



# Predict Real World Outage using Splunk MLTK

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Mission Statement



**BRIAN KING**

SVP and Chief, Technology  
Services & Operations



# AGENDA

- 1 **Impact of Cell Congestion**
- 2 **Solution Journey**
  - Data Analysis Techniques
  - Machine Learning Algorithms
- 3 **Benefits and Lessons Learned**





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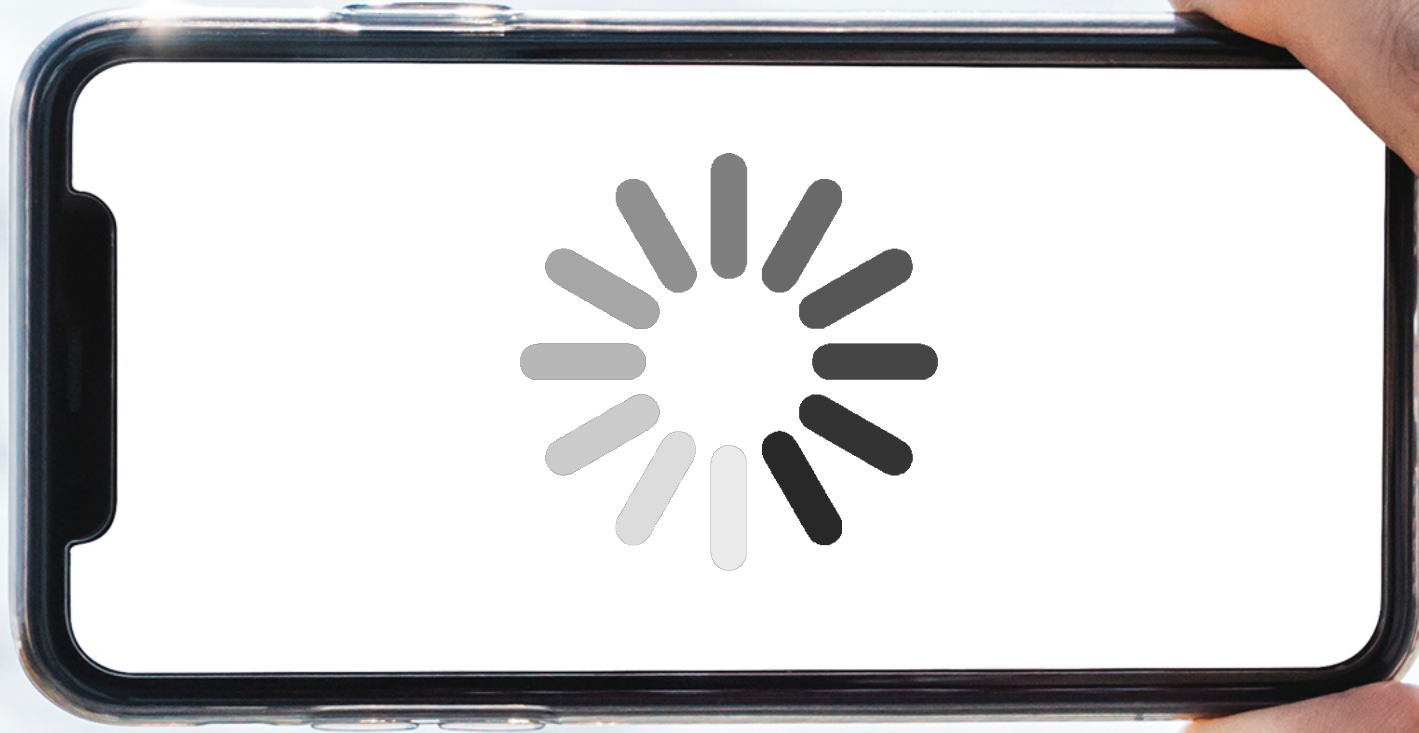
# The Impact of Cell Congestion

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# What Is Congestion?



