Monitoring Elastic Cloud Services

Demetris Trihinas

trihinas@cs.ucy.ac.cy

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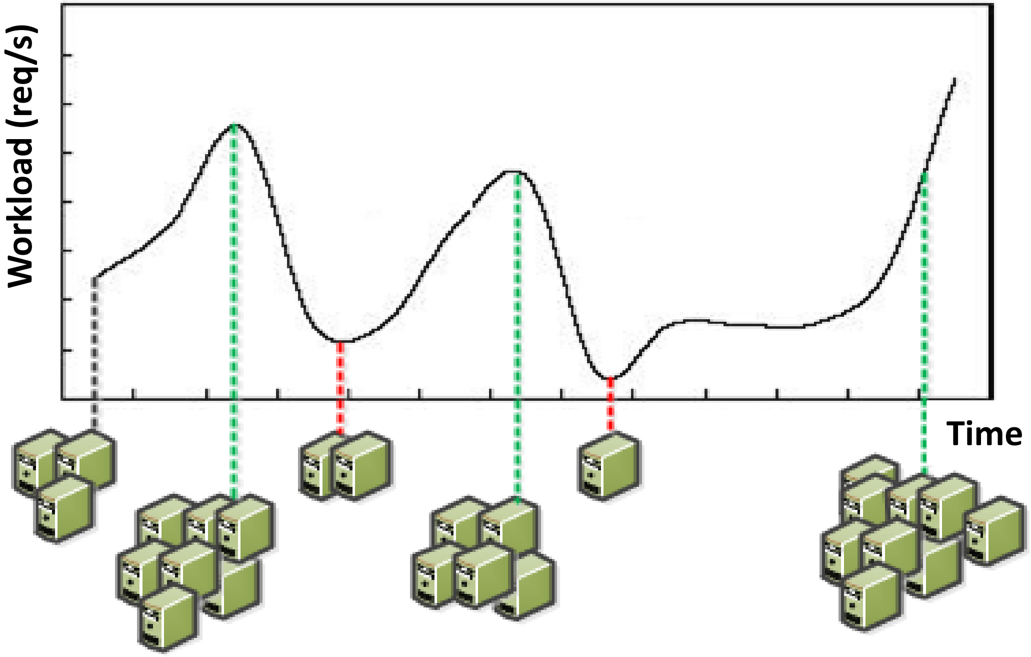
Presentation Outline

- Elasticity in Cloud Computing
- Cloud Service Monitoring Challenges
- Existing Monitoring Tools and their Limitations
- JCatascopia Monitoring System
  - Architecture
  - Features
  - Evaluation
- Conclusions and Future Work

Elasticity in Cloud Computing

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



Cloud Monitoring Challenges

- Monitor heterogeneous types of 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

Cloud Monitoring Challenges

- Operate on any Cloud platform
- Monitor Cloud services deployed across multiple Cloud platforms
- Detect configuration changes in a cloud service
  - Application topology changes (e.g. new VM added)
  - Allocated resource changes (e.g. new disk attached to VM)

Elasticity Support

"**Managing and Monitoring Elastic Cloud Applications**", D. Trihinas and C. Sofokleous and N. Loulloudes and A. Foudoulis and G. Pallis and M. D. Dikaiakos, *14th International Conference on Web Engineering (ICWE 2014)*, Toulouse, France 2014

Existing Monitoring Tools

Cloud Specific Monitoring Tools

Benefits

amazon web services CloudWatch
New Relic.
AzureWatch
HYPERIC
rackspace

- Provide MaaS capabilities
- Fully documented
- Easy to use
- Well integrated with underlying platform

Limitations

- Commercial and proprietary which limits them to operating on specific Cloud IaaS providers

General Purpose Monitoring Tools

Ganglia
Nagios
ZABBIX
cacti
MUNIN
MonALISA
MONitoring Agents using a Large Integrated Services Architecture
GridICE
the eyes of the Grid

Benefits

- Open-source
- Robust and light-weight
- System level monitoring
- Suitable for monitoring Grids and Computing Clusters

Limitations

- Not suitable for dynamic (elastic) application topologies

Monitoring Tools with Elasticity Support

- [de Carvalho et al., INM 2011]
  - Nagios + Controller on each physical host to notify *Nagios Server* with a list of instances currently running on the system
- Lattice Monitoring Framework [Clayman et al., NOMS 2011]
  - Controller periodically requests from hypervisor list of current running VMs

Limitations

- Special entities required at physical level
- Depend on current hypervisor

JCatascopia Monitoring System

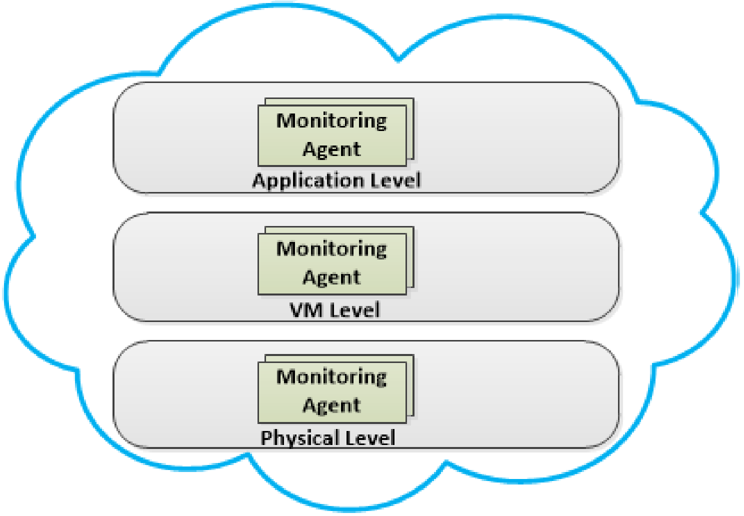
JCatascopia Monitoring System

- ✓ Open-source
- ✓ Multi-Layer Cloud Monitoring
- ✓ Platform Independent
- ✓ Capable of Supporting Elastic Applications
- ✓ Interoperable
- ✓ Scalable

