Network Failure Prediction on CNFs 5GC with Linux eBPF

UT-NakaoLab-AI

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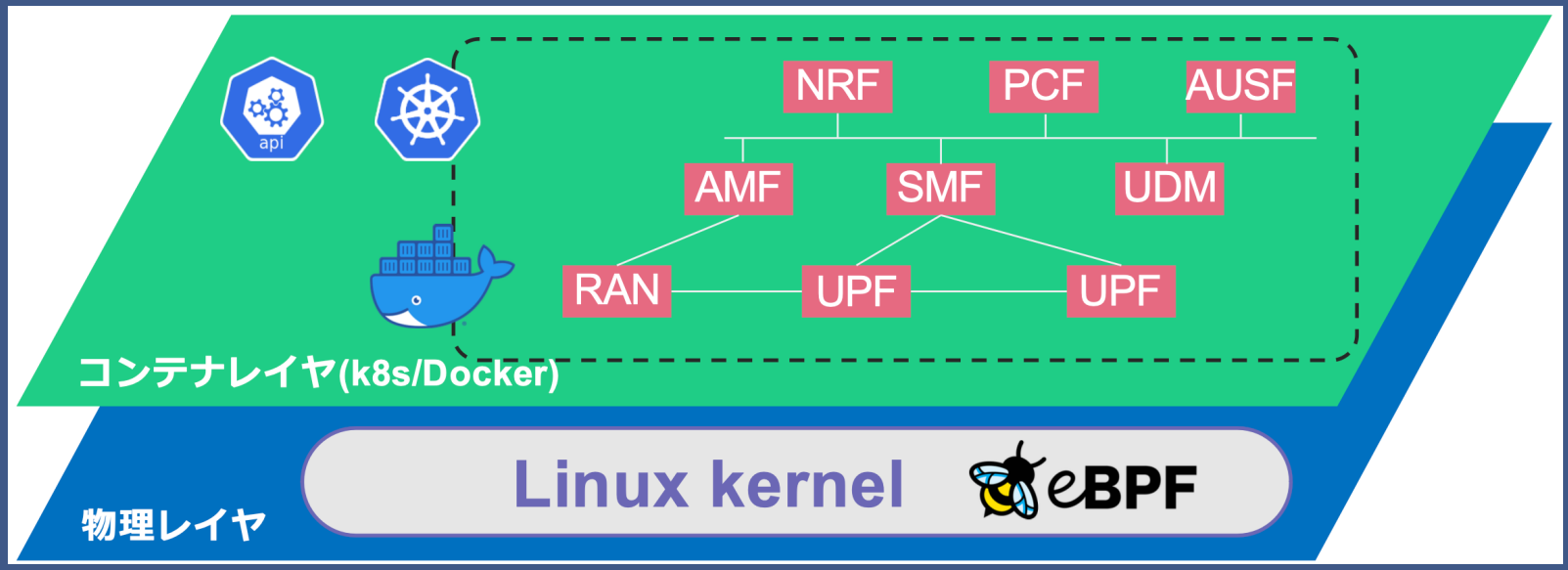
agenda

- Introduction
- Dataset description
- Task1
- Task1 method
- Task1 result
- Task2
- Task2 method
- Task2 result
- Feature analysis
- Visualization
- Conclusion
- Future works

summary

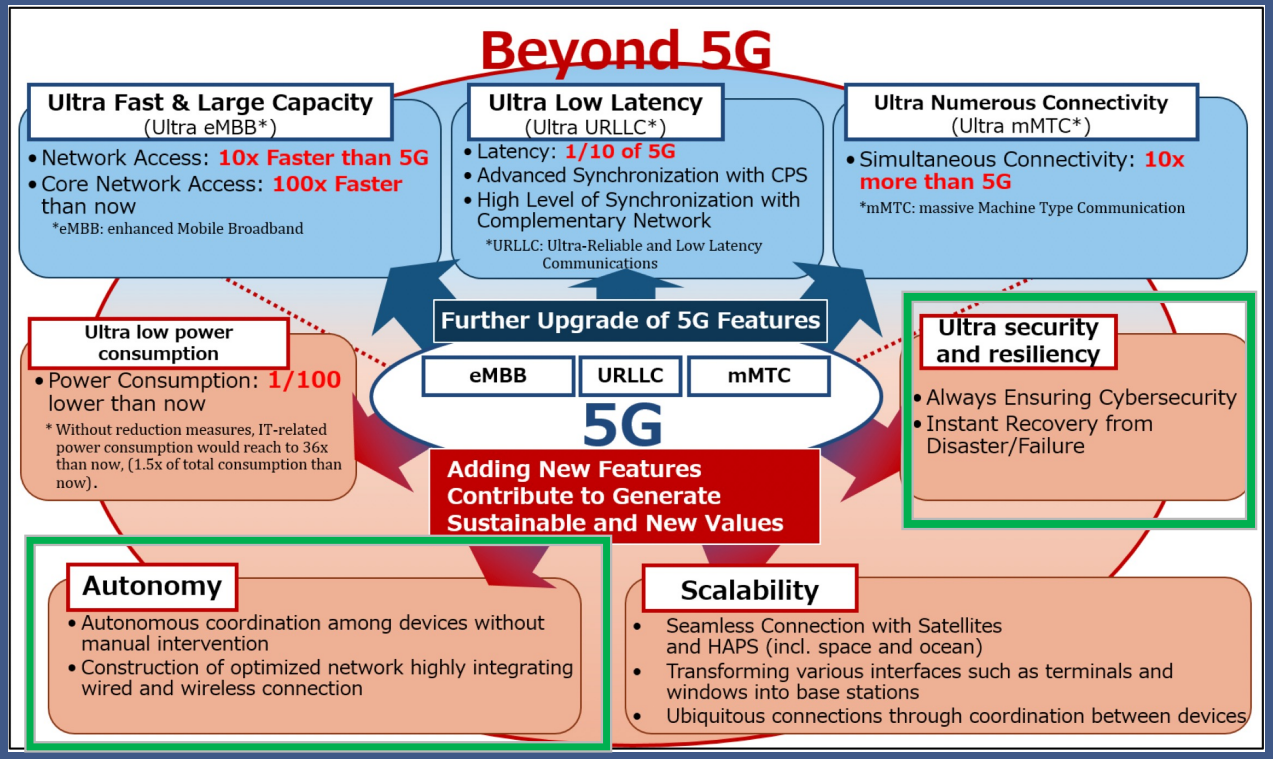
- In task1, my model achieved f1 score=0.92 with detection time=140s
- In task2, my model successfully reduced the number of features from 3325 to 329
- My best solution resulted in 329 features, detection time=140s, f1 score=0.97

