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THE LINUX FOUNDATION



## VIDEO

Q&A WITH SPEAKER [SPEAKER BIO](#)**Gavin Adams**Senior Solutions Architect, IoT  
Amazon Web Services

Gavin is a Senior Solutions Architect with Amazon Web Services (AWS), specializing in helping customers deploying IoT solutions. In his journey to his current role at AWS, Gavin began his technology career supporting nuclear energy testing missions in the Nevada desert. Since then, he has been involved in other aspects of information technology including software development, security, system automation, system architecture and design, and since 2012, focusing primarily on cloud-native solutions for customers. He now focuses on delivery of edge compute solutions, putting him back in physical world with

## SLIDES

## The laws of the edge

- **Law of Physics:** Light (data) can only travel so fast
- **Law of Economics:** Networks extend communication —at a cost
- **Law of the Land:** Data sovereignty laws to ensure data is secure and kept local

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#### Q&A WITH SPEAKER

#### SPEAKER BIO

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#### SLIDES

## Wind turbine farm



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### Automobile



infotainment, ADAS, CAN bus,  
autonomous, computer vision, machine  
learning, 3<sup>rd</sup> party devices

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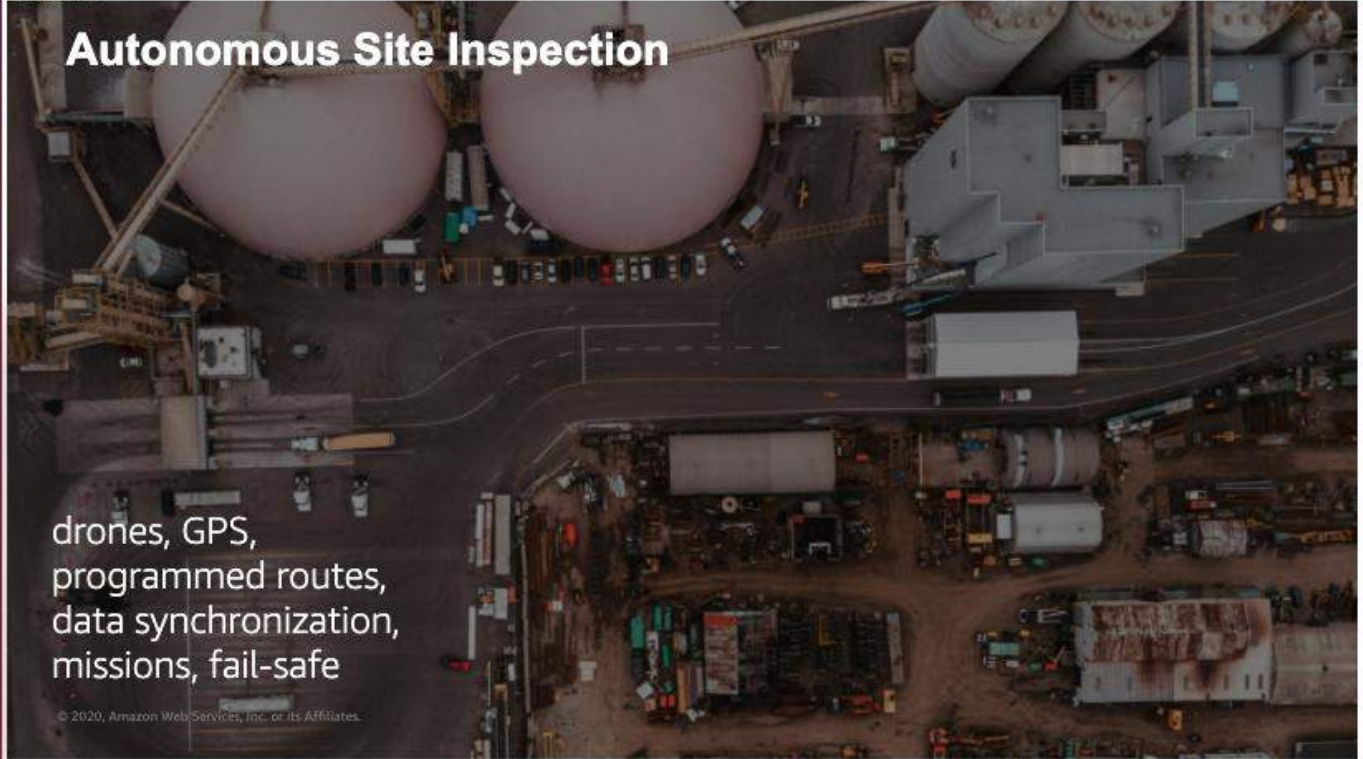
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# Autonomous Site Inspection

drones, GPS,  
programmed routes,  
data synchronization,  
missions, fail-safe

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## Constraints for use cases

	Physics	Economics	Law
Wind Turbine	Vibration detection	Telemetry via cellular	Critical infrastructure
Automobile	MobileEye (ADAS)	ML training data	-
Drone Site Inspection	Path and data collection	-	Corporate security

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# Edge implementation patterns

Abstracted compute, ML, etc.

