

COLUMBIA UNIVERSITY EECS E4764 FALL '18

IOT : INTELLIGENT CONNECTED SYSTEMS

CLOUD AND IOT

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Thanks to the following for slides

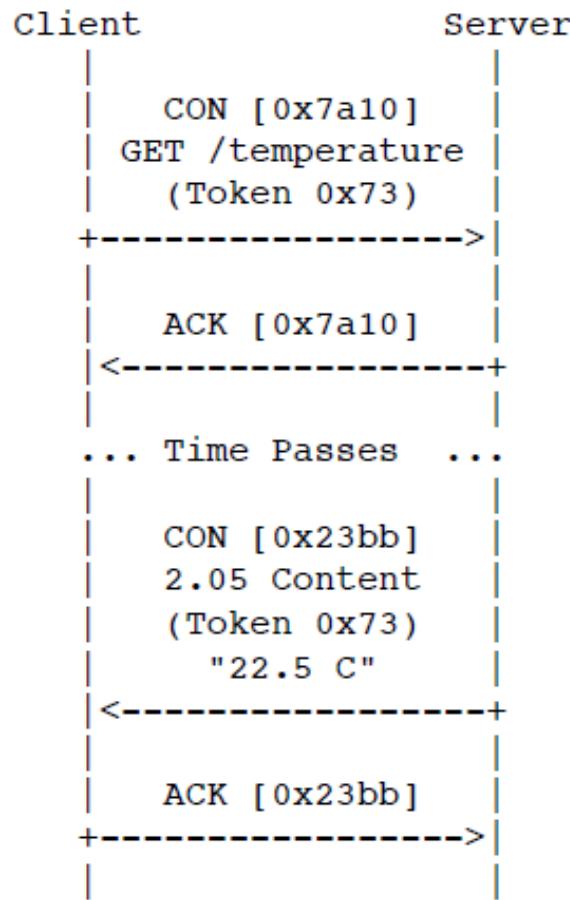
- Nathaniel Gates and Keith Dobson @ Cloud49
<http://www.math.uaa.alaska.edu/~afkjm/cs448/handouts/Cloud.pptx>
- Mehmet Hadi Gunes and Mark Baker @ University of Nevada, Reno
http://www.cse.unr.edu/~mgunes/cpe401/cpe401sp12/lect15_cloud.ppt
- CloudComputing
<http://docs.msl.mt.gov/presentations/DigitalLiteracy/CloudComputing.ppt>
- Ivan Yatskevich, Service Discovery with Consul, Docker and Registrar <http://www.slideshare.net/ivanyatskevich/service-discovery-with-consul-docker-and-registrator>

Review

- Transport Layer
 - TCP requires buffering
 - Memory-constrained IoT uses UDP
- Application Layer
 - HTTP requires reliability
 - CoAP allows more control over responses/ACKs
- Network Layer
 - 6LoWPAN
 - Resource constrained routing
 - Header compression
- Wireless Links
 - Wi-Fi
 - Bluetooth

CoAP GET Request

With a separate response



Resource Constrained Routing

"the Internet Protocol could and should be applied even to the smallest devices,"

IPv6

- MSS of at least 1.2KB
- 128-bit addresses
- 32 bytes just for to/from addresses

802.15.4 and 8-bit mcu

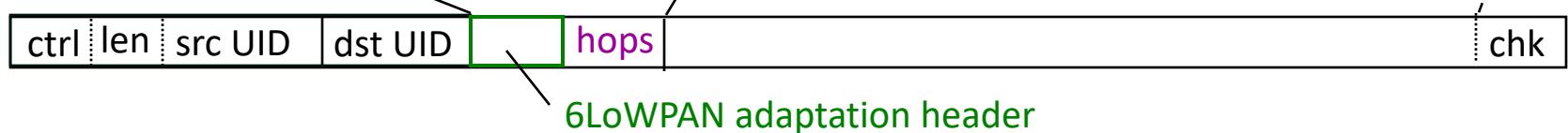
- Total RAM of 2KB
- Max packet size of 127 bytes
 - 25 bytes for frame headers
 - 21 bytes for encryption
 - 81 bytes for higher layers

