Mphasis
The Next Applied

Quantum Computing at Mphasis

March 8, 2021

Quantum Computing @ Mphasis

Quantum Research & Innovation Framework	Mphasis EON (Energy Optimized Network) driven solutions ranging form Quantum Consulting, Assessment, Workshops and Quantum Algorithm Development.		
Quantum Computing Applications & Use Cases	**Quantum Optimization** • Vehicle Routing Optimization • Traffic Optimization • Financial Services Portfolio optimization • Social Network Analysis	**Quantum Machine Learning** • Supply Chain Demand Prediction • Computer vision, Image, Video, Voice analytics	**Quantum Simulation & Modeling** • Cybersecurity • Drug Development • Human mobility modeling
Multiple Partners & Constituents of Quantum Computing bringing the compute capabilities			

Consulting Assessment Workshops and Algorithm Development

Quantum Consulting Assessment Workshop

Mphasis Quantum Consulting is a 3 weeks engagement

- To help clients evaluate software and hardware requirements for quantum engagements
- Fine tune identified use cases and set up the environment for **Quantum Algorithm Development**

Above objectives are achieved via:

- Leveraging our well designed **qualitative and quantitative questionnaire** for feasibility analysis of business relevant use cases
- Utilizing our **week-long quantum workshops** driven by quantum computing experts to:
  - Identify and prioritize business relevant use cases
  - Propose recommended quantum infrastructure

