4th Slide Set Cloud Computing

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Agenda for Today

- Amazon Web Services (AWS)
  - Reasons for using the AWS
  - Examples of applications that use the AWS
  - Elastic Compute Cloud (EC2)
  - Elastic Block Store (EBS)
  - Elastic Load Balancing (ELB)
  - Simple Storage Service (S3)
  - Google Cloud Storage and further alternative service offerings

Amazon Web Services (AWS)

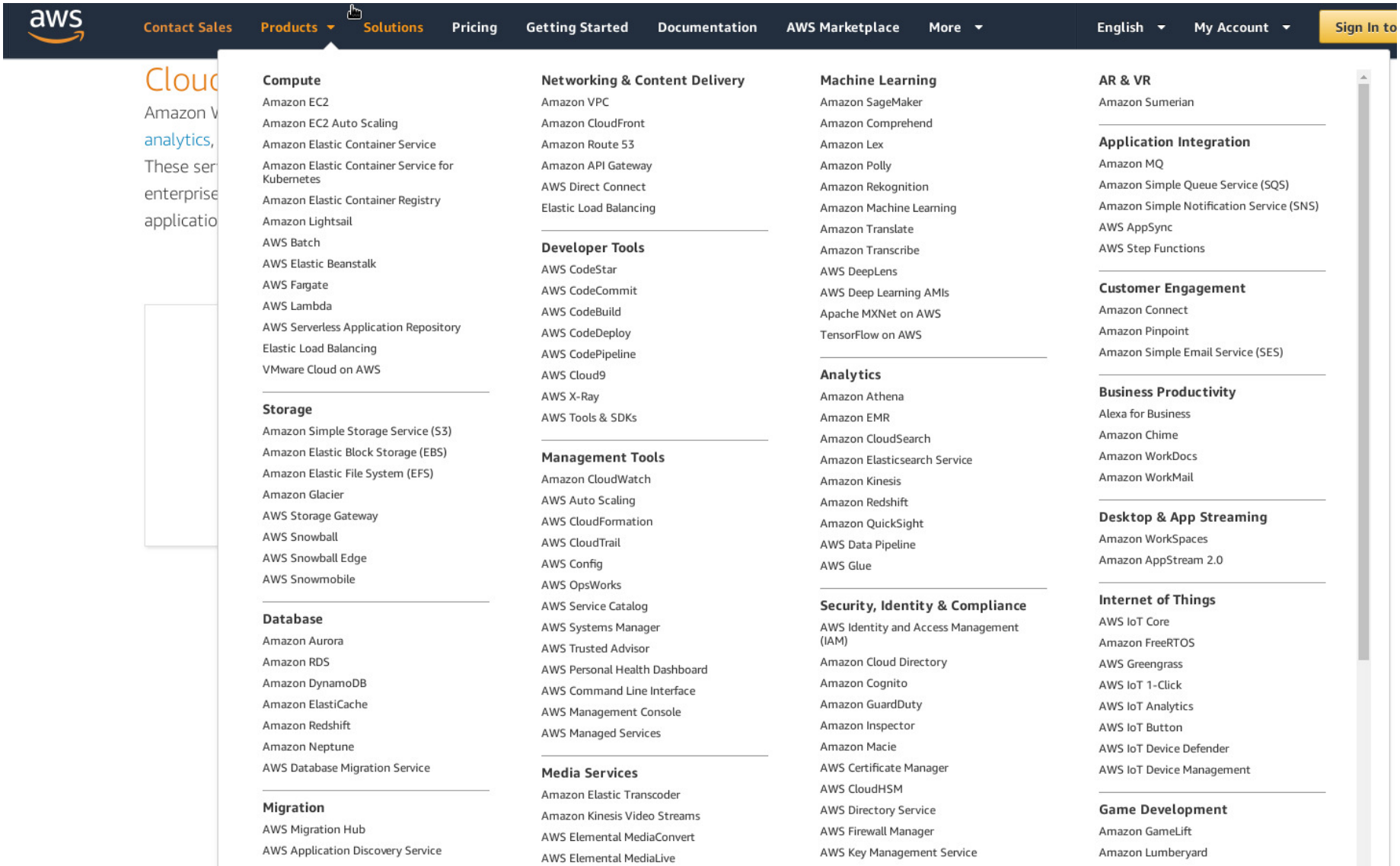
- The AWS is a collection of different public cloud services
  - Launched in 2002
  - Billed according to consumption
  - Services of the AWS are among others...

Elastic Compute Cloud (EC2)	$\Longrightarrow$	Infrastructure service for virtual servers
Simple Storage Service (S3)	$\Longrightarrow$	Storage service for web objects
Elastic Block Store (EBS)	$\Longrightarrow$	Storage service for virtual storage volumes
Elastic Load Balancing (ELB)	$\Longrightarrow$	Service for virtual load balancers
CloudWatch	$\Longrightarrow$	Service for monitoring AWS resources
Auto Scaling	$\Longrightarrow$	Service for scaling EC2 capacities
SimpleDB	$\Longrightarrow$	Service for distributed database
Amazon Simple Queue Service (SQS)	$\Longrightarrow$	Service for message queues
Amazon Mechanical Turk	$\Longrightarrow$	HuaaS/Crowdsourcing marketplace

Attention!

- Many screenshots in this slide set are from the years 2012/2013/2014
- The web interfaces of cloud service providers often change
- $\Longrightarrow$ Many screenshots are outdated! Sorry for that!
- The functionality and technical terms are seldom modified

AWS Overview – http://aws.amazon.com

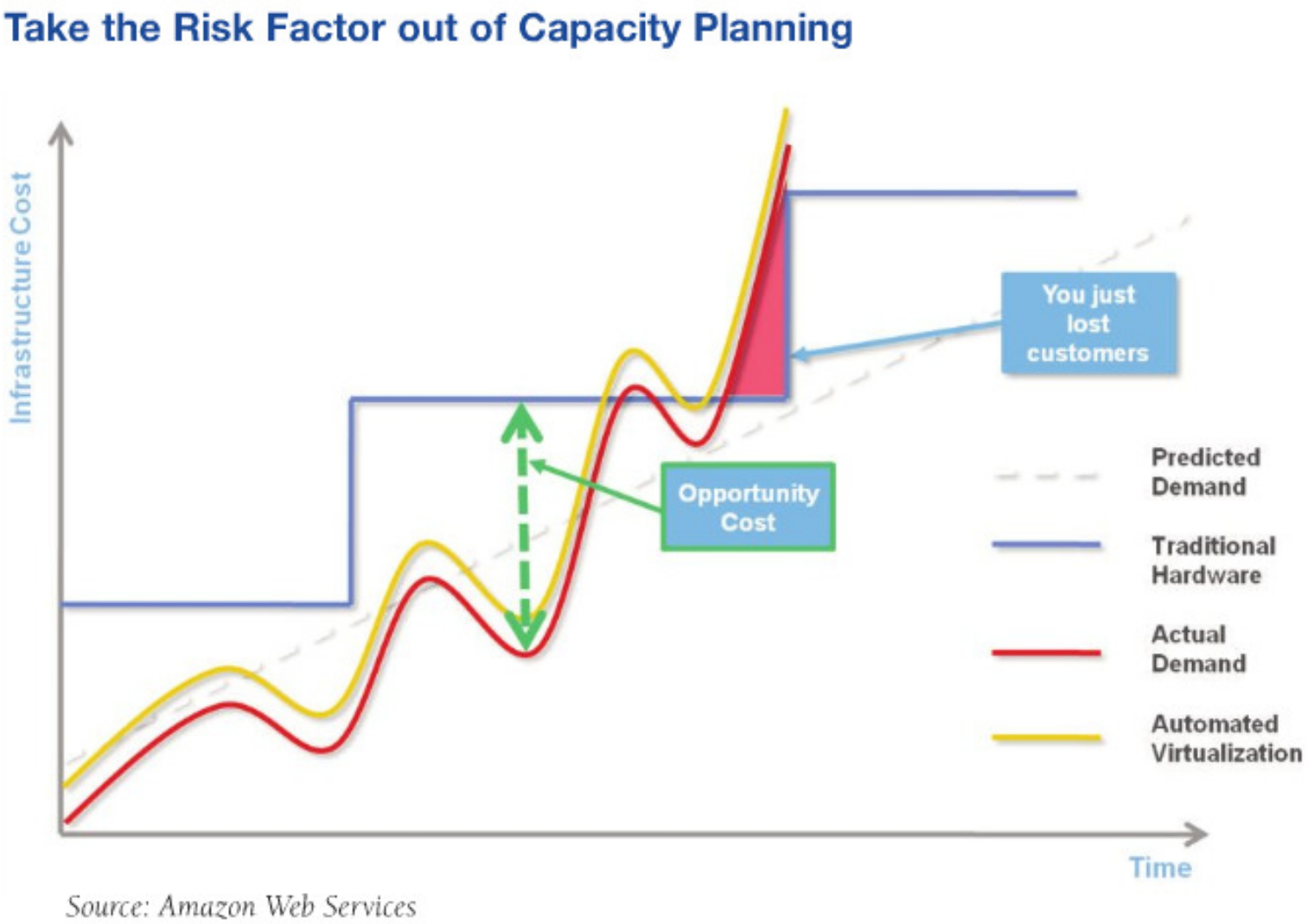


Why AWS?

- Why should a company use the AWS, instead of buying own resources?
- How many resources does the company need in the future?
- Scenario: A web offering of a startup company
  - How many resources will be consumed?
  - What costs will arise?
  - How much time is required to acquire additional resources and include them into the infrastructure?

