



**UiO** : Department of Technology Systems  
University of Oslo

**TEK5530 - Measurable Security for the Internet of Things**

# **L15 – Cloud basics**

*György Kálmán,  
UiO ITS*

[gyorgy.kalman@its.uio.no](mailto:gyorgy.kalman@its.uio.no)

*Josef Noll  
UiO ITS*

[josef.noll@its.uio.no](mailto:josef.noll@its.uio.no)



## Cloud – Security – IoT

- What is cloud computing
- Delivery models and shared responsibility
- Cloud architecture
- Recommended additional resources





## What is cloud computing

- A remote pool of (shared) resources on different levels
- Dynamic provisioning, elastic use of resources, pay-as-you-go
- A type of outsourcing

- Increased utilization of resources, economy of scale
- Multi-tenancy
- Global reach
- Running expense vs capital expense
- High availability – but assumes (fast) internet connectivity

Deployment: public, private, hybrid and community

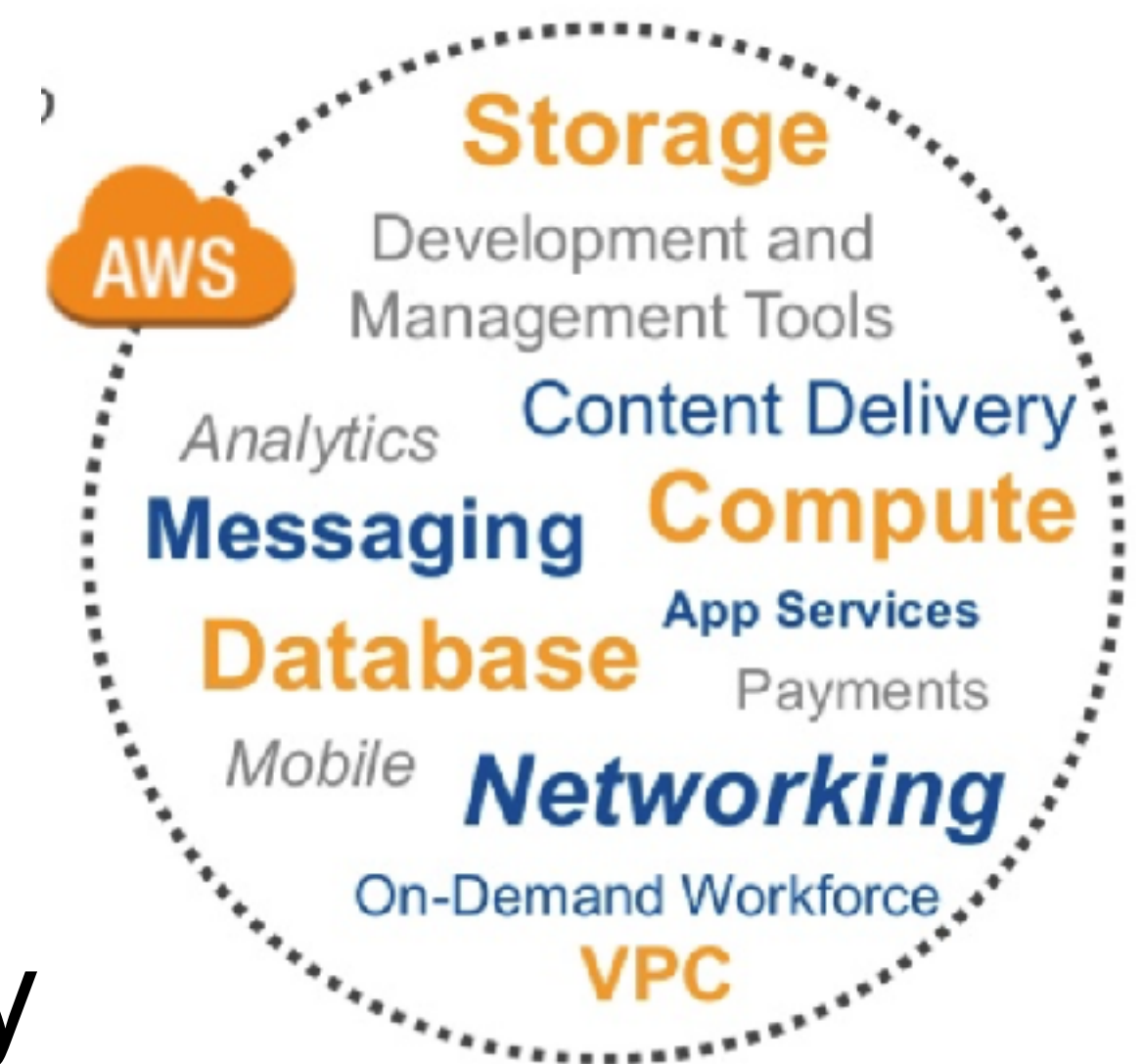
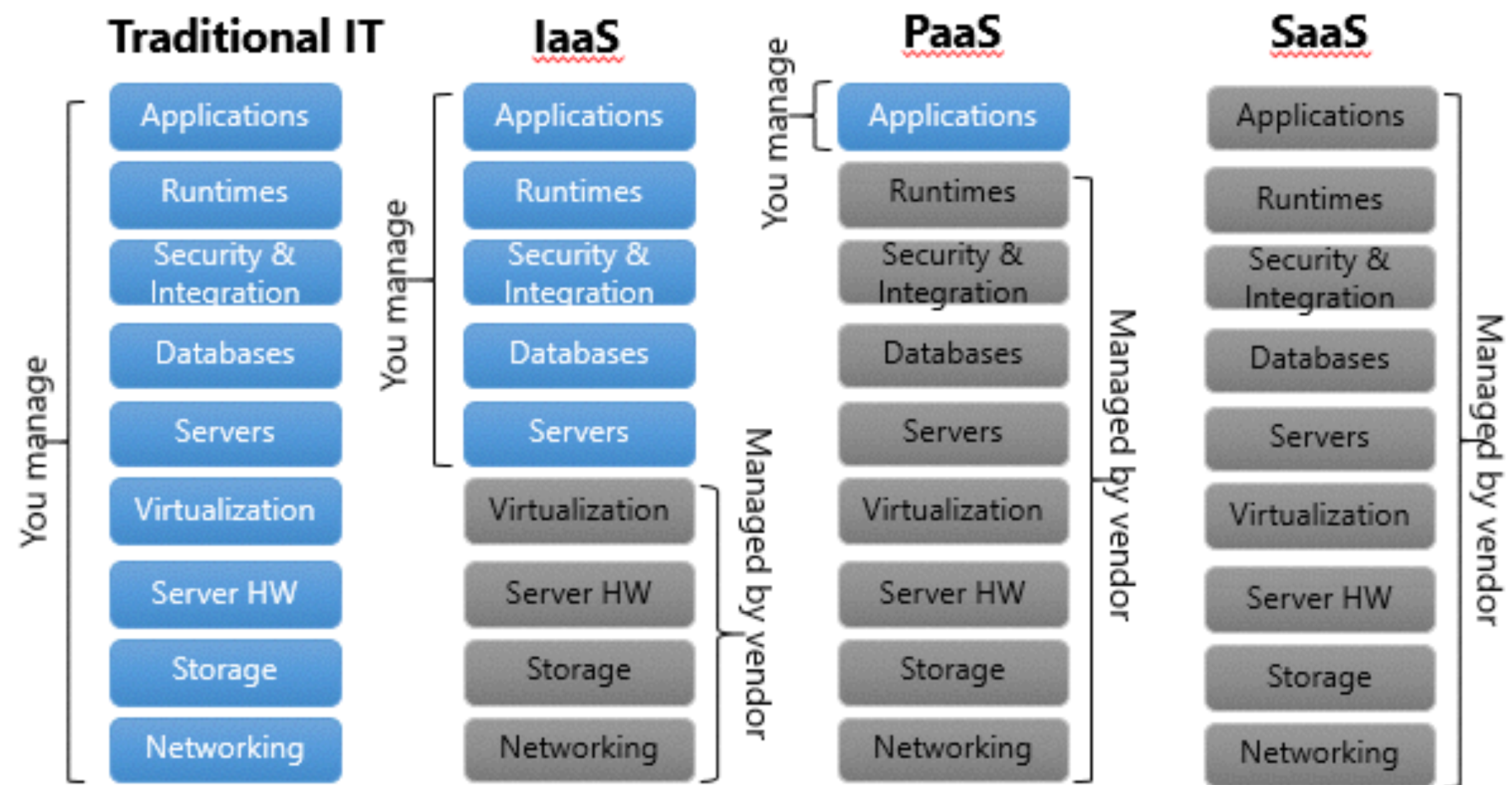
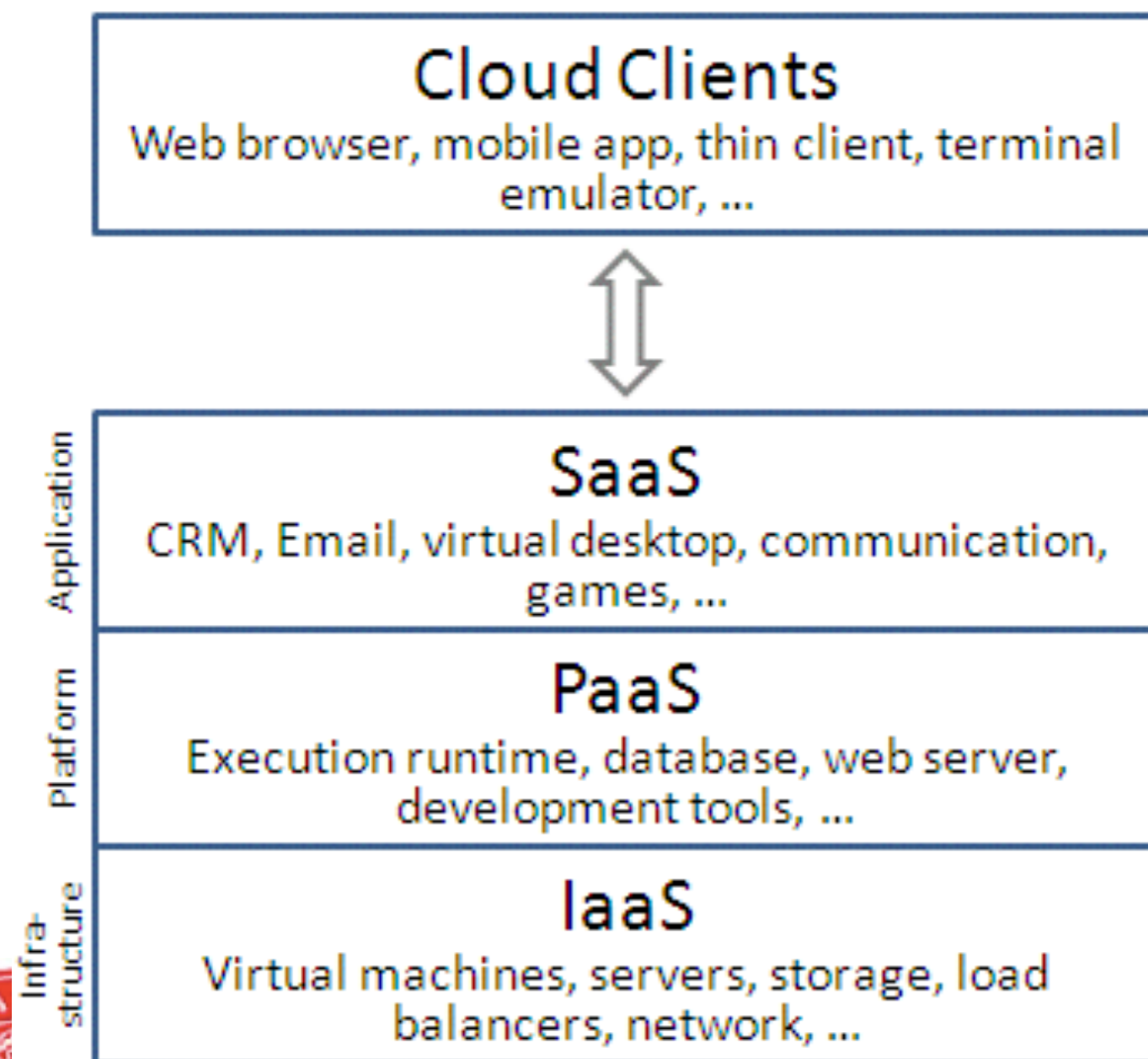


