AI for IT™

Building Autonomous Network Operation using Deep Learning and AI

Jisheng Wang, PhD
Senior Director of Data Science

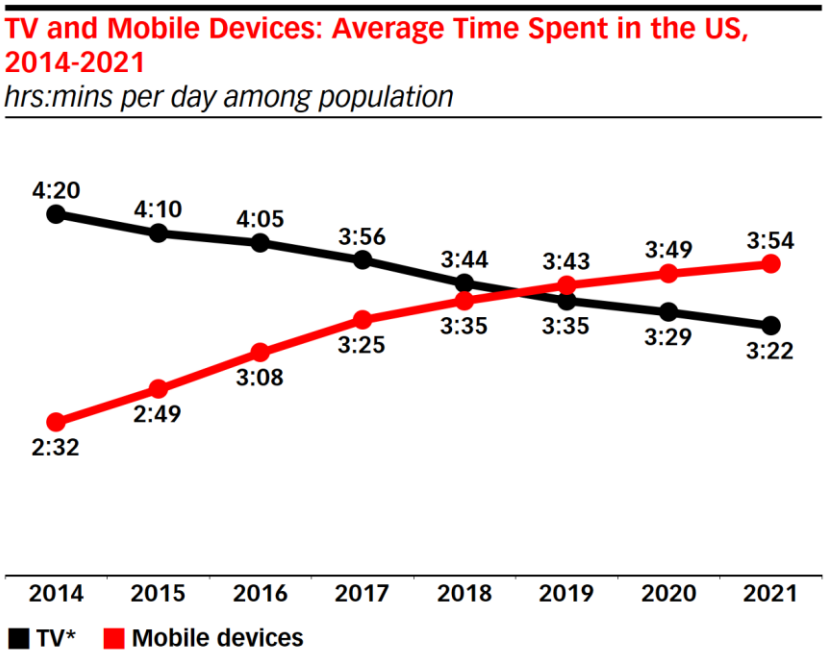
Ebrahim Safavi, PhD
Senior Data Scientist

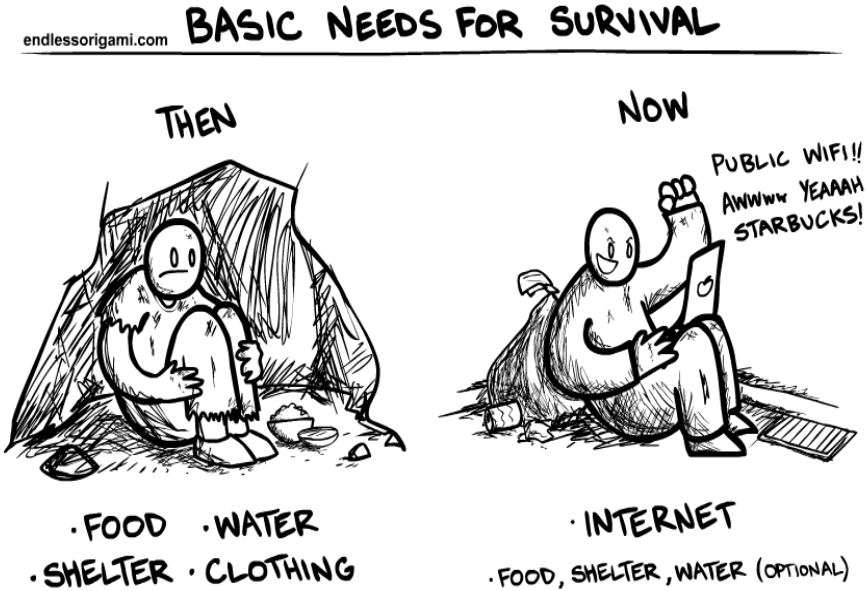
Juniper Networks | Mist A Juniper Company

©2019 Mist Systems, a Juniper company

- ***Opportunities and Challenges of Enterprise IT***
- Self-Driving Network: Framework
- Deep multivariate Anomaly Detection

WiFi is Basic Need for Human Survival





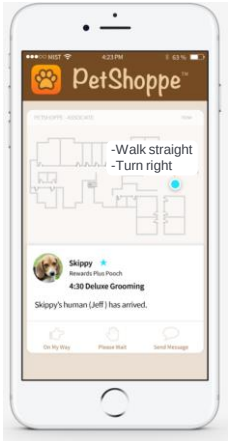
Stats collected from emarketer.com
Image from davidknappfisher.com