**Congestion  
degrades  
experience**

**Reduces  
speed and  
reliability**

# What is Cell?





# How Congestion Happens

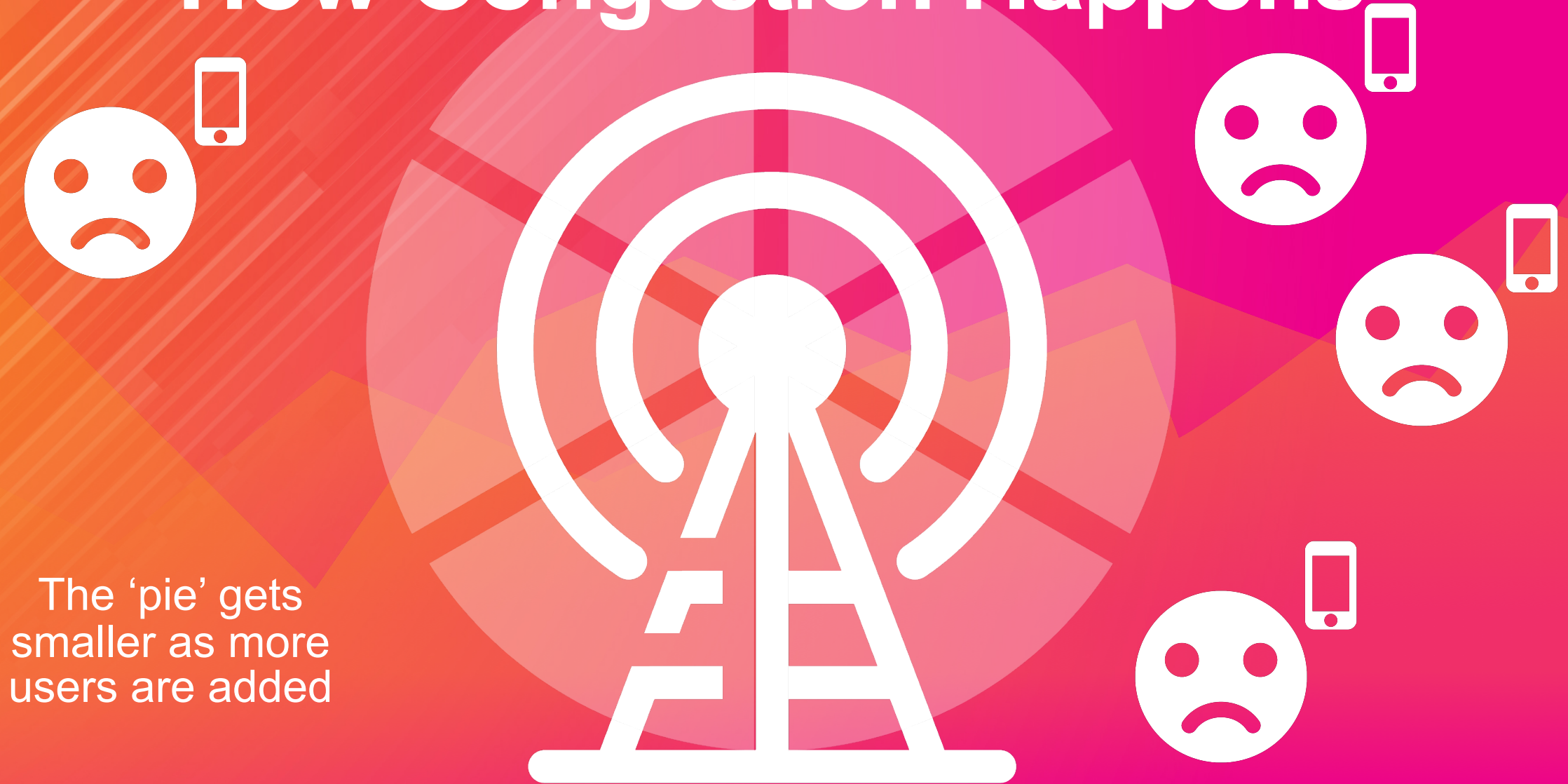


# How Congestion Happens





# How Congestion Happens



The 'pie' gets smaller as more users are added



# Impact of cell congestion

Customer dissatisfaction

Revenue loss

Cost for troubleshooting

**What can an  
RF engineer  
do to alleviate  
congestion?**