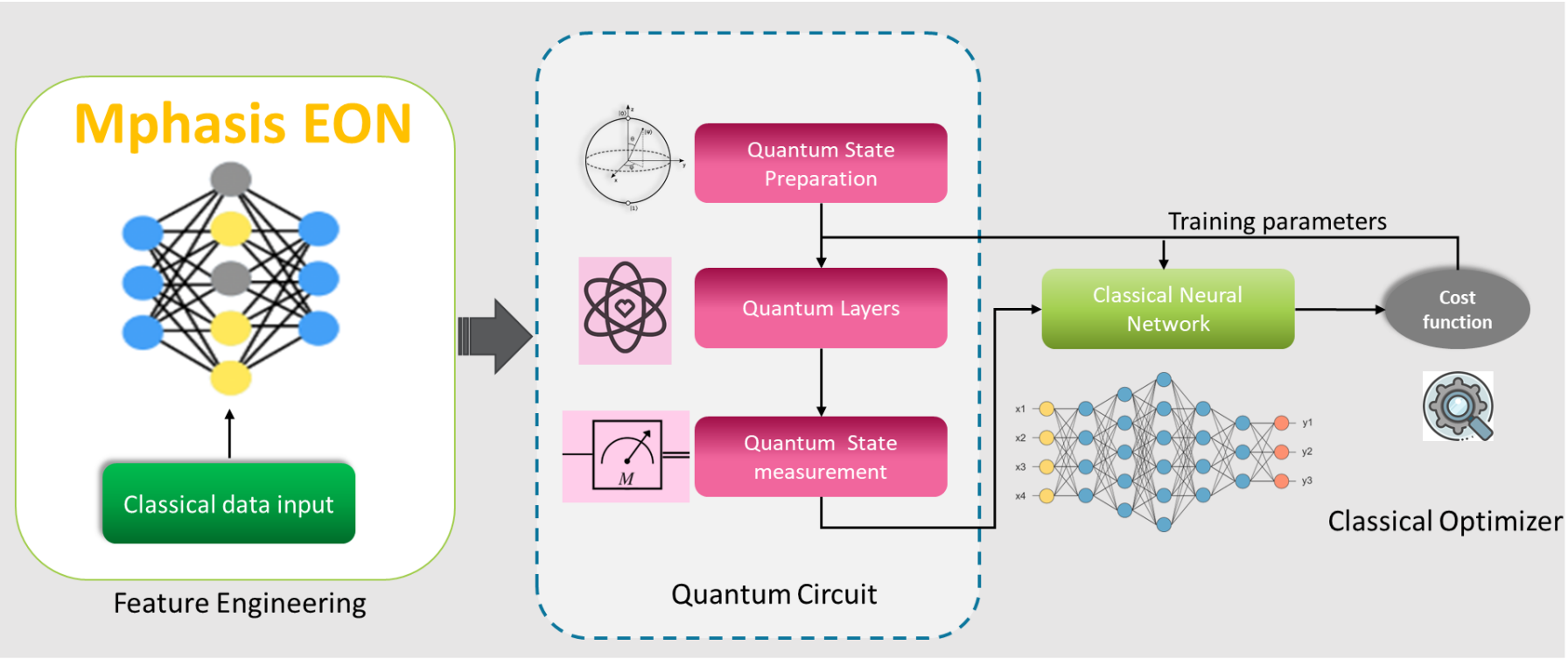
Quantum Algorithm Development

- Quantum Algorithm Development is a 2-3 months long engagement where our IP is customized to solve specific client problems
- Our quantum services are powered by patent pending framework Energy Optimized Network (Mphasis EON).
- Following are the salient features of our Quantum solution development framework:
  - The framework consists of Quantum assisted Machine Learning using **Quantum Circuits and Deep neural network layers**
  - Mphasis EON, the core engine of our framework:
    - Helps handle variety and volume of big data associated with real world problems
    - Prepares enhanced features from classical data suitable
    - Learns complex data patterns and performs quantum predictive tasks in an iterative mode accurately and quickly
    - Optimizes information representation using feature space transformation and batch sampling.

3 MPHASIS AI PLATFORMS, TOOLS, ACCELERATORS

Mphasis EON (Energy Optimized Network)

Mphasis EON (Energy Optimized Network) is our patent pending, classical-quantum hybrid network, consisting of energy optimization, quantum circuit and deep neural network layers. Mphasis EON is built to efficiently solve Machine learning problems using Quantum Computers by managing, preparing and learning from big data.



Need fewer Qubits

Reduced information loss

Reduced training time

4 CASE STUDIES

QUANTUM COMPUTING EXPERIMENTS

Problem	Description	Quantum Achievement	Algorithms
Distributional Supply Network Optimization	• Facility location problem • Select best among potential sites to equip with services, while minimizing costs.	• Around 400% improvement in Prediction time	Classical Simulated Annealer, Simulated Annealer, Hybrid Solver
Portfolio Optimization and Asset Allocation	• Maximizing portfolio return while minimizing risks	• 76.65 % Reduced Time taken in optimization • 2.29 % Better result for same no. of annealing steps • 5.6 % Increased Portfolio Return	Simulated Annealing, Hybrid Solver
Damaged Shipment Classification	• Predicting damaged/not damaged shipment images using computer vision	• 12.34% improvement in test accuracy • 325 % improvement in training time • 3.44 % improvement in test time	Image transformation + Transfer learning + quantum circuit layers + DNN (Hybrid QML model)
News Headlines Sentence Clustering	• Clustering of similar news headlines together to analyze the trends of news	• 98.75% improvement in Training time • 80% improvement in Testing time • 8% improvement in coherence score	QUBO HSS solver, QPU solver, K-means clustering
Covid 19 News Sentiment Analysis	• Categorizing the sentiment of the new headlines into Positive, Negative and Neutral	• 4% improvement in accuracy • 94% improvement in Training time • 98.57% improvement in Testing time	Qboost HSS solver, BERT, Qboost (Pure)

