Fine-Grained Elasticity Support for Cloud Applications: The CELAR Approach

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Hong Kong University of Science and Technology, May 8, 2015

Cloud Computing

- Ubiquitous, convenient, on-demand network access
- Shared pool of configurable resources
- Rapid provisioning and release
- Minimal management effort
- Minimal interaction with the service provider

The NIST Definition of Cloud Computing, NIST, 2011

Cloud Models

Service Models

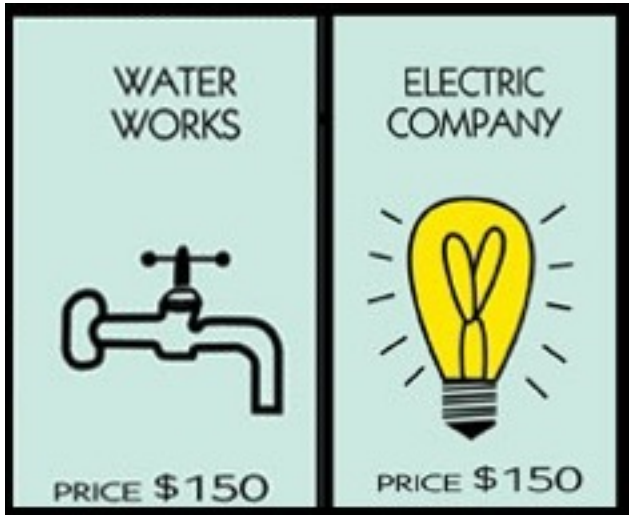
- Software as a Service (SaaS)
- Platform as a Service (PaaS)
- Infrastructure as a Service (IaaS)

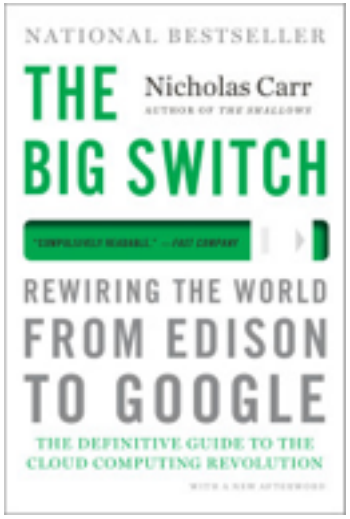
Deployment Models

- Private
- Community
- Public (IaaS)
- Hybrid

The NIST Definition of Cloud Computing, NIST, 2011

A Public Utility



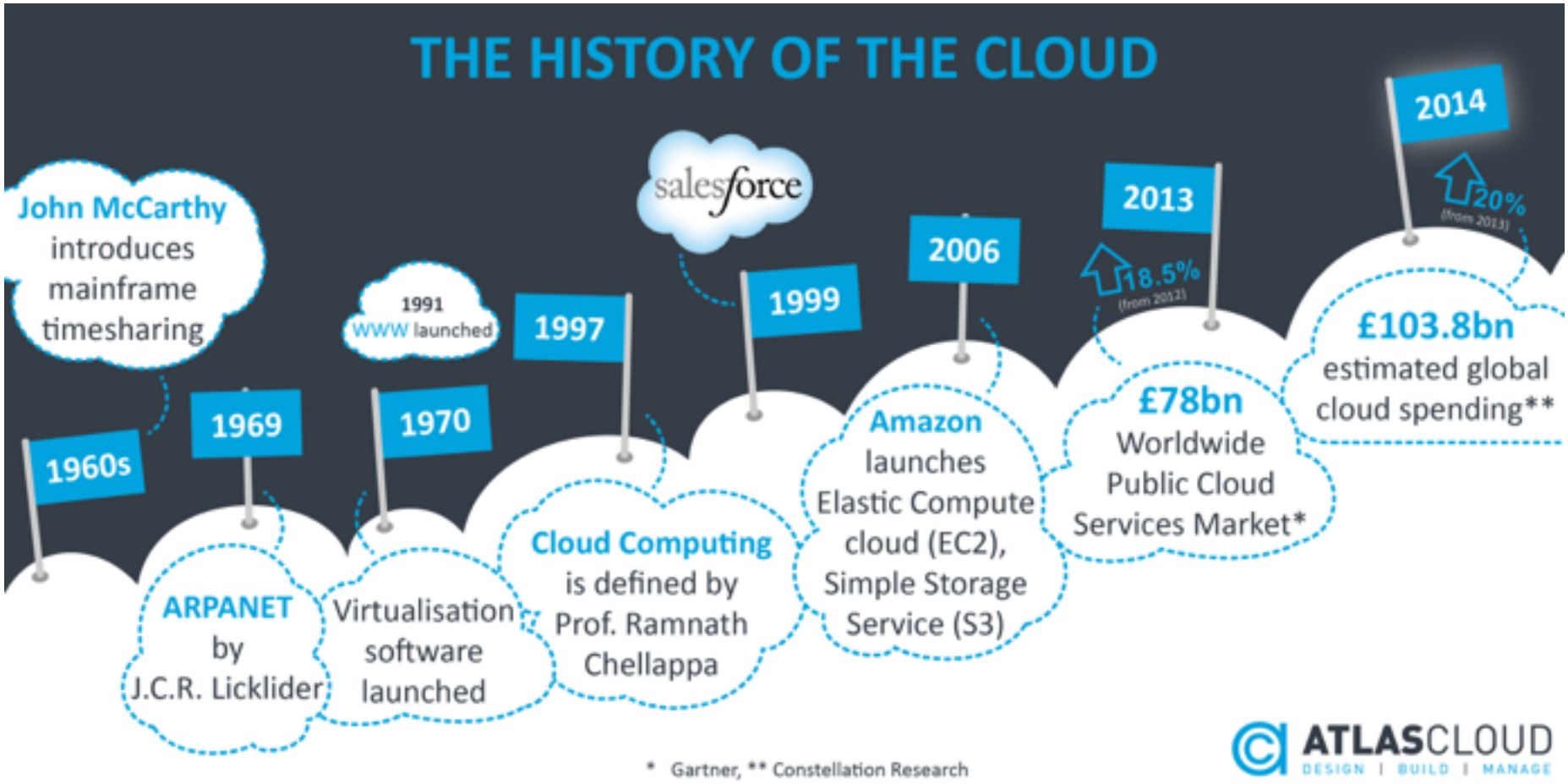


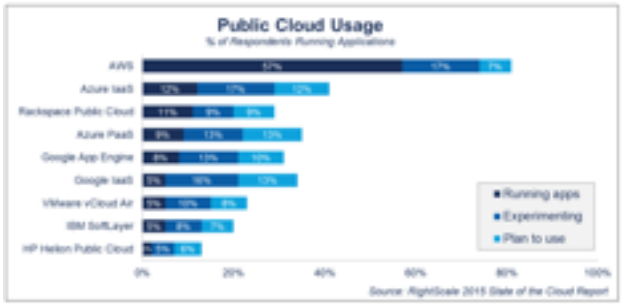
(Cloud) Computing is dubbed as the 5th utility

R. Buyya et al., 2009

…Computing may someday be organised as a public utility, just as the telephone system is organised as a public utility…

John McCarthy, 1961

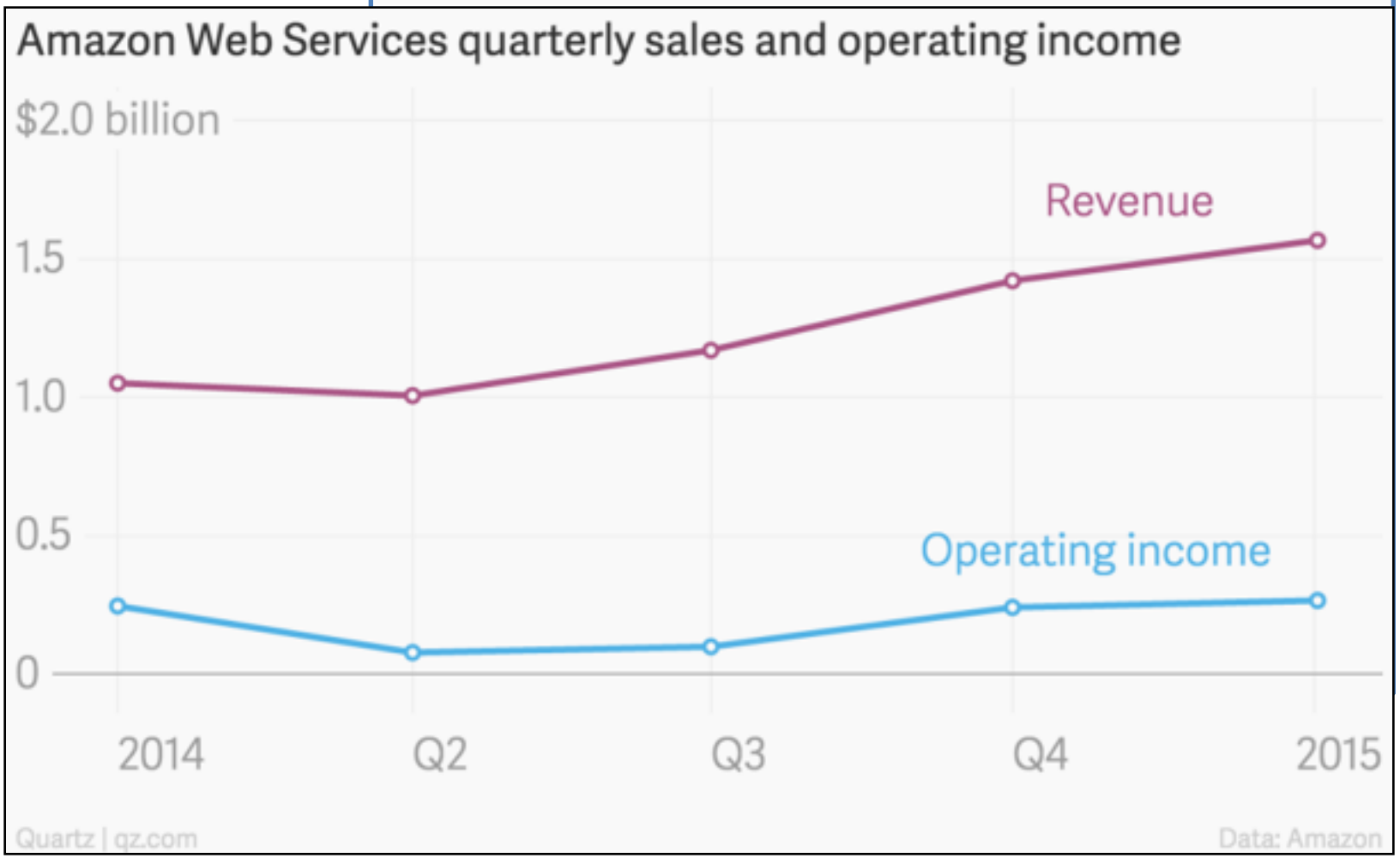

THE HISTORY OF THE CLOUD
1960s
John McCarthy introduces mainframe timesharing
1969
ARPANET by J.C.R. Licklider
1970
Virtualisation software launched
1991
WWW launched
1997
Cloud Computing is defined by Prof. Ramnath Chellappa
salesforce
1999
2006
Amazon launches Elastic Compute cloud (EC2), Simple Storage Service (S3)
2013
18.5% (from 2012)
£78bn Worldwide Public Cloud Services Market*
2014
20% (from 2013)
£103.8bn estimated global cloud spending**
* Gartner, ** Constellation Research
ATLASCLOUD
DESIGN | BUILD | MANAGE



QUARTZ

AWS-SOME

Amazon Web Services is a $5 billion business, and it's growing 50% a year



5 Essential Cloud Characteristics

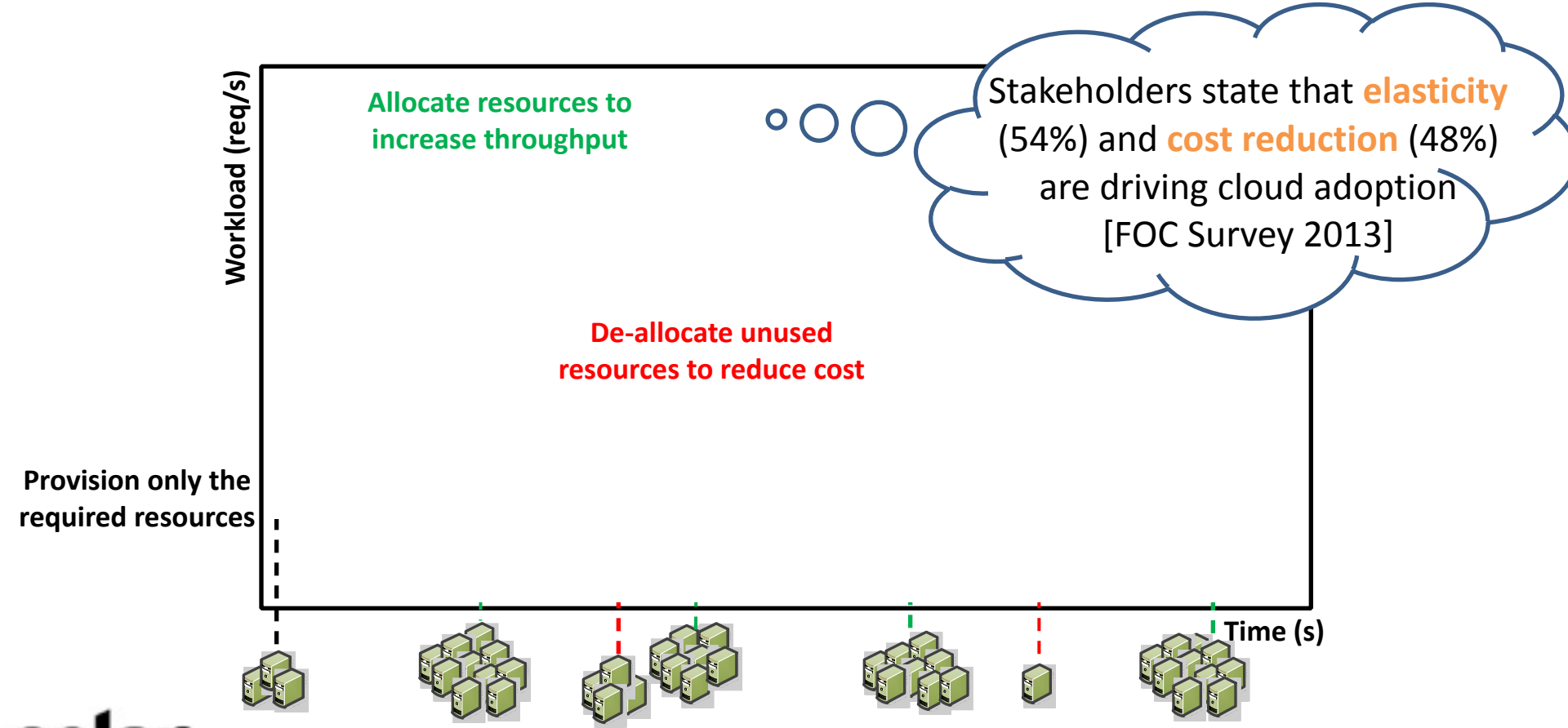
The NIST Definition of Cloud Computing, NIST, 2011

OUTLINE

- Cloud Computing
- Main topics:
  - **Elasticity**
  - Application Management
- CELAR Architecture
- Elasticity and Monitoring - JCatascopia
- c-Eclipse and CAMF
- Conclusions

Elasticity

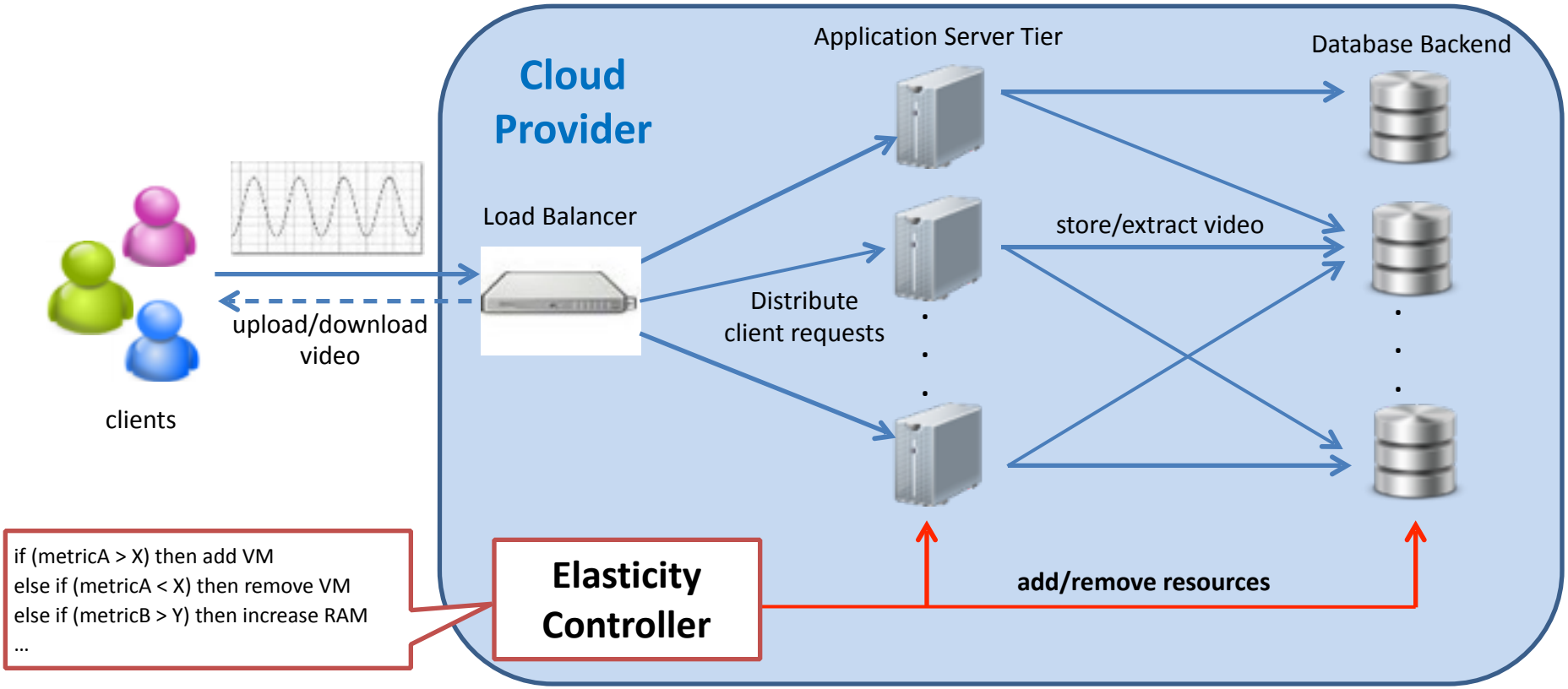
- Ability of a system to **expand** or **contract** its dedicated resources to meet the current demand



Three types of Elasticity

- Horizontal: On-demand provisioning
  - E.g.: Get more VMs
- Vertical: Resource re-configuration
  - E.g.: Main memory ballooning
- Live Migration:
  - E.g.: Move to another provider

Elasticity controller



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Emerging cloud applications

- Increasing complexity
- Dynamic behaviour
- A variety of deployment platforms with different:
  - configuration mechanisms
  - offered services
  - availability and pricing
  - elasticity capabilities

Use Case I: Cancer Genome Detection

CPU and disk I/O intensive

Ilumia HiSeq 2500

Gene Alignment → Gene Variation Detection

NGS Data Analysis

Memory intensive

Microscopy

Cell Profiler → Genotype to Phenotype

Cell Image Data Analysis

Disk I/O and memory intensive

Ilumia HiSeq 2500

Proteome Search → Max Quant

Protein Data Analysis

Cytoscape

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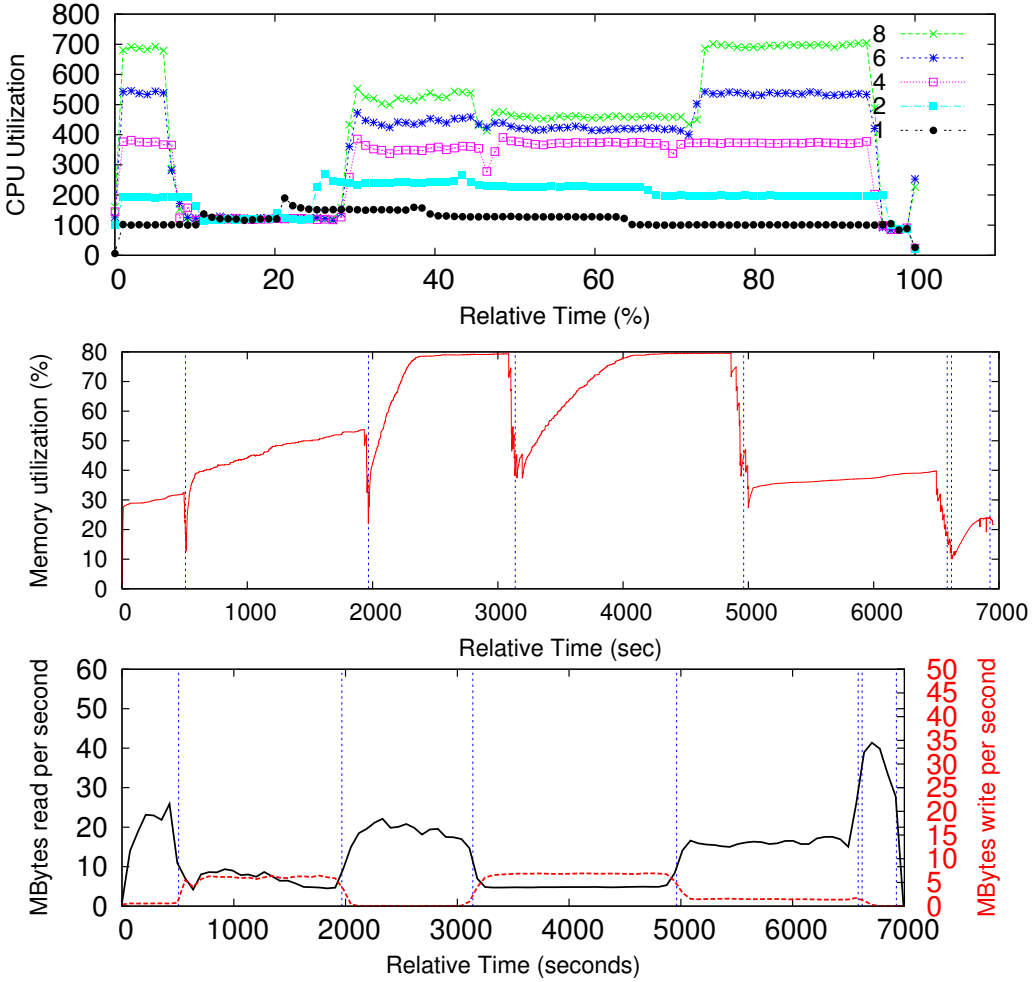
celar

Elasticity profile



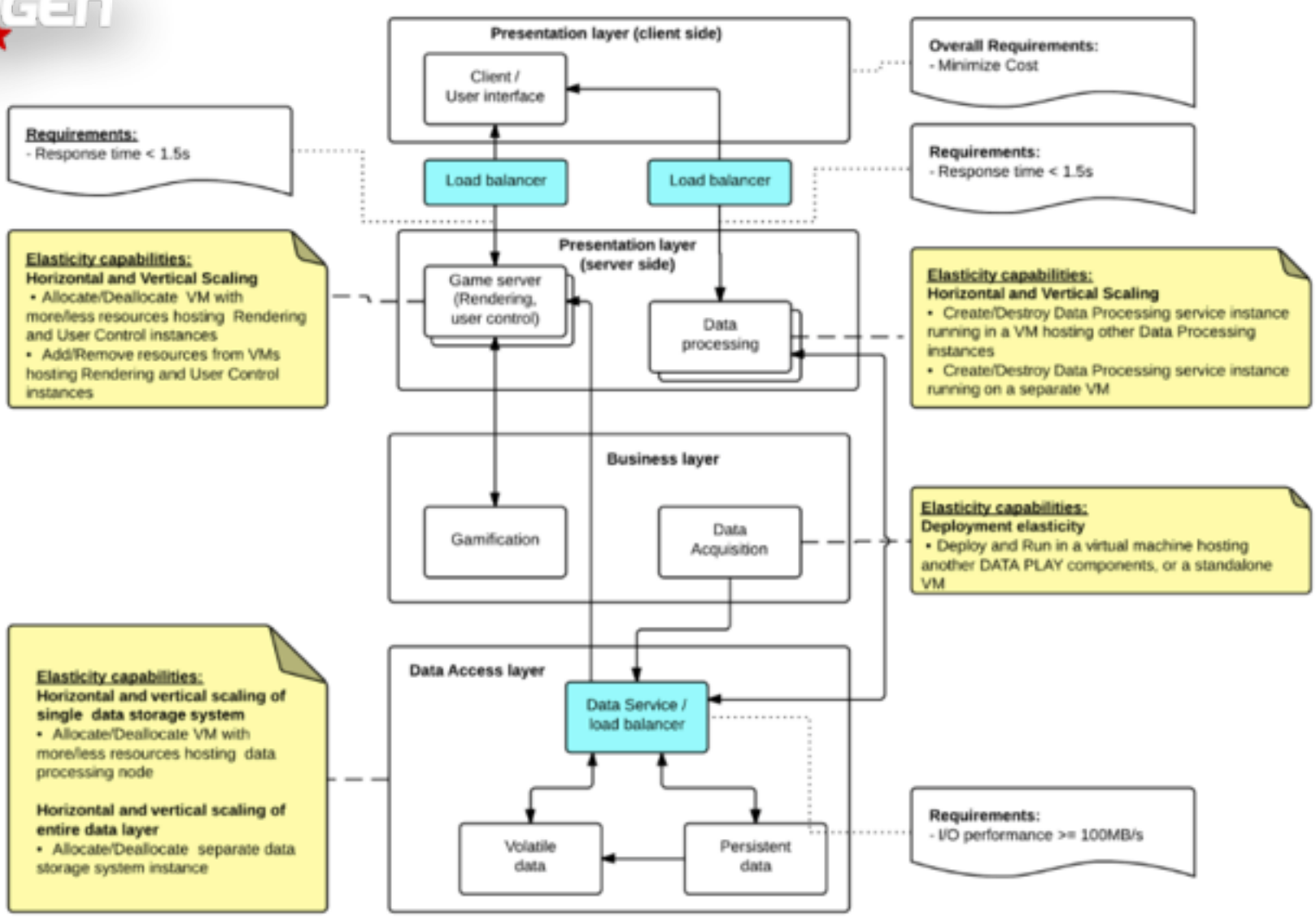
CPU

Memory

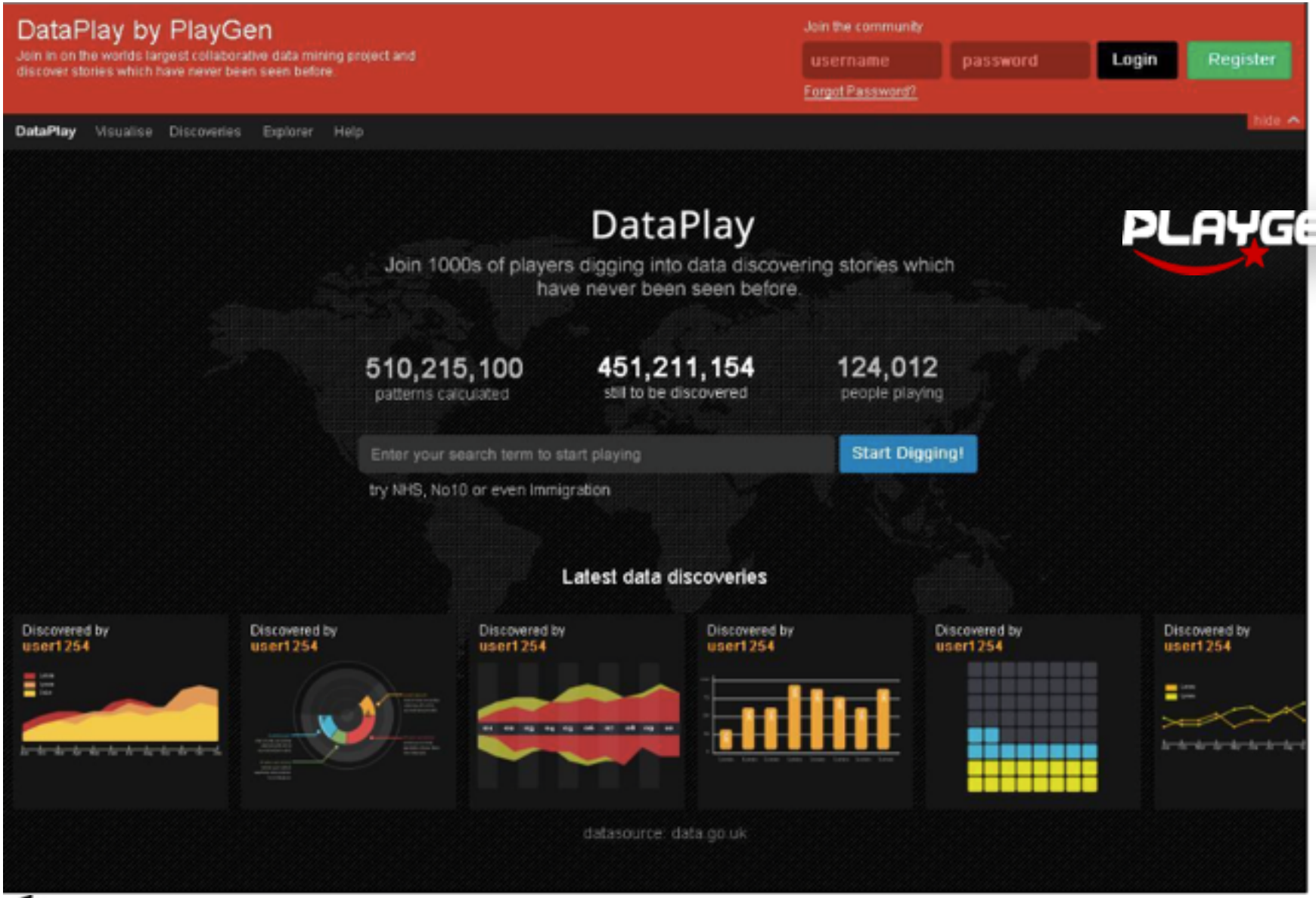
I/O

"Analysing Cancer Genomics in the Elastic Cloud" Smowton, Balla, Antoniades, Miller, Pallis, Dikaiakos, Xing CCGridLife2015, May 4, Shenzhen, CN

Use case II: DataPlay



Use Case II: DataPlay (serious games)




DataPlay
Search
Discoveries
Explore
Help
10 discoveries until next status
102 made so far
Adventurer User2423
Logout
<< Go back
Be the first to discover a new data story with
NHS Spending 2012 suggested correlations with 201,011 datasets
Visualise
First discovered by user12313
Happened on April 5th 2013 at 12:05pm
(3) Validations
Does the visualisation make sense? If so click the "Validate this" button, if not maybe you would like to explain why by clicking the "Make observation" button.
Make observation
Validate this
Tweet
A&E Spend London in correlation to Crime Rate London
Key
A&E Spend
Crime Rate
User Observations
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Nov
Oct
Dec
Primary datasource: NHS Spending 2012 - London
Secondary datasource: Met Police Crime Rate 2012
Pattern id#:145044111
Want to explore this correlation further, maybe find a deeper pattern in the data? click the "Explore" button now
Explore
OBSERVATIONS
Started a Week ago
(3) Validations
(23) Comments
by User2423
102 made so far
Validated by User2423
by User2423
by User2423
by User2423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182 made so far
Adventurer
User2423
Logout
NHS Spending
Search term
+ add term
Explorer
Map
OVERVIEW
NHS Spending 2012
User123 made a discovery
Source NHS Spending 2012
Happened on April 5th 2013 at 13:05pm
Health minister Jeremy Hunt announced new NHS budget for 2012
Source BBC News
Happened on April 5th 2013 at 13:05pm
Keywords nhs, jeremy hunt, budget cuts and a&e
The health minister announced the new #NHS budget in @parliment today for #2012
Source twitter
Happened on April 5th 2013 at 13:05pm
Keywords nhs, jeremy hunt, budget cuts and a&e
Alcohol and A&E
Source BBC news
Happened on April 5th 2013 at 13:05pm
Keywords
nhs, alchol emergency, drunks
User123 made a discovery
Source NHS Spending 2012
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London
Soho Square
Southwark
Lambeth
Victoria Tower Gardens
Bermondsey Spa Gardens
A&E Spending 2012
Colours
Dataset
Suggested
Discovery
News
Conversion
Media

Cloud application management challenges

- Time-consuming - requires manual effort
- Steep learning curve
- Relies on vendor-specific tools
- Offers limited portability
- Migration entails significant cost

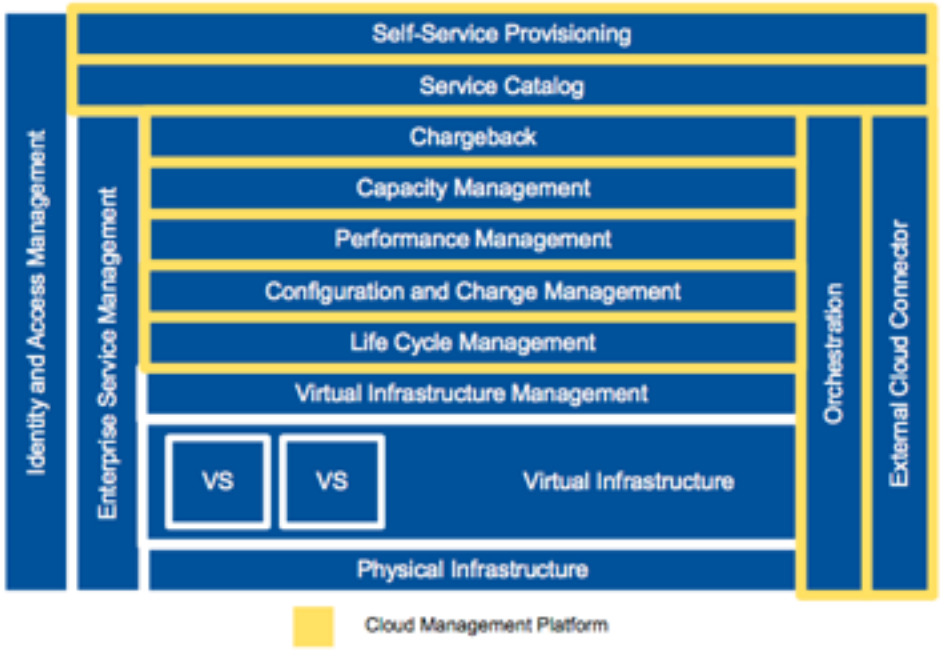
"Enabling Interoperable Cloud Application Management through an Open Source Ecosystem"
Loulloudes, Sofokleous, Trihinas, Dikaiakos, and Pallis. IEEE Internet Computing, May/June 2015.