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

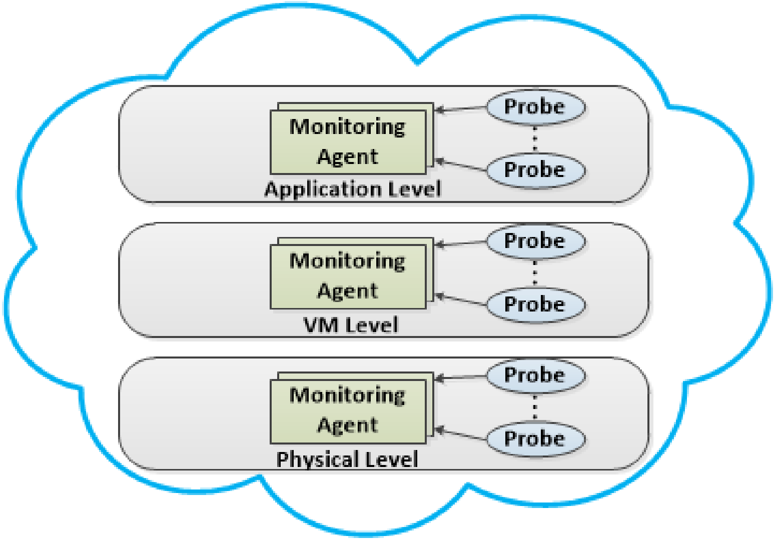
JCatascopia Architecture

Monitoring Agents



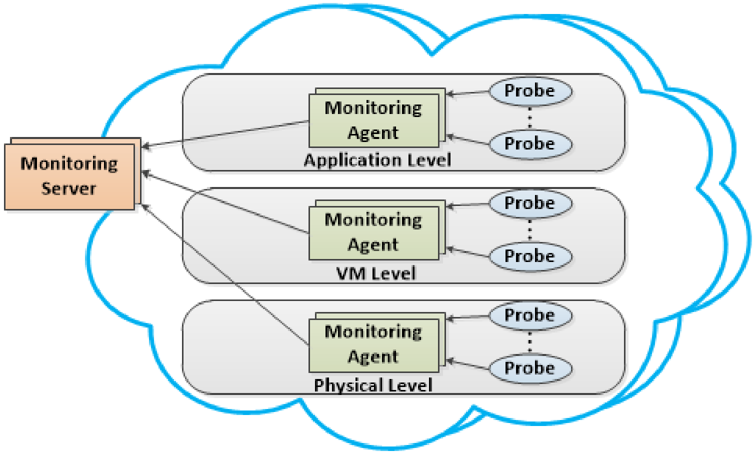
- Light-weight monitoring instances
- Deployable on physical nodes or virtual instances
- Responsible for the metric collection process
- Aggregate and distribute collected metrics (pub/sub)

Monitoring Probes



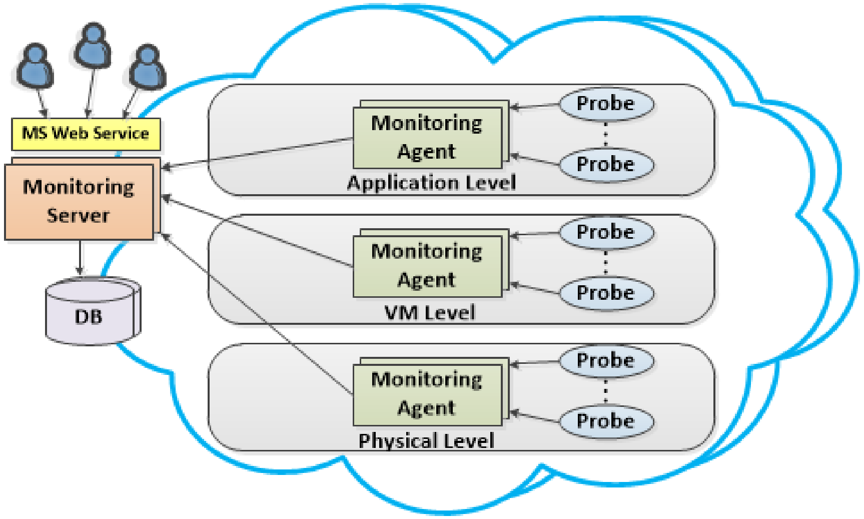
- The actual metric collectors managed by Monitoring Agents
- JCatascopia Probe API
- Dynamically deployable to Monitoring Agents
- Filtering mechanism at Probe level

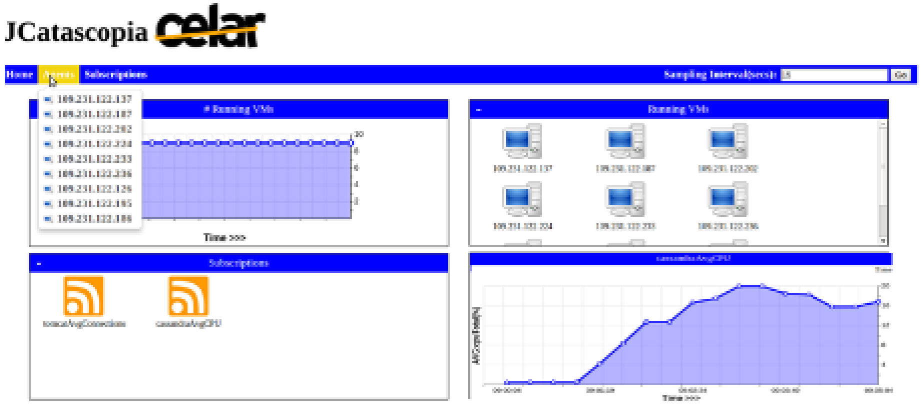
Monitoring Servers



- Receive metrics from Monitoring Agents
- process and store metrics in Monitoring Database
- Handle user metric and configuration requests
- Hierarchy of Monitoring Servers for greater scalability