Without a credit card, the AWS cannot be used

Own physical Infrastructure compared with the Cloud



AWS Customer Success Story: Animoto (1/2)

- Users can create videos from their own pictures and music
  - `http://animoto.com`
- The software analyzes the pictures and the music and generates videos in the style of a trailer or a MTV music video
- Videos can be uploaded to YouTube and exported to various formats

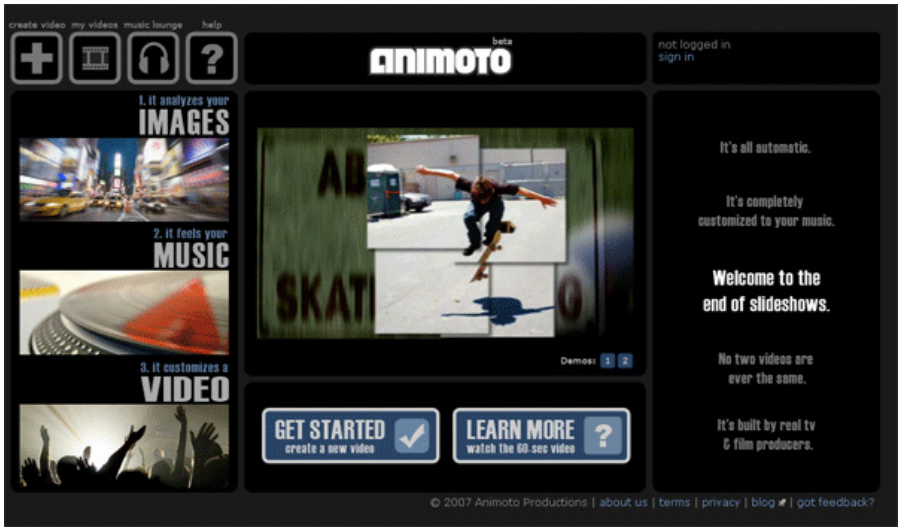
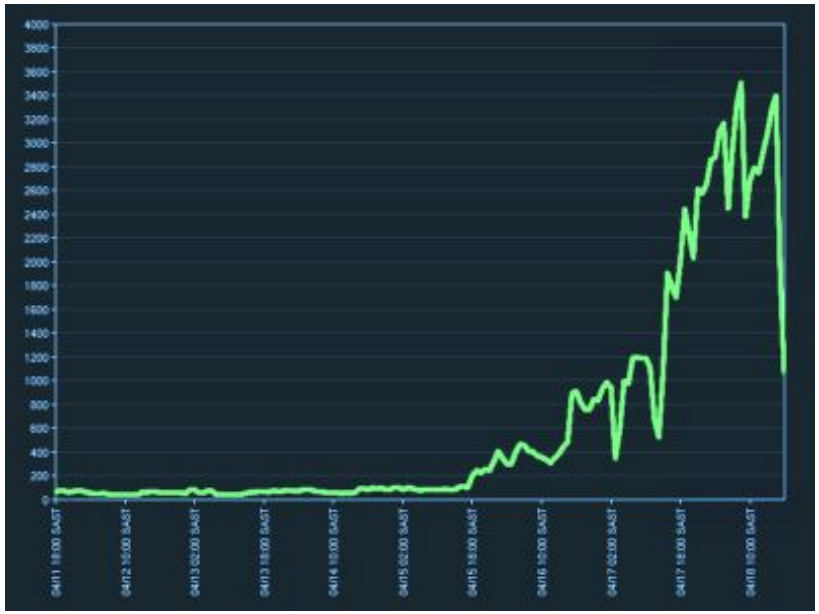


Image source: Google image search

AWS Customer Success Story: Animoto (2/2)

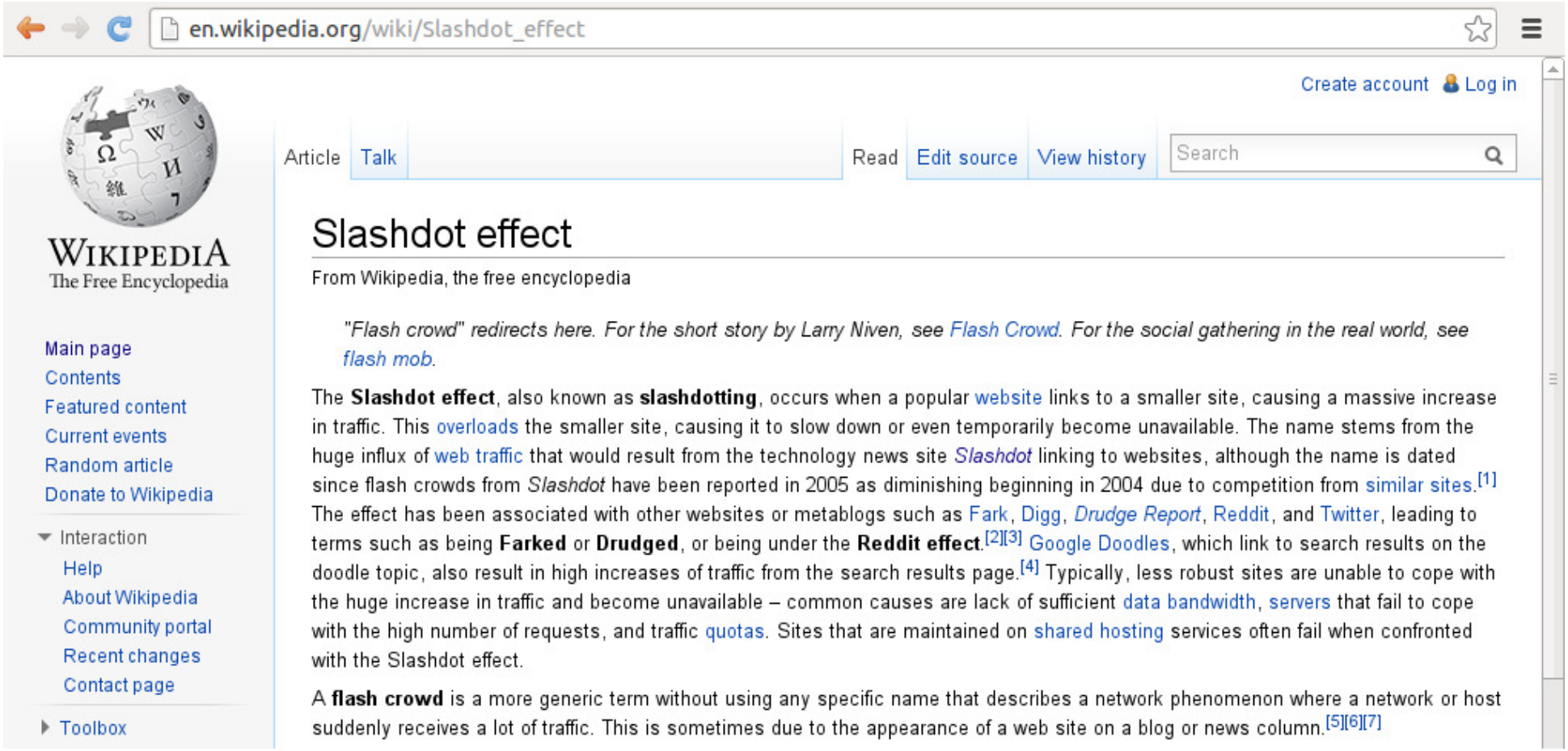
- 2006-2008: Only few users used the service
- April 2008: Facebook application launched
  - 750,000 new users in 3 days
  - At the peak, up to 25,000 people tried to render a video in a single hour
  - Slashdot effect!
  - Automatic adjustment of the instances to render the videos from 2 up to 450



`http://www.youtube.com/watch?v=VwDS6MexKEo`

Animoto on AWS - Customer Success Story

Slashdot Effect



en.wikipedia.org/wiki/Slashdot_effect

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Slashdot effect

From Wikipedia, the free encyclopedia

"Flash crowd" redirects here. For the short story by Larry Niven, see Flash Crowd. For the social gathering in the real world, see flash mob.

The **Slashdot effect**, also known as **slashdotting**, occurs when a popular website links to a smaller site, causing a massive increase in traffic. This overloads the smaller site, causing it to slow down or even temporarily become unavailable. The name stems from the huge influx of web traffic that would result from the technology news site *Slashdot* linking to websites, although the name is dated since flash crowds from *Slashdot* have been reported in 2005 as diminishing beginning in 2004 due to competition from similar sites.[1] The effect has been associated with other websites or metablogs such as Fark, Digg, *Drudge Report*, Reddit, and Twitter, leading to terms such as being **Farked** or **Drudged**, or being under the **Reddit effect**.[2][3] Google Doodles, which link to search results on the doodle topic, also result in high increases of traffic from the search results page.[4] Typically, less robust sites are unable to cope with the huge increase in traffic and become unavailable – common causes are lack of sufficient data bandwidth, servers that fail to cope with the high number of requests, and traffic quotas. Sites that are maintained on shared hosting services often fail when confronted with the Slashdot effect.

A **flash crowd** is a more generic term without using any specific name that describes a network phenomenon where a network or host suddenly receives a lot of traffic. This is sometimes due to the appearance of a web site on a blog or news column.[5][6][7]

- Linear increase of traffic is unrealistic
- Huge problem for startup companies with own resources

AWS Customer Success Story: New York Times

- 2007: The New York Times wants to create PDF versions from the articles from the years 1851-1980
  - The newspaper planned to make the articles from the years 1851-1922 available online for free
- The raw version of the articles were 11 million scanned images
  - Each article had to be composed of several TIFF files and had to be scaled
- First, 4 TB TIFF files had to be uploaded to S3
- 100 EC2 instances required approximately 24 hours for the calculation
- Result: 1.5 TB of PDF files inside S3
- `https://timesmachine.nytimes.com`


"All the News That's Fit to Print."

The New York Times.

TITANIC SINKS FOUR HOURS AFTER HITTING ICEBERG; 866 RESCUED BY CARPATHIA, PROBABLY 1250 PERISH; ISMAY SAFE, MRS. ASTOR MAYBE, NOTED NAMES MISSING

The Lost Titanic Being Towed Out of Belfast Harbor.

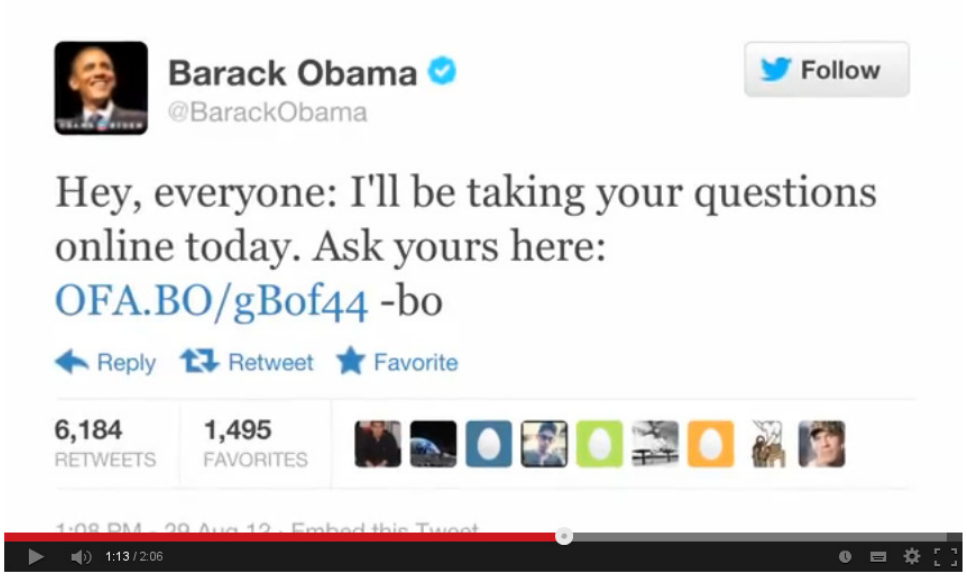
PARTIAL LIST OF THE SAVED.

