# Middleware and Web Services

## Lecture 6: High Availability and Performance

**doc. Ing. Tomáš Vitvar, Ph.D.**
tomas@vitvar.com • @TomasVitvar • http://vitvar.com

Czech Technical University in Prague
Faculty of Information Technologies • Software and Web Engineering • http://vitvar.com/courses/mdw

Modified: Tue Nov 22 2016, 20:46:32
Humla v0.3

# Good Performance

- What influences a good performance?
  - *Number of users and concurrent connections*
  - *Number of messages and messages' sizes*
  - *Number of services*
  - *Infrastructure – capacity, availability, configuration, ...*
- How can we achieve a good performance?
  - *Infrastructure*
    → *Scalability, failover, cluster architectures*
  - *Performance tuning*
    → *Application Server, JVM memory, OS-level tuning, Work managers configuration*
  - *Service configuration*
    → *Parallel processing, process optimization*

# Overview

- Infrastructure
  - *Load Balancers*
  - *Cluster Architecture*
- Performance Tuning

# Definitions

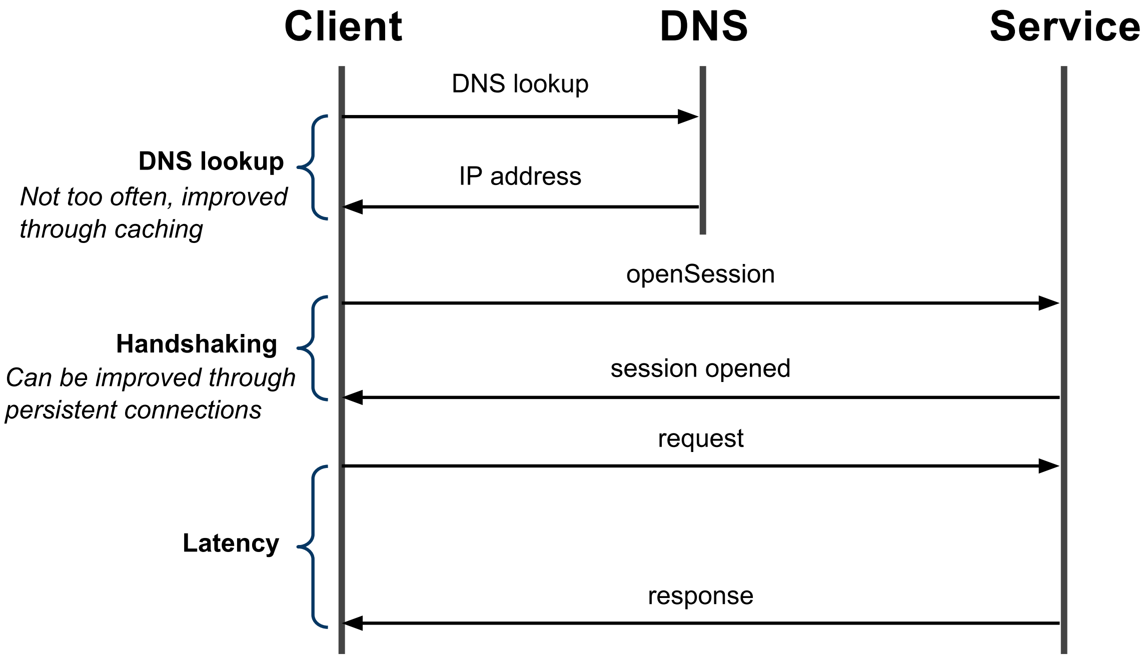
- Scalability
  - *server scalability*
    - → *ability of a system to scale – when input load changes*
    - → *users should not feel a difference when more users access the same application at the same time*
    - → ***horizontal scaling***
      - → *adding new instances of applications/servers*
    - → ***vertical scaling***
      - → *adding new resources (CPU, memory) to a server instance*
  - *network traffic*
    - → *bandwidth capacity influences performance too*
    - → *service should limit the network traffic through caching*
- Availability
  - *probability that a service is operational at a particular time*
    - → *e.g., 99.9987% availability – downtime ~44 seconds/year*

# Definitions (Cont.)

- High Availability
  - *When a server instance fails, operation of the application can continue*
  - *Failures should affect application availability and performance as little as possible*
- Application Failover
  - *When an application component performing a job becomes unavailable, a copy of the failed object finishes the job.*
  - *Issues*
    - → *A copy of the failed object must be available*
    - → *A location and operational status of available objects must be available*
    - → *A processing state must be replicated*
- Load Balancing
  - *Distribution of incoming requests across server instances*

# Performance Metrics

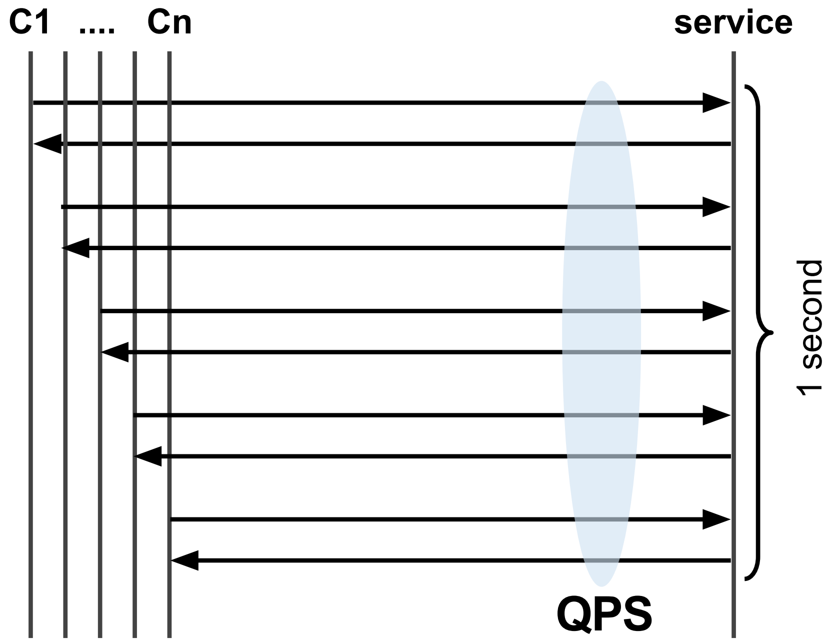
- Latency
  - *A client-side metric*



  - *CPU intensive service or a bad configuration of a service*
    *→ consider asynchronous processing when CPU intensive*
  - *Writing to a data store*