Introduction



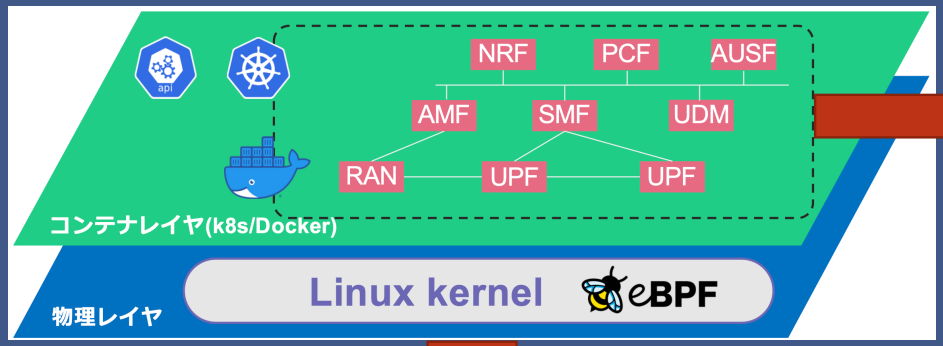
By leveraging flexible containerized network functions (NF)
Scalable networks can be rapidly deployed

Introduction



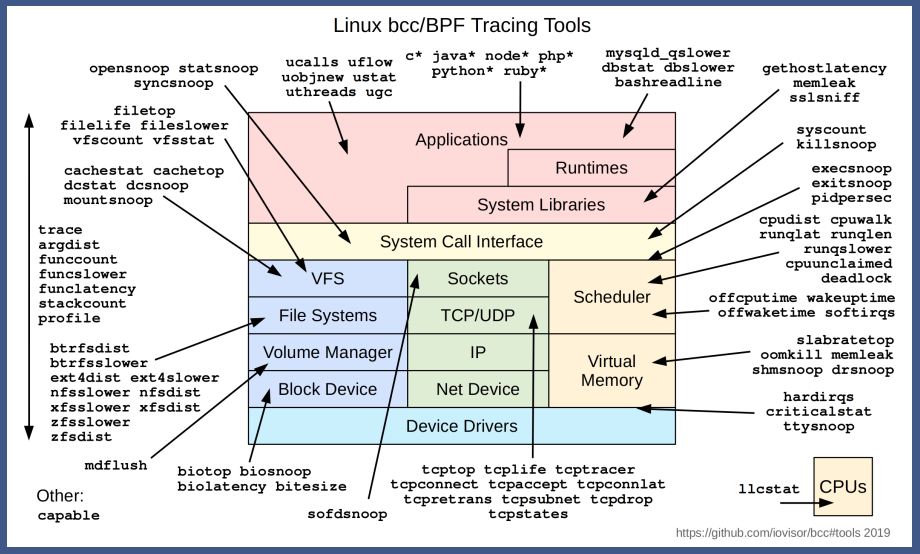
Need a system that monitors the network and automatically detects and restores failures.

