UiO : Department of Technology Systems
University of Oslo

TEK5530 - Measurable Security for the Internet of Things

L13 – Cloud Basics

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https://its-wiki.no/wiki/TEK5530

TEK5530: Lecture plan

- **21.01**
  - L1: Introduction (Josef Noll)
  - L2: Internet of Things (Josef Noll)
- 28.01 (Gyorgy Kalman)
  - L3: Security of IoT + Paper list
  - L4: Smart Grid, Automatic Meter Readings
- 04.02 (Josef Noll)
  - L5: Practical implementation of ontologies
  - L6: Multi-Metrics Method for measurable Security
- 11.02 (Josef Noll)
  - L7: Multi-metrics
  - L8: System Security and Privacy Analysis
- 18.02 (Josef Noll, Gyorgy Kalman)
  - L9: Paper analysis with 25 min presentation
  - L10: Security Controls
- 25.02 (Gyorgy Kalman)
  - L11: Communication in Smart grid, home and IoT
  - L12: Intrusion Detection Systems
- **04.03 (Gyorgy Kalman)**
  - **L13: Cloud Basics**
  - **L14: Cloud security and IoT**
- 11.03
  - L17: Selected recent topics from IoT security
  - L18: Wrap-up of the course
- 25.03
  - Exam? or after Easter

Cloud – Security – IoT

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

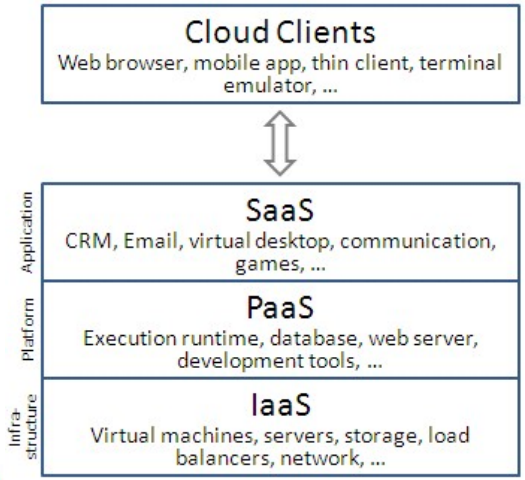
What is cloud computing

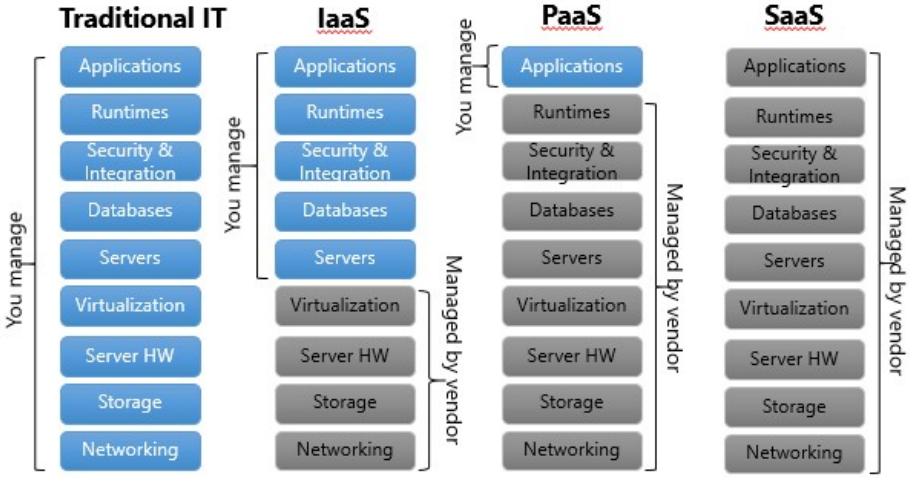
- A remote pool of (shared) resources on different levels
- Dynamic provisioning, elastic use of resources, pay-as-you-go
- A type of outsourcing