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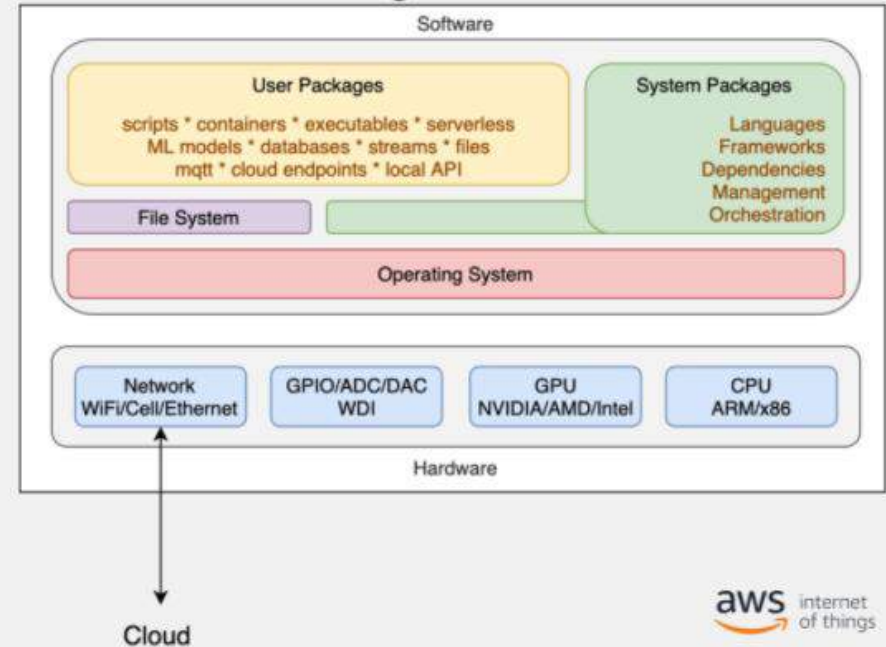
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## Operating system

- **Linux**
- **General purpose**
  - Ubuntu
  - Raspberry Pi OS
- **Embedded**
  - Yocto/  
OpenEmbedded
  - Buildroot
- **Others**
  - Busybox
  - Alpine
  - BalenaOS

## Edge Device



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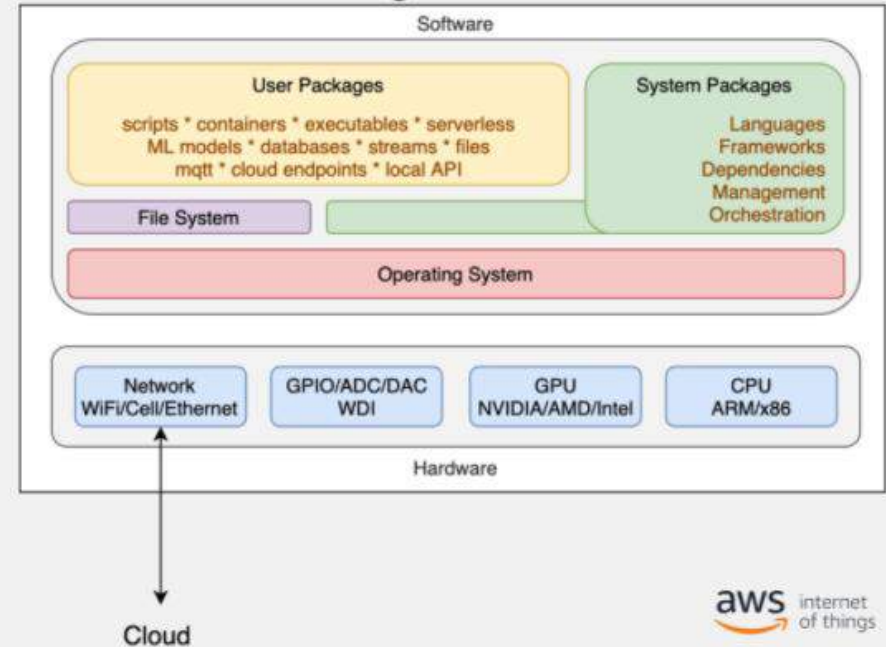
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## System packages

