Cloud-based **IoT Server** for energy savings

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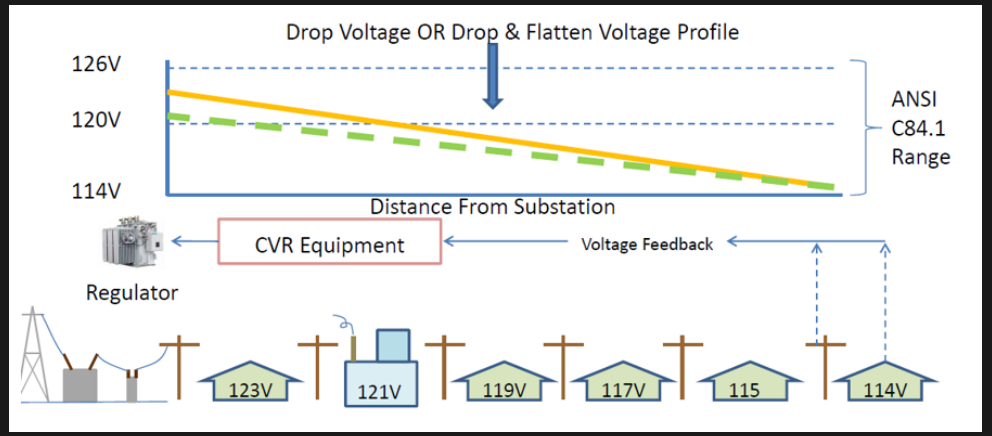
Use Case/Scope

CVR (Conservation Voltage Reduction) AWS IOT Server

Replace on-premise RDBMS systems that do not scale with frequent input data streams



- 300-600 households per feeder line of which ~ 40 SmartMeters are used as sensors (also called bellwether meters).
- These bellwether meters will report back voltage levels every 5 minutes.
- Voltage on the feeder should not exceed 3% of 120V (123 – 117V).

Ref. 1: Tennessee Valley Authority Voltage Optimization Program

Leverage AWS IoT Architecture

Data Ingestion:

- IOT Gateway

Data Storage:

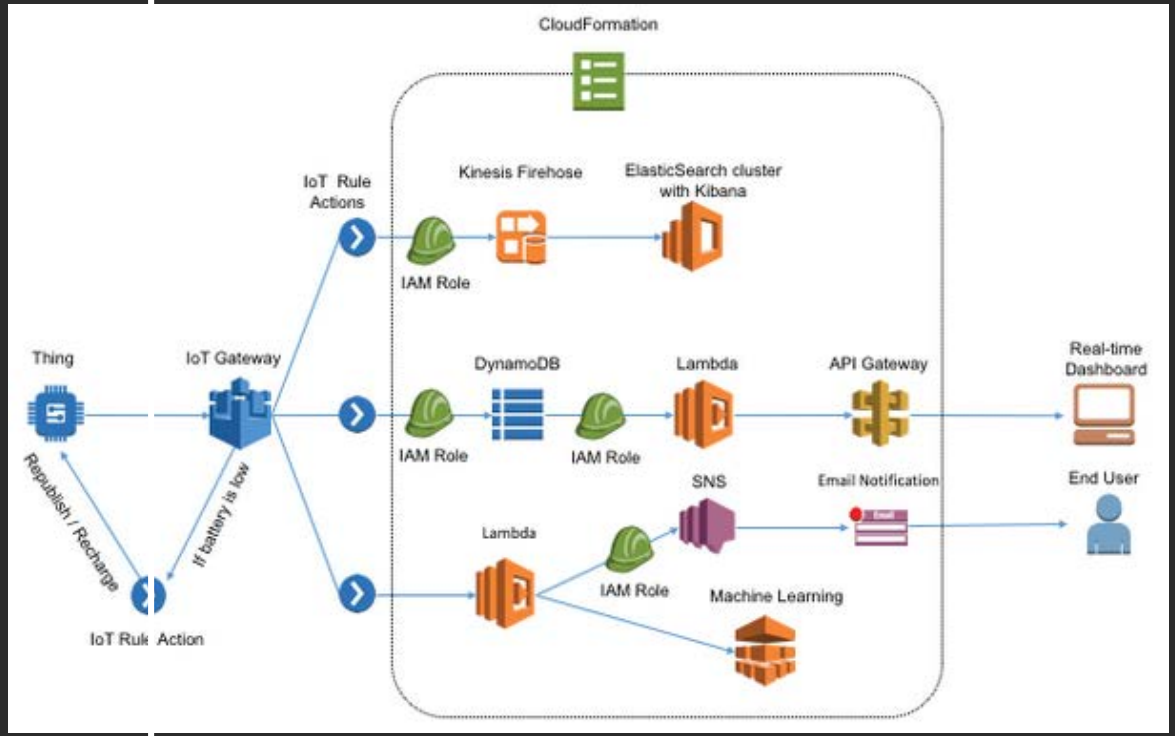
- DynamoDB

Stream Processing

- Kinesis/ElasticSearch

Data Exploration:

- Kibana and AWS ML

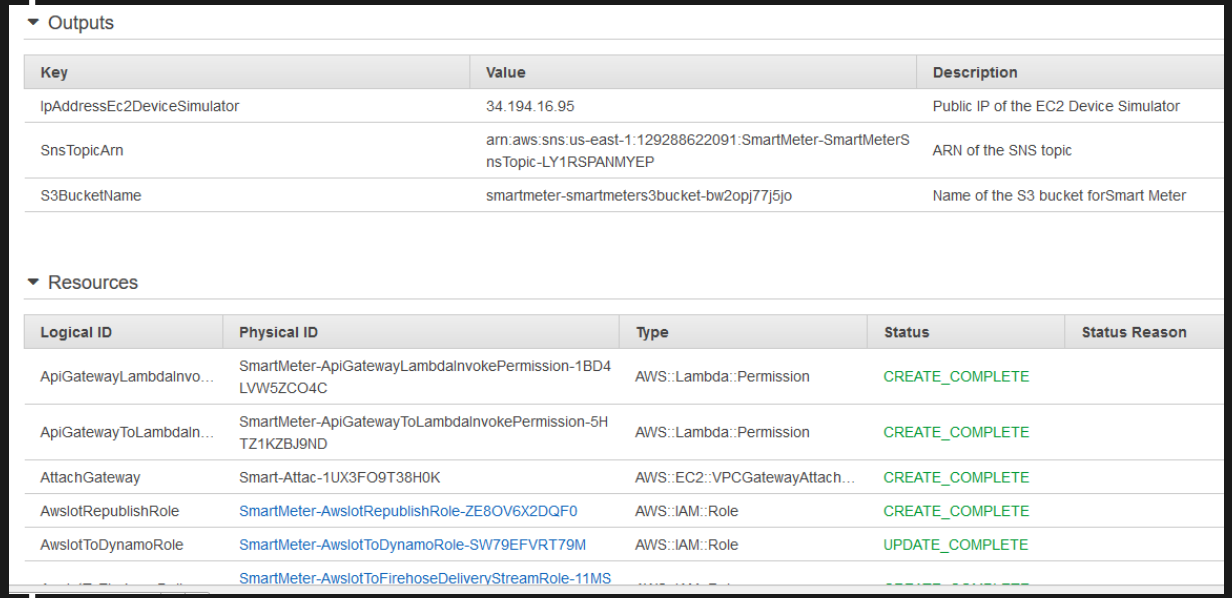


Ref. 2: [AWS IoT Pilot Light Hack Day]

Repeatable System Setup

AWS CloudFormation:

- 1,000+ lines of JSON statements
- Creates a new IOT Server instance in 15-20 minutes



▾ Outputs

Key	Value	Description
IpAddressEc2DeviceSimulator	34.194.16.95	Public IP of the EC2 Device Simulator
SnsTopicArn	arn:aws:sns:us-east-1:129288622091:SmartMeter-SmartMeterSnsTopic-LY1RSPANMYEP	ARN of the SNS topic
S3BucketName	smartmeter-smartmeters3bucket-bw2opj77j5jo	Name of the S3 bucket forSmart Meter

▾ Resources

Logical ID	Physical ID	Type	Status	Status Reason
ApiGatewayLambdaInvo...	SmartMeter-ApiGatewayLambdaInvokePermission-1BD4LVW5ZCO4C	AWS::Lambda::Permission	CREATE_COMPLETE	
ApiGatewayToLambdaIn...	SmartMeter-ApiGatewayToLambdaInvokePermission-5HTZ1KZBJ9ND	AWS::Lambda::Permission	CREATE_COMPLETE	
AttachGateway	Smart-Attac-1UX3FO9T38H0K	AWS::EC2::VPCGatewayAttach...	CREATE_COMPLETE	
AwslotRepublishRole	SmartMeter-AwslotRepublishRole-ZE8OV6X2DQF0	AWS::IAM::Role	CREATE_COMPLETE	
AwslotToDynamoRole	SmartMeter-AwslotToDynamoRole-SW79EFVRT79M	AWS::IAM::Role	UPDATE_COMPLETE	
	SmartMeter-AwslotToFirehoseDeliveryStreamRole-11MS			