Figure from <https://www.slideshare.net/AmazonWebServices/awesome-day-nashville-2018training>



## Delivery models

- Infrastructure as a Service (IaaS)
- Platform as a Service (PaaS)
- Software as a Service (SaaS)



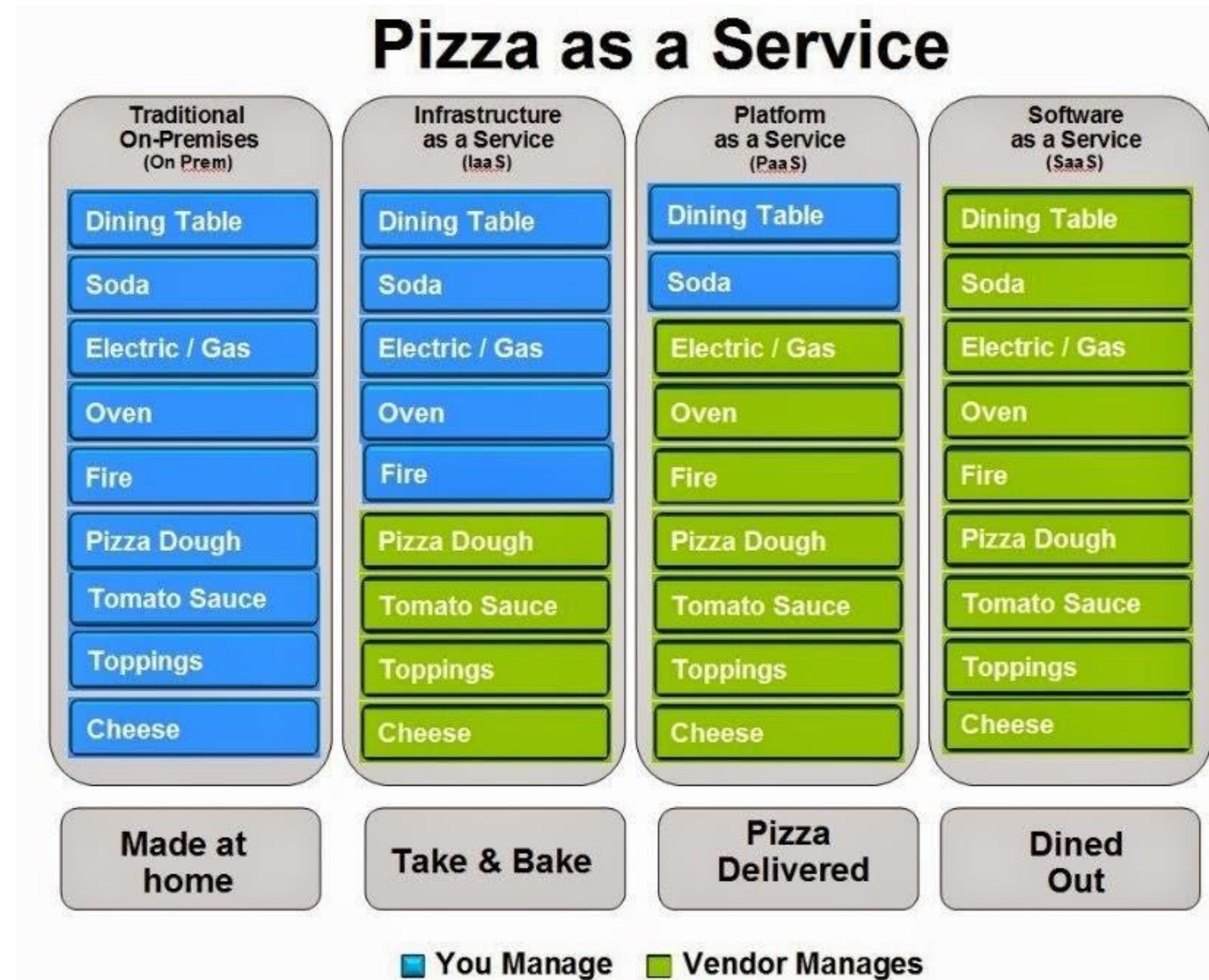
Both figures are from: <http://oracle-help.com/oracle-cloud/cloud-computing-stack-saas-paas-iaas/>





## Delivery models contd.

→ A perfect figure from Fred Bals at Episerver



<https://www.episerver.com/learn/resources/blog/fred-bals/pizza-as-a-service/>



## Delivery models contd.

- On demand, self-service provisioning
- Virtual workspaces
- Xen with para-virtualization (near-native performance, live migration)
- Patch management, golden images, instant update