- **Language specific**
  - Python 2.x, 3.x
  - Java, NodeJS
- **Dependencies**
  - .so (GLIBC)
  - Numpy
  - Gstreamer
- **ML/DCNN Frameworks**
  - MXNet
  - TensorFlow Lite/RT
  - Neo-Ai-DLR
- **Management**
  - Tunneling
  - OTA updates
- **Edge Frameworks**
  - K3s, K8s
  - EdgeX
  - AWS IoT Greengrass

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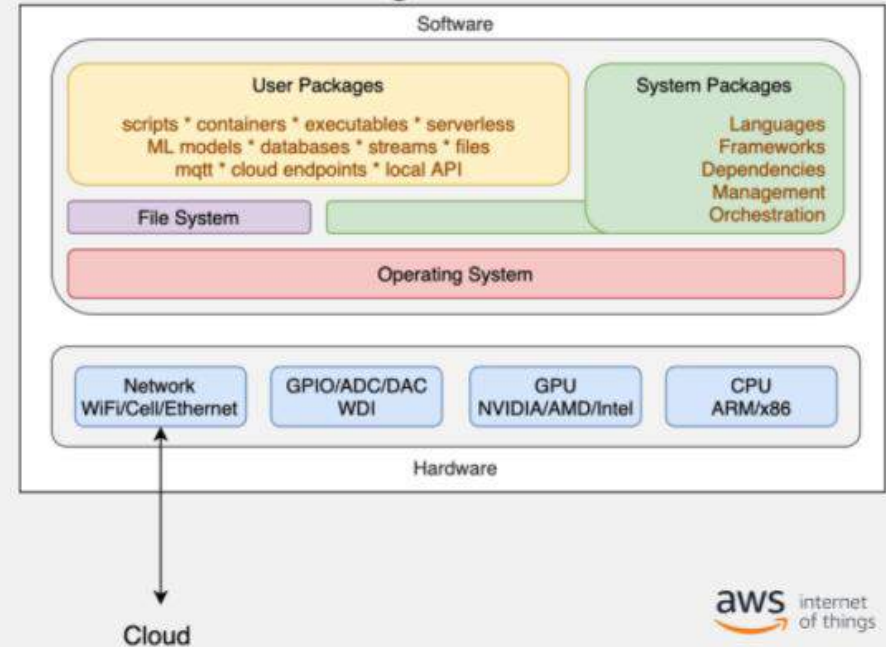
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## User packages

- **Native**
  - Scripts
  - Processes
  - Daemons
- **Containers**
  - OCI/Docker
- **Edge Framework**
  - Functions
  - Containers
  - Services
  - Queues
- **Local Device Interop**
  - APIs
  - Endpoints
- **ML Models**
  - Inference
  - Retraining
  - Drift

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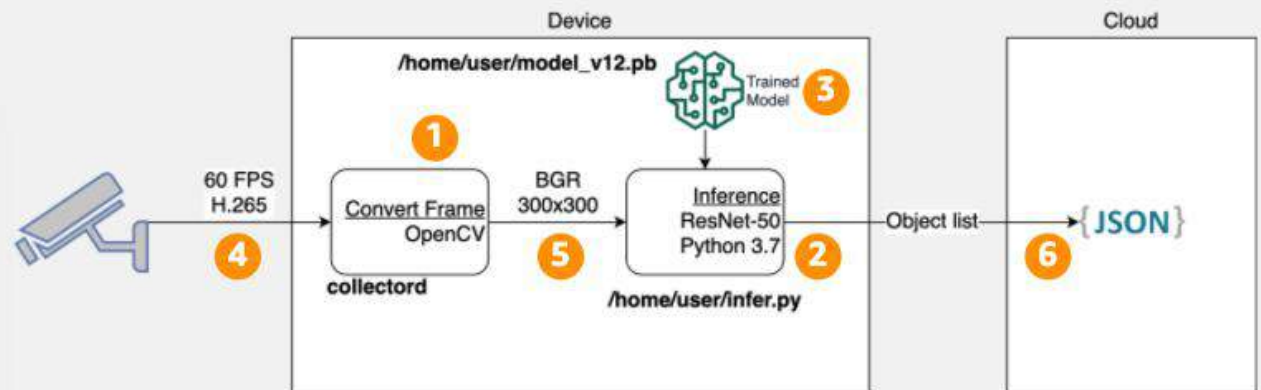
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## Edge computer vision (basic)