JCatascopia Architecture

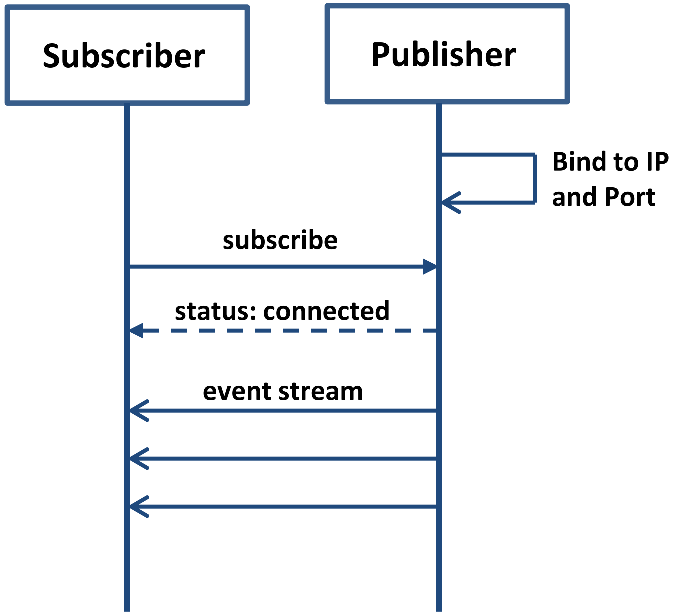




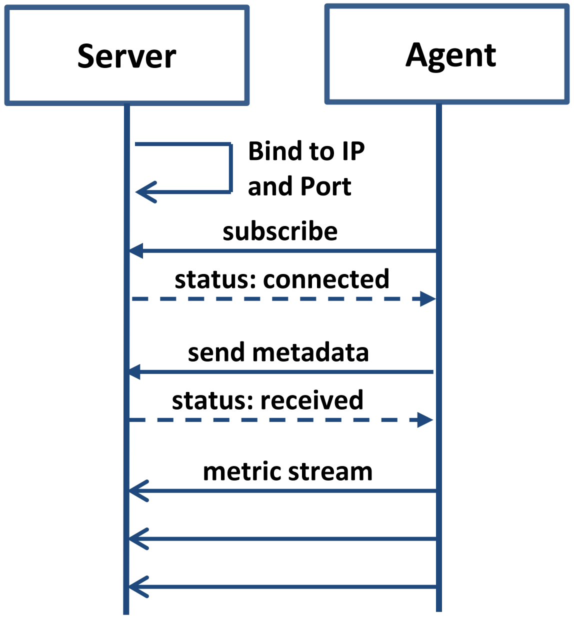
- JCatascopia REST API
- JCatascopia-Web User Interface

- JCatascopia Database Interface
  - Allows users to utilize their own Database solution with JCatascopia
  - Currently available: MySQL, Cassandra

Dynamic Agent Discovery and Removal



(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

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

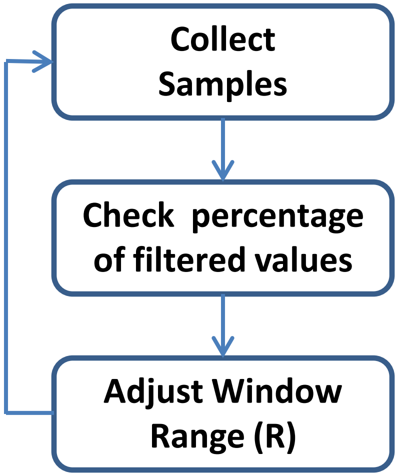
Average `DBthroughput` from the low-level metrics `readps` and `writeps` of a database cluster comprised of *N* nodes:

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

Adaptive Filtering

- Simple fixed uniform 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



JCatascopia Evaluation

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 Cloud	15	1GB RAM, 10GB Disk, Ubuntu Server 12.04 LTS	12 VMs Cassandra 3 VMs YCSB Clients
Flexiant FlexiScale platform	10	2 VCPU, 2GB RAM, 10GB Disk, Debian 6.07 (Squeeze)	HASCOP an attributed, multi-graph clustering algorithm
Amazon EC2	10	m1.small with CentOS 6.4 (1VCPU, 1.7GB RAM, 160GB Disk)	
OpenStack Private Cloud	60	2 VCPU, 2GB RAM, 10GB Disk, Ubuntu Server 12.04 LTS	

We have deployed on all VMs JCastascopia Monitoring Agents, Ganglia gmonds and Lattice DataSources

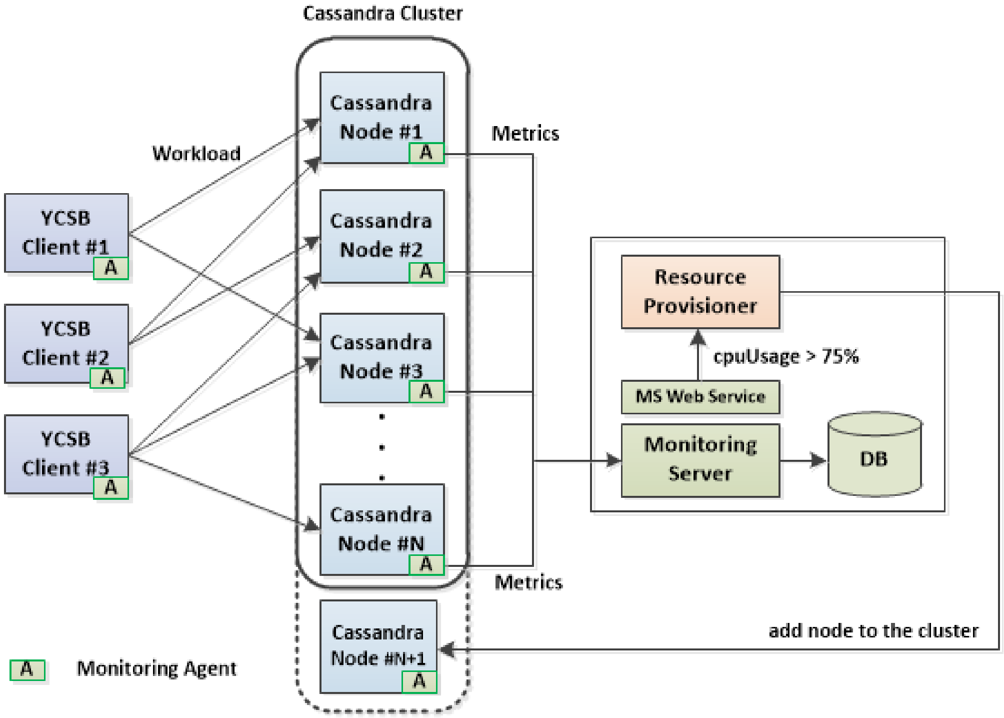
Testbed - Available Probes

Probe	Metrics	Period (sec)
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

Experiment 1. Elastically Adapting Cassandra Cluster

- Scale out Cassandra cluster to cope with increasing workload
- Experiment uses 15 VMs in Okeanos cluster
- Subscription Rule to notify Provisioner to add VM when scaling condition violated:

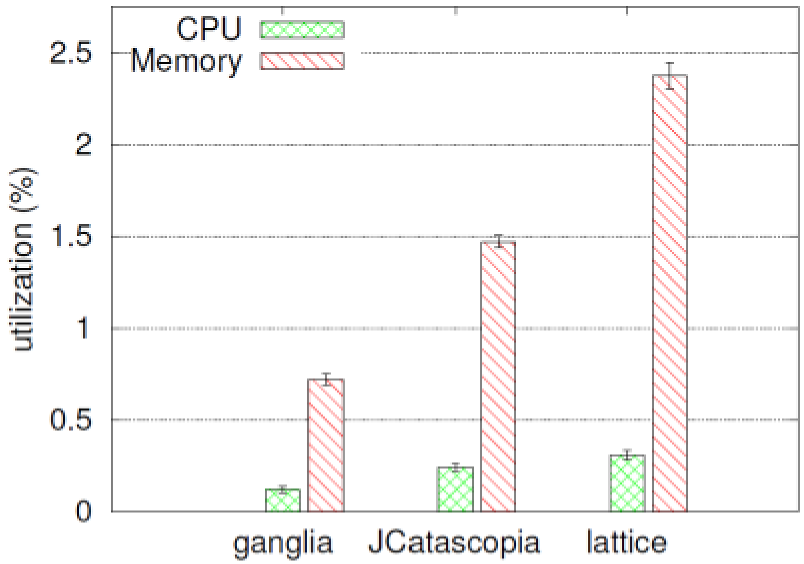
```
cpuTotalUsage = AVG(1 - cpuIdle)
   MEMBERS = [id1, ... ,idN]
    ACTION = NOTIFY(>=75%)
```