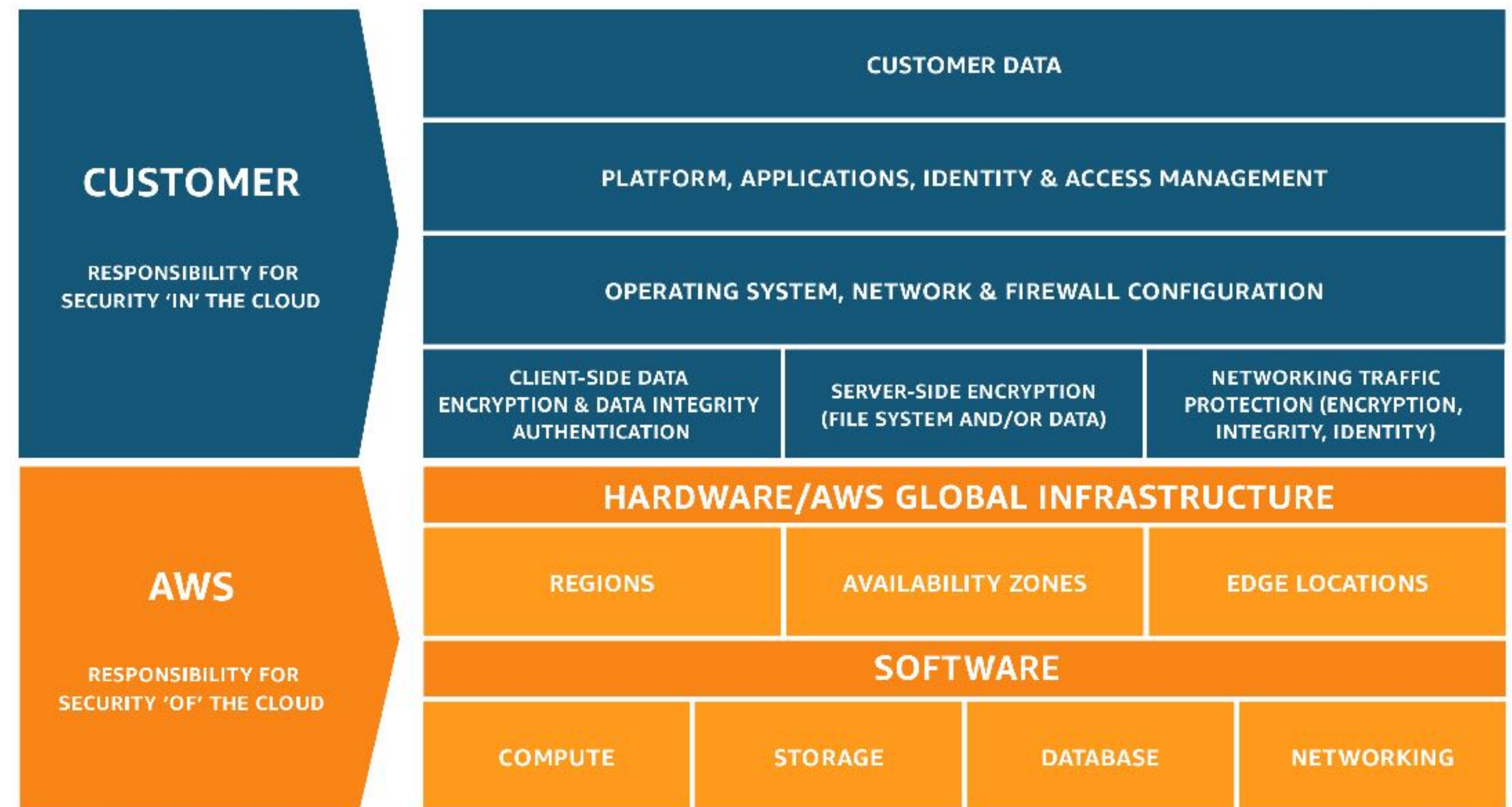


<https://www.episerver.com/learn/resources/blog/fred-bals/pizza-as-a-service/>



## AWS Shared Responsibility Model

- AWS responsibility is to provide a reliable and secure infrastructure, where the customer services can be built on, a «foundation»
- Customer responsibility is determined by the services chosen
- Wide range of services
- And third party deliveries



<https://aws.amazon.com/compliance/shared-responsibility-model/>



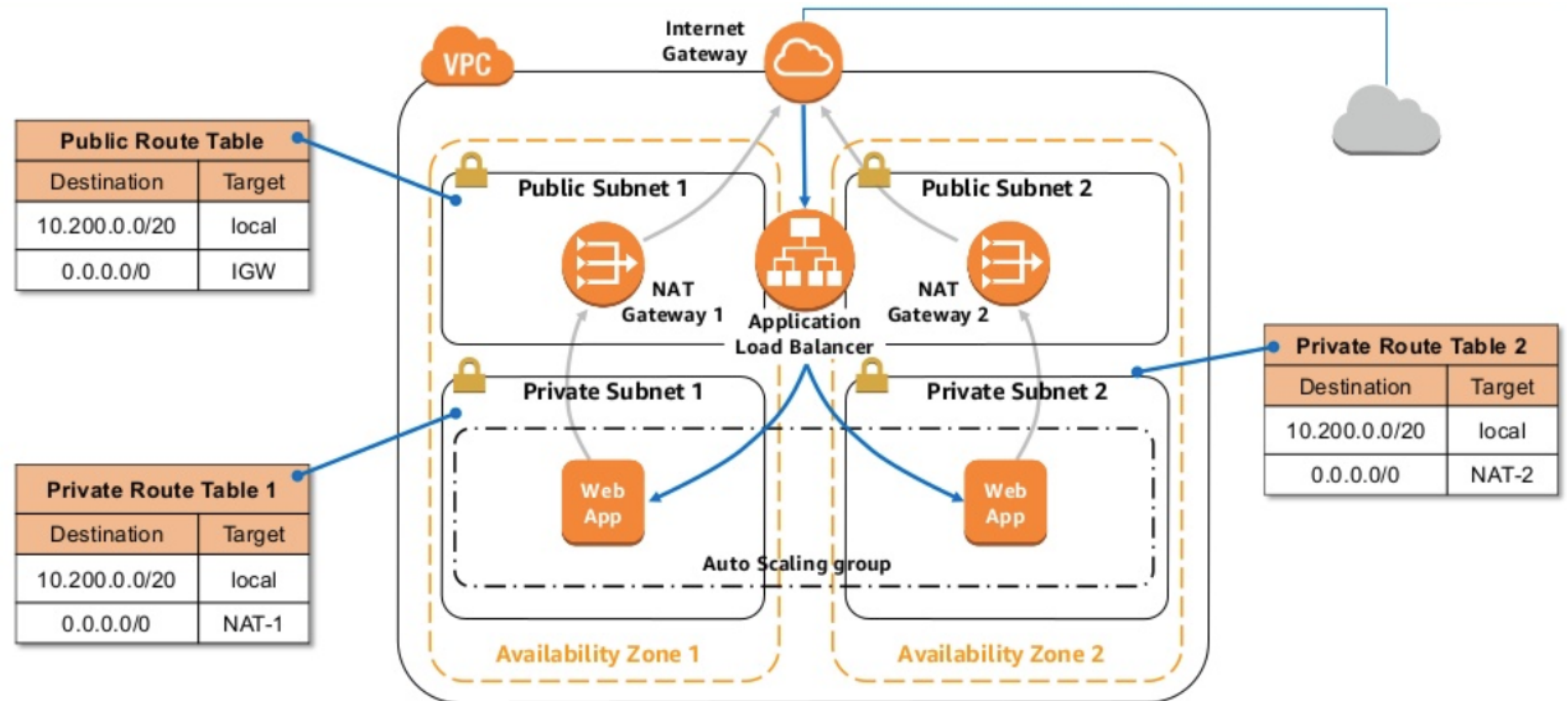
## Fundamentals

- Edge location
  - ▶ Border towards CloudFront, AWS' Content Delivery Network
  - ▶ Supports AWS DNS service (Route 53), WAF, Shield, Lambda@Edge
- Basic components
  - ▶ EC2
  - ▶ S3
  - ▶ VPC
- AWS Marketplace: a Play store for your cloud installation