# 2 T-Mobile's Solution Journey

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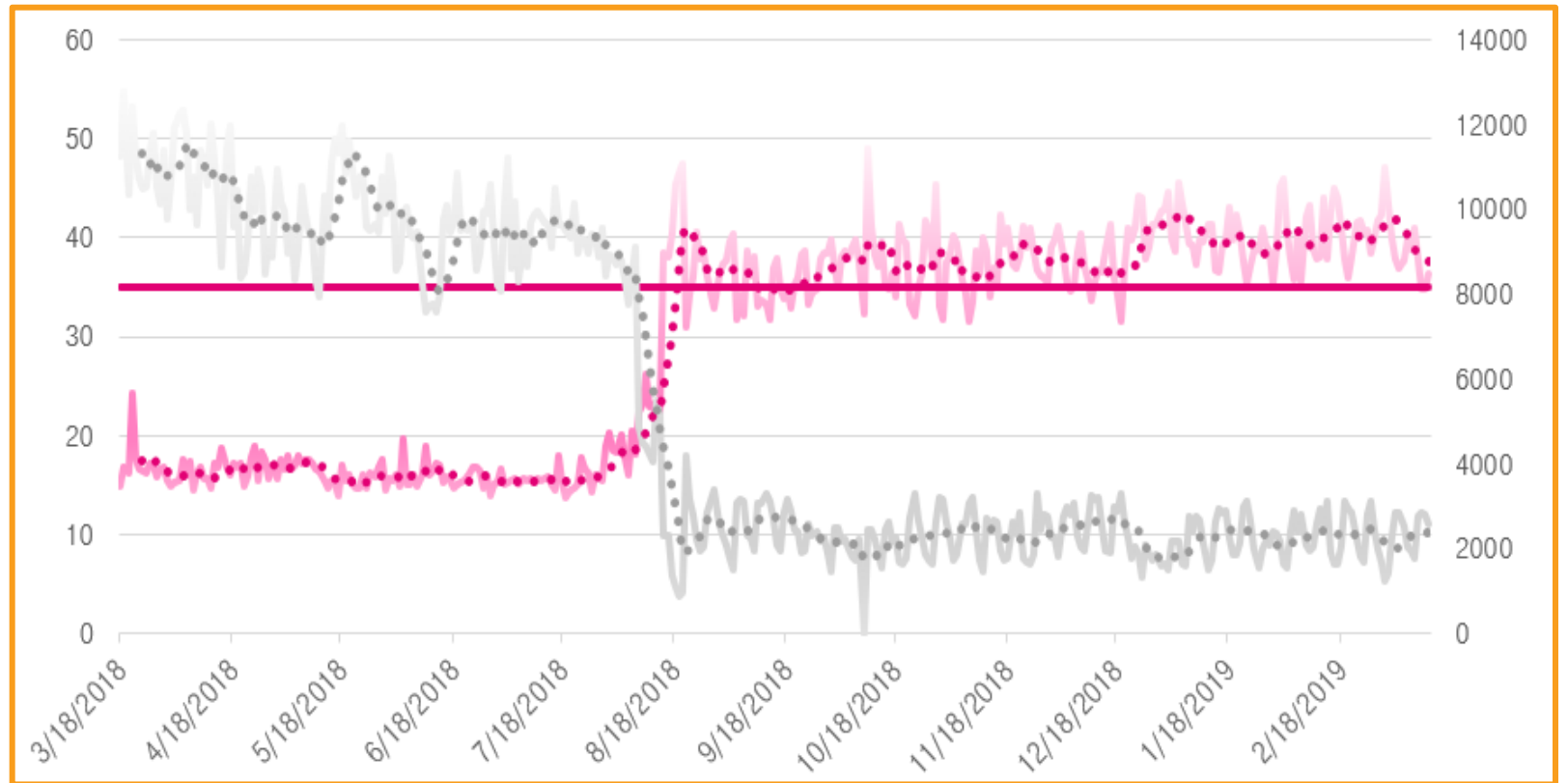
# Feasibility Tests | Forecasting Techniques

## Historical Data Analysis

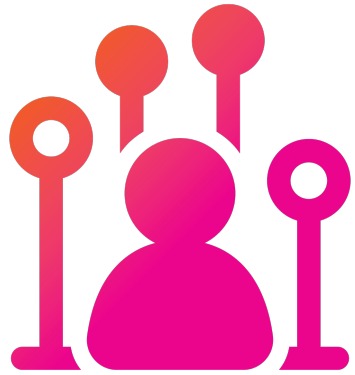
- Shows there is a few day gap before congestion occurs

## Select Data Frequency

- Daily versus Hourly Data



# Phases of the AIOps Journey



## Human in the Loop

### Cell level Prediction

- Manual Fine Tuning

### Predictive Alert Browser

- Measure. Manage.