6LoWPAN – IP Header Optimization

Network packet

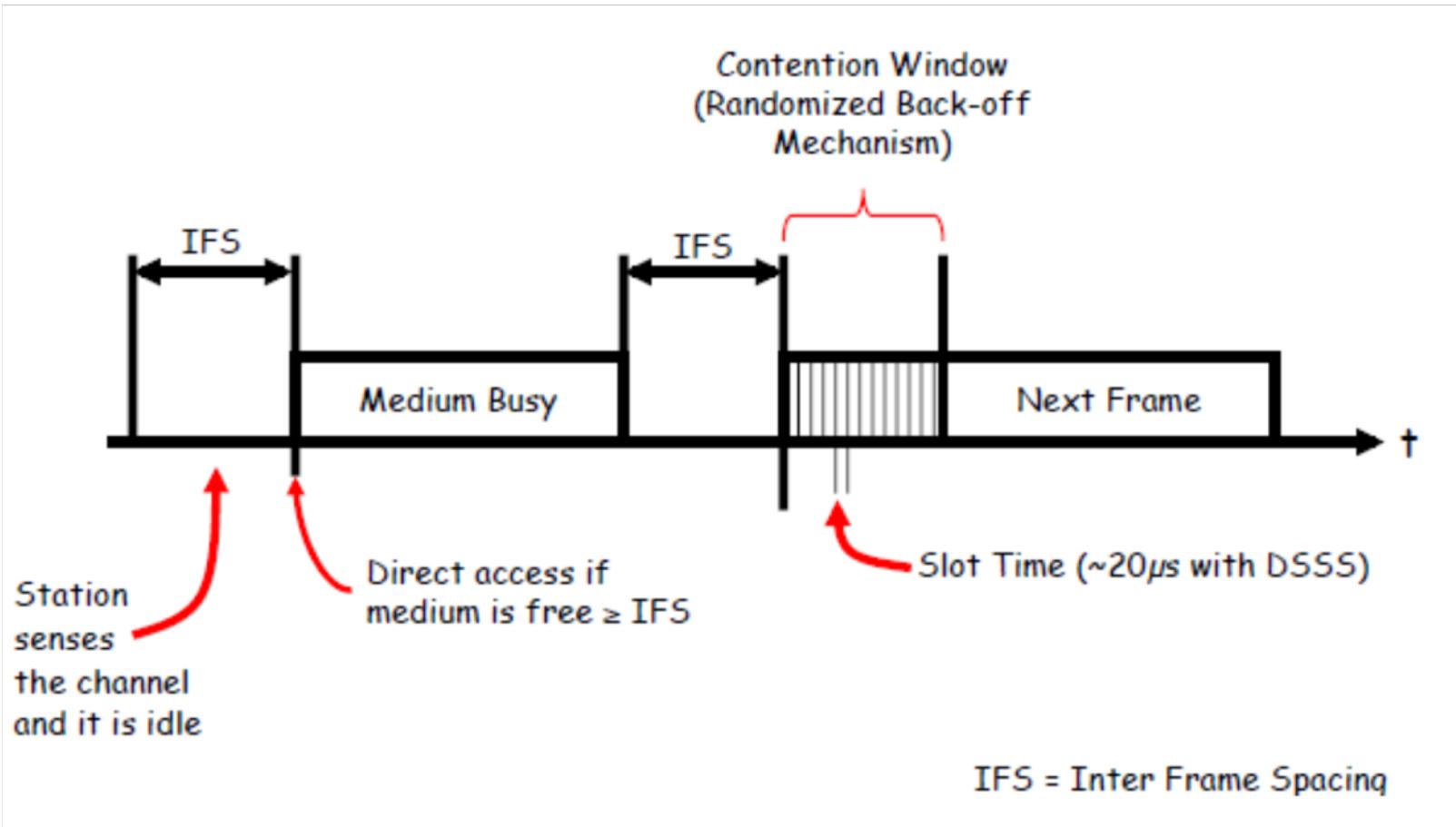


Link frame



- Eliminate all fields in the IPv6 header that can be derived from the 802.15.4 header in the common case
 - Source address : derived from link address
 - Destination address : derived from link address
 - Length : derived from link frame length
 - Traffic Class & Flow Label : zero
 - Next header : UDP, TCP, or ICMP
- Additional IPv6 options follow as options