## Generic service architecture



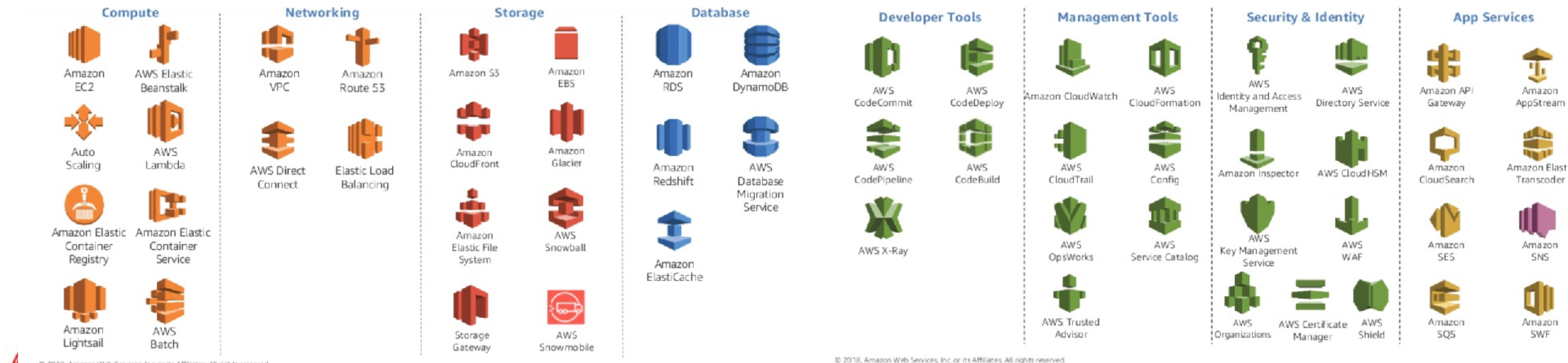
© 2018, Amazon Web Services, Inc. or its Affiliates. All rights reserved.





## AWS in a nutshell

- Launched in 2006, originally to utilize computing capacity investment for Christmas season
- Over a thousand features released every year
- In Europe, Ireland is the main site and expanding rapidly, also in the Nordics



© 2018, Amazon Web Services, Inc. or its Affiliates. All rights reserved.

© 2018, Amazon Web Services, Inc. or its Affiliates. All rights reserved.





## Security infrastructure

- ▶ Principles and tools
- ▶ Identity and Access Management, Certificates
- ▶ Security services
  - ▶ Security Group, Internet gateway, NAT gateway
  - ▶ Network security: IDS, WAF, network functions
  - ▶ Vulnerability management
  - ▶ Data encryption and protection



## Security infrastructure

- ▶ Isolation levels and possibilities:
  - ▶ Inside VPC: security groups, NACLs, IAM resource level constraints
  - ▶ Between VPCs: separate networks, peering, routing and IAM
  - ▶ Between accounts: treated as having no connection between «foreign network»





## Security controls

- ▶ Directive controls
  - ▶ AWS organizations and AWS IAM
- ▶ Preventive controls
  - ▶ Security Group, CloudFormation, OpsWorks, VPC, Shield, WAF
- ▶ Detective controls
  - ▶ CloudTrail, AWS Config, CloudWatch, Inspector, network flow logs
- ▶ Responsive controls
  - ▶ AWS Trusted Advisor, Amazon Config Rules,



## Identity and Access Management

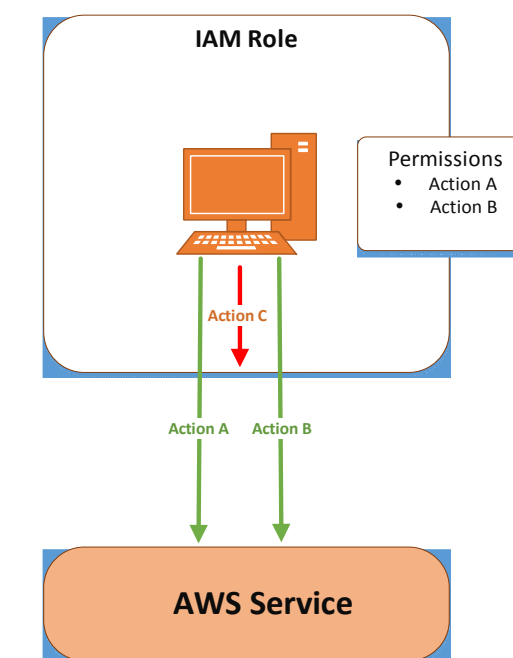
- ▶ Controls access to resources and services run on AWS
  - ▶ Manage and set up permissions for users and applications
  - ▶ Supports federation through standard interfaces
- ▶ Main components are: policy, role and group:
  - ▶ Policy defines the actions, resources and other options
  - ▶ Role is an identity with policies connected to it
  - ▶ Group is an entity, which can connect to multiple common policies





## Identity and Access Management

- ▶ Best practices:
  - ▶ Minimize root account use, multi-factor authentication is a must for root, enable at first use, create own IAM role at once, root shall not be used for management
  - ▶ Create individual user accounts – that we have talked about already, when the situation allows, use personal accounts, helps both in forensics and keeping your users cautious
  - ▶ Use groups and roles, avoid granting an access rule directly to a user
  - ▶ Use own roles for applications e.g. run on EC2
- ▶ Use AWS default policies if you can



## Security services

- ▶ AWS Key Management System
- ▶ CloudHSM
  - ▶ Highly secure tamper resistant component for cryptographic operations
  - ▶ To my knowledge, the only actual physical device you can own in aws
- ▶ AWS Inspector
  - ▶ Automated compliance and vulnerability scanner for applications deployed in aws.
- ▶ AWS Certificate Manager
  - ▶ Provision, manage and deploy TLS certificates, supports ELB or CloudFront

Security Groups





## AWS Key Management Service

- ▶ Managed service for encryption key management
- ▶ Allows importing keys
- ▶ Easy integration with other AWS services
- ▶ AWS SDK available to integrate with your own application
  
- ▶ To support cryptographic applications:
  - ▶ Encryption in transit and at rest
  - ▶ Disk volume encryption
  - ▶ Database encryption



## Cryptographic services – storage and database

- S3 server side (encryption after data is received):
  - ▶ S3-managed keys: SSE-S3
  - ▶ AWS KMS managed keys: SSE-KMS
  - ▶ Customer-provided keys: SSE-C
- S3 client side (encryption before data is sent):
  - ▶ Use an AWS KMS-managed customer master key
  - ▶ Use a client side master key
- Database: server side with KMS, server side with HSM, client side, support depends on the actual database solution (most support for KMS)





## Network security

- ▶ Secure DNS: Route 53
- ▶ GuardDuty – IDS
- ▶ AWS Shield (Advanced) – WAF
- ▶ Controlling in- and egress traffic: Internet Gateway, NAT Gateway, VPC, transit VPC, NACL, Security Groups
  
- ▶ DDoS: layer 3 and 4: using filtering, elasticity, routing, L7: Shield and WAF



## Shield Advanced

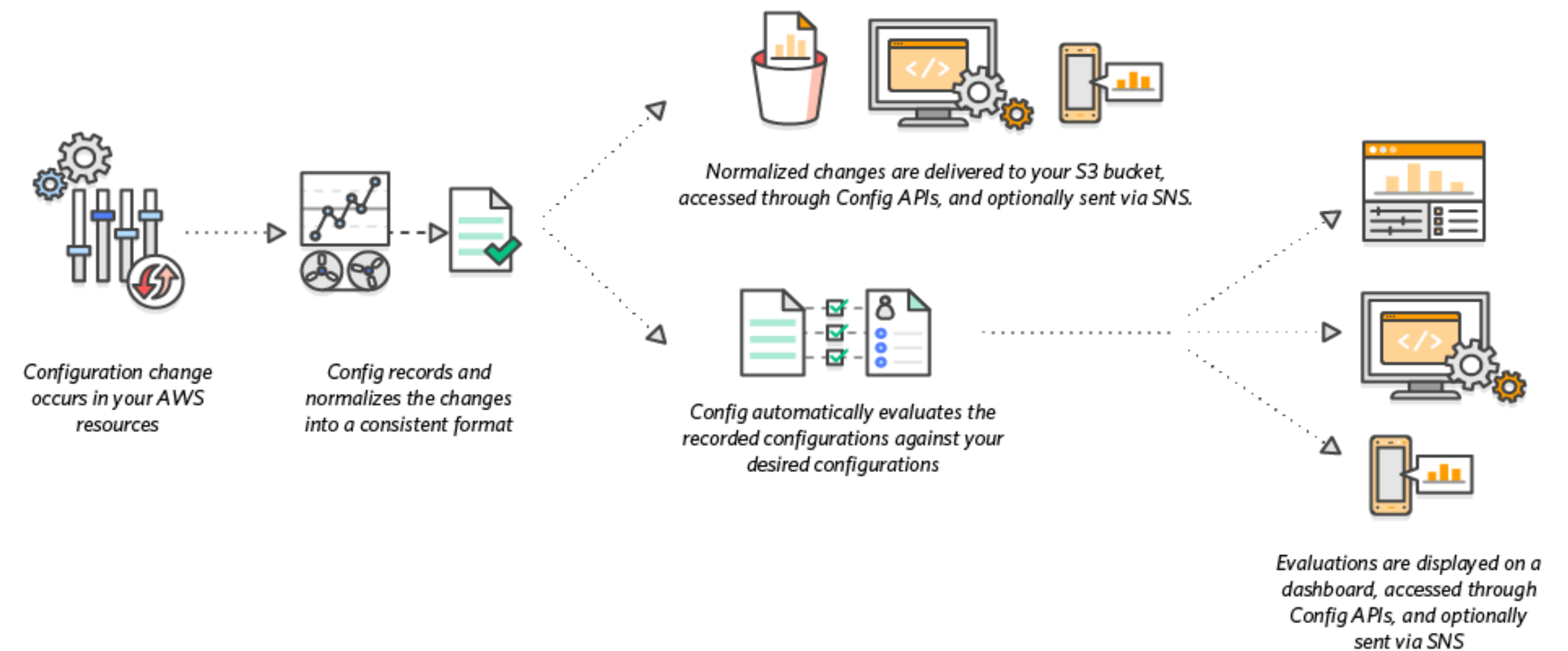
- ▶ Paid service (free version available)
  - ▶ Visibility into attacks
  - ▶ Custom mitigations
  - ▶ Post attack analysis
  - ▶ Instant rule updates and rule subscriptions