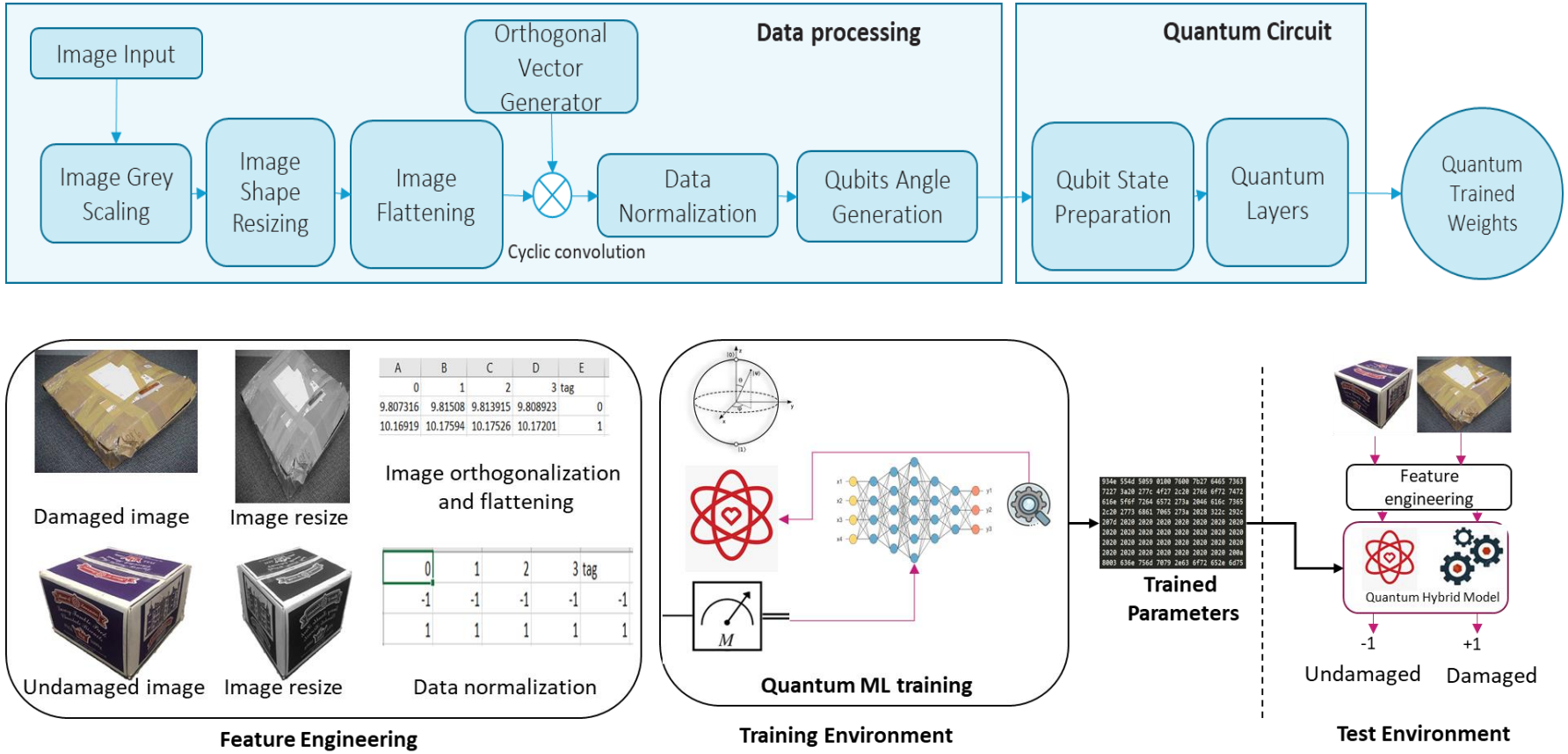
QUANTUM COMPUTING EXPERIMENTS

Problem	Description	Quantum Achievement	Algorithms
Resource Allocation Optimization	• Problem is to select a set of trajectories that complete all repairs of machine while minimize the congestion across all resources.	• The time takes to get results from classical system is 40x more than the time taken to get the quantum results	Classical Simulated Annealer, Simulated Annealer, Quantum Solver
Freight Route optimization	• identify the optimal route to transfer packages through available destination routes, with minimum operational cost, maximum capacity utilization of legs	• The time takes to get results from classical system is 25x more than the time taken to get the quantum results	Classical Simulated Annealer, Simulated Annealer, Quantum Solver
Capacitated Vehicle Routing Optimization	• Obtain optimal route and number of trucks to minimize the cost function	• 68.74 % Reduced Time taken in optimization	Genetic algorithm, Hybrid Solver
Time Series Forecasting	• Time Series Demand Forecasting problem • Predict the future 36 months of demands for the provided SKUs	• 2% Improved prediction percentage error achieved on 6 month future forecast.	Timeseries decomposition + Quantum circuit + Deep learning (Hybrid QML framework)