Introduction

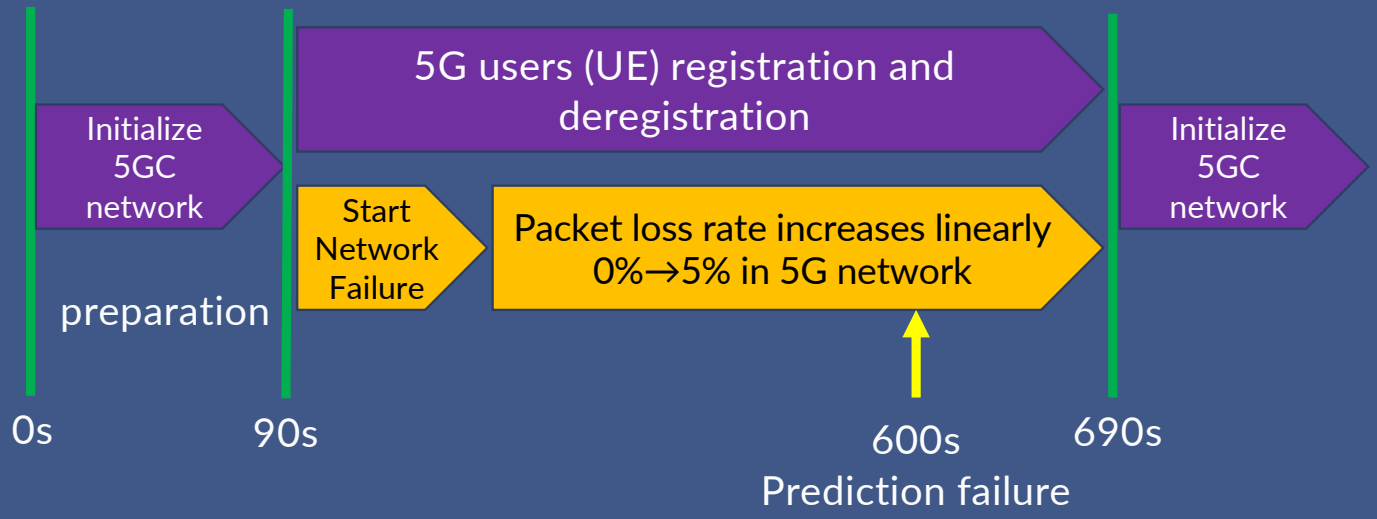


Only log data obtained from containers difficult to predict failures in advance

Using eBPF (extended Berkley Packet Filter), we get more detailed data



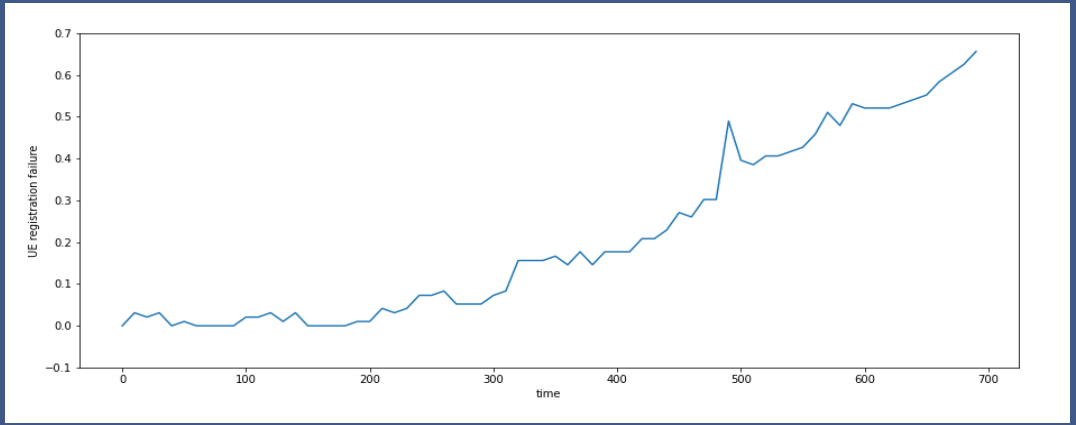
Dataset description

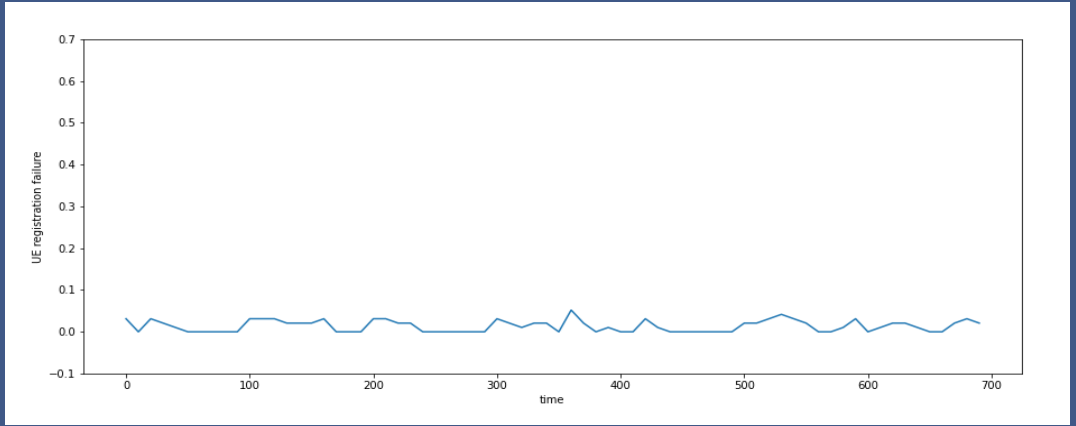


- One cycle is 690 seconds
- Logging every 10 seconds
- The first 90 seconds is a preparation period, initializing the network
- The subsequent 600 seconds (10 minutes) cause a failure, increasing the packet loss rate linearly

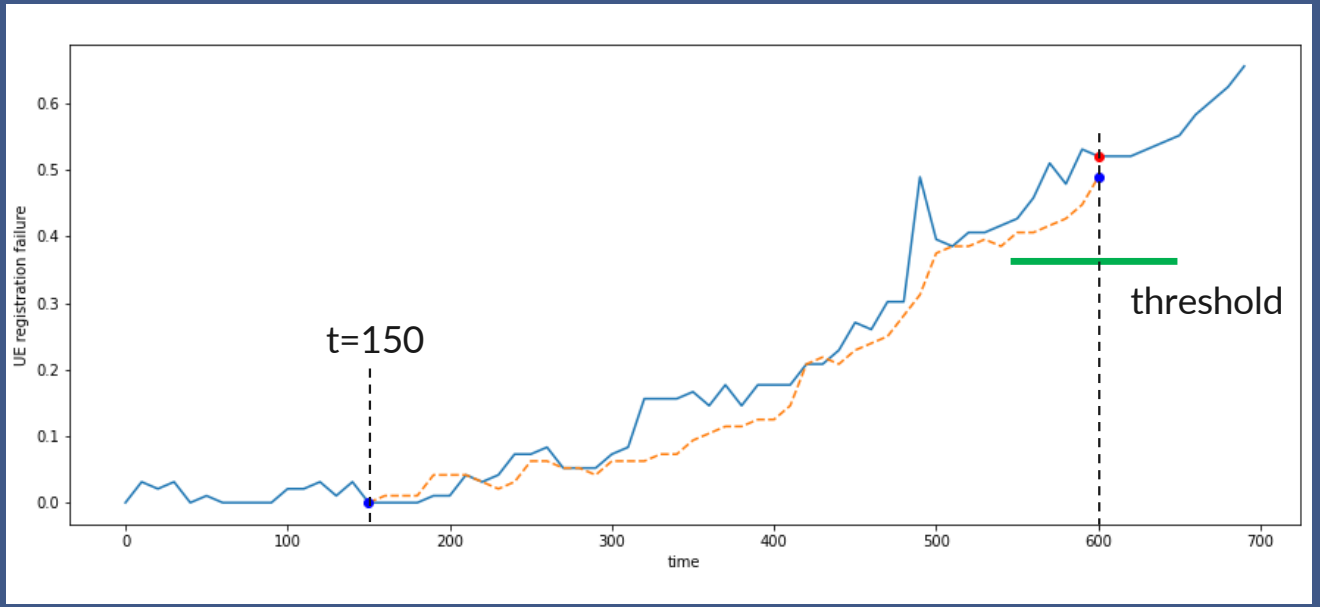
Dataset description

- Train : 600 cycles
- Test : 300 cycles
- Metrics : 3326





Task1



Predicts the number of UE registration failures at 600 seconds from a certain point *t*, and determines if a failure has occurred according to a threshold value.

Make t as small as possible so that the F1 score exceeds 0.9.