- 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

Delivery models

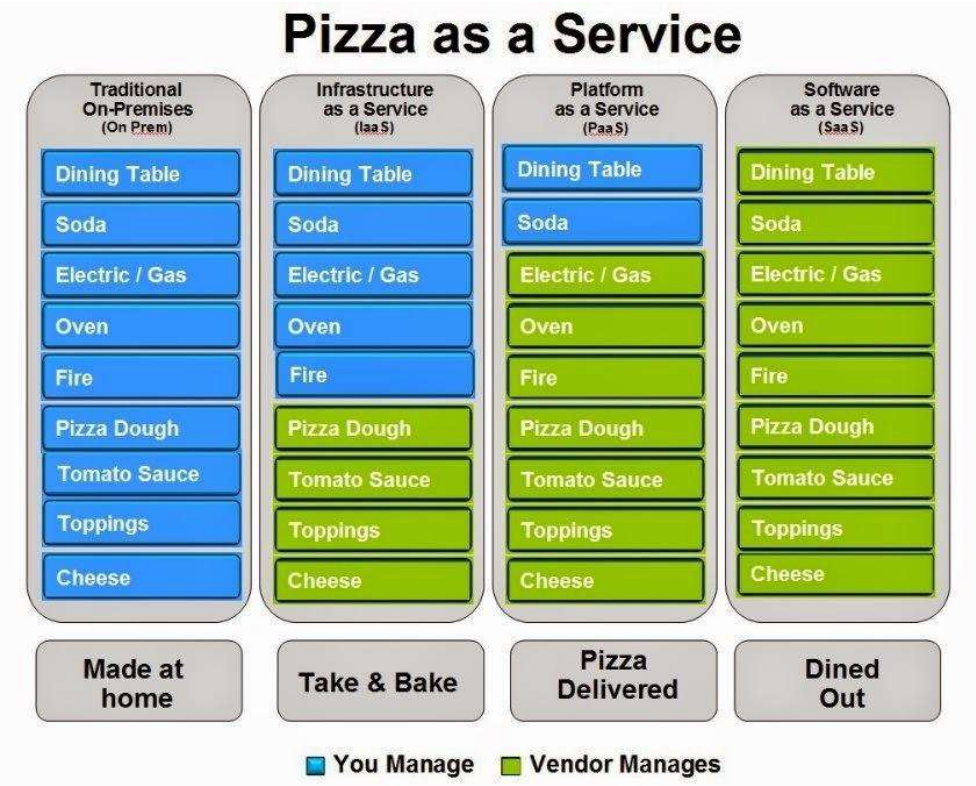
- Infrastructure as a Service (IaaS)
- Platform as a Service (PaaS)
- Software as a Service (SaaS)





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

A perfect figure from Fred Bals at Episerver

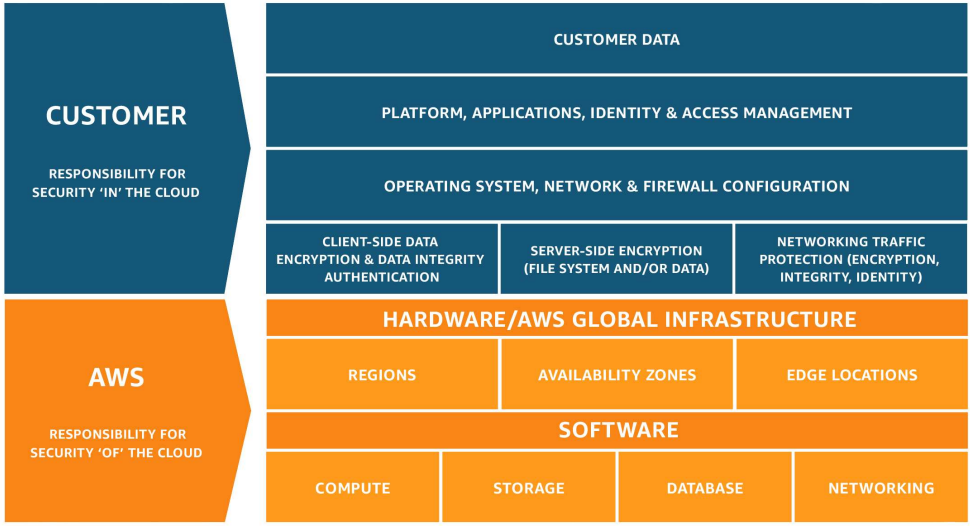


Delivery models contd.

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

AWS Shared Responsibility Model

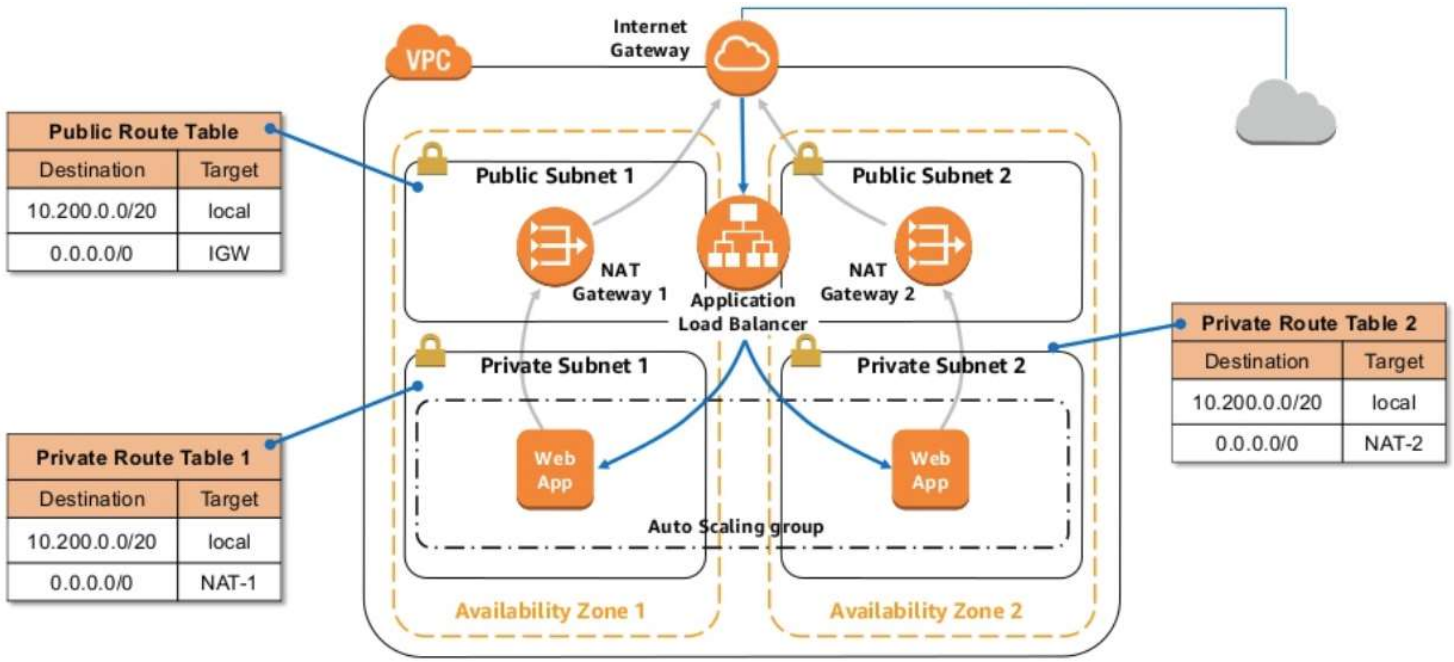
- AWS responsibility is to provide a reliable and secure infrastructure, where the customer services can be built on, a «foundation»
- Customer responsibility is determined by the services chosen
- Wide range of services
- And third party deliveries