©2019 Mist Systems, a Juniper company

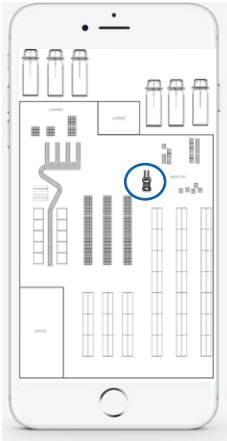
WiFi is Key for Business Success

Personalized greetings and notifications

Location based alerts and directions



Asset visibility and traffic analytics



Retail

Hospitality

Healthcare

Education

Warehouses

©2019 Mist Systems, a Juniper company

New Challenges for Enterprise IT Team

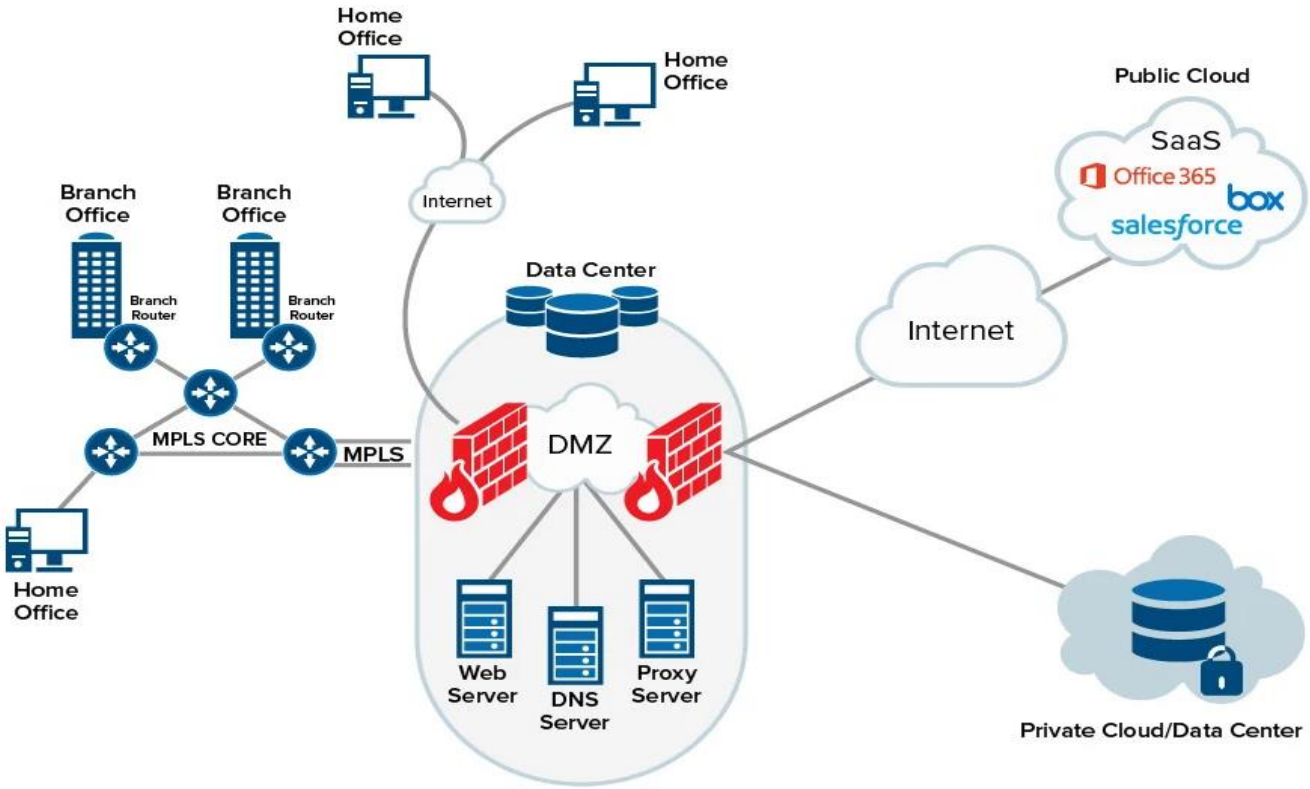
Growing number of devices with 5G and IoT

Cloud-driven dynamic and flexible environments

Workload and complexity exceeding human abilities

©2019 Mist Systems, a Juniper company

Architecture of Modern Enterprise Network



©2019 Mist Systems, a Juniper company

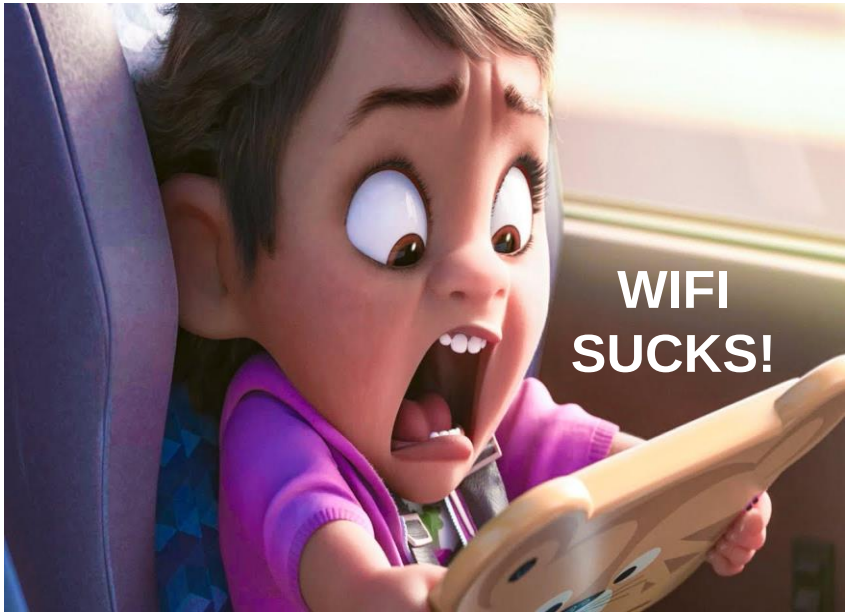
Image from blog.thousandeyes.com

What the Best Enterprise Network Should Be?

©2019 Mist Systems, a Juniper company

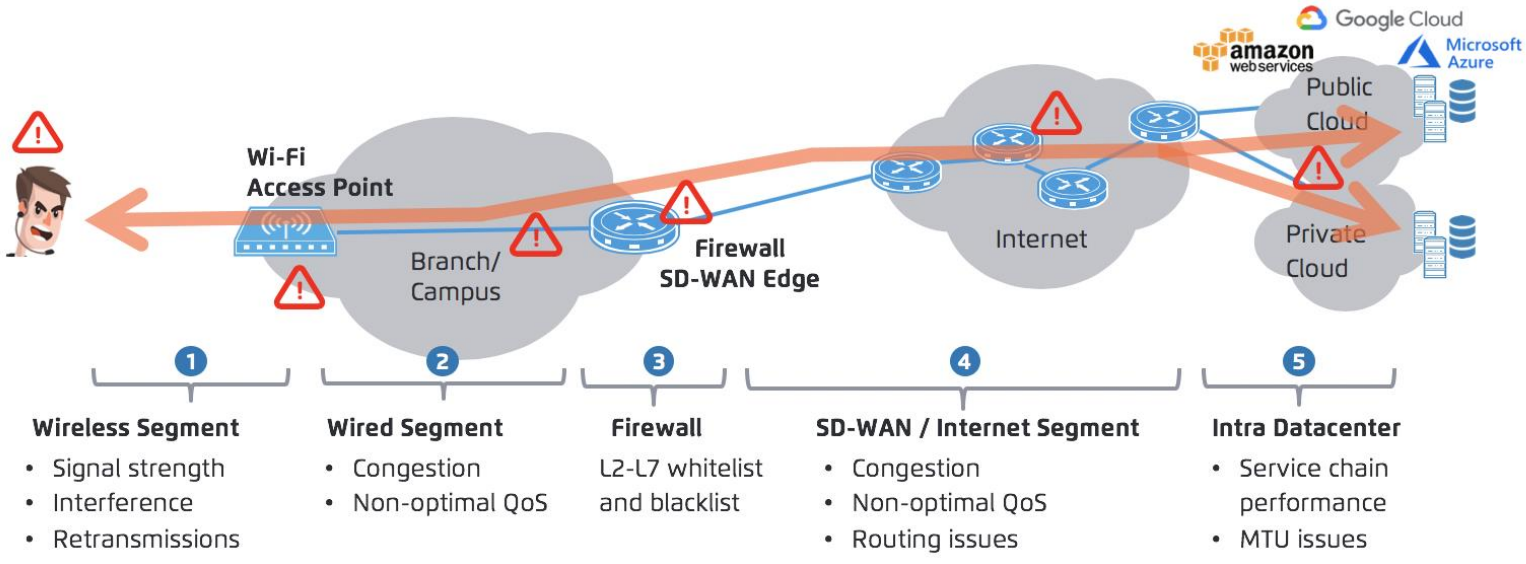
Image from blog.thousandeyes.com

It’s Not Always WiFi



©2019 Mist Systems, a Juniper company

What Could Possibly Go Wrong End-to-End?