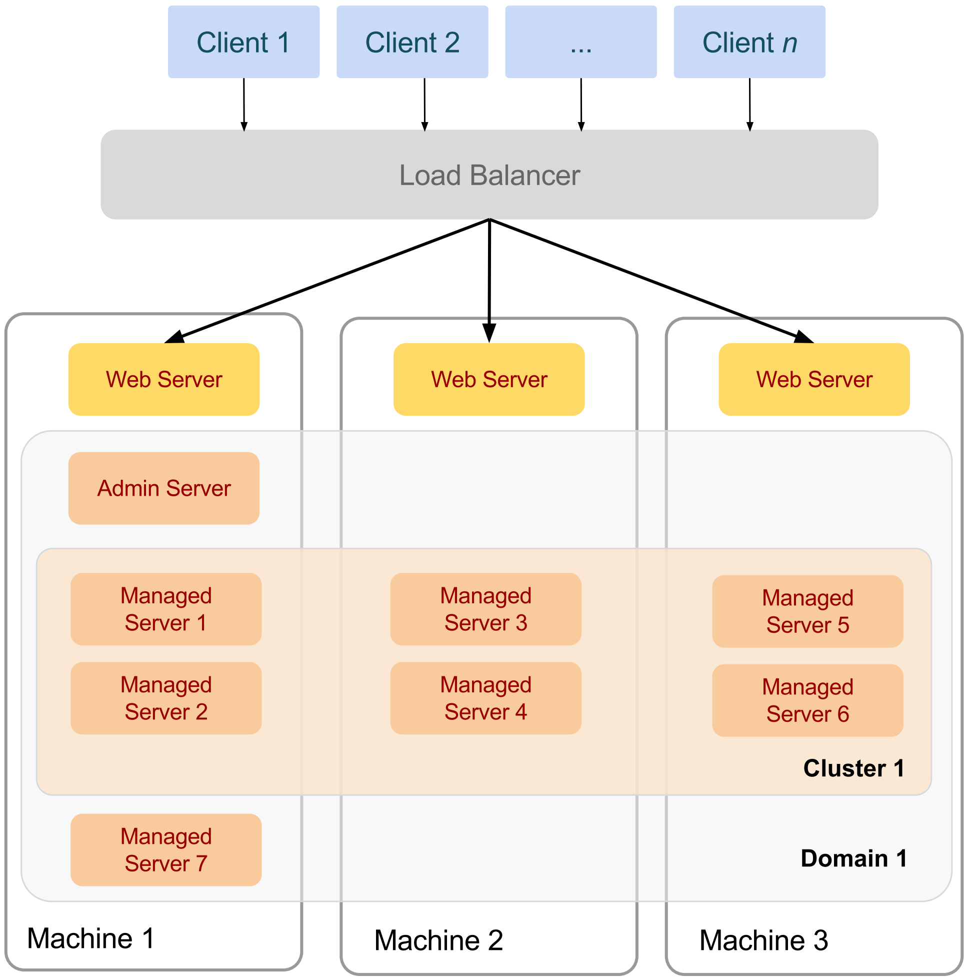
# Performance Metrics

- Queries/Requests per Second (QPS)
  – *A server-side metric*



– *Caching may improve performance*
→ *even if data changes often, with high QPS caching improves a lot*

# Infrastructure Example – Weblogic



**Clients**
Clients access objects or applications running on application server.

**Load Balancer**
External to application server. Distributes incoming requests to servers running on multiple machines.

**Web Tier**
Provides access to servers running in a domain on machines.

**Domain**
Collection of clusters and servers. Each domain contains one Admin Server.

**Cluster**
Collection of managed servers. Each managed server contains the same copy of objects.

# Best Configuration Practices

- Domain configuration
  - *A server is an admin server or a managed server*
  - *Each server is running on a separated JVM*
  - *A physical machine may run one or more servers*
  - *There should be at least two managed servers running on one machine*
    - → *This provides a better performance (as opposed to one server running on one machine)*
  - *A domain can have clustered or unclustered servers*
- Load balancers (LB)
  - *Load Balancers are not part of the domain*
    - → *They are external to Weblogic server*
    - → *There is usually one HW LB and several SW LBs*
    - → *Software LB*
      - → *Realized by the Web Tier (Apache HTTP server)*
      - → *Redirects requests too all managed servers in a domain (across multiple machines)*

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# Load Balancing

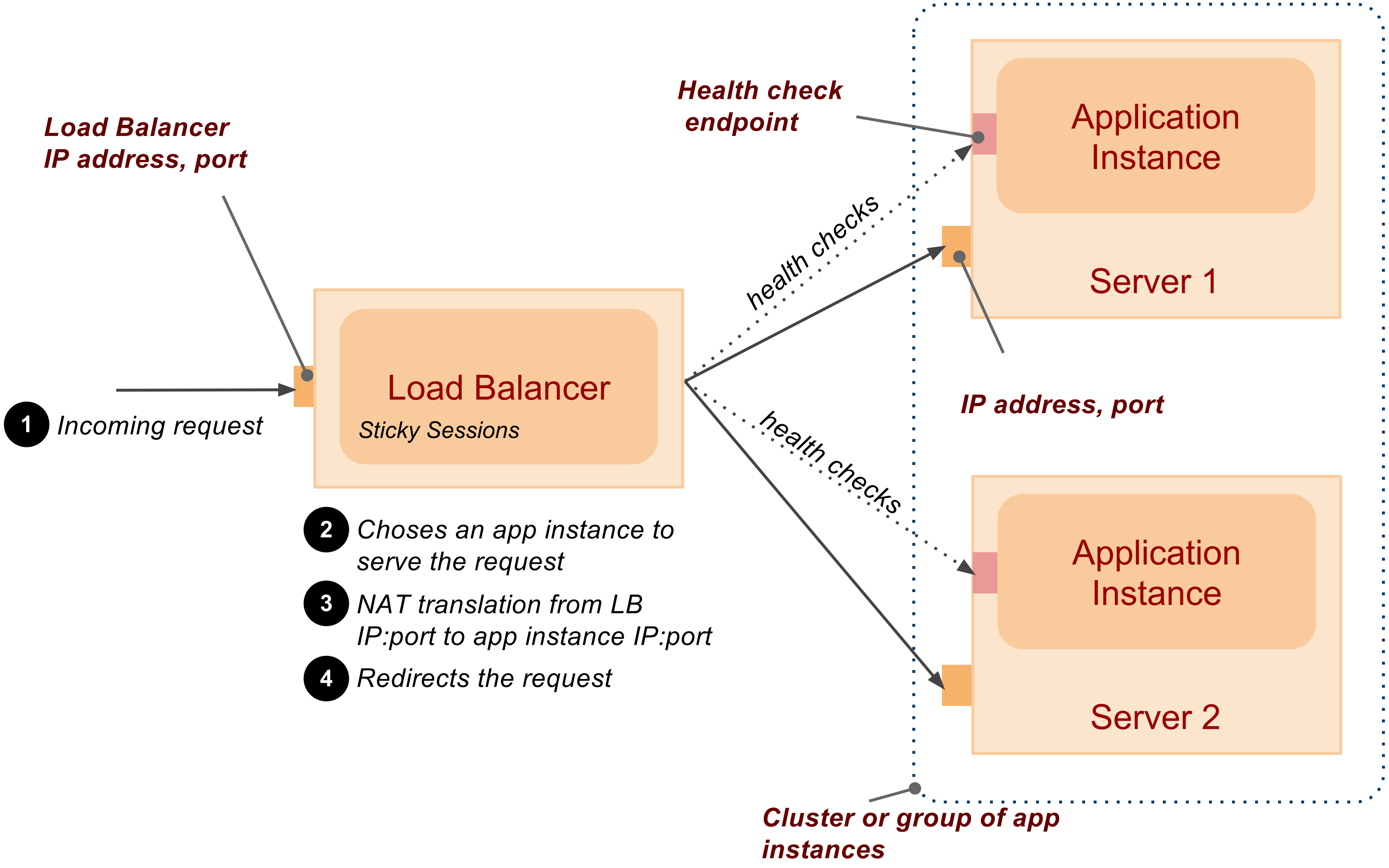
- Distributes a load to multiple app/object instances
  - *App instances run on different machines*
  - *Load sharing: equal or with preferences*
  - *Health checks*
- Types
  - *DNS-based load balancer*
    - → *DNS Round Robin*
  - *NAT-based load balancer (Layer-4)*
  - ***Reverse-proxy load balancer** (Layer-7)*
    - → *application layer*
    - → *Sticky sessions*
      - → *JSession, JSession-aware load balancer*
  - *Client-side load balancer*
    - → *LB run by a client*
    - → *a client uses a replica-aware stub of the object from the server*