Damaged Shipment Classification– Feature Decomposition

Classify shipment boxes into either damaged or not damaged categories

- Image preprocessing
- EON: Image orthogonalization through convolution
- Quantum variational classifier
- Quantum ML pipeline



	Accuracy(%)
With EON	100
Without EON	41

- Training sample: 132
- Validation of model: 23
- Prediction on new images: 10

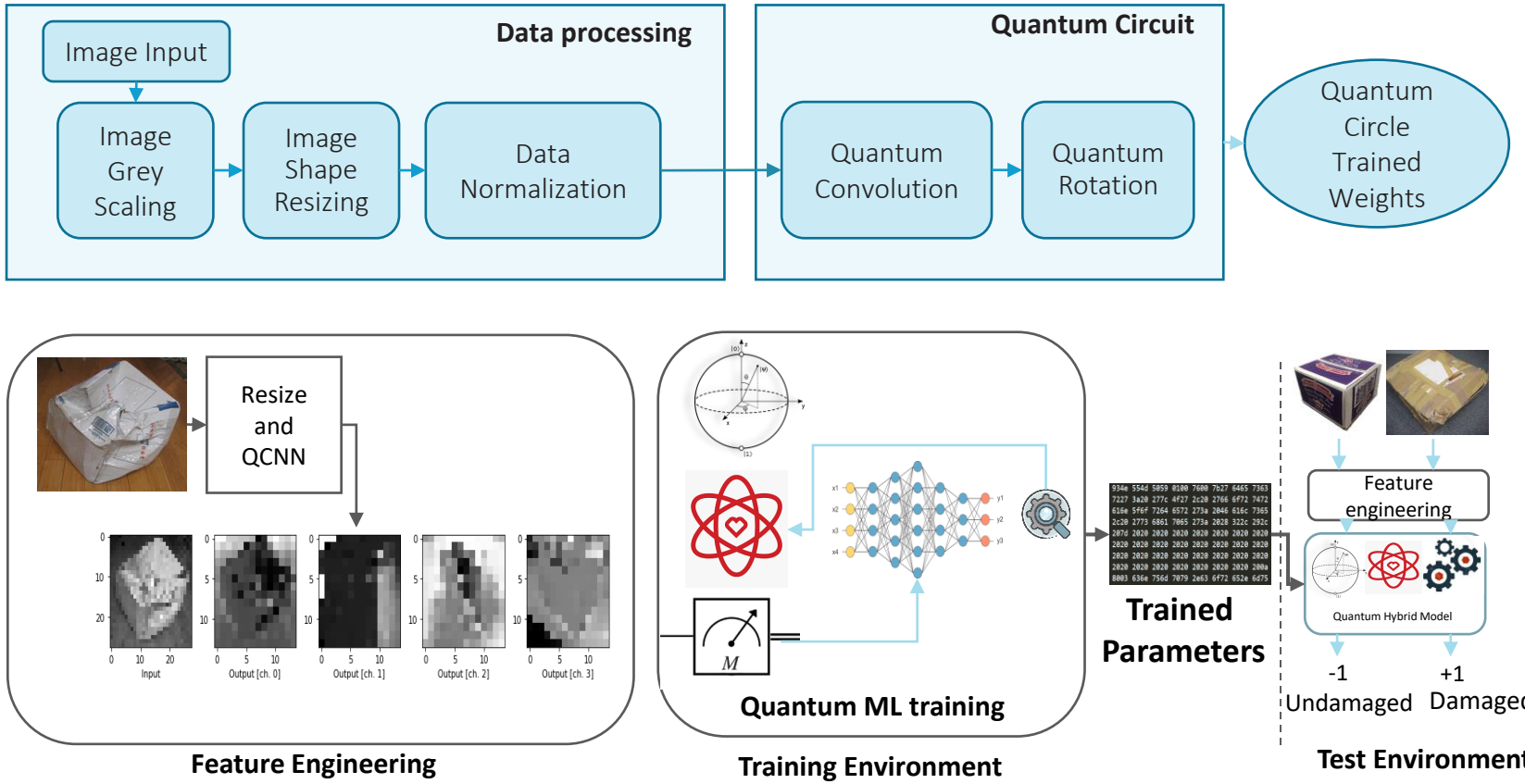
Damage Shipment Classification: Classical ML Vs Quantum ML

