MATLAB Based DevOps Workflow in AWS for Hospital Patient Monitoring Applications

GE Healthcare, Inc.

Mohammad Khair, Principal Engineer
High Level Architecture

- Video Feed
- Amazon Kinesis Producer SDK
- Patient Camera(s)
- Store encrypted stream
- NAT
- Edge Server
- Amazon Kinesis Video Streams for WebRTC
- AWS
- S3
- Convert to HLS or DASH
- AWS Key Management Service
- HLS: HTTP Live Streaming
- DASH: Dynamic Adaptive Streaming over HTTP
- Viewers
- NAT
- Camera Hub
- AWS Uses
- Live Feed Application

The diagram illustrates the integration of various components, such as Video Feed, Amazon Kinesis Producer SDK, and Patient Camera(s), flowing through Edge Server, Amazon Kinesis Video Streams for WebRTC, and NAT to the AWS ecosystem, including S3 for storage, AWS Key Management Service for encryption, and Live Feed Application for converting streams to HLS or DASH formats. Viewers access these streams through NAT connections.
Development and Operations Model: DevOps

Development:
- Develop Models & Code Algorithms
- Build
- Test

Operations:
- Deploy Models & Algorithms
- Monitor & Track Metrics
- Operate & Manage Models & Algorithms
- Release

3rd party dashboard
- Grafana

MATLAB Parallel Server
- MATLAB Web App Server
- Mobile Devices

Cloud Streaming
- Cloud Streaming
- User Data Database

MATLAB Scripts Restful API
- Matlab Compiler
- Matlab Compiler SDK

MATLAB Production Server
- MATLAB Parallel Server
- Cloud Streaming
- User Data Database
Tools Used for DevOps

Release
Stabilize
Measure
Learn

Hypothesize
Collaborate & Research
Architect
Synthesize

Deploy
Verify
Monitor
Respond

Continuous Monitoring
Continuous Exploration
Continuous Deployment
Continuous Integration

Develop
Build
Test End-To-End Stage
Choosing the right tool for your application

- **Plan**
  - JIRA

- **Develop**
  - GitLab
  - Terraform
  - Ansible

- **Code**
  - Maven
  - Gradle
  - Docker

- **Build**
  - PyB
  - SonarQube
  - Checkmarx

- **Secure**
  - Twistlock
  - Nessus
  - JFrog Xray

- **Store Artifacts**
  - JFrog Artifactory

- **Deploy**
  - GitLab
  - Docker

- **Operate**
  - DATADOG
  - Grafana

- **Monitor**
  - Helm

- **Scale**
  - Kubernetes

Continuous Integration & Continuous Delivery Orchestration
DevOps Culture Development

• Make the DevOps dashboard as one of the input metrics
• Follow DevOps Industry Trends and Best Practices
• Create a “DevOps Week” annually to showcase DevOps process best practices which helps collaboration
• Measure DevOps maturity as make a key NPI metric
  • Standardization of Tools & Processes
  • Documentation of Procedures & Training
  • Optimization of Cost
  • Optimization of Performance
• Periodic skill assessment and trainings for DevOps Engineers
• Collaborate with other teams and stakeholders
• Host brainstorming sessions – document solutions, ideas, automation.
Develop and deploy a patient monitoring application

**Problem:** *Provide patient video/data feed to the cloud and provide access on mobile devices and web browser-based dashboards.*

**Solution:**

- Use Deep Learning models to perform classification/measurement and deploy models into a secure and reliable service with scalable computing resources.
- Develop a Web-Browser/Mobile based application that allows viewing patient video/data feed and returns models’ output to devices.

**System Management:**

- Deploy into a secure, scalable, and reliable environment.
- Tools for automated model training, testing, and deploying.
- Tools for monitoring of operational and performance metrics.
Challenges & Solutions in Developing a Patient Video Monitoring Application

- **Video / Data Streaming to the Cloud**
  - Near Real-Time performance

- **AI Model Development / Training, Data Diversity**

- **Scalable Compute & Memory for Deployment of AI Models**

- **Data Storage & Cost Optimization**

- **Data Visualization & Event Retrieval**

- **AWS Kinesis offers optimized streaming to cloud services with data/video channels**

- **Matlab toolsets provide model training on large data with Datastores to optimize memory utilization**

- **Cloud services offer configurable machines, Matlab Production Server flexibly scales processing based on traffic demand.**

- **AWS data lake offers storage and configures data retention period**

- **Matlab Web Server provides simple web application development.**
Architecture of Patient Monitoring System

Data sources
- Big Data Applications
- Databases & Cloud storage

MATLAB Online Server
- One instance, many workers

Data access and exploration

Develop, build, and test models

Parallel Computing
- Parallel Server

Train Model

MATLAB
- Publish operational and model metrics
- Deploy Models to Production
- Publish and view operational metrics

Monitoring and Metrics
- Grafana

Operate models with Web Apps

MATLAB Web App Server
- MATLAB Production Server
- MATLAB Client for Production Server
- AWS
- Kubernetes
- Request Broker
- Operationalize Models as RESTful APIs

Operate models with Web Apps

Deploy Model front-ends as Web Apps

Face Bonded Optic Humidity Drift Calculator

Deploy Models to Production

MATLAB Online Server
- MATLAB Production Server
- Worker processes

Publish operational and model metrics
Architecture of Cloud-Based AI Model Software as a Medical Device (SaMD) - Model Development & Deployment

Model Training
- Patient Image
- Train Deep Networks
- Trained Model

Train model using GPU

Model Inference
- New Image
- Predict Classification

Deploy on AWS Cloud
Architecture of Cloud-Based Software as a Medical Device (SaMD): Cloud architecture

- Cloud architecture
  - Edge Hub
  - AWS Kinesis
  - Kinesis for Stream Processing
  - Matlab Connector

- Data Streaming
- Patient Data
- Data Visualization
- Data Routing
- Kinesis / Kafka Connector for DB
- Classification
- Algorithm Engine and Scaling

- Image Acquisition
- Data Acquistion
- Matlab Connector
- IEC 62304 compliant algorithm from MATLAB/Simulink

- Power BI
- SQL
Architecture of Cloud-Based Software as a Medical Device (SaMD): MATLAB Products Ecosystem

**Data Acquisition**
- Camera as the upstream data source.

**Kafka or Kinesis Streaming**
- Amazon MSK
- Amazon Kinesis Data Streams

**MATLAB Production Server Cluster**
- IEC 62304 compliant algorithm from MATLAB/Simulink

**Data Visualization**
- Reporting Dashboard on a Web App or Phone App
- Reporting WebApp / PowerBI / Spotfire server as Dashboard Using Web App Server

**MATLAB Parallel Server**
- MATLAB/Simulink with Deep Learning, Parallel Server to develop and train AI models,
- MATLAB compiler provides the algorithm to Matlab Production Server & Web App Server

**MATLAB Deep Learning toolbox**
- MATLAB Deep Learning, Parallel Server to develop and train AI models,
DevOps Opportunities

- Data: Research Data access, Automated Labeling to facilitate iterative retraining
- ML/AI Algorithms: Enhance ML Algorithms, Development of Predictive Algorithms
- Personalized Medicine: Adaptive Modeling, Adaptive Control, Digital Twin
- Research Support: ML Research Tools, Improve Algorithms
- Usability: ML/AI Algorithms, Use Case Scenarios, Usability
References

- https://www.scaledagileframework.com/devops/
- https://www.devops-research.com/research.html
- https://www.atlassian.com/devops
- https://aws.amazon.com/devops/continuous-integration/
- https://cloud.google.com/devops
Thank You!