## Closed Loop | Partial

### Manual Resolution

- RCA & Fix

### Automate Resolution

- Scripting



## Self Healing

### Automated Scripts

- Fine tune RAN



# Human in the Loop | Predictive Alert Browser

Human In the Loop Dashboard for Cell Congestion Predictions

Edit

Export

...

Predictive Alert Count

13

Prediction Success Rate

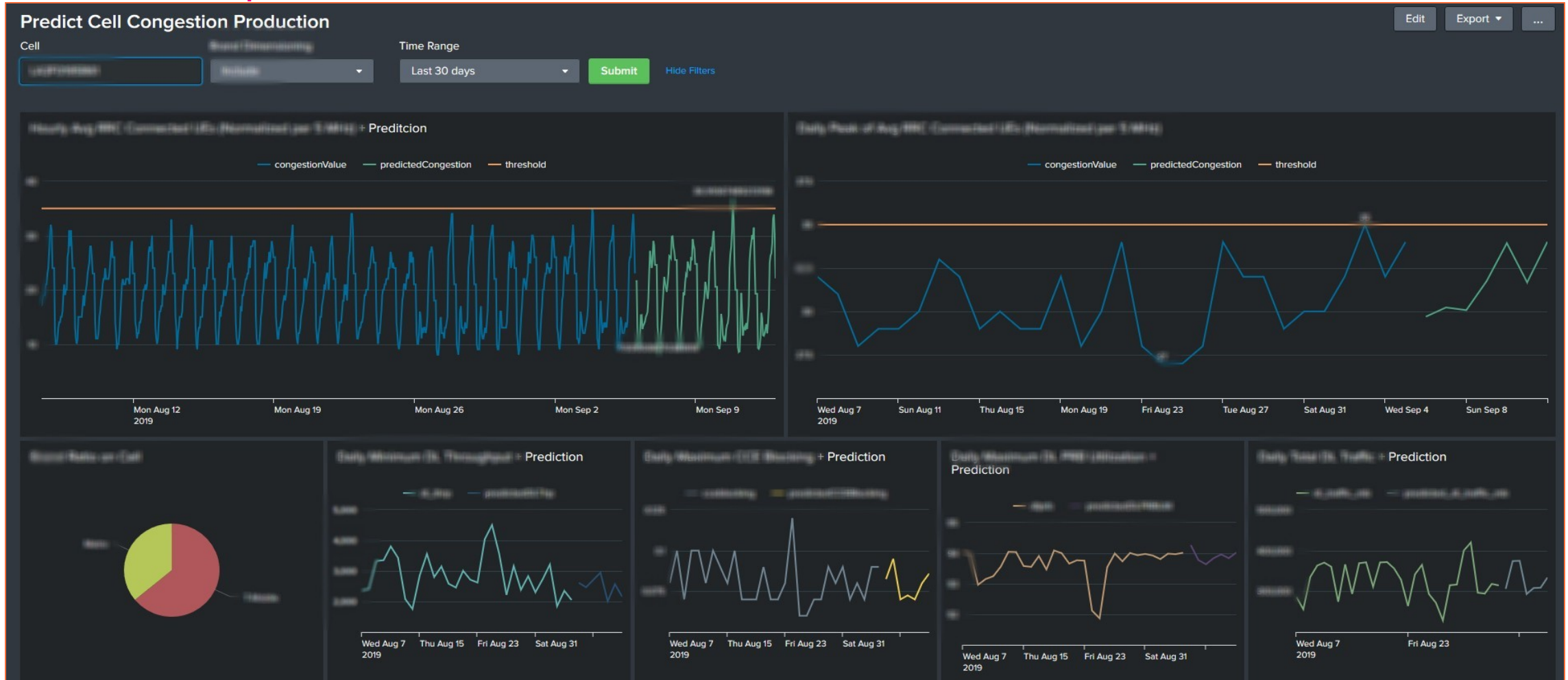
92.3%

Click Valid or Invalid button for each predictive alert's accuracy

| datetime             | validity | Alert_Description                                                                 | key_alert_id |         |
|----------------------|----------|-----------------------------------------------------------------------------------|--------------|---------|
| 1 09/17/19 00:00:00  | valid    | B-100-0001_cell_congestion_predicted_at_2019-09-17_for_100.46%_value_of_threshold | VALID        | INVALID |
| 2 09/13/19 00:00:00  | valid    | B-100-0002_cell_congestion_predicted_at_2019-09-13_for_104.70%_value_of_threshold | VALID        | INVALID |
| 3 09/13/19 00:00:00  | valid    | B-100-0003_cell_congestion_predicted_at_2019-09-13_for_102.38%_value_of_threshold | VALID        | INVALID |