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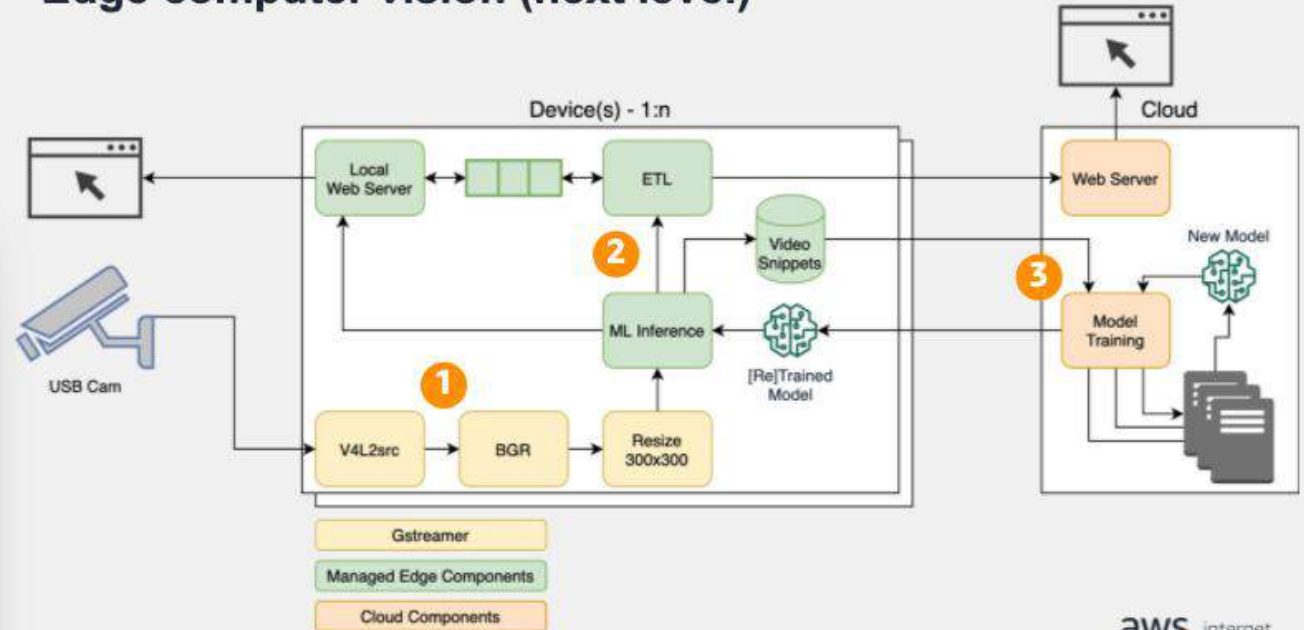
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## Edge computer vision (next level)



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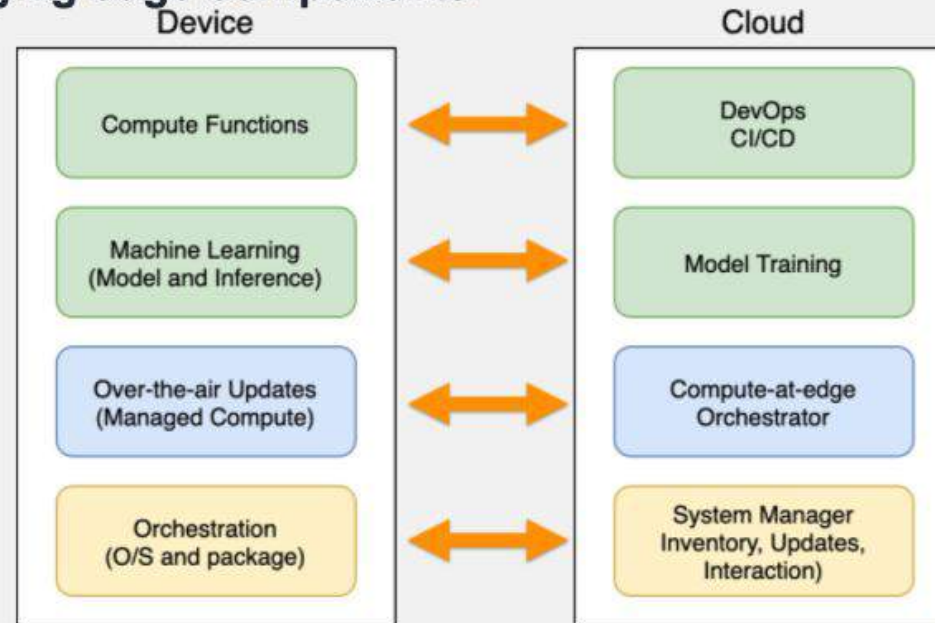
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## Managing edge components