Cloud management platforms

- Integrated software stacks for the management of Cloud environments [Gartner]
- Goal: ease the description & deployment of applications over Cloud infrastructures
- A critical component to the overall success of a cloud initiative [Gartner, CMP Landscape, 2012]
- Expected to provide application portability: "define once, deploy anywhere"

Cloud management platforms

- Requirements
  - Self-service interface
  - Provision system images
  - Metering and billing
  - Include service catalogs
  - Support configuration of resources
  - Policy-based workload optimisation
  - Application Monitoring
  - etc



Source: Gartner (October 2012)

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Fully Automated

Open-Source

Intelligent Decision Making Algorithms

Vendor Neutrality

Multi-Dimensional Control

Application Management

Multi-layer Scalable Monitoring

Multi-Grain Elasticity Control

www.celarcloud.eu

University of Cyprus

TU WIEN

flexiant
your cloud simplified

celar

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PLAYGEN

sixsq

grnet

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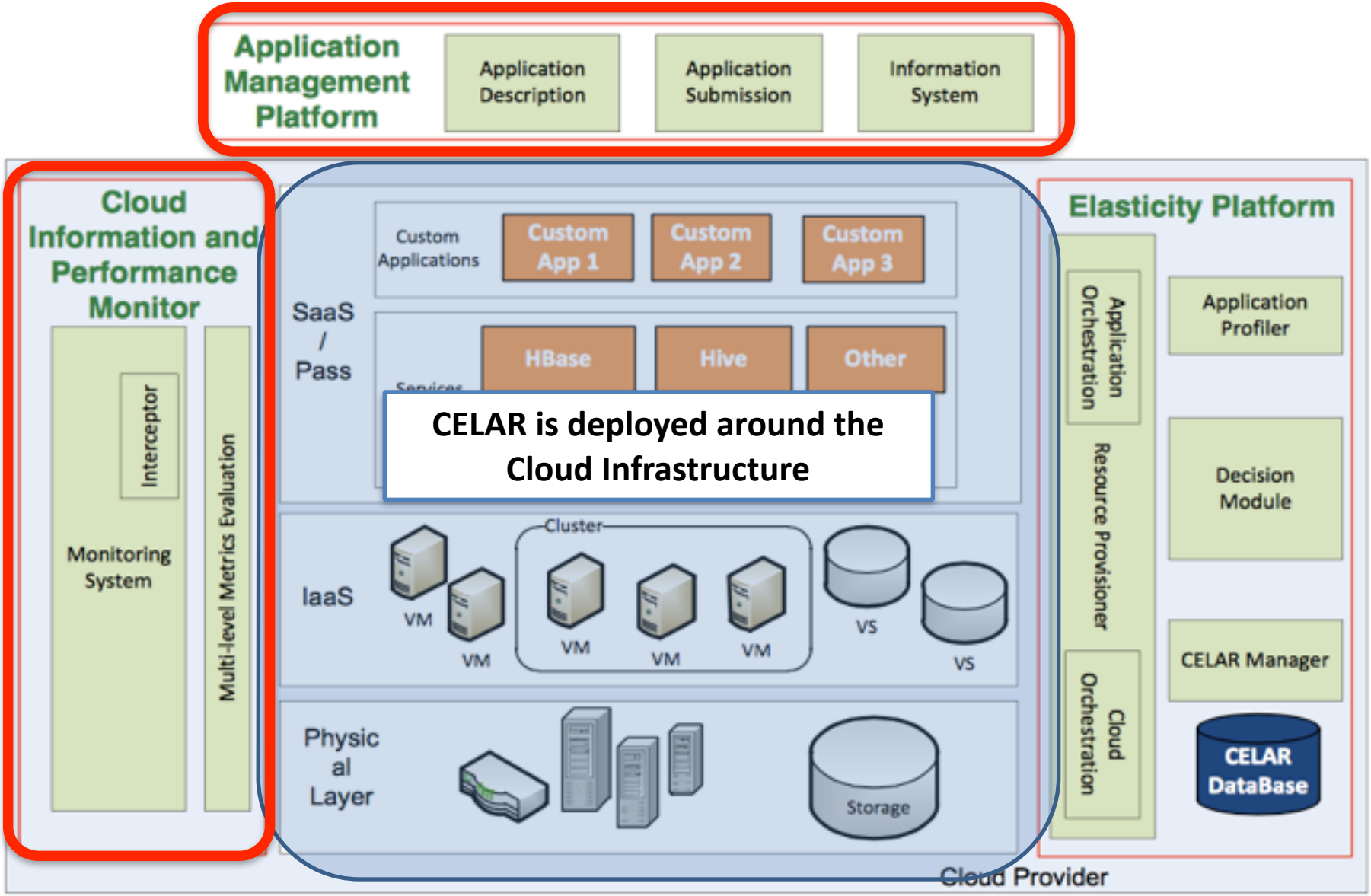
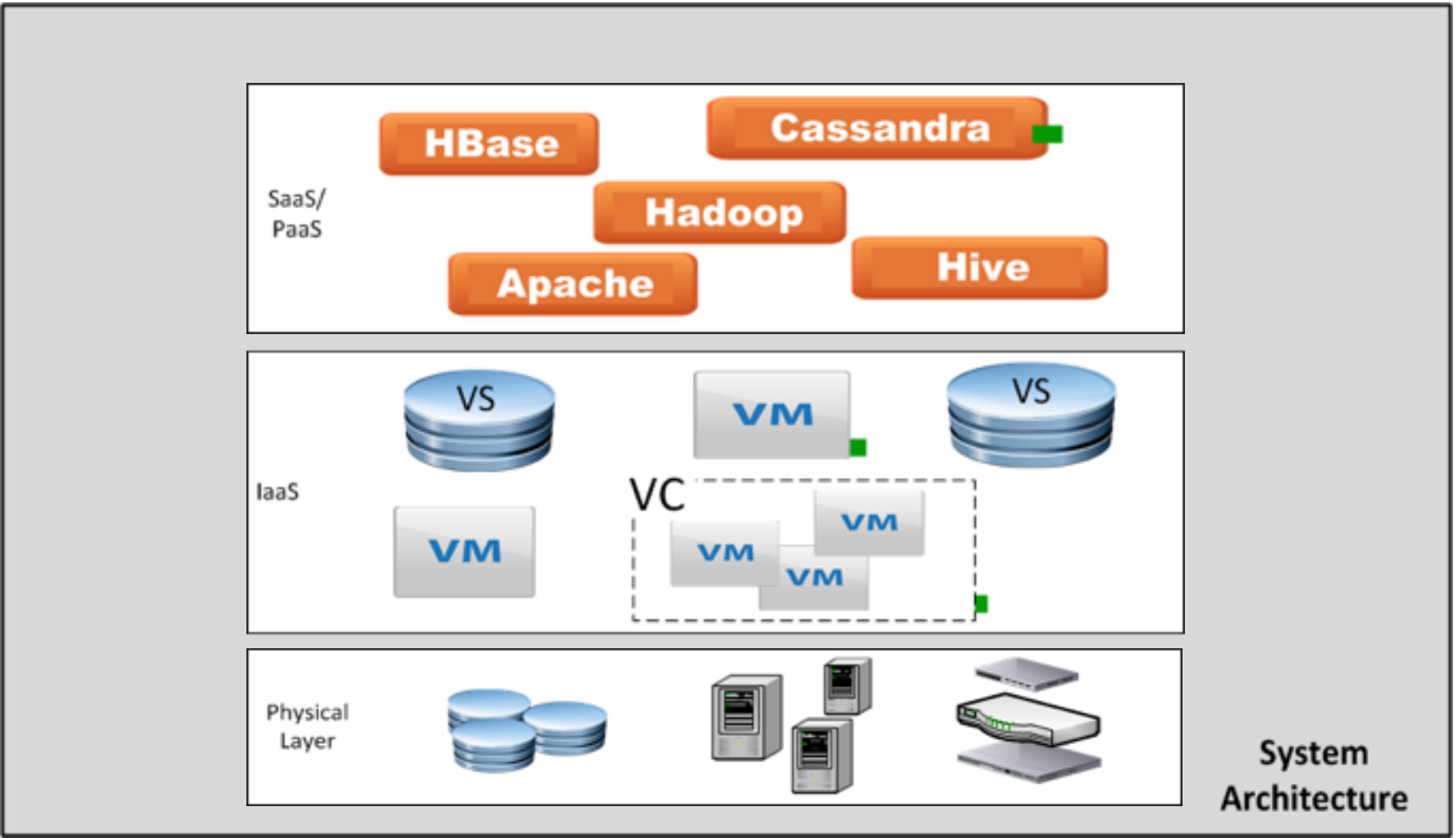
CELAR Architecture