## Management

- ▶ AWS Config
  - ▶ Resource inventory, configuration history and change notifications
  - ▶ Record, archive and compare
  - ▶ Secure against accidental €



## Management

- ▶ Vulnerability management
  - ▶ Nessus or Qualys
  - ▶ Golden image creation with aws AMI
- ▶ AWS Inspector
  - ▶ Automatic assessment of applications for vulnerabilities and deviations from best practice
- ▶ AWS Macie
  - ▶ Accidental exposure, focuses on leaking personal information and other confidential information
- ▶ Amazon Config Rules:
  - ▶ Enforce best practice, automatic roll-back, trigger additional workflow
- ▶ AWS Trusted advisor: cost, performance, security and availability optimizations





## Management – Infrastructure as Code

- ▶ With AWS CloudFormation
- ▶ Orchestrate changes across aws services
- ▶ JSON-based text file to describe infrastructure
- ▶ Resources created based on template
- ▶ Example: [https://s3-us-west-2.amazonaws.com/cloudformation-templates-us-west-2/Windows\\_Single\\_Server\\_Active\\_Directory.template](https://s3-us-west-2.amazonaws.com/cloudformation-templates-us-west-2/Windows_Single_Server_Active_Directory.template)



## Management – Trusted Advisor

- ▶ Checks available for all (some features free):
  - ▶ Security: security groups, IAM use, MFA for root, snapshots, S3 bucket permissions, CloudTrail,
  - ▶ Performance: are you within service limits (user plane vs management plane), EC2 with high load, database throughput
  - ▶ Cost optimization: EC2 reserved instances, Idle EC2, Idle LB, RDS idle
  - ▶ Fault tolerance: snapshots, Availability zones, VPN redundancy, auto scaling group resources, RDS backup and multi AZ
  - ▶ Service limits





## Management

- ▶ Data protection in practice:
- ▶ S3: add metadata and set permissions, switch on native KMS-based encryption at rest, limit access (no public avail. -> e.g. Macie can find it)
- ▶ EBS (elastic block storage, volume type): restrict to be accessible only by creating account, only users in AWS IAM, integrates with KMS



## Logging: monitoring, forensics and compliance

- ▶ Sources:
  - ▶ CloudTrail: records AWS API calls
  - ▶ CloudWatch logs and events (alarms)
  - ▶ Load balancer logs
  - ▶ S3 logs
  - ▶ AWS IAM
  - ▶ VPC flowlogs
    - This looks like e.g. a wireshark capture
- ▶ Splunk





## Logging: monitoring, forensics and compliance

- ▶ Compliance:
  - ▶ AWS Artifact: access to aws compliance reports
  - ▶ AWS Macie
  - ▶ Amazon Config Rules



## Penetration testing

- ▶ Customers can execute tests against 8 services without prior permission (new)
- ▶ But not:
  - o DNS zone walking via Amazon Route 53 Hosted Zones
  - o Denial of Service (DoS), Distributed Denial of Service (DDoS), Simulated DoS, Simulated DDoS
  - o Port flooding
  - o Protocol flooding
  - o Request flooding (login request flooding, API request flooding)





## AWS IoT

- In general: exploit the global reach, flexible infrastructure
- Larger operations are especially interesting: predictive maintenance, traffic management, logistics, demand estimation
- Provides infrastructure to get information from the edge and process it with AWS services.
- An interesting feature is the Rules engine, which can be queried with SQL-like expressions
- Higher-level services built on the acquired data (e.g. traffic stats -> prediction)
- Device Shadow, use Lambdas



## Main steps in AWS IoT

“Securely connect one or one-billion devices to AWS, so they can interact with applications and other devices”

1

Securely connect any physical device to AWS



Connect any device via MQTT/HTTP securely. Quickly get started with AWS IoT Starter Kits and Scale to billions of messages across millions of devices

2

Respond to signals from your fleet of devices and take action with Rule Engine



Shift business logic from device to cloud and route data to AWS service of your choice for storage and analysis using rules engine.

3

Create Web and Mobile Applications that Interact with Devices reliably at any time

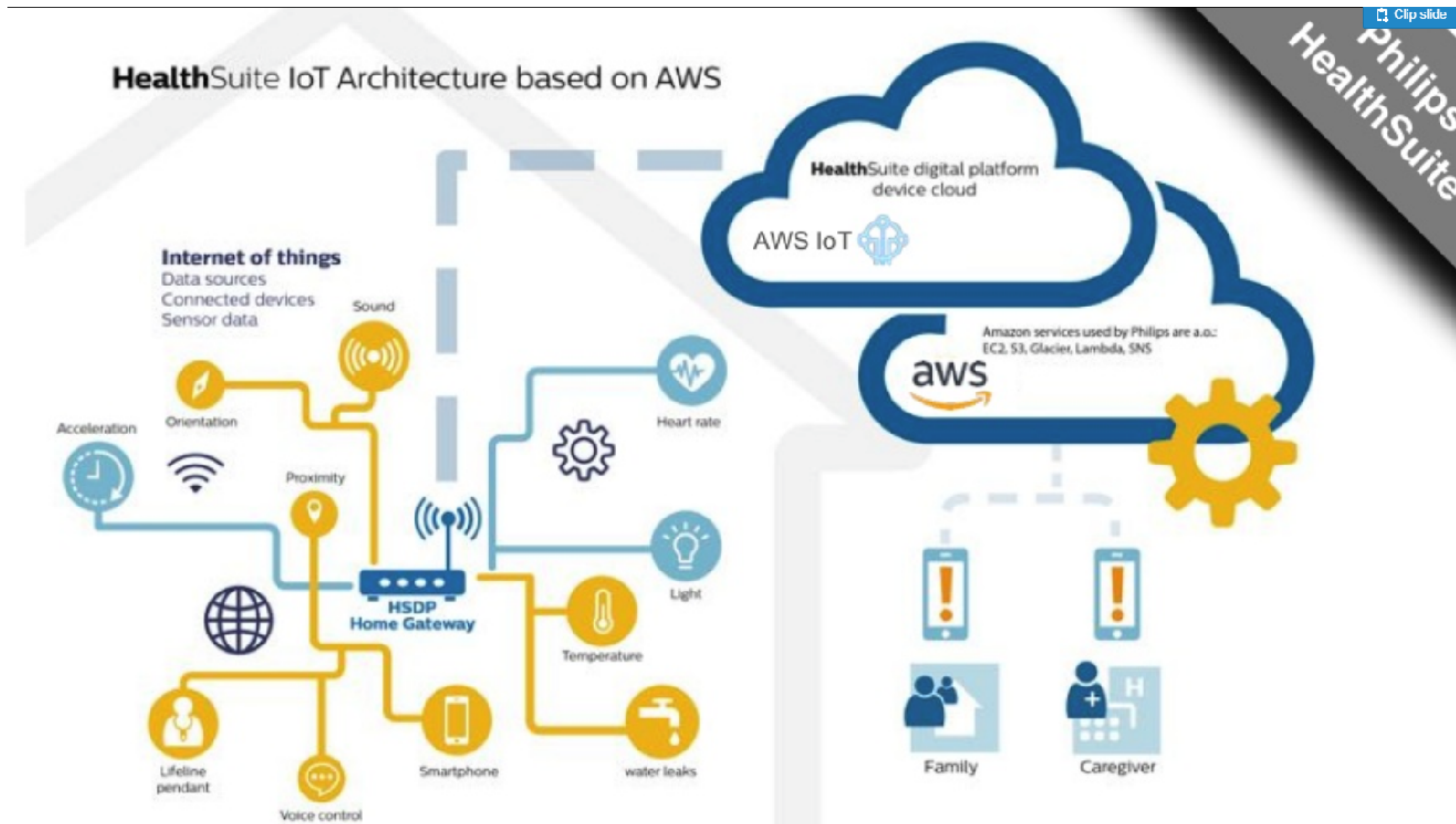


Easily build applications on web and mobile that interact with devices, even when they are offline, with AWS SDK and Device Shadow.



