

BIG DATA AND CLOUD PLATFORMS

Cluster migration - Based on a true story

Migration

Goals

- Evaluating the costs for a cloud/on-premises data platform
- Real-world case study
- Fill in this table

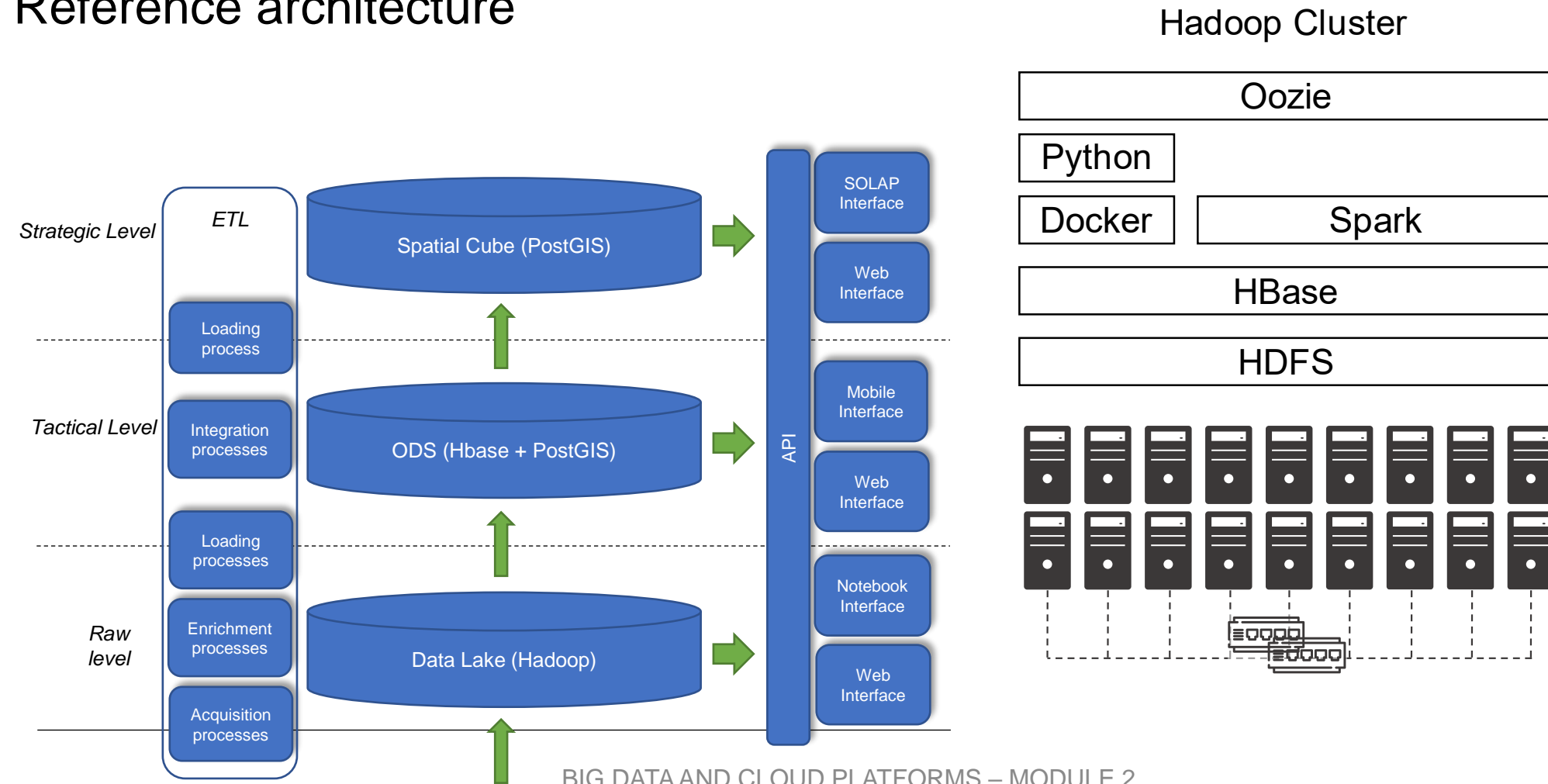
Cost	On-premises	On cloud
Hardware	?	?
Software	?	?

Case study

Business intelligence group

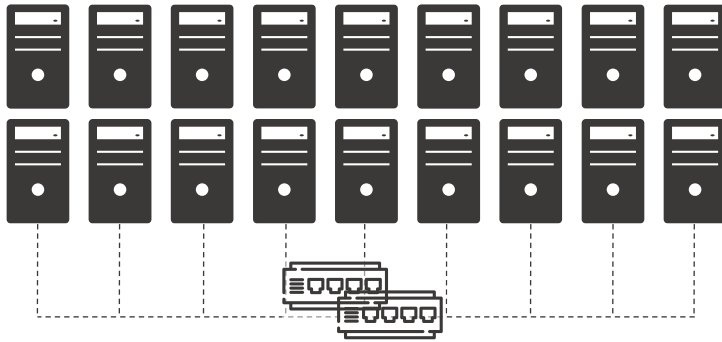
Migration

Reference architecture



Migration

Hardware



8 CPUs (144 total)
- Intel(R) Core(TM) i7-8700 CPU @ 3.20GHz
32GB RAM (576GB total)
- 2 x 16GB DIMM DDR4 2666 MHz
12TB HDD Disk (216TB total)
- 3 x 4TB ST4000DM004-2CV1

```
lshw -short -C cpu  
lshw -short -C memory  
lshw -short -C disk
```

Software

- "Classic" Hadoop stack

Migration

SOL_{onprem}	On-premises	On cloud
Hardware	?	?
Software	?	?