# DNS-based Load Balancer

- DNS Round Robin
  - *A DNS record has multiple assigned IP addresses*
  - *DNS system delivers different IP addresses from the list*
  - *Example DNS A Record:*

    ```
    company.com A 147.32.100.71 147.32.100.72 147.32.100.73
    ```
- Advantages
  - *Very simple, easy to implement*
- Disadvantages
  - *IP address in cache, could take hours to re-assign*
  - *No information about servers' loads and health*

# Reverse Proxy Load Balancer



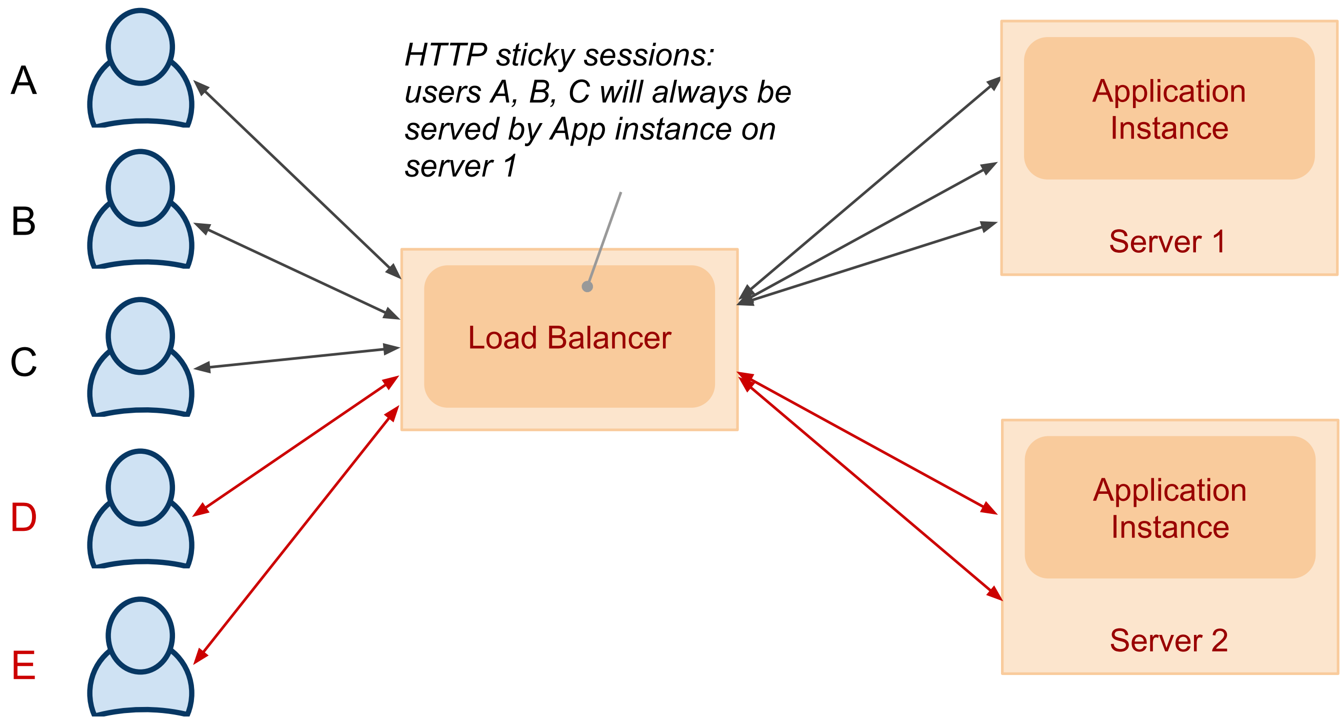
1 Incoming request

2 Choses an app instance to serve the request

3 NAT translation from LB IP:port to app instance IP:port

4 Redirects the request

# HTTP Sticky Sessions Example



*HTTP sticky sessions: users A, B, C will always be served by App instance on server 1*

- How to identify a server that hosts the session state
  - *Passive cookie persistence – LB uses a cookie from the server*
  - *Active cookie persistence – LB adds its own cookie*

# Types of Load Balancers

- Software
  - *Apache* `mod_proxy_balancer`

    → *HTTP Session persistence – sticky sessions*
  - *WebLogic proxy plug-in*

```
<Location /soa-infra>
    SetHandler weblogic-handler
    WebLogicCluster czfmwapp03-vf:8001,czfmwapp04-vf:8001,czfmwapp05-vf:8001
</Location>

```

`/soa-infra` *is a first part of an URL path that rules in this* `Location` *will be applied (this is a standard Apache configuration mechanism)* `czfmwapp{N}` *is a hostname that corresponds to a virtual IP to which the managed server JVM processes is bounded (using the tcp port* `8001`*).*