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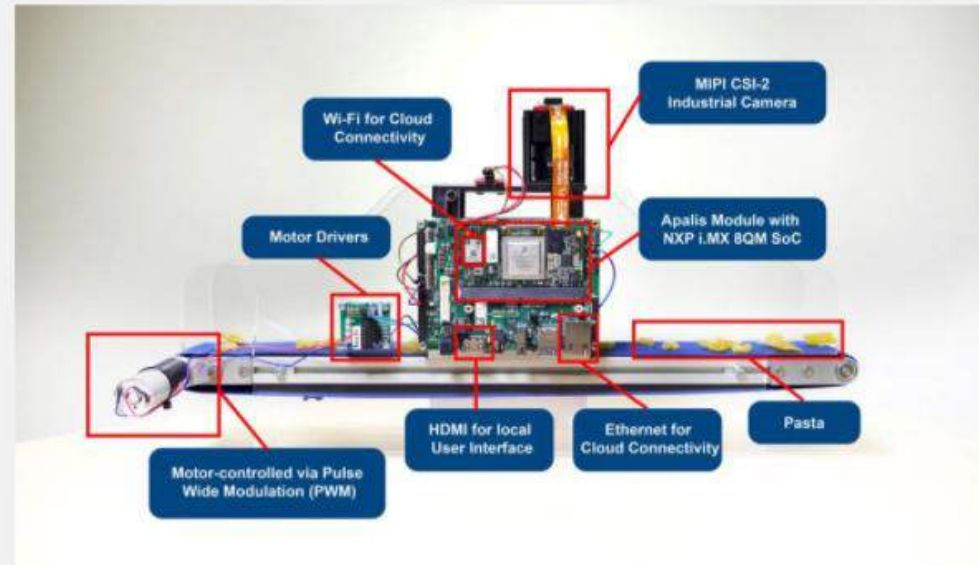
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## Toradex Demo Hardware



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Cloud-enabled AI demonstration

https://www.youtube.com/watch?v=moMTJ1bABfA&feature=youtu.be&t=31

Premium

Search



**Apalis iMX8**  
Powered by NXP® i.MX 8QuadMax (i.MX 8QM)

#ArtificialIntelligence #AWSIoTGreenGrass #iMX8SystemOnModule  
Cloud-enabled AI demonstration - Toradex | Amazon Web Services | NXP

1,037 views • Oct 28, 2019

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Toradex

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AUTOPLAY

My desktop is a laptop! 27:55

Laptop Docks! They're pretty neat! Technology Connections 293K views • 1 day ago New







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Cloud-enabled AI demonstration

https://www.youtube.com/watch?v=moMTJ1bABfA&feature=youtu.be&t=31

Premium

Search

Deep Learning Model Performance

CONVEYOR BELT STATUS

COMPUTE PERFORMANCE

Inference Confidence by Pasta Type

Pasta in Current Frame

Shells

Farfalle

Penne

Elbows

1

2

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Laptop Docks! They're pretty neat!