Hardware cost: ?

- Refer to <https://www.rect.coreto-europe.com/en/search.html?clearsearch=1>

On-premises

Hardware cost (up to Mar 05, 2021):

$1767\text{€} \times 18 = 31806\text{€}$

- Amortization over 3 years (i.e., 10602€/year)

SOL _{onprem}	On-premises	On cloud
Hardware	10602€/year	?
Software	?	?

RECT™ WS-2270C
Main configuration **669.00** €
Configuration:
Intel Core i7-10700K + 216.00
32 GB DDR4-3200 RAM + 146.00
Workstation-Mainboard with ... + 101.00
3 x 4 TB WD Blue 291.00
1x 2.5 Gbit LAN onboard
Sound on board
Solid black
High-Efficiency Noctua CPU ... + 39.00
DVD-Writer 24x DVD + 13.00
High-efficiency 750W power ... + 79.00
1 x Your Operating System 30.00
with an individual capacity of... + 35.00
36 months pick-up + 148.00
Complete Configuration 1,098.00
Current price 1,767.00
[Plus VAT](#)
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<https://www.rect.coreto-europe.com/en> (Accessed 2021-08-01)

On-premises

SOL_{onprem}	On-premises	On cloud
Hardware	10602€/year	?
Software	?	?

Software cost: ?

On-premises

SOL _{onprem}	On-premises	On cloud
Hardware	10602€/year	?
Software	0€	?

Software cost (up to 2020): 0€

- Free Cloudera Management System
- No software licensing (for research purpose)

On-premises

SOL _{onprem}	On-premises	On cloud
Hardware	10602€/year	?
Software	180000€/year	?

Software cost (up to Mar 05, 2021): 10000€/year x 18 = 180000€/year

- Cloudera is no more free, 10K€ per node
- <https://www.cloudera.com/products/pricing.html#private-cloud-services>
- <https://www.cloudera.com/products/pricing/product-features.html>
- No license for research purpose

“Houston we’ve had a problem!”

- We cannot update/extend the cluster anymore
- What about migrating to the cloud? (we only consider AWS)

Migration

Moving a Hadoop cluster to the cloud (we only consider AWS)

- AWS price calculator <https://calculator.aws/#/estimate>

How do we start?

- We have already defined the hardware and the software stack
- Start with coarse tuning, identify the dominating costs first
 - Is it computing, storage, or processing?
- Identify a suitable budget, implement, refine later
 - Wrong refinements can do a lot of damage

On cloud v1

SOL_{cloud1}	On-premises	On cloud
Hardware	10602€/year	?
Software	180000€/year	?

Migrating the cluster as-is: ?

- Hint: add 18 EC2 instances satisfying the hardware requirements

On cloud v1

SOL _{cloud1}	On-premises	On cloud
Hardware	10602€/year	162000\$/year
Software	180000€/year	?

SOL_{cloud1} migrating the cluster as-is:
13500\$/month = 162000\$/year

- 18 EC2 instances (t4g.2xlarge) with 12TB EBS storage each machine
- Still, we have no software configuration

Amazon EC2
Region: EU (Ireland)

EditAction ▼

Quick estimate

Operating system (Linux), Quantity (18), Pricing strategy (EC2 Instance Savings Plans 1 Year No Upfront), Storage amount (12 TB), Instance type (t4g.2xlarge)

Monthly: 13,499.30 USD

Amazon EC2
Region: EU (Milan)

EditAction ▼

Quick estimate

Operating system (Linux), Quantity (18), Pricing strategy (EC2 Instance Savings Plans 1 Year No Upfront), Storage amount (12 TB), Instance type (t3.2xlarge)

Monthly: 14,785.47 USD

<https://calculator.aws/#/estimate?id=7757affccc3cafdcfdeb212b74623ef02ed5a36>

Migration

Pay attention to the region

- Different regions, different prices
- Different regions, different services
- Remember the GDPR and data locality

Amazon EC2 Region: EU (Ireland)	Edit	Action ▼
Quick estimate		
Operating system (Linux), Quantity (18), Pricing strategy (EC2 Instance Savings Plans 1 Year No Upfront), Storage amount (12 TB), Instance type (t4g.2xlarge)		Monthly: 13,499.30 USD
Amazon EC2 Region: EU (Milan)	Edit	Action ▼
Quick estimate		
Operating system (Linux), Quantity (18), Pricing strategy (EC2 Instance Savings Plans 1 Year No Upfront), Storage amount (12 TB), Instance type (t3.2xlarge)		Monthly: 14,785.47 USD

Migration

It makes no sense to move the cluster as-is

- More machines ensure better (on-prem) scalability but higher costs

How do we proceed with the migration?