Data Sources/Data Generation

- External SmartMeter data was not available with necessary Voltage information
- Created Simulator in Python using MQTT for message push
- Test config had 20 Feeder Lines with 40 Bellwether meters each
- Messages sent every 500 msec (i.e. 6.67 minutes for a single meter)
- Stepdown of Voltage data per hop on Feeder Line with some randomization
- Inserting anomaly Voltage value with a possibility of 0.1%
- Test runs were done for approx. 25 minutes each

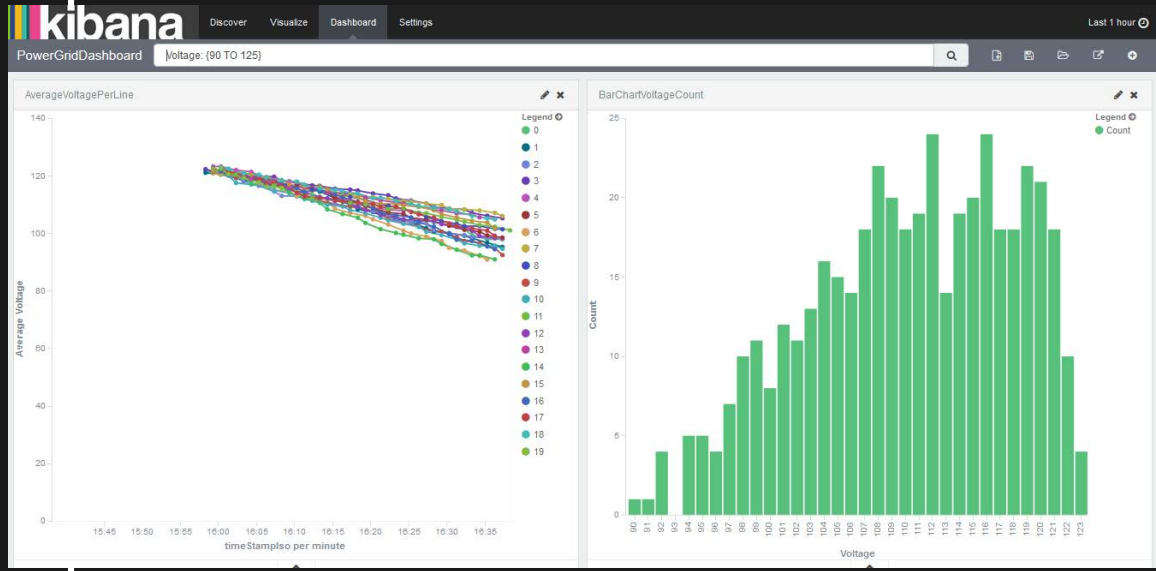
Streaming Analytics with ElasticSearch & Kibana

Anomalies Dashboard:

- Anomalies Count per Feeder
- DrillDown by Timestamp

PowerGrid Dashboard:

- Voltage per Line over Time
- Voltage Measurement Count
- Voltage Statistics Table



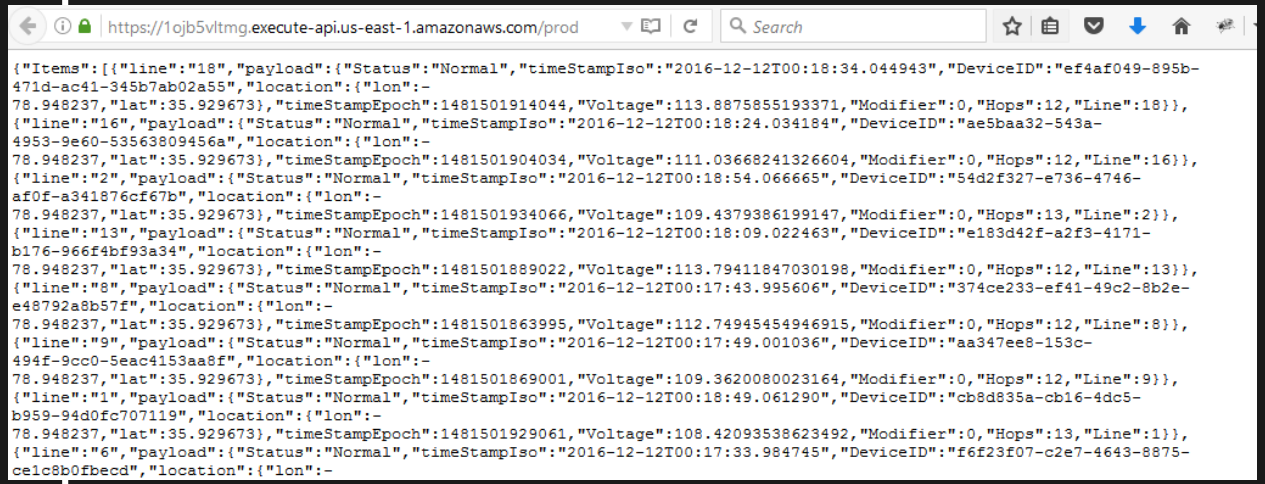
Storing Data and Making it Available through API