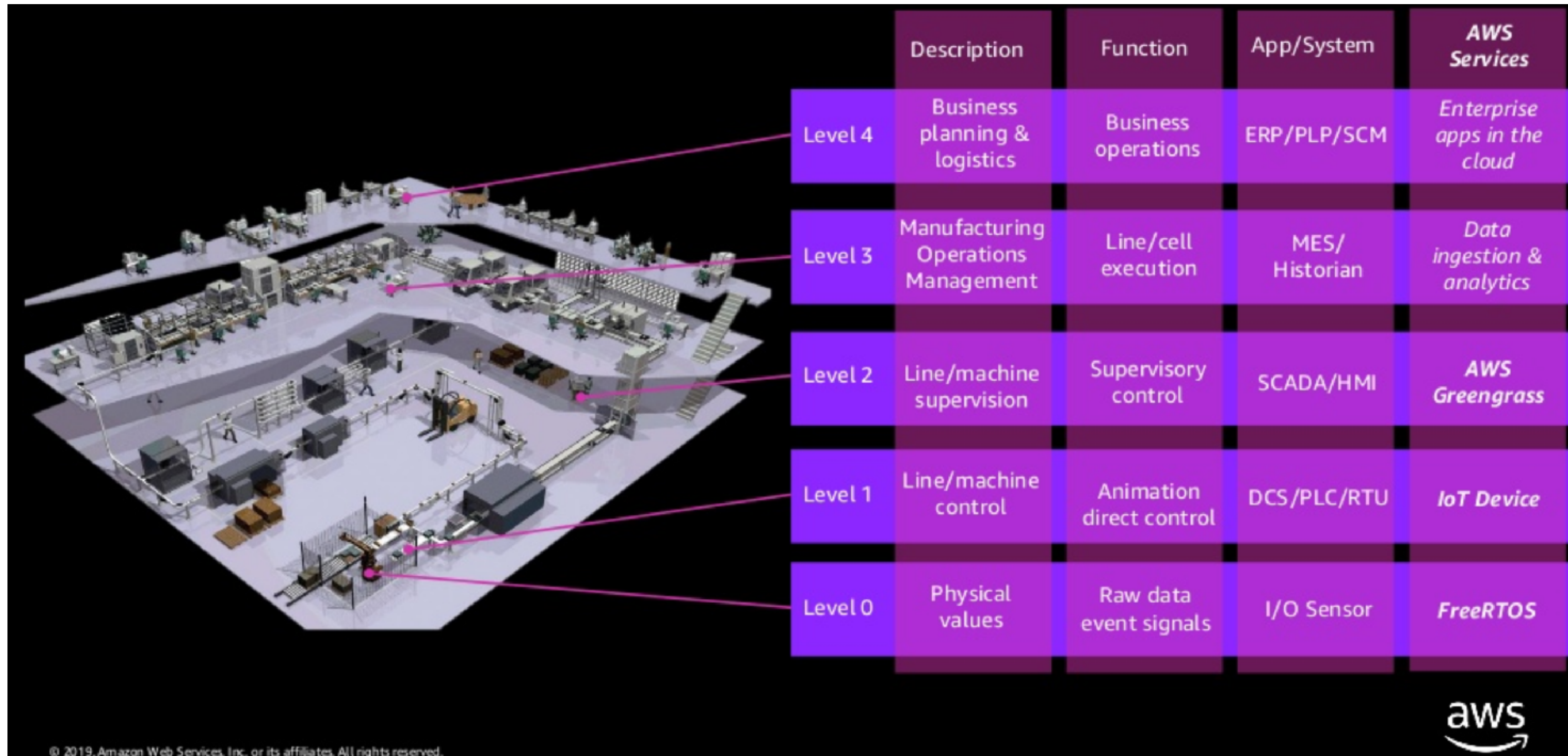


## Healthcare example





## AWS in relation to ISA-95





## Be careful!

- Slide from the same presentation as on the previous one
- One has to be careful: the system is getting cheaper, but the capabilities and the environment, where they can be operated is changing
- It is not this easy to cut the automation costs

PLC + PC + SCADA	Soft PLC + SCADA	SBC + SCADA
<i>Required for control:</i>	<i>Required for control:</i>	<i>Required for control &amp; remote data:</i>
PLC (CPU 416-3 PN/DP) ----- €8.000	Panel PC (Windows) ----- €3.400	Raspberry Pi 3 model B+ ----- €33
PLC components ----- €3.600	Simatic Net Licentie ----- € 600	Raspberry Pi components ----- €50
Brewmaxx Express V9 500 ----- €11.000	SoftPLC ViCA (Pentair owned) ----- €0	Codesys control for RPi SL ----- €50
Panel PC ----- €3.400	Office home and business ----- €200	Codesys Runtime Key, kompakt ---- €45
Office home and business ----- €200		15" Flat panel ----- €760
<i>Required for remote data</i>		
Simatic Net Licentie ----- € 600		
Raspberry Pi cloud gateway ----- € 83*		
<b>Total costs ----- €26.883</b>	<b>Total costs ----- €4.200</b>	<b>Total costs ----- €950</b>



## AWS FreeRTOS

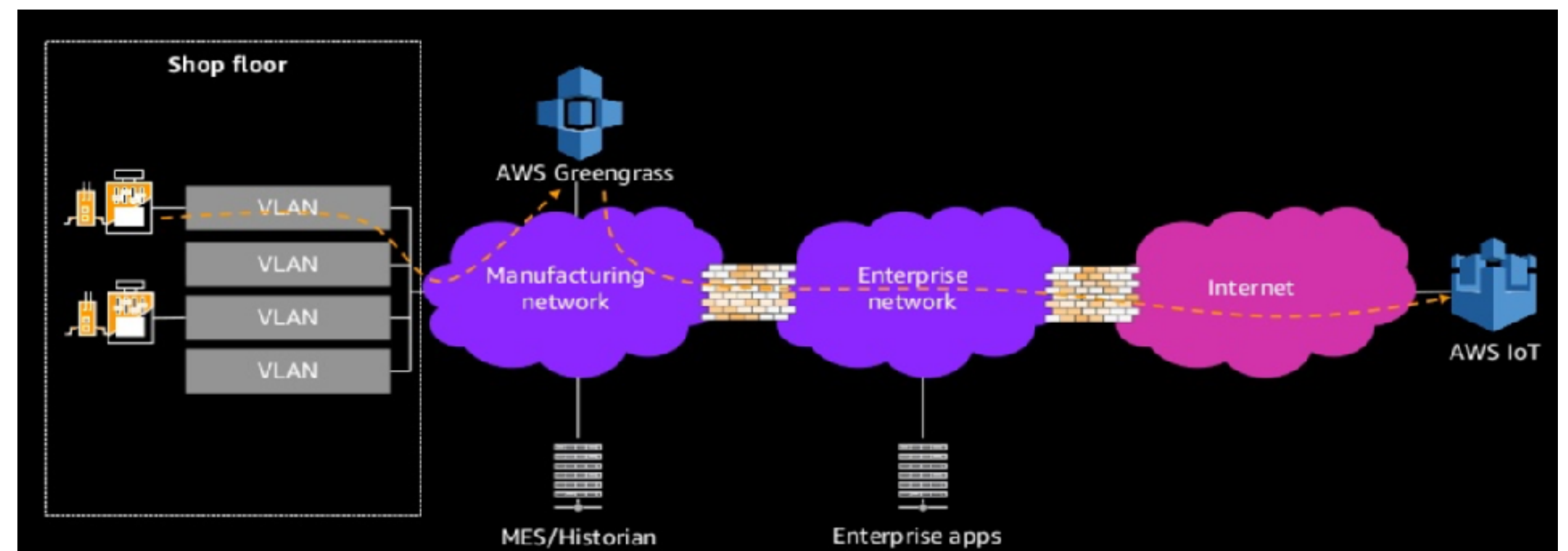
- A free RTOS with extensions to connect to AWS services
  - ▶ Key importance for getting market share
  - ▶ OS is important in the budget of embedded projects
  - ▶ <https://aws.amazon.com/freertos/>