- We need minimum software requirements
- Try to achieve the smallest migration impact
 - Find the most similar cloud-based solution to a Hadoop cluster
 - Rethink applications (later) when you got the know-how
- Identify a suitable budget, implement, refine later
 - Wrong refinements can do a lot of damage

Migration

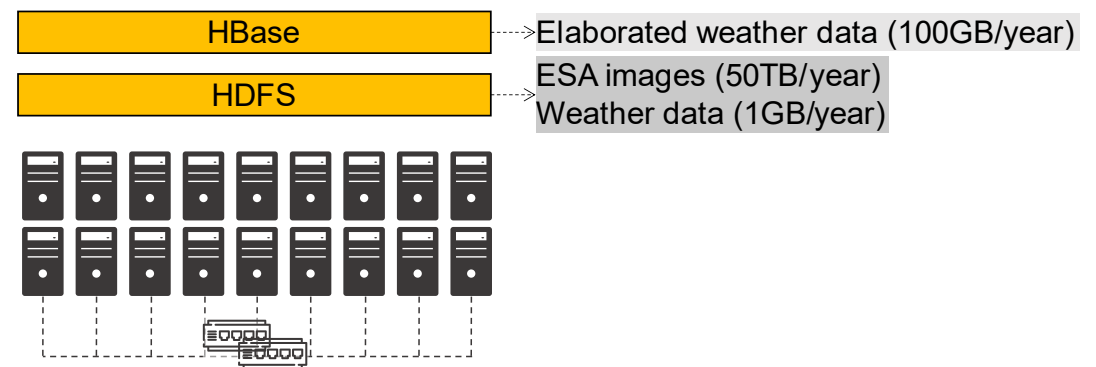
HDFS

- How much durability do we need?
 - HP_0 : three replicas (we stick to this)
 - HP_1 : decrease replicas for cold data
 - HP_2 : move cold data to glacier or delete id
 - ...

HBase has marginal effects on the pricing (100GB \ll 50TB)

- For simplicity, we can omit it

Overall: 50TB storage/year



Migration

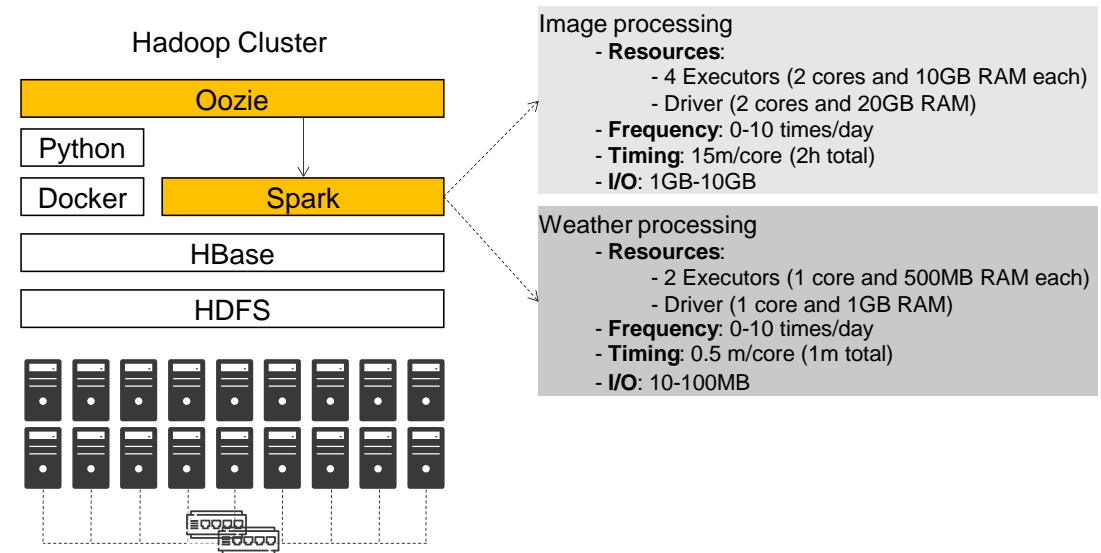
Processing takes place each time that ESA provides a satellite image

- Some days no images are available
- Some days up to 10 images are available
- Spark jobs are always executed with the same parameters

Image processing

- 4 machines, 2 cores, 10GB RAM at least

Weather processing is negligible



On cloud v2

	On-premises	On cloud
Hardware	2356€/year	38000\$/year
Software	100000€/year	?