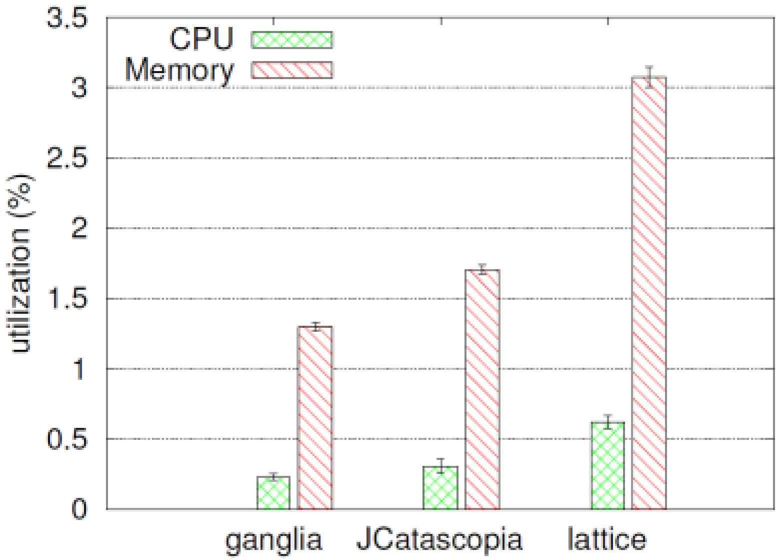
VMs	Probes
YCSB Clients	YCSB
Cassandra	CPU, Memory, Network, DiskIO, Cassandra

Experiment 1. Elastically Adapting Cassandra Cluster

Monitoring Agent Runtime Impact



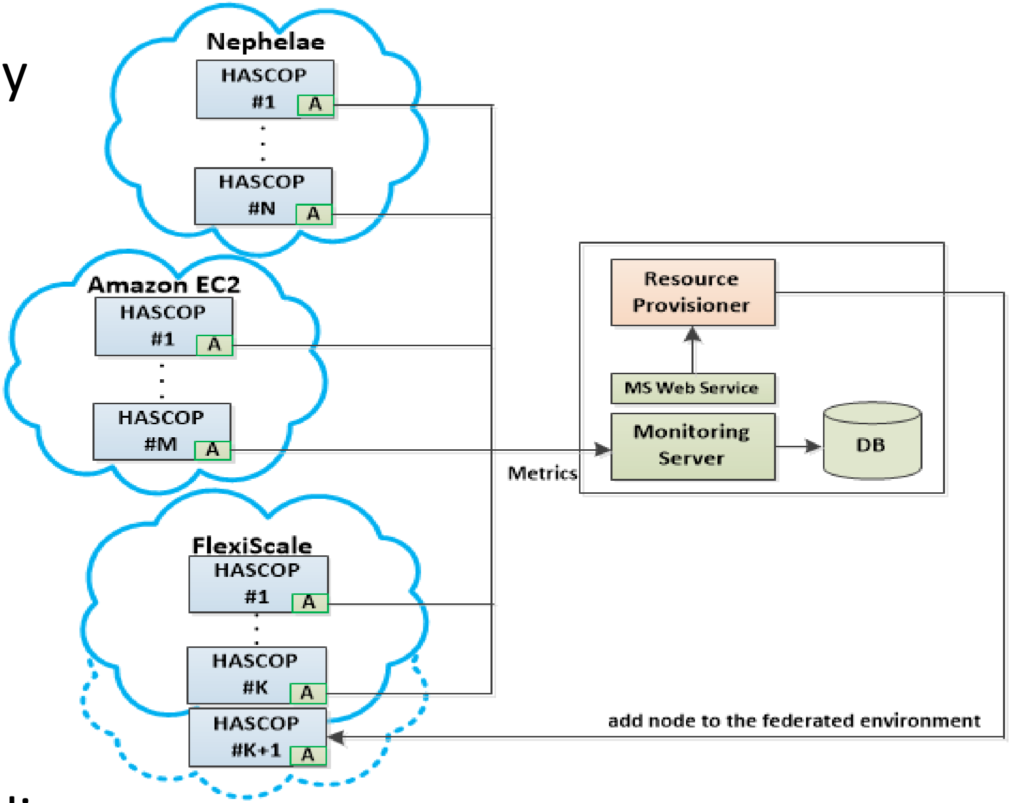
YCSB Agent Utilization



Cassandra Agent Utilization

Experiment 2. Monitoring a Cloud Federation Environment

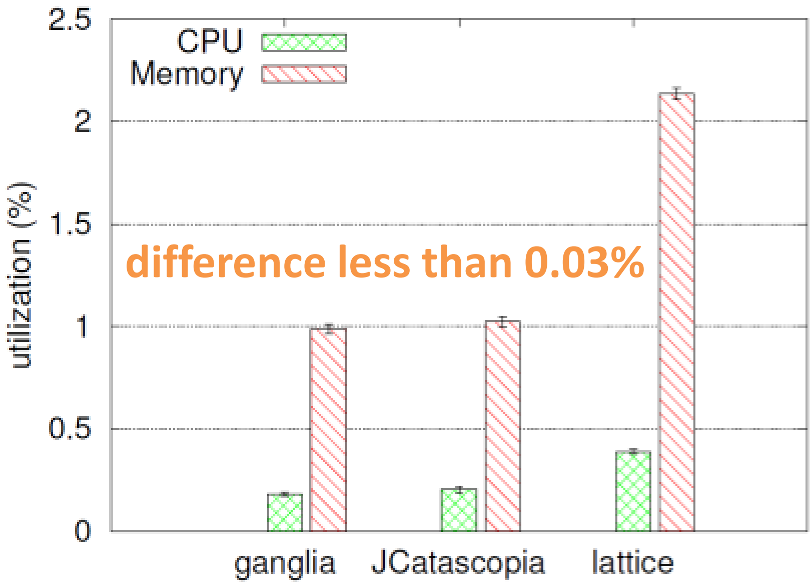
- Monitor an application topology spread across multiple Clouds:
  - OpenStack (10 VMs)
  - Amazon EC2 (10 VMs)
  - Flexiant (10 VMs)
- Compare JCatascopia, Ganglia and Lattice runtime footprint
- Compare JCatascopia and Ganglia network utilization