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



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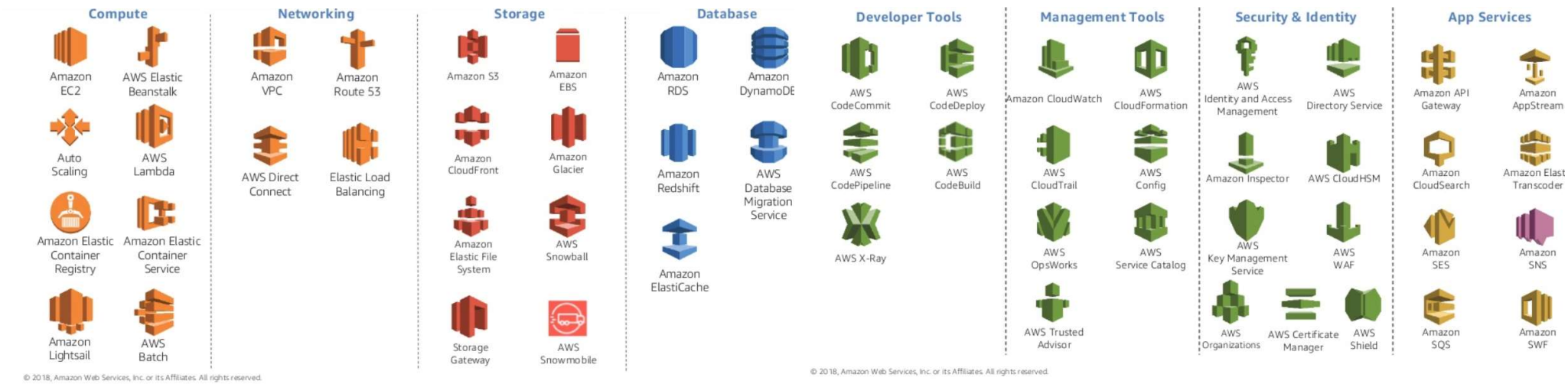
AWS in a nutshell

- Launched in 2006, originally to utilize computing capacity investment for Christmas season, thousands of new features per year



Security infrastructure

- Principles and tools
- Identitiy 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 connec to mulitple common policies

Identity and Access Management

- Best practices:
  - Minimize root account use, mulit-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 cryptograpic applicatons:
  - 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

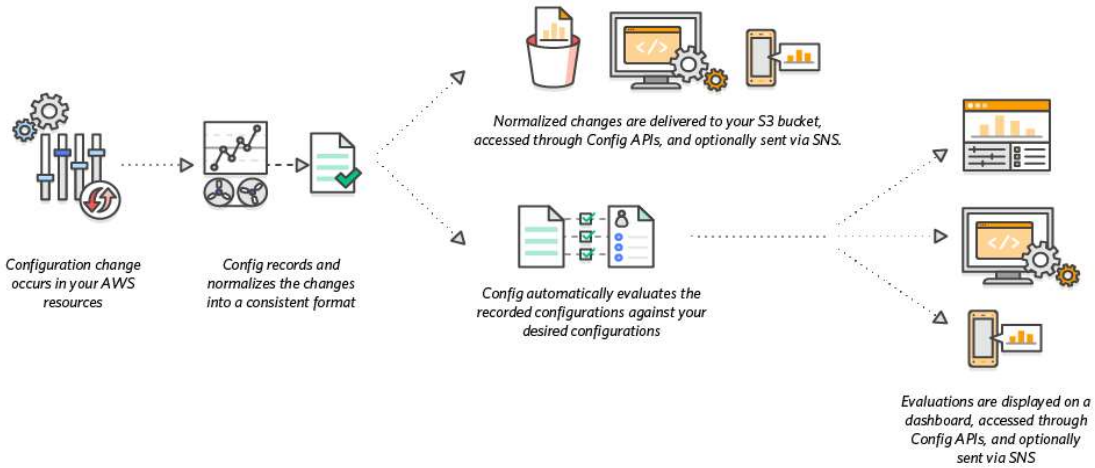
- DDoS: layer 3 and 4: using filtering, elasticity, routing, L7: Shield and WAF