Assuming 1 Executor = 1 Machine

- Compare 4 machines on-premises vs on cloud

On-premises

- 4 machines: 10602€/year / 18 machines x 4 machines = 2356€/year
- Cloudera requires at least 10 nodes: 100000€/year

AWS

- 4 EC2 instances: 162000\$/year / 18 machines x 4 machines = 36000\$/year
 - Plus the resources for master services = 2000\$/year
- Problems
 - Still no software stack
 - A lot of storage cost
 - Machines are up-and-running even when no computation is necessary (just to persist data)

On cloud v2

AWS

- Still, we have no software stack configuration
- Which is the major cost?

On cloud v2

AWS

- Still, we have no software stack configuration
- Which is the major cost?

Amazon EC2

ModificaOperazione ▼

Regione: US East (Ohio)

Quick estimate

Operating system (Linux), Quantity (1), Pricing strategy (EC2 Instance Savings Plans 1 Year No Upfront), Storage amount (12 TB), Instance type (t4g.2xlarge)

Monthly: 676,04 USD

Amazon EC2 stima

Amazon EC2 Instance Savings Plans instances (monthly)	123,08 USD
Amazon Elastic Block Storage (EBS) pricing (monthly)	552,96 USD
Costo mensile totale:	676,04 USD

Migration

S3 standard

Unit conversions

S3 Standard storage: 50 TB per month x 1024 GB in a TB = 51200 GB per month

Calcolo dei prezzi

Tiered price for: 51200 GB

51200 GB x 0.0230000000 USD = 1177.60 USD

Costo totale del piano = 1177.6000 USD (S3 Standard storage cost)

1.000 PUT requests for S3 Storage x 0,000005 USD per request = 0,005 USD (S3 Standard PUT requests cost)

1.000 GET requests in a month x 0,0000004 USD per request = 0,0004 USD (S3 Standard GET requests cost)

1.177,60 USD + 0,0004 USD + 0,005 USD = 1.177,61 USD (Total S3 Standard Storage, data requests, S3 select cost)

S3 Standard cost (monthly): 1,177.61 USD

S3 Infrequent Access

Unit conversions

S3 One Zone-IA storage: 50 TB per month x 1024 GB in a TB = 51200 GB per month

Calcolo dei prezzi

51.200 GB x 0,01 USD = 512,00 USD (S3 One Zone-IA storage cost)

1.000 PUT requests for S3 One Zone-IA Storage x 0,00001 USD per request = 0,01 USD (S3 One Zone-IA PUT requests cost)

1.000 GET requests for S3 One Zone-IA Storage x 0,000001 USD per request = 0,001 USD (S3 One Zone-IA GET requests cost)

1.000 lifecycle request count for S3 One Zone-IA x 0,00001 USD per request = 0,01 USD (S3 One Zone-IA lifecycle requests cost)

10 GB x 0,01 USD = 0,10 USD (S3 One Zone-IA data retrievals cost)

512,00 USD + 0,01 USD + 0,001 USD + 0,01 USD + 0,10 USD = 512,121 USD (Total S3 One Zone-IA Storage and other costs)

S3 One Zone - Infrequent Access (S3 One Zone-IA) cost (monthly): 512.12 USD

Migration

AWS Storage

HDFS on EC2

- Heavy price
- Machine must be always on to guarantee data persistency
- Data locality

S3

- Much cheaper
- Does not require machines for data storage
- Data locality is lost

Amazon EC2

ModificaOperazione ▼

Regione: US East (Ohio)

Quick estimate

Operating system (Linux), Quantity (1), Pricing strategy (EC2 Instance Savings Plans 1 Year No Upfront), Storage amount (12 TB), Instance type (t4g.2xlarge)

Monthly: 676,04 USD

Amazon EC2 stima

Amazon EC2 Instance Savings Plans instances (monthly)	123,08 USD
Amazon Elastic Block Storage (EBS) pricing (monthly)	552,96 USD
Costo mensile totale:	676,04 USD

Migration

	On-premises	On cloud
Hardware	2356€/year	
Software	100000€/year	?

Migrating cluster to EMR: ?

Given the software requirements, we need

- 1 x Master Node (to manage the cluster)
- 1 x Core node (with HDFS/EBS)
- 4 x Task Nodes (to compute)

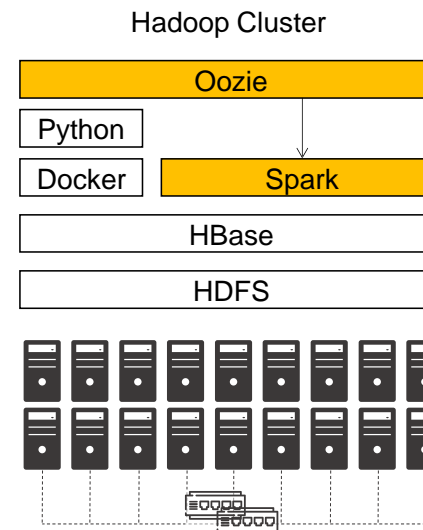


Image processing

- **Resources:**

- 4 Executors (2 cores and 10GB RAM each)
- Driver (2 cores and 20GB RAM)

- **Frequency:** 0-10 times/day

- **Timing:** 15m/core (2h total)