| 4 09/12/19 00:00:00  | valid    | B-100-0004_cell_congestion_predicted_at_2019-09-12_for_98.34%_value_of_threshold  | VALID        | INVALID |
| 5 09/09/19 15:44:37  | valid    | B-100-0005_cell_congestion_predicted_at_2019-09-14_for_98.09%_value_of_threshold  | VALID        | INVALID |
| 6 09/09/19 15:44:36  | valid    | B-100-0006_cell_congestion_predicted_at_2019-09-13_for_100.00%_value_of_threshold | VALID        | INVALID |
| 7 09/09/19 15:44:36  | valid    | B-100-0007_cell_congestion_predicted_at_2019-09-12_for_95.04%_value_of_threshold  | VALID        | INVALID |
| 8 09/09/19 15:44:35  | valid    | B-100-0008_cell_congestion_predicted_at_2019-09-11_for_97.39%_value_of_threshold  | VALID        | INVALID |
| 9 09/09/19 15:44:35  | valid    | B-100-0009_cell_congestion_predicted_at_2019-09-11_for_96.96%_value_of_threshold  | VALID        | INVALID |
| 10 09/09/19 15:44:34 | valid    | B-100-0010_cell_congestion_predicted_at_2019-09-11_for_99.40%_value_of_threshold  | VALID        | INVALID |
| 11 09/09/19 15:44:33 | valid    | B-100-0011_cell_congestion_predicted_at_2019-09-10_for_96.26%_value_of_threshold  | VALID        | INVALID |
| 12 09/06/19 18:41:41 | invalid  | B-100-0012_cell_congestion_predicted_at_2019-09-04_for_98.86%_value_of_threshold  | VALID        | INVALID |