VMs	Probes
HASCOP	CPU, Memory, DiskUsage, HASCOP

Experiment 2. Monitoring a Cloud Federation Environment

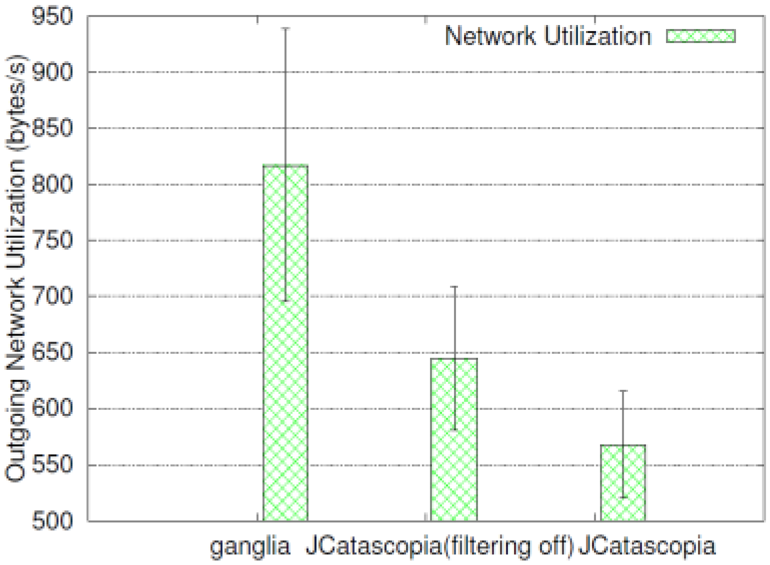
Monitoring Agent Runtime Impact



difference less than 0.03%

HASCOP Agent Utilization

Monitoring Agent Network Utilization



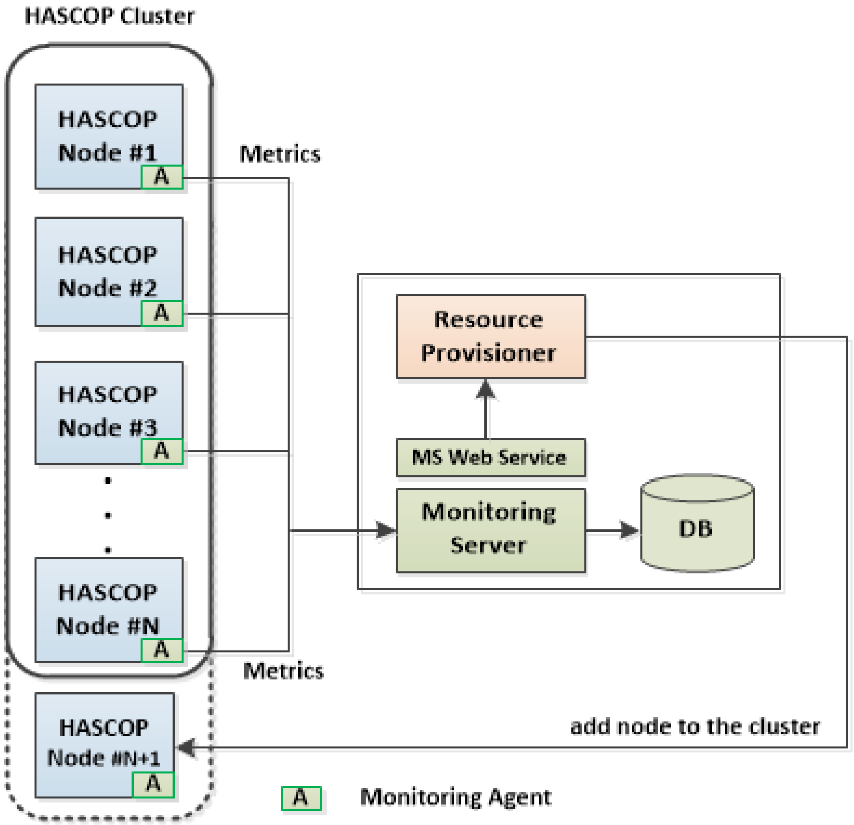
Agent Network Utilization

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

Experiment 3. JCatascopia Scalability Evaluation

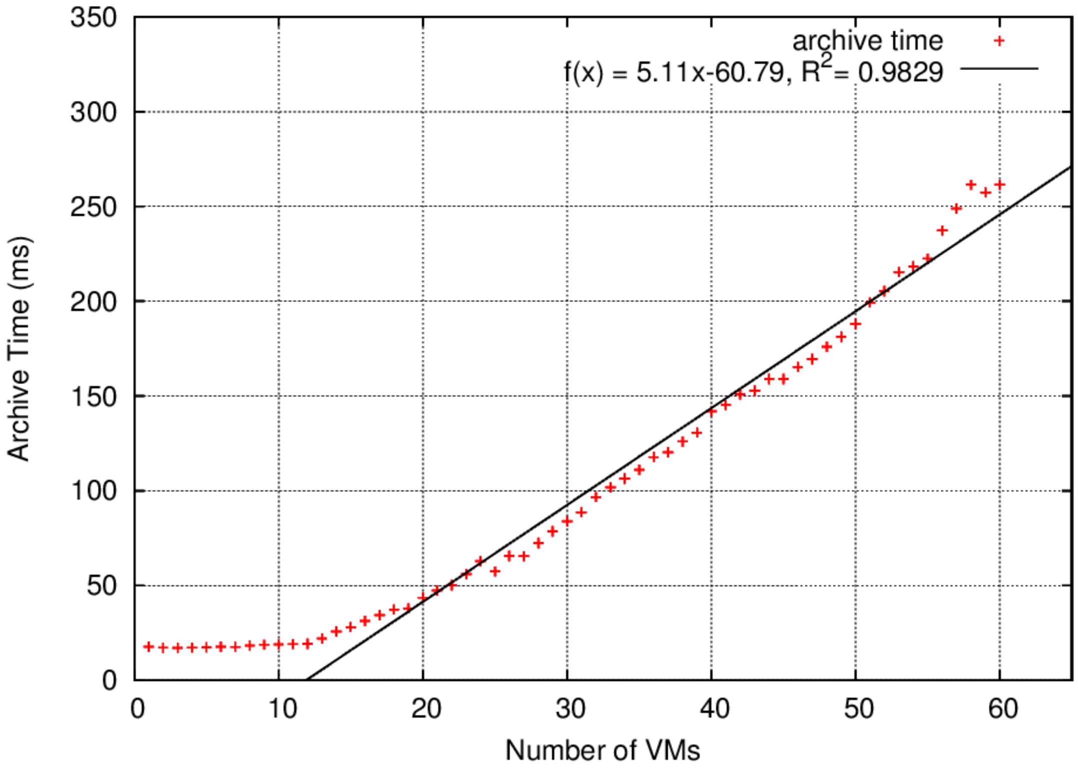
- Experiment uses the 60 VMs on OpenStack private Cloud to scale a HASCOP cluster
- 1 Monitoring Server for 60 Agents
- Subscription Rule:

```
hascopIterElapsedTime = AVG(iterElapTime)
       MEMBERS = [id1, ... ,idN]
         ACTION = NOTIFY(ALL)
```