	Google Auto ML	EON powered QML
Training time (Sec)	8820	875
Training accuracy (%)	94.7	100
Validation accuracy (%)	82.6	100
Prediction accuracy (%)	9 out of 10	All 10

Damaged Shipment Classification – QCNN

Classify shipment boxes into either damaged or not damaged categories

- Image preprocessing
- EON: Feature transformation, Resizing
- Quantum CNN
- Integrated DL-QML pipeline



	Accuracy(%)
With EON	81.25
Without EON	50

- Training sample: 132
- Validation of model: 23
- Prediction on new images: 10

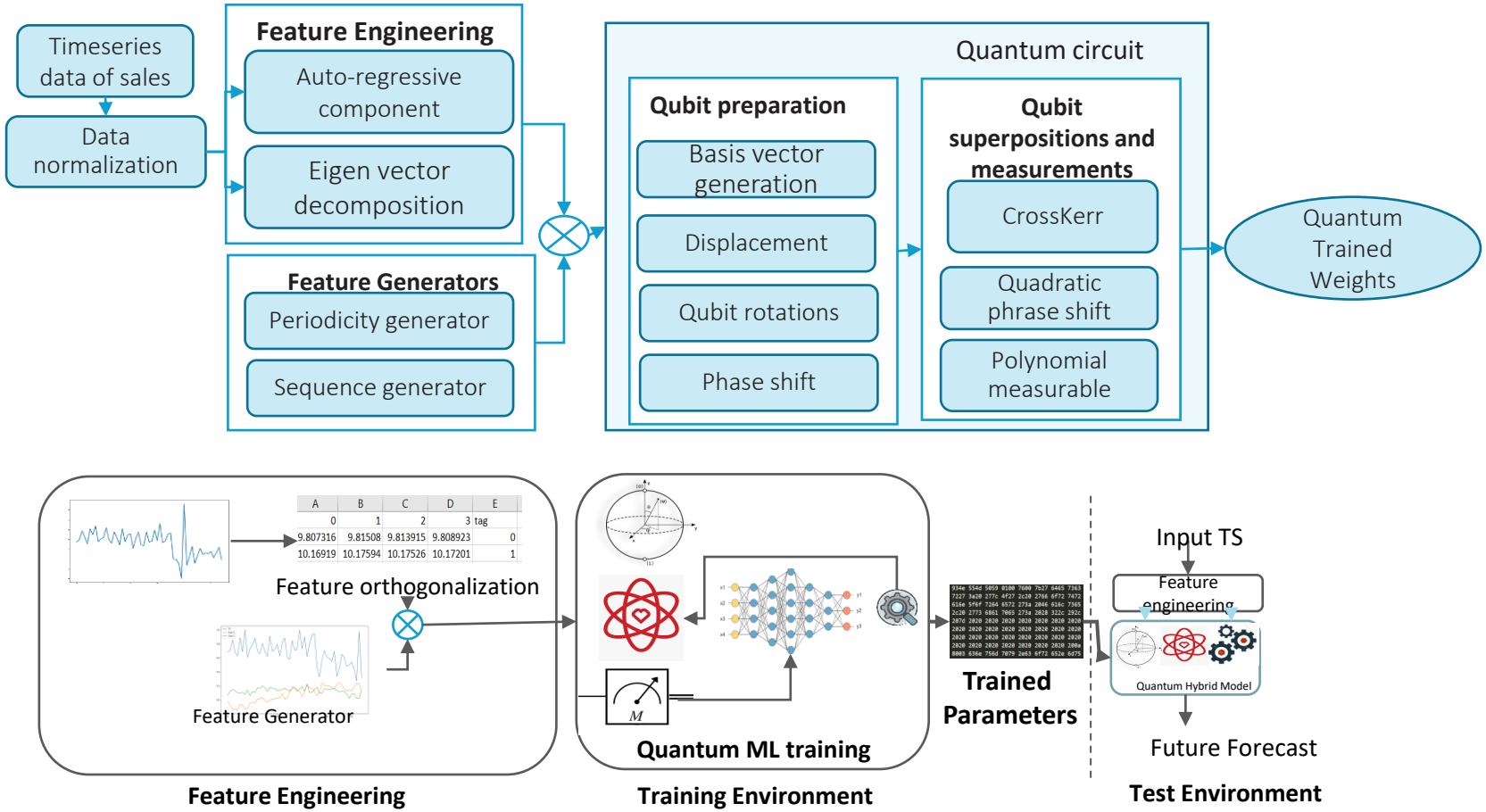
Image Classification – Traditional CNN Vs. QCNN