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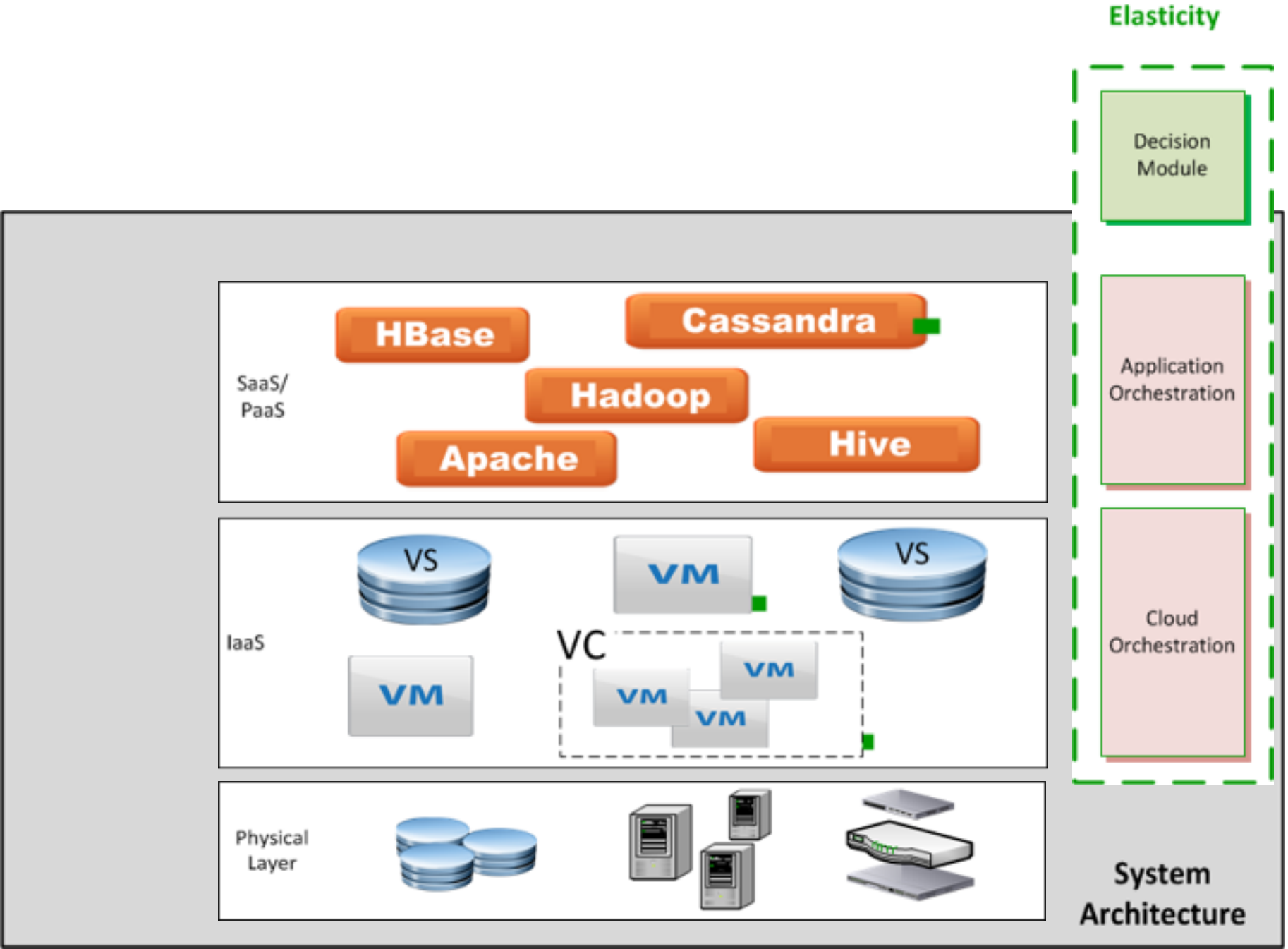
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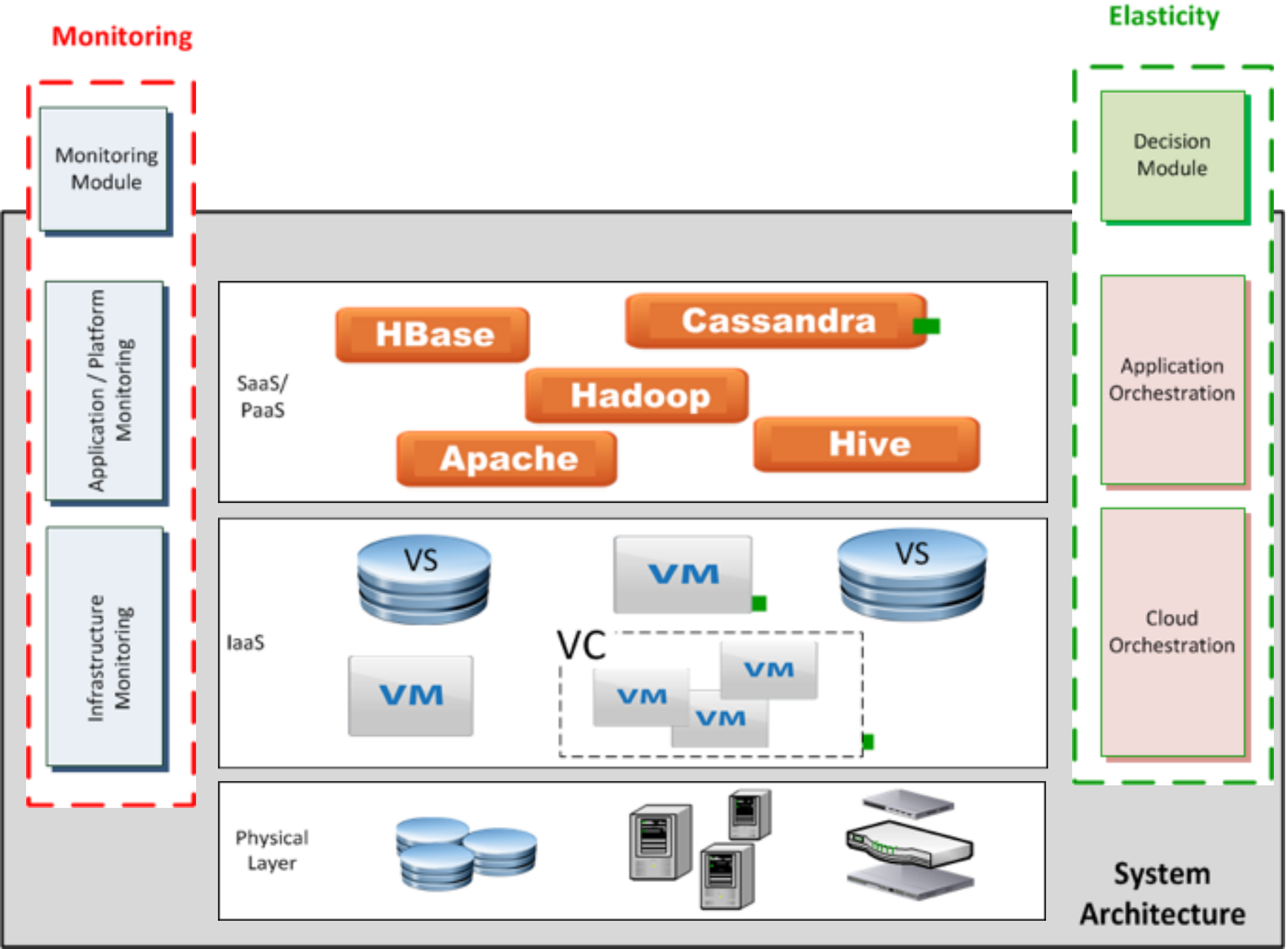
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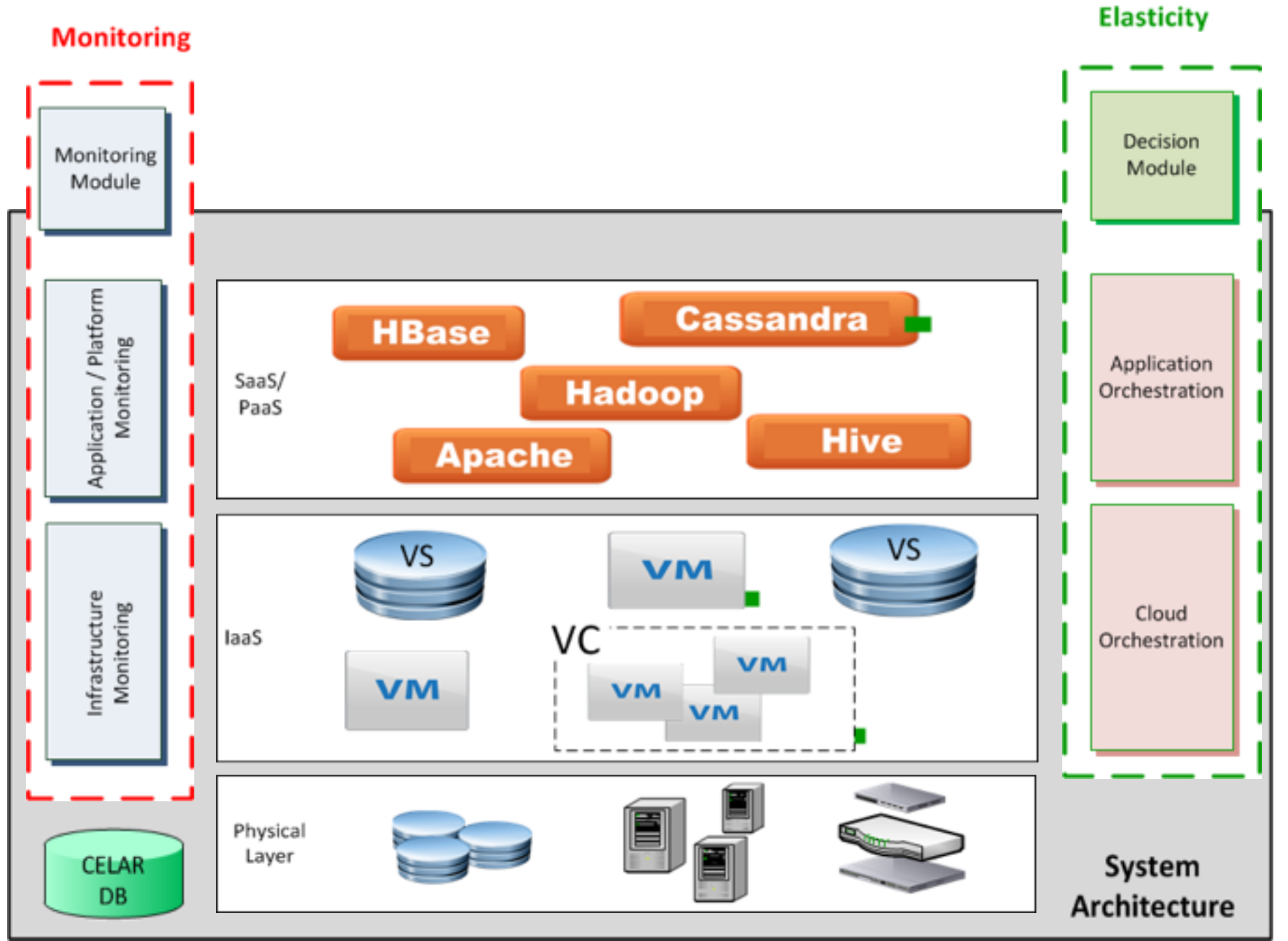
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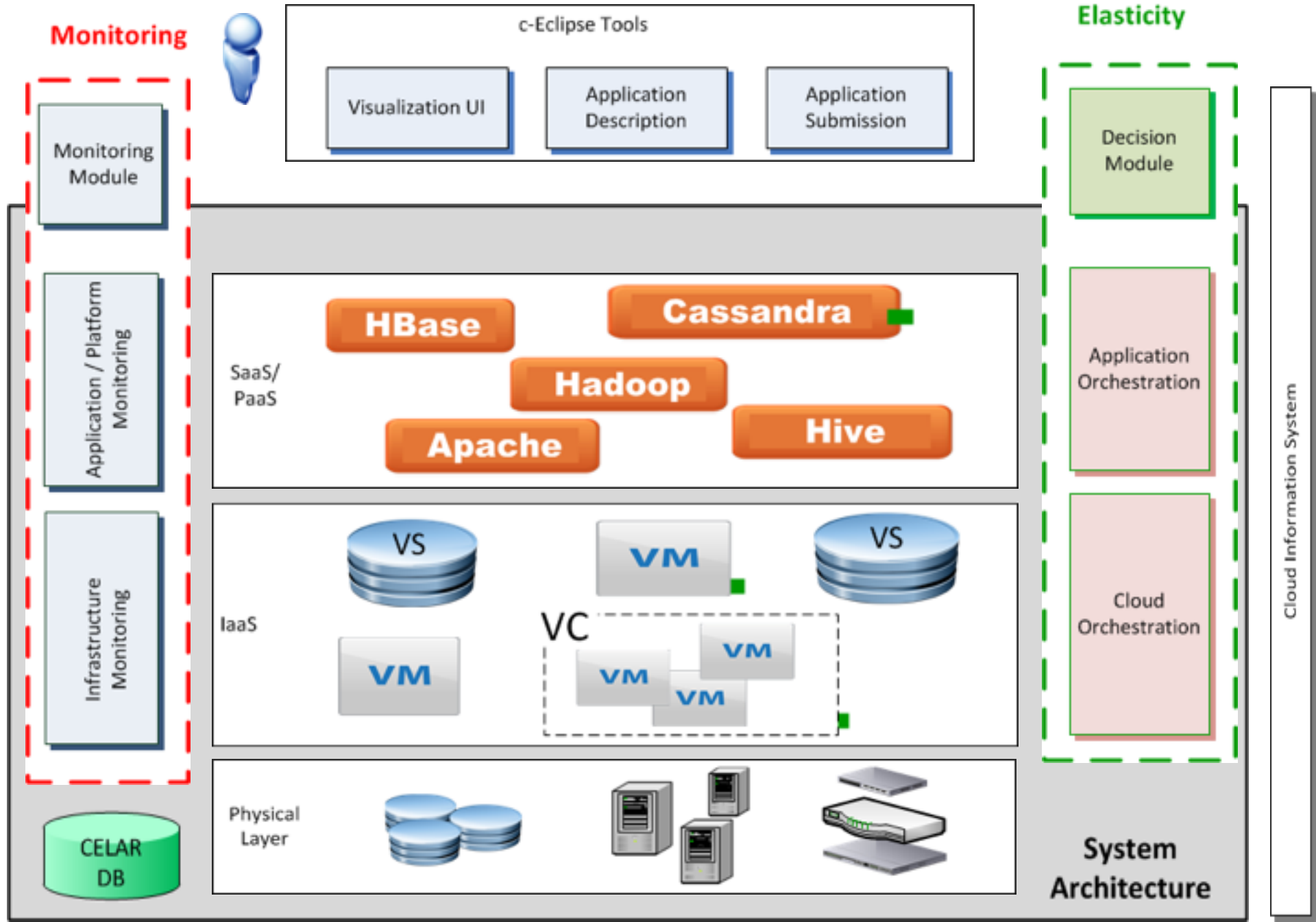
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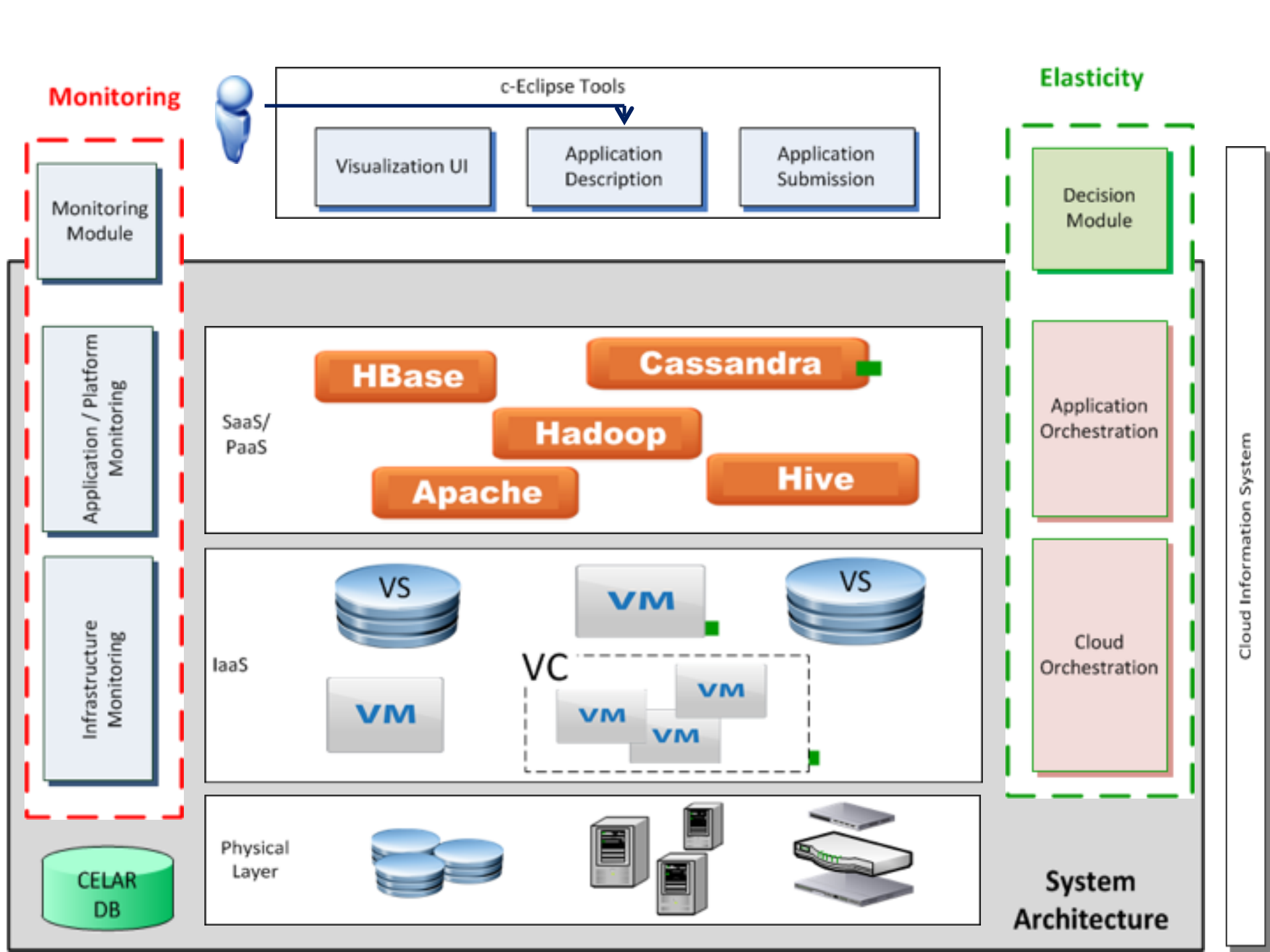
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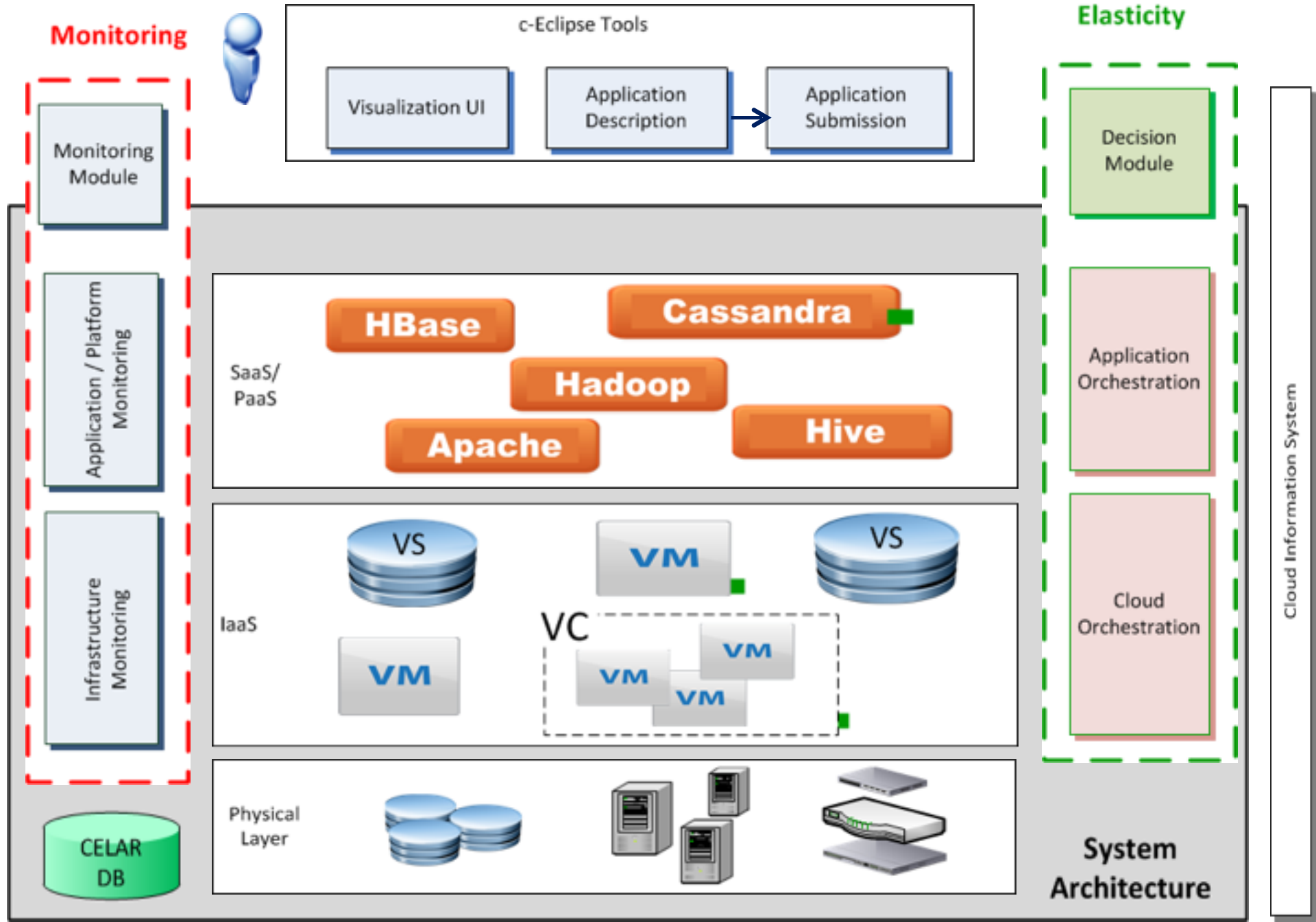
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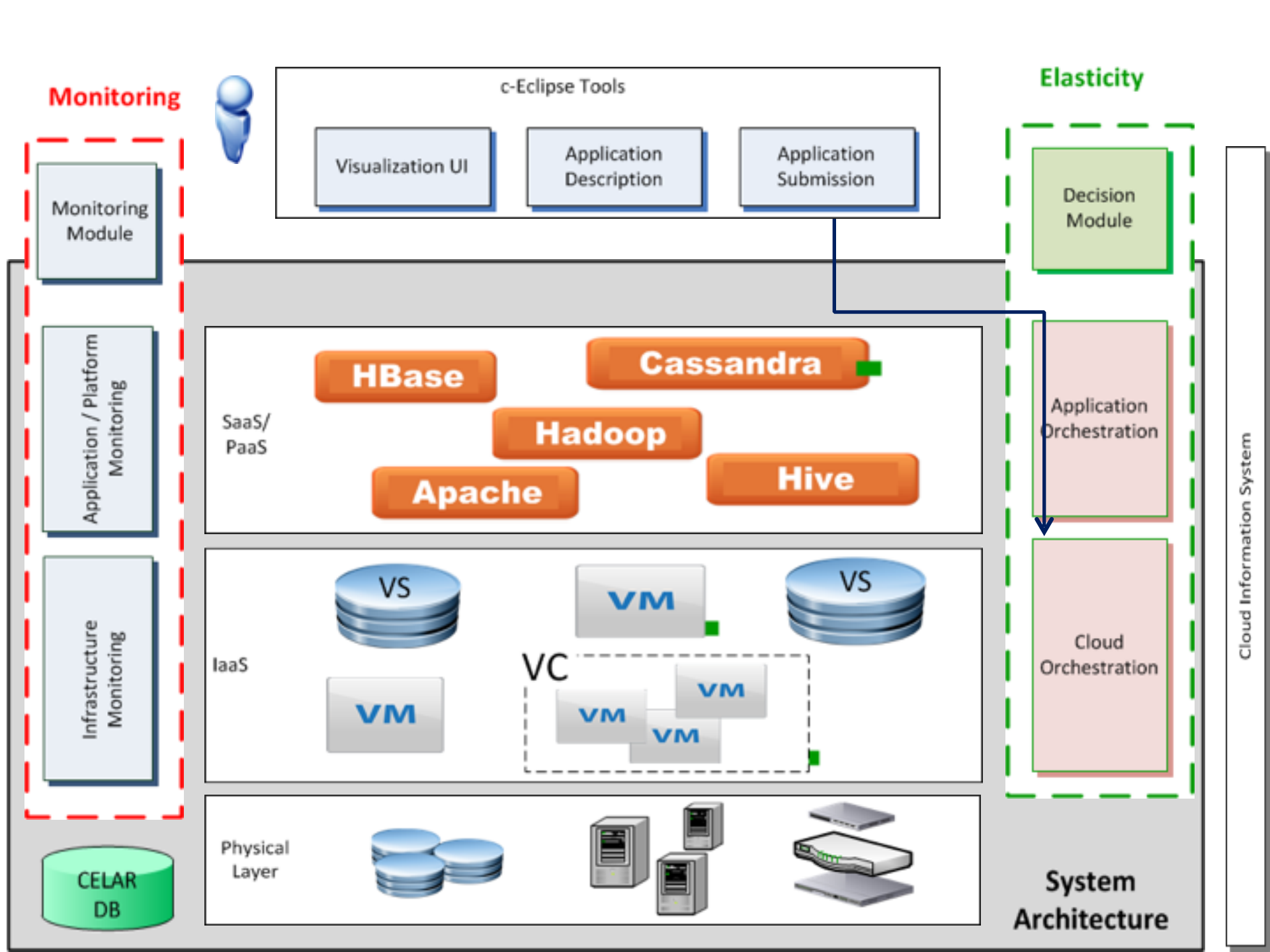
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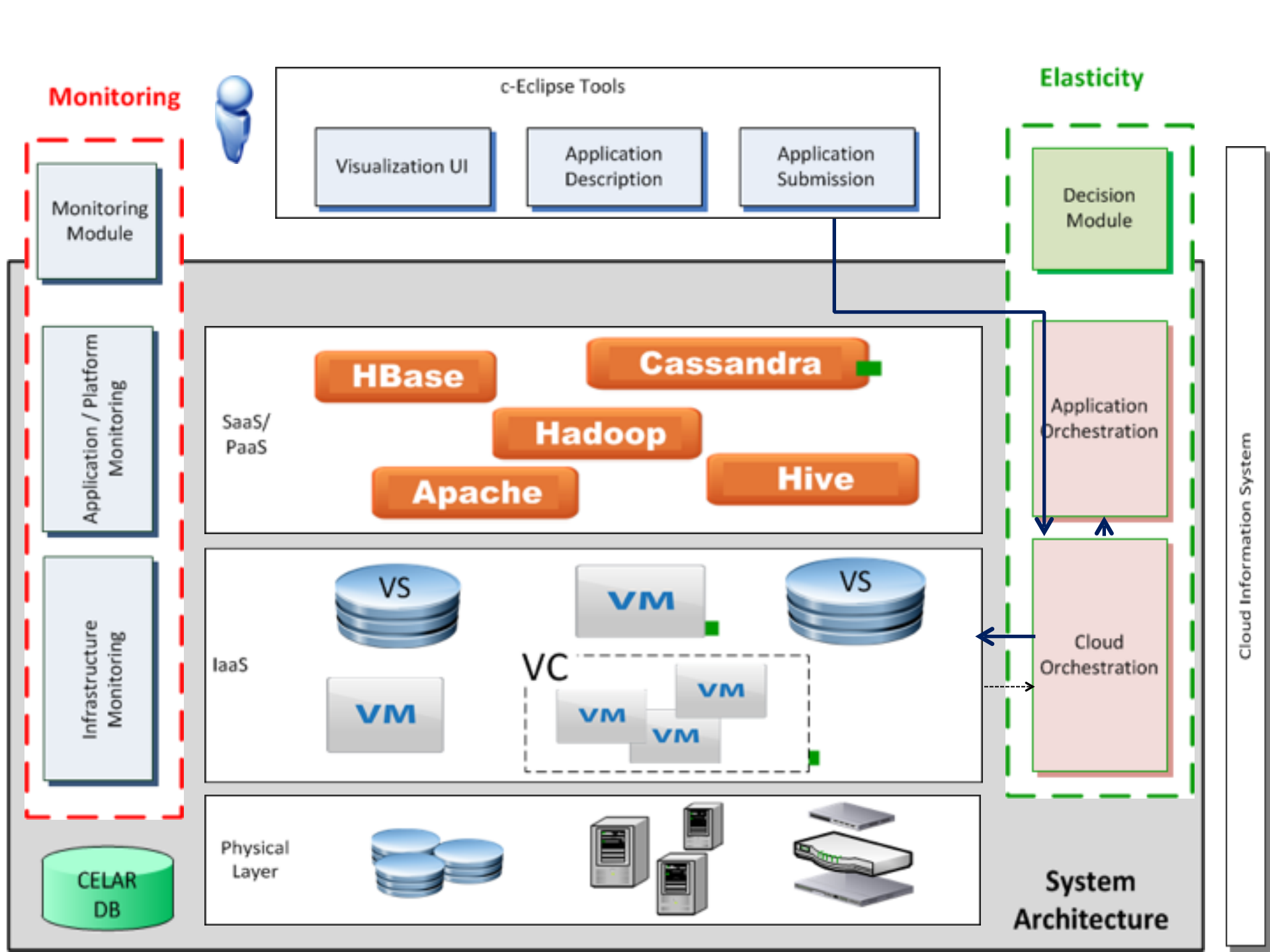
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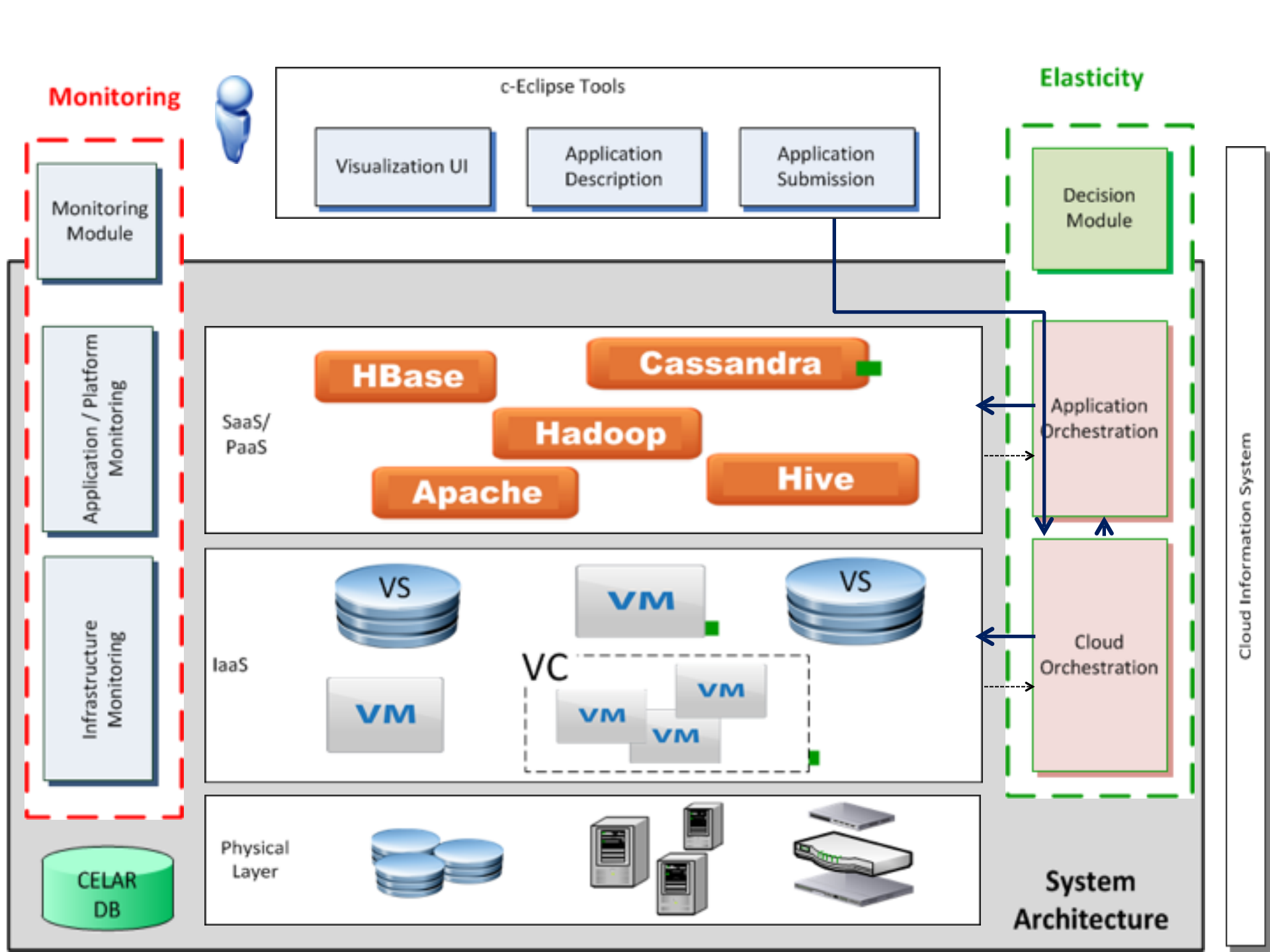
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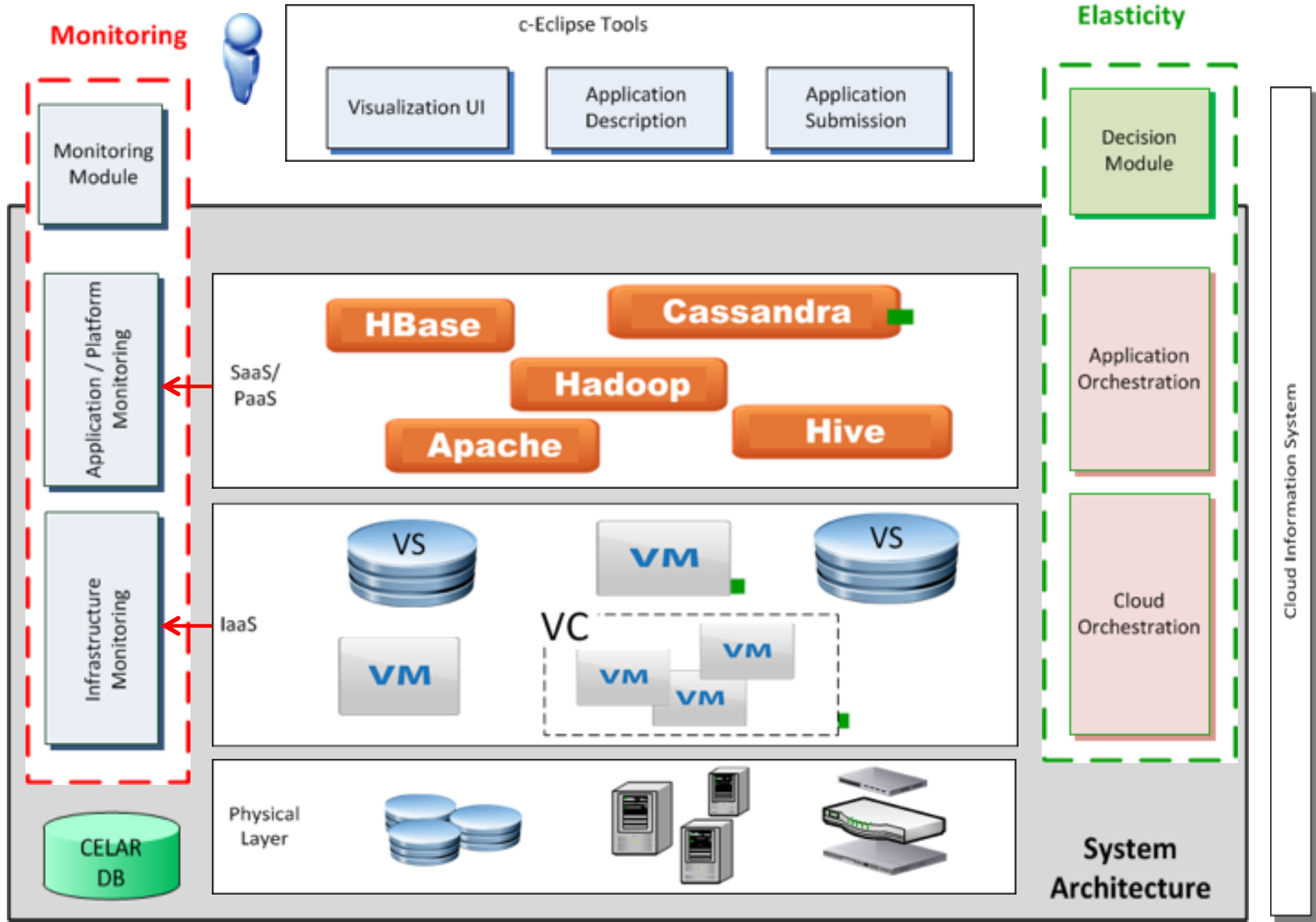
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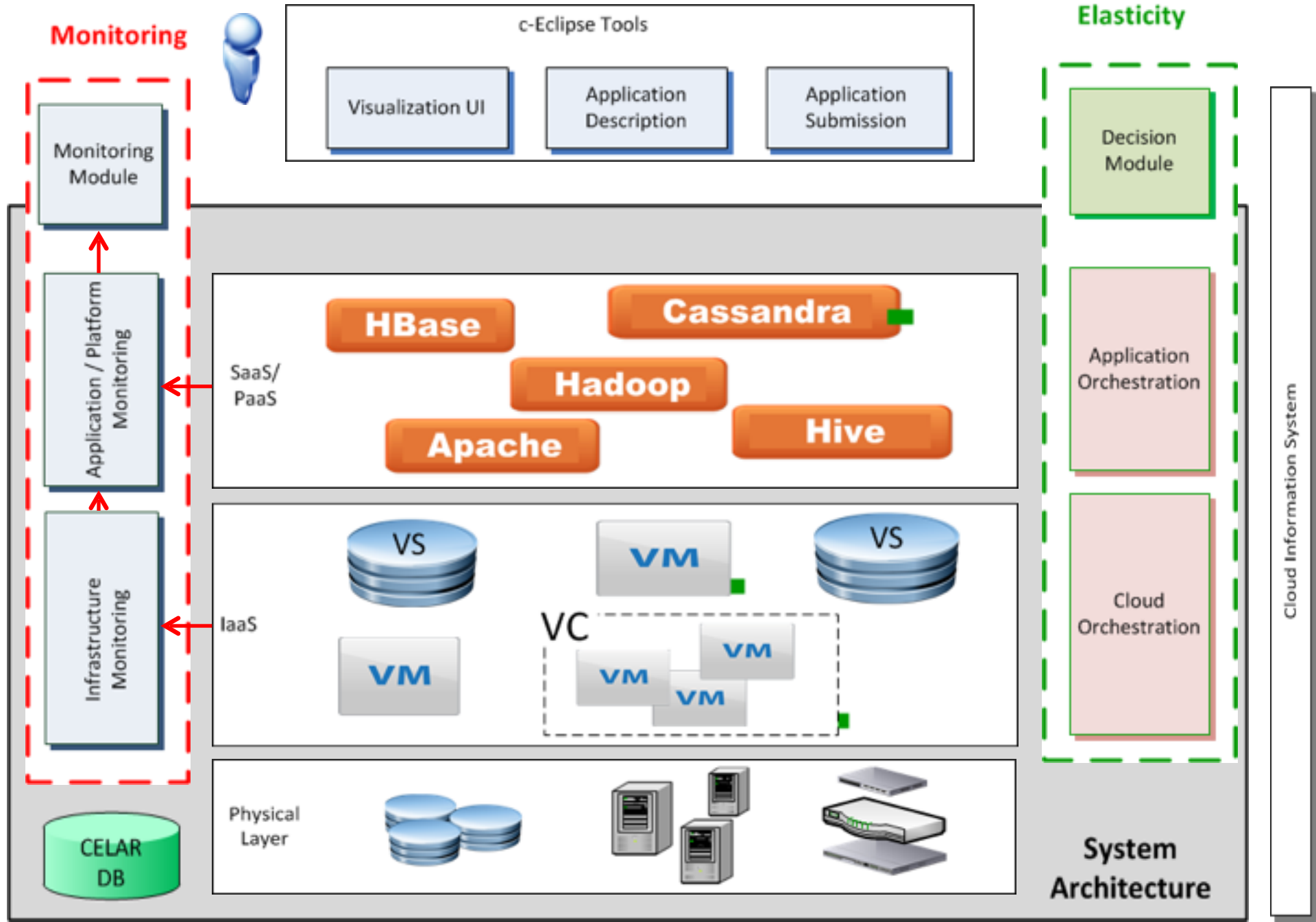
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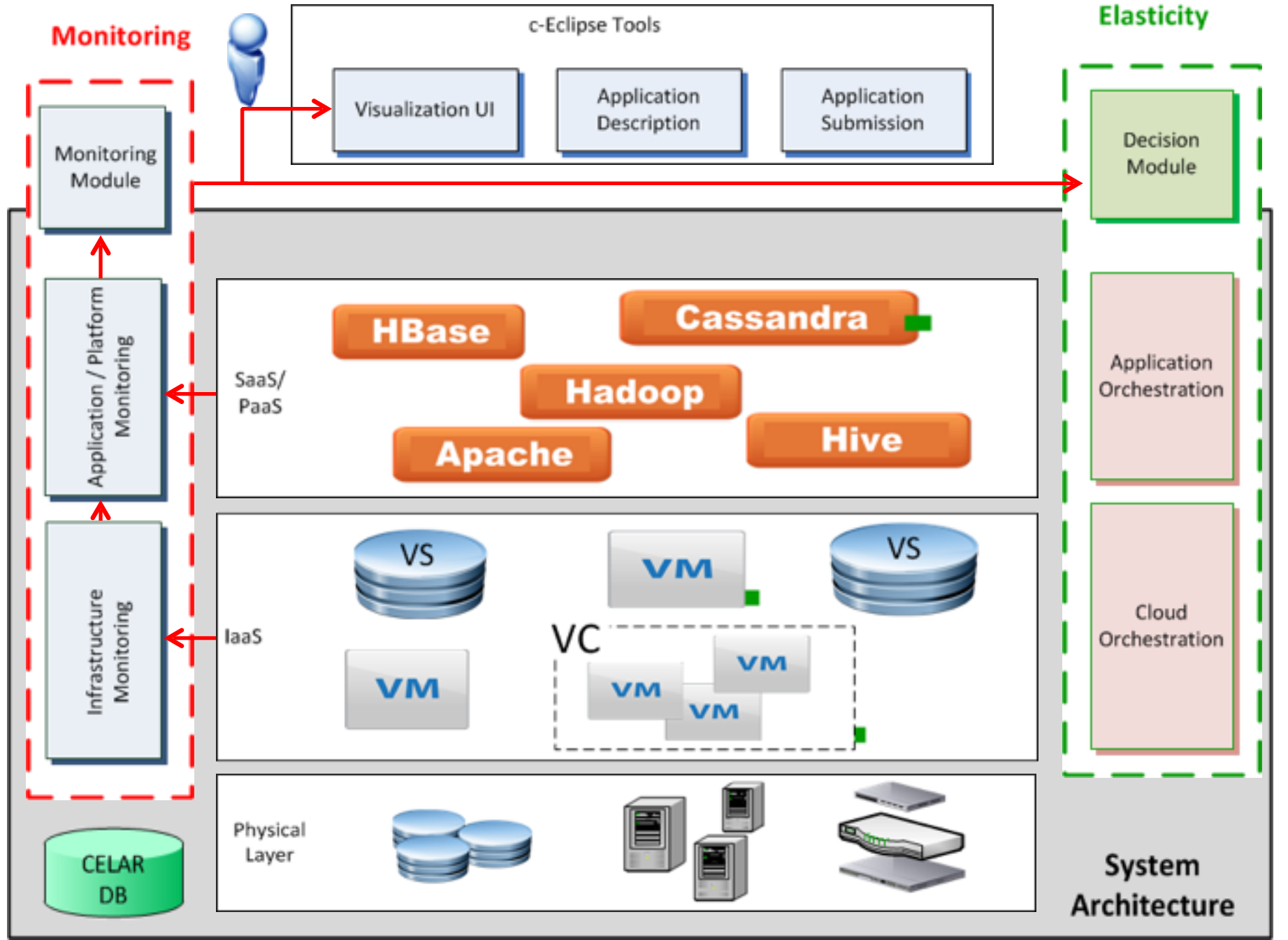
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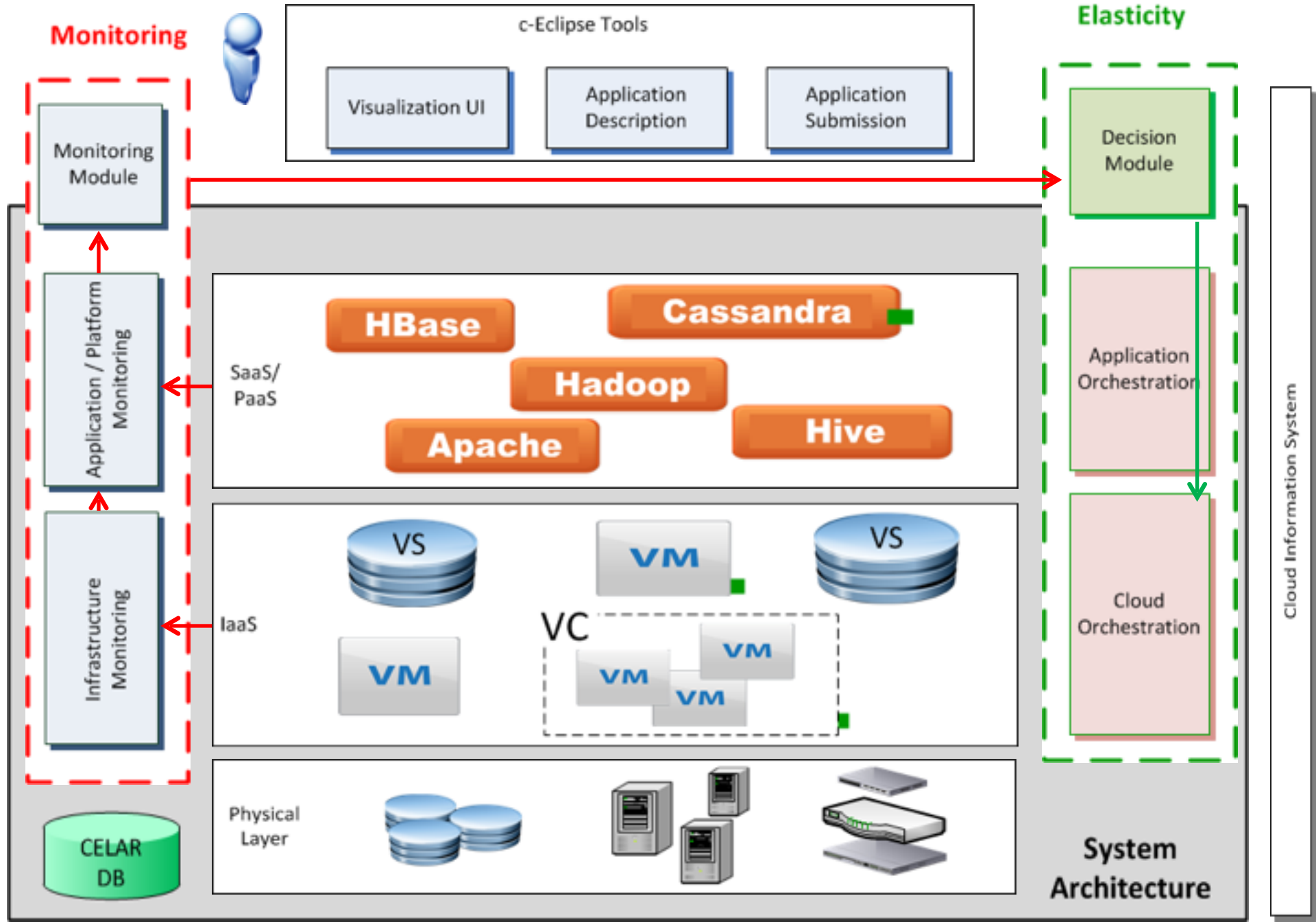
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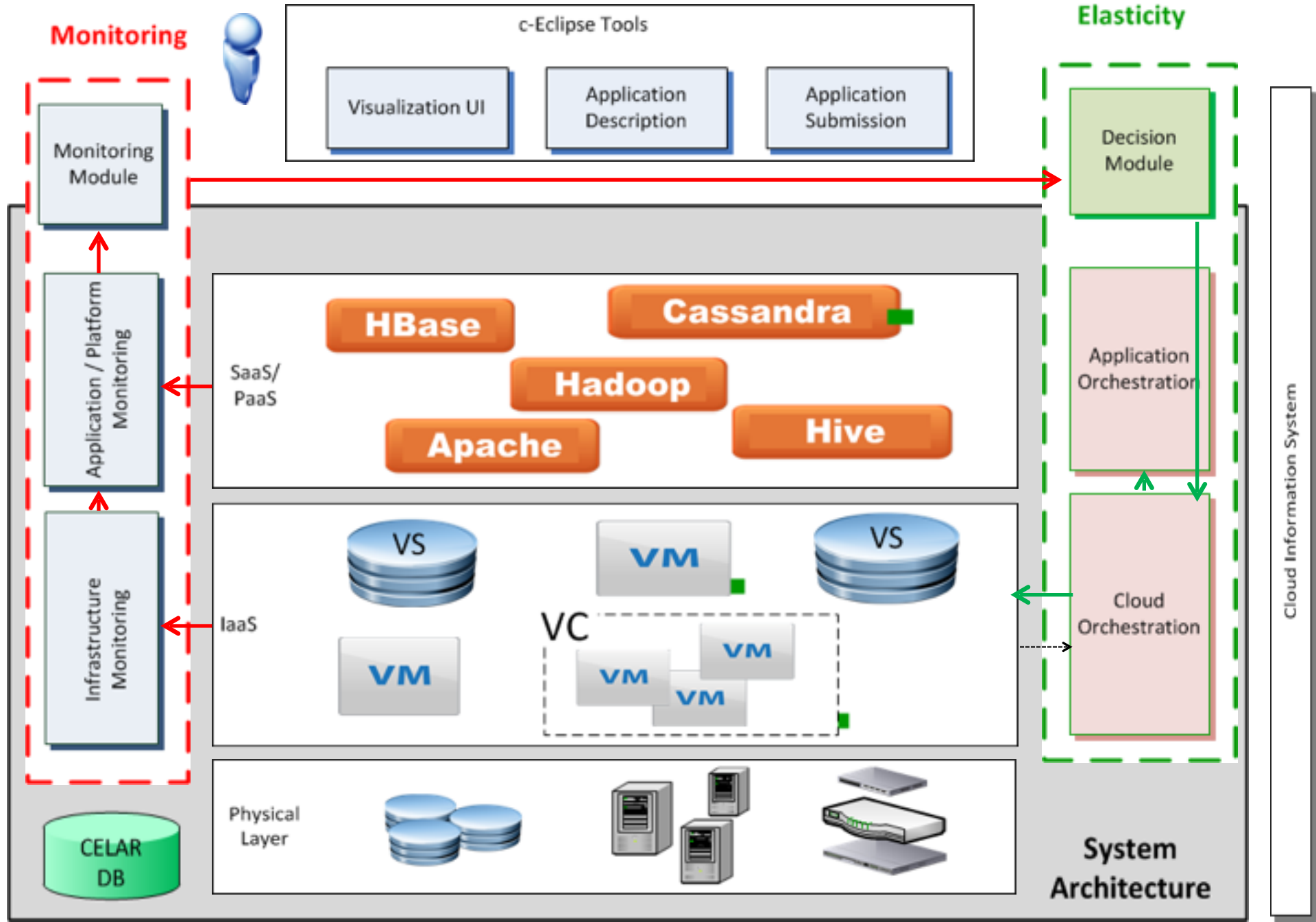
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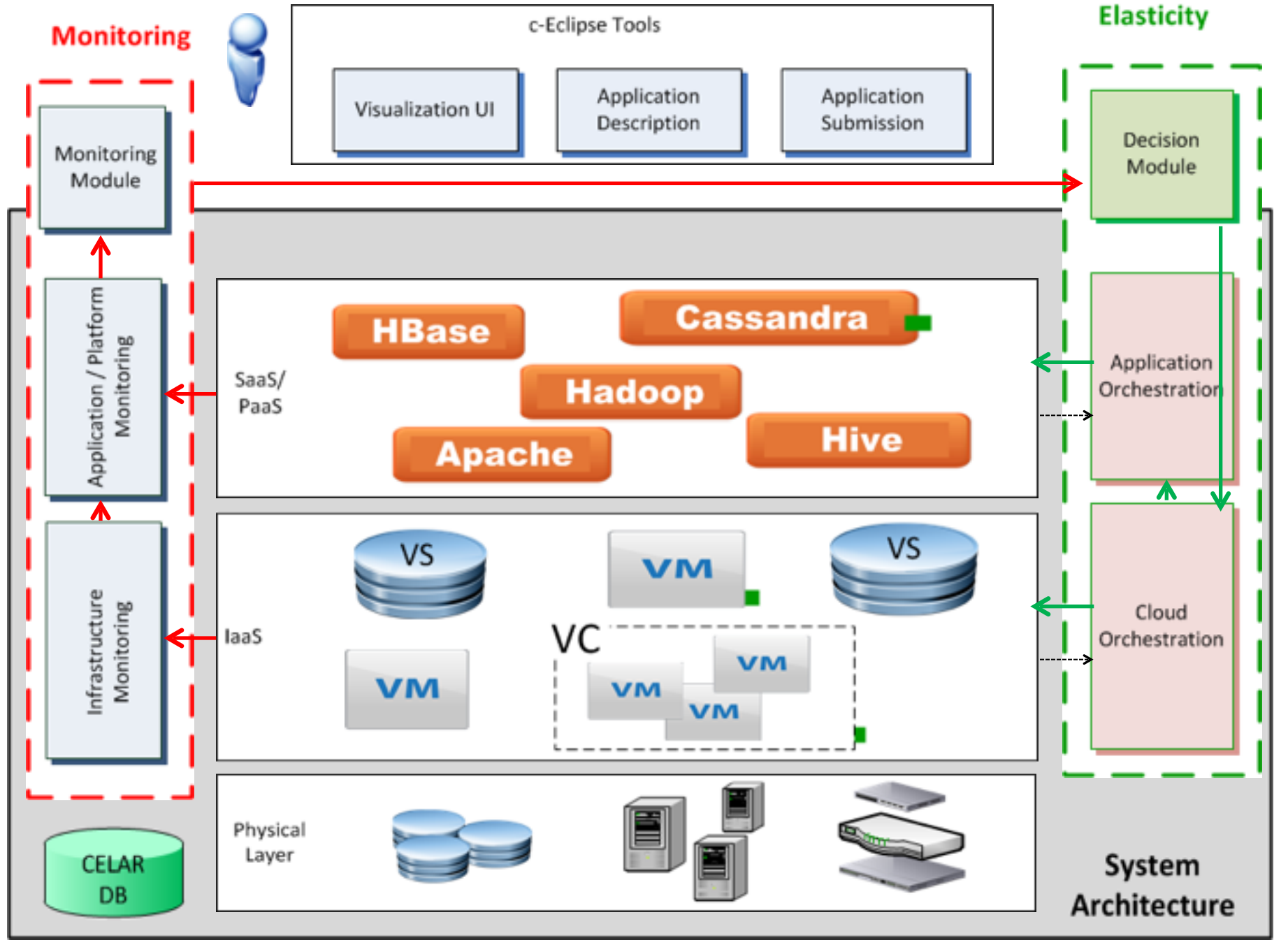
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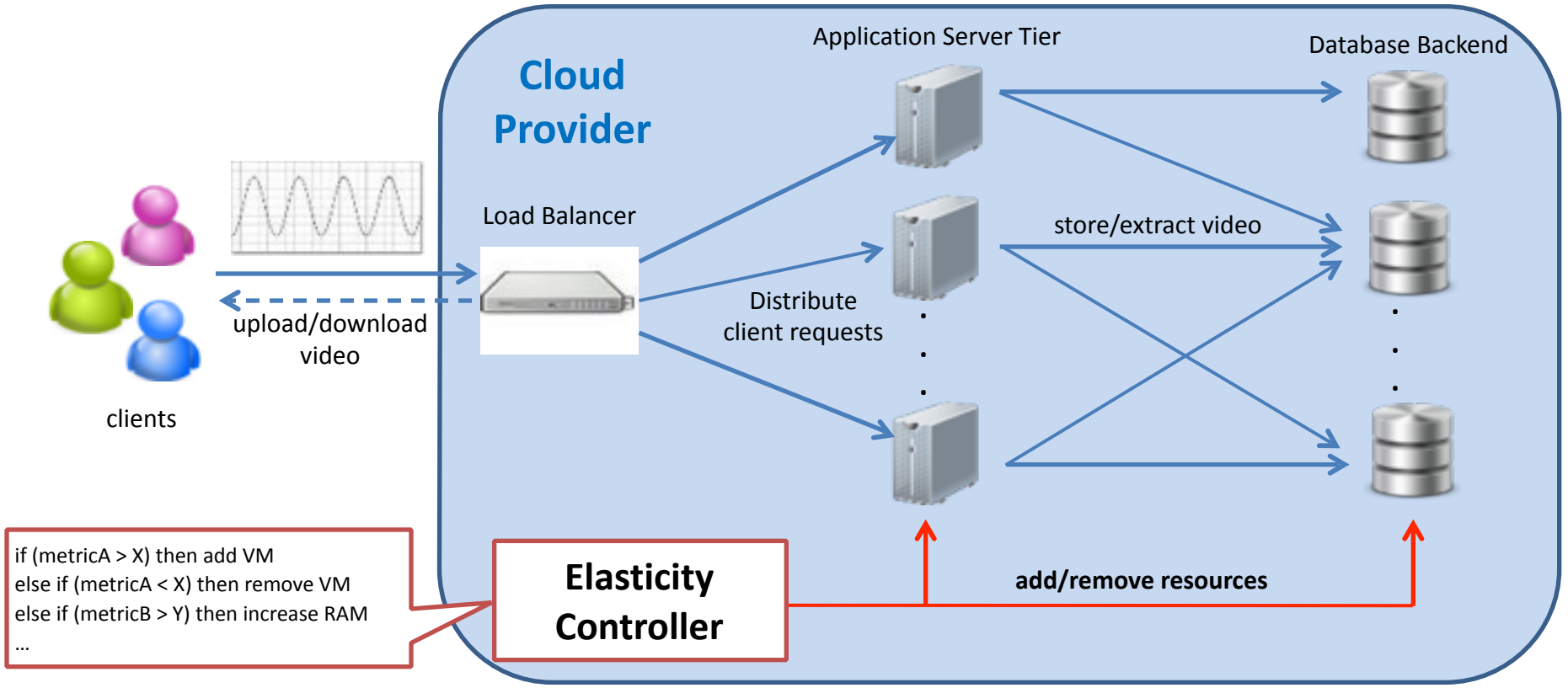