Basic CSMA-CA



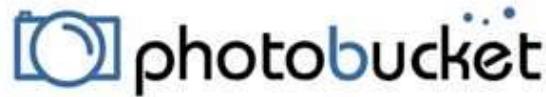
Cloud



Do you use the Cloud?



iCloud



From ground to cloud

Local Storage

- Content is stored on THAT computer
- To use content must return to THAT computer
- Cannot access this content from another device or computer



Programs

- Purchase programs
- Load to the computer
- Each computer would need the program loaded and stored on the internal drive



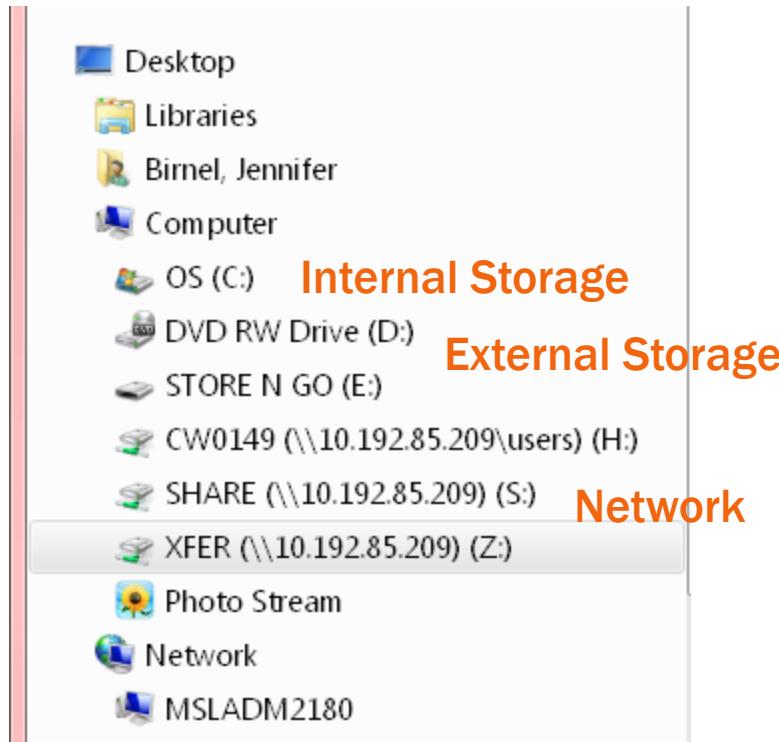
Networked Storage

- Multiple work stations talk to one unit that stores information and data.
- Data is not saved to the C: drive, but to a network drive
- Can retrieve the data stored to the network from any of the connected workstations.



Saving documents

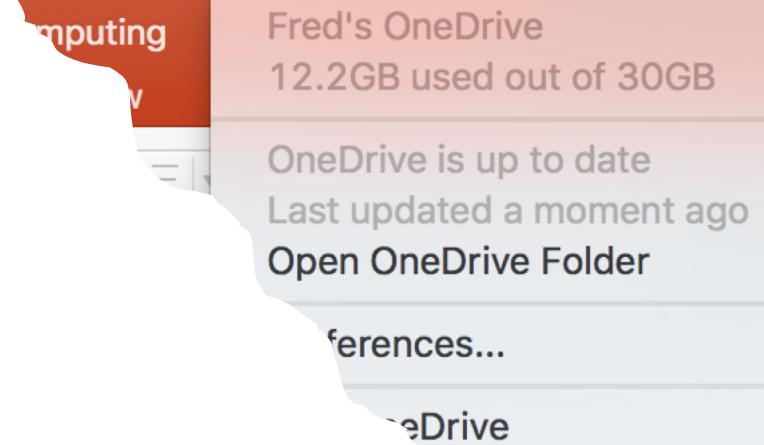
- When you do a “save as” on your computer, you choose where to save the material.