How Do We Detect and Fix These Issues Automatically?

©2019 Mist Systems, a Juniper company

Image from www.netrounds.com

- *Opportunities and Challenges of Enterprise IT*
- ***Self-Driving Network: Framework***
- Deep multivariate Anomaly Detection

How to Build an Enterprise AI

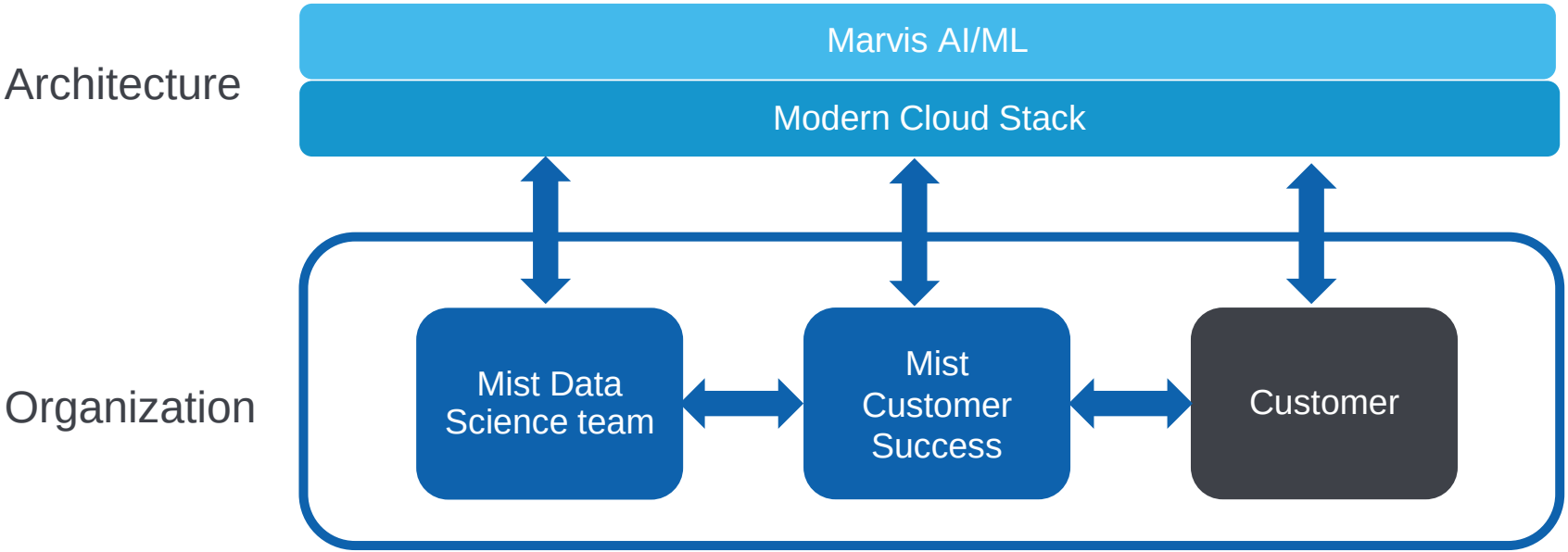
Start with real problems

Keep human in the loop

Build a step-by-step process for continuous improvement

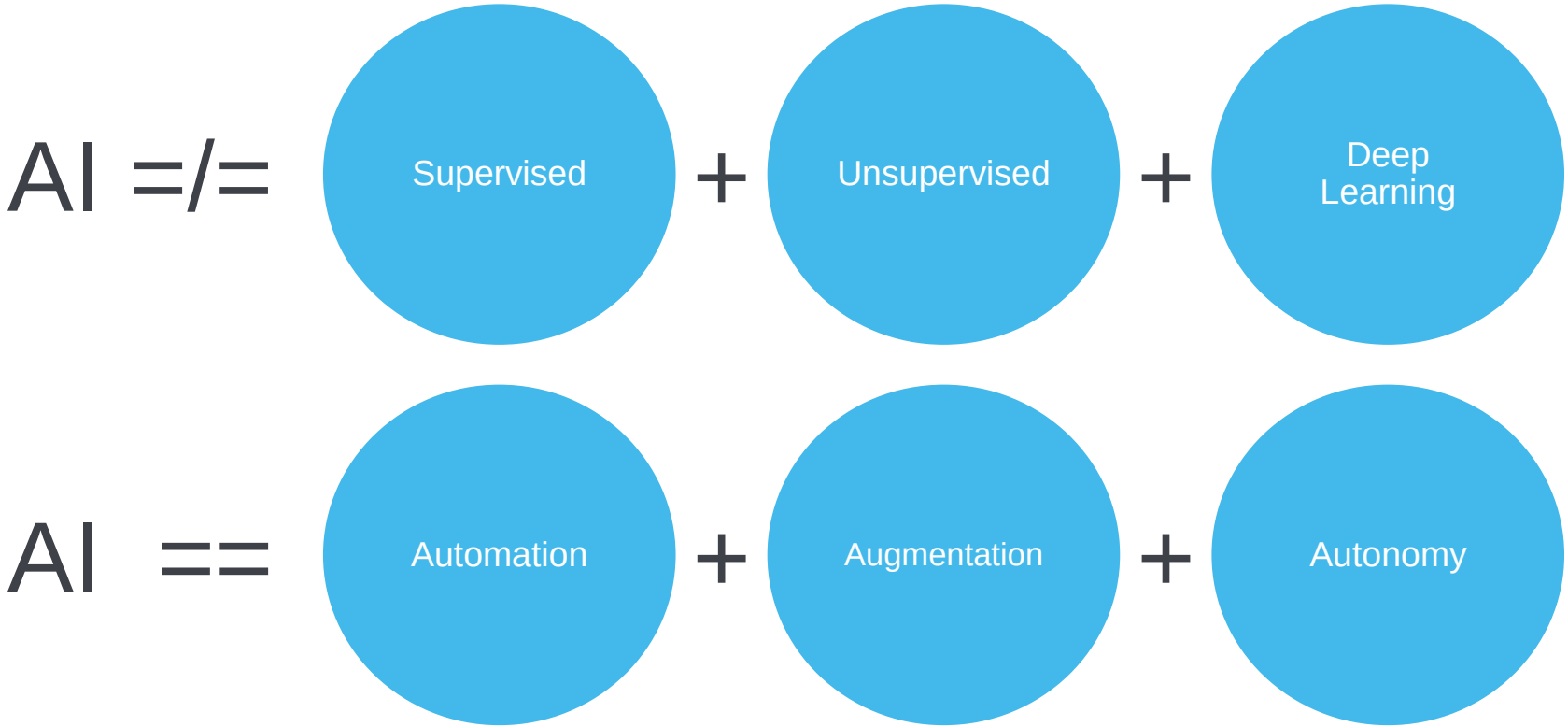
©2019 Mist Systems, a Juniper company

AI-Driven Customer Support Model



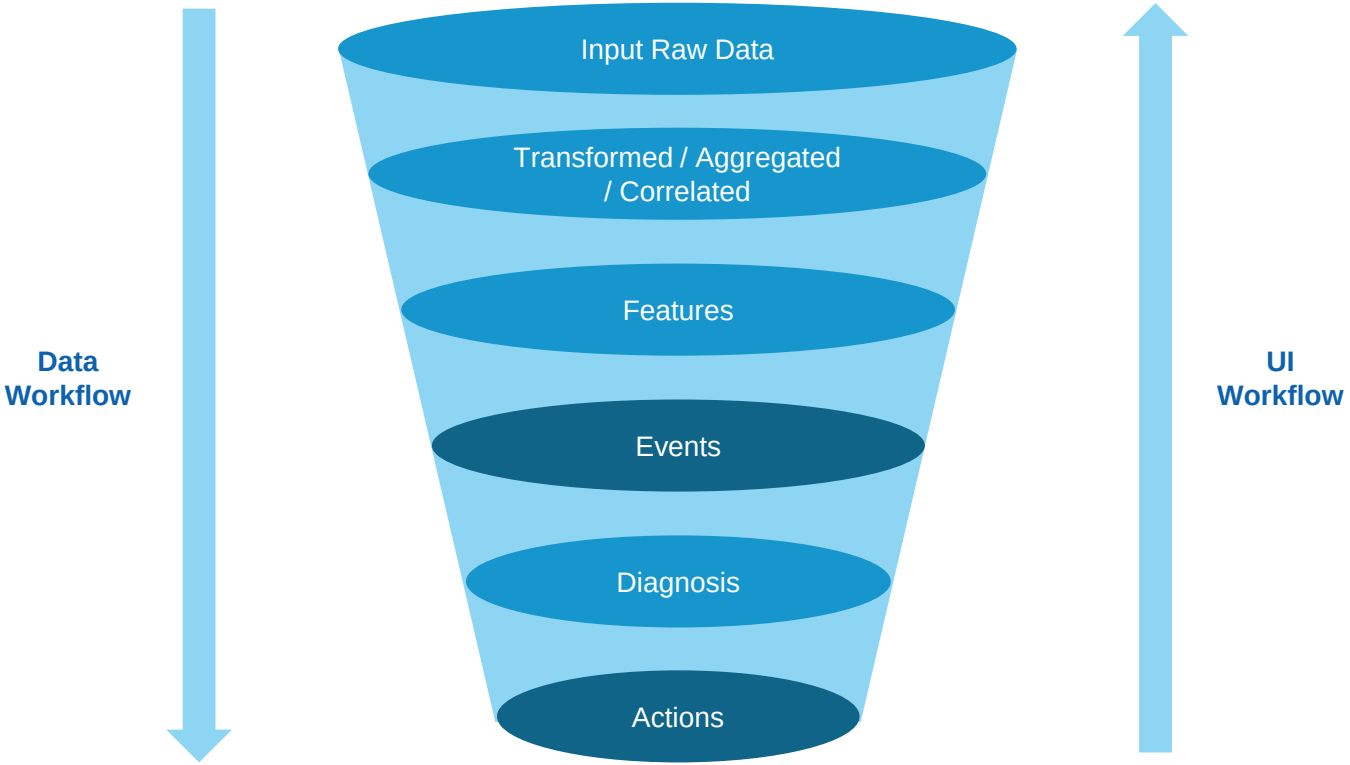
©2019 Mist Systems, a Juniper company

Building AI is a Step-by-Step Process



©2019 Mist Systems, a Juniper company

Data Funnel - From Inputs to Actions



©2019 Mist Systems, a Juniper company