VMs	Probes
HASCOP	CPU, Memory, DiskUsage, HASCOP

Scalability Evaluation

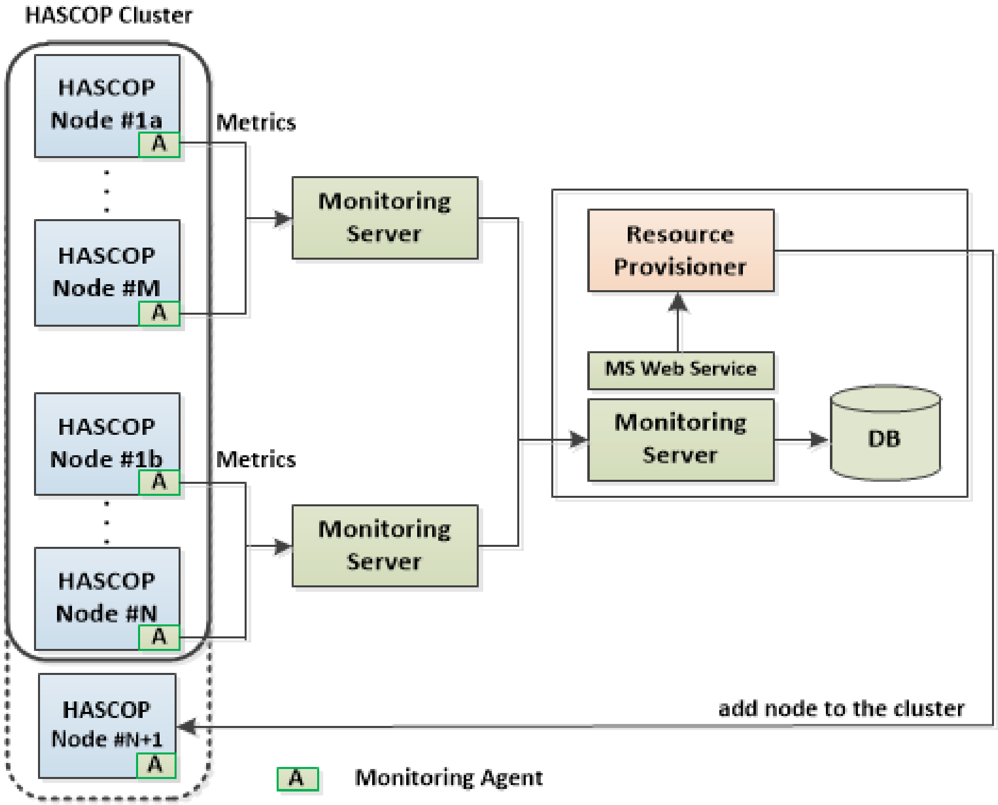


Archiving time grows linearly

Experiment 3. JCatascopia Scalability Evaluation

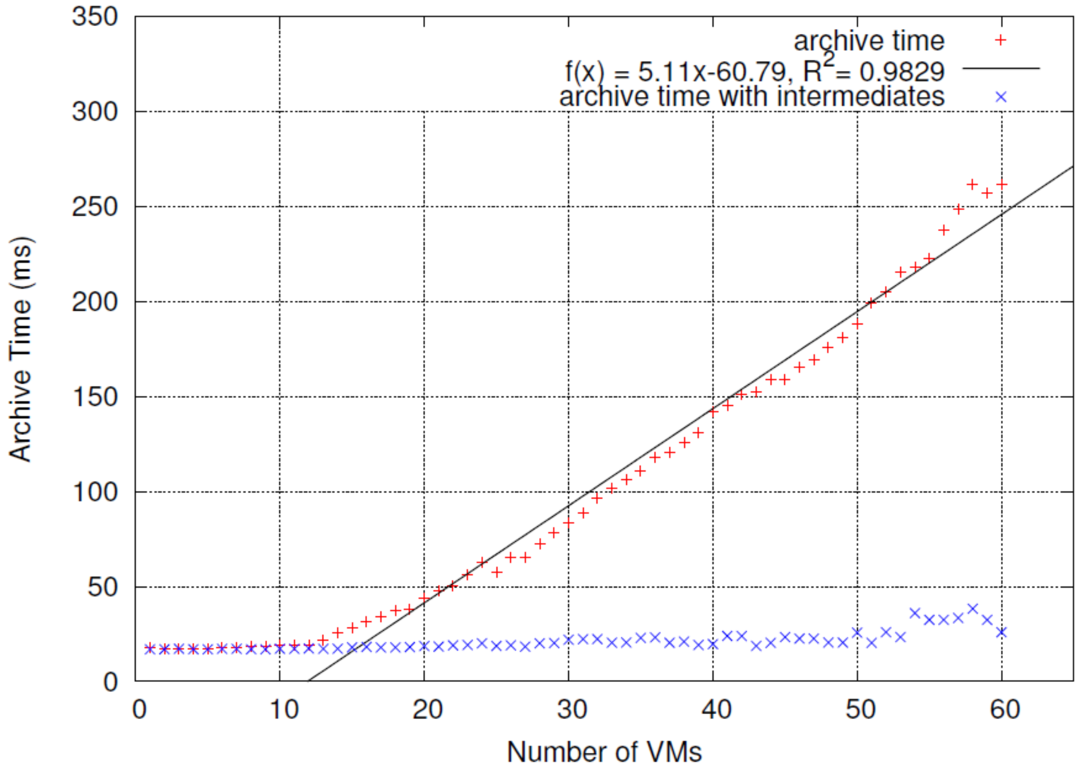
New Setup

- 2 Intermediate Monitoring Servers which aggregate metrics from underlying Agents
- 1 root Monitoring Server