	CNN	EON powered QML
Training accuracy (%)	73.89	99.36
Test accuracy (%)	50.00	81.25
Prediction accuracy (%)	5 out of 10	7 out of 10

Time Series Demand Forecasting

Forecast future demand using historic global demand data

- Time Series Forecasting
- EON: Vector decomposition and learning, Wave fit for seasonality
- Quantum function fit
- Quantum ML pipeline



	% of Wins over ML
With EON	62
Without EON	36

- Number of SKUs for forecasting: 10
- Size of timeseries: 53 months of sales for each SKU
- Train: 47 months data
- Forecast: Next 6 months
- Number of traditional trained: 42

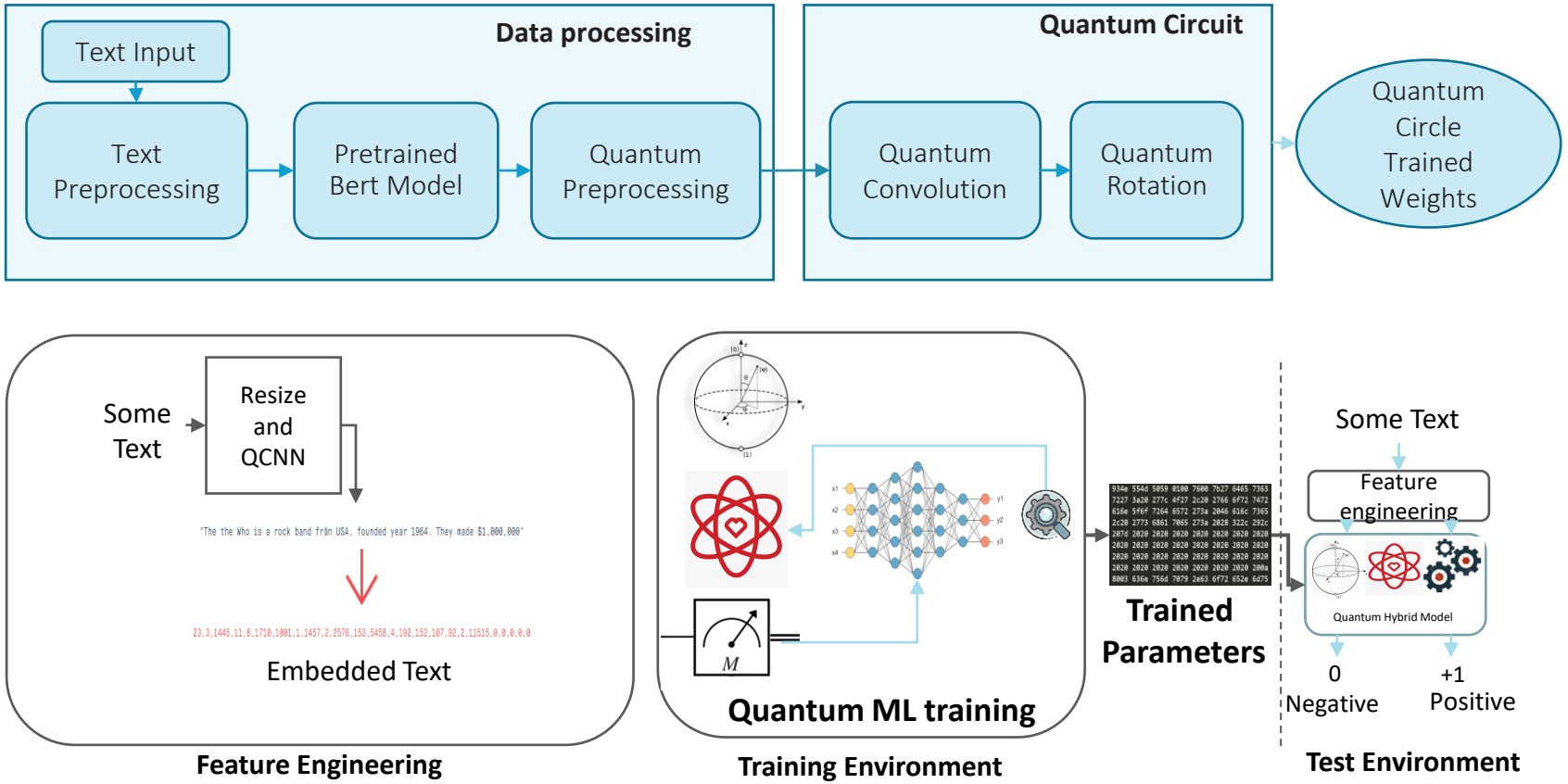
Traditional Time Series Vs. Quantum function fit