Shield Advanced

- Paid service (free version available)
  - Visiblity 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 exposure



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

- Or use third party solutions like Hashicorp Terraform

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

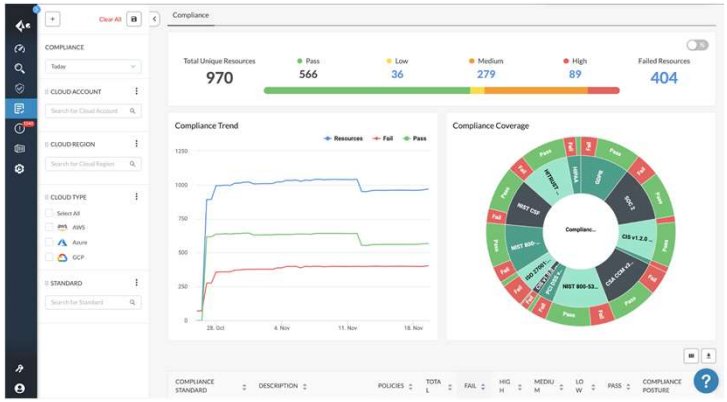
- Data protection in practice:
- S3: add metadata and set permissions, switch on native KMS-based encryption at rest, limit access (no public avail. -> e.g. Macie can find it)
- EBS (elastic block storage, volume type): restrict to be accessible only by creating account, only users in AWS IAM, integrates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

Logging: monitoring, forensics and compliance

- Compliance:
  - AWS Artifact: access to aws compliance reports
  - AWS Macie
  - Amazon Config Rules
- Third party solutions like Palo Alto's Prisma Cloud



Penetration testing

- Customers can execute tests agains these services without prior permission
  - Amazon EC2 instances, NAT Gateways, and Elastic Load Balancers
  - Amazon RDS
  - Amazon CloudFront
  - Amazon Aurora
  - Amazon API Gateways
  - AWS Lambda and Lambda Edge functions
  - Amazon Lightsail resources
  - Amazon Elastic Beanstalk environments
- But not:
  - DNS zone walking via Amazon Route 53 Hosted Zone
  - Denial of Service (DoS), Distributed Denial of Service (DDoS), Simulated DoS, Simulated DDoS
  - Port flooding
  - Protocol flooding
  - 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.

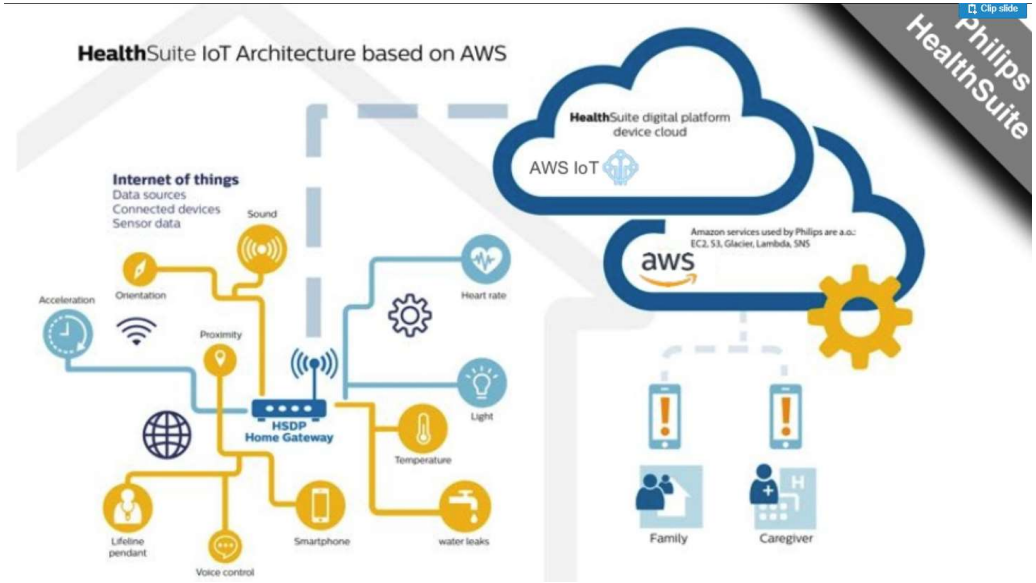
3

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.

