Middleware and Web Services

Lecture 6: High Availability and Performance

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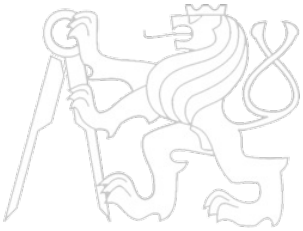

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Good Performance

- What influences 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 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*

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  - *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*

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

Infrastructure Example – Weblogic

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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)*

Overview

- Infrastructure
  - *Load Balancers*
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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

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HTTP Sticky Sessions Example

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- 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*

```
1  <Location /soa-infra>
2      SetHandler weblogic-handler
3      WebLogicCluster czfmwapp03-vf:8001,czfmwapp04-vf:8001,czfmwapp05-vf:800
4  </Location>
5
```

  `/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

- Uses

  `request` – *client request with or without a cookie information*
  `server_list` – *a list of servers that can process the request*
  `rbinx` – *round robin index*
  `sticky_sessions` – *associative array of pairs* `<session_id,server>`
  `unhealthy_treshhold` – *a number of negative consecutive health checks before moving the server to the "unhealthy" state.*

- Round Robin Algorithm
  - *if* `session_id` *exist in the* `request` *and in* `sticky_sessions`
    - → *send the* `request` *to the server* `sticky_sessions[session_id]`
  - *otherwise*
    - → *send the* `request` *to the* `rbinx` *server in the* `server_list`
    - → *extract* `session_id` *from the response from the server*
    - → *if the* `session_id` *exist, add a pair* `<session_id;server_list[rbinx]>` *to* `sticky_sessions`
    - → *increase* `rbinx` *by one or reset it to* `0` *if it exceeds the length of* `server_list`

Health Check

- Health Check
  - *For each server in the* `server_list`
    - → *call the server's heatlhcheck endpoint*
    - → *if a number of failed health checks for the server exceeds the* `unhealthy_threshold`
      - → *remove the server from the* `server_list`
    - → *if the server was unhealthy and a there was a successful healthcheck*
      - → *add the server back to the* `server_list`

Session State Persistence and Replication

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- 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

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Overview

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

Overview

- Cluster capabilities
  - *A group of servers (aka cluster members) act together to serve clients' requests*
  - *Cluster is transparent to clients*
  - *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*
    - → *See Cluster-wide JNDI tree in Lecture 4*
- Cluster Messaging Protocols
  - *When servers need to send messages to other members of the cluster*
  - ***Unicast** - one-to-one communication using TCP/IP sockets*
  - ***Multicast** - one-to-many communication*
  - *Cluster services that rely on the cluster messaging protocol*
    - → *Cluster Membership*
    - → *JNDI Replication*
  - *There are services using persistent RMI connections between cluster members*
    - → *such as during in-memory replication of HTTP session information*

Unicast

- Overview
  - *Uses standard TCP/IP sockets to send messages across cluster members*
  - *Uses a **group leader strategy** to limit the number of sockets required to send messages within the cluster*
- Groups in the cluster
  - *Cluster is split into `M` groups with `N` servers, each group has a leader*
  - *Servers communicate with the group leader, group leaders communicate with servers in the group and other group leaders*
  - *When a group leader dies, the group elects another group leader*
  - *There is up to `MxN` network messages for every cluster message*

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Cluster Services

- Cluster Membership
  - *Cluster members maintain their view on what servers are in the cluster*
  - *Each server sends heartbeat messages to the cluster*
    → others know it is alive
  - *Each server receives heartbeat messages*
    → When a server misses a number of messages from a cluster, it removes the servver from the list until it receives the next heartbeat message.
- JNDI Replication
  - *Provides each server with a cluster-wide view of the JNDI tree.*
  - *Servers send JNDI update messages to the cluster when an object is bound or removed to their local tree.*
  - *When a server leaves the cluster*
    → other members remove its JNDI bindings from their three.
  - *When a server joins the cluster*
    → The server asks other server for a JNDI state dump.

Overview

- Infrastructure
- Performance Tuning

Performance Limiting Factors

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Monitoring

- Important to understand performance
  - *DevOps monitoring trends*
- What you need
  - *Collect → Filter → Store → View →* ***Tune***
  - *Metrics, dashboards, alerting, log management, reporting, tracing capabilities*
  - *It is necessary to organize metrics well in order to understand what is going on*
  - *Start from a high-level process, detail to technical components*
- Source
  - *Application server*
    - *→ usually management beans with JMX interfaces*
    - *→ log files (access logs, server logs, etc.)*
  - *OS*
    - *→ many utilities available out of the box*
    - *→ open sockets, memory, context switches, I/O performance, CPU usage*
  - *Database*
    - *→ applications may write metrics to the DB*
    - *→ SQL scripts to collect metrics*

Monitoring Tools

- Commercial Monitoring Solutions
  - *Application server vendor usually offers a monitoring solution*
  - *AppDynamics, Oracle Enterprise Manager, Splunk*
  - *Google stackdriver, Amazon AWS CloudWatch*
- Open source examples
  - *Elasticsearch + LogStash + Kibana*
  - *InfluxDB + Telegraph + DataGraph*

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

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- 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, The server 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*

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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*

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- 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*