CAPT. E. J. SMITH.

https://aws.amazon.com/de/blogs/aws/new-york-times/
http://open.blogs.nytimes.com/2007/11/01/self-service-prorated-super-computing-fun/
http://open.blogs.nytimes.com/2008/05/21/the-new-york-times-archives-amazon-web-services-timesmachine/

AWS Customer Success Story: reddit

reddit on AWS - Customer Success Story

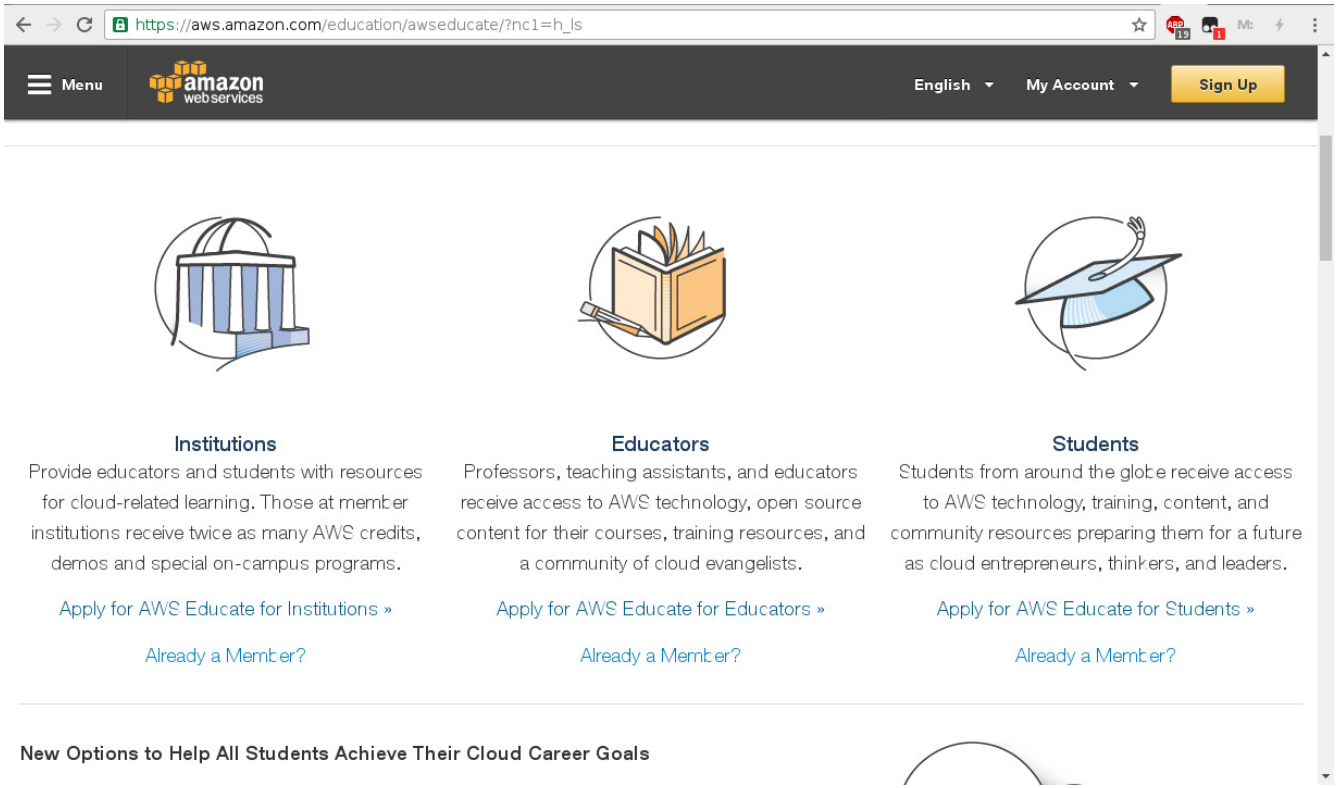


reddit on AWS - Customer Success Story

- 2012: reddit has 4 billion page views per month
  - Scalable infrastructure based of AWS
- Server capacity was doubled in minutes for President Obama's live Q&A session in 2012

`http://www.youtube.com/watch?v=BPMNB29zDvk`
Update (May 2018): The video is not online any more...

AWS Credits – https://aws.amazon.com/education/awseducate/

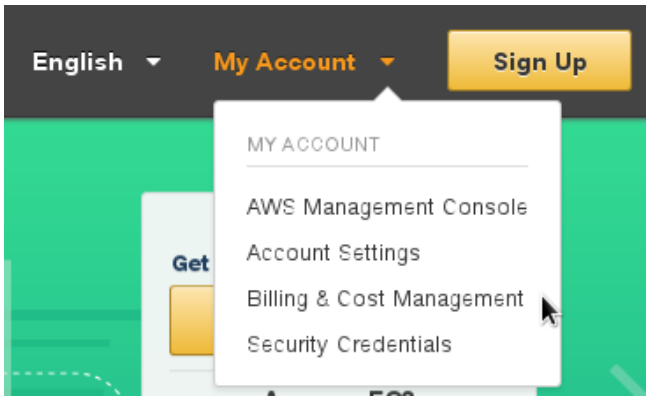


- Each student which registers at the AWS gets a credit
  - The AWS credit is good for a limited time.
  - If the credit is consumed or expired and the user continues to consume resources, your credit card will be charged!

AWS – Check your Account Activity !!!

State: October 2016

- Please regularly check their user account!
  - Login at the AWS page and check the **Billing & Cost Management** page
- Running lots of instances all the time quickly melts together your credit
  - If the credit is spend and resources are still consumed, the credit card will be charged
    - The account holder is responsible for resulting costs
  - You can specify limits and alerts $\Longrightarrow$ do it!



Amazon Elastic Compute Cloud (EC2)

- Users can create, use and control virtual server instances in Amazons data centers
  - Supported operating systems: Linux and Windows Server

Operating Systems		
CentOS	Debian	SUSE Linux Enterprise
Amazon Linux	Oracle Enterprise Linux	Ubuntu
Red Hat Enterprise Linux	Windows Server	

- Virtual servers are created from Amazon Machine Images (AMI)
  - These are like a blueprint to be used when creating new virtual servers
  - Amazon provides prebuilt images
  - Besides Amazon, a number of third-party vendors, such as IBM, Oracle, and SAP, provide AMIs including proprietary software packages
  - End users as well can create their own images for later reuse
    - End users can publish their AMIs and put them on the market using a product ID (paid instances)

EC2 Terminology

State: October 2016

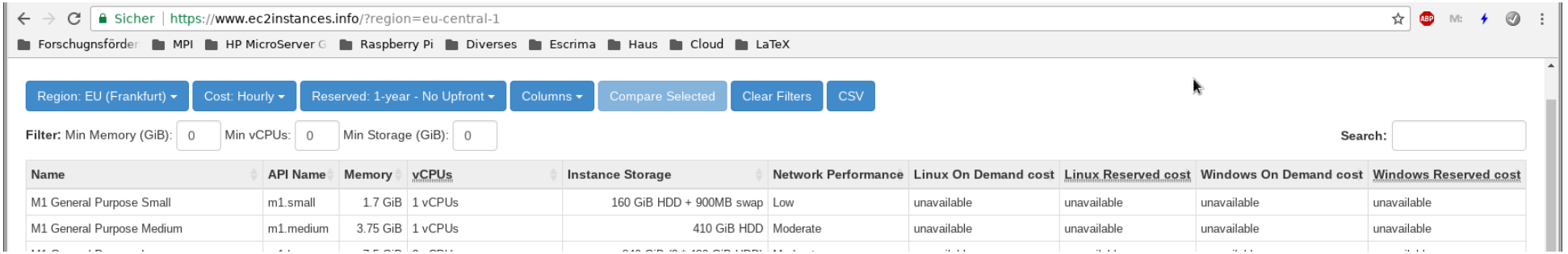
- EC2 provides 11 sites (**regions**) with resources:
  - Virginia, California, Oregon, Ireland, Frankfurt, Singapore, Sydney, Tokyo, Seoul, Mumbai, Sao Paulo
- Each region contains **availability zones**
  - Each availability zone is a cluster

Region	Availability Zones
Virgina	`us-east-1a`, `us-east-1b`, `us-east-1c`, `us-east-1d`, `us-east-1e`
California	`us-west-1a`, `us-west-1b`, `us-west-1c`
Oregon	`us-west-2a`, `us-west-2b`, `us-west-2c`
Ireland	`eu-west-1a`, `eu-west-1b`, `eu-west-1c`
Frankfurt	`eu-central-1a`, `eu-central-1b`
Singapore	`ap-southeast-1a`, `ap-southeast-1b`
Sydney	`ap-southeast-2a`, `ap-southeast-2b`, `ap-southeast-2c`
Tokyo	`ap-northeast-1a`, `ap-northeast-1b`, `ap-northeast-1c`
Seoul	`ap-northeast-2a`, `ap-northeast-2c`
Mumbai	`ap-south-1a`, `ap-south-1b`
Sao Paulo	`sa-east-1a`, `sa-east-1b`, `sa-east-1c`

Update May 2018: The list of availability zones did grow: Missing in this slide are Oregon, Canada, Paris and Osaka

EC2 Instance Types

State: May 2018



Name	API Name	Memory	vCPUs	Instance Storage	Network Performance	Linux On Demand cost	Linux Reserved cost	Windows On Demand cost	Windows Reserved cost
M1 General Purpose Small	m1.small	1.7 GiB	1 vCPUs	160 GiB HDD + 900MB swap	Low	unavailable	unavailable	unavailable	unavailable
M1 General Purpose Medium	m1.medium	3.75 GiB	1 vCPUs	410 GiB HDD	Moderate	unavailable	unavailable	unavailable	unavailable