- **I/O:** 1GB-10GB

Weather processing

- **Resources:**

- 2 Executors (1 core and 500MB RAM each)
- Driver (1 core and 1GB RAM)

- **Frequency:** 0-10 times/day

- **Timing:** 0.5 m/core (1m total)

- **I/O:** 10-100MB

On cloud v3

	On-premises	On cloud
Hardware	2356€/year	14710€/year
Software	100000€/year	

Migrating cluster to EMR: 14710€/year

- S3 Infrequent Access storage (50 TB per month): 640€
- 1 x Master EMR nodes, EC2 (m4.xlarge), Utilization (75 h/month): 4.5€
 - 75 h/month = 15min/task x 10task/day x 30day/month / 60min/hour
- 1 x Core EMR nodes, EC2 (m4.xlarge), Utilization (75 h/month): 4.5€
- 4 x Task EMR nodes, EC2 (m4.4xlarge), Utilization (75 h/month): 72€
- 4 x EC2 on demand (task node): 174.83€
 - Storage amount (30 GB)
 - Workload (Daily, Duration of peak: 0 Hr 15 Min)
 - Instance type (m4.xlarge)
- 2 x EC2 on demand (master and core nodes): 330€
 - Storage amount (30 GB)
 - Instance type (m4.xlarge)

On cloud v3

	On-premises	On cloud
Hardware	2356€/year	13445€/year
Software	100000€/year	

Migrating cluster to EMR: 13445€/year

- S3 Infrequent Access storage (50 TB per month): 640€
- 1 x Master EMR nodes, EC2 (m4.xlarge), Utilization (75 h/month): 4.5€
 - 75 h/month = 15min/task x 10task/day x 30day/month / 60min/hour
- 1 x Core EMR nodes, EC2 (m4.xlarge), Utilization (75 h/month): 4.5€
- 4 x Task EMR nodes, EC2 (m4.4xlarge), Utilization (75 h/month): 72€
- 4 x EC2 **spot (task node): 69.55€**
 - Storage amount (30 GB)
 - Workload (Daily, Duration of peak: 0 Hr 15 Min)
 - Instance type (m4.xlarge)
- 2 x EC2 on demand (master and core nodes): 330€
 - Storage amount (30 GB)
 - Instance type (m4.xlarge)

<https://calculator.aws/#/estimate?id=c3780b12bb43b593d05def5a1d5218d9764b8a65>

Migration

Summing up (cloud options)

Machine uptime	Storage	Software	Feasible?	Cost per year
Constant	EC2	Manual	YES: but high storage cost	~36K€
Constant	EC2	EMR	YES: but high storage cost	~37K€
Constant	S3	Manual	YES: but still manual provisioning	~17K€
Constant	S3	EMR	YES	~18K€
Pay-per-use	EC2	Manual	NO: pay-per-use + EC2 = Data unpersisted	-
Pay-per-use	EC2	EMR	NO: pay-per-use + EC2 = Data unpersisted	-
Pay-per-use	S3	Manual	ISH: repetitive manual provisioning	-
Pay-per-use	S3	EMR	YES	~14K€

Migration

Summing up

- We estimated the cluster costs
 - On-premises solution with 18 machines: no go
 - Cloud solution with 18 EC2 instances: no go
- We reduced the solution based on software requirements
 - On-premises solution with 4 machines: no go
 - Cloud solution with 4 EC2 instances: no go, we miss the software configuration
- We moved the cluster to AWS EMR + spot instances + S3 storage

Can we do better?

- Pick ad-hoc cloud services (AWS Lambda e AWS Batch)
- ... to re-think the applications (food for thoughts)