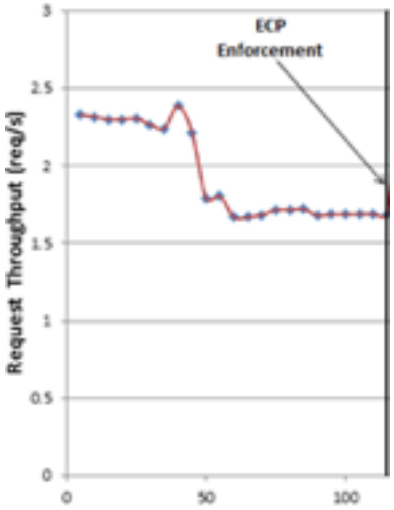
In general, elasticity constraints are too complex for users and based on low-level metrics

Elasticity Control Estimation and Evaluation

- How should we interpret a sudden drop in request throughput at the business tier of a 3-tier cloud service?

A. There are **less clients**; this makes the business tier inefficiently utilised
   - Right Decision: Remove an Application Server

B. Video storage **backend under-provisioned**, requests are getting queued at business tier
   - Right Decision: Add another Database Node



Elasticity Controller with simple IF-THEN-ELSE policies based on metric violations cannot determine the right ECP to improve QoS or cost

Current Elasticity Controllers

- *Manual* or *semi-automated* elasticity control
- Vendor-specific
- Elasticity modelled as a one-dimensional property
  - No control over cost, performance and quality
- Only "horizontal" elasticity control
  - e.g. add/remove virtual instances

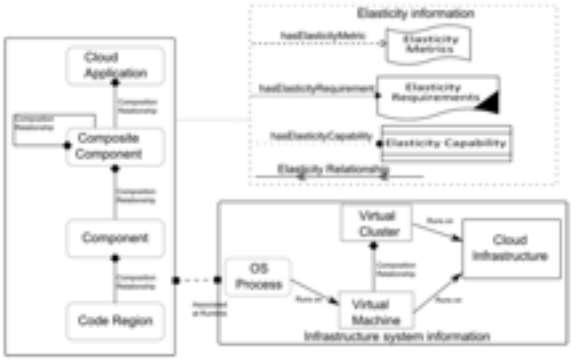
CELAR Elasticity Building Blocks

- Conceptualising and modelling elastic objects and execution environments
- Defining and capturing elasticity primitive operations associated with elastic objects
- Programming elastic objects and actions
- Runtime deployment, control and monitoring techniques for elastic objects

Source: Hong-Linh Truong (TUW), Cloudcom '14

Elasticity in CELAR

Dependency Graph capturing application structure and enabling a multi-level specification of elasticity: Application unit, service topology, application



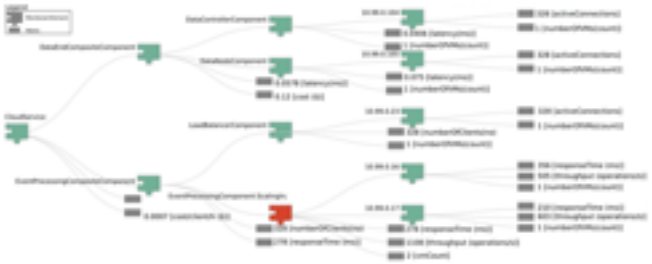
Elasticity requirement specification - SYBL: Monitoring, constraint, strategy

```
#SYBL.CloudServiceLevel
Cons1: CONSTRAINT responseTime < 5 ms
Cons2: CONSTRAINT responseTime < 10 ms
WHEN nbOfUsers > 10000
Str1: STRATEGY CASE fulfilled(Cons1) OR
fulfilled(Cons2): minimize(cost)

#SYBL.ServiceUnitLevel
Str2: STRATEGY CASE ioCost < 3 Euro :
maximize( dataFreshness )

#SYBL.CodeRegionLevel
Cons4: CONSTRAINT dataAccuracy>90%
AND cost<4 Euro
```

Multi-dimensional Modeling & analysing Elasticity of Cloud Services - MELA: Resources, cost, quality



Multi-level elasticity control through rSYBL

Elasticity Policies Specification in SYBL

- *SYBL* language enables elasticity requirements description for Cloud applications
- Elasticity specification at different levels
  - Component, composite component, application
- Two types of SYBL elasticity requirements:
  - Constraint: "Constraint 1: CPU_Usage < 80%"
  - Strategy: "Strategy 1: CASE Violated (Constraint 1) : Scale_Out"

"**SYBL: an Extensible Language for Controlling Elasticity in Cloud Applications**", G. Copil, D. Moldovan, H. Truong and S. Dustdar, 13th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGrid 2013), 2013

```
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#SYBL.ServiceUnitLevel
Str2: STRATEGY CASE ioCost < 3 Euro :
maximize( dataFreshness )

#SYBL.CodeRegionLevel
Cons4: CONSTRAINT dataAccuracy>90%
AND cost<4 Euro
```
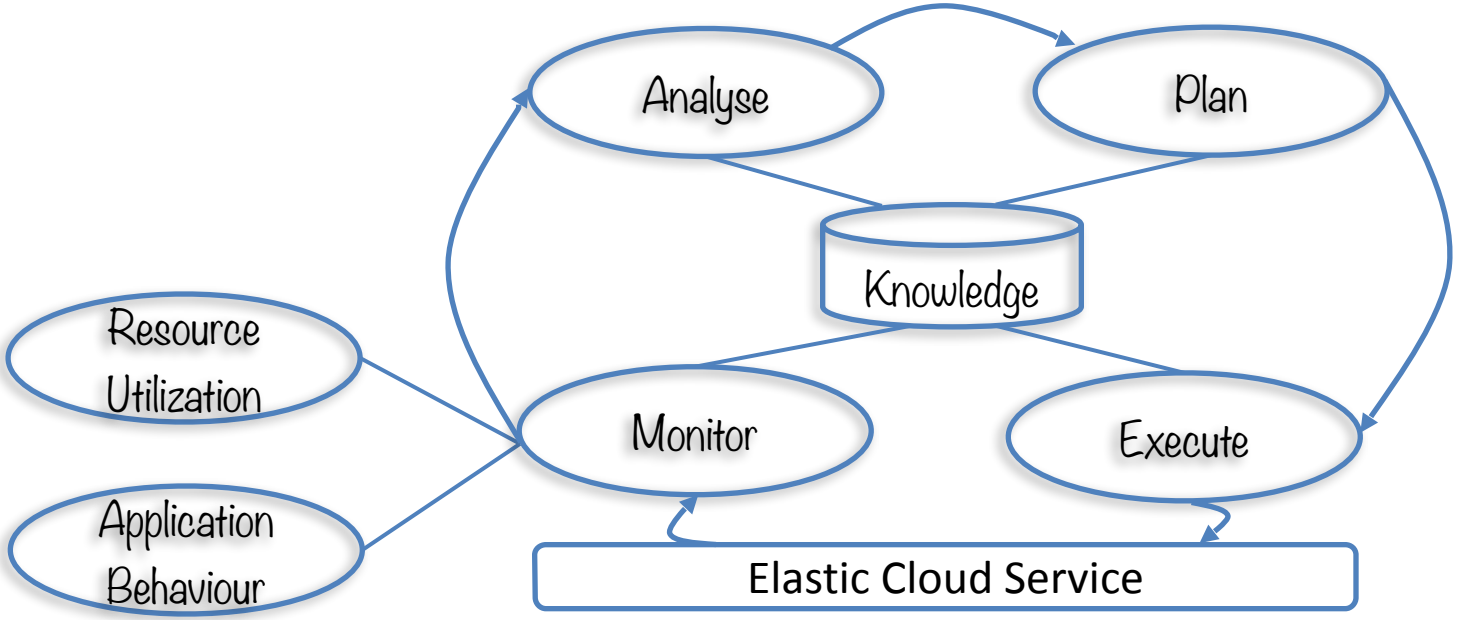

Monitoring for Elastic Control

- MAPE-K control loop (Monitoring, Analysing, Planning, Executing using Knowledge)



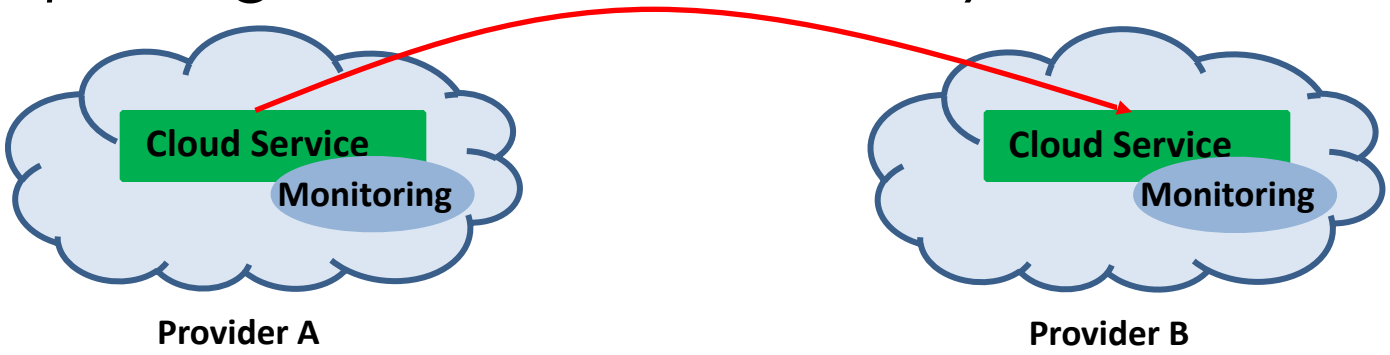
Trihinas, D., Pallis, G., & Dikaiakos, M. D. (2014a) JCatascopia: Monitoring Elastically Adaptive Applications in the Cloud, in *14th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing*, 2014.

Cloud Monitoring Challenges

- Monitor heterogeneous types of run-time information and resources
- Extract metrics from multiple levels of the cloud
  - Low-level metrics (i.e. CPU usage, network traffic)
  - High-level metrics (i.e. application throughput, latency, availability)
- Metrics collected at different time granularities
- Non-intrusiveness

Cloud Monitoring Challenges

- Cloud Platform Independence
  - If a cloud service is portable then it can be moved to another platform due to better *pricing schemes, availability, QoS*, etc.

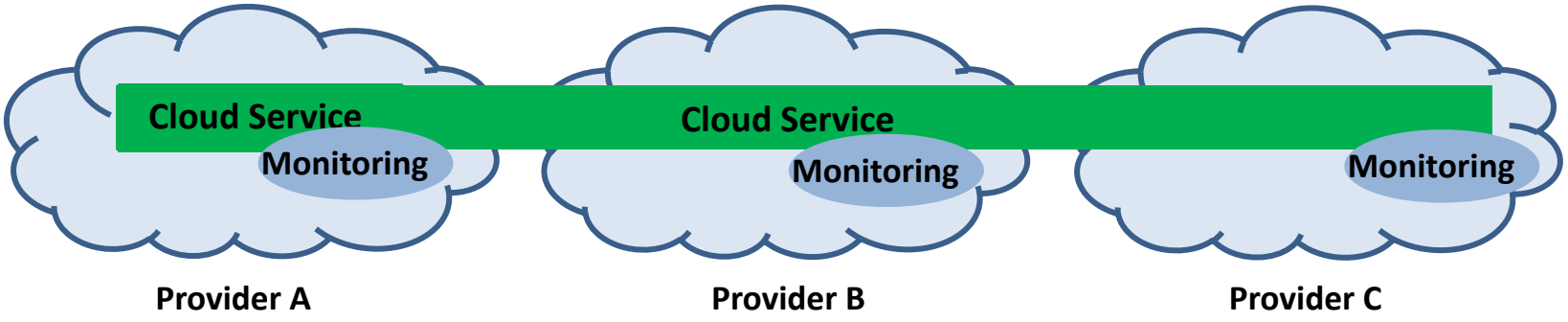


- Monitoring System?
  - Portable
  - Easily configurable on new platform

Cloud Monitoring Challenges

- Interoperability
  - Distribute a cloud service across multiple providers due to better resource locality, availability or security concerns

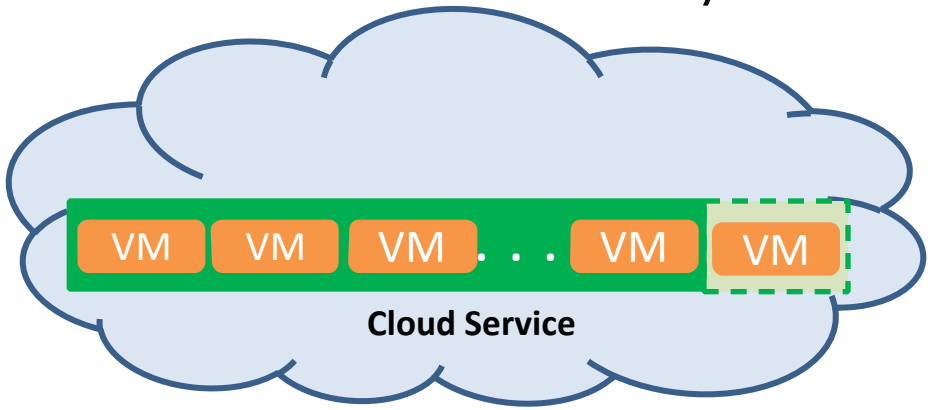
42% are interested in adopting hybrid cloud. Estimated to rise to 55% by 2016 [GIGAOM 2014]



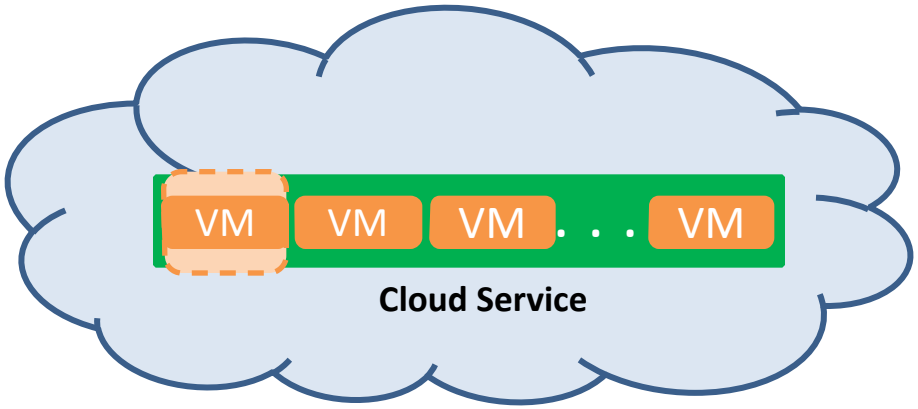
- Monitoring System?
  - Operate and collect metrics seamlessly across multiple providers

Cloud Monitoring Challenges

- Elasticity Support
  - Detect configuration changes in a cloud service
- Monitoring System?
  - Detect configuration changes automatically without restarting monitoring process or part of it and without any human intervention



Application topology changes
(e.g. new VM added)



Allocated resource changes
(e.g. new disk attached to VM)

Cloud Monitoring State-of-the-art

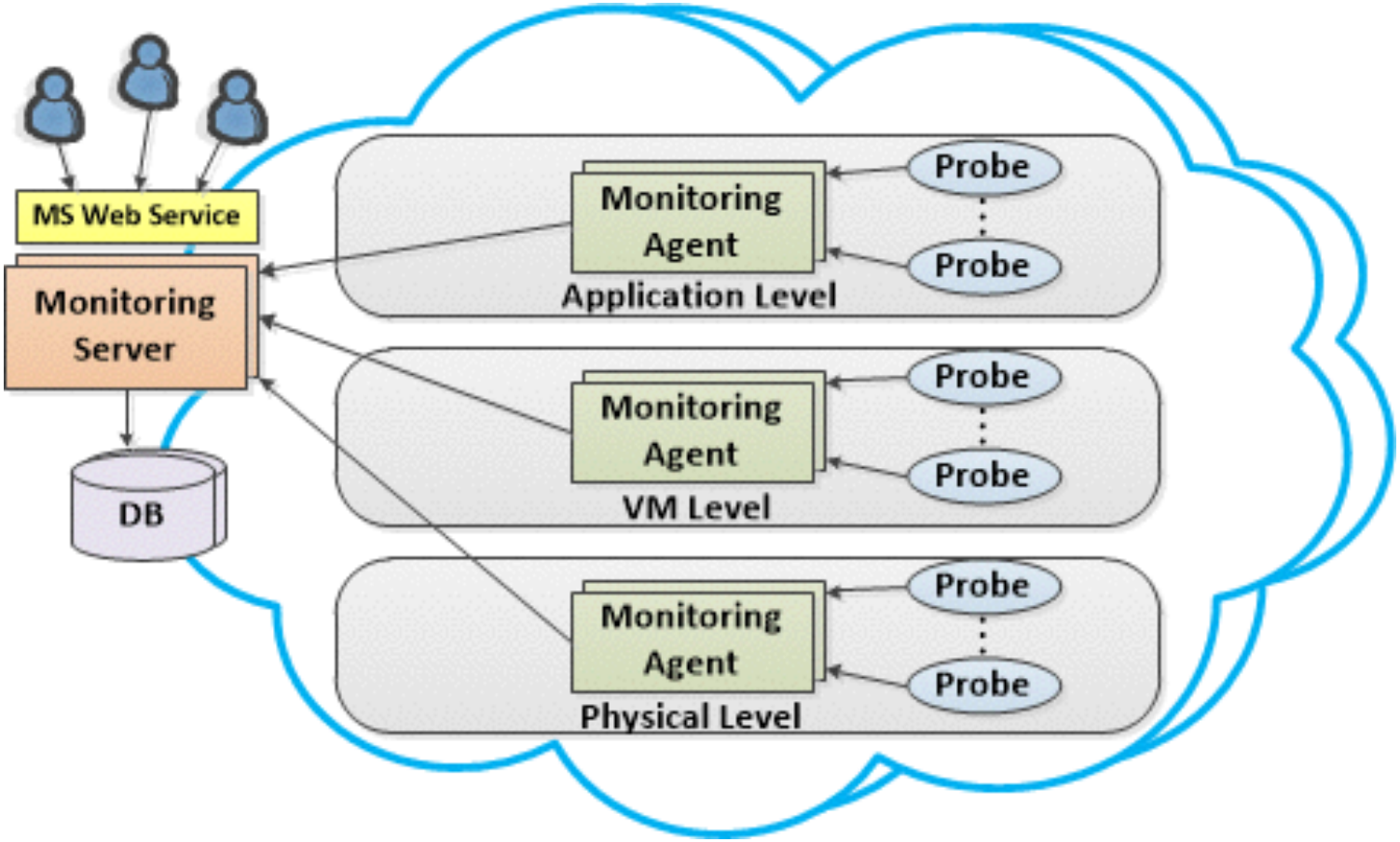
- Cloud-specific Monitoring Tools
  - Limited to a specific number of cloud platforms
  - **Commercial** and **proprietary** -> limited portability and interoperability
- General Purpose Monitoring Tools
  - Suitable for only slowly changing fixed infrastructures
  - Limited application-level monitoring support
- No elasticity support
  - Detect configuration changes in:
    - Application topology (e.g. new VM added)
    - Allocated resource (e.g. new disk attached to VM)

JCatascopia Monitoring System

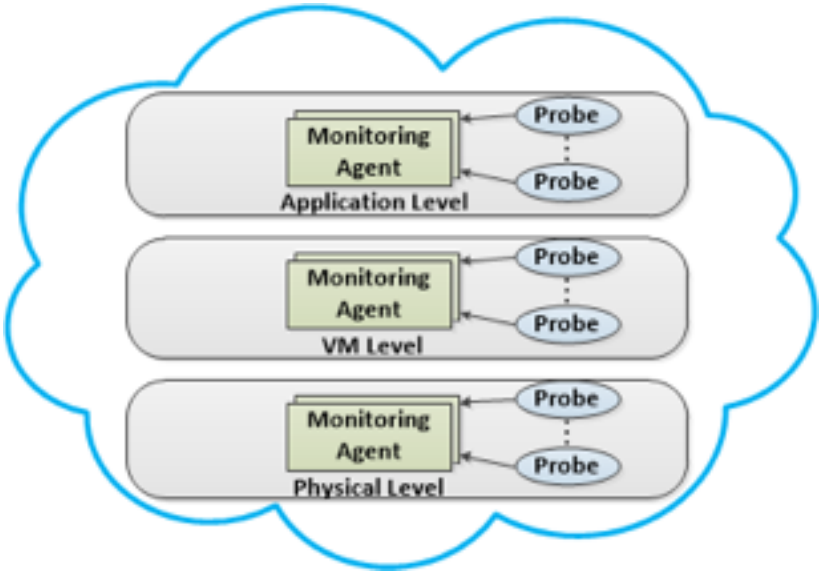
- Open-source
- Interoperable
- Scalable
- Multi-Layer Cloud Monitoring
  - Customisable and Extensible by Users
  - *Metric Subscription Rule Language*
- Platform Independent
  - Operates on any cloud platform
  - Metric collection, distribution or storage are *independent* to underlying infrastructure
- Elastic by design

"**JCatascopia: Monitoring Elastically Adaptive Applications in the Cloud"**, Trihinas, Pallis, & Dikaiakos, *CCGrid*2014.