• • •

T1 Micro	t1.micro	0.613 GiB	1 vCPUs	EBS only	Very Low	unavailable	unavailable	unavailable	unavailable
T2 Nano	t2.nano	0.5 GiB	1 vCPUs for a 1h 12m burst	EBS only	Low	$0.006700 hourly	$0.005000 hourly	$0.009000 hourly	$0.007000 hourly
T2 Micro	t2.micro	1.0 GiB	1 vCPUs for a 2h 24m burst	EBS only	Low to Moderate	$0.013400 hourly	$0.010000 hourly	$0.018000 hourly	$0.014000 hourly
T2 Small	t2.small	2.0 GiB	1 vCPUs for a 4h 48m burst	EBS only	Low to Moderate	$0.026800 hourly	$0.019000 hourly	$0.036000 hourly	$0.028000 hourly
T2 Medium	t2.medium	4.0 GiB	2 vCPUs for a 4h 48m burst	EBS only	Low to Moderate	$0.053600 hourly	$0.038000 hourly	$0.071600 hourly	$0.056000 hourly
T2 Large	t2.large	8.0 GiB	2 vCPUs for a 7h 12m burst	EBS only	Low to Moderate	$0.107200 hourly	$0.076000 hourly	$0.135200 hourly	$0.104000 hourly
T2 Extra Large	t2.xlarge	16.0 GiB	4 vCPUs for a 5h 24m burst	EBS only	Moderate	$0.214400 hourly	$0.153000 hourly	$0.255400 hourly	$0.194000 hourly
T2 Double Extra Large	t2.2xlarge	32.0 GiB	8 vCPUs for a 4h 3m burst	EBS only	Moderate	$0.428800 hourly	$0.306000 hourly	$0.490800 hourly	$0.368000 hourly
M5 General Purpose Large	m5.large	8.0 GiB	2 vCPUs	EBS only	High	$0.115000 hourly	$0.082000 hourly	$0.207000 hourly	$0.174000 hourly
M5 General Purpose Extra Large	m5.xlarge	16.0 GiB	4 vCPUs	EBS only	High	$0.230000 hourly	$0.164000 hourly	$0.414000 hourly	$0.348000 hourly
M5 General Purpose Double Extra Large	m5.2xlarge	32.0 GiB	8 vCPUs	EBS only	High	$0.460000 hourly	$0.328000 hourly	$0.828000 hourly	$0.696000 hourly
M5 General Purpose Quadruple Extra Large	m5.4xlarge	64.0 GiB	16 vCPUs	EBS only	High	$0.920000 hourly	$0.655000 hourly	$1.656000 hourly	$1.391000 hourly

• • •

I3 High I/O Large	i3.large	15.25 GiB	2 vCPUs	475 GiB NVMe SSD	Up to 10 Gigabit	$0.186000 hourly	$0.126000 hourly	$0.278000 hourly	$0.218000 hourly
I3 High I/O Extra Large	i3.xlarge	30.5 GiB	4 vCPUs	950 GiB NVMe SSD	Up to 10 Gigabit	$0.372000 hourly	$0.252000 hourly	$0.556000 hourly	$0.436000 hourly
I3 High I/O Double Extra Large	i3.2xlarge	61.0 GiB	8 vCPUs	1900 GiB NVMe SSD	Up to 10 Gigabit	$0.744000 hourly	$0.504000 hourly	$1.112000 hourly	$0.872000 hourly
I3 High I/O Quadruple Extra Large	i3.4xlarge	122.0 GiB	16 vCPUs	3800 GiB (2 * 1900 GiB NVMe SSD)	Up to 10 Gigabit	$1.488000 hourly	$1.008000 hourly	$2.224000 hourly	$1.744000 hourly
I3 High I/O Eight Extra Large	i3.8xlarge	244.0 GiB	32 vCPUs	7600 GiB (4 * 1900 GiB NVMe SSD)	10 Gigabit	$2.976000 hourly	$2.016000 hourly	$4.448000 hourly	$3.488000 hourly
I3 High I/O 16xlarge	i3.16xlarge	488.0 GiB	64 vCPUs	15200 GiB (8 * 1900 GiB NVMe SSD)	25 Gigabit	$5.952000 hourly	$4.032000 hourly	$8.896000 hourly	$6.976000 hourly

EC2 - Required Steps to work with the Service (1/2)

- The user needs a **key pair** to authenticate at its instances
  - Login without password (public key method)
  - Public keys are stored inside the instances
  - Private keys are stored on the users client
  - A new key pair can be created or an existing key pair can be used
- User decides, which ports must be open
  - The fewer ports are opened, the better is the security
  - The user creates for the instance a **security group**, in which the required ports are opened
    - The user can also use an existing security group
- User decides which **operating system (AMI)** and which **instance type** meets his requirements best
- User decides which **region** and **availability zone** he prefers
- The instance is created according to the decisions made before

EC2 - Required Steps to work with the Service (2/2)

- After the virtual server has been created, a **public** and a **private IP address** is dynamically assigned to the instance
  - With the public address the instance can be accessed from the Internet
  - With the private address it can be accessed by other instances inside the Amazon cloud
- Private and public addresses are assigned dynamically each time a new instance is created
  - Dynamically assigned addresses are not suited for the long-term operation of a server
  - Servers need to be restarted from time to time
  - Solution: **elastic IP addresses**
- Users can assign Elastic IPs – once reserved – their own server instances again and again

Persistence of Data in EC2

- At the termination of an instance all changes are lost
- Valuable data must be stored outside the instance
  - Large amounts of structured data can be stored in S3
  - EBS provides block-based storage

EC2 Pricing

$\Longrightarrow$ `https://aws.amazon.com/ec2/pricing/`

- On-Demand instances
- Spot instances
  - Instances have flexible start and end times
- Reserved instances
  - Customers can rent EC2 instances over a 1 or 3 year term to reduce their total costs
- Dedicated Hosts

EC2 Pricing: Internet Data Transfer

State: November 2017

- The import of data to AWS resources is for free
- If data is copied between AWS resources it is for free if these resources are inside the same availability zone

Data Transfer OUT From Amazon EC2 To Internet

First 1 GB / month	$0.000 per GB
Up to 10 TB / month	$0.090 per GB
Next 40 TB / month	$0.085 per GB
Next 100 TB / month	$0.070 per GB
Next 350 TB / month	$0.050 per GB
Next 524 TB / month	Contact Us
Next 4 PB / month	Contact Us
Greater than 5 PB / month	Contact Us

EC2 Pricing: Elastic IP und Load Balancing

State: November 2017

- Elastic IP adresses

Region: EU (Frankfurt)

- $0.00 for one Elastic IP address associated with a running instance
- $0.005 per additional Elastic IP address associated with a running instance per hour on a pro rata basis
- $0.005 per Elastic IP address not associated with a running instance per hour on a pro rata basis
- $0.00 per Elastic IP address remap for the first 100 remaps per month
- $0.10 per Elastic IP address remap for additional remaps over 100 per month

- Elastic Load Balancers

EU (Frankfurt)

$0.0270 per Application Load Balancer-hour (or partial hour)

$0.008 per LCU-hour (or partial hour)

EC2 Pricing: CloudWatch

State: November 2017

Region: EU (Frankfurt)

Amazon CloudWatch Dashboards

- $3.00 per dashboard per month

Detailed Monitoring for Amazon EC2 Instances

- $2.10 down to $0.14 per instance per month at 1-minute frequency******

Amazon CloudWatch Custom Metrics

- $0.30 per metric per month for the first 10,000 metrics
- $0.10 per metric per month for the next 240,000 metrics
- $0.05 per metric per month for the next 750,000 metrics
- $0.02 per metric per month for metrics over 1,000,000

Amazon CloudWatch Alarms

- $0.10 per alarm per month
- $0.30 per high-resolution alarm per month

Amazon CloudWatch API Requests

- $0.01 per 1,000 GetMetricStatistics, ListMetrics, PutMetricData, GetDashboard, ListDashboards, PutDashboard and DeleteDashboards requests

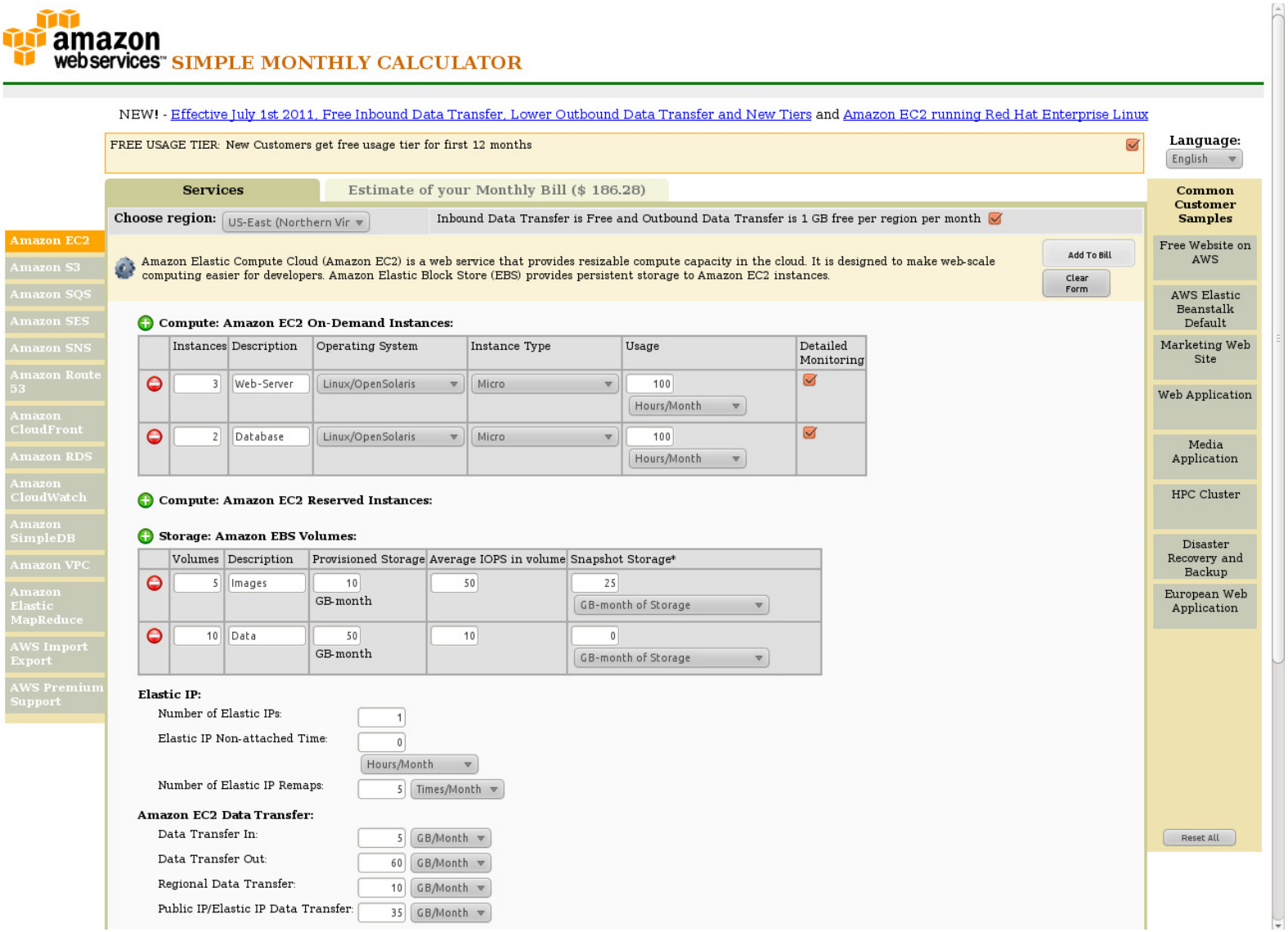
Amazon CloudWatch Logs*

- $0.63 per GB ingested**
- $0.0324 per GB archived per month***
- Data Transfer OUT from CloudWatch Logs is priced equivalent to the "Data Transfer OUT from Amazon EC2 To" and "Data Transfer OUT from Amazon EC2 to Internet" tables on the EC2 Pricing Page.