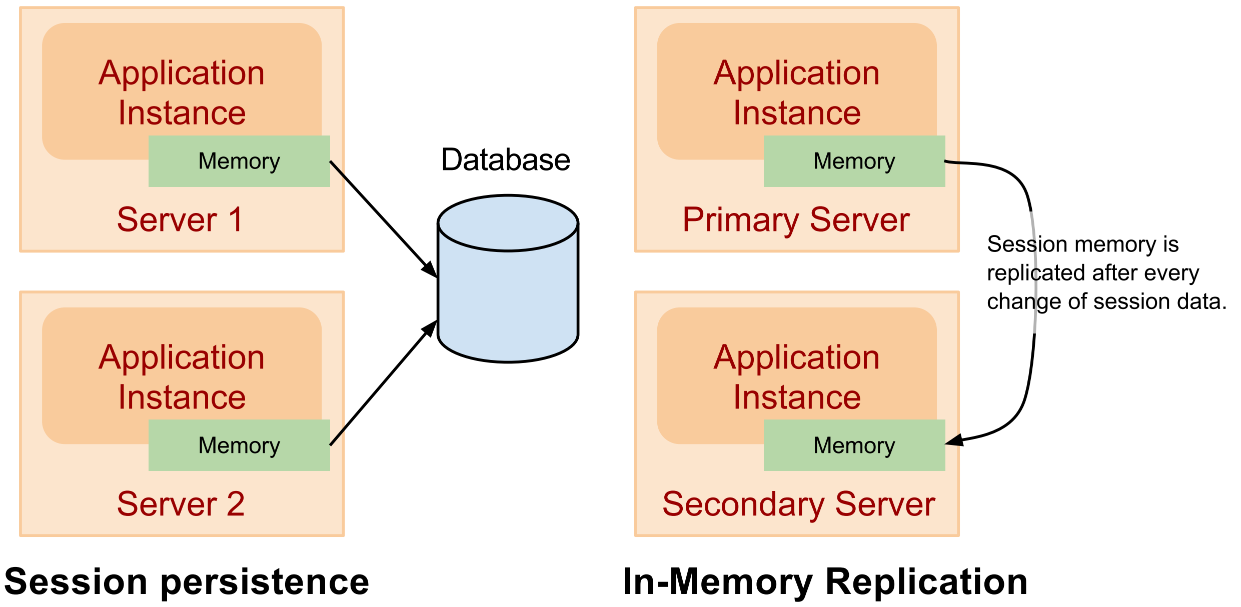
`WebLogicCluster` *specifies the list of servers for load balancing*

- Hardware
  - *Cisco, Avaya, Barracude*

# Round-Robin Algorithm with Health Check

- Uses
  - *request – client request with or without a cookie information*
  - *server list – a list of servers that can process the request*
    *→ e.g.* `WebLogicCluster` *value (see previous slide)*
  - *unhealthy treshhold – a number of negative consecutive health checks before moving the server to the "unhealthy" state.*
- Steps
  - ***if a cookie exist in the request that identifies a server***
  - *always use that server*
  - ***health check***
  - *LB polls the servers' heatlhcheck endpoints*
  - *if a number of health checks exceeds the unhealthy threshold*
    *→ LB removes the server from the server list*
  - *if a server was unhealthy and a there was a successful healthcheck*
    *→ LB adds the server to the server list*

# Session State Persistence and Replication



- Session persistence
  - *Session information is maintained in the database*
  - *Does not require sticky sessions*
  - *Implements* `HttpSession` *interface that writes data to the DB*
- In-memory replication
  - *A **primary server** holds a session state, the **secondary server** holds its replica.*
  - *Information about primary and secondary servers are part of JSession*

# In-Memory Replication

- Session format
  - *It's a cookie*
  - `JSESSIONID=SESSION_ID!PRIM_SERVER_ID!SEC_SERVER_ID!CREATION_TIME`

    `SESSION_ID` – *session id, generated by the server to identify memory associated with the session on the server*

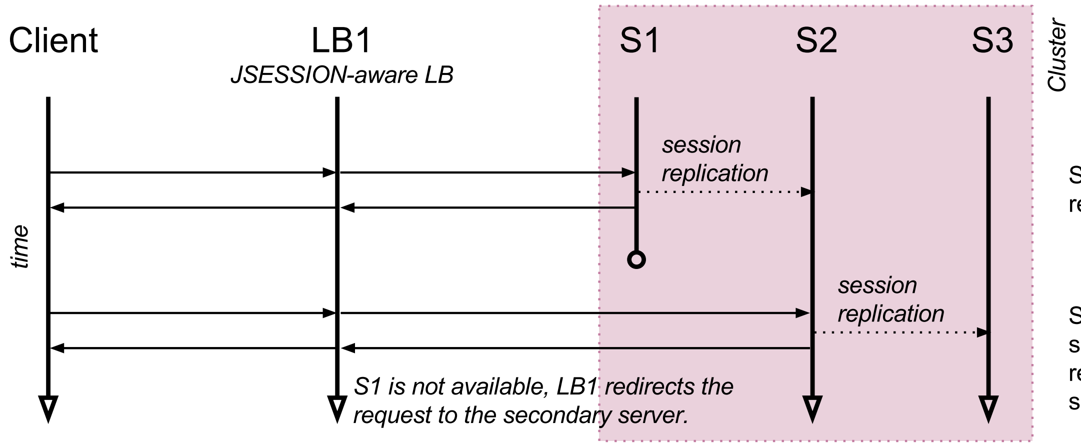
    `PRIM_SERVER_ID` – *ID of the managed server holding the session data*

    `SEC_SERVER_ID` – *ID of the managed server holding the session replica*

    `CREATION_TIME` – *time the session data was created/updated*
- How LB uses this information
  - *LB has information whether the server is running or not (via healthchecks)*
  - *if the primary server is running, it redirects the request there*
  - *if the primary server is not running, it redirects the request to the secondary server directly*
  - *if primary and secondary servers are not running, it redirect the request to any other server it has in the list – this may cause side effects!*

# In-Memory Replication Scenarios

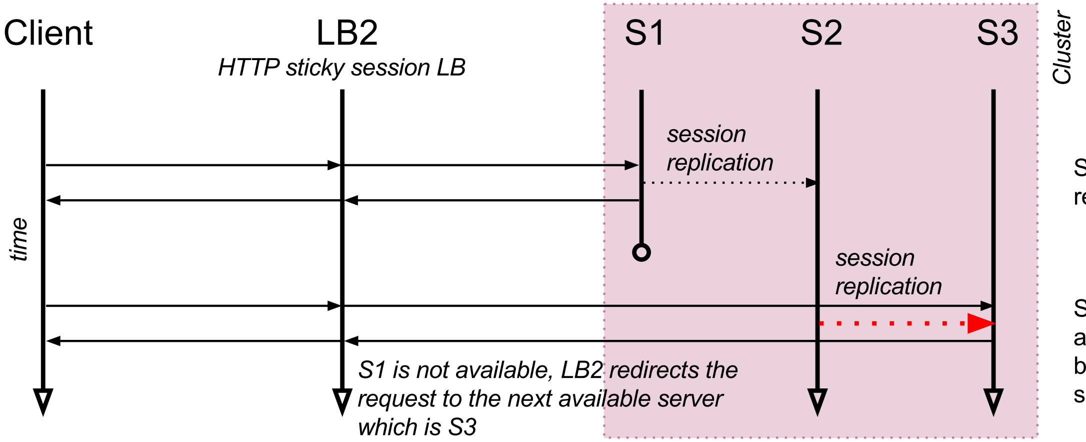
### Scenario A: JSession-aware load balancer



S1 is primary, S2 is secondary; S1 replicates the session to S2

S1 fails, S2 becomes primary, S3 becomes secondary; LB1 directly redirects the request to S2 as it knows the secondary server from the first request.