VMs	Probes
HASCOP	CPU, Memory, DiskUsage, HASCOP

Scalability Evaluation



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

Conclusions

- Experiments on public and private Cloud platforms show that JCatascopia is:
  - capable of **supporting automated elasticity controllers**
  - able to adapt in a **fully automatic** manner when **elasticity** actions are enforced
  - **<u>open-source</u>**, **interoperable**, **scalable** and has a **low runtime footprint**

Future Work

- Further pursue **adaptive filtering**
- Enhance Probes with **adaptive sampling**
  - Adjust sampling rate when stable phases are detected
- Create **Monitoring Toolkit** for **PaaS** Cloud applications
- Provide **Monitoring as a Service** to Cloud consumers

Acknowledgements

celar

www.celarcloud.eu

co-funded by the
European Commission

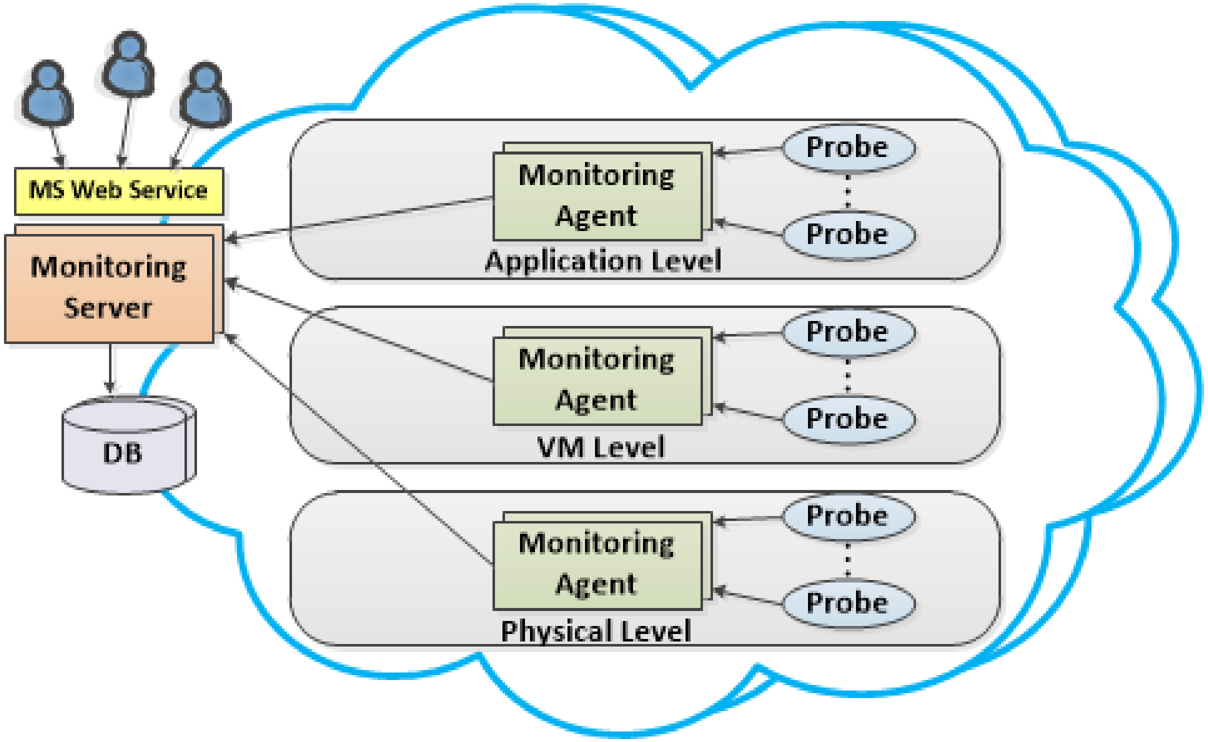
JCatascopia

https://github.com/CELAR/cloud-ms

Laboratory for Internet Computing
Department of Computer Science
University of Cyprus
http://linc.ucy.ac.cy