Amazon CloudWatch Events - Custom Events****

- $1.00 per million custom events generated*****

AWS Simple Monthly Calculator



EC2 – Availability

http://aws.amazon.com/ec2-sla/

- Amazon guarantees a monthly uptime percentage of at least 99.99%
- Maximum downtime: approximately 4 1/2 minutes per month
  $\Longrightarrow$ 52 minutes per year

Monthly Uptime Percentage	Service Credit Percentage
Less than 99.99% but equal to or greater than 99.0%	10%
Less than 99.0%	30%

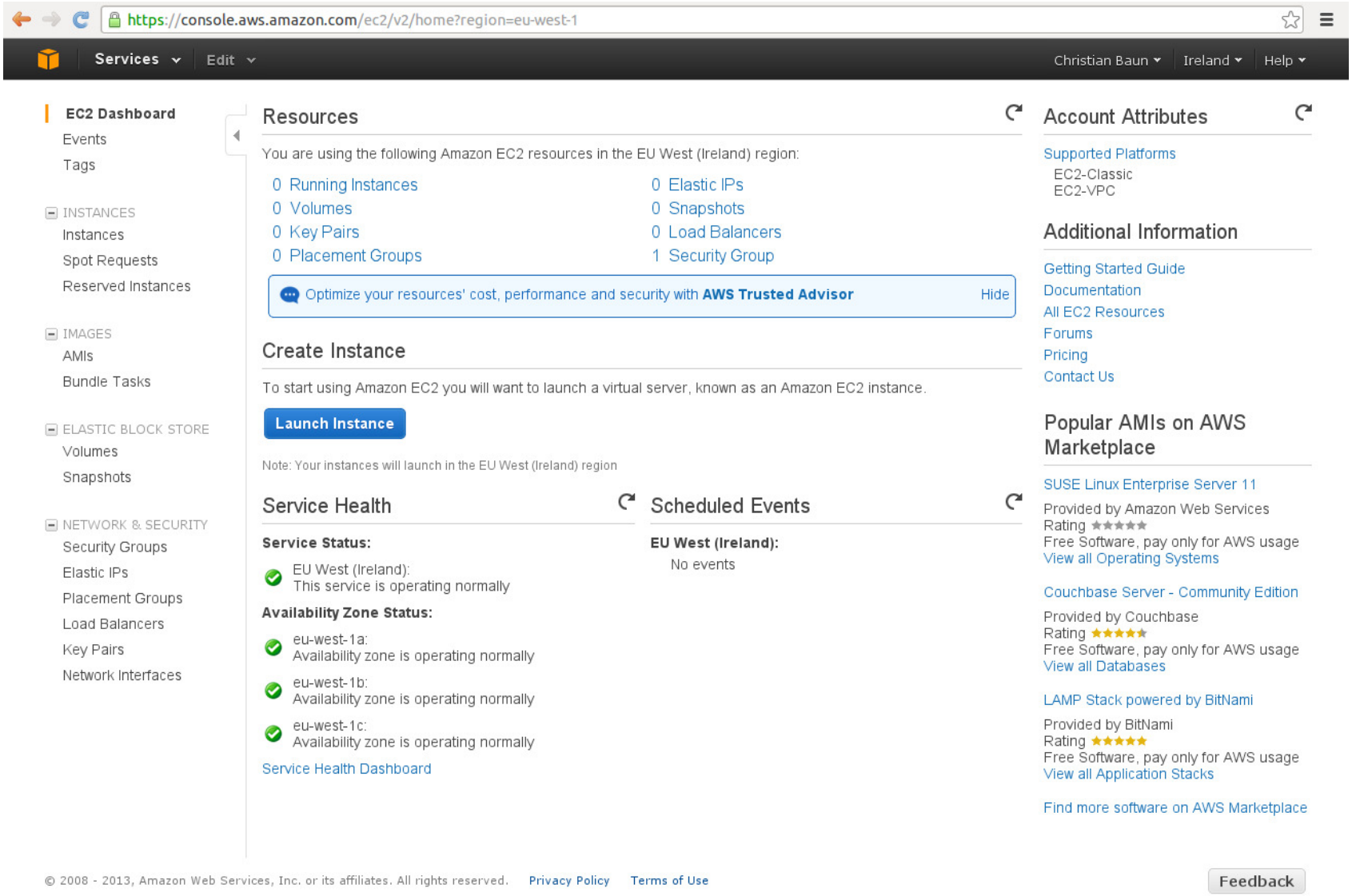
- If the guaranteed uptime percentage falls below 99.99%, the customer gets a refund
  - Will a refund of 10% or 30% help any further, if the service fails and thus the own data is not available (or gone)?

Working with EC2

- Command line tools and tools with a GUI
  - Universal Command Line Interface for Amazon Web Services
    - `https://github.com/aws/aws-cli`
  - ElasticWolf
    - `http://www.elasticwolf.com`
    - `https://aws.amazon.com/tools/aws-elasticwolf-client-console/`
- Firefox extension
  - `http://s3.amazonaws.com/ec2-downloads/elasticfox.xpi`
- Web applications/SaaS
  - `http://aws.amazon.com/console/`
  - `http://ylastic.com`
  - `https://github.com/christianbaun/koalacloud` (**outdated!**)

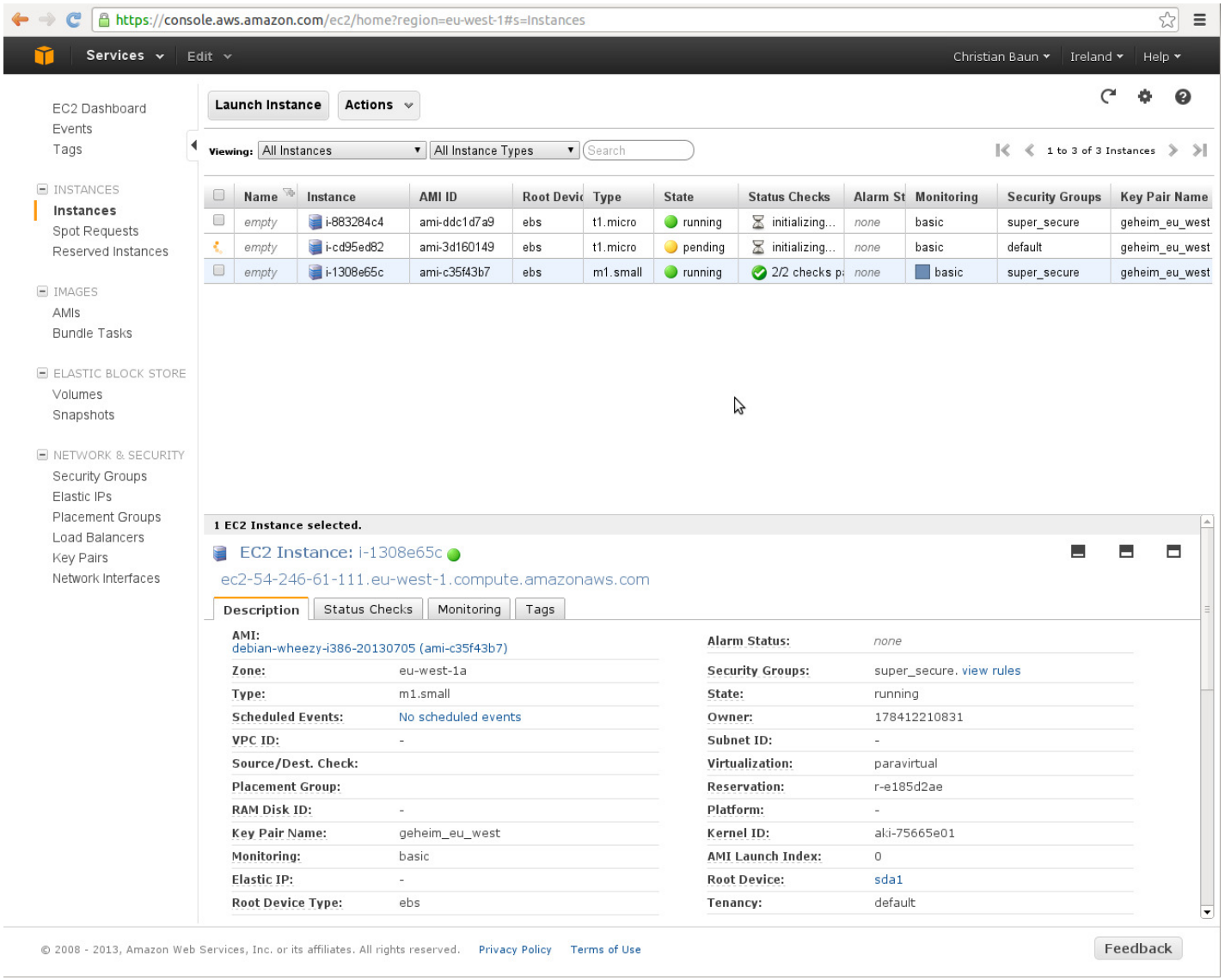
AWS Management Console (EC2 Dashboard)

State: 2013



AWS Management Console (Instances)