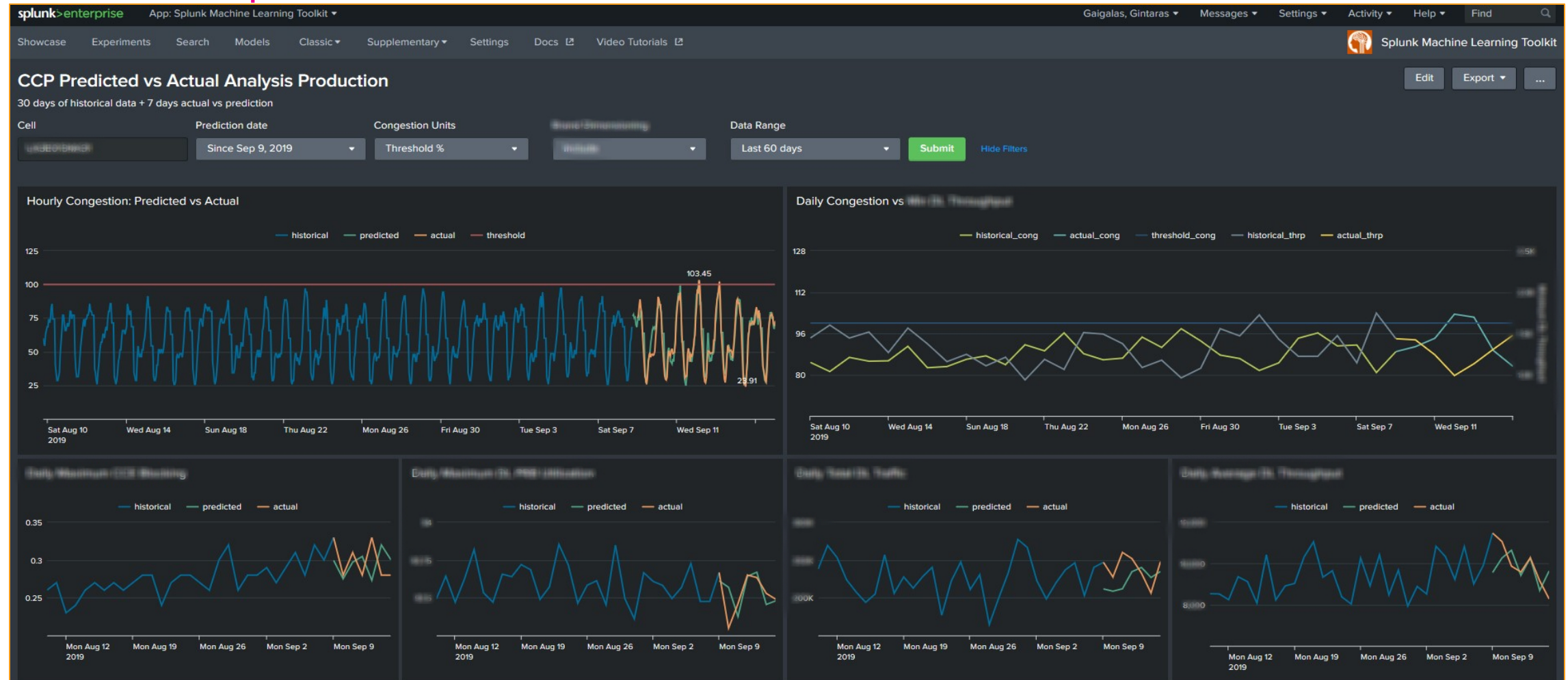
# Cell Congestion Dashboards

## Drill Down Capabilities



# Cell Congestion Dashboards

## Drill Down Capabilities – With Actuals





# Algorithms Comparison

## Forecasting Techniques

### ARIMA

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- Time consuming to fine tune the parameters
- Seasonal Variations not taken into account
- Models cannot be saved and used at a later time

### State Space Forecasting

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- Automatically chooses parameters such as period
- Effects of special days taken into account
- Models are persisted and can be “applied”