Cloud Storage



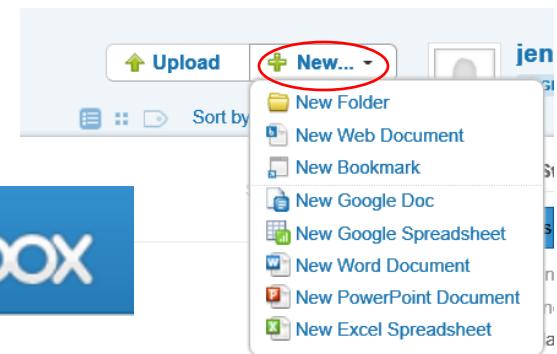
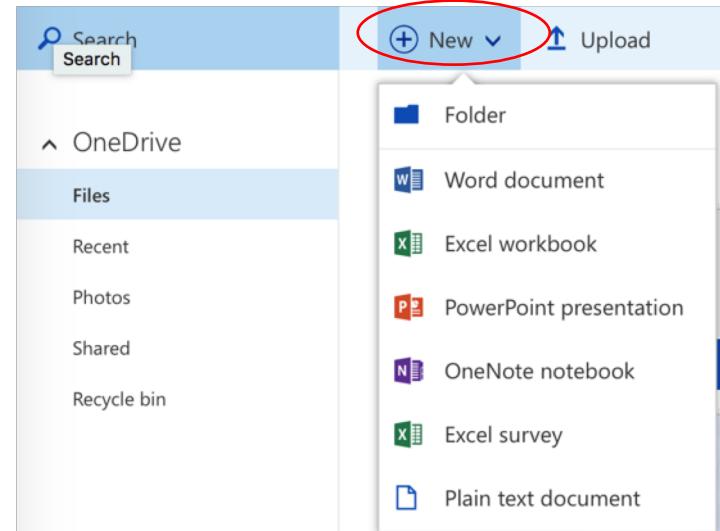
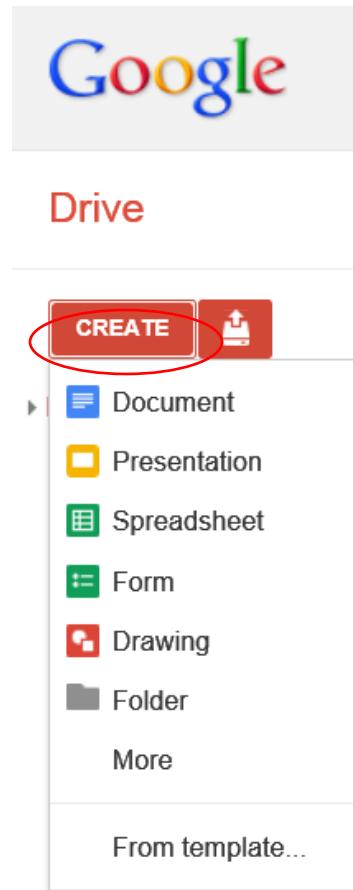
- Create an Account – User name and password
- Content lives with the account in the cloud
- Log onto any computer with Wi-Fi to find your content
- Synced to local storage