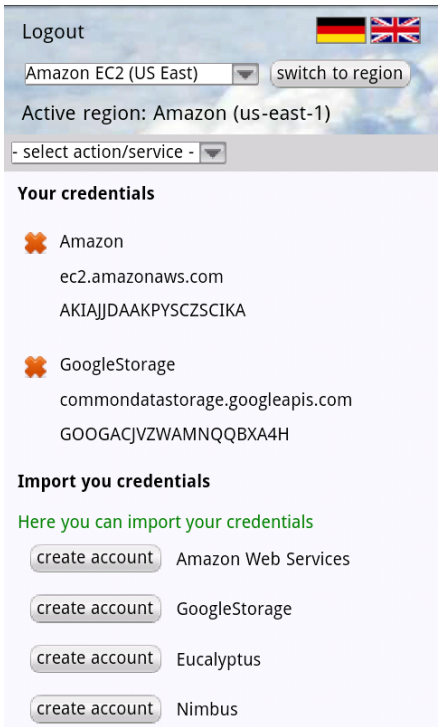
State: 2013

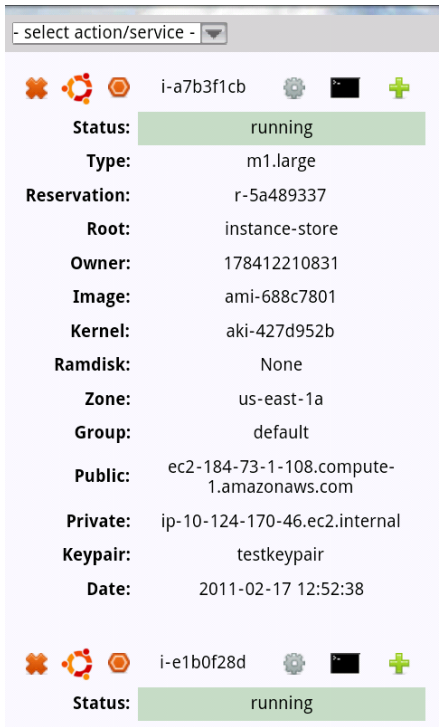


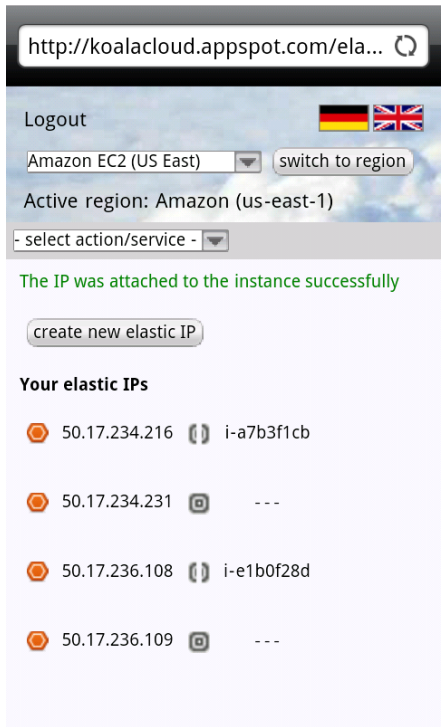
KOALA

State: 2011

- **K**arlsruhe **O**pen **A**pplication for c**L**oud **A**dministration
  - `https://github.com/christianbaun/koalacloud`
- Web application which supports working with AWS-compatible infrastructure and storage services







Working with the EC2 API and boto (1/2)

- Access the EC2 API the simple way via boto and Python
  - `https://github.com/boto/boto`

```
1  #!/usr/bin/env python
2
3  from boto.ec2.connection import EC2Connection
4  # Establish connection to EC2
5  # Variable "conn" points to an "EC2Connection" object
6  conn = EC2Connection('<aws access key>', '<aws secret key>')
7
8  # Receive a list of all regions and print it out
9  list_regions = conn.get_all_regions()
10 print list_regions
11
12 # Receive a list of all availability zones and print it out
13 list_zones = conn.get_all_zones()
14 print list_zones
```

Working with the EC2 API and boto (2/2)

```
15 # Receive a list of all security groups and print it out
16 list_groups = conn.get_all_security_groups()
17 print list_groups
18
19 # Receive a list of all key pairs and print it out
20 list_keys = conn.get_all_key_pairs()
21 print list_keys
22
23 # Create instances
24 reservation = conn.run_instances('ami-e348af8a',
25                                  min_count=2,
26                                  key_name='secret',
27                                  instance_type='m1.small')
28
29 # Receive a list of all instances and print it out
30 list_instances = conn.get_all_instances()
31 print list_instances
```

Amazon Elastic Block Store (EBS)

- EBS is a part of EC2
- Inside each availability zone, the users can create EBS volumes
  - Size: Up to sevral 16 TB
- An EBS volume implements persistent storage
- A new EBS volume behaves just like an unformatted block device
- an EBS volume can only be mounted to one single instance
  - Volume and instance must be located in the same availability zone
- A volume can contain any filesystem
- The way of using a volume is equal to using an USB flash drive
- Note: EBS is storage for people and S3 is storage for applications
- Volume snapshots can be created (and stored in S3) any time

Pricing of EBS

State: November 2017

Region: EU (Frankfurt)

Amazon EBS General Purpose SSD (gp2) volumes

- $0.119 per GB-month of provisioned storage

Amazon EBS Provisioned IOPS SSD (io1) volumes

- $0.149 per GB-month of provisioned storage
- $0.078 per provisioned IOPS-month

Amazon EBS Throughput Optimized HDD (st1) volumes

- $0.054 per GB-month of provisioned storage

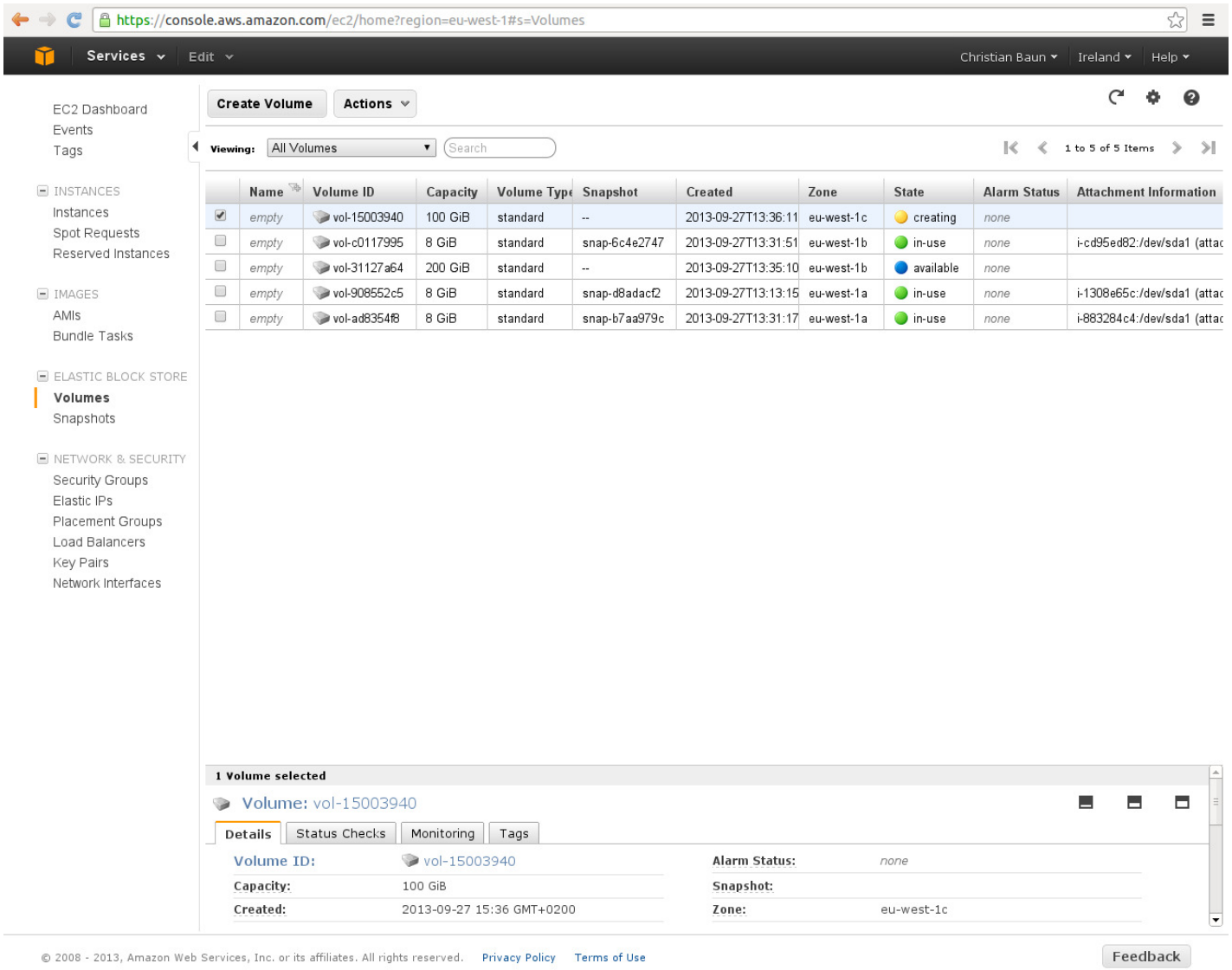
Amazon EBS Cold HDD (sc1) volumes

- $0.03 per GB-month of provisioned storage

Amazon EBS Snapshots to Amazon S3

- $0.054 per GB-month of data stored

AWS Management Console (EBS Volumes)



Working with the EBS API and boto

```
1  #!/usr/bin/env python
2
3  from boto.ec2.connection import EC2Connection
4  # Establish connection to EC2
5  # Variable "conn" points to an "EC2Connection" object
6  conn = EC2Connection('<aws access key>', '<aws secret key>')
7
8  # Create a volume (1 GB) in region "us-east-1a".
9  volume = conn.create_volume(1, 'us-east-1a')
10 # Print out the ID of the volume
11 print volume.id
12
13 # Erase volume "vol-1e0f0677"
14 conn.delete_volume('vol-1e0f0677')
```

- Attach a volume at an instance $\Longrightarrow$ `attach_volume()`
- Detach a volume from an instance $\Longrightarrow$ `detach_volume()`

Amazon Elastic Load Balancing (ELB)

State: November 2017

- ELB is a part of EC2
- Users can create elastic load balancers inside each availability zone
- The user assigns each of its load balancers a pool of instances
- An elastic load balancer automatically distributes incoming requests to the EC2 instances of its pool
- A ELB identified failed instances inside its pool and distributes the requests automatically to the working instances of the pool

EU (Frankfurt)

$0.0270 per Application Load Balancer-hour (or partial hour)

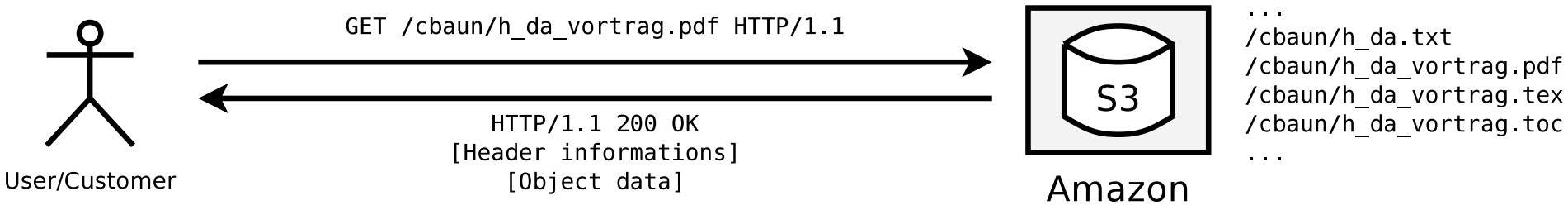
$0.008 per LCU-hour (or partial hour)