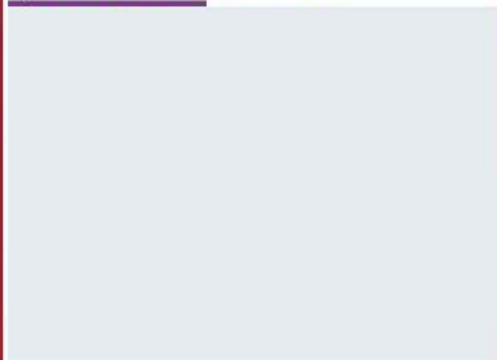
Technology Connections

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27:55

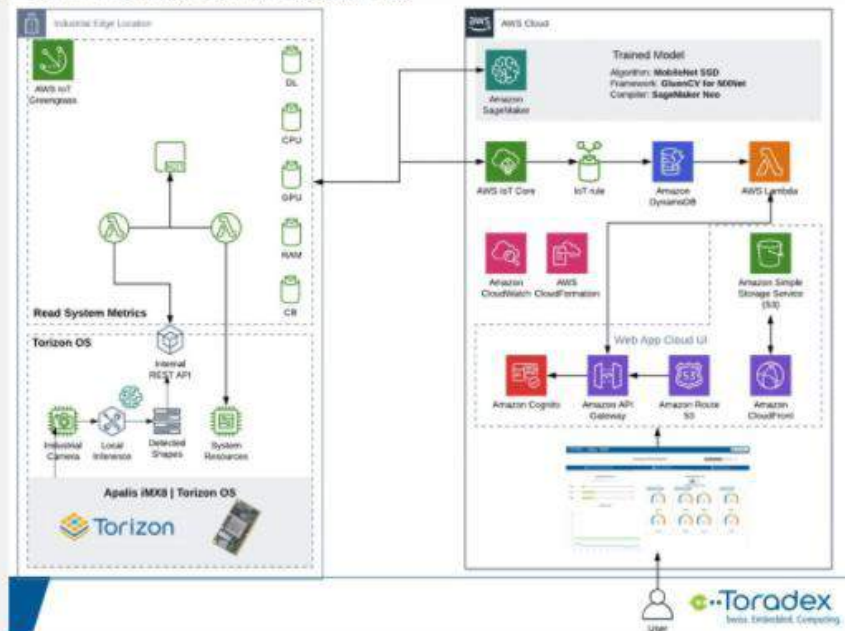


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## Toradex Demo Architecture



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# Hey! Wait! Don't pick up the ph{#`%\${%&`+'\$`{%&NO CARRIER"

When things go horribly, horribly wrong

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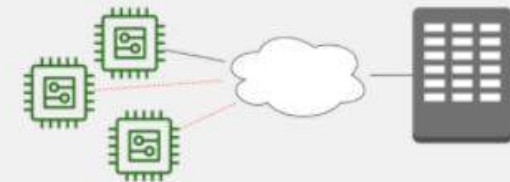
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## SLIDES

# Intermittent connectivity



- Everything fails, all the time
- Design for failure
- Address state and operation
  - Online->offline
  - Offline->online
  - Minutes, hours, ..., years



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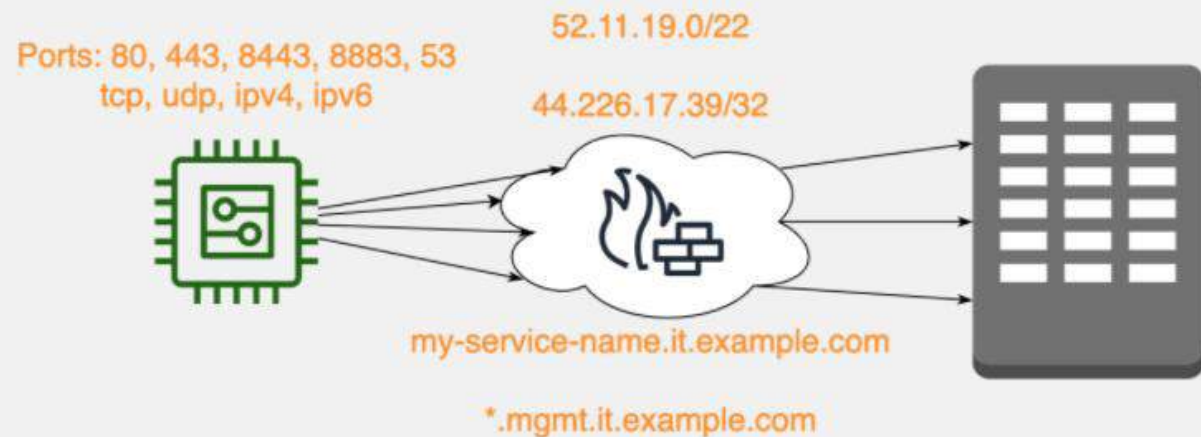


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## Security constraints



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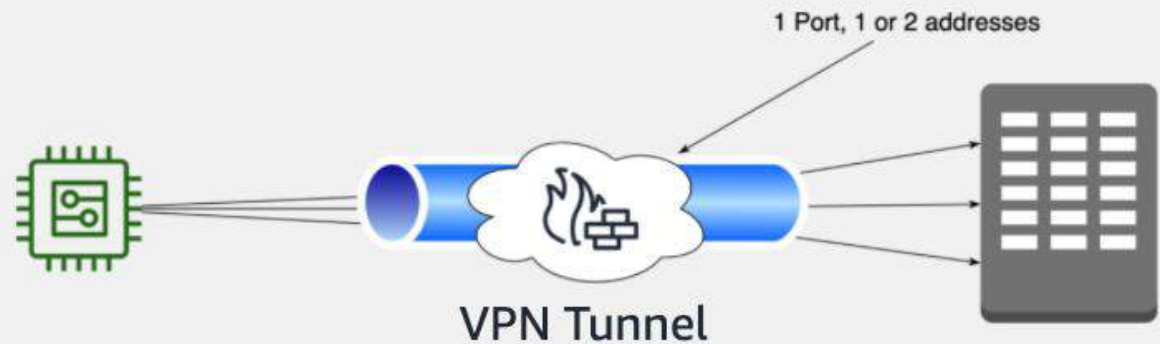
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## Reduce access surface area