DynamoDB:

- TimeSeriesTable
- DeviceStatusTable

API Gateway:

- Device data in JSON format
- Future Web Dashboard



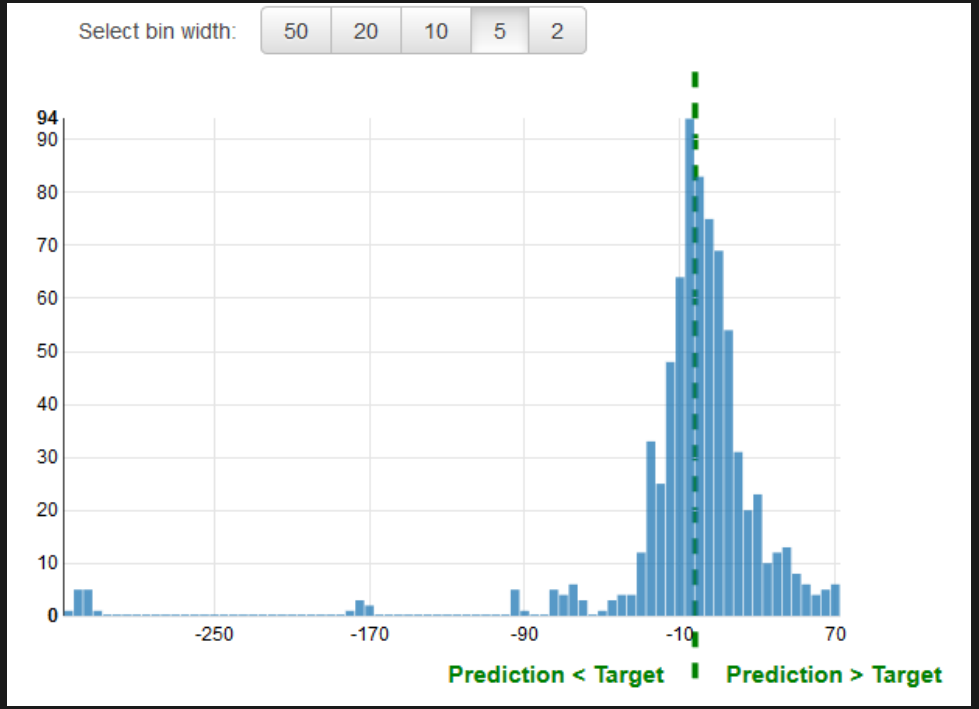
Anomaly Detection using Machine Learning

AWS ML:

- 25 min and 2,500 training data
- Numerical Regression

SNS Notification Service:

- Email alert based on deviation from prediction



Data Processing and Cost Assessment

EC2 t2 Medium:

- Only DynamoDB, S3
- Less than 0.2% CPU utilization

AWS IOT Gateway:

- $300/year (6 million messages)

Lambda functions:

- Server-less; on any AWS resource when executed

Future Extensions

Data Acquisition:

- Finetuning the Simulator to have less Voltage swings
- Add location information
- Enable automatic control loop from IOT Server
- Validate with real SmartMeters and Voltage Regulators

IOT Server:

- Enable DR and Elastic Instance Scaling using AWS Autoscaling Groups
- Run system with 100,000 of bellwether meters
- More advanced control algorithms
- Complete a web dashboard

References

1. Tennessee Valley Authority Voltage Optimization Program
2. AWS IoT Pilot Light Hack Day