Amazon Simple Storage Service – S3 (1/2)

- Data is stored as **(web-)objects**
- No files or folders exist, but only **objects**
  - The size of each object can be 1 Byte to 5 TB
  - For each object, 2 KB metadata is stored
  - Each user can store an unlimited number of objects
- Each object is assigned to a **bucket**
  - Buckets have unique names and contain no other buckets
    $\Longrightarrow$ Directories are impossible
  - The name of an object is also called **key**

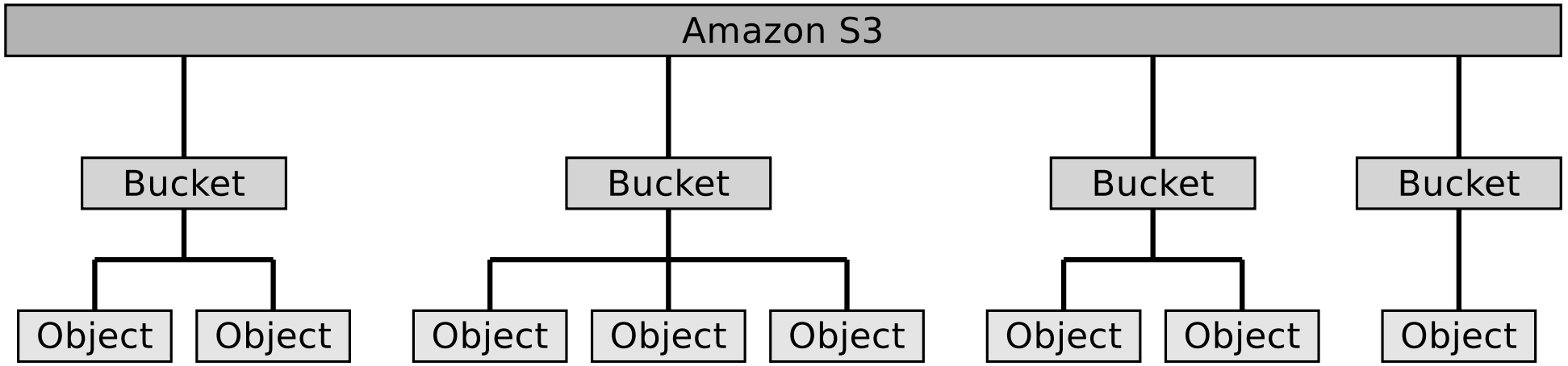
Amazon Simple Storage Service – S3 (2/2)

- Objects are accessible online
  - `http://s3.amazonaws.com/bucket/objekt`
  - `http://bucket.s3.amazonaws.com/objekt`
- Access to buckets and objects is done via REST or SOAP (deprecated)
  - Objects can also be downloaded via BitTorrent



- Users can specify for all their objects and buckets the access privileges
  - Access Control List (ACL)

Flat Name Space of S3



- S3 does not support folders
  - Only buckets and objects can be created
  - But folders can be simulated
    - S3Fox, Google and KOALA simulate folder by attaching `_$folder$` at the end of an objects key
    - Objects, which are assigned to such a *folder*, have a key with the naming scheme `folder/subfolder/object`

S3 Pricing (Storage)

November 2017

Region: EU (Frankfurt)

	Standard Storage	Standard - Infrequent Access Storage †	Glacier Storage
First 50 TB / month	$0.0245 per GB	$0.0135 per GB	$0.0045 per GB
Next 450 TB / month	$0.0235 per GB	$0.0135 per GB	$0.0045 per GB
Over 500 TB / month	$0.0225 per GB	$0.0135 per GB	$0.0045 per GB

- **Standard Storage** is designed for 99.999999999% durability and 99.99% availability of objects over a given year
- **Reduced Redundancy Storage** (RRS) is designed to provide 99.99% durability and 99.99% availability of objects over a given year
  - This durability level corresponds to an average annual expected loss of 0.01% of the objects

S3 Pricing (Storage)

November 2017

Region: EU (Frankfurt)

	Standard Storage	Standard - Infrequent Access Storage †	Glacier Storage
First 50 TB / month	$0.0245 per GB	$0.0135 per GB	$0.0045 per GB
Next 450 TB / month	$0.0235 per GB	$0.0135 per GB	$0.0045 per GB
Over 500 TB / month	$0.0225 per GB	$0.0135 per GB	$0.0045 per GB

- **Glacier** is designed for 99.999999999% durability and 99.99% availability of objects over a given year
  - Extremely low-cost storage service option for data archival
  - Stores data for as little as $0.01 (in US-East) per GB per month
  - Optimized for data that is infrequently accessed and for which retrieval times of several hours are suitable

S3 Pricing (Requests)

November 2017

Request Pricing

Amazon S3 request costs are based on the request type, and are charged on the quantity of requests or the volume of data retrieved as listed in the table below.

Region: EU (Frankfurt)

	Pricing
For Requests Not Otherwise Specified Below	
PUT, COPY, POST, or LIST Requests	$0.0054 per 1,000 requests
GET and all other Requests	$0.0043 per 10,000 requests
Delete Requests	Free †
For Standard – Infrequent Access Requests	
PUT, COPY, or POST Requests	$0.01 per 1,000 requests
GET and all other Requests	$0.01 per 10,000 requests
Lifecycle Transition Requests into Standard – Infrequent Access	$0.01 per 1,000 requests
Data Retrievals	$0.01 per GB

S3 Pricing (Data Transfer)

November 2017

Data Transfer Pricing

The pricing below is based on data transferred "in" to and "out" of Amazon S3 (over the public Internet). AWS Direct Connect pricing can be found here. Transfers between S3 buckets or from S3 to any service(s) within the same region are free.

Region: EU (Frankfurt)

	Pricing
Data Transfer IN To Amazon S3	
All data transfer in	$0.000 per GB
Data Transfer OUT From Amazon S3 To	
Another AWS Region	$0.020 per GB
Amazon CloudFront	$0.000 per GB
Data Transfer OUT From Amazon S3 To Internet	
First 1 GB / month	$0.000 per GB
Up to 10 TB / month	$0.090 per GB
Next 40 TB / month	$0.085 per GB
Next 100 TB / month	$0.070 per GB
Next 350 TB / month	$0.050 per GB
Next 524 TB / month	Contact Us
Next 4 PB / month	Contact Us
Greater than 5 PB / month	Contact Us

AWS Import/Export Disk

- Helps to transfer large amounts of data into or out from the cloud

Available Internet Connection	Theoretical Min. Number of Days to Transfer 1TB at 80% Network Utilization	When to Consider AWS Import/Export Disk?
T1 (1.544Mbps)	82 days	100GB or more
10Mbps	13 days	600GB or more
T3 (44.736Mbps)	3 days	2TB or more
100Mbps	1 to 2 days	5TB or more
1000Mbps	Less than 1 day	60TB or more

- The customers sends a storage device (HDD) to Amazon
- The device concent is copied by Amazon employees into a S3 bucket
  - File systems: NTFS, ext2, ext3 and FAT32 with a mximum size of 16 TB
- Pricing per storage device: $80
- Pricing for the transfer at Amazon site per hour: $2.49
- `https://aws.amazon.com/snowball/disk/`

AWS Import/Export Snowball

Image Source: Amazon

- Amazon offers the Snowball Appliances for importing data into S3
- `https://aws.amazon.com/snowball/`

- Capacity: 50 TB or 80 TB
- 10 Gbit Ethernet interface
- AES 256-bit encryption
- Price: $200 or $250 per device for 10 days
- Each additional day costs $15

Similar offering – Cloud Mass Data Migration

Image Source: IBM

- IBM offers a similar import service for its own IaaS offerings
- **Cloud Mass Data Migration**
- Capacity: 120 TB
- AES 256-bit encryption
- RAID-6
- 10 Gbit Ethernet interface
- Price: $395 per device for 10 days
- Each additional day: +$30

- Customers can migrate 120 TB of data in seven days, with round-trip use of UPS Next Day Air included in the overall service

AWS Snowmobile

Image Source: AWS

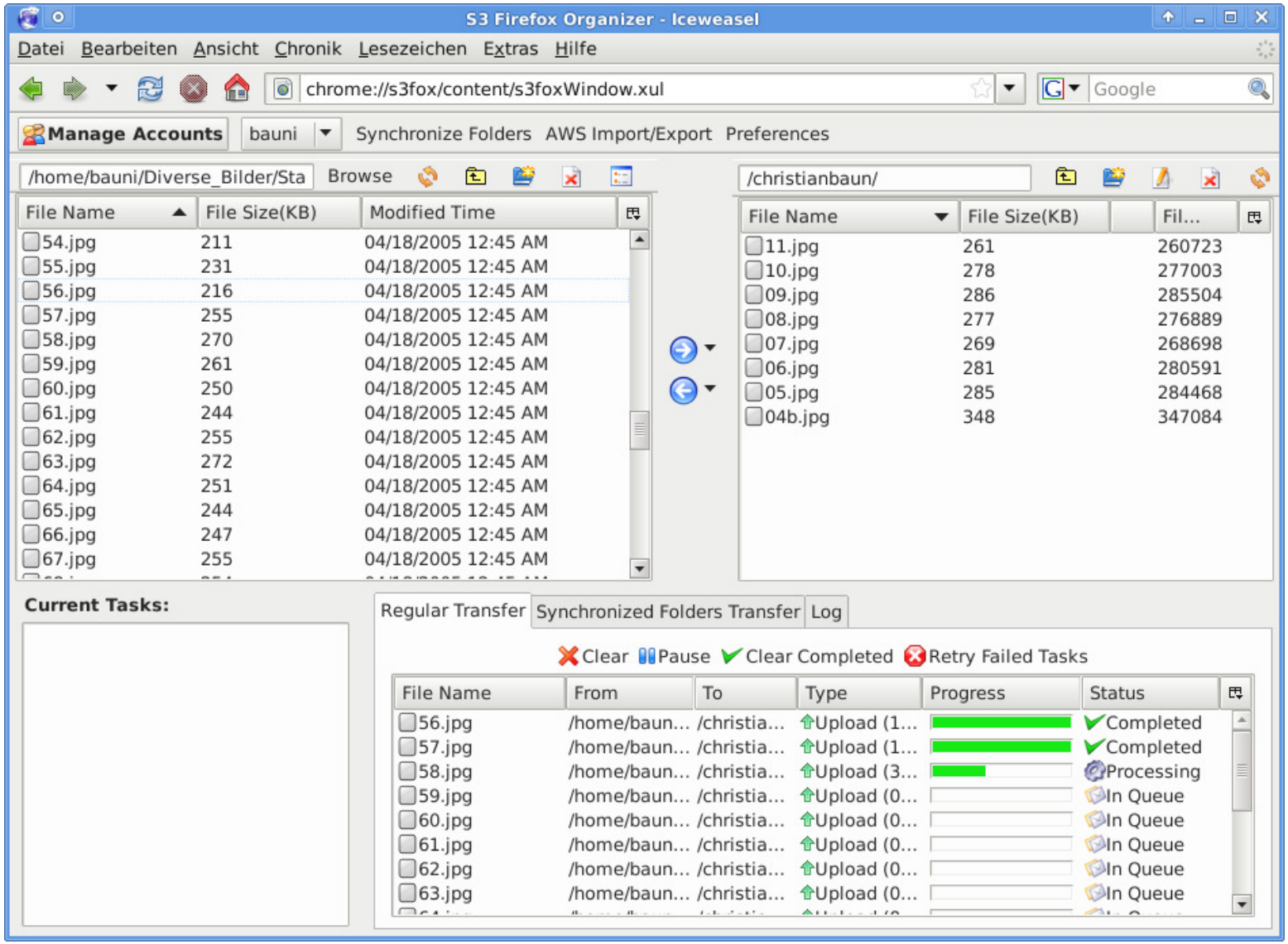
- Helps to transfer very large amounts of data into the cloud
  - Customers can transfer up to 100 PB per Snowmobile
    - Data is copied by Amazon employees into a S3 bucket or into Glacier
- Snowmobile is a 45-foot long shipping container, pulled by a truck
  - Includes security personnel, GPS tracking, alarm monitoring, 24/7 video surveillance, and an optional escort security vehicle while in transit
  - All data is encrypted with 256-bit encryption keys
- `https://aws.amazon.com/snowmobile/`