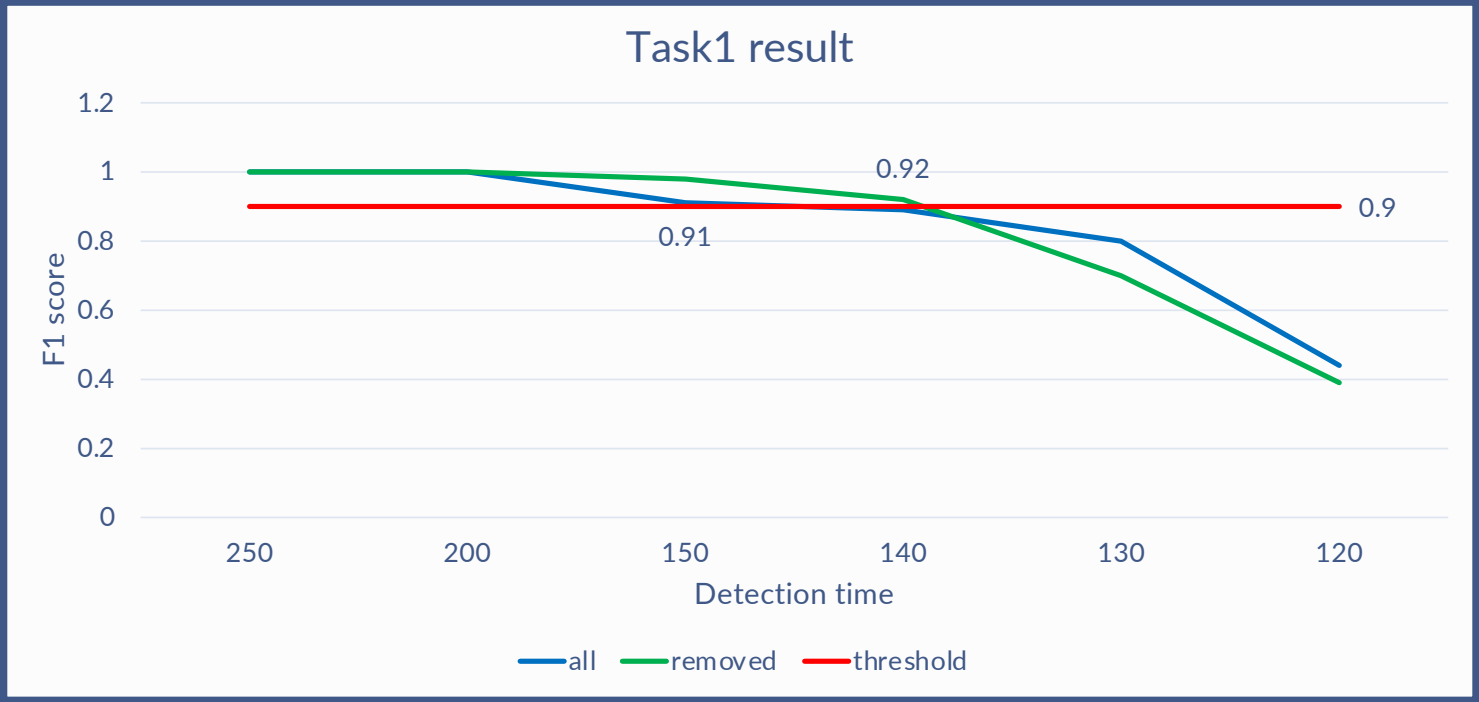
Method(Task1)

- Use all features (all) and remove features that are 0 for all periods (removed)
- Feature size
  - all: 3325
  - removed: 1723
- Scaling of both training and test data using minimum and maximum values of training data
- Threshold = 0.3 (28.8)
- timesteps: the input sequence size
- delay: interval between input and output

- Model: LSTM
- Loss function: MSE
- Optimizer: adam
- Epochs: 15
- Training data: 500 cycles
- Validation data: 100 cycles

Detection time *t*	timesteps	delay	Data size	Loss input
250	15	35	10000	15
200	15	40	7500	10
150	15	45	5000	5
140	14	46	5000	4
130	13	47	5000	3
120	12	48	5000	2

Removed model has high performance



Successful prediction at detection time 150s by using all features
Successful prediction at detection time 140s by removing 0 metrics
The removed model has higher performance than the all model.