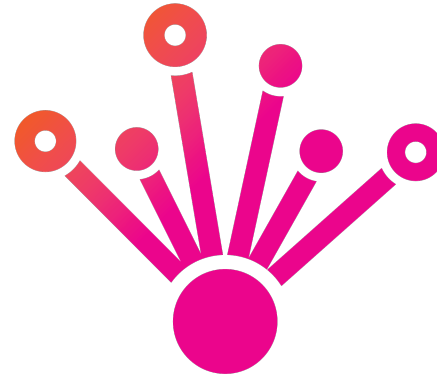
# ML Algorithms Used | EDA Steps



## Preprocessing for Accuracy

**Principal Component  
Analysis**

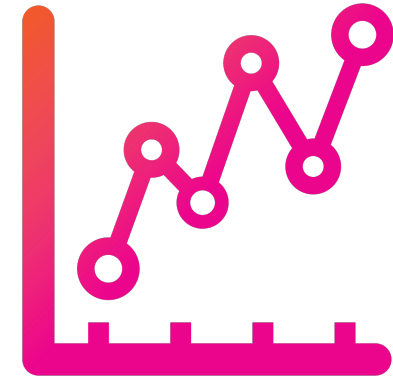
**Standard scaling**



## Clustering for Scale

**Cluster similar cells**

**~ 1000:1 model  
reduction**



## Forecasting for Prediction

**Time Series Forecasting**

- State Space

**Cluster Level**



# 3 Benefits and Lessons Learned

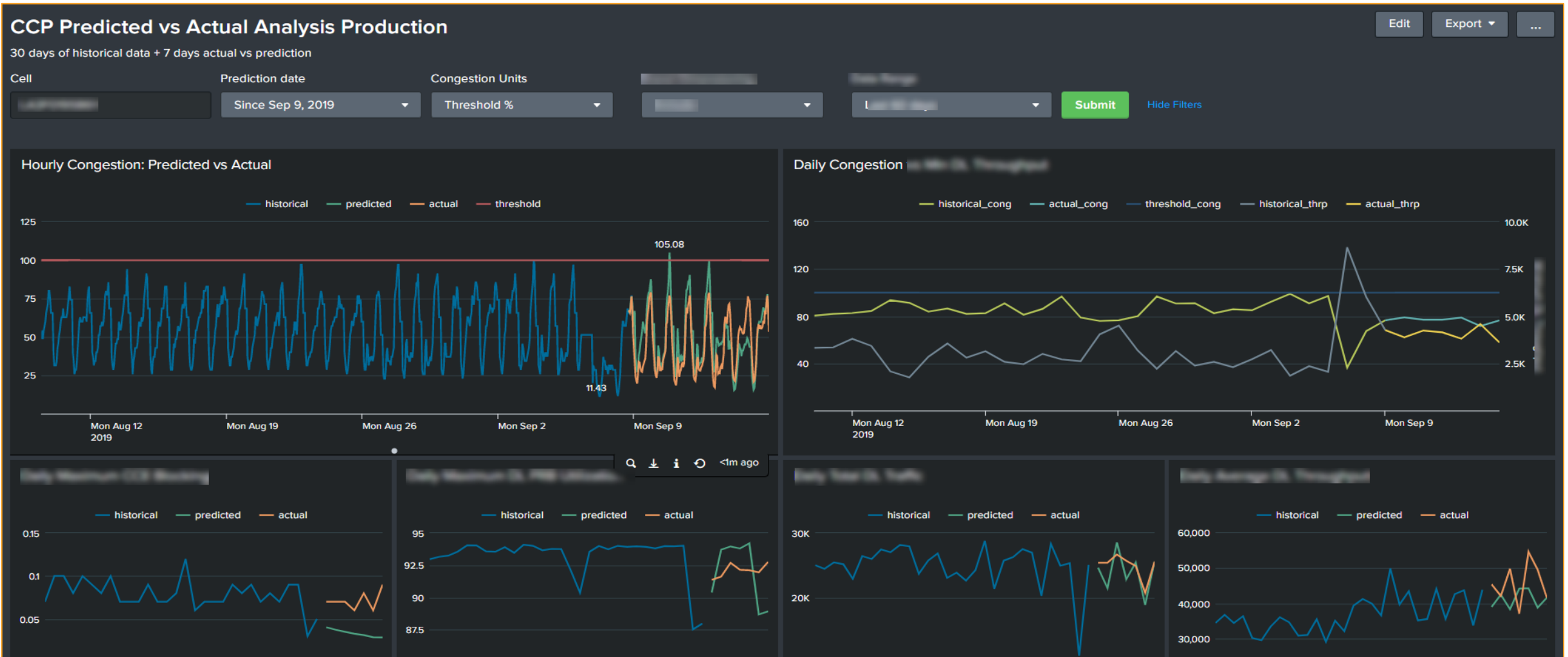
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# Benefits | Example of Prevented Congestion