https://www.slideshare.net/AmazonWebServices/intro-to-aws-iot-80291679

Healthcare example



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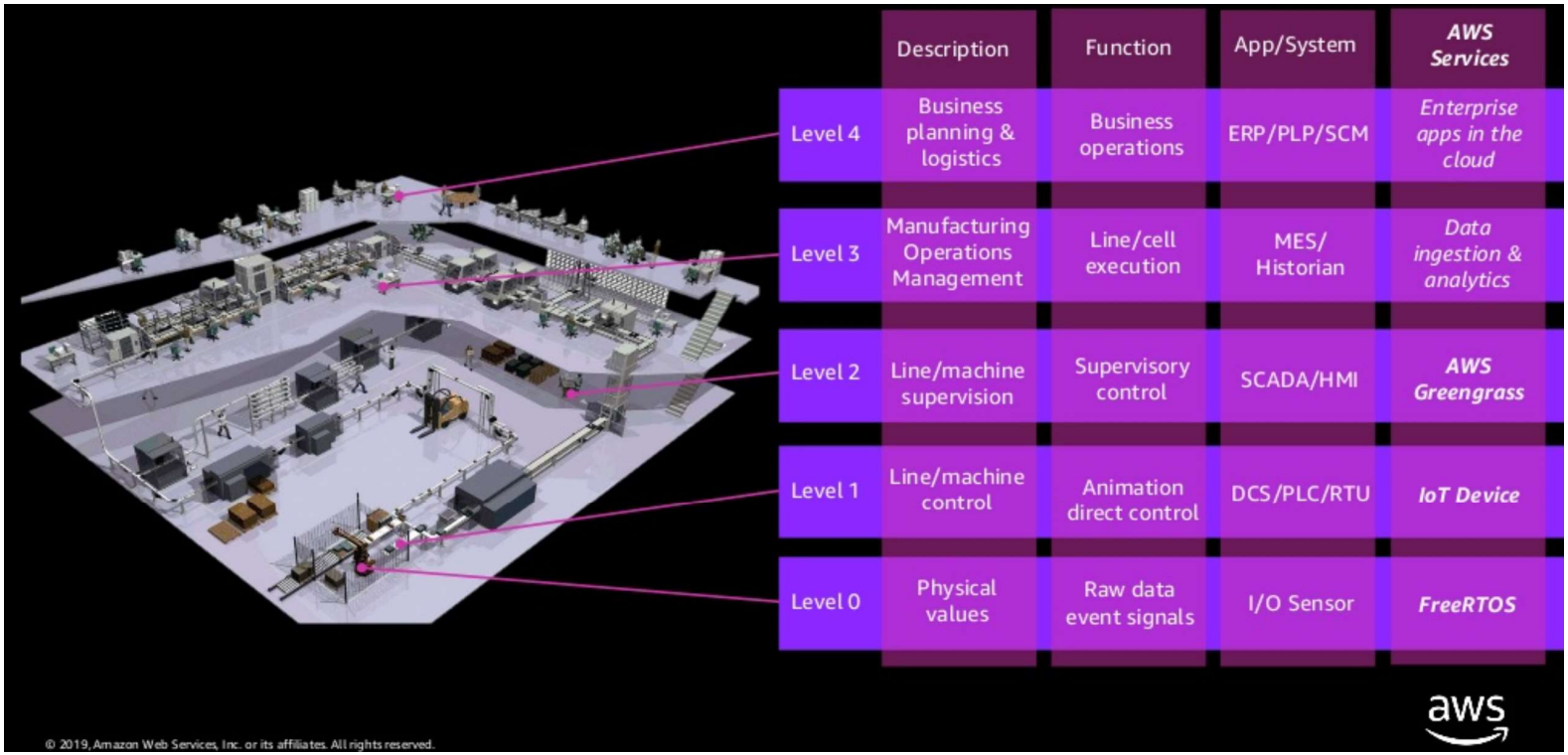
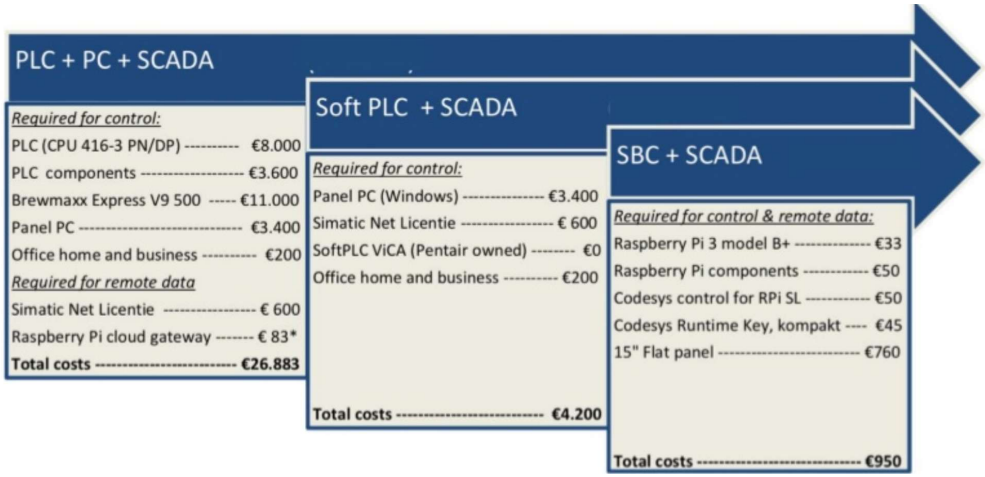
AWS in relation to ISA-95