Event Action Framework

DATA	EVENTS	DIAGNOSIS	ACTIONS
Time-series stats / Events / Config / Logs	Monitoring and Baselining	Spatial / Scope Analysis	Automated Actions
User / Application / Network Device	Incident / Health Events (heuristics, supervised)	Temporal Event Correlation	Suggested Actions
Transform / Correlate / Aggregate	Anomaly Detection (unsupervised)	Cross Entity Correlation	Troubleshoot Assistant

Cloud-Based Distributed (Micro-Services) Software Architecture

(AWS/GCP, Mesos, Kafka, Storm, Spark, Airflow, ElasticSearch, Cassandra, TensorFlow, Keras, Spark MLlib)

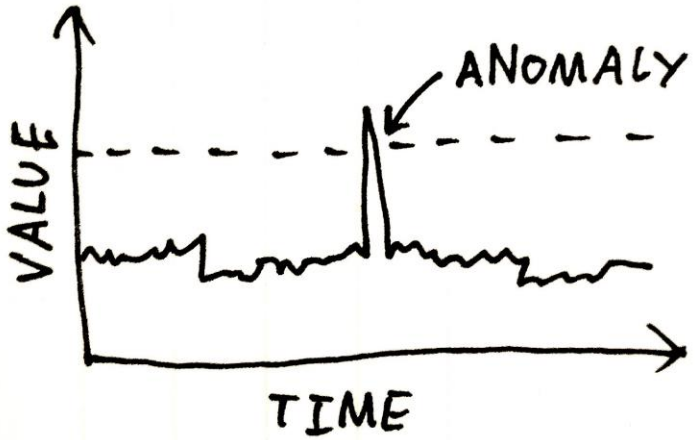
©2019 Mist Systems, a Juniper company

- Opportunities and Challenges of Enterprise IT
- Self-Driving Network: Framework
- ***Deep multivariate Anomaly Detection***