JCatascopia Architecture



Monitoring Probes

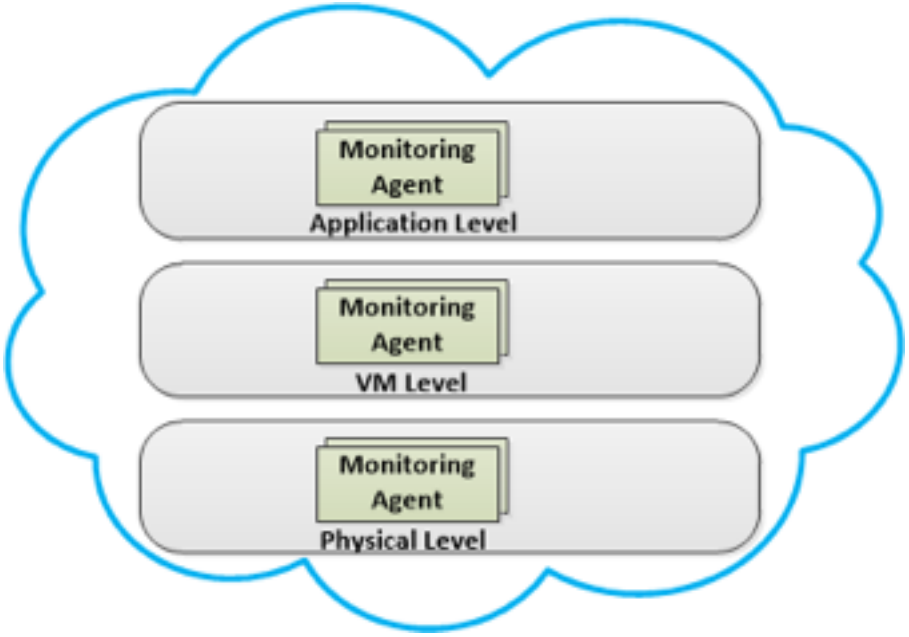


- The actual metric collectors managed by Monitoring Agents
- Collect system-level and application performance metrics
- Push or Pull mechanism to forward metrics to their corresponding Agent

JCatascopia Probes

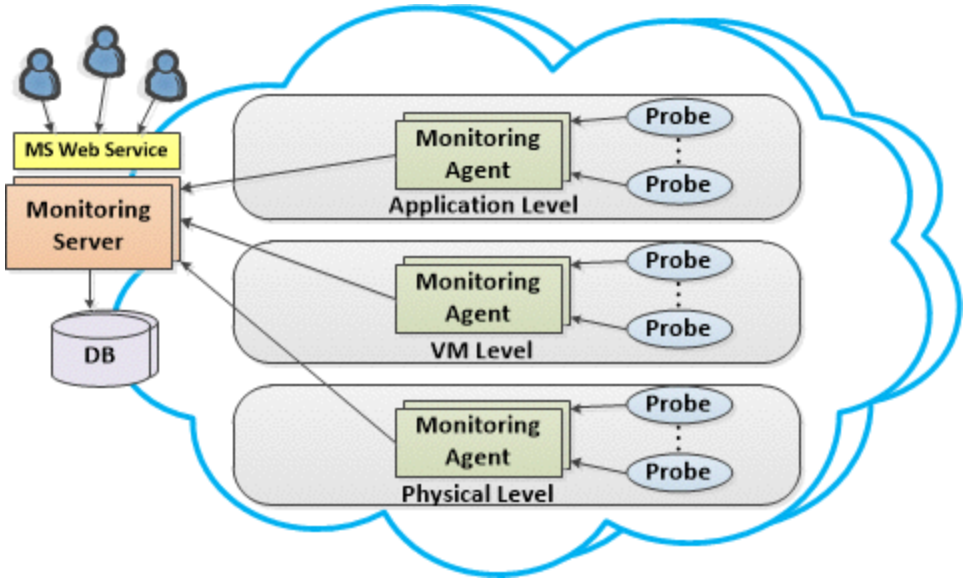
- JCatascopia Probe API
- Application developers can implement their own Probes
- Dynamically deployable to Monitoring Agents
- Push and Pull metric delivery mechanism
- Filtering mechanism at Probe level
  - Minimizes communication and storage overhead
  - Probe developers can create their own metric filters

Monitoring Agents

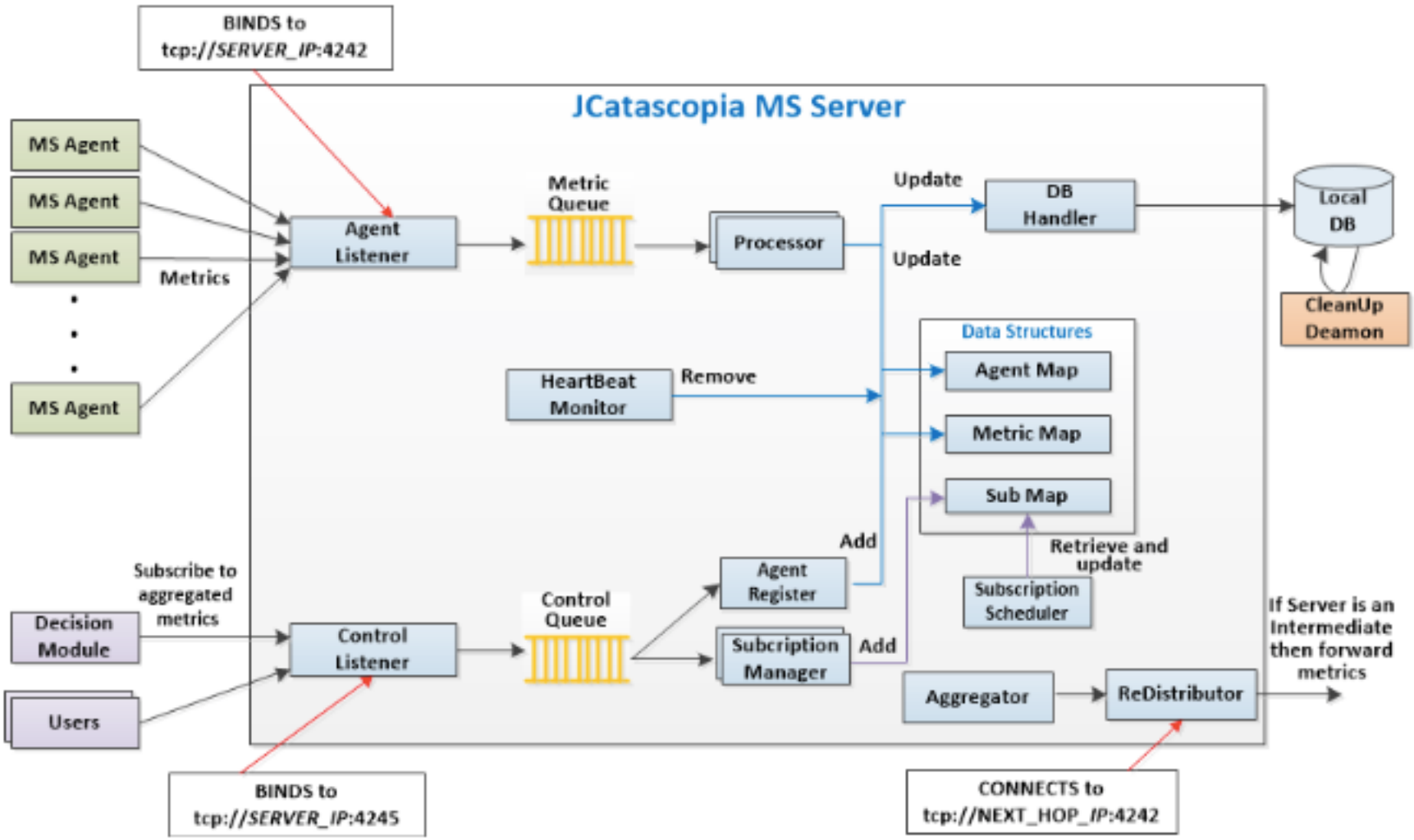


- Light-weight monitoring instances
- Deployable on physical nodes or virtual instances
- Responsible for the metric collection process
- Aggregate and distribute collected metrics (pub/sub)

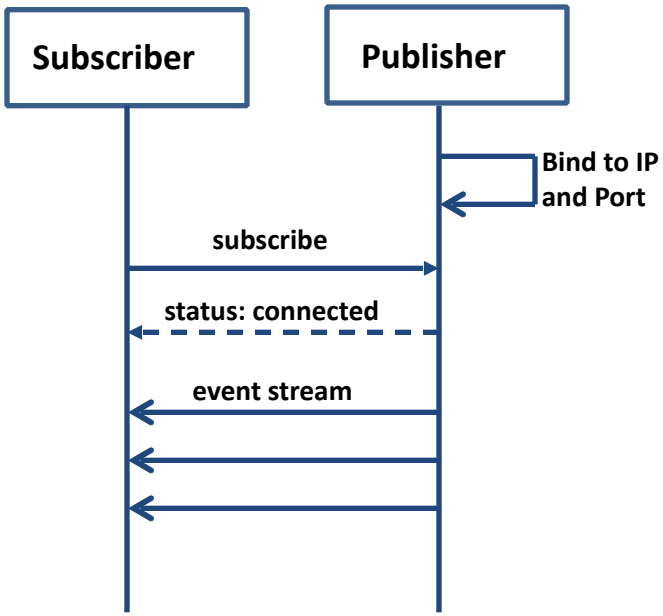
Monitoring Server



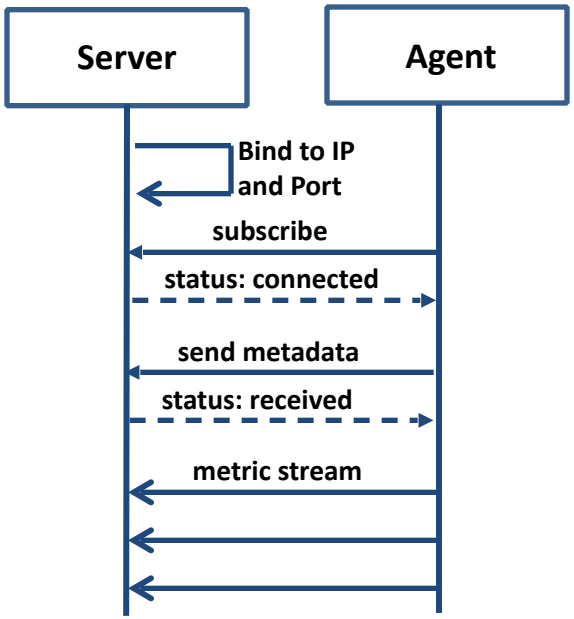
- Receives metrics from Monitoring Agents
- Aggregates, filters, processes and stores metrics in Database
- Handles user metric and configuration requests
- Hierarchy of Monitoring Servers for greater scalability


BINDS to
tcp://SERVER_IP:4242
JCatascopia MS Server
MS Agent
MS Agent
MS Agent
Metrics
MS Agent
Agent
Listener
Metric
Queue
Processor
Update
Update
DB
Handler
Local
DB
CleanUp
Deamon
Data Structures
Agent Map
Metric Map
Sub Map
HeartBeat
Monitor
Remove
Add
Retrieve and
update
Subscription
Scheduler
Agent
Register
Subscription
Manager
Add
Subscribe to
aggregated
metrics
Decision
Module
Users
Control
Listener
Control
Queue
Aggregator
ReDistributor
If Server is an
Intermediate
then forward
metrics
BINDS to
tcp://SERVER_IP:4245
CONNECTS to
tcp://NEXT_HOP_IP:4242

Dynamic Agent Discovery



(a) Classic pub/sub



(b) JCatascopia

Benefits

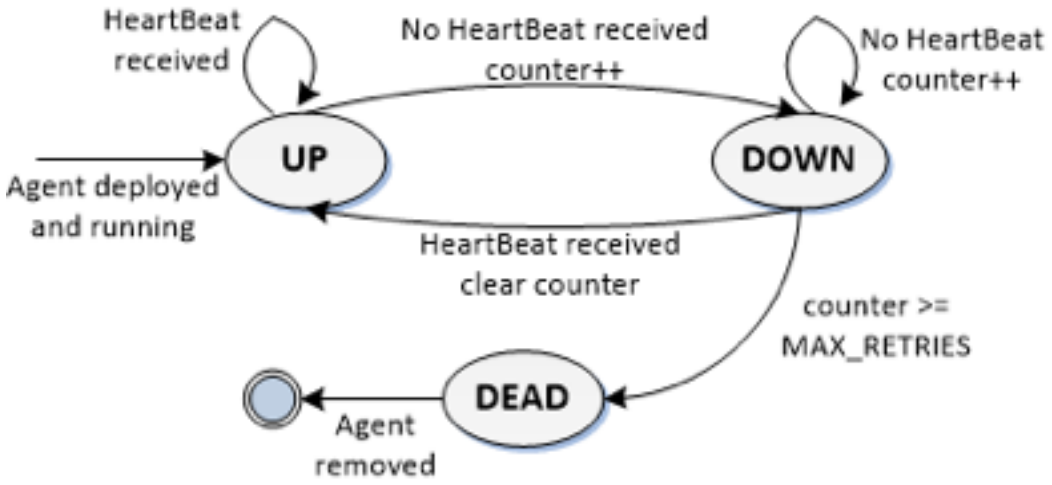
- Monitoring Servers are agnostic of Agent network location
- Agents appear dynamically

Eliminated the need to

- Restart or reconfigure Monitoring System
- Depend on underlying hypervisor
- Require directory service with Agent locations

Dynamic Agent Removal

- Heartbeat monitoring to detect when Agents:
  - Removed due to scaling down elasticity actions
  - Temporary unavailable (network connectivity issues)



Metric Subscription Rule Language

- Aggregate single instance metrics

```
SUM(errorCount)
```

- Generate high-level metrics at runtime

```
DBthroughput =
            AVG(readps+writeps)
```

```
<SubscriptionRule> ::= <Filter>, <Members>, <Action>

<Filter> ::= <MetricName> = <Expression> | <GroupFunction>(<Expression>)
<Expression> ::= <Operand> | <Operand> <Op> <Expression>
<Operand> ::= <Number> | <MetricName> | (<Expression>)
<Op> ::= +|-|*|/
<MetricName> ::= <String>
<GroupFunction> ::= AVG|SUM|MIN|MAX

<Members> ::= MEMBERS = ({<AgentID>,} <AgentID>)
<AgentID> ::= <String>

<Action> ::= ACTION = NOTIFY(<Act>) | PERIOD(<Number>)
<Act> ::= ALL | {<Relation> <Number>,} <Relation> <Number>
<Relation> ::= <|>|=|!=|>=|<=
```

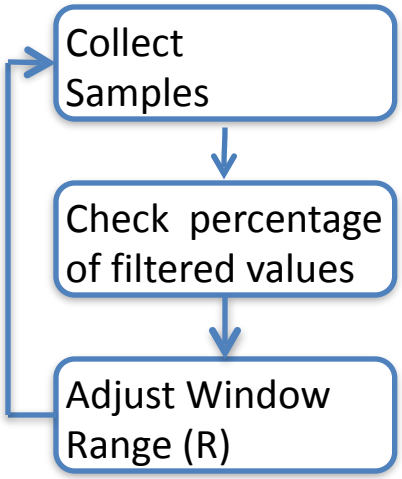
Subscription Rule Example

Average `DBthroughput` from the low-level metrics `readps` and `writeps` of a database cluster comprised of *N* nodes:

```
DBthroughput = AVG(readps + writeps)
     MEMBERS = [id1, ... ,idN]
     ACTION = NOTIFY(<25,>75%)
```

Adaptive Filtering

- Simple fixed range filter windows are not effective:
  - i.e. filter currentValue if in window previousValue±R
  - No guarantee that any values will be filtered at all
- Adaptive filter window range
  - Window range (R) is not static but depends on percentage of values previously filtered



Evaluation

- Validate JCatascopia functionality and performance
- Compare JCatascopia to other Monitoring Tools
  - Ganglia
  - Lattice Monitoring Framework
- Testbed
  - Different domains of Cloud applications
  - Various VM flavors
  - 3 public Cloud providers and 1 private Cloud

Testbed

Cloud Provider	*VM no.*	*VM Flavor*	*Applications*
GRNET Okeanos public Cloud1	*15*	*1GB RAM, 10GB Disk, Ubuntu Server 12.04 LTS*	*12 VMs Cassandra[7] 3 VMs YCSB Clients[8]*
Flexiant FlexiScale platform2	*10*	*2 VCPU, 2GB RAM, 10GB Disk, Debian 6.07 (Squeeze)*	*HASCOP[9]*
Amazon EC23	*10*	*m1.small with CentOS 6.4 (1VCPU, 1.7GB RAM, 160GB*	*HASCOP*
UCY Nephelae Private Cloud4	*60*	*2 VCPU, 2GB RAM, 10GB Disk, Ubuntu Server 12.04 LTS*	*HASCOP*

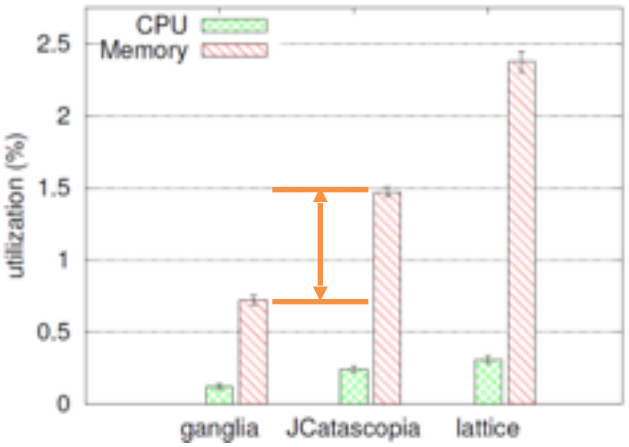
We have deployed on all VMs JCastascopia Monitoring Agents, Ganglia gmonds[5] and Lattice[6] DataSources

1 https://okeanos.grnet.gr/
2 http://www.flexiscale.com/
3 http://aws.amazon.com/ec2/
4 http://linc.ucy.ac.cy/Nephelae/
5 Ganglia v3.1.7
6 Lattice v0.6.4
7 http://cassandra.apache.org/
8 [B.F. Cooper, 2010]
9 [A. Papadopoulos, 2013]

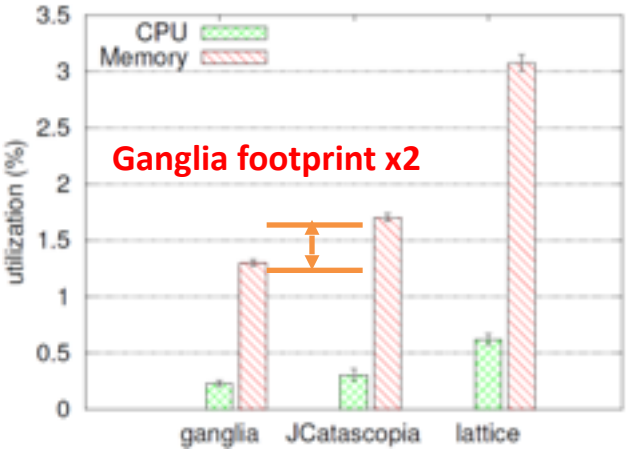
Testbed - Available Probes

Probe	*Metrics*	*Period (s)*
CPU	*cpuUserUsage, cpuNiceUsage, cpuSystemUsage, cpuIdle, cpuIOWait*	*10*
Memory	*memTotal, memUsed, memFree, memCache, memSwapTotal, memSwapFree*	*15*
Network	*netPacketsIN, netPacketsOUT, netBytesIN, netBytesOUT*	*20*
Disk Usage	*diskTotal, diskFree, diskUsed*	*60*
Disk IO	*readkbps, writekbps, iotime*	*40*
Cassandra	*readLatency, writeLatency*	*20*
YCSB	*clientThroughput, clientLatency*	*10*
HASCOP	*clustersPerIter, iterElapTime, centroidUpdTime, pTableUpdTime, graphUpdTime*	*20*

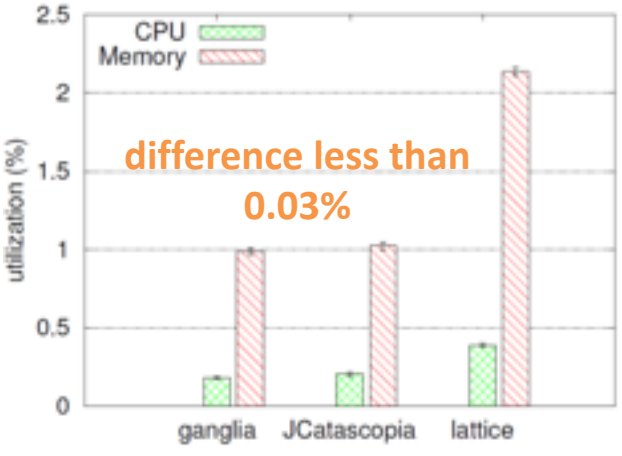
Monitoring Agent Runtime Footprint



YCSB Agent Client (11 metrics)

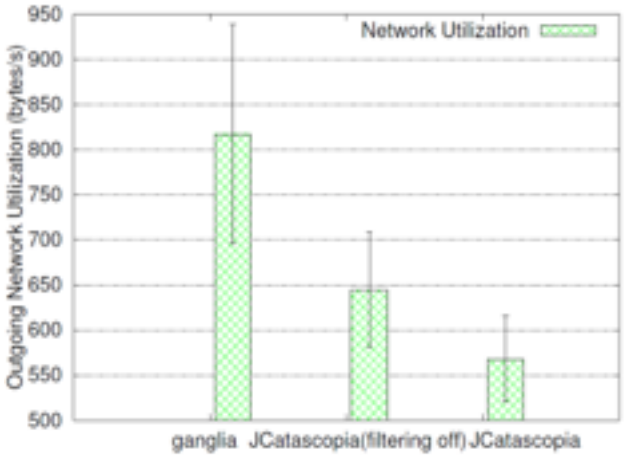


Cassandra Agent Utilization (27 metrics)



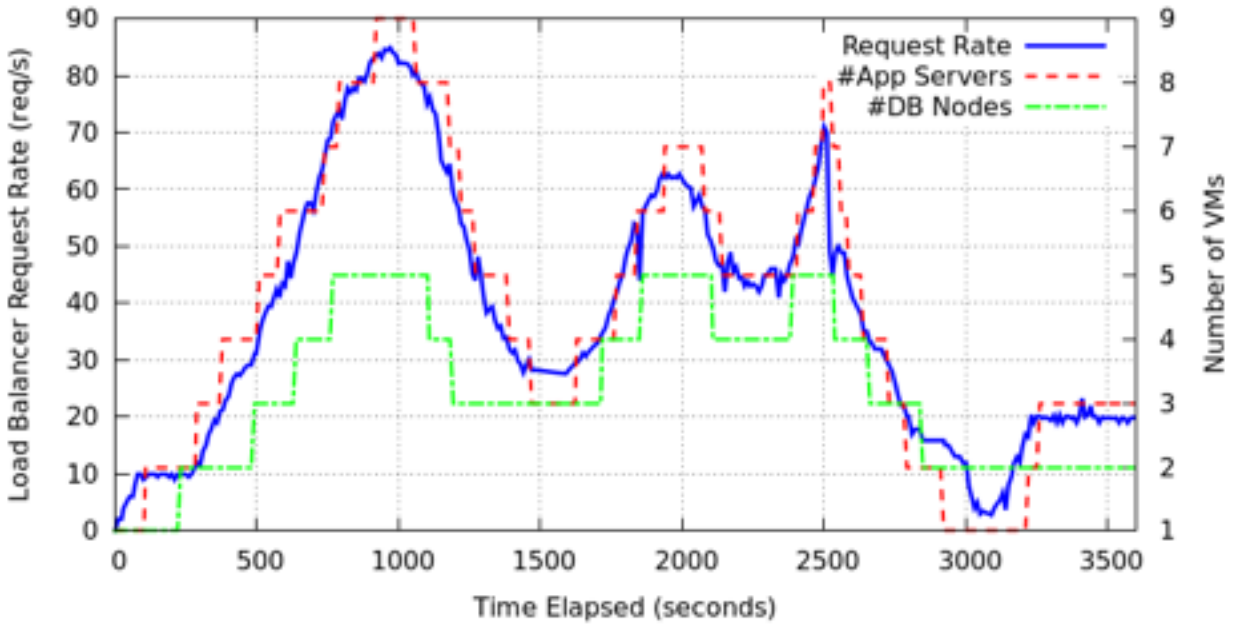
HASCOP (Distributed Clustering Algorithm) Agent (39 metrics)

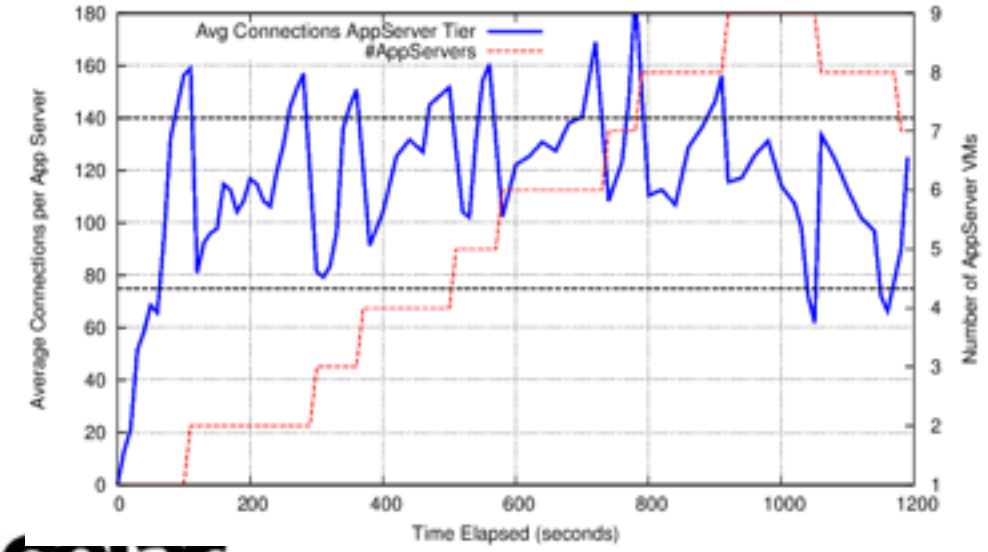
More Application-Specific Metrics



When in need of **application-level monitoring**, for a small runtime overhead, **JCatascopia** can **reduce** monitoring network traffic and consequently **monitoring cost**

Multi-Tier Monitoring





JCatascopia Metric Rule Language and Mechanism

```
avgActiveConnections = AVG(busyThreads)
MEMBERS = [id1, ... ,idN]
ACTION = NOTIFY(<70, >=140)
```

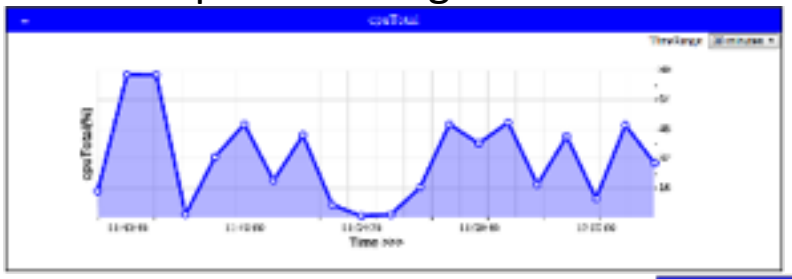
```
avgCPUUsage = AVG(1-cpuIdle)
MEMBERS = [id1, ... ,idN]
ACTION = NOTIFY(<30, >=85)
```