## AWS Greengrass

- Together with Amazon FreeRTOS: enable amazon IoT for a wider audience
- Offline operation with Lambda and device shadow support
- Local extraction, processing and reaction possibility → QoS, criticality!
- Forwards information to AWS IoT core → which can then serve them as SaaS to Enterprise IT
- Secrets manager
- HW security

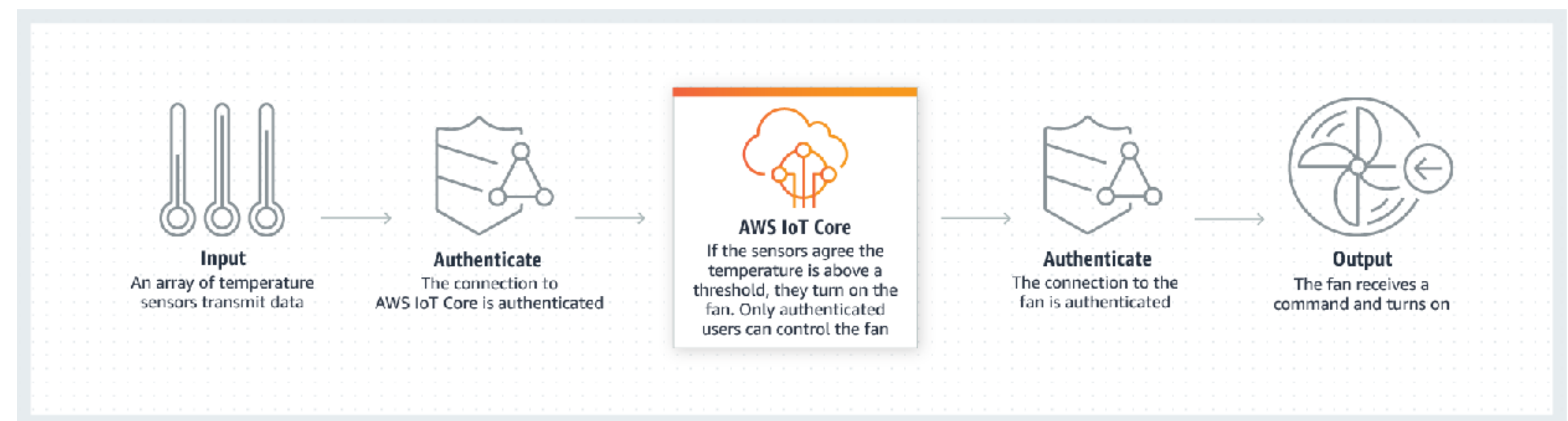
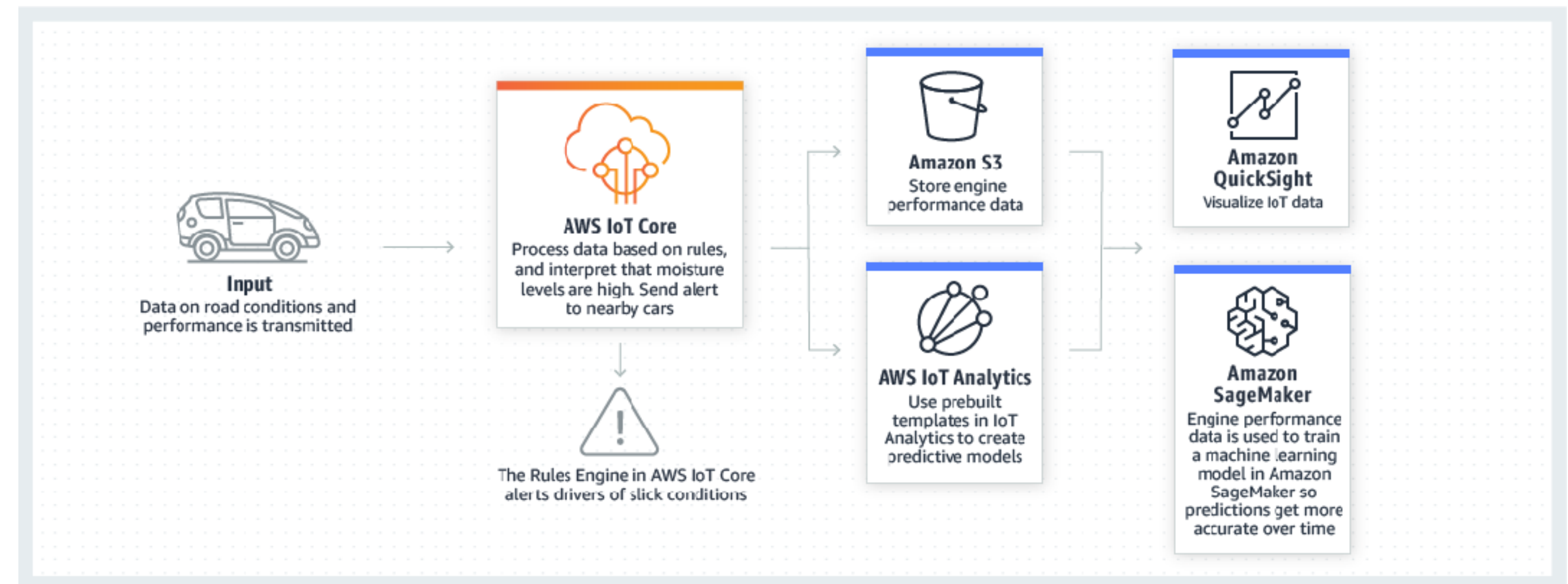


<https://www.slideshare.net/AmazonWebServices/aws-intelligent-at-edge-for-iot>



## AWS IoT Core

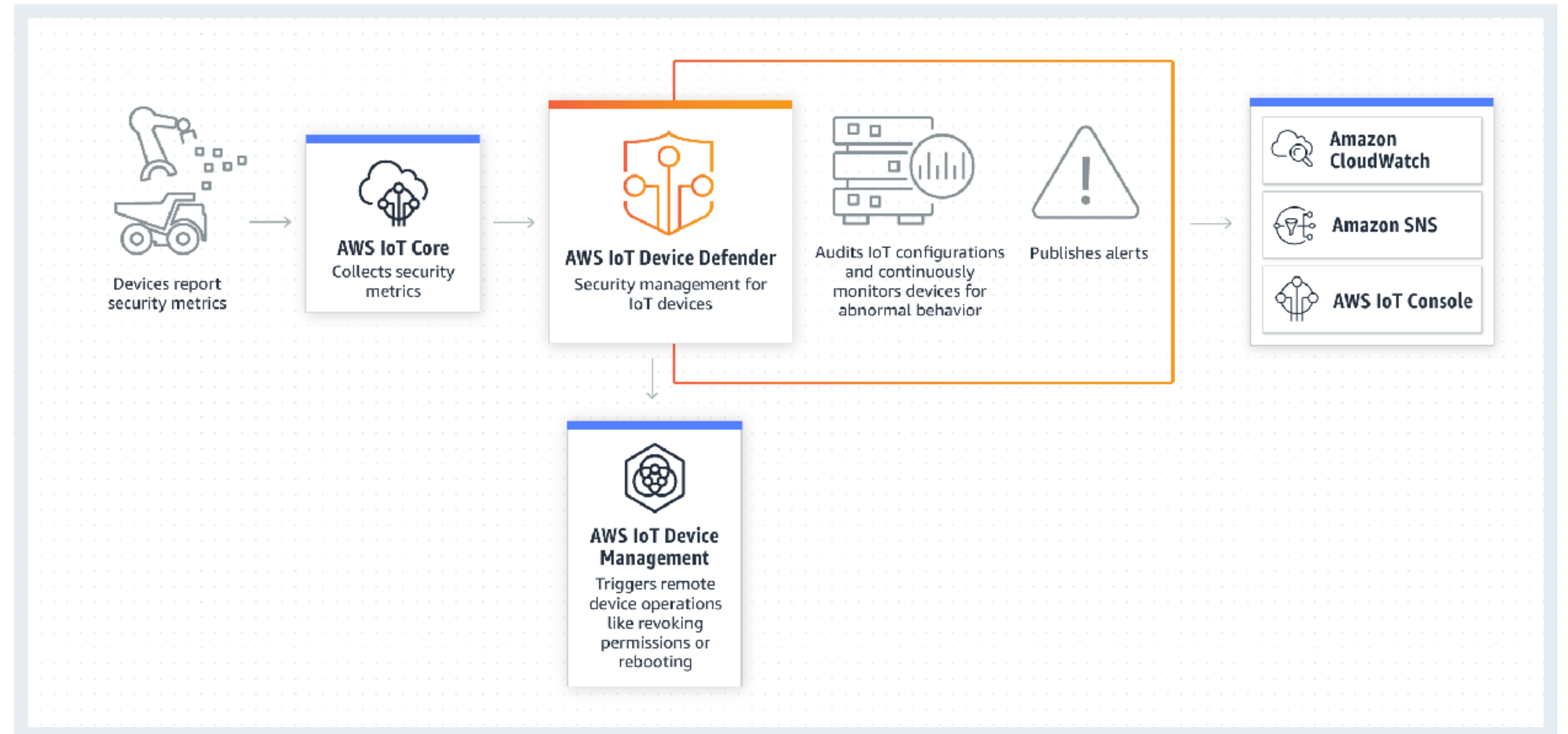
→ Is a managed service to allow connectivity from the field to cloud services