Anomaly Detection

Temporal-Spatial Information

Proactive monitoring

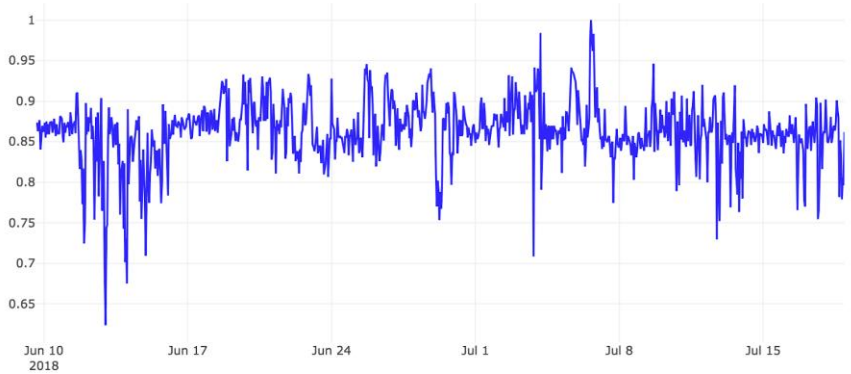


©2019 Mist Systems, a Juniper company

Anomaly Detection

Model iterations at Mist:

- Heuristic models
- Moving average
- Online ARIMA
- LSTM Neural Networks



©2019 Mist Systems, a Juniper company

Anomaly Detection-Data

Baselining Key Performance Indicators:

- 10K+ sites
- Variety of patterns
- Multivariate timeseries
- $Input = Vector_{in}(t)$

©2019 Mist Systems, a Juniper company

Key Performance Indicators

What feature users care about?

- Statistical Anomaly Vs. User Impacting anomaly
  - ***Working closely with beta customers!***

- **Service level features:** *Failure, Success, Unique Clients, Unique Impacted Clients*

- **Seasonality features:** *Hour of day, Day of week*

- **State features:** *Network specific features*

©2019 Mist Systems, a Juniper company

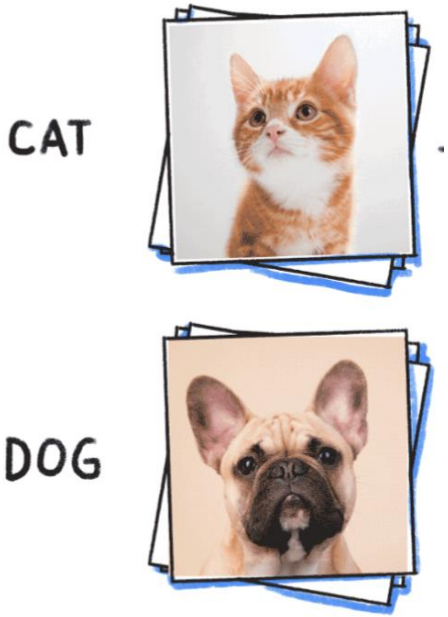
Challenges: Labeled Data

Challenges

- What is abnormal?
- Labeled anomaly data

Decoupling Prediction and Detection

- What is normal?
- Semi-Supervised prediction
- $x(t) \rightarrow \text{PM} \rightarrow x(t+1)$



©2019 Mist Systems, a Juniper company

Challenges: Confidence Prediction

Model Uncertainty: Models are unable to capture all the behavior of the input and outputs

How certain is the model about it's outcome?!

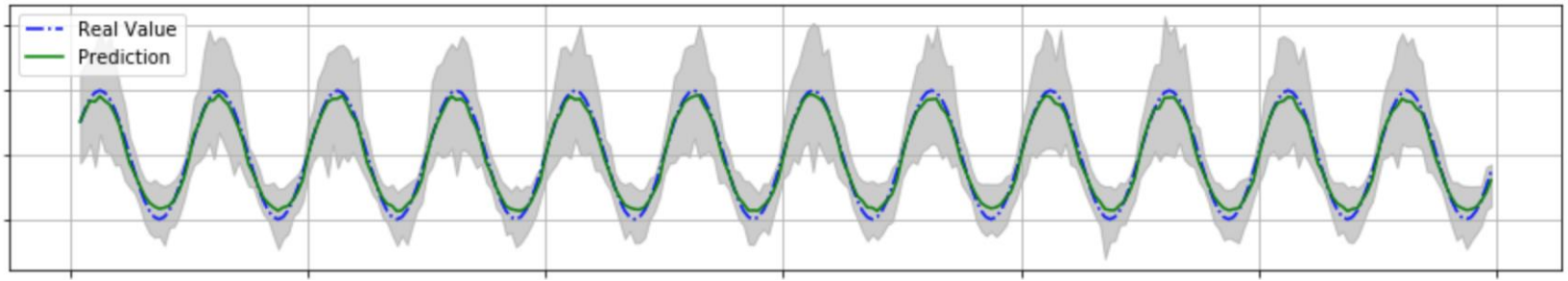
What is the distribution of the output?

©2019 Mist Systems, a Juniper company

Confidence Prediction

Bayesian Neural Networks

- Monte Carlo Dropout
- Dropout during inference
- ***B*** samples $\left\{\widehat{y}^{*}_{(1)}, \ldots, \widehat{y}^{*}_{(B)}\right\}$
- Sin wave test
  - *Not very good!*

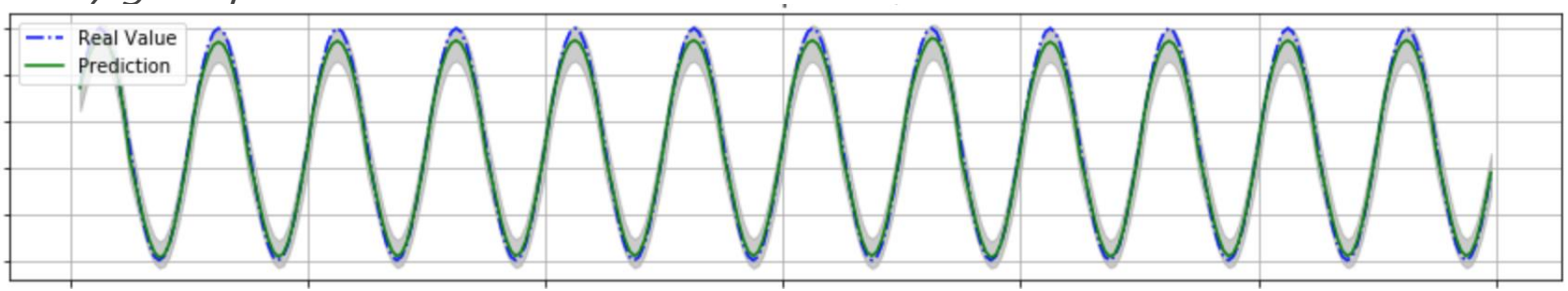


©2019 Mist Systems, a Juniper company

Confidence Prediction cont.