Task2

```
Index(['amf.amf.app.cadvisor.container_cpu_cfs_periods',
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       'amf.amf.app.cadvisor.container_memory_cache',
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```
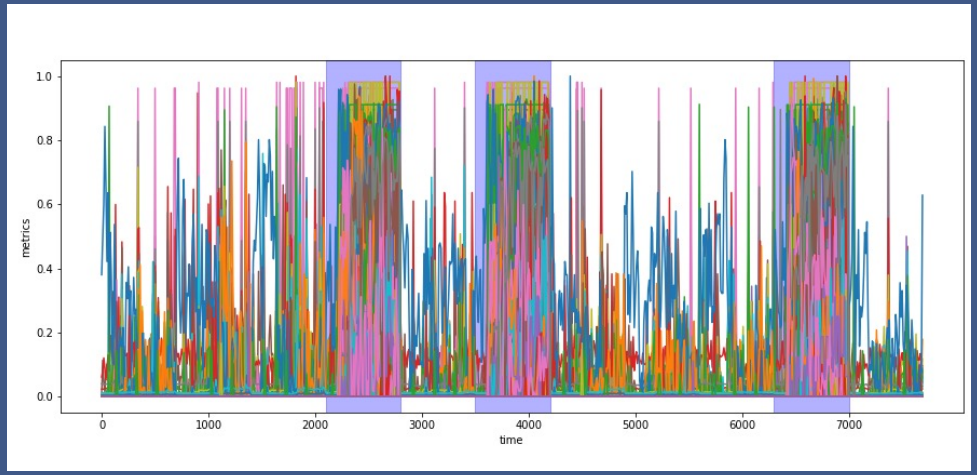
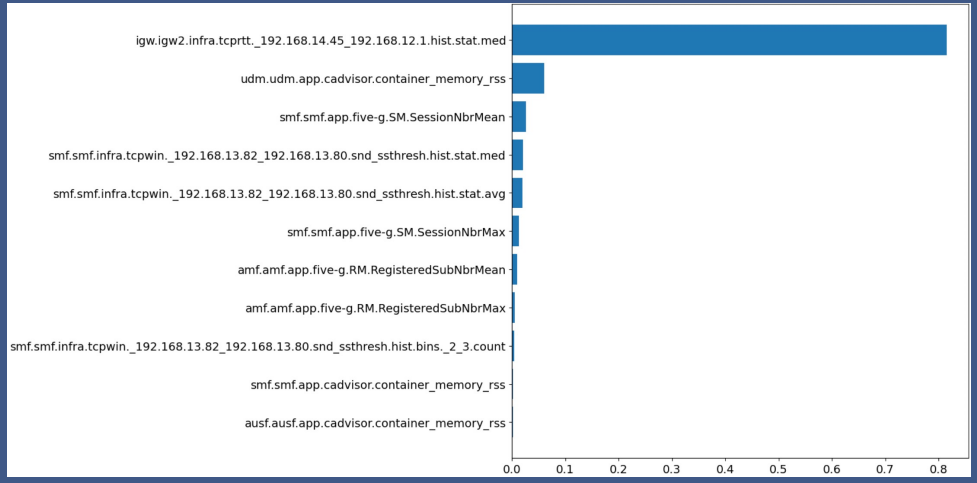

Reduce metrics as much as possible from over 3000 metrics

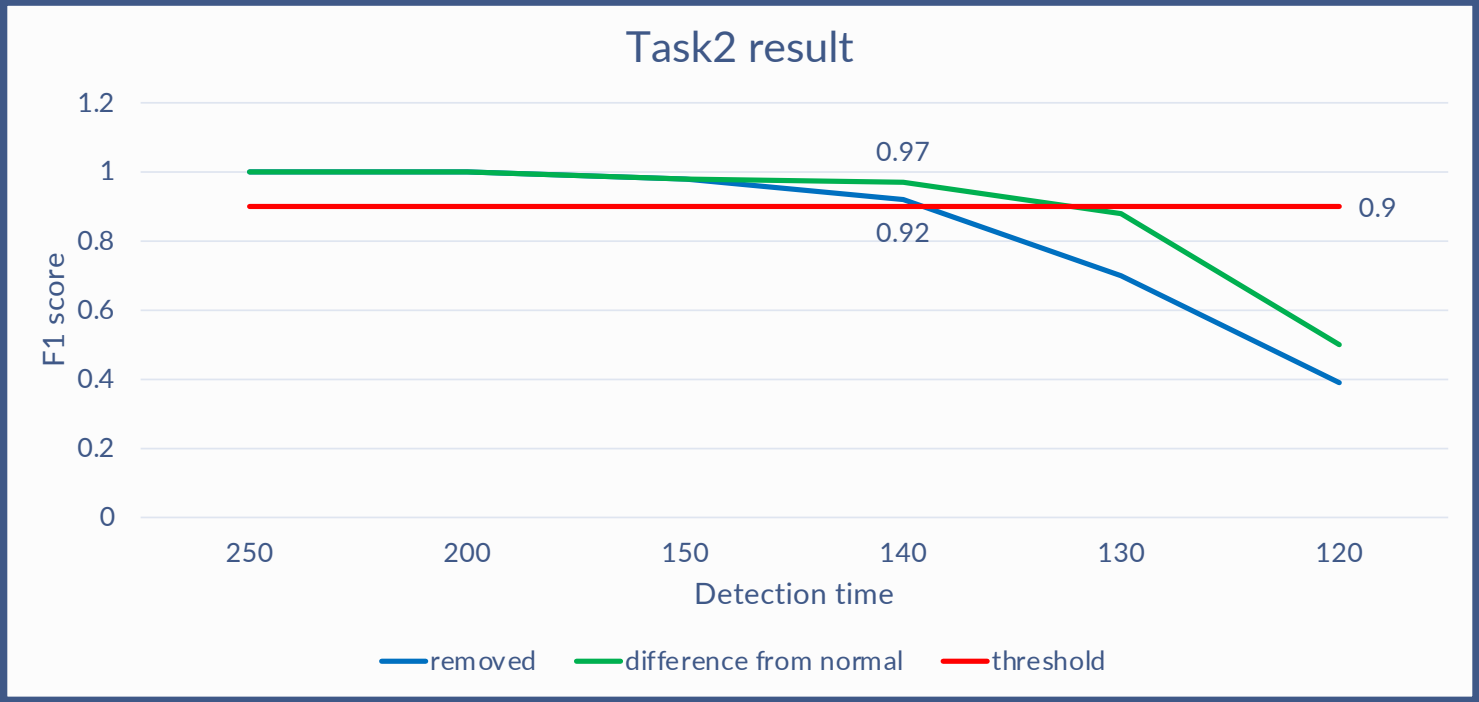
Method(Task2)

- method1 (difference from normal)
  - |mean(loss)|>2|mean(normal)|
  - feature size: 3326→329
- method2 (feature importance)
  - calculate feature importance by training random forests
  - sort features in order of importance and use for LSTM training
  - Feature size: 1723, 1500, 1000, 500, 400, 329
  - Detection time: 140s





Difference from normal model has best performance



The F1 score for the diff model was 0.97 with detection time 140s.
The diff model has higher performance than the removed model.
The model with 3000 features reduced had the best performance.

Differencing process is effective

Difference from normal			
Detection time	F1 score	MSE	Metrics num
250	1.00	0.00249	329
200	1.00	0.00215	329
150	0.98	0.00232	329
140	0.97	0.00279	329
130	0.88	0.00449	329
120	0.50	0.00676	329

Feature importance			
Detection time	F1 score	MSE	Metrics num
140	0.93	0.00444	1723
140	0.88	0.00411	1500
140	0.89	0.00326	1000
140	0.75	0.00592	500
140	0.79	0.00757	400
140	0.73	0.00626	329

- The difference from normal model has better performance than the feature importance model under the same condition.
- The differencing process was shown to be effective.

Feature analysis

Difference from normal model-specific metrics