# Lessons | Overlay Actual with Predicted



# Challenges Faced | Operational Issues



## Data Integrity

### Monitoring Data Gaps

- Data Fill Strategy

### Additional Features

- Feedback Loop

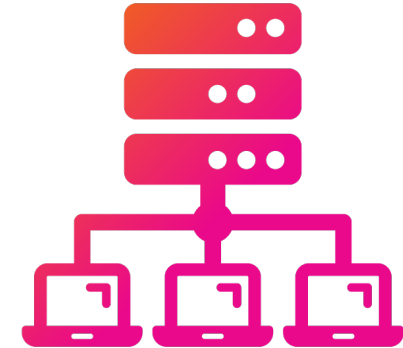


## Configuration

### Load Balancing

### Fine tuning

### High Number of Cells



## Sizing

### Memory Limits

- Algorithm
- Splunk Instance

### Number of Clusters



# Cross Functional Effort

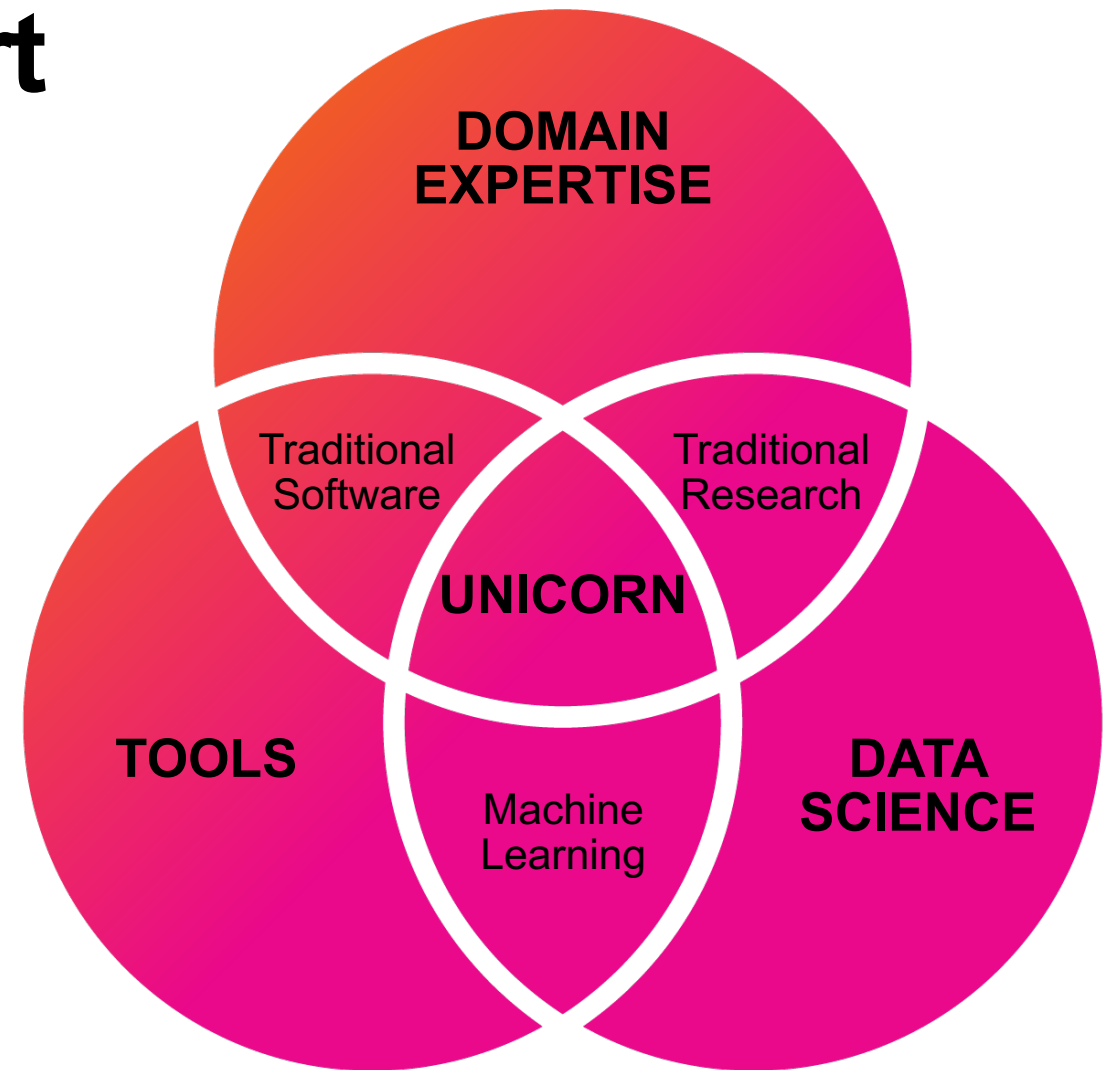
Faster Delivery

Leadership Team commitment

Good cross-functional team

- RF SME
- Splunk Development
- Streaming & Big Data
- Splunk ML Advisory

Don't be the unicorn!



# Splunk Machine Learning Advisory Program

Get help from the Splunk Data Scientists to solve your business use case with Machine Learning Toolkit

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# KEY TAKEAWAYS

PREDICTION  
is POSSIBLE!

1. Leverage machine learning for enhancing solution scalability
2. Implement human in the loop and closed loop in phases
3. Gain leadership and cross-functional team commitment

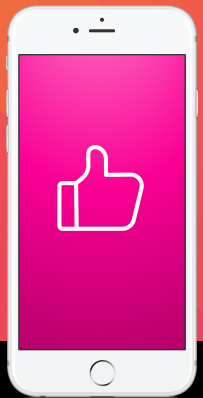




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# Q&A

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**GINTARAS GAIGALAS** | Senior RF Engineer