Injecting noise at input, and measuring noise distribution at output

- Sliding time window with uniform distribution
- Augmented output: **(min, average, max)**
- $x(t) \rightarrow \text{LSTM} \rightarrow x^{Aug}{}_{out}(t+1)$
- Sin wave test
  - *Very good performance!*



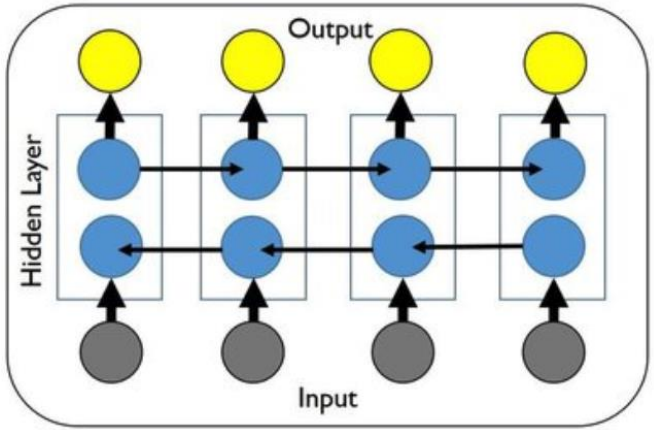
©2019 Mist Systems, a Juniper company

Multivariate Time-Series Detection Model

Predictive model:

$Vector_{in}(t) \rightarrow \text{PM} \rightarrow Vector^{Aug}{}_{out}(t+1)$:

- BiLSTM layer(100 hidden node)
  - Recurrence 12 (hours)
- Dropout
- Dense layer
- 27K parameters

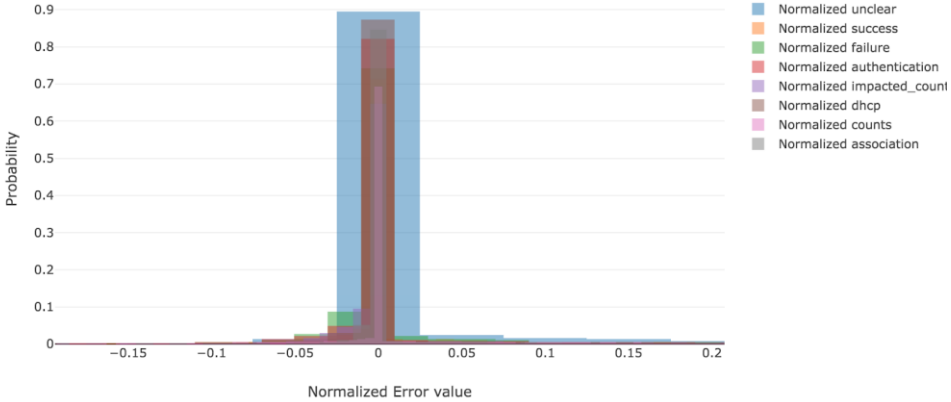


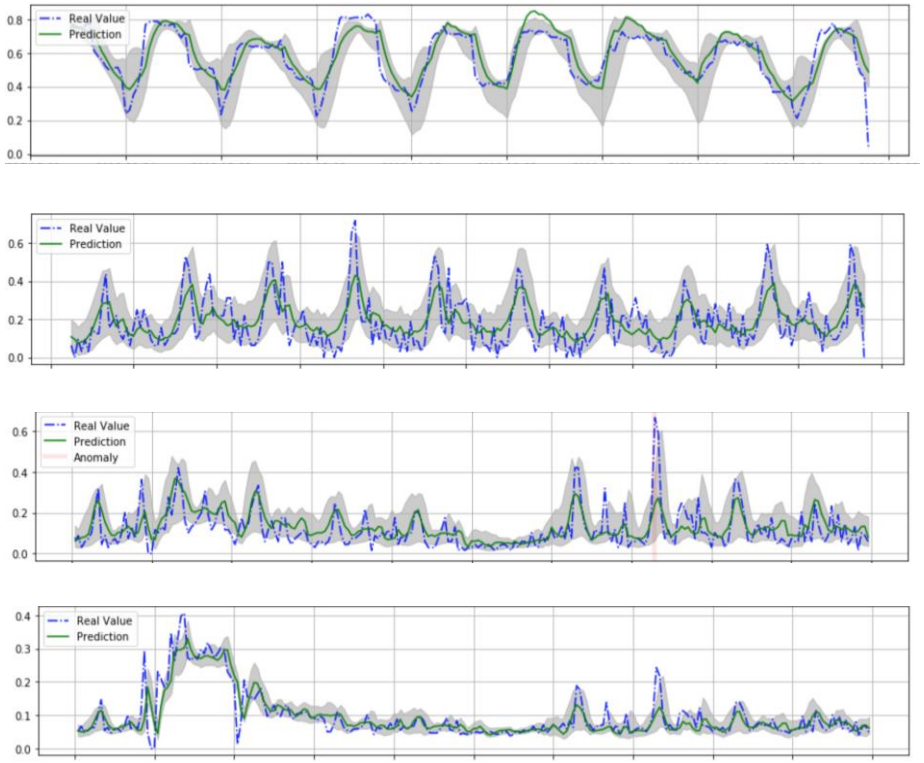
©2019 Mist Systems, a Juniper company

Prediction Verification

Prediction error:

- **%1-%5** normalized error





©2019 Mist Systems, a Juniper company

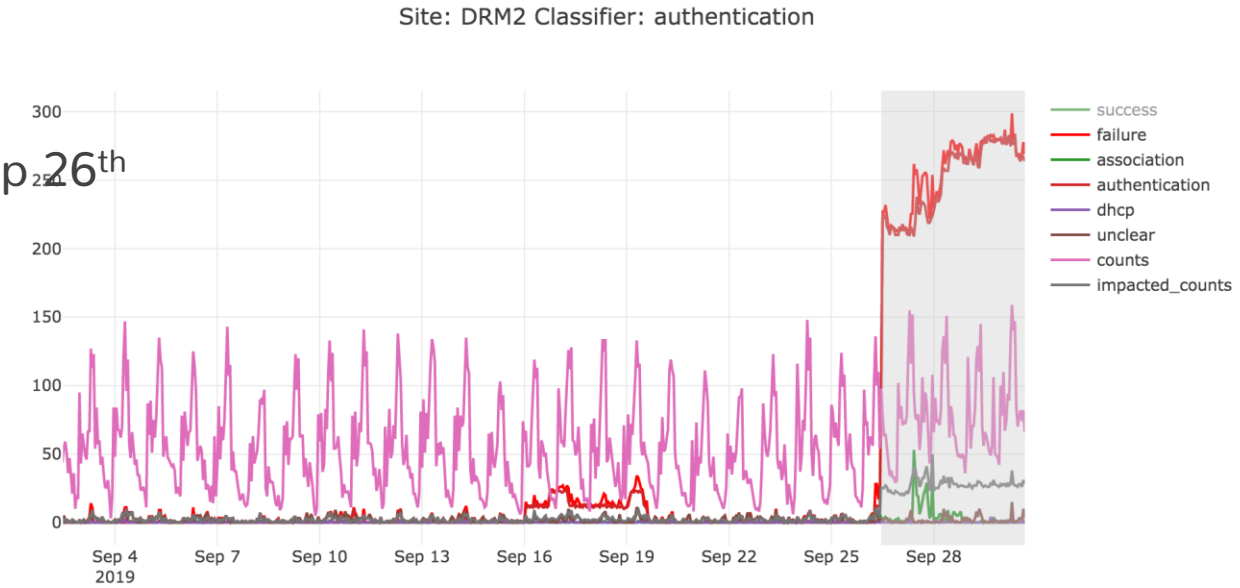
Real World Anomalies

A few bad clients on Sep 16th-19th

- False Positive

Persistent anomalies on Sep 26th

- True Positive
- Temporal features

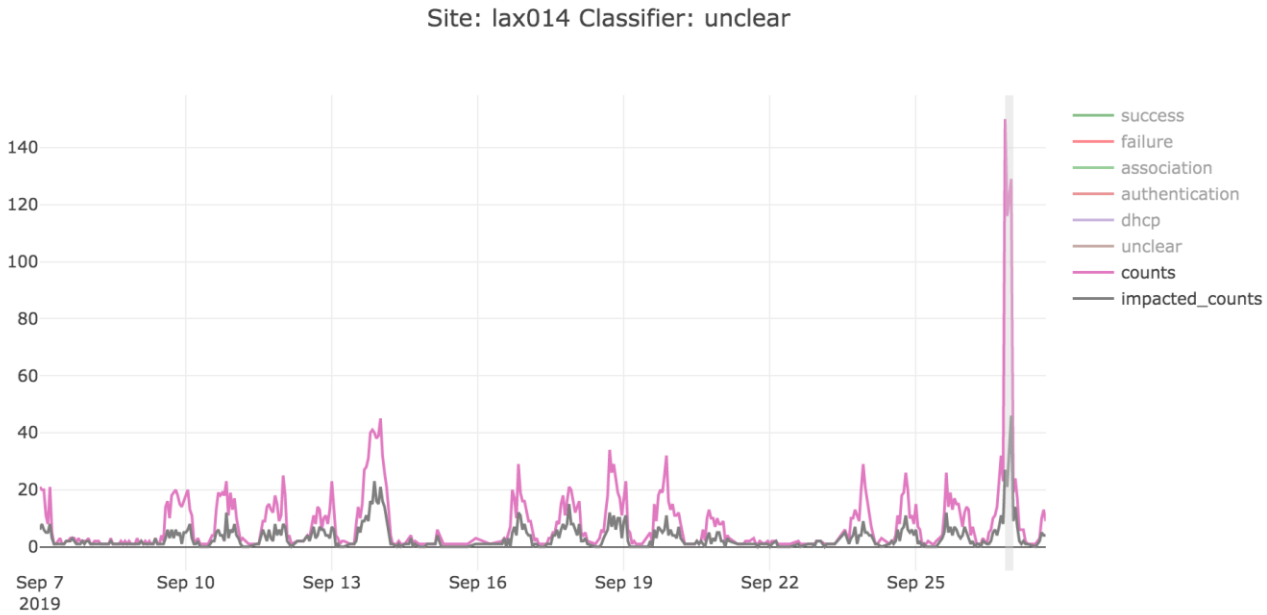


©2019 Mist Systems, a Juniper company

Real World Anomalies

Short span anomalies on Sep 26th

- State features



©2019 Mist Systems, a Juniper company

Diagnosis and Actions

Information Augmentation

- Information (mutual entropy)
- Probability (Bayesian inference)
- Suggested Actions

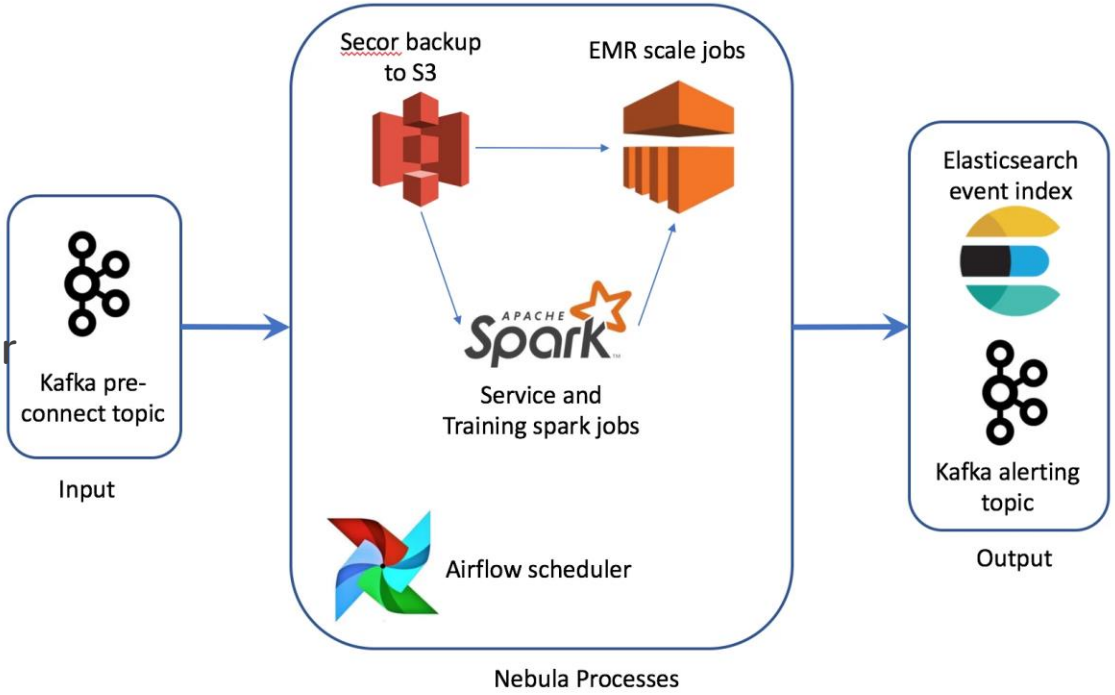
©2019 Mist Systems, a Juniper company

Thank you.