More than Storage

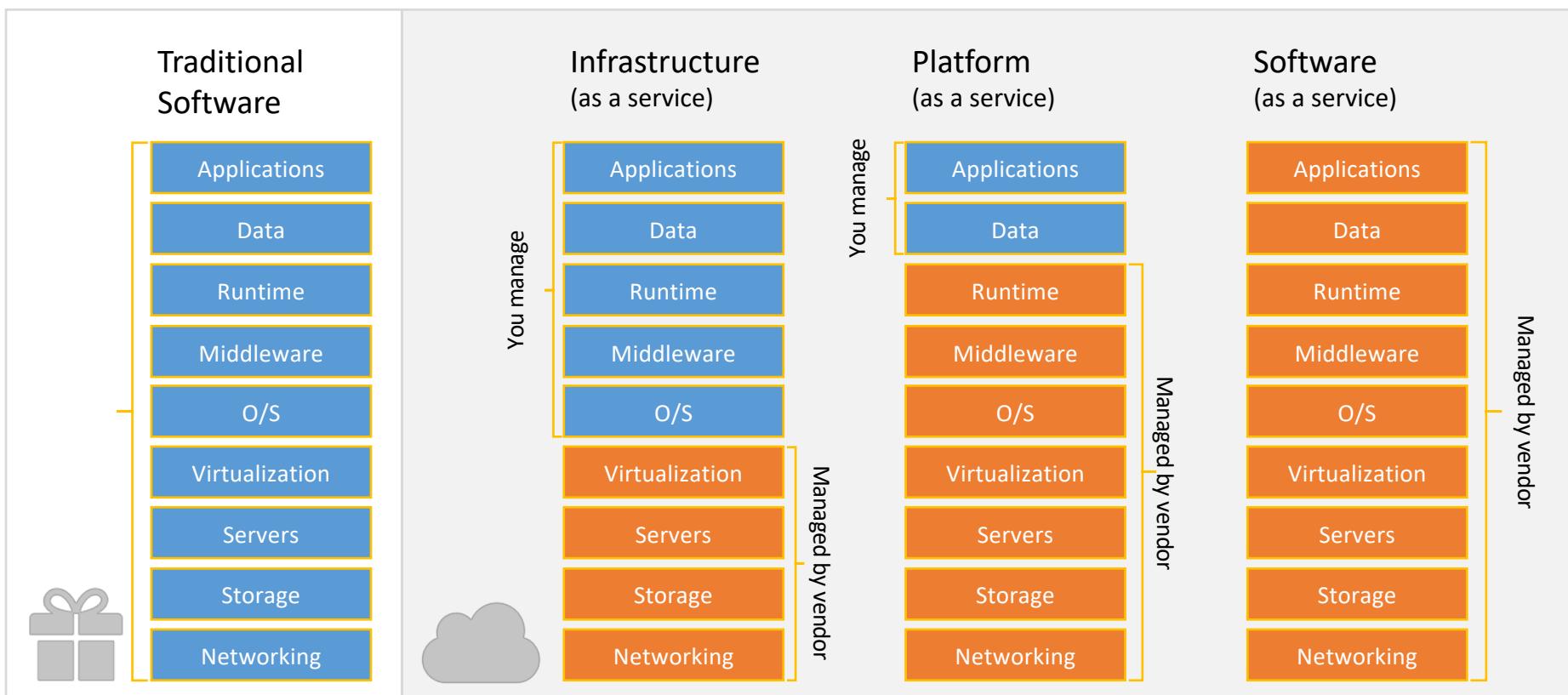
Document Creation

- Google Docs
- OneDrive
- Box



More than just software

CLOUD OVERVIEW



What is Software as a Service? (SaaS)

- SaaS is a software delivery methodology that provides licensed multi-tenant access to software and its functions remotely as a Web-based service.
 - Usually billed based on usage
 - Usually multi tenant environment
 - Highly scalable architecture

SaaS Examples



Platform as a Service (PaaS)

- PaaS provides all of the facilities required to support the complete life cycle of building and delivering web applications and services entirely from the Internet.
 - Typically applications must be developed with a particular platform in mind
 - Multi tenant environments
 - Highly scalable multi tier architecture

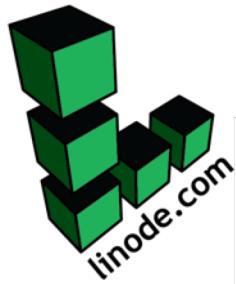
PaaS Examples



Infrastructure as a Service (IaaS)

- IaaS is the delivery of technology infrastructure, including storage, hardware, servers and networking components, as an on demand scalable service
 - Usually billed based on usage
 - Usually multi tenant virtualized environment
 - Can be coupled with Managed Services for OS and application support

IaaS Examples



Databases

SQL

- Stored in **tables** - relational model with rows and columns
- **Fixed schema**, which is easier for structured data, support **join** operations
- Scaling is vertical – need bigger servers for larger data
- MySQL, SQLite, IBM DB2, PostgresSQL, Oracle, MS SQL, etc.