- Number of SKUs for forecasting: 10
- Size of timeseries: 53 months of sales for each SKU
- Train: 47 months data
- Forecast: Next 6 months
- Number of traditional models used in past: 42

Models on which EON powered QML won (Out of 42)		
ID	# models	% of win
SKU1	24	57.14%
SKU2	39	92.86%
SKU3	22	52.38%
SKU4	23	54.76%
SKU5	42	100.00%
SKU6	30	71.43%
SKU7	28	66.67%
SKU8	30	71.43%
SKU9	19	45.24%
SKU10	30	71.43%

Sentiment Analysis - QCNN

Classify text input into either positive or negative sentiment



- Text preprocessing
- EON: Embedding and Autoencoder
- Quantum CNN
- Quantum ML pipeline

	Accuracy(%)
With EON	84
Without EON	67

- Dataset: COVID 19 News Headlines
- Training set size: 1216
- Validation set size: 304

Sentiment Analysis: Traditional ML Vs. Quantum Sentiment

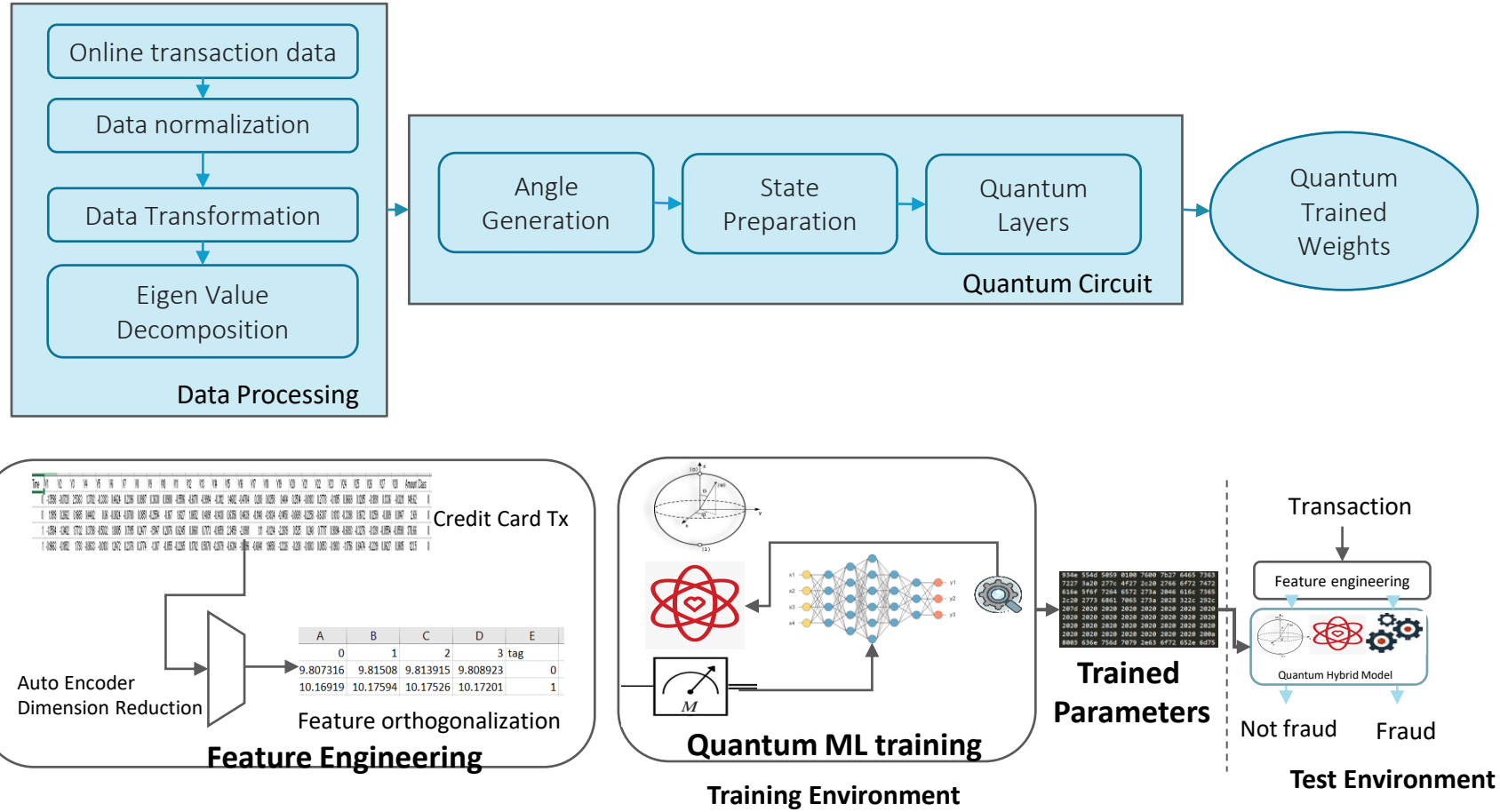
	Traditional	EON powered QML
Training accuracy (%)	96	97
Validation accuracy (%)	82	84

Anomaly Detection

Classify shipment boxes into either damaged or not damaged categories

- Preparing Quantum data using Mphasis EON
- Quantum circuit design
- Quantum ML training
- Variational Classifier

- We were able to detect 3 out of 10 fraudulent transactions
- Need some more work



Data set Details

- Data set source: Kaggle
- Total transactions: 284807
- Fraudulent Transactions: 492
- Dataset is not balanced

Anomaly Detection (Contd.)

- Total transactions: 284807
- Fraudulent Transactions: 492
- Dataset is not balanced

	Quantum Circuit
Training accuracy (%)	88.4
Validation accuracy (%)	88.2
Prediction accuracy (%)	12.60

Conclusion

- Results of Quantum Machine Learning are encouraging
  - Data of different nature are handled for Quantum algorithms: Image, Text, Timeseries data
  - The results of image classification and Time series forecasting are promising and match the existing framework/techniques
  - Very good model accuracy and reduced training time compared to classical counter parts

- Currently, there is a limitation on the number of qubits available, which may result in
  - Increased training time
  - Information loss due to data transformation, especially while handling large set of attributes

Mphasis
The Next Applied

THANK YOU

About Mphasis

Mphasis (BSE: 526299; NSE: MPHASIS) applies next-generation technology to help enterprises transform businesses globally. Customer centricity is foundational to Mphasis and is reflected in the Mphasis' Front2Back™ Transformation approach. Front2Back™ uses the exponential power of cloud and cognitive to provide hyper-personalized ($C=X2C^2_{TM}=1$) digital experience to clients and their end customers. Mphasis' Service Transformation approach helps 'shrink the core' through the application of digital technologies across legacy environments within an enterprise, enabling businesses to stay ahead in a changing world. Mphasis' core reference architectures and tools, speed and innovation with domain expertise and specialization are key to building strong relationships with marquee clients. Click here to know

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