Data Pipeline

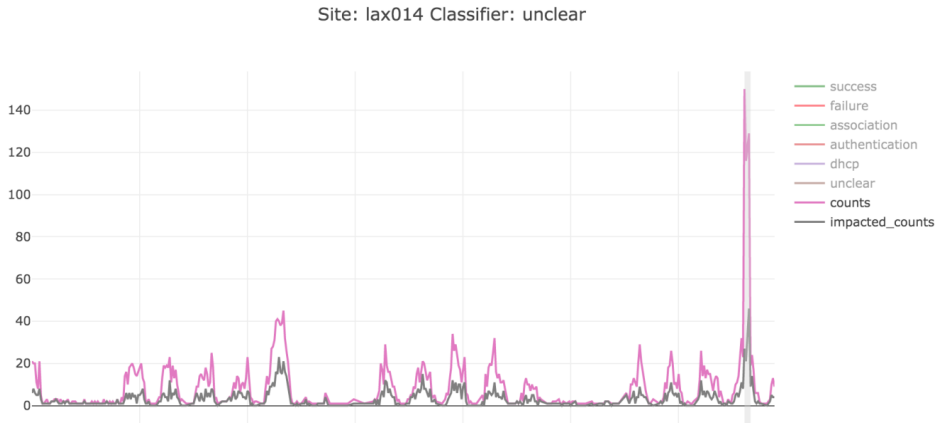
Technology stack

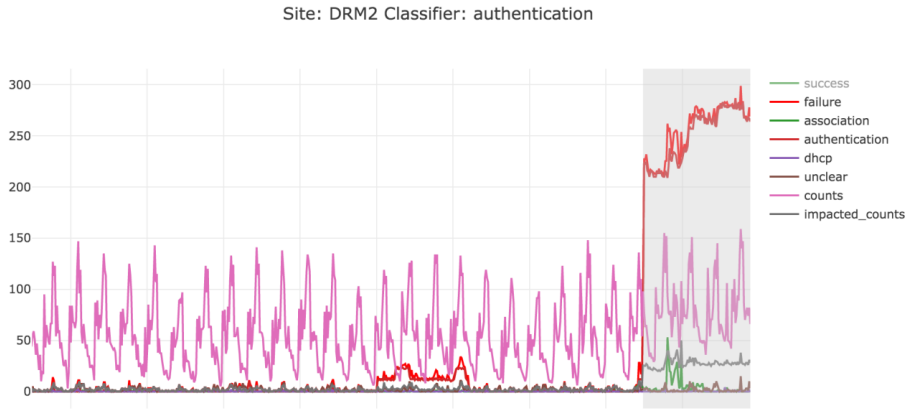
- Kafka input
- Secor backup
- Spark jobs on EMR cluster
- Airflow scheduler
- Elasticsearch database

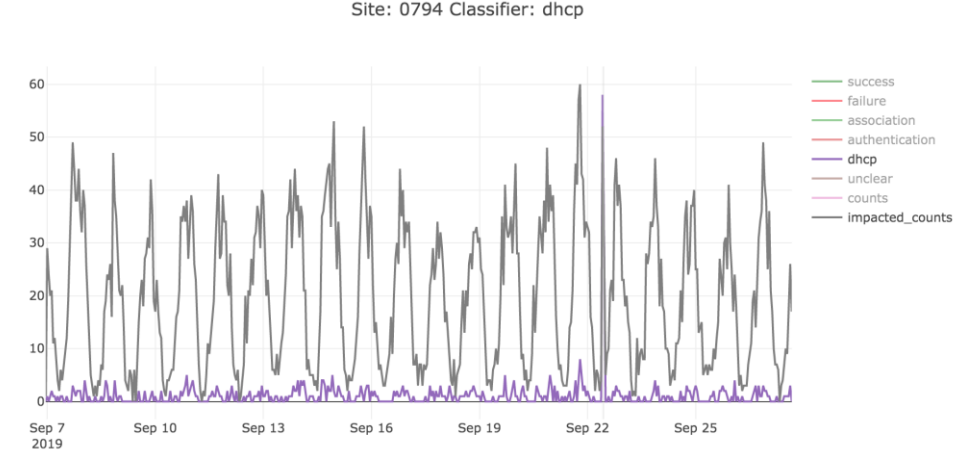


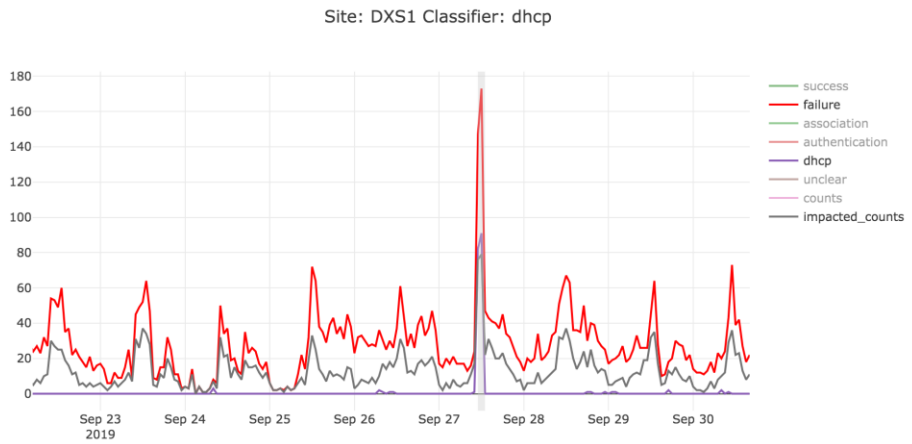
©2019 Mist Systems, a Juniper company

Wide Range of Anomalies









Diagnosis Analysis

Anomaly event is found, now what?!

Many network parameter (hidden)

- Access Points
- WLANs
- Switches
- Channel interferences
- Clients HW
- …

©2019 Mist Systems, a Juniper company