NoSQL

- Stored as document, graph, key-value pairs
- **Scaling** – better for massively parallel processing, lends better to numerous commodity servers, virtual machines or cloud instances
- MongoDB, Couchbase, Riak, Memcached, Redis, CouchDB, Hazelcast, Apache Cassandra and HBase

Service Discovery



- mDNS / Apple Bonjour (IP multicast on UDP port 5353)
- SSDP / UPnP (IP multicast on UDP port 1990)
- Distributed k/v store (w/ consensus and fault tolerant)



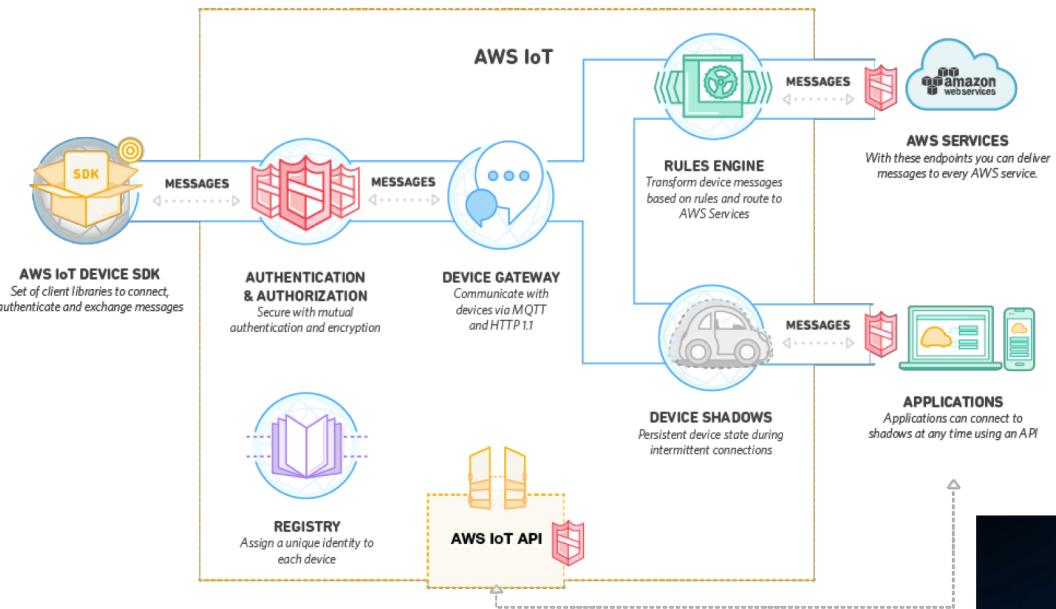
ZooKeeper



SkyDNS



Cloud for IoT?



In Lab: create RESTful web service and database in Amazon AWS

Amazon Web Services

Compute

- EC2**
Virtual Servers in the Cloud
- EC2 Container Service**
Run and Manage Docker Containers
- Elastic Beanstalk**
Run and Manage Web Apps
- Lambda**
Run Code without Thinking about Servers

Storage & Content Delivery

- S3**
Scalable Storage in the Cloud
- CloudFront**
Global Content Delivery Network
- Elastic File System**
Fully Managed File System for EC2
- Glacier**
Archive Storage in the Cloud
- Snowball**
Large Scale Data Transport
- Storage Gateway**
Hybrid Storage Integration

Database

- RDS**
Managed Relational Database Service
- DynamoDB**
Managed NoSQL Database
- ElastiCache**
In-Memory Cache
- Redshift**
Fast, Simple, Cost-Effective Data Warehousing
- DMS**
Managed Database Migration Service

Networking

- VPC**
Isolated Cloud Resources
- Direct Connect**
Dedicated Network Connection to AWS
- Route 53**
Scalable DNS and Domain Name Registration

Developer Tools

- CodeCommit**
Store Code in Private Git Repositories
- CodeDeploy**
Automate Code Deployments
- CodePipeline**
Release Software using Continuous Delivery

Management Tools

- CloudWatch**
Monitor Resources and Applications
- CloudFormation**
Create and Manage Resources with Templates
- CloudTrail**
Track User Activity and API Usage
- Config**
Track Resource Inventory and Changes
- OpsWorks**
Automate Operations with Chef
- Service Catalog**
Create and Use Standardized Products
- Trusted Advisor**
Optimize Performance and Security