```
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```
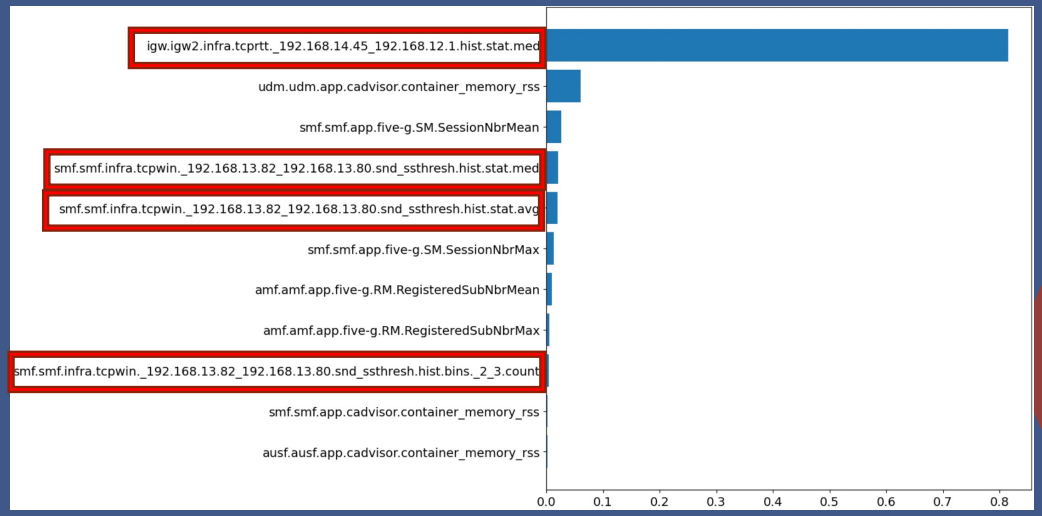

Feature importance

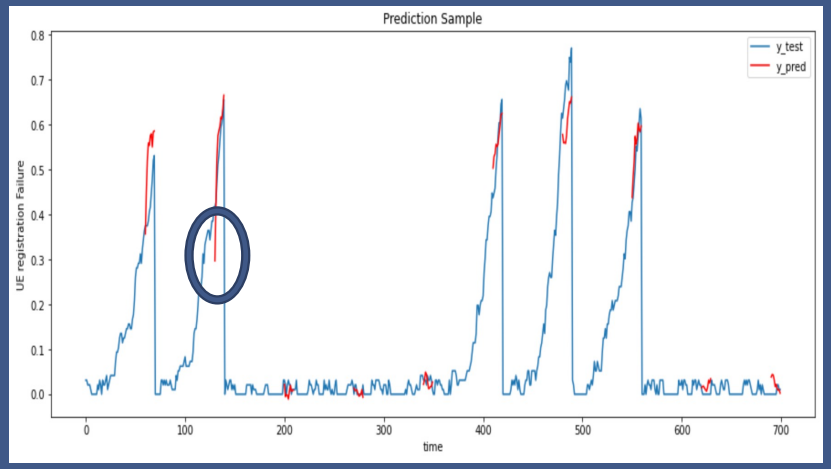


Count metrics are important

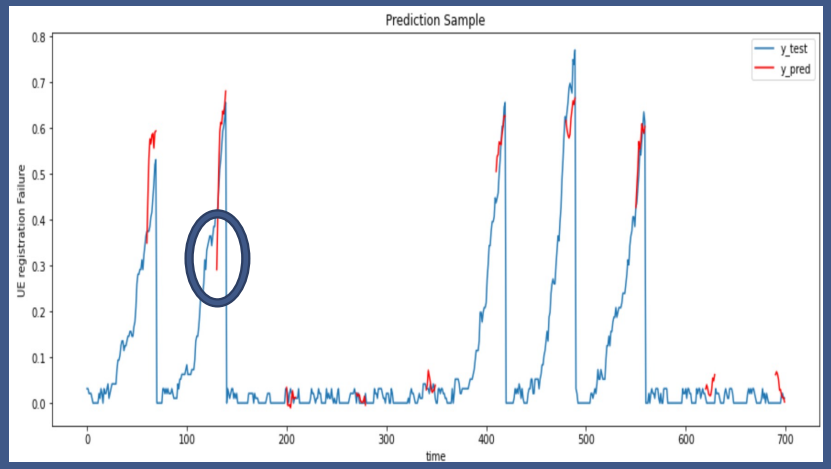
TCP metrics are important in loss failure

Visualization

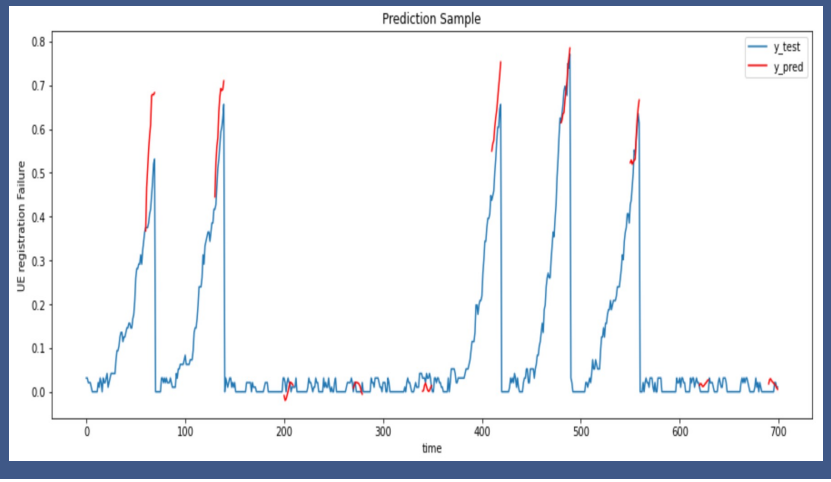
all model



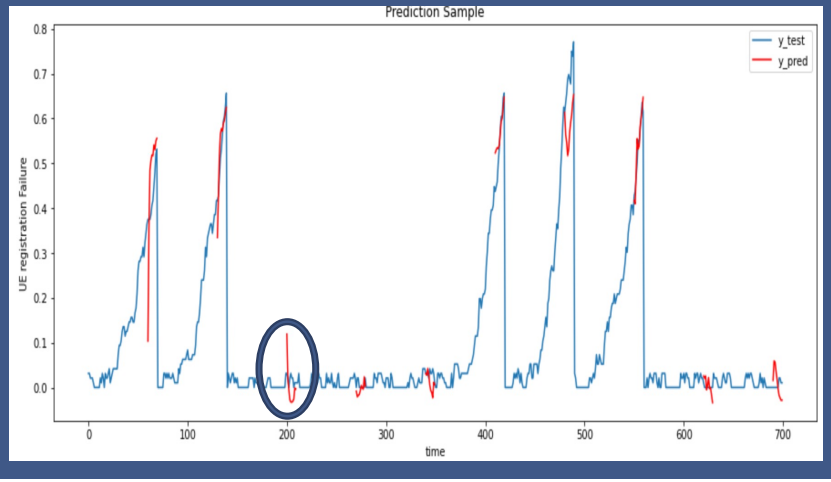
removed model



Difference from normal model



Feature importance model



Conclusion

Model name	Detection time (s)	F1 score	Metrics num
all model	150	0.91	3325
Removed model	140	0.92	1723
Difference from normal model	140	0.97	329
Feature importance model	140	0.93	1723