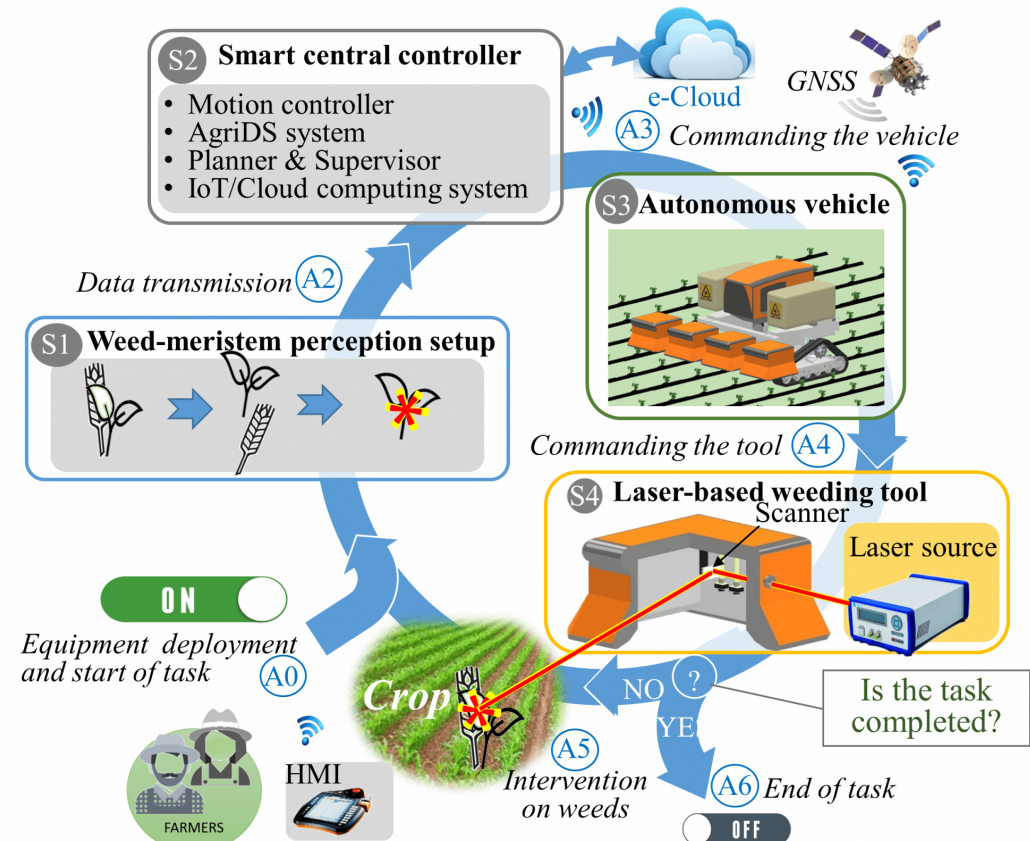
Case study

WeLASER

The WeLASER project

Project description

The increased use of pesticides and fertilisers damages the environment, destroys non-target plants and beneficial insects for the soil and harms human and animal health. Most seeds develop herbicide-resistant properties, rendering pesticides ineffective. Mechanical automatic systems that are studied as alternatives to pesticides deteriorate soil features, damage beneficial soil organisms and offer limited results for in-row weeding. The EU-funded WeLASER project will develop a non-chemical solution for weed management based on pioneering technology consisting of the application of lethal doses of energy on the weed meristems through a high-power laser source. An AI-vision system separates crops from weeds, identifying the weed meristems and pointing the laser at them. A smart controller based on IoT and cloud computing techniques coordinates the system, which is transferred all over the field by an autonomous vehicle.



<https://cordis.europa.eu/project/id/101000256> (accessed 2020-08-01)

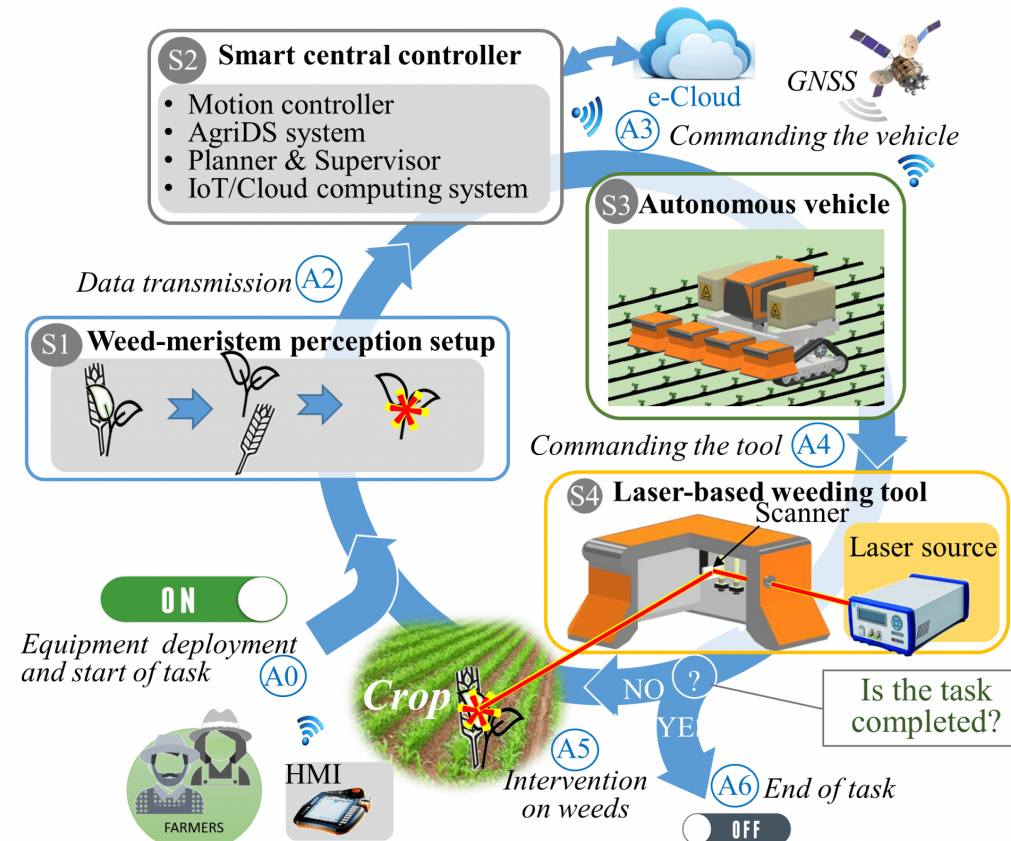
The WeLASER project

Which requirements do you foresee?