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

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

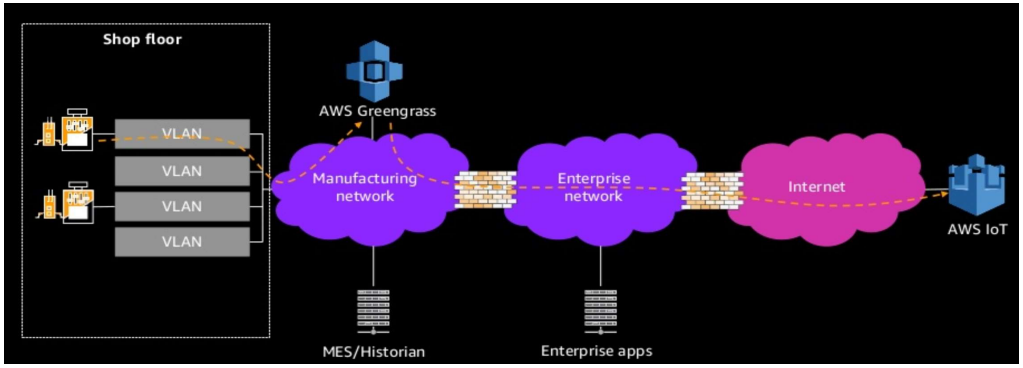


AWS FreeRTOS

- A free RTOS with extensions to connect to AWS services
  - Key importance for getting market share
  - OS is important in the budget of embedd 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 possiblity → QoS, criticality!
- Forwards information to AWS IoT core → which can then serve them as SaaS to Enterprise IT
- Secrets manager
- HW security



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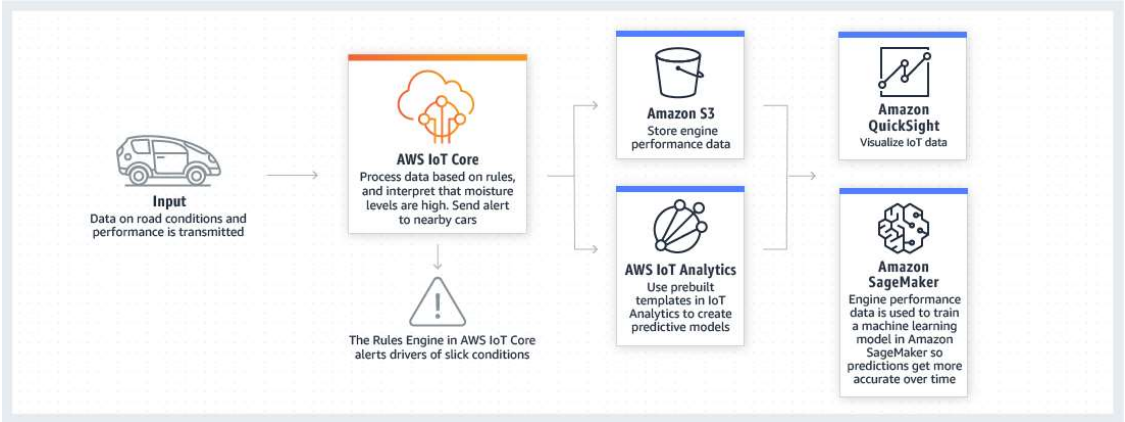
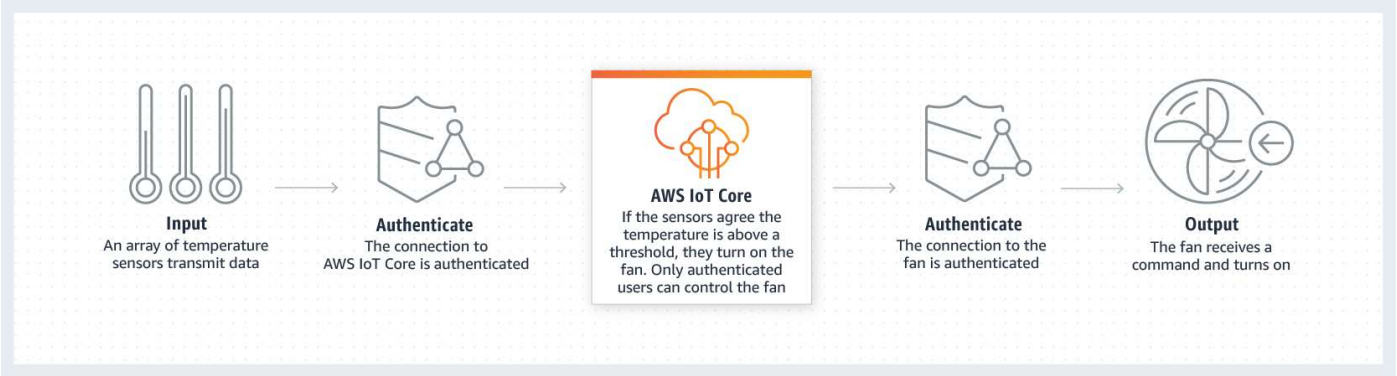
AWS IoT Core