- The difference from normal model is the best solution.
- Successfully predicted with a detection time of 140s
- Improved model performance by reducing the number of features
- The model performance was most improved after reducing the number of features by 3,000

Future work

- Prediction for other failure scenarios such as CPU overload
- Predictions for different user traffic characteristics
- Analysis of metrics that are important for many factors such as failure scenarios, traffic characteristics, network size, network topology etc.
- Analysis of when the model will need to be re-trained or changed

Thank you for listening

The University of Tokyo Nakao lab M1
Takeru Hakii

Appendix Task1 Table

all			
Detection time	F1 score	MSE	Metrics num
250	1.00	0.00198	3325
200	1.00	0.00199	3325
150	0.91	0.00294	3325
140	0.89	0.00317	3325
130	0.80	0.00344	3325
120	0.44	0.00533	3325

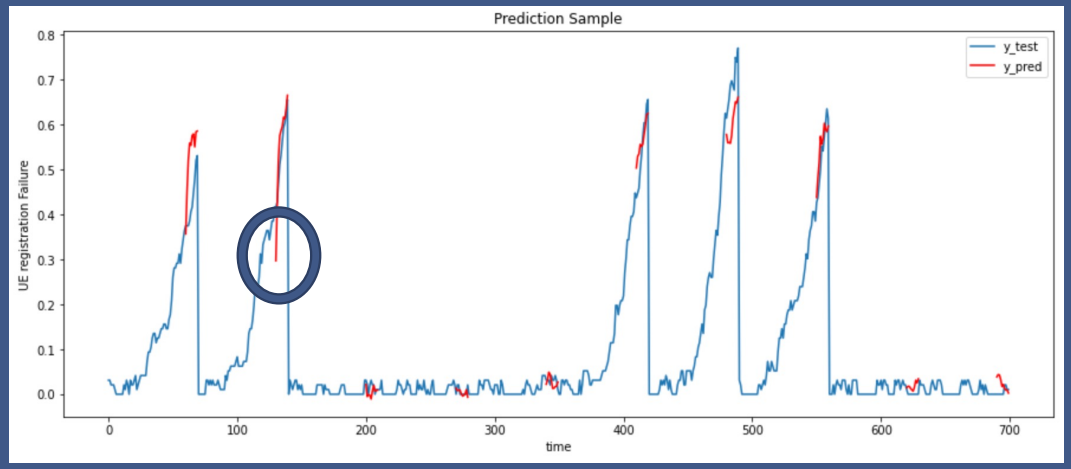
removed			
removed	F1 score	MSE	Metrics num
250	1.00	0.00196	1723
200	1.00	0.00209	1723
150	0.98	0.00268	1723
140	0.92	0.00301	1723
130	0.70	0.00498	1723
120	0.39	0.00606	1723

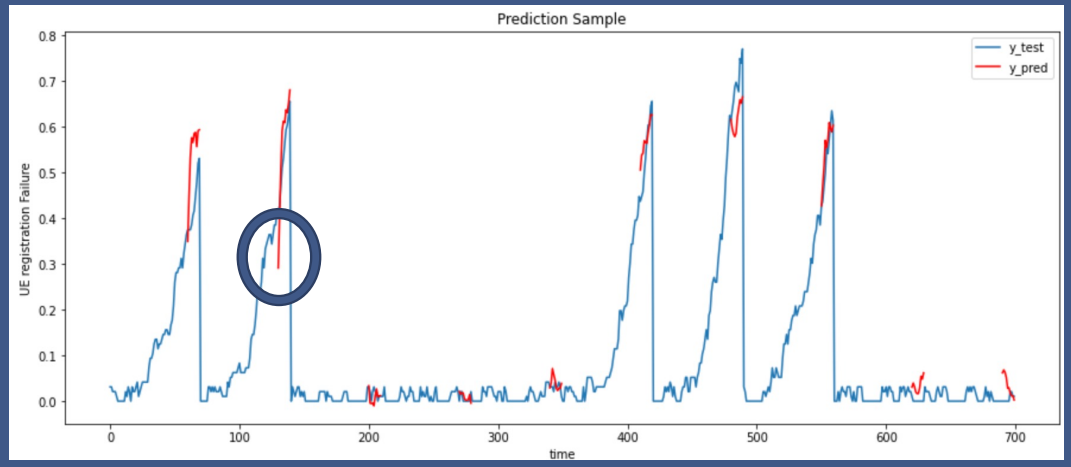
Successful prediction at detection time 150s by using all features

Successful prediction at detection time 140s by removing 0 metrics

The removed model has higher performance than the all model.

Appendix Task1 visualization





Both models may underpredict the number of UE registration failures at 600 seconds

Appendix Task2 Table

removed			
removed	F1 score	MSE	Metrics num
250	1.00	0.00196	1723
200	1.00	0.00209	1723
150	0.98	0.00268	1723
140	0.92	0.00301	1723
130	0.70	0.00498	1723
120	0.39	0.00606	1723

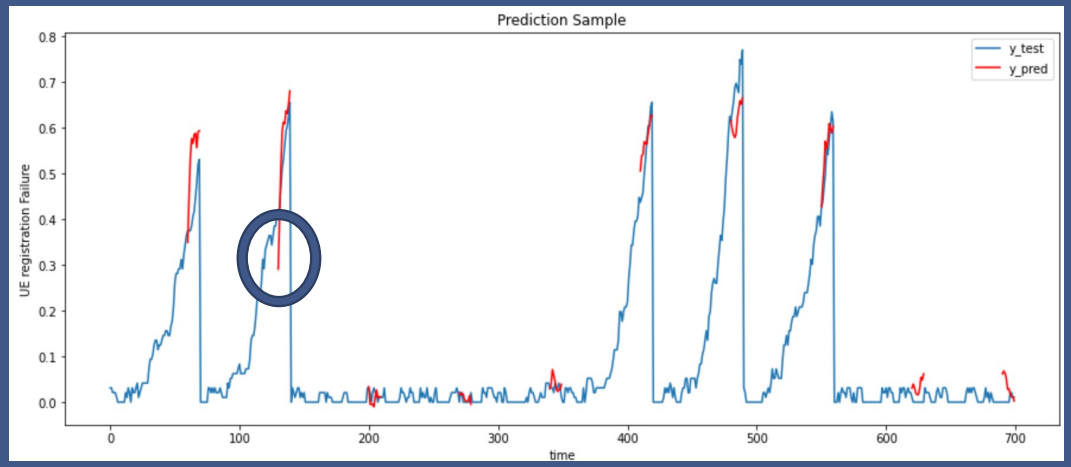
Diffenrence from normal			
diff	F1 score	MSE	Metrics num
250	1.00	0.00249	329
200	1.00	0.00215	329
150	0.98	0.00232	329
140	0.97	0.00279	329
130	0.88	0.00449	329
120	0.50	0.00676	329