### Scenario B: HTTP sticky session load balancer



Client
LB2
HTTP sticky session LB
S1
S2
S3
Cluster
time
session replication
session replication
S1 is not available, LB2 redirects the request to the next available server which is S3

S1 is primary, S2 is secondary; S1 replicates the session to S2

S1 fails, S3 discovers that S2 has a session and gets the session data from it. S3 becomes primary and S2 becomes secondary.

# Overview

- Infrastructure
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- Performance Tuning

# Overview

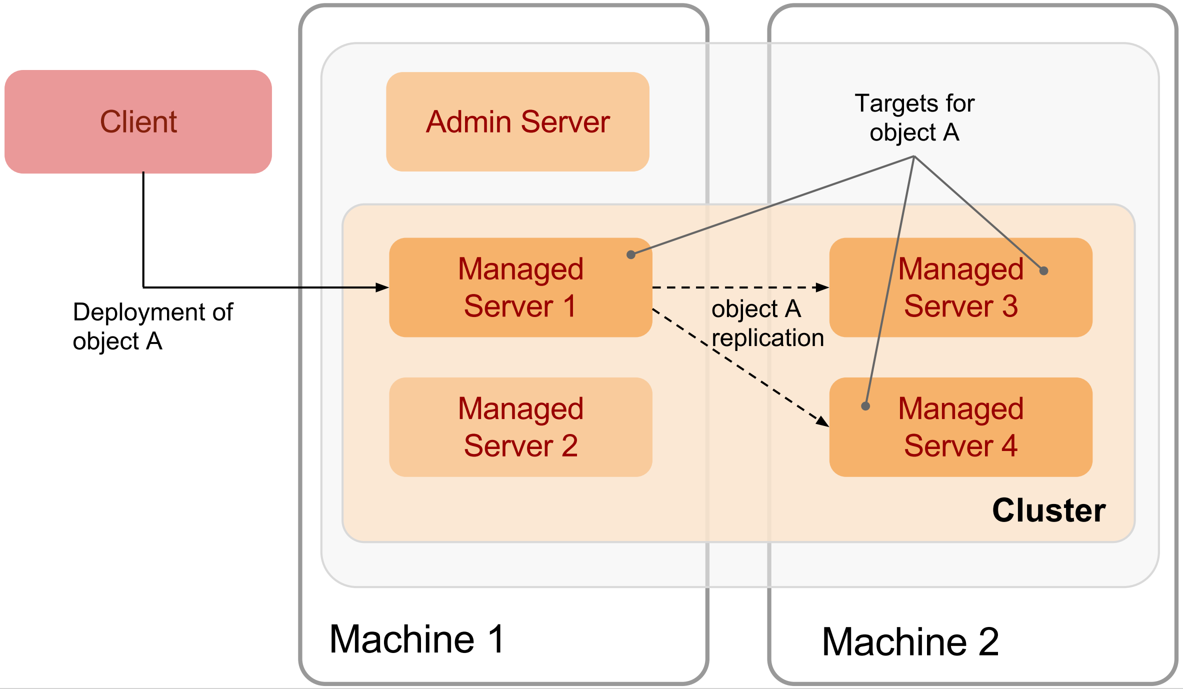
- Cluster
  - *A group of servers that act together to serve client requests*
  - *Cluster appears to clients as a single application server*
  - *Servers can run on the same machines or on different machines*
  - *Cluster's capacity can be increased by adding servers to the cluster*
  - *Servers in a cluster may have the same copy of objects and they are aware of each other objects*

    → *objects: applications, JMS destinations, RMI objects*
- Communication in the cluster
  - *peer-to-peer communication using IP sockets*
  - *IP multicast which servers use to broadcast availability of objects and heartbeats*
- Configurations
  - *Objects deployed to to all servers in a cluster*

    → *Cluster-wide JNDI tree allows to look-up clustered objects*
  - *Servers in a cluster may get replicated through migration*

# Deployment to Cluster

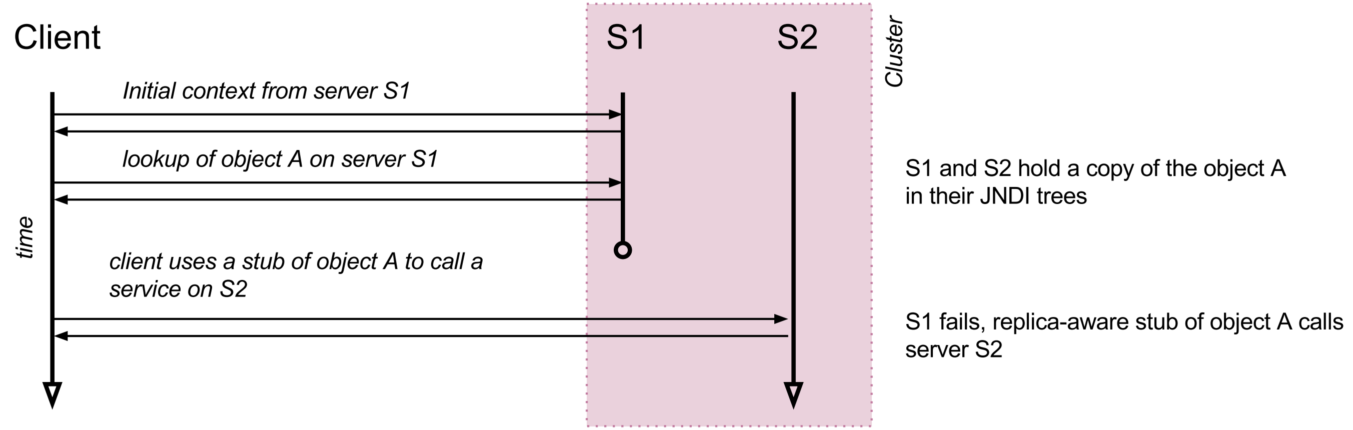
- Deployment of an object
  - *Client deploys to one managed server in the cluster*
  - *Object gets replicated to its targets*
    - → *Targets can be configured for the object, usually all servers but can be selected servers*
    - → *See Lecture 4 for the definition of the object*



# Object Failover

- Failover
  - *Failover = ability to locate an object on another server that holds a copy of the object without an impact on the performace and configuration*

**Replica-aware stub of object A, failover in cluster**


Client
S1
S2
Cluster
Initial context from server S1
lookup of object A on server S1
time
client uses a stub of object A to call a service on S2