Can we define a tentative (service) architecture for the WeLASER project?

Assumptions

- Do not consider the collection of weed/crop images & training/deploying of the CV algorithm



<https://cordis.europa.eu/project/id/101000256> (accessed 2020-08-01)

Data sources

- 8 cameras on the field, average image size 3MB; two services:
 - Alerting**: a camera sends an image when smt enters the field (at most 1 img/5 min); assuming 20 alerts/day
 - $20 \frac{\text{alert}}{\text{day}} \cdot 1 \frac{\text{image}}{\text{alert}} \cdot 8 \frac{\text{camera}}{\text{field}} = 160 \frac{\text{image}}{\text{day} \cdot \text{field}}$
 - $160 \frac{\text{image}}{\text{day} \cdot \text{field}} \cdot 3 \frac{\text{MB}}{\text{image}} = 480 \frac{\text{MB}}{\text{day} \cdot \text{field}} \sim 500 \frac{\text{MB}}{\text{day} \cdot \text{field}}$
 - Monitoring** the crop/weed; assuming 2 images/day
 - $2 \frac{\text{image}}{\text{day}} \cdot 8 \frac{\text{camera}}{\text{field}} = 16 \frac{\text{image}}{\text{day} \cdot \text{field}}$
 - $16 \frac{\text{image}}{\text{day} \cdot \text{field}} \cdot 3 \frac{\text{MB}}{\text{image}} = 48 \frac{\text{MB}}{\text{day} \cdot \text{field}} \sim 50 \frac{\text{MB}}{\text{day} \cdot \text{field}}$
- Weather station**: 24 measurement/day for humidity/solar radiation/temperature/wind; 1KB/measurement
 - $24 \frac{\text{sample}}{\text{day}} \cdot 4 \frac{\text{measurement}}{\text{sample}} \cdot 1 \frac{\text{weather station}}{\text{field}} = 96 \frac{\text{measurement}}{\text{day} \cdot \text{field}}$
 - $96 \frac{\text{measurement}}{\text{day} \cdot \text{field}} \cdot 1 \frac{\text{KB}}{\text{measurement}} = 96 \frac{\text{KB}}{\text{day} \cdot \text{field}} \sim 0.1 \frac{\text{MB}}{\text{day} \cdot \text{field}}$
- Robot mission**: lasts 4 hours, 100 measurement/s from sensor systems; 1KB/measurement
 - $3600 \frac{\text{second}}{\text{hour}} \cdot 4 \frac{\text{hour}}{\text{mission}} \cdot 100 \frac{\text{measurement}}{\text{second}} \cdot 1 \frac{\text{mission}}{\text{day} \cdot \text{field}} = 1\,440\,000 \frac{\text{measurement}}{\text{day} \cdot \text{field}}$
 - $1\,440\,000 \frac{\text{measurement}}{\text{day} \cdot \text{field}} \cdot 1 \frac{\text{KB}}{\text{measurement}} = 1.44 \frac{\text{GB}}{\text{day} \cdot \text{field}} \sim 2 \frac{\text{GB}}{\text{day} \cdot \text{field}}$
- Historic data**; worst case of 1KB/document: 10^3 Json documents describing the farm $\sim 1 \frac{\text{MB}}{\text{farm}}$

<https://docs.google.com/spreadsheets/d/17zEr62Czygely0vU-DcjEUoxf6bMd3ziLSSelXvk4Lg/edit?usp=sharing>

Workload

Nothing special

- Every night compute aggregated indexes on the collected data (2h/day)

On-premises (HDFS cluster)

- How many machines do we need?
- With which resources?



On-premises

	On-premises	On cloud
Hardware	2900€/year	
Software	40000€/year	?

On-premises

- How many machines do we need?
 - 4: 1 master node + 3 HDFS data nodes
- With which resources?
 - Assuming a HDFS replication factor of 3, we need at least 1TB of disk overall (not that much)
 - Think bigger: at least 8 cores, 64GB RAM, 500GB SSD + 4TB HDD, no GPU
- $8700\text{€} / 3 \text{ years} = 2900\text{€}$

RECT™ WS-2273C

€


Main configuration 871.00

Configuration:


- Intel Core i7-12700K + 361.00
- Workstation-Mainboard with ... + 137.00
- 64 GB DDR5-4800 RAM + 340.00
- 1 x 500 GB M.2 SSD Samsu... 103.00
- 1 x 4 TB WD Blue 104.00
- 1x 2.5 Gbit LAN onboard
- Sound on board
- Solid black
- High-Efficiency Noctua CPU ... + 48.00
- single power supply 750W + 63.00
- 36 months pick-up + 148.00

