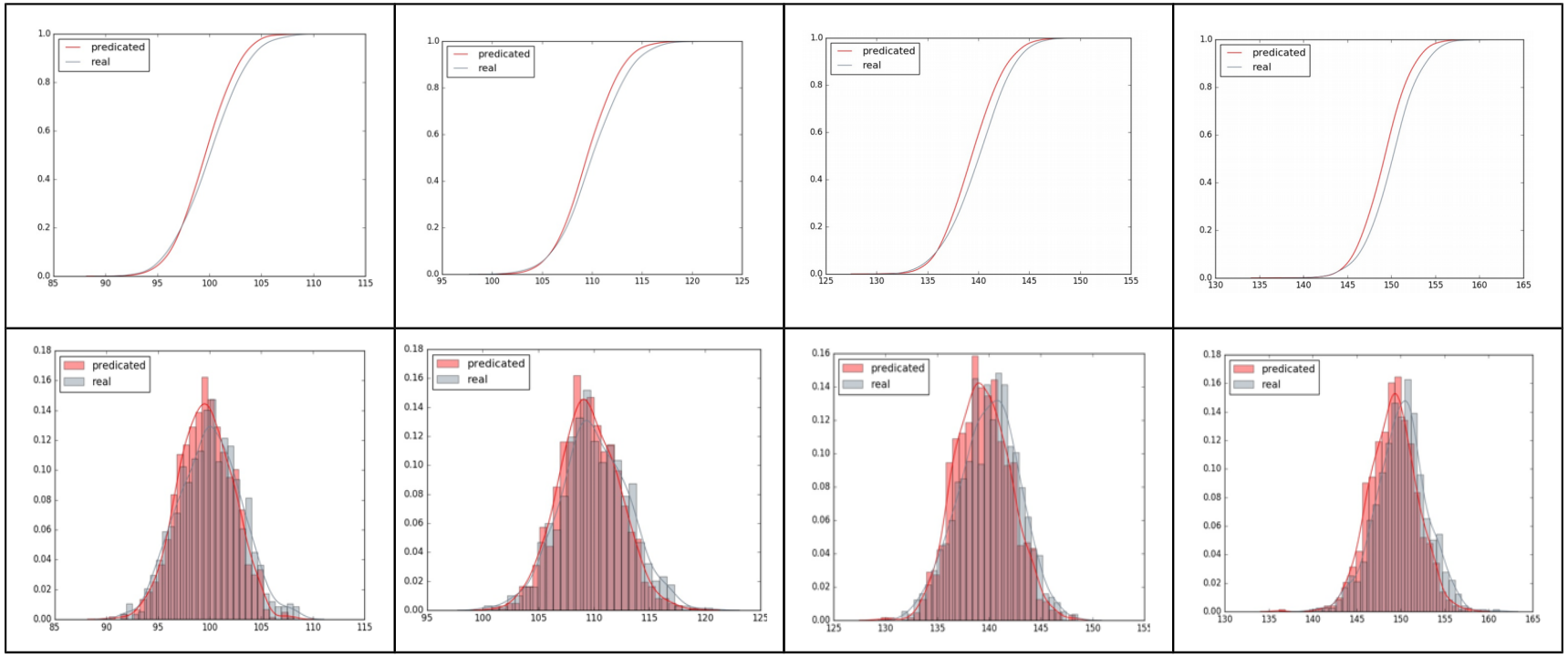
For **UNKNOWN** label, we can also obtain the accurate distribution

err_mean=-0.597%, err_std=-8.124%, err_90p=-2.798%

90p: CDF (pred − real)/real

Cumulative Distribution Function (CDF)

Probability Distribution Function (PDF)



Required

Measurement

- High frequency and accuracy data (e.g. how to obtain the accurate traffi c matrix)

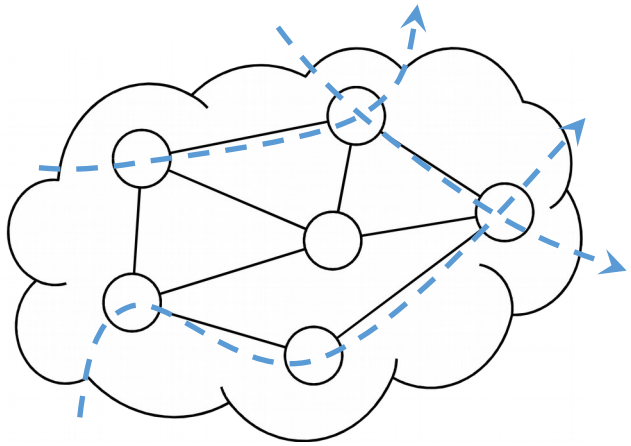
Data Expression and Transmission

- Translation between Network Data and Algorithm Data

Path Mode vs Node Mode

Path Mode

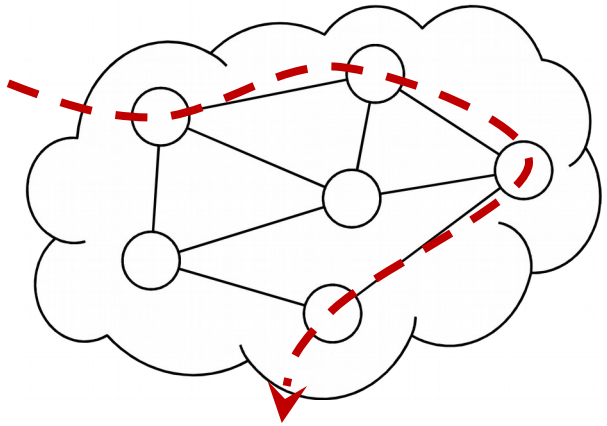
- per path as unit.



Path set based on route

Node Mode (challenge)

- per node as unit.



Combine the QoS distribution of each node as a path QoS

CVAE Model vs Traditional Statistics Model

- Perform well for known distribution and better than other “competitors”, e.g . Generative Adversarial Networks (GANs)
- **Can infer/generate unknown cases, few of tools can do this**
- Can solve complex problem
  - The relationship is complex (e.g. the QoS parameters of a specific link may be relative with the whole network traffic)
  - The known conditions are complex (e.g. multiple QoS parameters may influence each other. There is always some conditions that cannot be measured in advance)
  - The hide information may be complex (e.g. some unfocused routes may change when traffic changes so that influence the focused parameters)

Doing and will do

CVAE can

- Predict / Infer the QoS in give conditions and proactively avoid the bad p erformance
- Infer “how” under “if” (for the simulation before deploying a TE policy)

Will use the real QoS data (delay, jitter, loss, utilization, …) to train th e model (an experimental network with 16 nodes)

Explore the solution of node mode

Conclusion

CVAE can be used to model the network QoS. The feasibility has be en proved

Many advantages, especially can **infer the unknown cases**

Path mode is easier. Node mode is still a challenge.

Need measurement technology to support

FYI

https://arxiv.org/abs/1406.2661

https://wiseodd.github.io/techblog/2016/12/17/conditional-vae/

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