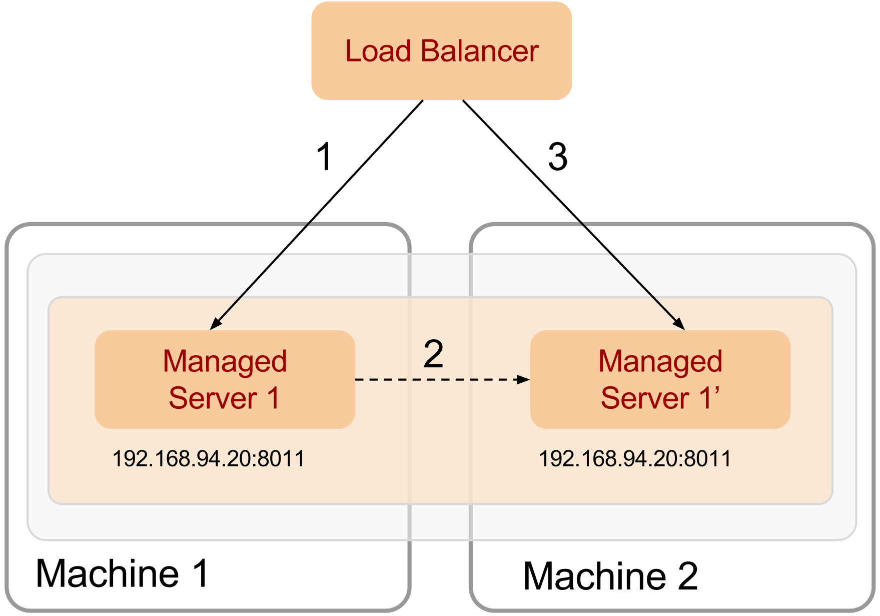
S1 and S2 hold a copy of the object A in their JNDI trees

S1 fails, replica-aware stub of object A calls server S2

  - *A client gets a stub of the object by calling* `lookup` *on the context*
  - *A client uses the stub of the object to access the object on the server*
  - *When a server fails, replicate-aware stub calls the next server that holds the object copy*

# Server Failover

- Failover
  - *Failover = ability to relocate the server to another machine without an impact on the performance*

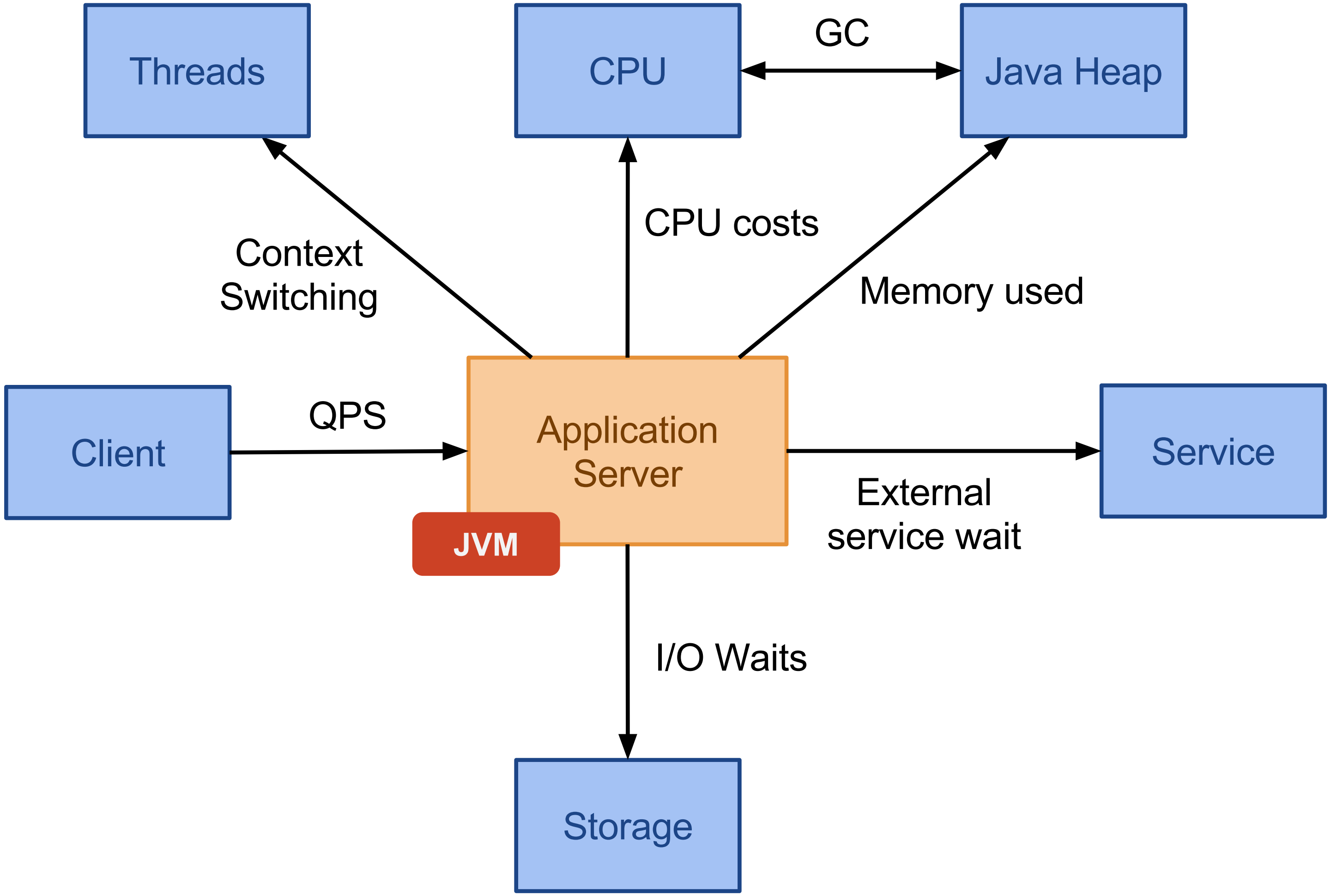


  - *Managed server listens on* `virtual_IP:port`
  - *A load balancer forwards a request to* `virtual_IP:port`
  - *When the server moves,* `virtual_IP:port` *remains the same*