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aws internet of things



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## Other design considerations

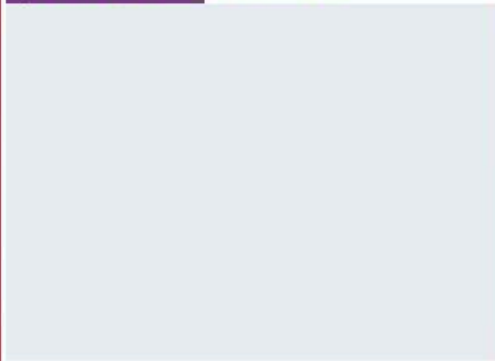
- **Dependencies for functions**
  - Python 2.7 vs 3.6 vs 3.x
  - Common vs packaged per-entity
- **Fail-fast and rollback (don't brick the device)**
  - Watchdog or supervisor
  - Atomic operations
- **Varying environment**
  - Connectivity: hard-wired vs WiFi vs cellular vs LPWAN
  - Off-device resources: file shares, sensors, etc.
- **Secure and rotate credentials**

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# Designs that align

When IT ain't happy, ain't nobody happy\*

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\*Paraphrased from Tracy Bryd



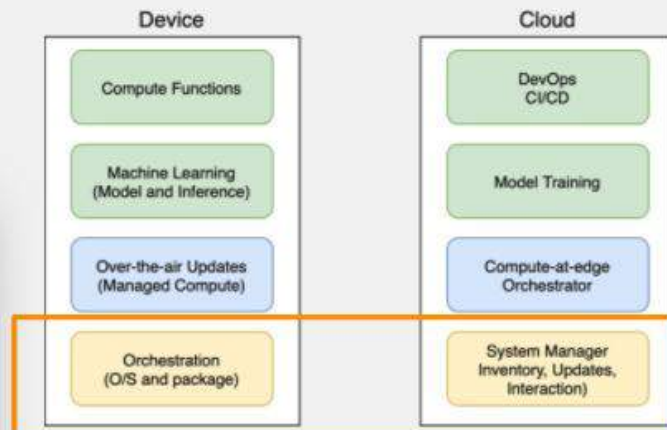


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**NEW QUESTION****SLIDES**

## Managing edge components – Operating System



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- **Operating system**

- Distribution (Debian, RHEL, Yocto)
- Repositories
  - Public, private, baked-in
- Packages
  - Python, Java, .so

- **Orchestration**

- O/S – Salt, Ansible, Puppet
- Container – K8s/K3s, AWS IoT Greengrass
- Serverless – OpenWhisk, OpenFaaS, AWS IoT Greengrass



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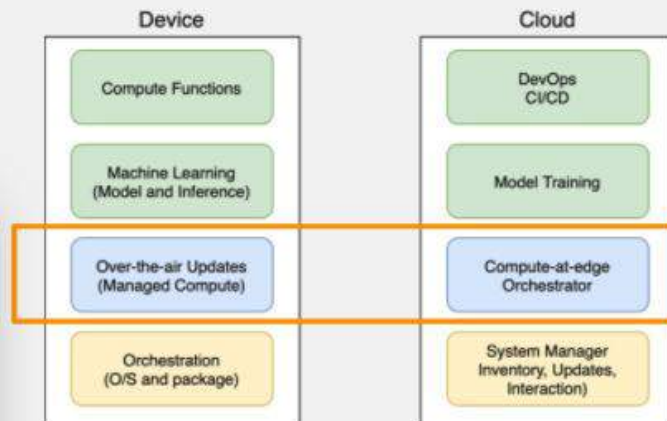
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## Managing edge components – Orchestration



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- **Assets**
    - Functions
    - Image and compose files
    - Machine learning models
    - O/S updates
    - Firmware
  - **Asset access – endpoints**
  - **Fleet management**
    - Deploy, update, report
    - Asset deployment
  - **Status and reporting**
    - Dashboard
    - Device and fleet metrics
  - **Device security/identity**
- 