## AWS IoT Device Defender

- Supports IoT Core with auditing the configuration against best practice and company policy
- Continuous compliance, Attack surface evaluation, Threat impact analysis



# IoT ThingsGraph

The screenshot displays the AWS IoT ThingsGraph console interface. The main workspace shows a flow configuration for a project named "HotelRoomPersonalization". The flow starts with a "Device DoorLock" connected to a "Service GetGuestData". This service then branches into several paths: "Device Thermostat", "Device HumiditySensor", "Device SmartTV", "Service Daylight", "Device Radio", and "Service TimeoftheDay". The "Service Daylight" and "Service TimeoftheDay" further connect to multiple devices: "Device MainLights", "Device Blinds", and "Device ReadingLights". The "Service TimeoftheDay" also connects to "Device AromaDiffuser".

On the right side, there is a "Library" panel with a search bar and two tabs: "Device" and "Services". The "Device" tab is active, showing a list of available devices including: AromaDiffuser, BadgeReader, Blinds, BrightnessSensor, Camera, CapacitySensor, DoorLock, Humidifier, HumiditySensor, MainLights, MotionSensor, Radio, ReadingLights, and Screen.

At the top of the console, there are navigation options: "Edit flow configuration", "View definition document", and "Publish". The bottom of the console includes a footer with "Feedback", "English (US)", and copyright information: "© 2008 - 2018, Amazon Web Services, Inc. or its affiliates. All rights reserved. Privacy Policy Terms of Use".



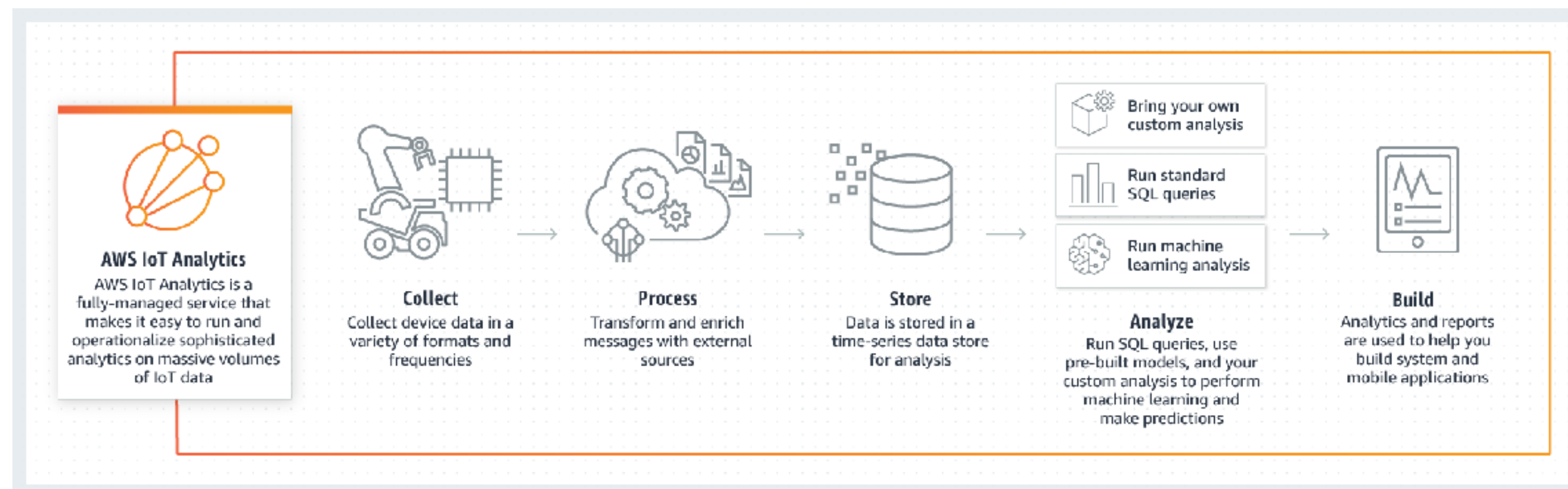


## IoT and analytics - SiteWise

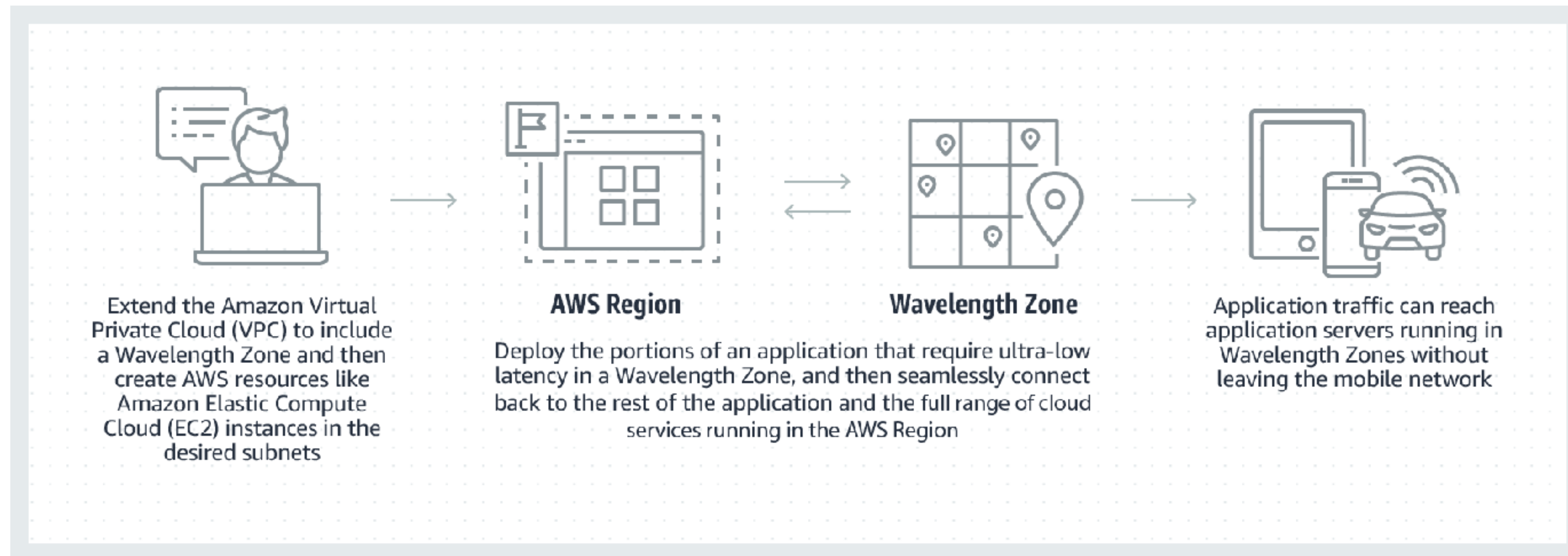
→ A combination of insight into IoT and processing power and analytics in cloud allows us to work on optimizations in different fields:

- ▶ Classification
- ▶ Route optimization
- ▶ Anomaly detection
- ▶ Prediction and forecast
- ▶ Language processing
- ▶ KPI identification

→ Data lake: store unstructured data and run analytics on it



## IoT 5G integration – AWS Wavelength





## Security resources

- <https://aws.amazon.com/security/videos/>
- <https://aws.amazon.com/security/penetration-testing/>
- <https://aws.amazon.com/blogs/security/videos-and-slide-decks-from-the-aws-reinvent-2017-security-compliance-identity-track/>