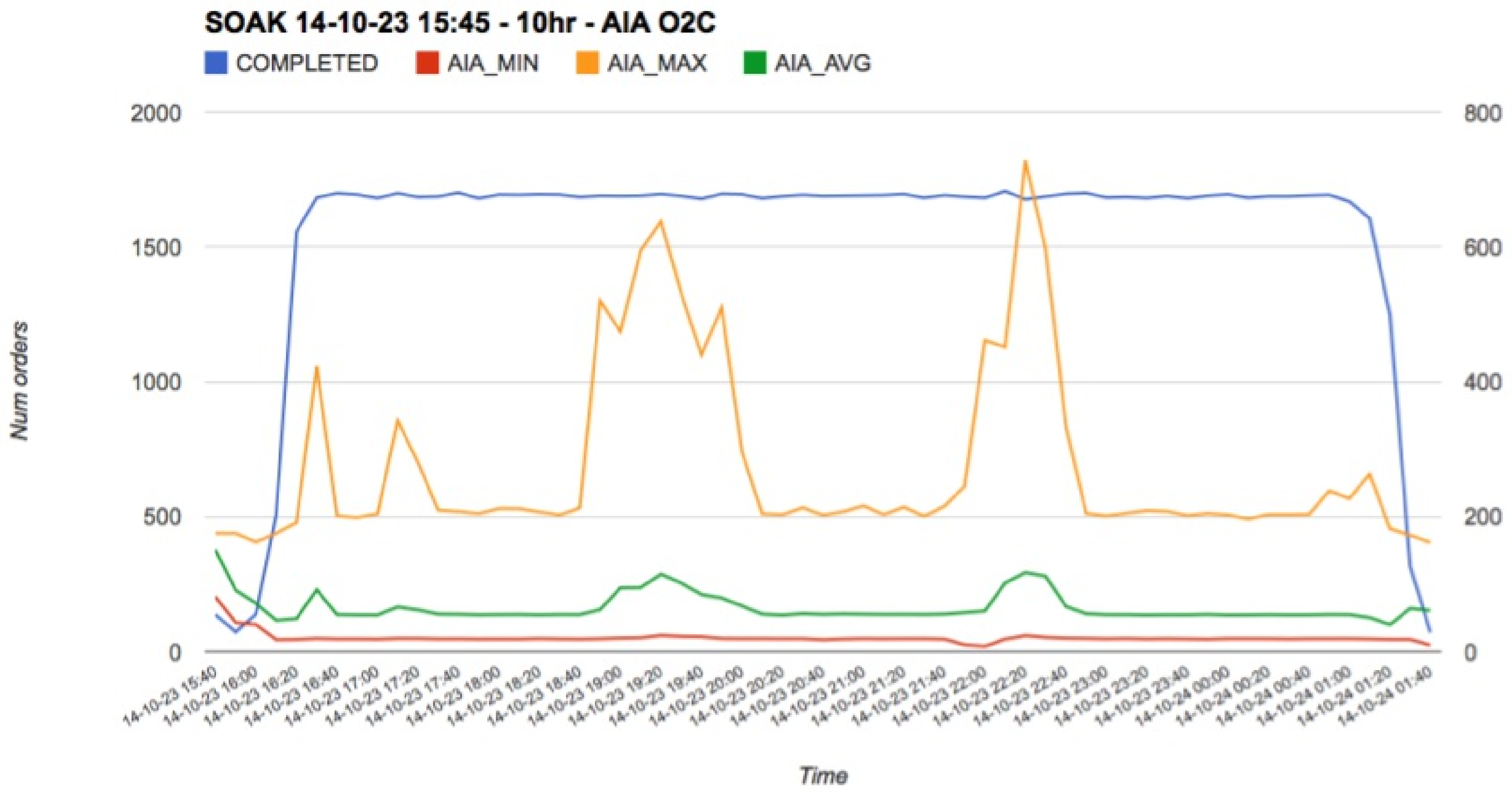
# Overview

- Infrastructure
- Performance Tuning

# Performance Limiting Factors



# Example Performance Testing



– *Completed – number of completed orders*

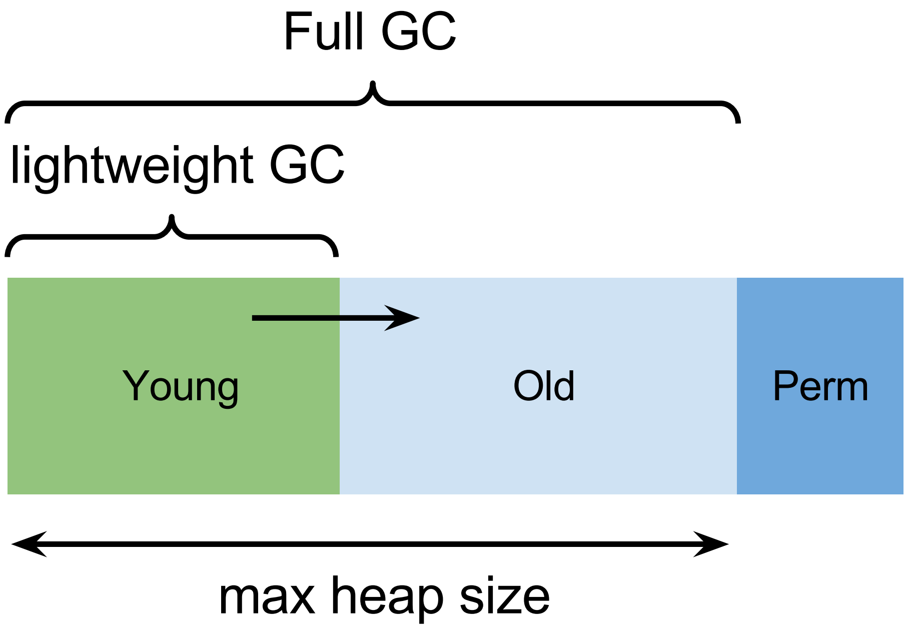
– *MIN, MAX, AVG – a minimum/maximum/average processing time in 10 minutes*

– *At 18:30–20:20 was a performance issue with OMS environment*

# Tuning – A Layered Approach

- Application server can be tuned at multiple layers
  - *Service configuration optimization*
  - *Transport-level tuning*
  - *Application Server Tuning*
  - *JVM Memory Tuning*
  - *OS Tuning*
- Lower levels are cheaper to tune

