The Robotic Edge

The Role of the Cloud
In the Future of Robotics

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Robotics development and deployment challenges

- Multi-domain expertise required to build robots
- Iterative development to get it right
- Configuration management is hard
- Limited robot hardware available for testing
- Deployment and updates need to be managed
Robotics application development

Test and verify

Design and develop

Deploy and update
AWS RoboMaker

a cloud service to build, test, deploy, and manage robotics applications at cloud scale
Design and Develop
robotics applications and functionality

Agile development of robotics application requires software reuse and iterative development
ROS2
Core architectural change between ROS 1 and ROS 2:

- Addition of ROS Middleware (RMW) & Data Distribution Service (DDS).
- Security
- Reliability
- Determinism
AWS Robotics
Select contributions to ROS2

- Quality of Service (QoS) Features for Topics
- Cross-Compilation Tools
- rosbag2 splitting, compression
- ROS2 Launch Sandboxing Extension
- Nodes and example applications for AWS integration
- Runtime Analysis Tools Address & Thread Sanitizers
Support for ROS Kinetic, ROS Melodic, ROS 2 Dashing (beta)

Native ROS packages for AWS services:
- Amazon S3 for secure, scalable storage
- Amazon CloudWatch for logging and metrics
- Amazon Rekognition for image and video recognition
- Amazon Kinesis for video streaming
- Amazon Lex and Amazon Polly for voice recognition and text-speech conversion
Amazon Kinesis Video Streams

Welcome to Amazon Go and the world’s most advanced shopping technology. No lines, no checkout—just grab and go!

Ingests, stores, and indexes video streams from millions of cameras
What we have done

- Surveillance Intelligent Asset with site trials
- Task autonomy with manipulation
- Integration
- Digital Twin or Workspace – Fuse Demo
Test & Verify
simulations at cloud scale

Use simulation to replicate your environment, test application, and optimize usage of robot resources
Pre-built virtual 3D worlds provided out of box, or bring your own

Zero infrastructure to provision, configure, or manage

Run multiple simulations in parallel

Auto-scale based on simulation complexity

Pay-as-you-go simulation resource consumption
Test & Verify
Able to run thousands of concurrent simulations
iRobot accelerates robot regression testing

- **Need**
  - Test coverage for different floor layouts and scenarios
  - Improve code release speed

- **Challenges**
  - Costly and time consuming to test
  - Limited test cases and coverage
  - Late bug discovery in the field

- **Solution**
  - iRobot built a CI/CD pipeline for large-scale and automated testing using RoboMaker’s simulation service
  - More than 40 automated tests on each code commit and more than 500 automated tests for each release candidate
  - Much faster testing and release cycle (1 hour versus 3 weeks for testing 70 complex localization scenarios)
In Production

*Within 3 months!*

5,000 missions a month
Gating submissions
Catching issues
Higher quality mainline
Developers want more

*Credit: Chris Kruger, iRobot*
Simulate multiple robots within the same environment

Connect multiple simulations to a central fleet-management software to test multi-robot scenarios

Simulate inter-robot interactions or missions across robots
Bastian Solutions uses RoboMaker to simulate multi-robot fleets

- **Problem statement**
  Bastian Solutions enables orchestration of a fleet of robots
  Software testing currently requires physical robots; practical limitation of 8–10 robots in test lab

- **Use of AWS RoboMaker**
  AWS enabled simulation of a multi-robot environment with 35+ robots, thus enabling testing without physical robots
  AWS services used: AWS RoboMaker, AWS IoT Greengrass, AWS Lambda

- **Business benefits**
  Bastian Solutions easily able to test application for larger environments without having to stand up physical devices
Multi Robot Simulation

contact: bargar@amazon.com to discuss rqmts!
Simulation for Model Training

- Rapidly generate trial data in simulation to train reinforcement learning model
- Train reinforcement learning model natively in the simulation or in AWS SageMaker
- Run concurrent simulations to speed up training of a single model
AWS DeepRacer
SageMaker training

Simulation environment

Actions

Observation

RL agent

Model updates

Simulation environment

Observation

Actions

Model updates

Training data

Observation action reward
Successful Transfer from Simulation to Real World
Persistent Emergency Detecting Drones built on AWS RoboMaker

**Application Architecture**

- DJI M600 Pro Drone
- ROS Node with ML Libraries
- ROS Application
- AWS RoboMaker ROS Extensions
- AWS RoboMaker Fleet Management
- AWS Greengrass Core Device
- Amazon CloudWatch
- Amazon Kinesis Video Streams
- Video Recordings Captured for Retraining

**AWS RoboMaker**
- Download New Models
- Trained ML Model
- Training

**Amazon SageMaker**
- More...
- Iterative, Test-driven Development
- Reliable Over-the-Air (OTA) Deployments
- Iterative, Test-driven Development
- Trigger Deployments

**AWS RoboMaker Simulation Environment**

**AWS Amplify React Website**
- Dashboard User Interaction
- Trigger New Model Training

**Remote Monitoring Drone**
Robot Simulation Survey

Please take this short survey on requirements and desired features for simulation…

https://tinyurl.com/rr6amyh
Enterprise need greater command and control over robot assets.
Problem statement
- Enterprise customers are unable to easily manage a fleet of multiple AMR brands
- Inability to orchestrate across AMR brands
- Inability to share map information across robots

AWS RoboMaker and AWS cloud services
Enable a unified interface to orchestrate robots and share maps across multiple brands

Business benefits
Ability to plan a mission across robot brands and robot types
Deploy and Update
robot registration, over-the-air deployment with AWS RoboMaker

- Register robots with RoboMaker fleet management and organize them into fleets
- Deploy a robotics application into a robot fleet securely through just a few clicks
- Conditional over-the-air updates
- Fleet monitoring and alerting*
- Fleet deployment rollback*

* Coming soon
Fusion Data Streaming Hub “intdash”
- Provide data handling edge agent, server APIs and visualization dashboard for industrial fusion data streaming
- Low latency bidirectional data streaming via cloud hub
- Simultaneously data acquisition and data analytics pipelines

Telemetry and Teleoperation
- Rapidly develop Telemetry, Data Acquisition and Tele-operation functions into robots, simulation and physical environment

User benefits
- Machine learning pipelines
- “intdash” enables data acquisition of ROS messages
- Data orchestration for machine learning on Amazon SageMaker

Aptpod
Digital twin environment for AWS RoboMaker
Role of the Cloud

1. Intelligent cloud services can enhance local processing on the robot and improve performance over time.

2. Simulation can be used to test application correctness, and ensure performance across a range of conditions.

3. Simulation, combined with reinforcement learning, can be used to program robot actuation.

4. Cloud services enable developers to build applications for their business, end-to-end, that include robotics.
Questions?