JCatascopia: Portability and Interoperability

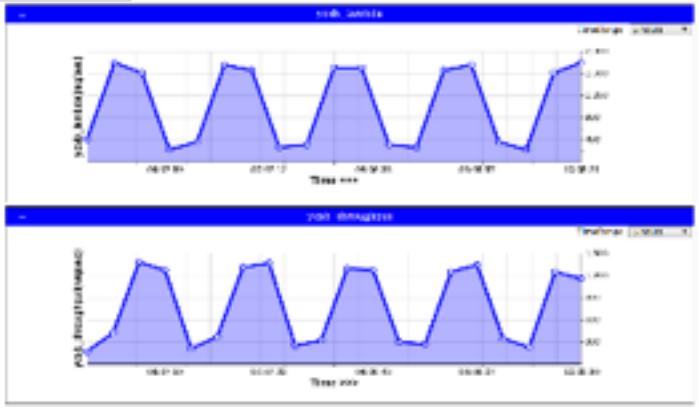
Online Gaming

Multi-Tier Video Streaming

Multi-Graph Clustering in the Cloud

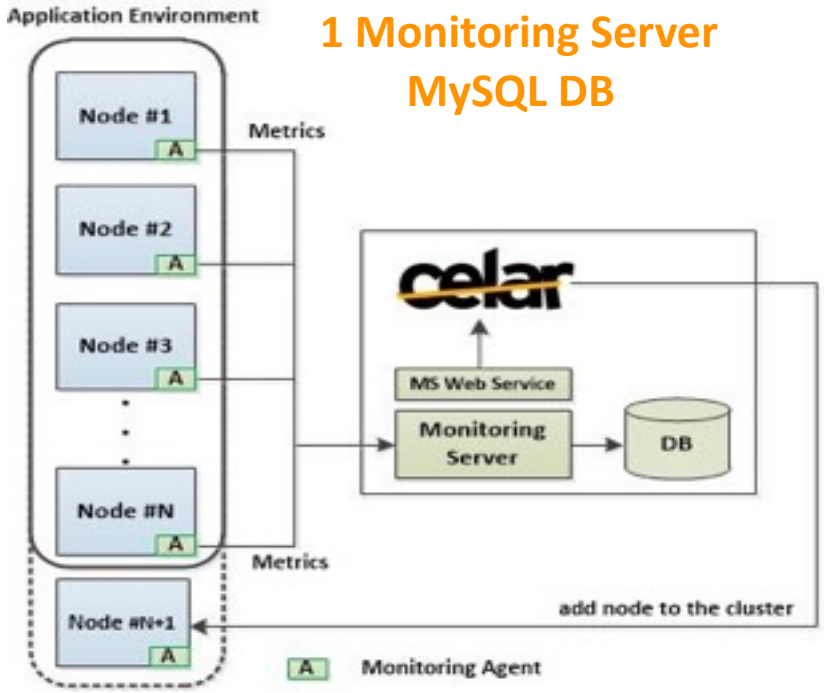


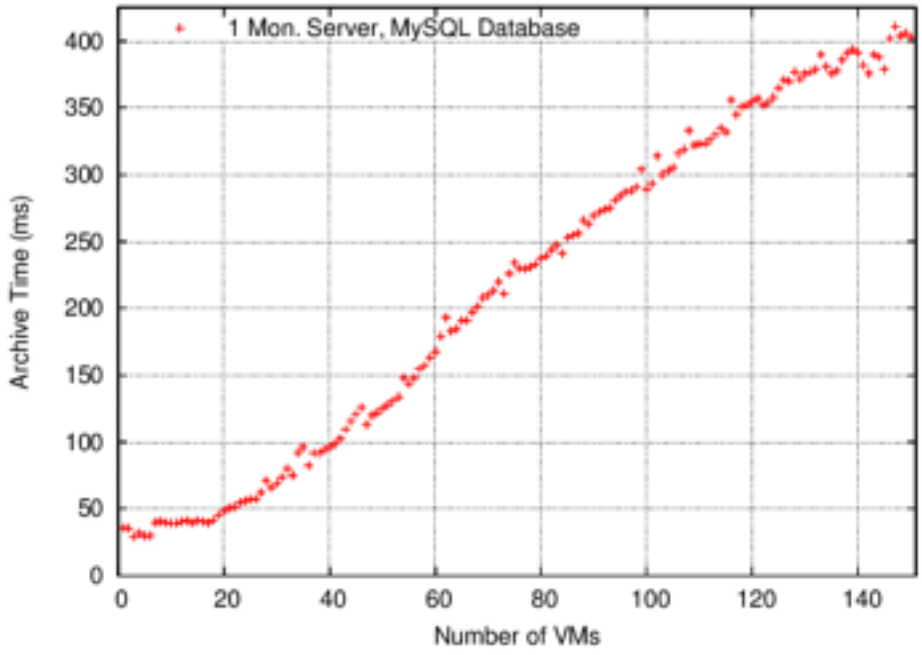
XDB In-Memory Data Analytics



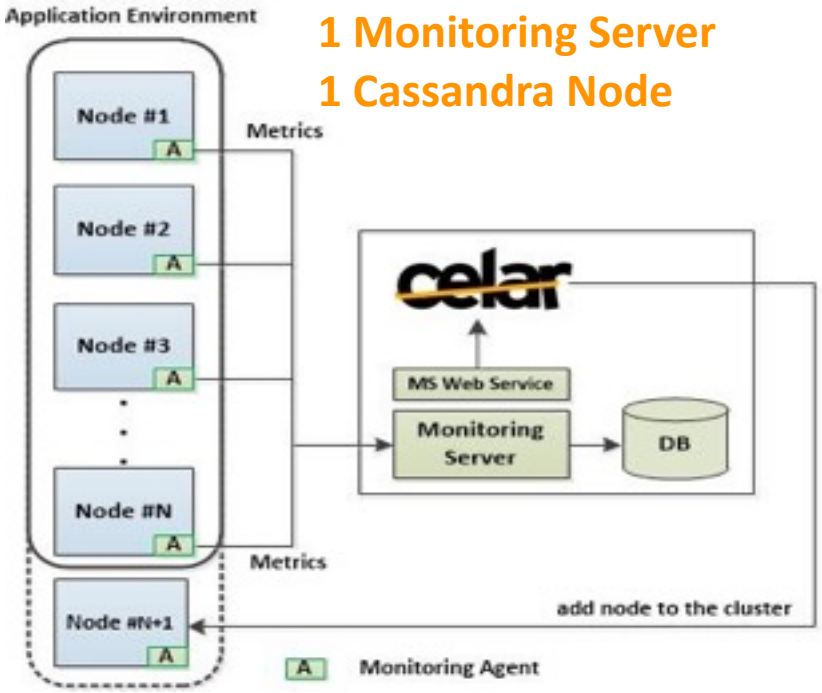
SCAN Genome Pipeline

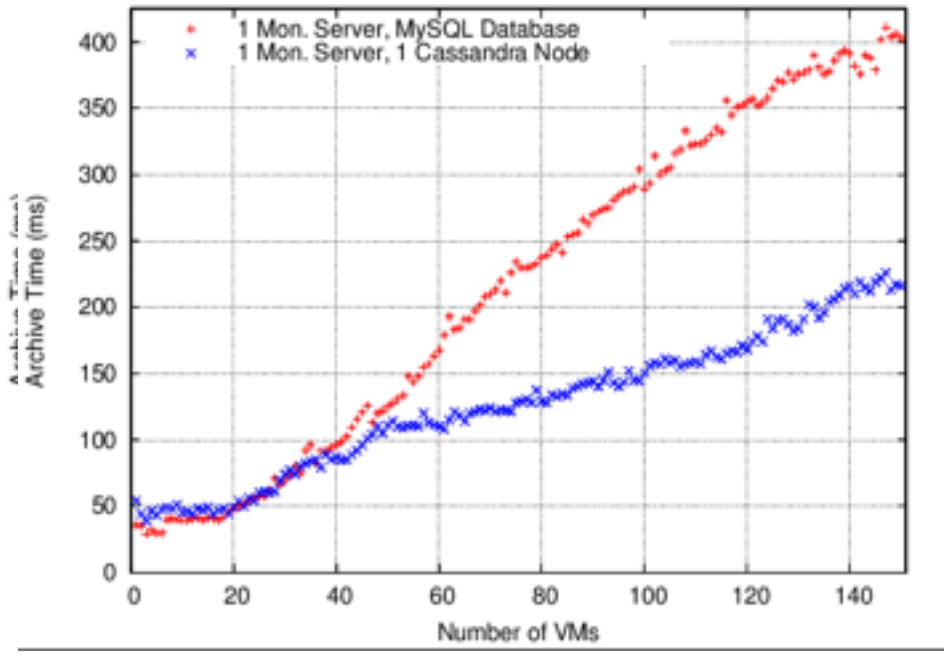
JCatascopia: Scalability Evaluation



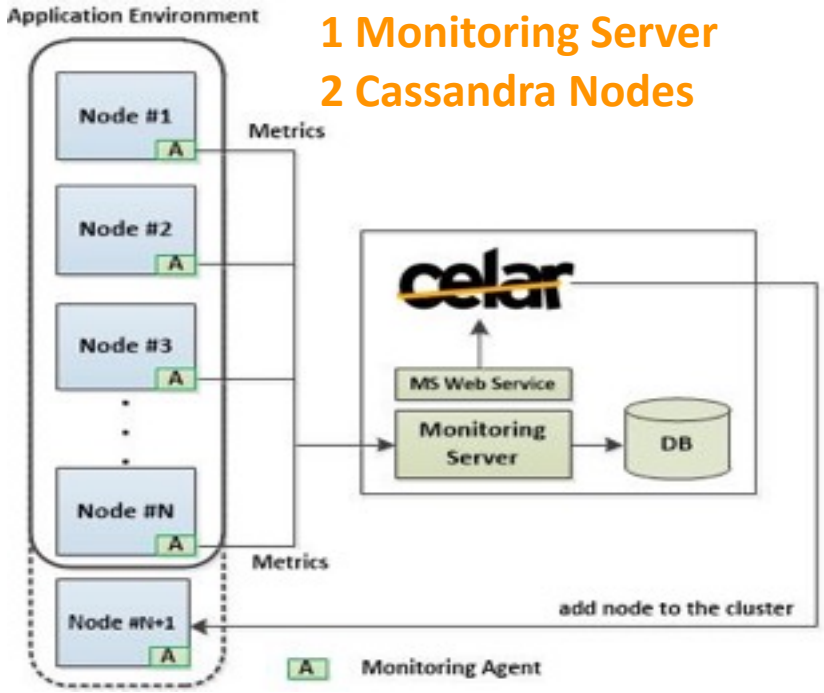


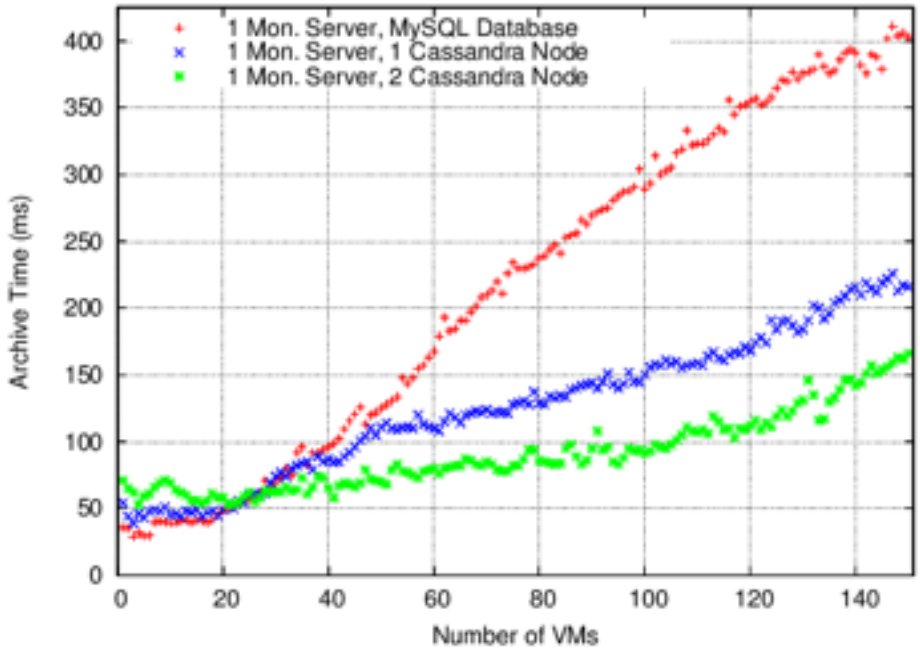
JCatascopia: Scalability Evaluation





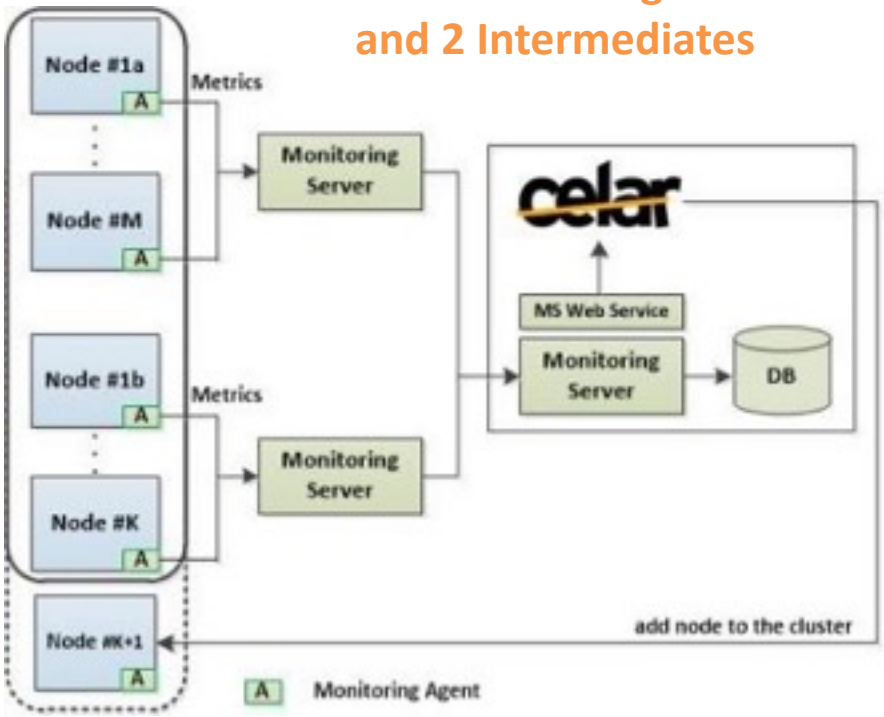
JCatascopia: Scalability Evaluation

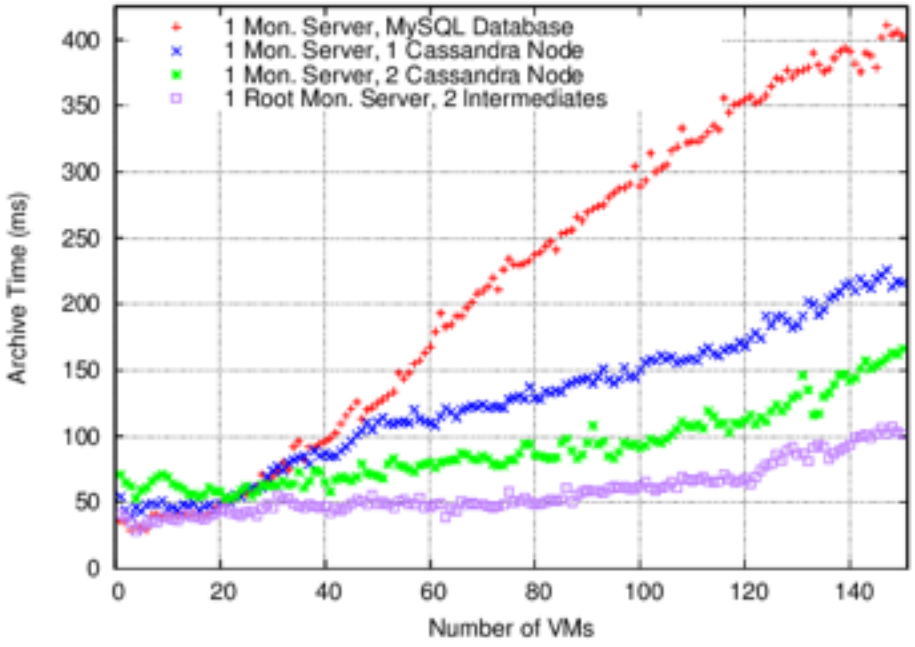




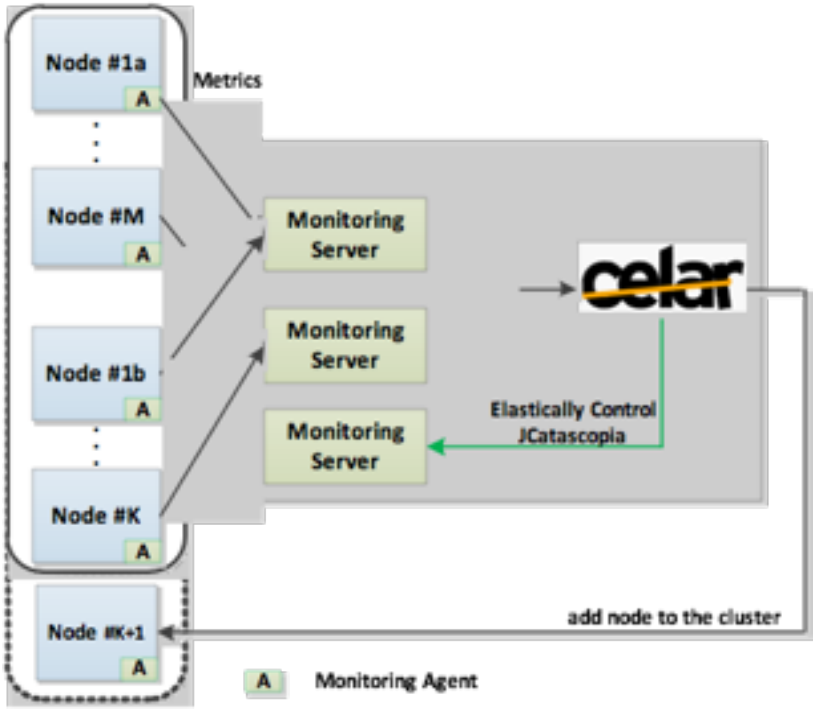
JCatascopia: Scalability Evaluation

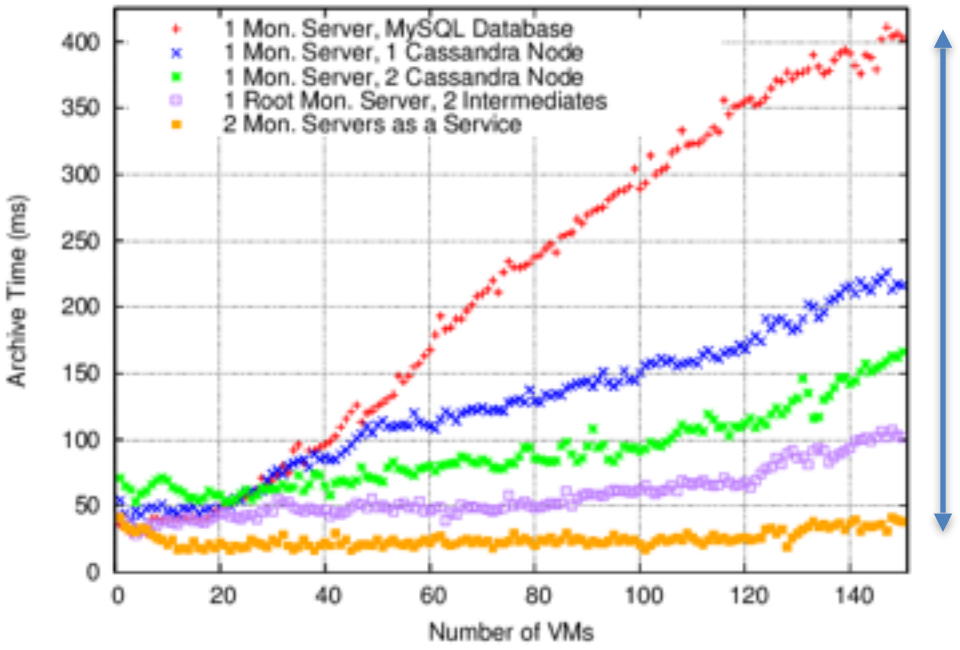
1 root Monitoring Server and 2 Intermediates





JCatascopia: Scalability Evaluation





When archiving time is high, we can direct monitoring metric traffic through multiple Monitoring Servers, allowing the monitoring system to scale

JCatascopia Release

- Open-source under **Apache 2.0 Licence**
  - **Github:** https://github.com/CELAR/cloud-ms
- JCatascopia Website (docs, examples, videos, publications, etc.)
  - http://linc.ucy.ac.cy/CELAR/jcatascopia
- Packaging (**JARs, tarballs, RPMs and Chef recipes**) available in CELAR repo
- JCatascopia **Probe Library** and Java Probe API
  - https://github.com/dtrihinas/JCatascopia-Probe-Library
  - System-level monitoring probes (for both Linux and Windows)
  - Application-specific probes (Tomcat, Cassandra DB, HAProxy, Postgres DB, RabbitMQ)
- Supporting **2 Different Database Backends** (MySQL, Cassandra DB)

OUTLINE

- Cloud Computing
- CELAR main topics:
  - Elasticity
  - Application Management
- CELAR Architecture
- Elasticity and Monitoring - JCatascopia
- **c-Eclipse and CAMF**
- Conclusions

Cloud Application Management

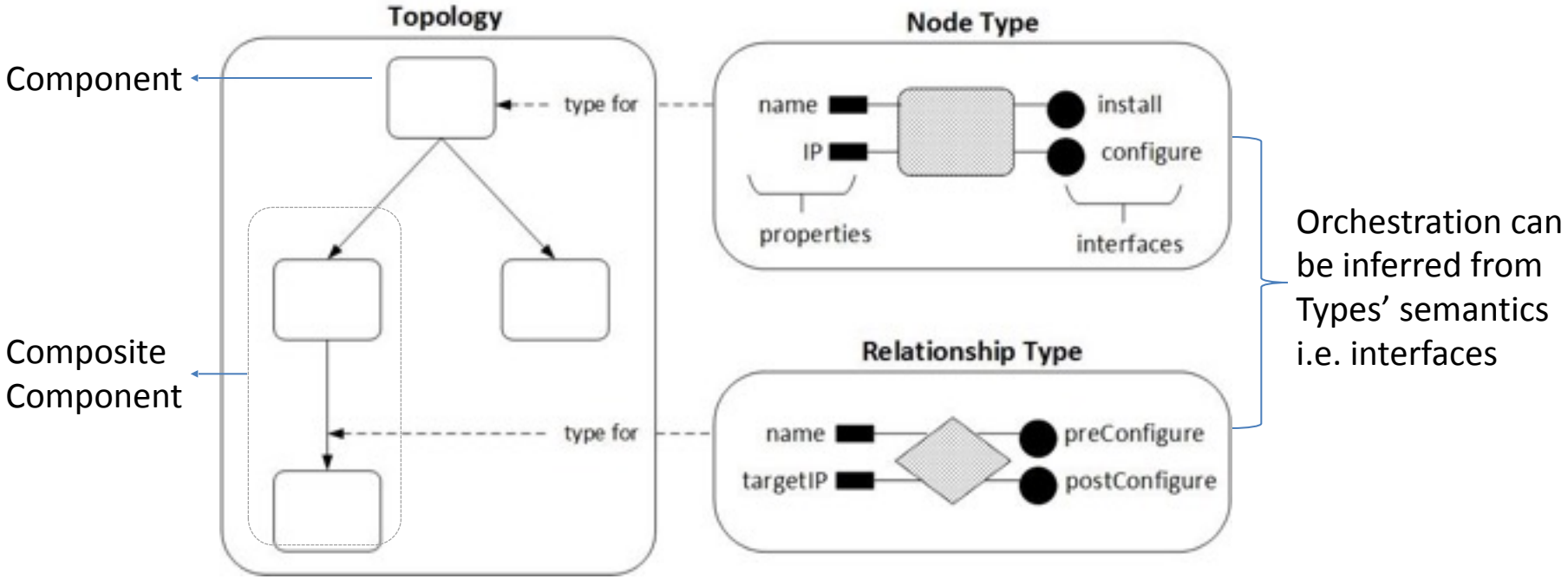
- Goal: ease the description & deployment of applications over Cloud infrastructures.
- However:
  - Most frameworks are vendor-specific and fail to address one of the main challenges in cloud application management, that is the vendor neutrality [Gartner]
  - Proprietary
  - Provide limited support for elasticity


c-Eclipse

- Open-source (on top of Eclipse platform)
- Manages Complete Cloud Application Life Cycle
- Platform independent
- Intuitive graphical drag-and-drop UI
- Adopts open Cloud specifications
- Separates general-purpose functionality from IaaS platform-specific details (portable/extensible)
- Supports an open language for describing Cloud applications' elasticity requirements

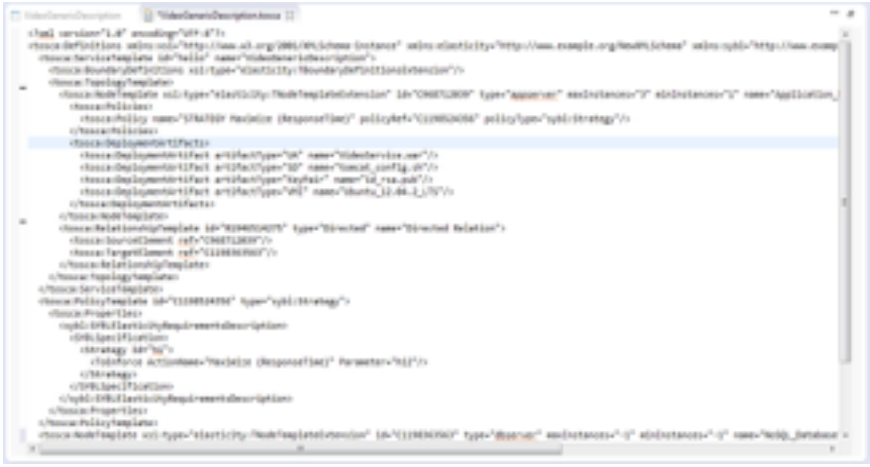
TOSCA

- TOSCA provides a language to describe:
  - Application components & relationships (topology)
  - Application management procedures (orchestration)

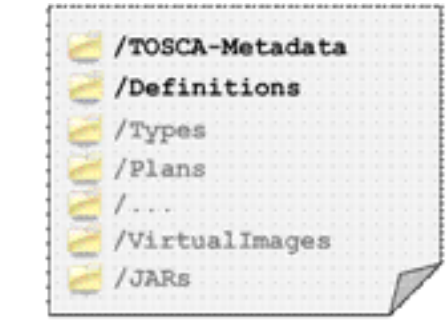


TOSCA

- Specifies an XML Binding
  - Implemented in c-Eclipse

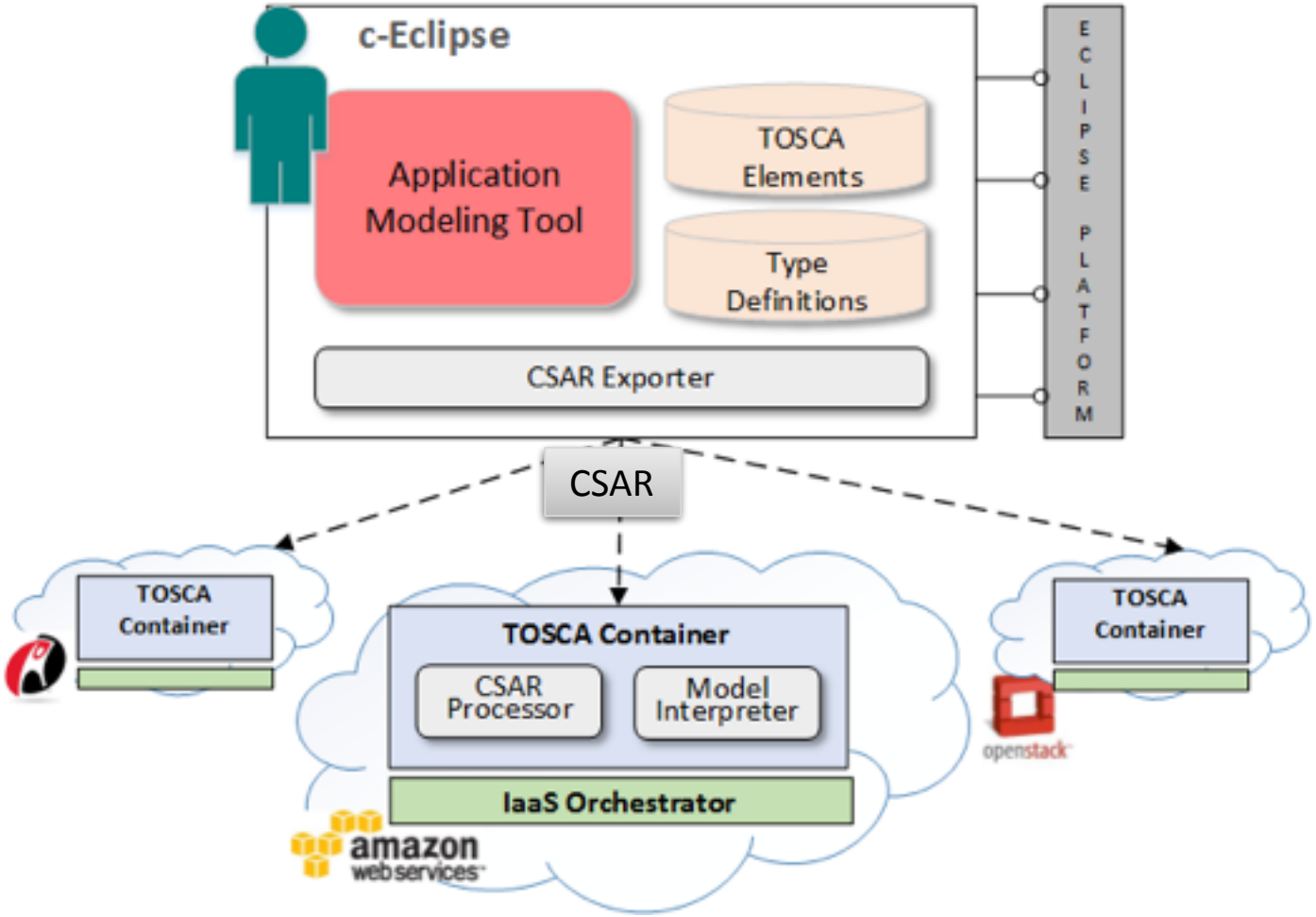


- Specifies CSAR (Cloud Service Archive) an exchange format to package Cloud applications



CSAR Format

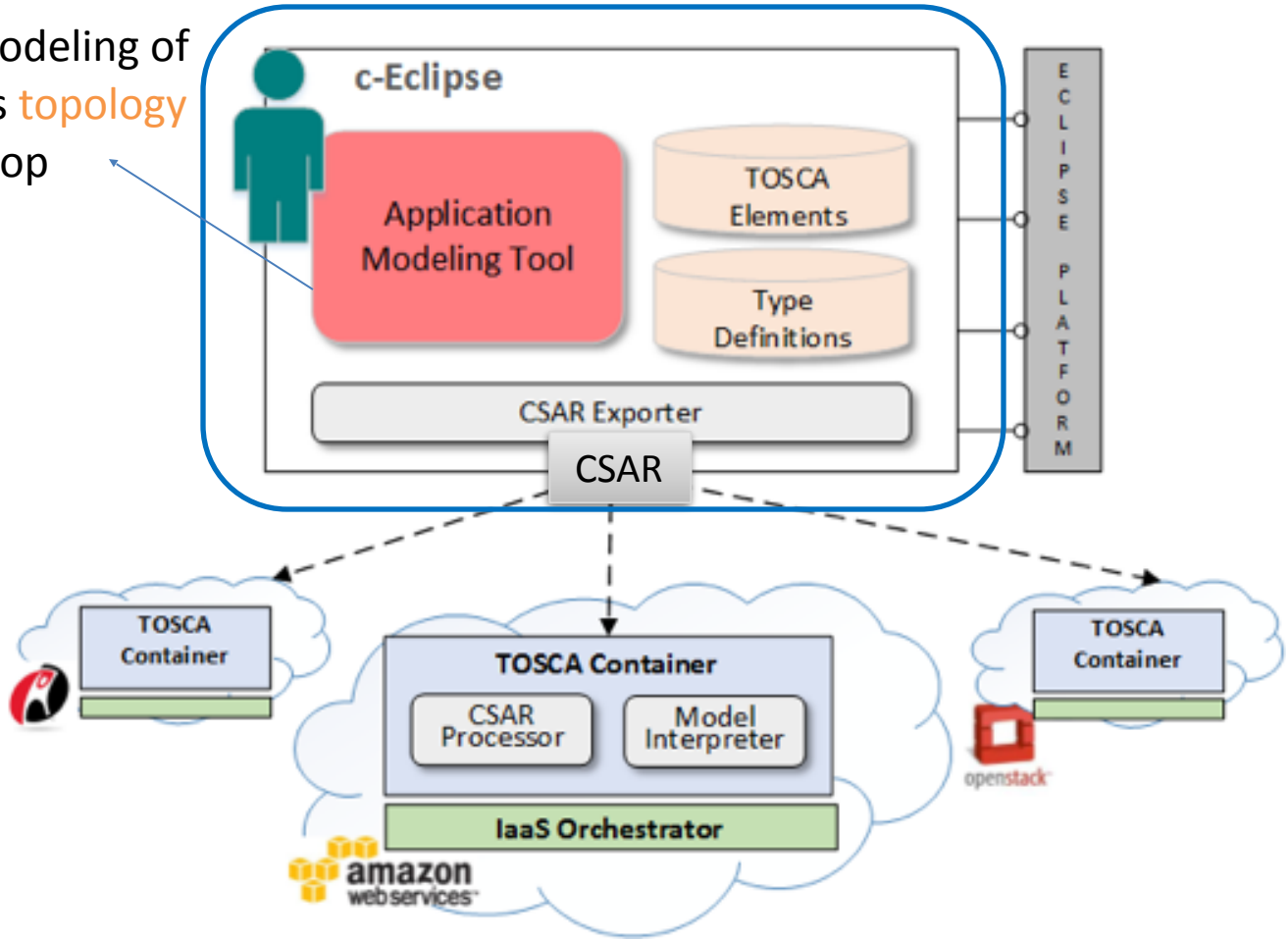
c-Eclipse Architecture



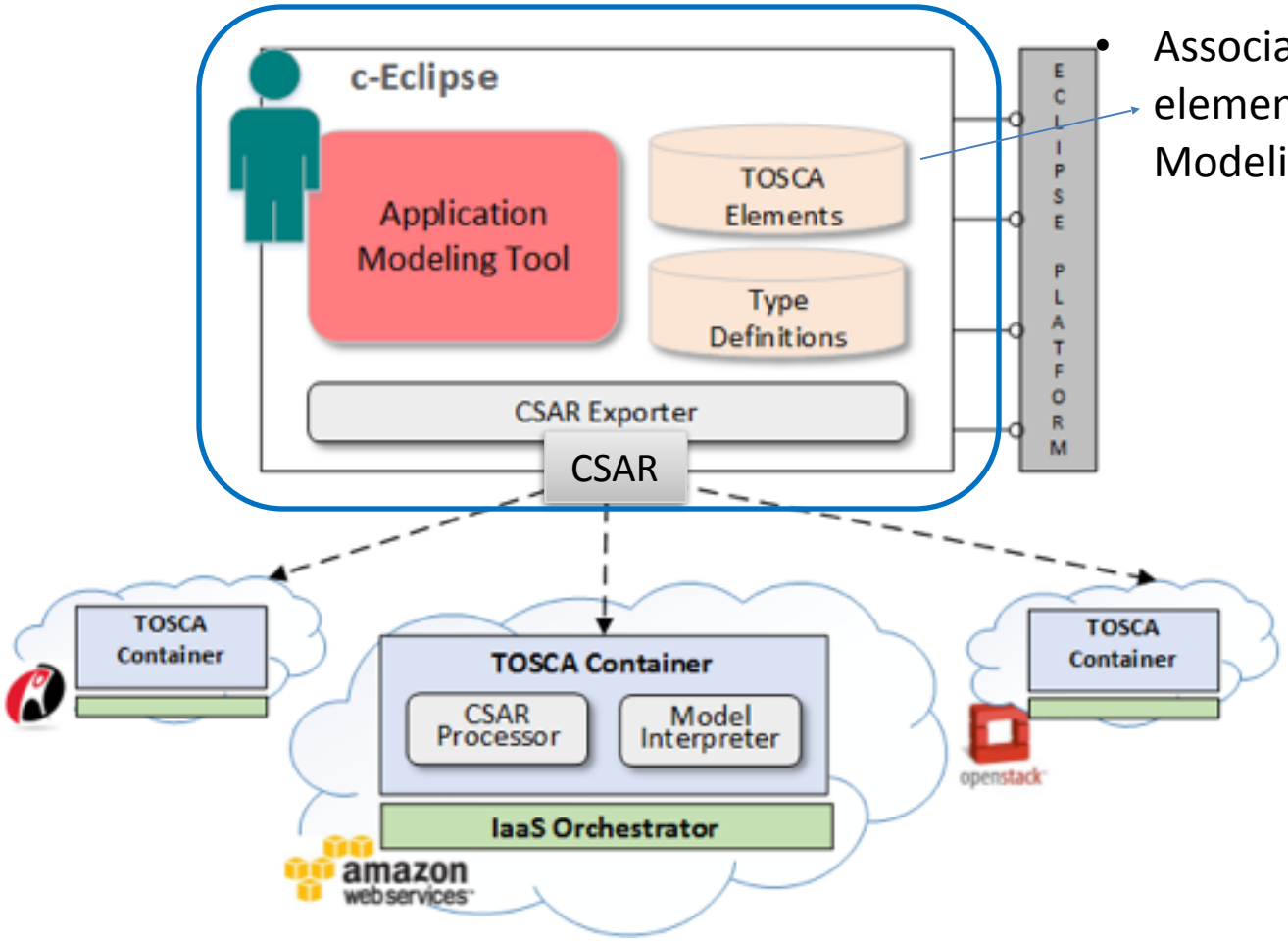
"c-Eclipse: An Open-Source Management Framework for Cloud Applications" C. Sofokleous, N. Loulloudes, D. Trihinas, G. Pallis and M. Dikaiakos, *EuroPar 2014*