Security & Identity

- Identity & Access Management**
Manage User Access and Encryption Keys
- Directory Service**
Host and Manage Active Directory
- Inspector**
Analyze Application Security
- WAF**
Filter Malicious Web Traffic
- Certificate Manager**
Provision, Manage, and Deploy SSL/TLS Certificates

Analytics

- EMR**
Managed Hadoop Framework
- Data Pipeline**
Orchestration for Data-Driven Workflows
- Elasticsearch Service**
Run and Scale Elasticsearch Clusters
- Kinesis**
Work with Real-Time Streaming Data
- Machine Learning**
Build Smart Applications Quickly and Easily

Internet of Things

- AWS IoT**
Connect Devices to the Cloud

Game Development

- Gamelift**
Deploy and Scale Session-based Multiplayer Games

Mobile Services

- Mobile Hub**
Build, Test, and Monitor Mobile Apps
- Cognito**
User Identity and App Data Synchronization
- Device Farm**
Test Android, iOS, and Web Apps on Real Devices in the Cloud
- Mobile Analytics**
Collect, View and Export App Analytics
- SNS**
Push Notification Service

Application Services

- API Gateway**
Build, Deploy and Manage APIs
- AppStream**
Low Latency Application Streaming
- CloudSearch**
Managed Search Service
- Elastic Transcoder**
Easy-to-Use Scalable Media Transcoding
- SES**
Email Sending and Receiving Service
- SQS**
Message Queue Service
- SWF**
Workflow Service for Coordinating Application Components

Enterprise Applications

- WorkSpaces**
Desktops in the Cloud
- WorkDocs**
Secure Enterprise Storage and Sharing Service
- WorkMail**
Secure Email and Calendaring Service

Course Project

Course Project

- 35% of class grade
 - 5% Project Proposal
 - 5% Milestone checkpoints
 - 25% Final Project – novelty, technical merit, impact
 - Project report + Project presentation at EE Project Expo
- Project Proposal
- Budget
- Proposal Presentation and Feedback
- Final Presentation
- Project report – a 5 minute video!
- Needs to be reproducible

Cloud Computing Resources

- Amazon AWS
- Microsoft Azure
- <https://thingspeak.com>
- Google Charts APIs
- Google Apps Engine
- <https://electricimp.com>
- And much more...

Data Resources

- Data.gov <http://data.gov>
- US Census Bureau <http://www.census.gov/data.html>
- The CIA World Factbook
<https://www.cia.gov/library/publications/the-world-factbook/>
- Healthdata.gov <https://www.healthdata.gov/>
- AWS public datasets <http://aws.amazon.com/datasets>
- Facebook Graph <https://developers.facebook.com/docs/graph-api>
- Google Finance <https://www.google.com/finance>
- National Climatic Data Center <http://www.ncdc.noaa.gov/data-access/quick-links#loc-clim>
- New York Times <http://developer.nytimes.com/docs>
- Million Song Data Set
<http://aws.amazon.com/datasets/6468931156960467>
- Weather <http://www.wunderground.com>
- Carioca Digital: <http://carioca.rio.rj.gov.br/>

Hardware Resources

- Sparkfun
- Parallax
- Adafruit
- Makershed
- Seeed Studios
- Netmf
- Digikey
- Jameco
- Raspberry Pi and ecosystem
- Arduino and ecosystem
- Intel Edison ecosystem
- Custom PCBs
 - Advanced devices, etc.
- Particle / Photon
- Hue / Nest / IFTTT
- Drones
- Robots
- Maker space
 - 3D Printer
 - Laser cutter

Project Areas

- Anything you want!
 - Novelty
 - Technical Merit
 - Impact
 - Solves a problem
 - Useful
 - Fun
- Smart buildings and smart cities
- Quantified self
- Mobile fitness
- Healthcare and medical applications
- Energy and sustainability
- Smart grid
- Smart retail
- Wearables
- Data Analytics
- Security

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SLIDES AND CLASS MATERIALS
ON ONLINE SITES**