Using S3 with s3cmd

- s3cmd is a simple to use command line tool for uploading, retrieving and managing data in Amazon S3
  - http://s3tools.org/s3cmd

Configure login information	`s3cmd -configure`
List own buckets	`s3cmd ls`
Create bucket	`s3cmd mb s3://Bucket`
Upload object	`s3cmd put LocalFile s3://Bucket/DistantObjekt`
List content of a bucket	`s3cmd ls s3://Bucket`
Download object	`s3cmd get s3://Bucket/DistantObjekt LocalFile`
Erase objekt	`s3cmd del s3://Bucket/DistantObjekt`
Erase (empty) bucket	`s3cmd rb s3://Bucket`

Firefox Extension S3Fox: http://www.s3fox.net



Working with the S3 API and boto

```
1  #!/usr/bin/env python
2
3  from boto.s3.connection import S3Connection
4  # Establish connection to EC2
5  # Variable "conn" points to an "EC2Connection" object
6  conn = S3Connection('<aws access key>', '<aws secret key>')
7
8  # Create bucket "testbucket"
9  conn.create_bucket('testbucket')
10
11 # Retrieve a list of own buckets and print it out
12 request_buckets = conn.get_all_buckets()
13 print(request_buckets)
```

Upload Objects via HTTP POST to S3 (1/3)

- One way to upload objects in S3, is via HTTP POST

```
http://doc.s3.amazonaws.com/proposals/post.html
http://s3.amazonaws.com/doc/s3-example-code/post/post_sample.html
```

- To upload a file via HTTP POST, the customer needs:
  - Access to S3
    - Access Key and Secret Access Key
  - Bucket
  - Policy document
  - Signature
  - HTML form

Upload Objects via HTTP POST to S3 (2/3)

```
{ "expiration": "2100-01-01T00:00:00Z",
  "conditions": [
    {"bucket": "<bucket>"},
    ["starts-with", "$acl", ""],
    {"redirect": "<DestinationAddress>"},
    ["starts-with", "$key", ""],
    ["starts-with", "$Content-Type", ""]
  ]
}
```

- A prefix can be specified for the object name
  z.B. `["starts-with", "$key", "diagrams/"]`,
- A prefix can be specified for the content type name
  z.B. `["starts-with", "$Content-Type", "image/"]`,
- The Policy document is Base64 encoded $\Longrightarrow$ **Policy**
- The Policy is attached to the Secret Access Key and then again Base64 encoded $\Longrightarrow$ **Signature**

Upload Objects via HTTP POST to S3 (3/3)

```
<form action="http://s3.amazonaws.com/<bucket>" method="post" enctype="
    multipart/form-data">
    <input type="hidden" name="key" value="${filename}">
    <input type="hidden" name="acl" value="<ACL>">
    <input type="hidden" name="Content-Type" value="<Content Typ>">
    <input type="hidden" name="redirect" value="<DestinationAddress>">
    <input type="hidden" name="AWSAccessKeyId" value="<Access Key>">
    <input type="hidden" name="policy" value="<Policy>">
    <input type="hidden" name="signature" value="<Signature>">

    <input type="file" name="file">
    <input type="submit" name="submit" value="Upload to S3">
</form>
```

- Access Control List (ACL) can be: `private`, `public-read`, `public-read-write` or `authenticated-read`
- Values of the form must match the policy document
- Object successfully transmitted $\Longrightarrow$ Browser redirect to dest. address

Some Applications and Services which use S3

- Image Hosting Service **SmugMug**
  - Uses S3 since April 2006 to store images
  - April 2008: SmugMug claimed to have saved almost $1 million in storage costs because of using S3
  - Calculation:

    `http://don.blogs.smugmug.com/2006/11/10/amazon-s3-show-me-the-money/`
  - `http://www.smugmug.com`
- Online Backup **Jungle Disk**
  - `http://jungledisk.com`
- Online Backup **ElephantDrive**
  - `http://elephantdrive.com`
- Online Backup **Dropbox** (until 2016)
  - `http://www.dropbox.com`
  - `http://www.wired.com/2016/03/epic-story-dropboxs-exodus-amazon-cloud-empire/`

More and more NAS Devices implement S3 support – HP

- Example: HP MediaSmart Server EX485
- Users can specify which data should be stored in S3 for backup

Image Source: HP

More and more NAS Devices implement S3 support – Qnap

Netzwerkspeicher – technische Daten

Modell	TS-239 Pro II	TS-459 Pro
Hersteller/Anbieter	Qnap	Qnap
Web-Adresse	www.qnap.com	www.qnap.com
Hardware und Lieferumfang		
Firmware	3.2.2 (0128T)	3.2.2 (0128T)
Prozessor/RAM	Intel Atom D410 (1,66 GHz)/ 1 GByte DDR2	Intel Atom D510 (1,66 GHz)/ 1 GByte DDR2
LAN-Interface/Link Aggregation/Auto-failover/ Jumbo Frames	2 × Gigabit-Ethernet/✓/✓/✓	2 × Gigabit-Ethernet/✓/✓/✓
Sharing-Funktionen		
FTP/FTP verschlüsselt/abschaltbar	✓/✓/✓	✓/✓/✓
HTTP/HTTPS/abschaltbar	✓/✓/✓	✓/✓/✓
NFS/abschaltbar	✓/✓	✓/✓
AppleShare/abschaltbar	✓/✓	✓/✓
UPnP/abschaltbar	✓/✓	✓/✓
Medienserver per	UPnP-AV (TwonkyMedia), iTunes	UPnP-AV (TwonkyMedia), iTunes
weitere Protokolle	BitTorrent, Bonjour, IPv6, iSCSI, rsync, SNMP, SSH, telnet, WebDAV	BitTorrent, Bonjour, IPv6, iSCSI, rsync, SNMP, SSH, telnet, WebDAV
Printserver/Protokolle	✓/Windows-Share	✓/Windows-Share
Besonderheiten	Unterstützung für DFS u. Amazon S3, IP-Kameras, MySQL, PHP	Unterstützung für DFS u. Amazon S3, IP-Kameras, MySQL, PHP

- *„. . . Daten sichern die Qnap-NAS nicht nur über gängige Mechanismen wie rsync auf andere Server im Netz weg, sondern schicken sie auf Wunsch jetzt auch zeitgesteuert an den Cloud-Speicherdienst Amazon S3. . . “*

Source: c't. *Schnelle Gigabit-NAS für zu Hause und das Büro*. 5/2010. S.114

S3 - Availability

http://aws.amazon.com/s3-sla/

- Amazon guarantees a monthly uptime percentage of at least 99.9%

	Downtime (HH:MM:SS)		
Availability	per Day	per Month	per Year
99.9%	00:01:26	00:43:49	08:45:56

- If the guaranteed uptime percentage falls below 99.9%, the customer gets a refund

Monthly Uptime Percentage	Service Credit Percentage
Equal to or greater than 99.0% but less than 99.9%	10%
Less than 99.0%	25%

- Will a refund of 10% or 25% help any further, if the service fails and thus the own data is not available (or gone)?
- Solution: keep data and services available in a redundant way
  - Use several public cloud offerings
  - Build up a private cloud (eventually realize a hybrid cloud)

Google Cloud Storage

https://cloud.google.com/storage/

- Storage service for web objects
  - Interface is compatible with S3
  - Functionality is (almost) identical to S3
- Objects are accessible online
  - `http://bucket.commondatastorage.googleapis.com/object`
  - `http://commondatastorage.googleapis.com/bucket/object`
- Access to buckets and objects is done via REST or SOAP
- Users can specify for all their objects and buckets the access privileges
  - Access Control List (ACL)
- Provides the command line tool GSutil and the software service (SaaS) Google Storage Manager
  - GSutil can interact with Google Cloud Storage and S3
    - GSutil is based on the Python library boto

Some further S3-compatible Service Offerings

This list from November 2017 is not complete! Many more S3-compatible Service Offerings may exist

Service Offering	URL/Status
Aruba Object Storage service	`https://www.arubacloud.com`
BetterServers Object Storage	`https://www.betterservers.com`
e24cloud	`https://www.e24cloud.com/en/cloud-features/`
Rackspace Cloud Files	`https://www.rackspace.com/de/cloud/files`
Caringo Cloud Storage	`https://www.caringo.com`
Cloudian	`http://www.cloudian.com`
DreamHost DreamObjects	`https://www.dreamhost.com/cloud/storage/`
Dunkel S3	`https://www.dunkel.de/s3`
S3FOR.ME	`http://www.s3for.me`
Connectria Cloud Storage	It is unclear if this service is still available
HP Helion Public cloud	Defunct since January 2016
Host Europe Cloud Storage	Defunct since end 2014
Nirvanix	Defunct since September 2013

Never forget...

a Cloud Service Providers may modify of service offering (functionality) or even go out of business at any time