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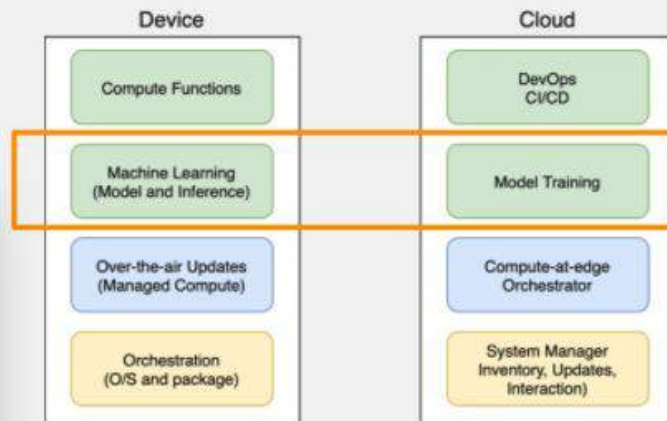
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Q&A area with a large text input field for questions.

Enter question here...

**NEW QUESTION****SLIDES**

## Managing edge components – Machine Learning



### • Training

- Notebooks
- Training dataset
- Validation and test sets
- Training resources (cloud, VM, dedicated hardware)

### • Model Output

- DLR, TVM, Treelite
- Mxnet, TensorFlow, Caffe
- Asset storage location

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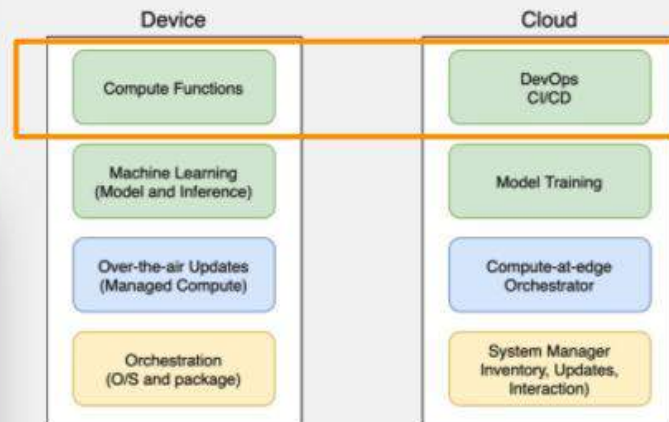


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## Managing edge components – Edge Logic



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- **Development**
  - Git, IDEs, CI/CD pipeline
  - Unit and regression testing
  - Artifact location
- **Testing**
  - Unit, regression, simulated device
  - Inclusive of O/S, orchestration and ML
- **Deployment**
  - One-box (if available)
  - Blue-green
  - Fleet deployment
- **Roll-back**



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# Pulling it all together

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### In summary

- If there is any semblance of connectivity for a device, edge compute and machine learning can be adopted
- Define or adopt patterns to build a “full-stack” edge device
- Depending upon where and how deployed, research potential “gotcha’s” and address or accept
- Leverage the hard work and tools of your IT or OT department
- Look to AWS IoT Greengrass as an example of edge compute and machine learning capabilities

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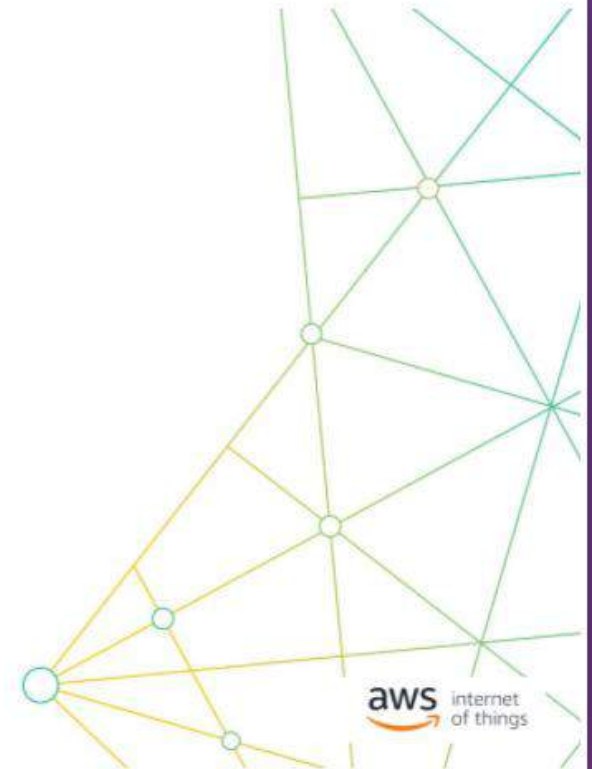
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# Q&A

## Deep Learnings at the Edge

Gavin Adams, Specialist Solutions Architect  
Amazon Web Services

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