c-Eclipse Architecture

- Graphical modeling of application's topology
- Drag-and-drop interface

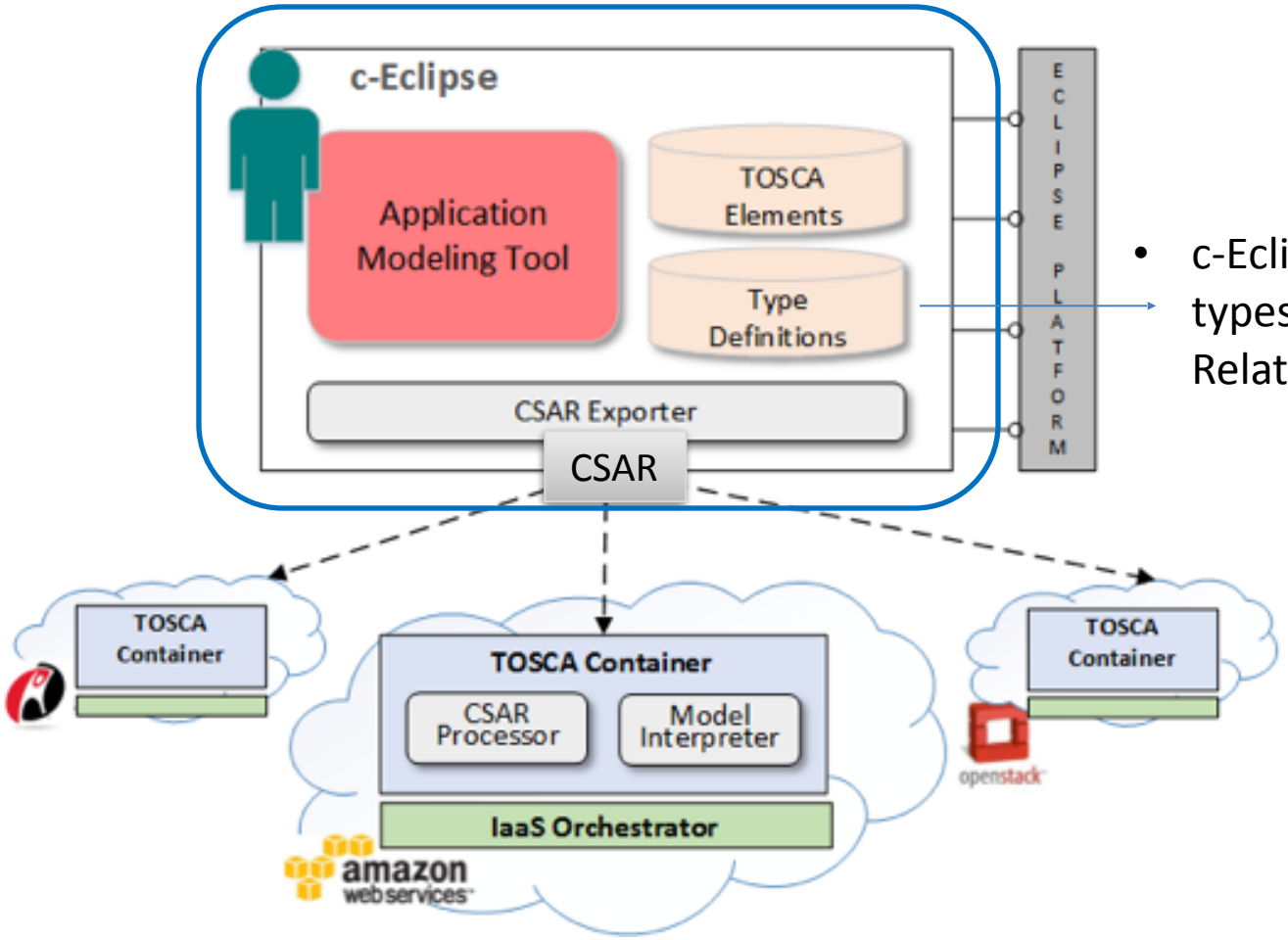


c-Eclipse Architecture



- Associated with visual elements by the Modeling Tool

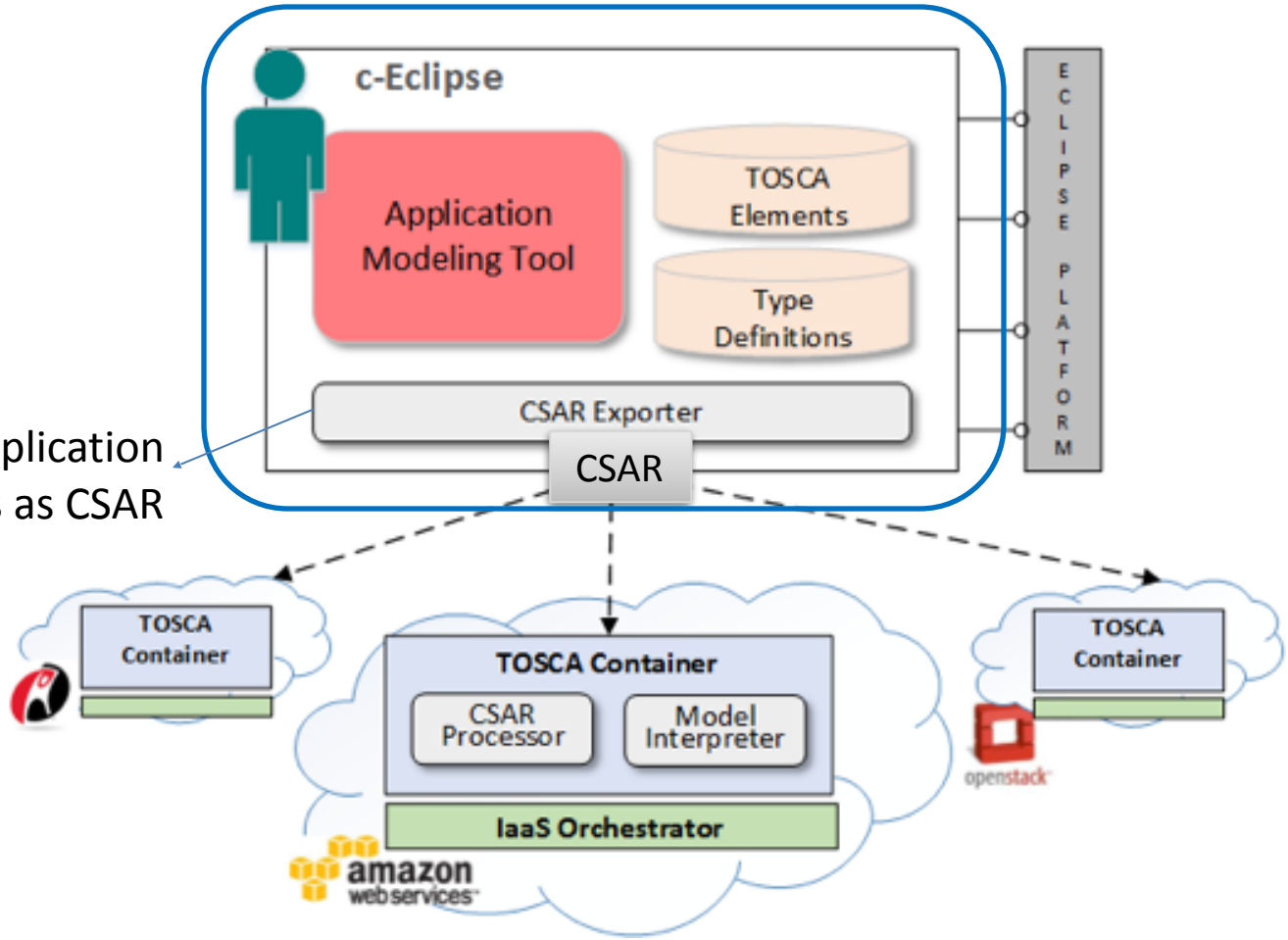
c-Eclipse Architecture



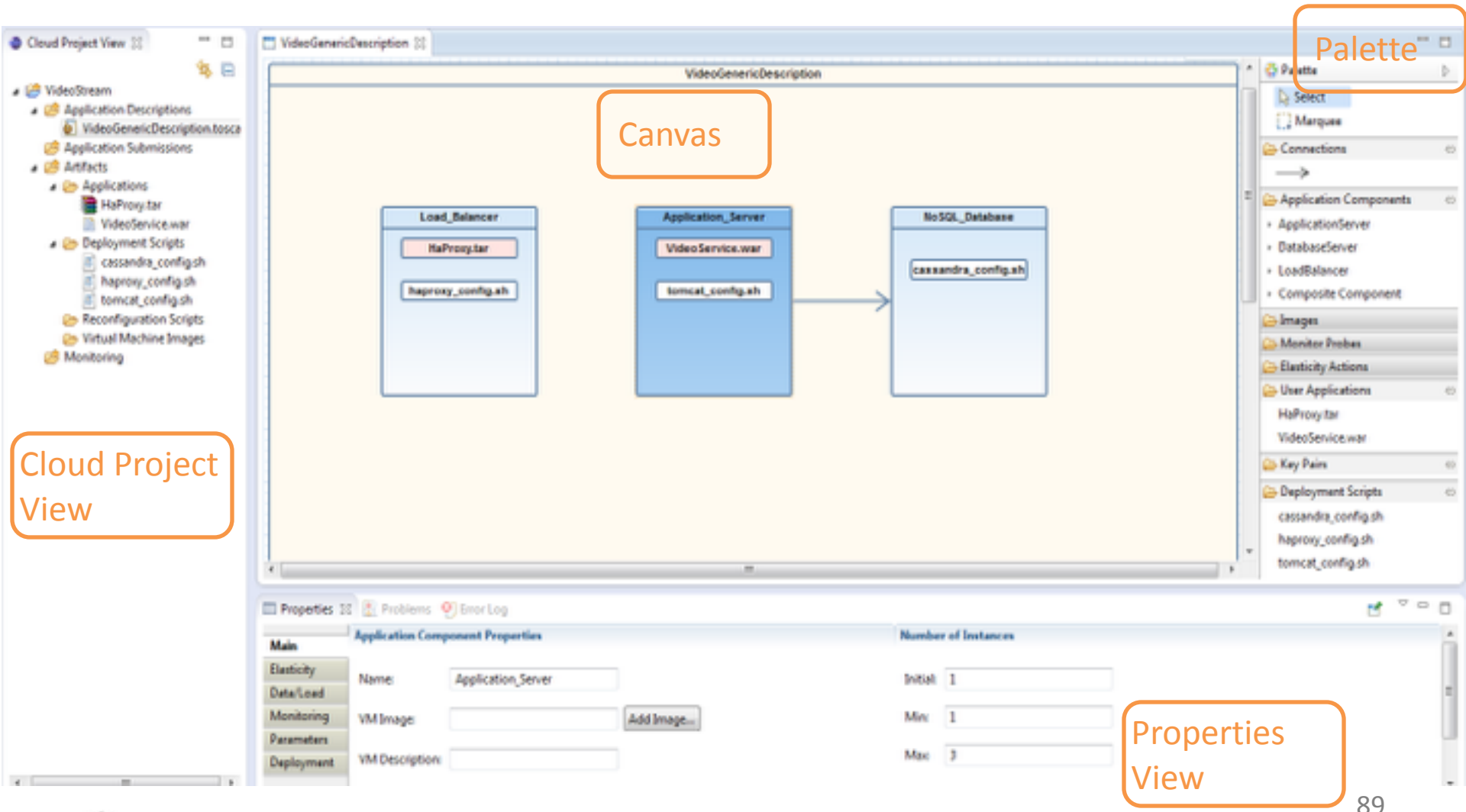
- c-Eclipse specific types for Nodes, Relationships etc.

c-Eclipse Architecture

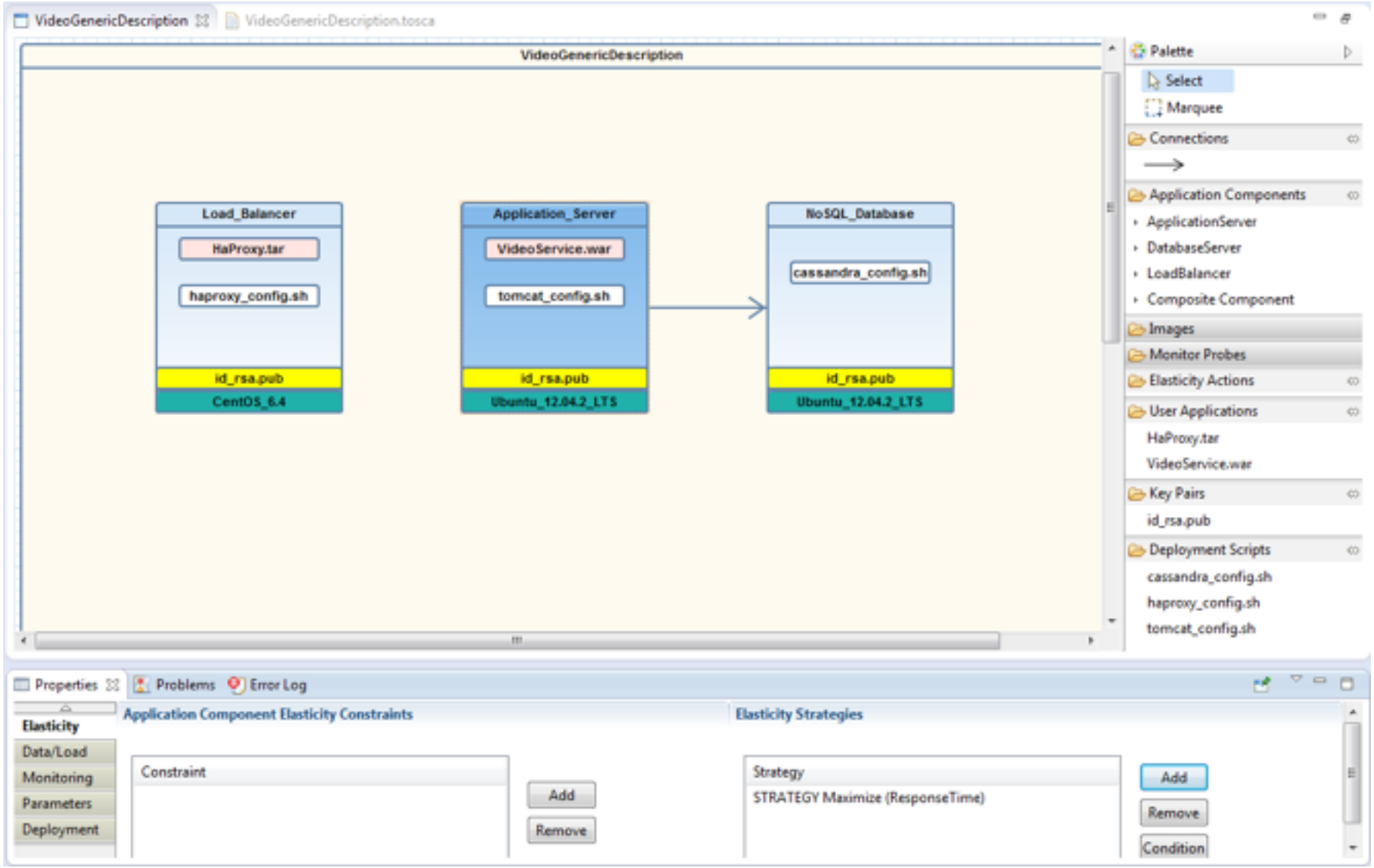
- Packages application descriptions as CSAR archives



Application Modeling Tool

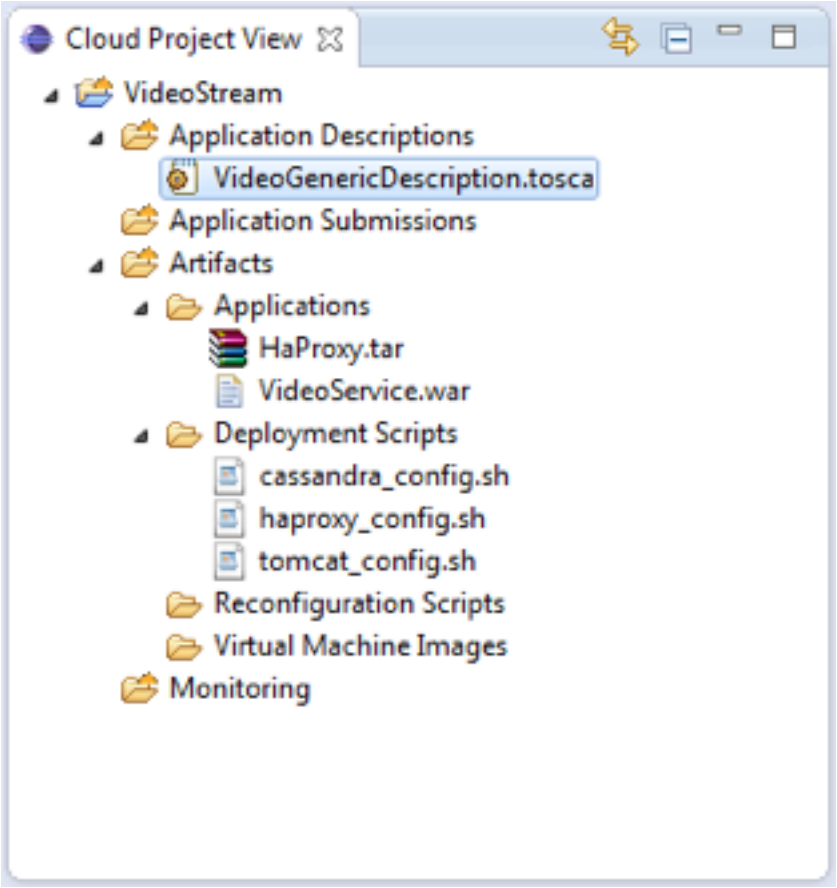


Graphical TOSCA Modeling

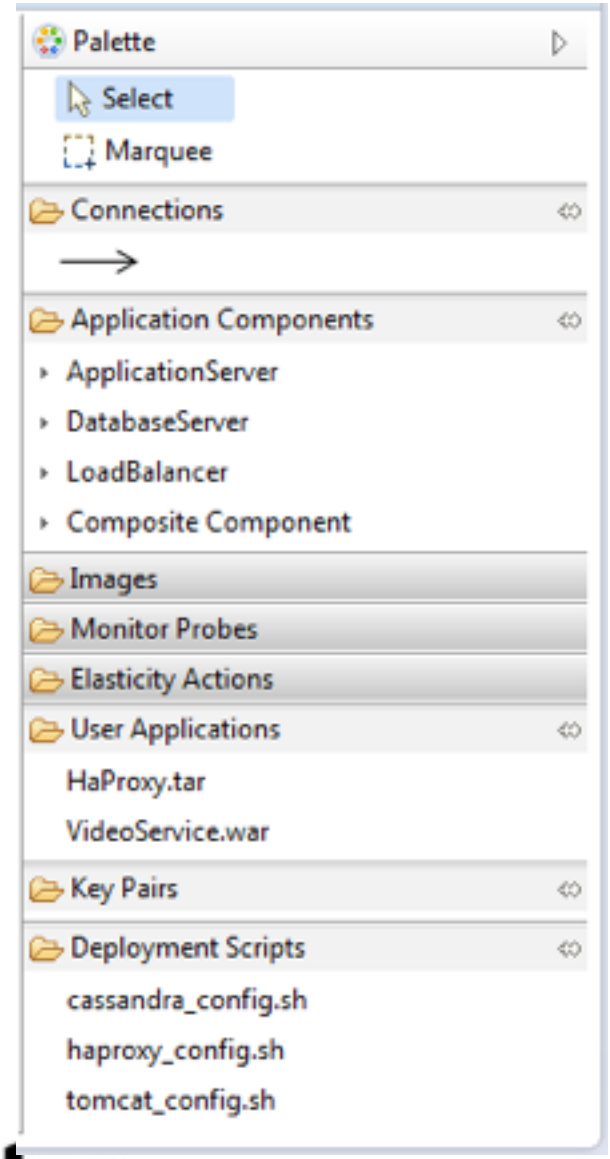


Cloud Project View

- c-Eclipse organizes files in a structured hierarchy
  - Just like any other Eclipse project
- Folders are placeholders for files required throughout application's lifecycle i.e.
  - Content needed to realize a deployment (executables, configuration files, VM images etc.)
- Folders' structure is automatically created on project's creation

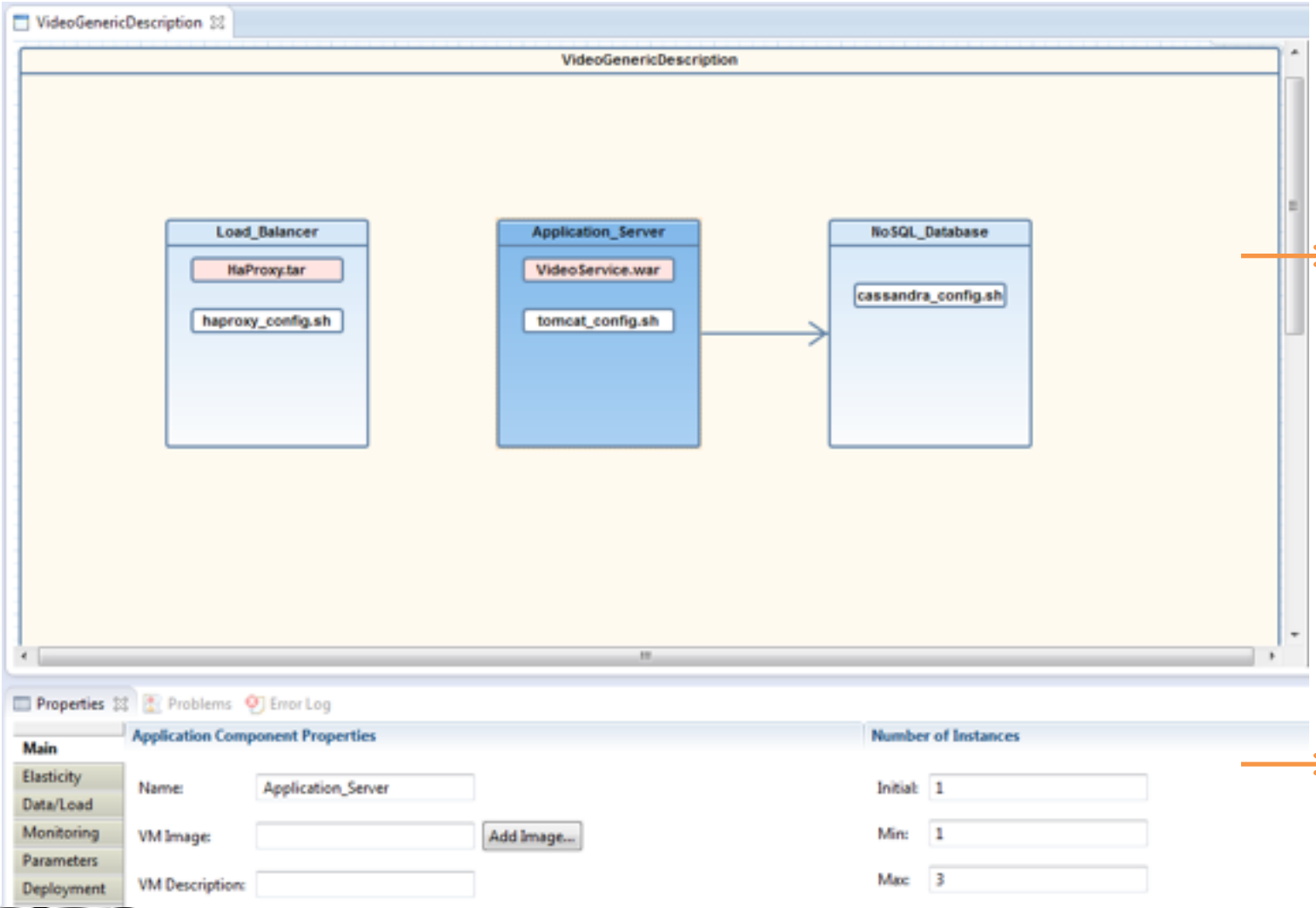


Palette



- **Connections**: Different relationship types can be specified i.e. "Depends On", "Connects To"
- **Application Components**: Application component types + composite component
- **Images**: Provider's images & user's custom built images
- **Monitoring Probes**: Monitoring metrics available by the provider's monitoring system or by the integrated to c-Eclipse monitoring system
- **Elasticity Actions**: Provider supported elasticity actions & user's custom elasticity actions
- **User Applications**: User's custom created applications
- **Key Pairs**: Generated by the user, used for accessing the deployed components
- **Deployment Scripts**: User's custom configuration scripts

Canvas / Properties View

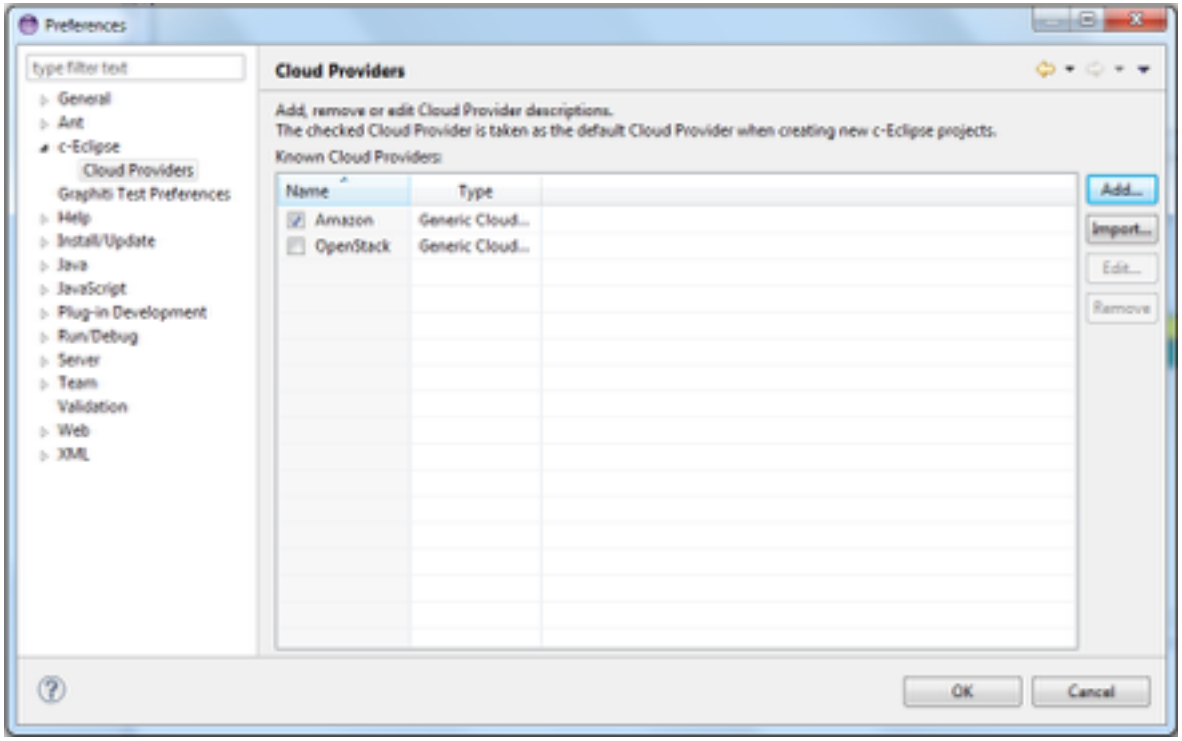


Palette elements can be dragged-and-dropped onto the canvas

More details can be specified through the Properties View

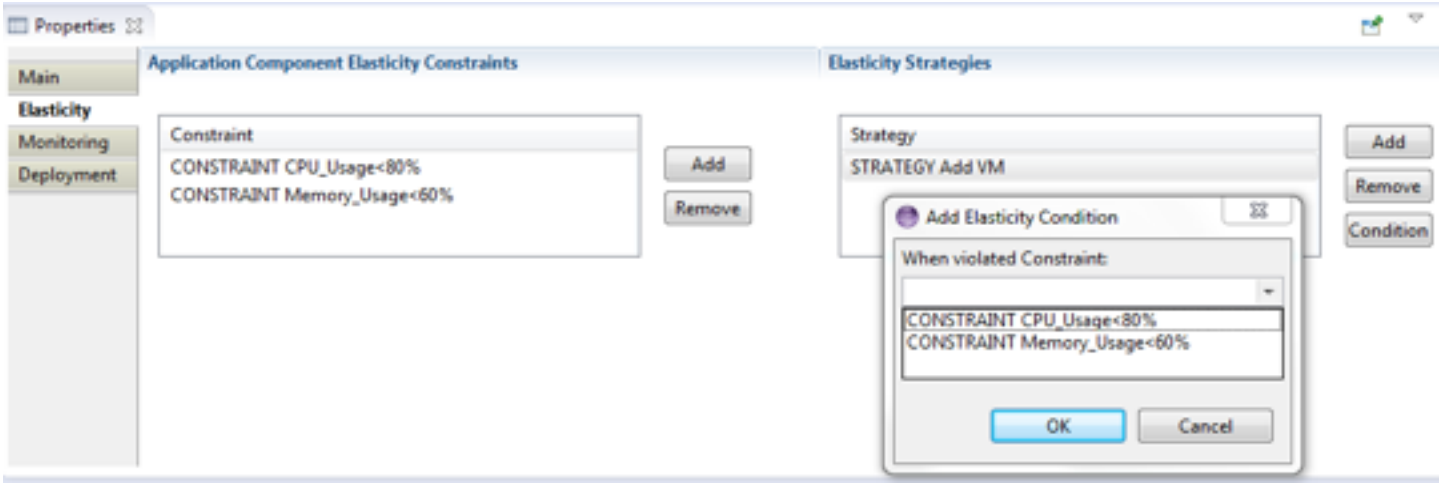
Cloud Provider Selection

- Users can select Cloud providers for deploying their applications
  - Authentication credentials must be provided
  - c-Eclipse uses vendor's API to retrieve required info



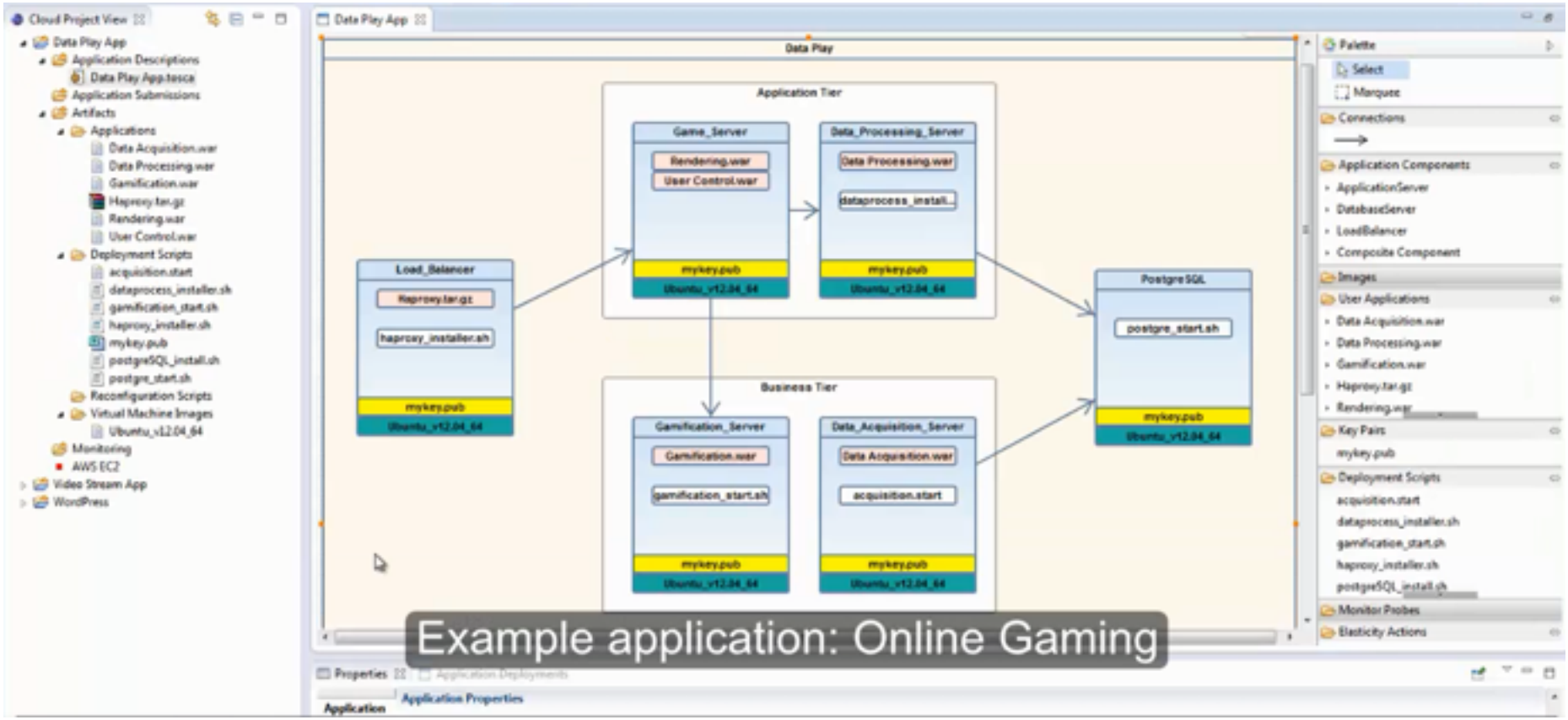
Elasticity Policies Specification

- c-Eclipse facilitates the specification of applications' elasticity policies
- Applications can scale at runtime based on user defined policies