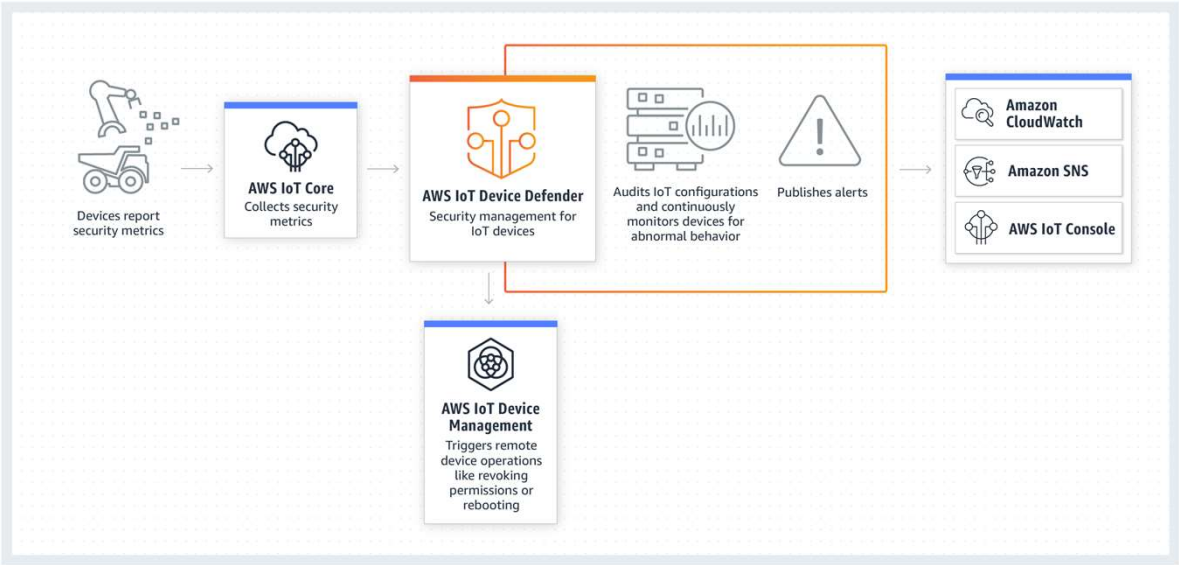
Is a managed service to allow connectivity from the field to cloud services