Complete Configuration 1,304.00

Current price 2,175.00

Plus VAT 

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Private Cloud pricing			Annual subscription ⁵
Services ¹	Data Engineering Data Service		
	Data Warehouse Data Service		\$650/CCU ⁶
	Machine Learning Data Service		
	Ozone Object Store with SDX ²		
	Select Third-Party Storage with SDX ²		\$10,000/Node + Variable Compute & Storage ⁷
	HDFS with SDX ^{2,3}		
	Traditional Data Clusters Spark, Kafka, HBase, Hive, Impala ⁴		

¹Runs on embedded ECS or dedicated OpenShift and relies on Base for storage

²Storage subscription required for total capacity under management

³HDFS storage limited to 100TB per server

⁴Base edition data cluster open source [projects & components](#)

⁵CDP Private Cloud Pricing reflects Business Level Support

⁶Cloudera Compute Unit (CCU) - 1 Core and 8 GB RAM

⁷Variable compute price: \$75 per CCU over 16 Cores / 128GB RAM Node cap; Variable storage price: HDFS: \$25 per TB over 48TB Node cap or Ozone/Third Party Storage \$100 per TB over 48TB Node cap.

<https://www.rect.coreto-europe.com/en> (accessed 2022-09-01)

<https://www.cloudera.com/products/pricing.html> (accessed 2022-09-01)

On cloud v1

	On-premises	On cloud
Hardware	2900€/year	~40000\$/year
Software	40000€/year	

Moving the Hadoop cluster as IAAS

EC2

- Quantity (4), Pricing strategy (EC2 Instance Savings Plans 3 Year No Upfront), **Storage amount (4 TB)**, Instance type (r6g.2xlarge)

EMR

- Number of master EMR nodes (1), EC2 instance (r5.2xlarge), Utilization (100 %Utilized/Month) Number of core EMR nodes (3), EC2 instance (r5d.2xlarge), **Utilization (100 %Utilized/Month)**

MKS (KAFKA)

- Storage per Broker (10 GB), Number of Kafka broker nodes (3), Compute Family (m5.2xlarge)

My Estimate [Edit](#) [Export](#) [Share](#)

Estimate summary [Info](#)

Upfront cost 0.00 USD	Monthly cost 3,297.46 USD	Total 12 months cost 39,569.52 USD Includes upfront cost
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Getting Started with AWS

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[Sign in to the Console](#)

My Estimate [Duplicate](#) [Delete](#) [Move to](#) [Create group](#) [Add support](#) [Add service](#)

<input type="checkbox"/>	Service Name		Upfront cost	Monthly cost
<input type="checkbox"/>	Amazon EC2	Info	0.00 USD	1,455.55 USD
<input type="checkbox"/>	Amazon EMR	Info	0.00 USD	407.34 USD
<input type="checkbox"/>	Amazon Managed Streaming for Apache Kafka (MSK)	Info	0.00 USD	1,434.57 USD

<https://calculator.aws/#/estimate?id=05965ca7de23fd9e7d2ab2cd0175fe8c01822c9c> (accessed 2022-09-01)

On cloud v2

	On-premises	On cloud
Hardware	2900€/year	~4000\$/year
Software	40000€/year	

Moving the Hadoop cluster as PAAS

EC2

- Quantity (4), Pricing strategy (**On-Demand Instances**), Storage amount (30 GB), Instance type (r6g.2xlarge)

EMR

- Number of master EMR nodes (1), EC2 instance (r5.2xlarge), Utilization (2 Hours/Day)
Number of core EMR nodes (3), EC2 instance (r5d.2xlarge), **Utilization (2 Hours/Day)**

S3

- Standard storage (60 GB per month)

Kinesis

- Days for data retention (1 days), Records (100 per second), Consumer Applications (3)

<https://calculator.aws/#/estimate?id=53f60ff0412a18877dc8e1274f7d9875aa3bf665> (accessed 2022-09-01)

My Estimate		Export	Share
Estimate summary Info			
Upfront cost	Monthly cost	Total 12 months cost	
0.00 USD	306.14 USD	3,673.62 USD	
Includes upfront cost			
		Getting Started with AWS	
		Contact Us	
		Sign in to the Console	
My Estimate		Duplicate	Delete
		Move to	Create group
		Add support	Add service
<input type="text" value="Find resources"/>			
<input type="checkbox"/>	Service Name	Upfront cost	Monthly cost
<input type="checkbox"/>	Amazon EC2	0.00 USD	129.42 USD
<input type="checkbox"/>	Amazon EMR	0.00 USD	33.95 USD
<input type="checkbox"/>	Amazon Kinesis Data Streams	0.00 USD	140.80 USD
<input type="checkbox"/>	Amazon Simple Storage Service (S3)	0.00 USD	1.97 USD

Cost vs price

How would you evaluate the cost and the price?



Cost vs price

Price is the amount a customer is willing to pay for a product or service

Cost is the expense incurred for creating a product or service

- Hardware
- Development
- Maintenance

Profit is the difference between price paid and costs incurred is profit

- If a customer pays \$10 for a product that costs \$6 to make and sell, the company earns \$4