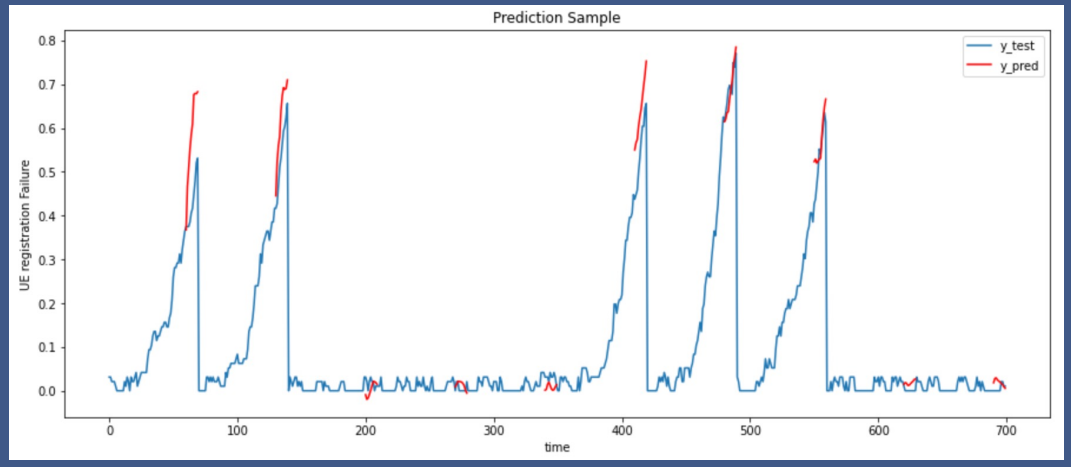
The F1 score for the diff model was 0.97 with detection time 140s.

The diff model has higher performance than the removed model.

The model with 3000 features reduced had the best performance.

Appendix Task2 visualization

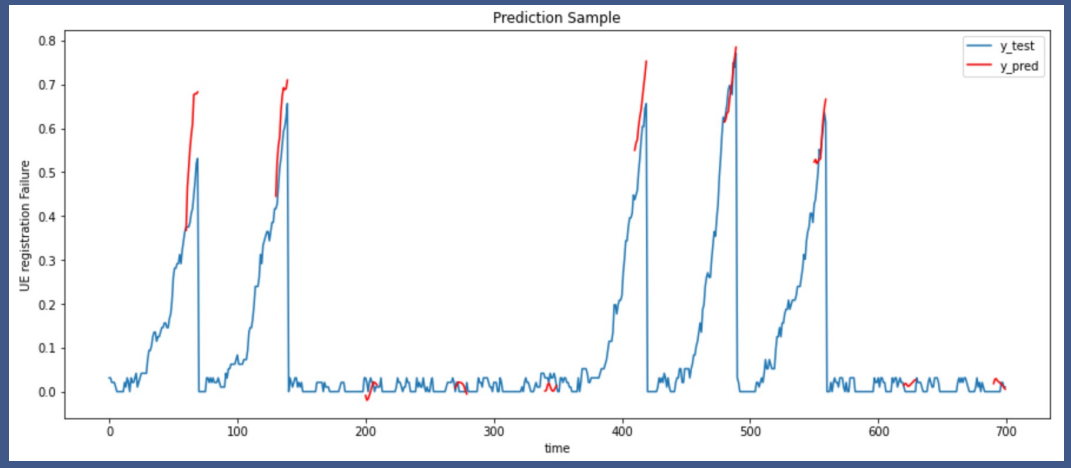


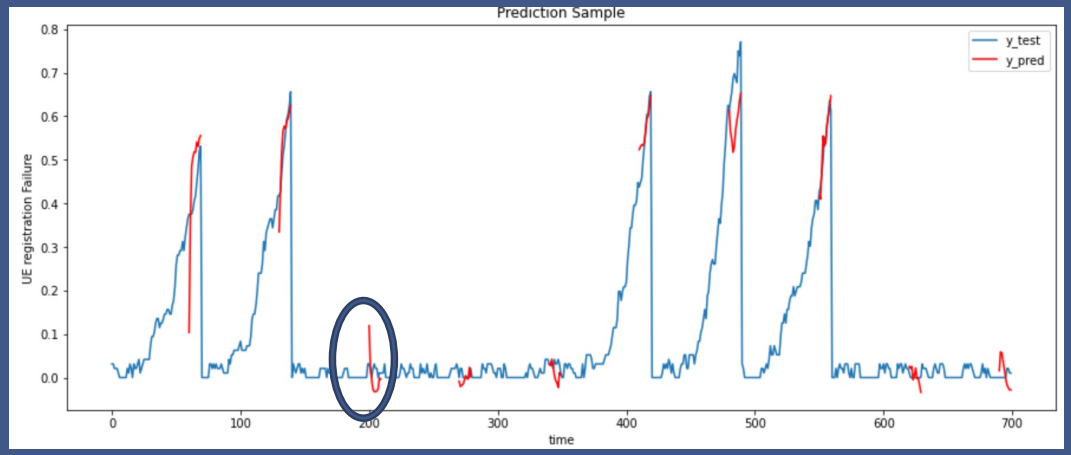


The removed model may underpredict the number of UE registration failures at 600 seconds.

The diff model may overpredict.

Appendix task2 visualization





The diff model predicts more accurately than the RF model.

The RF model does not accurately predict normal phase.