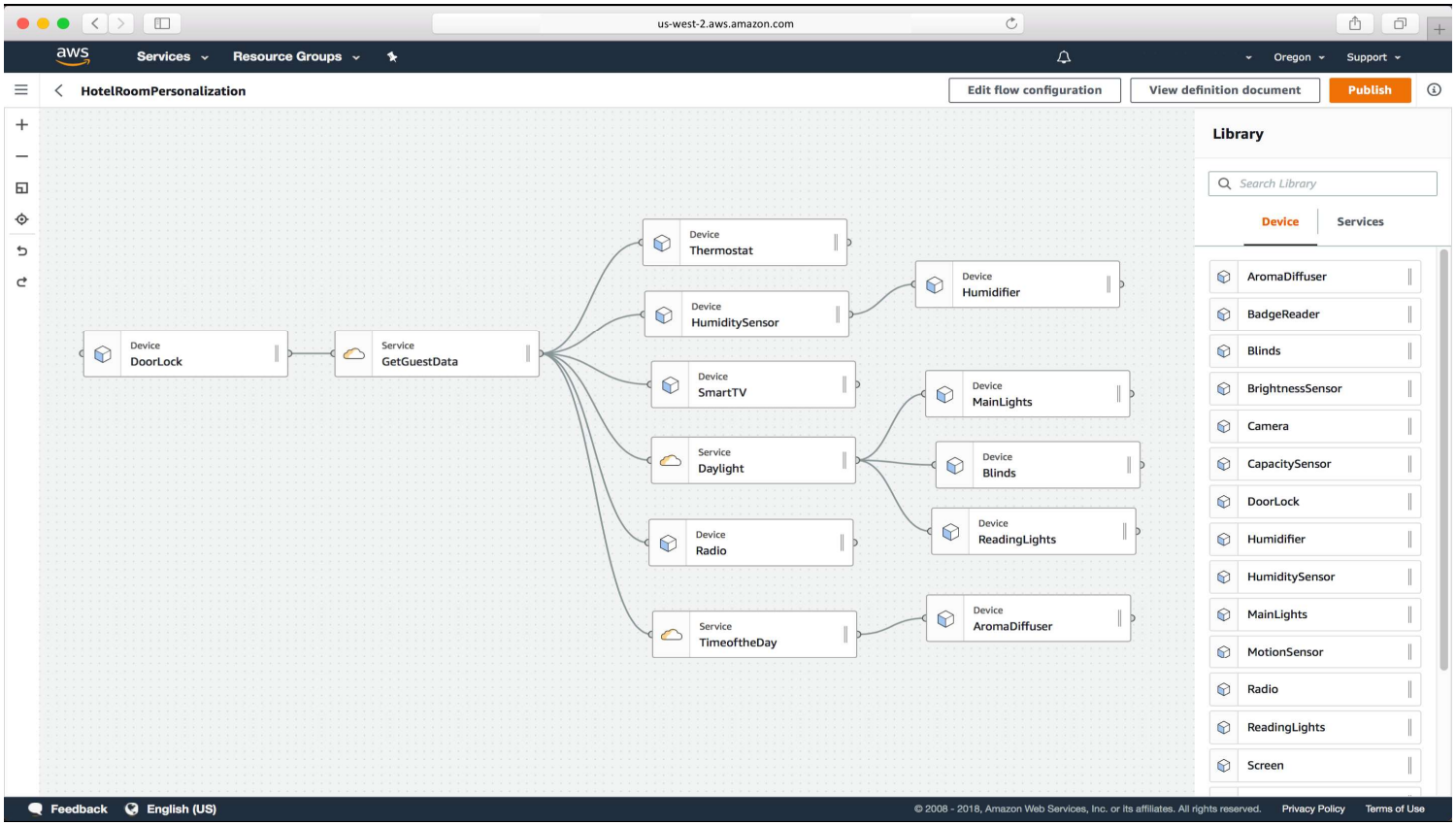


AWS IoT Device Defender

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

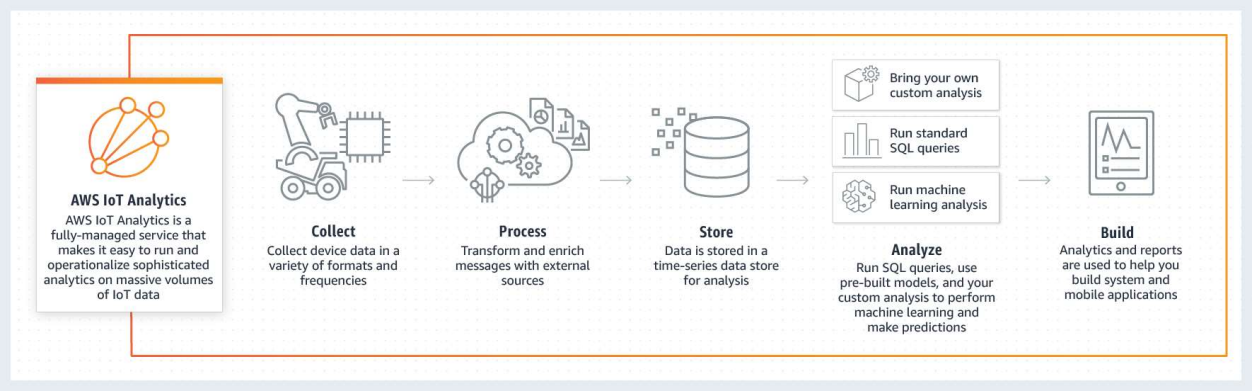


IoT ThingsGraph



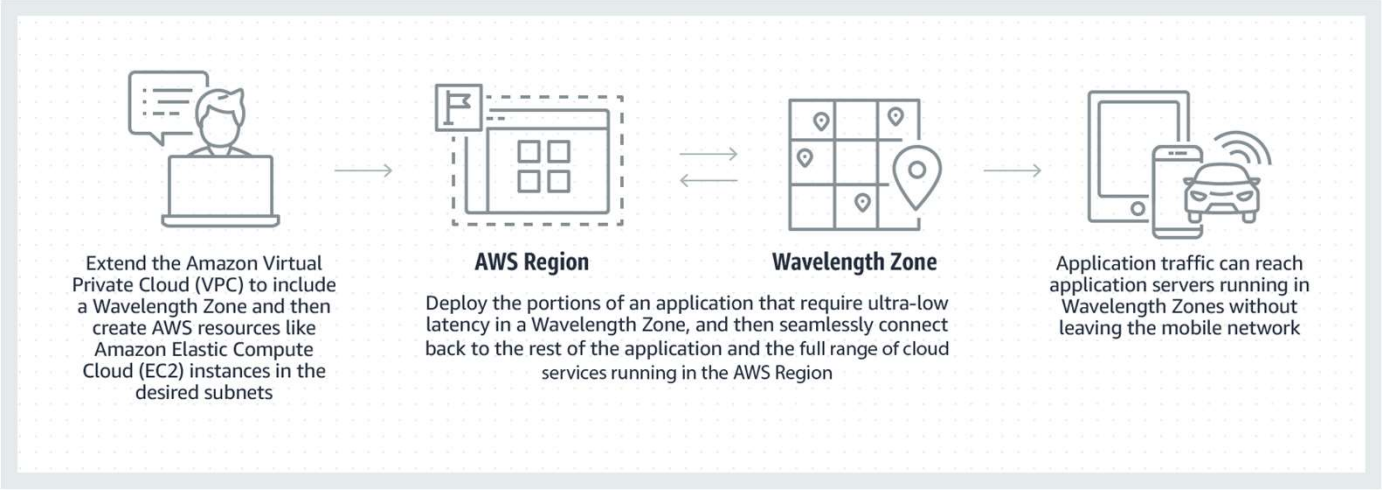
IoT and analytics - SiteWise

- 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/tag/reinvent-2020/