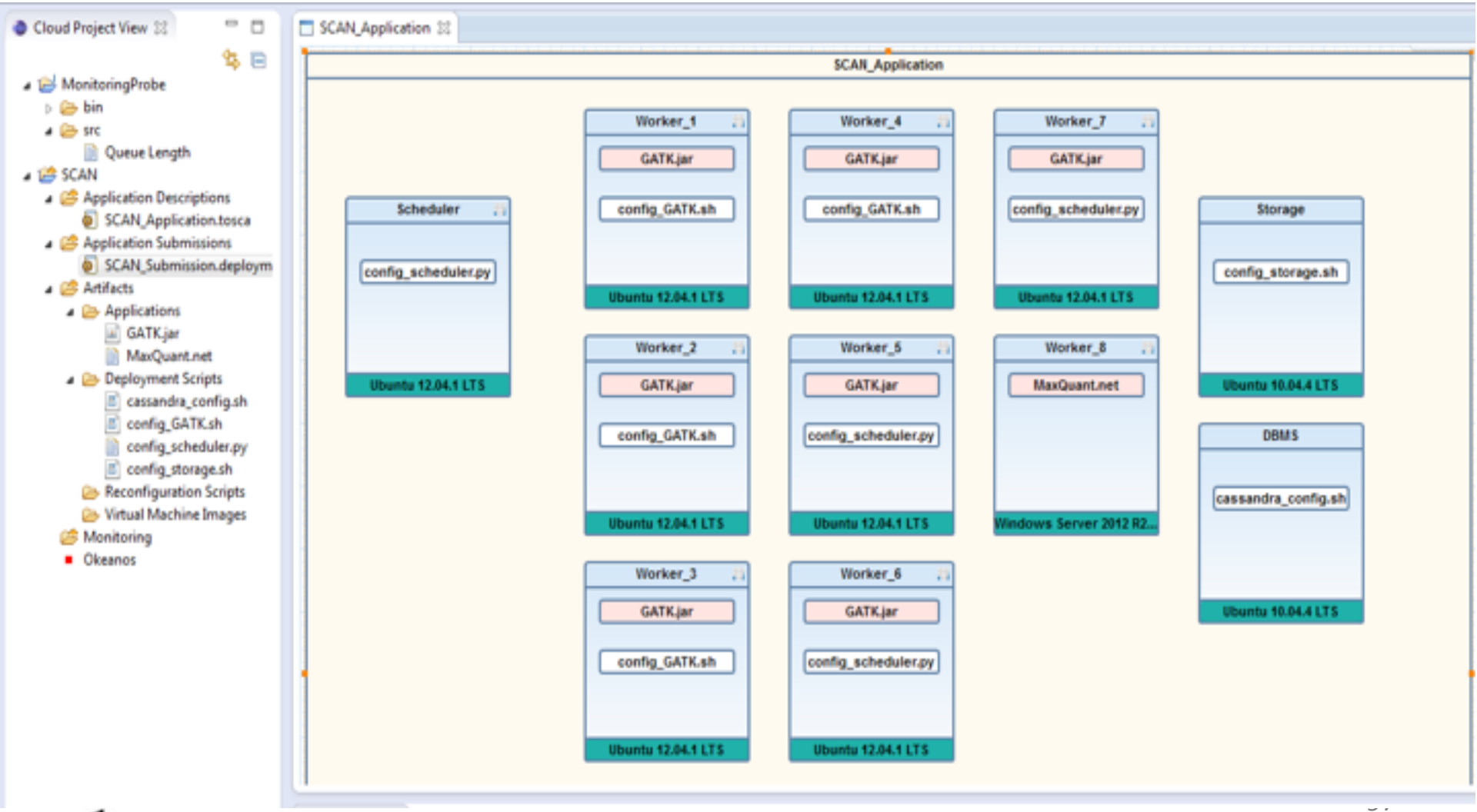


c-Eclipse Properties View: Elasticity Policies Specification

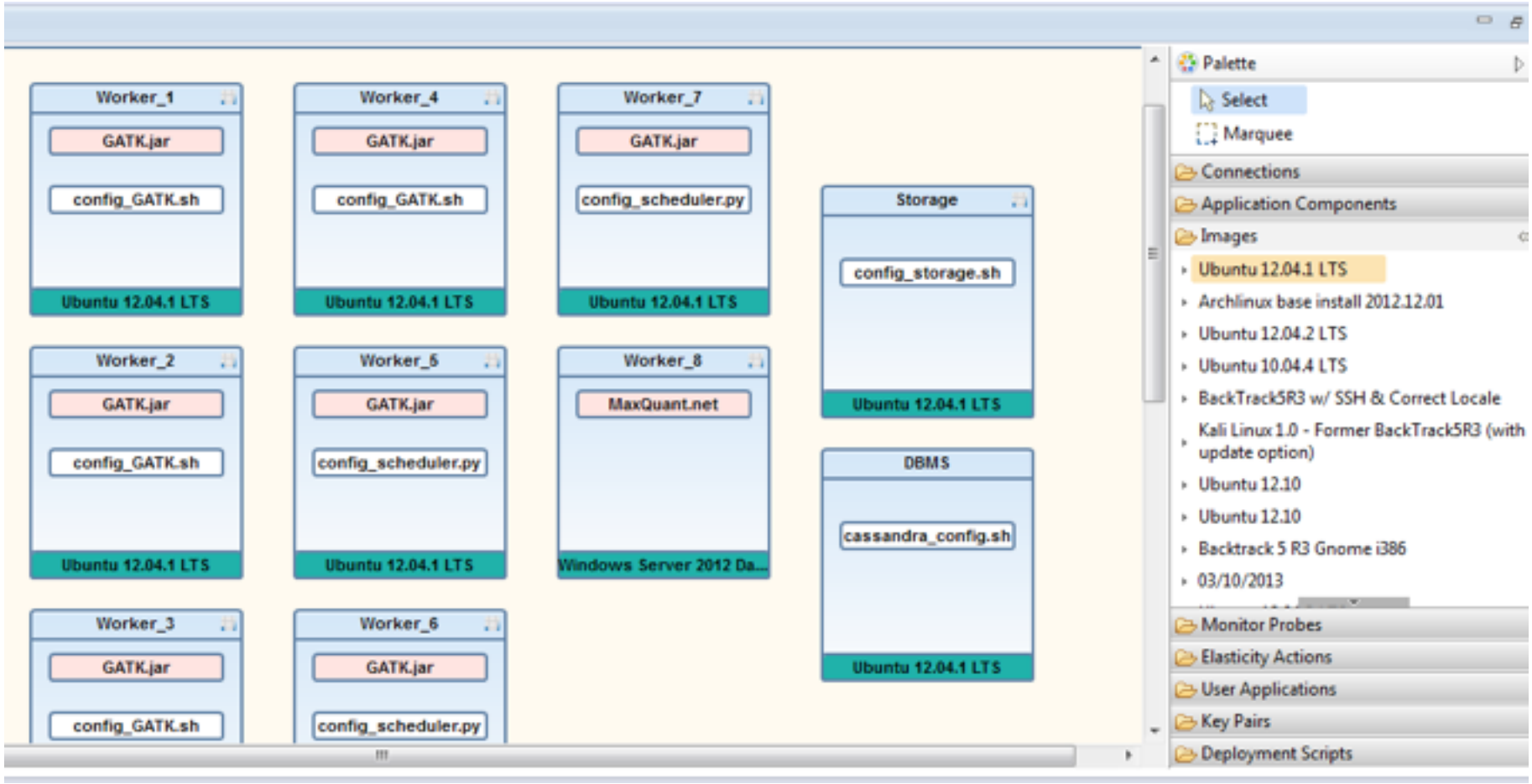
DataPlay in c-Eclipse



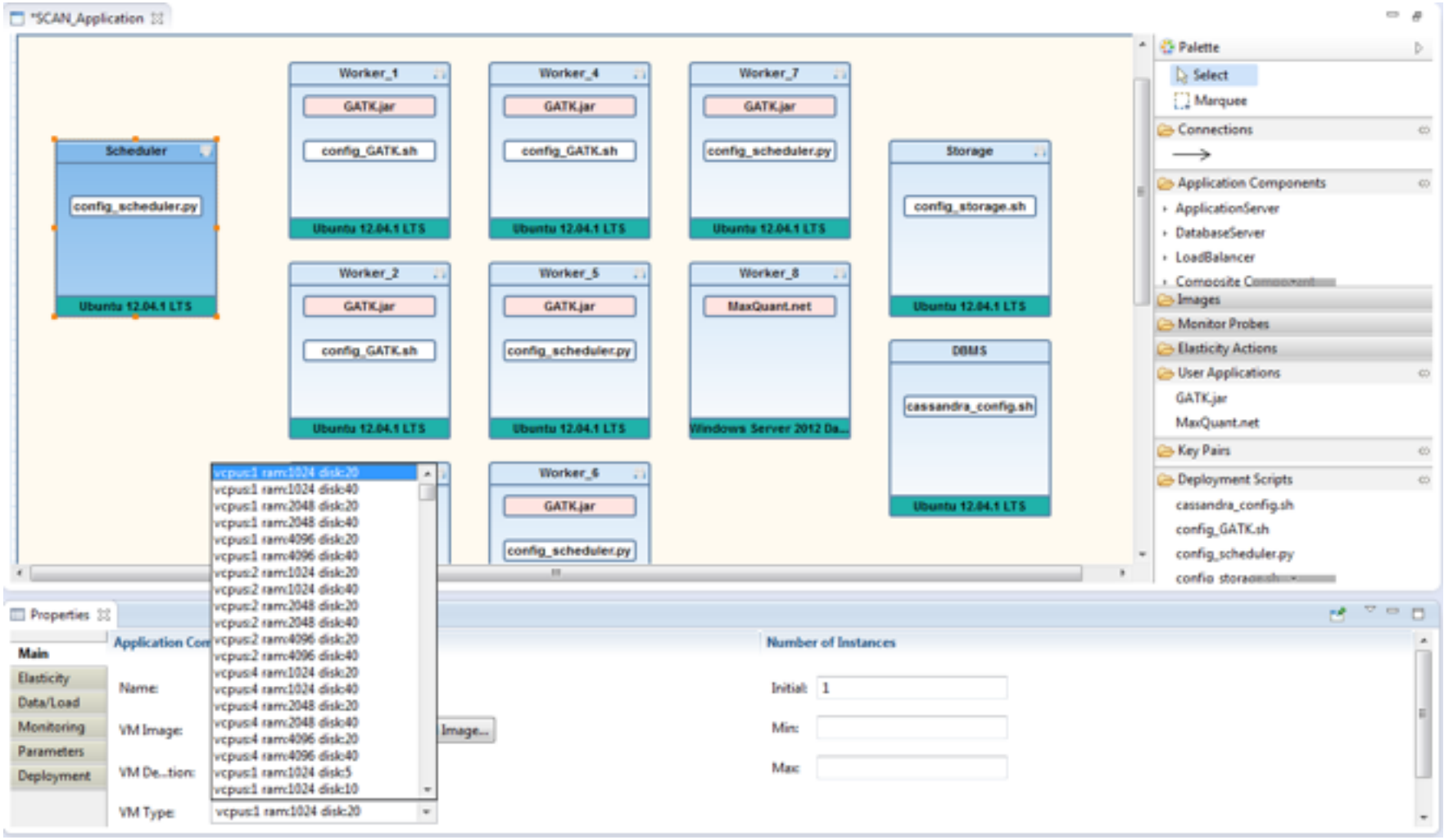
Cancer Genome Detection in c-Eclipse



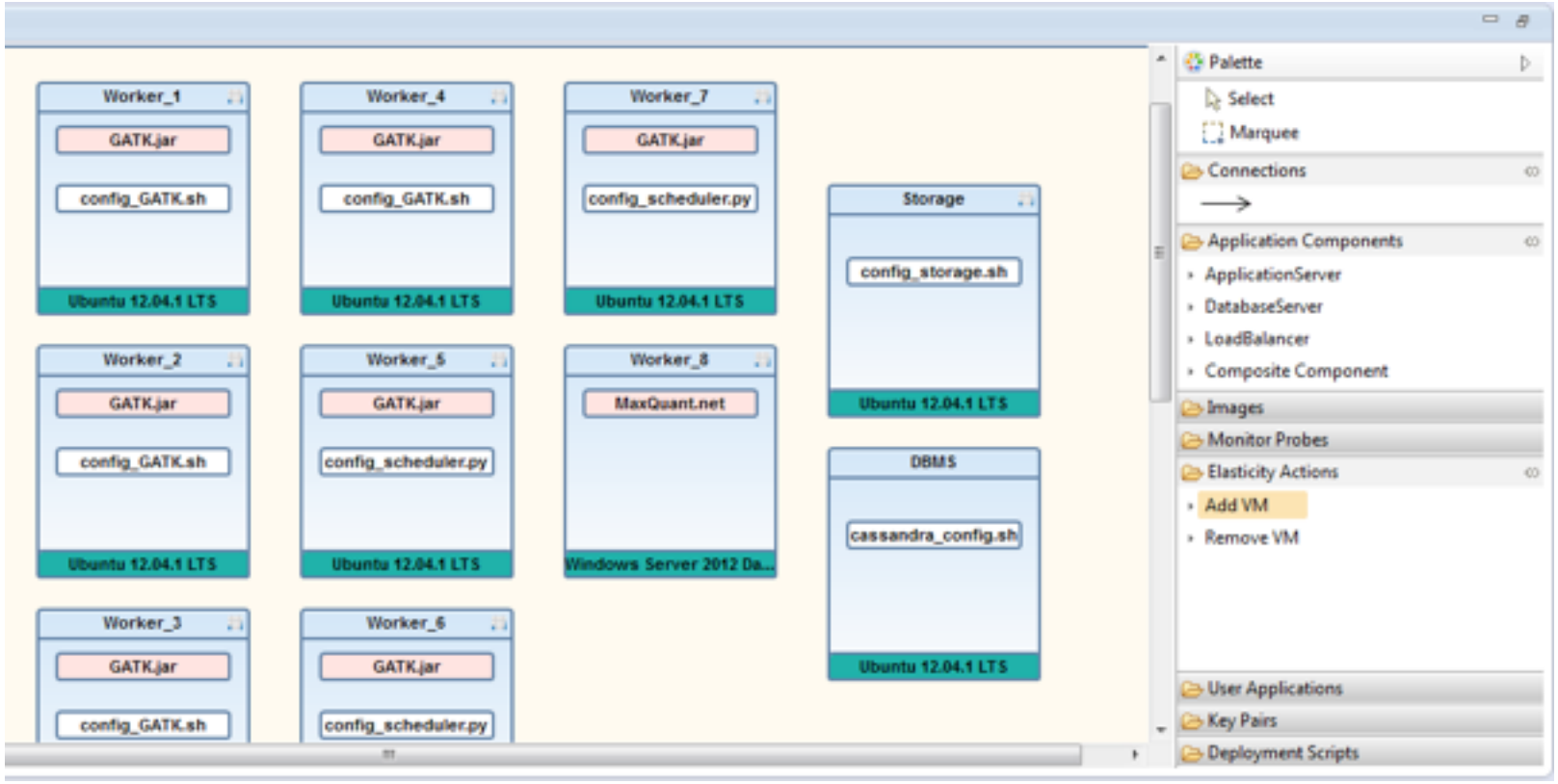
Images


Worker_1
GATK.jar
config_GATK.sh
Ubuntu 12.04.1 LTS
Worker_4
GATK.jar
config_GATK.sh
Ubuntu 12.04.1 LTS
Worker_7
GATK.jar
config_scheduler.py
Ubuntu 12.04.1 LTS
Storage
config_storage.sh
Ubuntu 12.04.1 LTS
Worker_2
GATK.jar
config_GATK.sh
Ubuntu 12.04.1 LTS
Worker_5
GATK.jar
config_scheduler.py
Ubuntu 12.04.1 LTS
Worker_8
MaxQuant.net
Windows Server 2012 Da...
DBMS
cassandra_config.sh
Ubuntu 12.04.1 LTS
Worker_3
GATK.jar
config_GATK.sh
Worker_6
GATK.jar
config_scheduler.py
Palette
Select
Marquee
Connections
Application Components
Images
Ubuntu 12.04.1 LTS
Archlinux base install 2012.12.01
Ubuntu 12.04.2 LTS
Ubuntu 10.04.4 LTS
BackTrack5R3 w/ SSH & Correct Locale
Kali Linux 1.0 - Former BackTrack5R3 (with update option)
Ubuntu 12.10
Ubuntu 12.10
Backtrack 5 R3 Gnome i386
03/10/2013
Monitor Probes
Elasticity Actions
User Applications
Key Pairs
Deployment Scripts

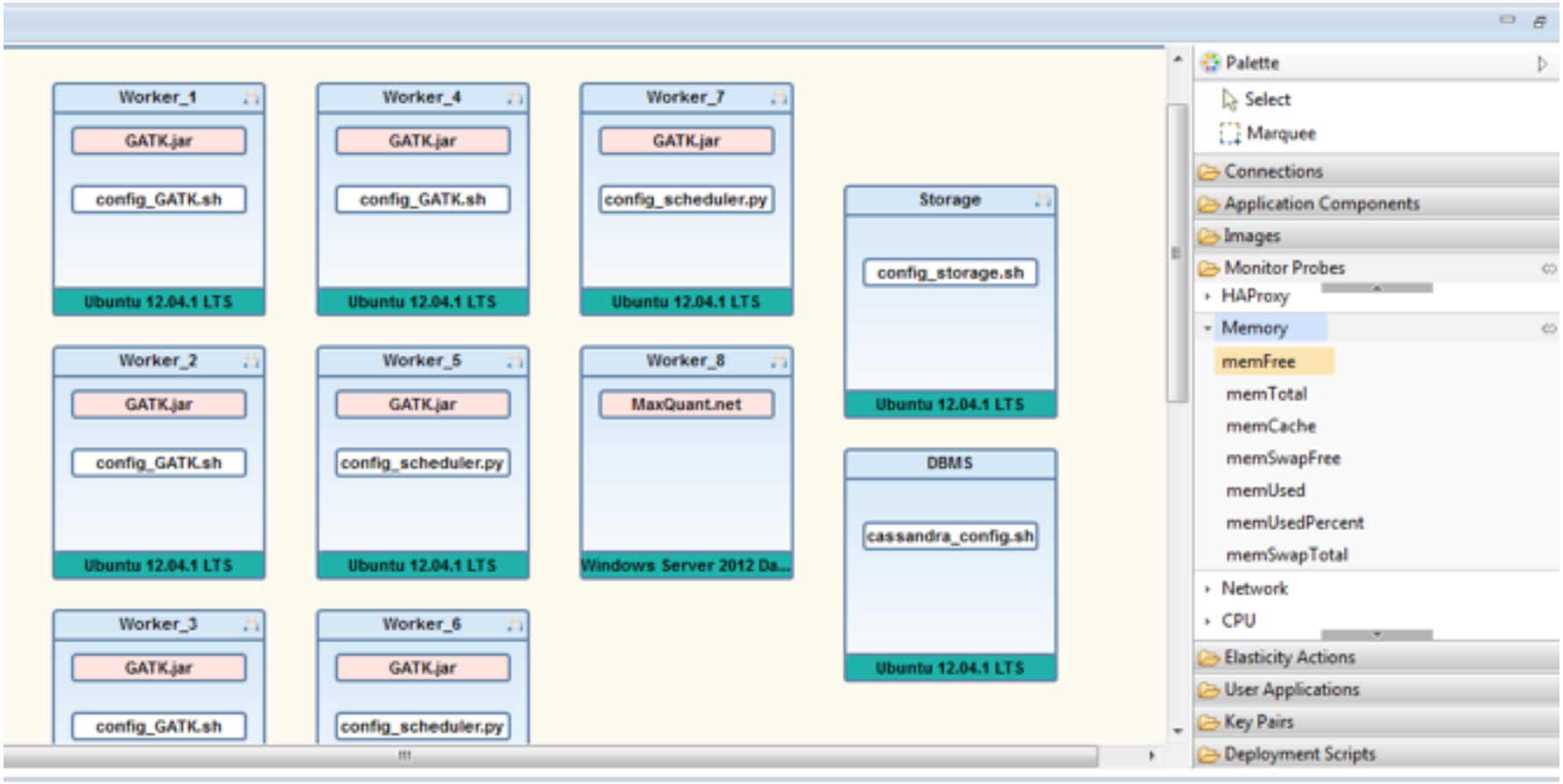
Flavors


*SCAN_Application
Scheduler
config_scheduler.py
Ubuntu 12.04.1 LTS
Worker_1
GATK.jar
config_GATK.sh
Ubuntu 12.04.1 LTS
Worker_4
GATK.jar
config_GATK.sh
Ubuntu 12.04.1 LTS
Worker_7
GATK.jar
config_scheduler.py
Ubuntu 12.04.1 LTS
Storage
config_storage.sh
Ubuntu 12.04.1 LTS
Worker_2
GATK.jar
config_GATK.sh
Ubuntu 12.04.1 LTS
Worker_5
GATK.jar
config_scheduler.py
Ubuntu 12.04.1 LTS
Worker_8
MaxQuant.net
Windows Server 2012 Da...
DBMS
cassandra_config.sh
Ubuntu 12.04.1 LTS
Worker_6
GATK.jar
config_scheduler.py
Palette
Select
Marquee
Connections
Application Components
ApplicationServer
DatabaseServer
LoadBalancer
Images
Monitor Probes
Elasticity Actions
User Applications
GATK.jar
MaxQuant.net
Key Pairs
Deployment Scripts
cassandra_config.sh
config_GATK.sh
config_scheduler.py
vcpus:1 ram:1024 disk:20
vcpus:1 ram:1024 disk:40
vcpus:1 ram:2048 disk:20
vcpus:1 ram:2048 disk:40
vcpus:1 ram:4096 disk:20
vcpus:1 ram:4096 disk:40
vcpus:2 ram:1024 disk:20
vcpus:2 ram:1024 disk:40
vcpus:2 ram:2048 disk:20
vcpus:2 ram:2048 disk:40
vcpus:2 ram:4096 disk:20
vcpus:2 ram:4096 disk:40
vcpus:4 ram:1024 disk:20
vcpus:4 ram:1024 disk:40
vcpus:4 ram:2048 disk:20
vcpus:4 ram:2048 disk:40
vcpus:4 ram:4096 disk:20
vcpus:4 ram:4096 disk:40
vcpus:1 ram:1024 disk:5
vcpus:1 ram:1024 disk:10
Properties
Main
Elasticity
Data/Load
Monitoring
Parameters
Deployment
Name:
VM Image:
VM De...tion:
VM Type:
vcpus:1 ram:1024 disk:20
Image...
Number of Instances
Initial:
1
Min:
Max:

Resizing Actions

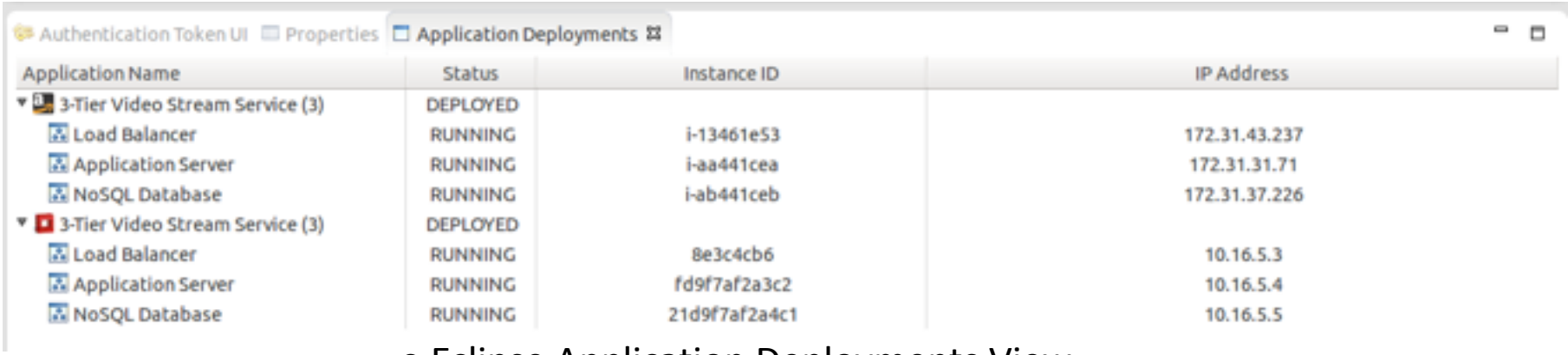


Monitoring Probes and Metrics



Deployment over different Cloud Infrastructures

- Applications' deployment request are sent
- Applications are up and running on 2 infrastructures
- The status of the two deployments is shown in the Application Deployments View of c-Eclipse



Application Name	Status	Instance ID	IP Address
3-Tier Video Stream Service (3)	DEPLOYED		
Load Balancer	RUNNING	i-13461e53	172.31.43.237
Application Server	RUNNING	i-aa441cea	172.31.31.71
NoSQL Database	RUNNING	i-ab441ceb	172.31.37.226
3-Tier Video Stream Service (3)	DEPLOYED		
Load Balancer	RUNNING	8e3c4cb6	10.16.5.3
Application Server	RUNNING	fd9f7af2a3c2	10.16.5.4
NoSQL Database	RUNNING	21d9f7af2a4c1	10.16.5.5

c-Eclipse Application Deployments View

CAMF

c-Eclipse

… now becoming …

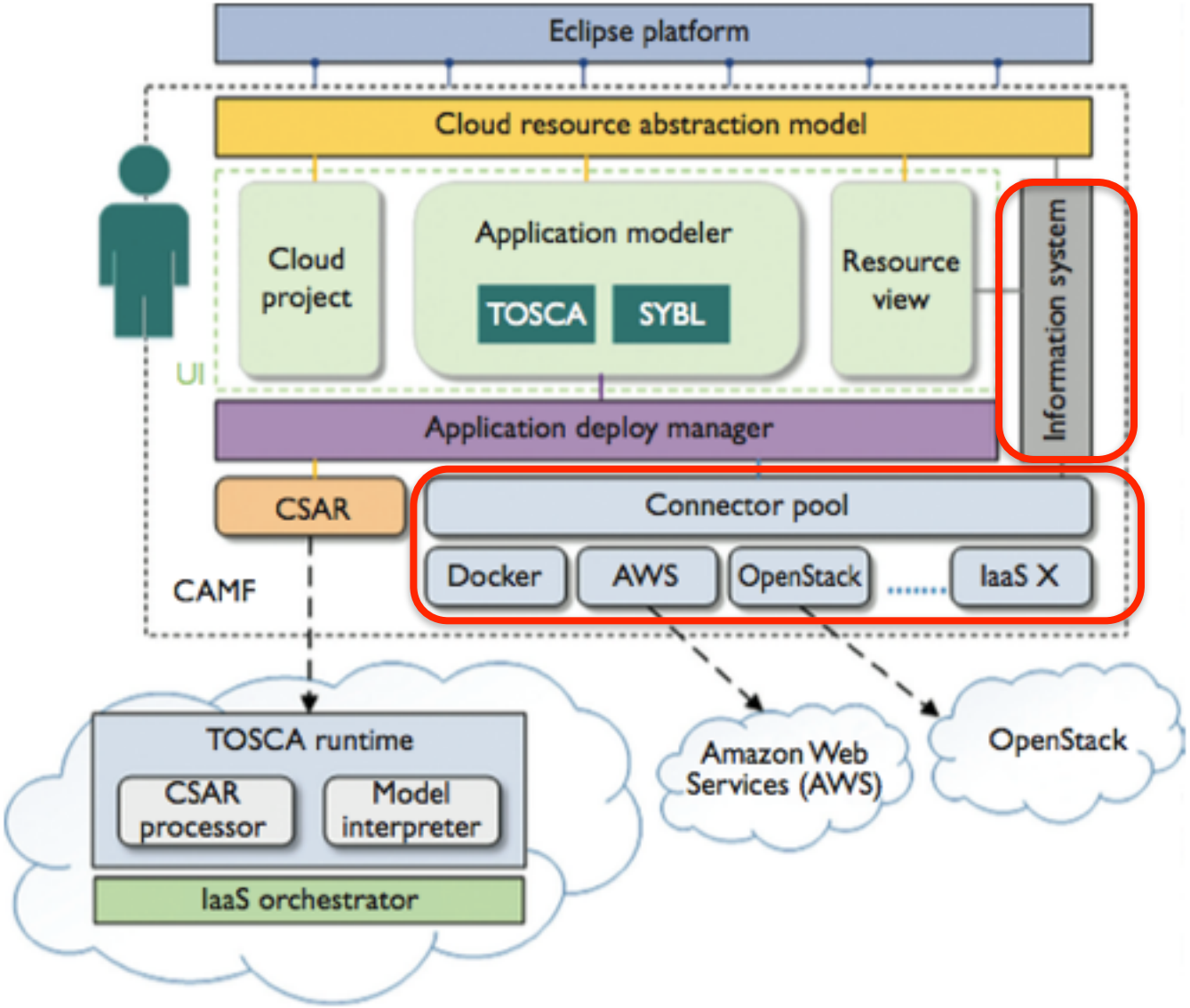
Cloud Application Management Framework (CAMF)

official Eclipse Project since October 2014

https://projects.eclipse.org/projects/technology.camf

http://linc.ucy.ac.cy/CAMF

CAMF Extended Architecture

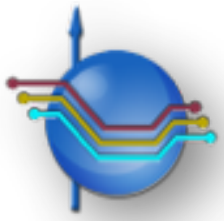


Summary and Conclusions

- Elasticity works! Videos with demos are available online (Youtube channel: CELAR Cloud)
- Elastic Monitoring can be performed in a platform-independent and scalable way, non-intrusively.
- **CAMF** represents a powerful vendor-neutral environment for the Cloud application lifecycle.
- In progress: Information System and Cloud Analytics.
- Open-source and available on github

Acknowledgments

- G. Pallis, Assistant Professor
- D. Antoniades, Postdoctoral Fellow
- N. Loulloudes, Ph.D. Candidate
- S. Sofokleous, Senior Research Engineer
- D. Trihinas, Ph.D. Candidate
- A. Foudoullis, Research Engineer
- A. Balla, Senior IT Engineer
- A. Kastanas, B.Sc. Student



THANK YOU!

DOWNLOAD celar NOW

https://github.com/celar

Video demos online on YouTube channels CELAR EU, LINC-UCY

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@dikaiakos

celar