# Memory Allocations



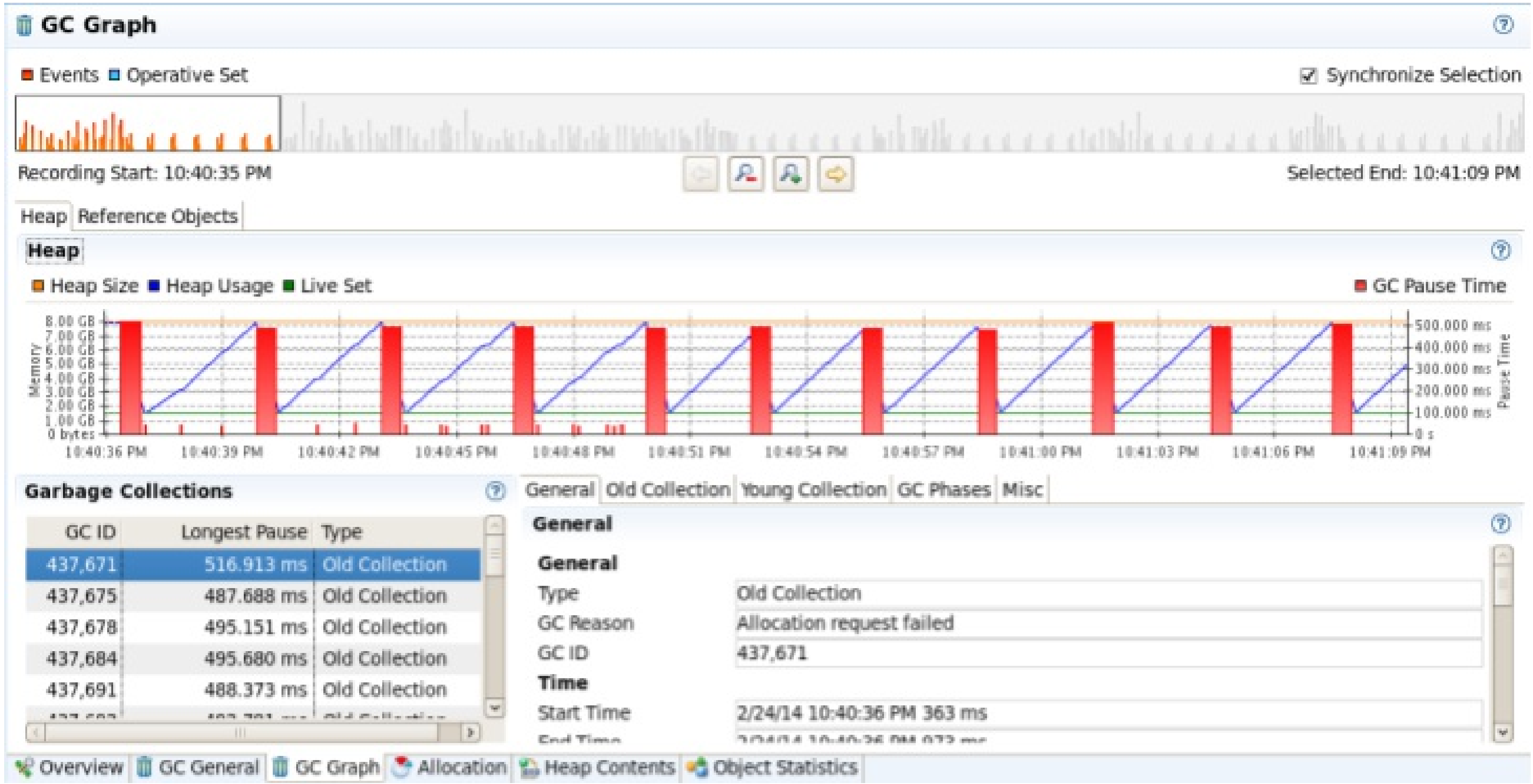
- Generations
  - *Young – objects get allocated in this space initially*
  - *Old – objects get promoted to old from young*
  - *Perm – space for permanent allocations, e.g. objects describing classes and methods*

# Garbage Collection

- Steps to move objects around
  1. *Objects are created in young*
  2. *When young is full, the live objects are copied to old, dead are discarded*
     - ***lightweight GC***
  3. *When young is full and no space in old → the full GC frees the old space*
     - ***Full GC*** *– nothing is running in JVM, the application stops*
  - ***Too frequent full GC has an impact on performance***
- A memory leak or inadequate heap allocation
  - *Old is out of space → full GC will run often (or continously)*
  - *High CPU utilization, ESB will not be able to process/respond to requests*

# Heap Size and GC Runs

- Heap Size and GC runs
  - *Wrong heap size allocation – too small or memory leaks*
  - *GC full runs too often, this has a negative impact on performance*



| GC ID | Longest Pause | Type |
|---|---|---|
| 437,671 | 516.913 ms | Old Collection |
| 437,675 | 487.688 ms | Old Collection |
| 437,678 | 495.151 ms | Old Collection |
| 437,684 | 495.680 ms | Old Collection |
| 437,691 | 488.373 ms | Old Collection |

**General**

**General**

| | |
|---|---|
| Type | Old Collection |
| GC Reason | Allocation request failed |
| GC ID | 437,671 |

**Time**

| | |
|---|---|
| Start Time | 2/24/14 10:40:36 PM 363 ms |

# JVM Memory Tuning

- JVM Memory Parameters

  `-Xms` – *initial java heap size*

  `-Xmx` – *maximum java heap size*

  `-XX:NewSize` – *the initial size of the heap for young generation*

  `-XX:MaxNewSize` – *the maximum size of the heap for young generation*

- General recommendations

  `-Xms` *and* `-Xmx` *should be set to the same value*
  *(do not allow the heap to grow → limit the overhead)*

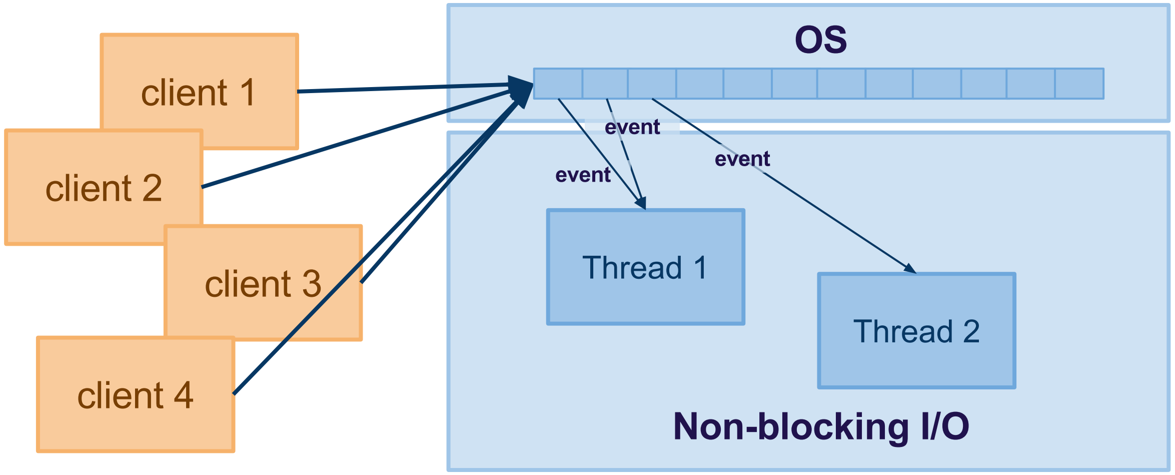
  `-XX:NewSize` *and* `-XX:MaxNewSize` *should be set to the one half of maximum heap*

  – *Example, 1GB heap size*

```
–Xms1024m –Xmx1024m -XX:NewSize=500m -XX:MaxNewSize=500m
```

# Asynchronous I/O: Recall

- Connections maintained by the OS, not the Web app
  - *The Web app registers events, OS triggers events when occur*



- Characteristics
  - *Event examples: new connection, read, write, closed*
  - *The app may create working threads, but controls the number!*
    *→ much less number of working threads as opposed to blocking I/O*

# Work Manager Configuration

- Work Manager
  - *Controls the number of thread allocated to processing of requests*
  - *In WLS is called a dispatch policy*
    - → *Can be assigned to OSB proxy services*
  - *Parameters*
    - → ***maximum threads*** *(*`max`*) – maximum number of working threads*
    - → ***capacity*** *(*`cap`*) – maximum number of connections*
  - *maximum connections waiting to be processed:* `cap - max`
  - *refused connections: when number of connections is* `> cap`
- Inbound throtling
  - *A dispatch policy applied to a single proxy service*
  - *Rejected connections will not be processed*