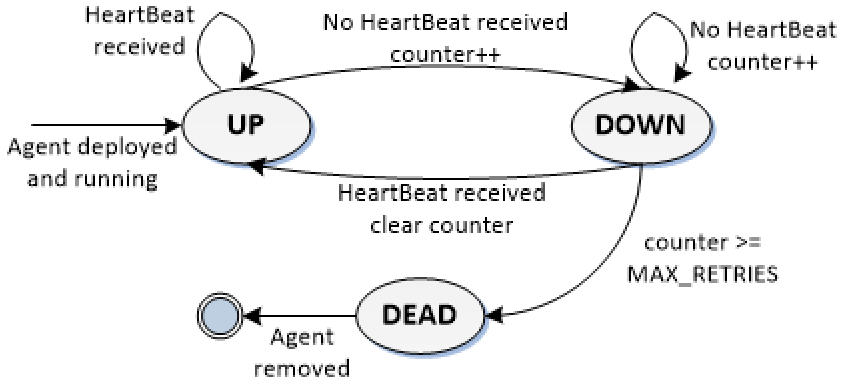
BACKUP SLIDES

JCatascopia Architecture

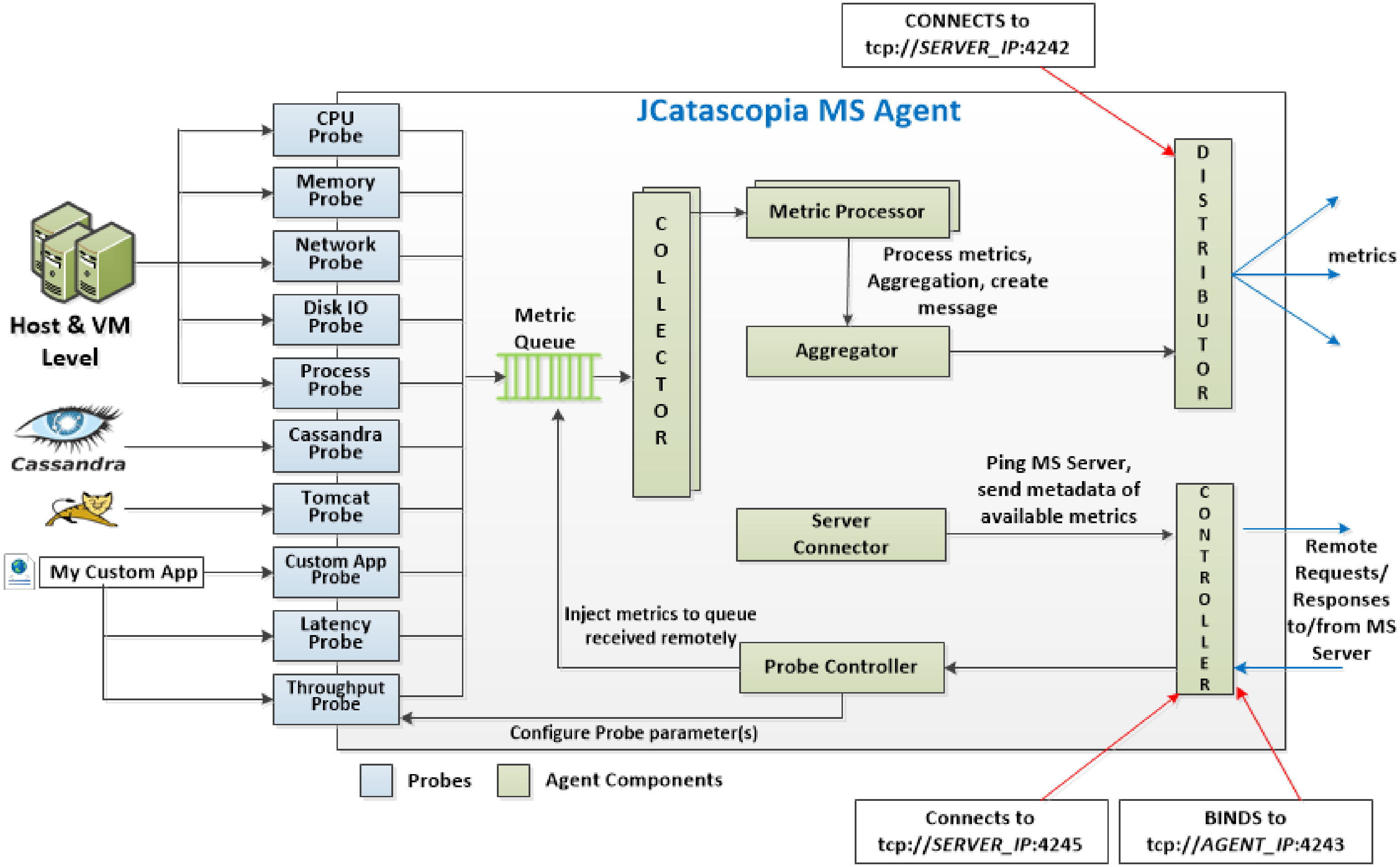


Dynamic Agent Removal

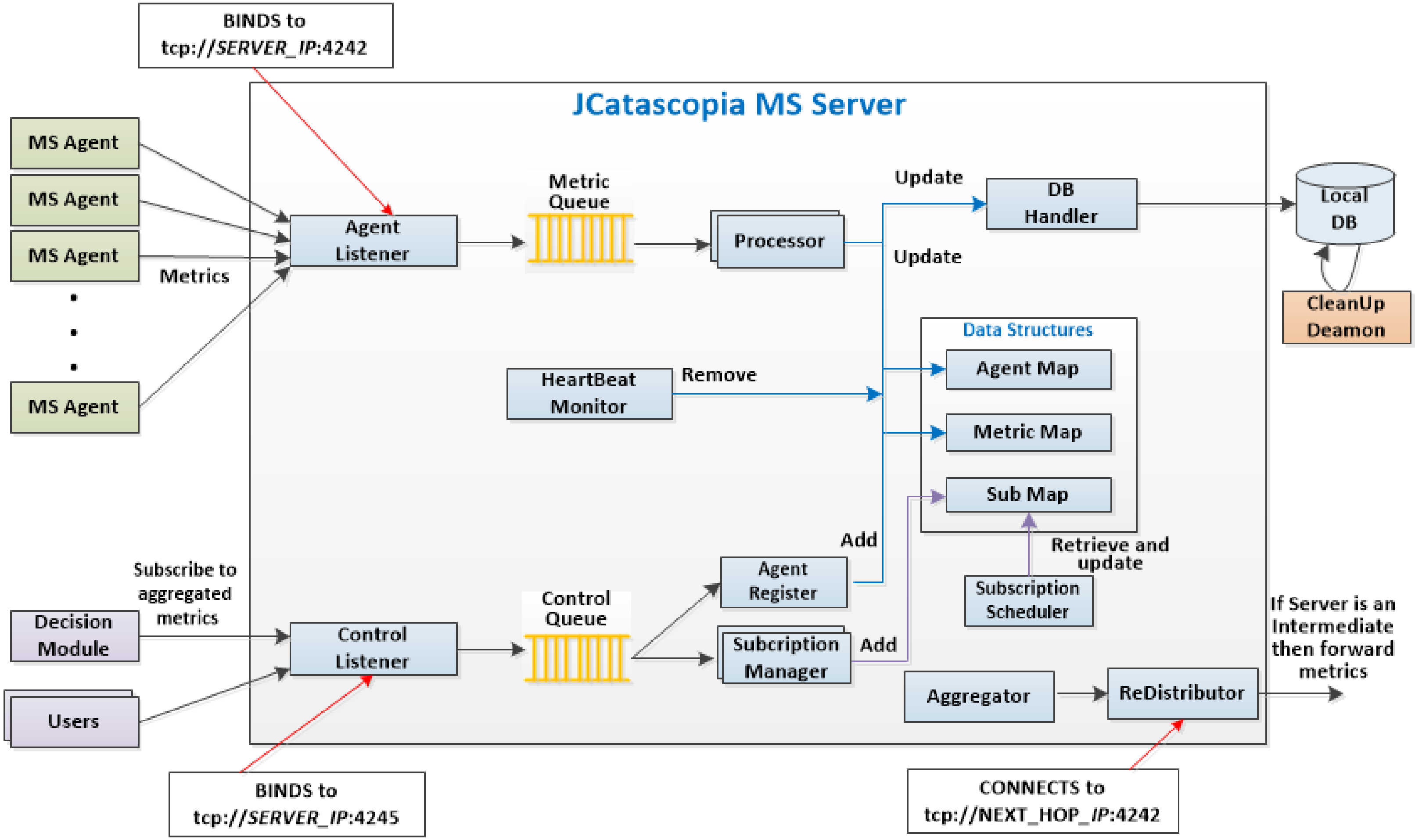
- Heartbeat monitoring to detect when Agents:
  - Removed due to scaling down elasticity actions
  - Temporary unavailable (network connectivity issues)


HeartBeat received
No HeartBeat received counter++
No HeartBeat counter++
UP
DOWN
Agent deployed and running
HeartBeat received clear counter
counter >= MAX_RETRIES
DEAD
Agent removed

Monitoring Agents



Monitoring Servers


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