SOA and Virtualization Technologies
(ENCS 691K – Chapter 2)

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The Key Technologies on Which Cloud Computing Relies

- Web Services
- Virtualization
References (Web Services)


References (Virtualization)


9. J. Carapinha et al., Network Virtualization – A View from the Bottom, VISA '09 Proceedings of the 1st ACM workshop on Virtualized infrastructure systems and architectures, Pages 73-80
Web Services
Outline

1. Introduction to Web Services
2. RESTful Web Services Overview
Introduction to Web Services

1. Definition and principles
2. Overall business model
3. Technologies
Web Services so far

- SOAP – BASED WEB SERVICES
- RESTFul Web Services

This part of the course will discuss the general characteristics of Web services
Definitions and principles

Today

• Publication of documents
• Human interaction
• Proprietary ad-hoc interfaces

Tomorrow

• Publication of “reusable business logic”
• Automated Program to program interaction
• Industry standard interfaces

Note: There are other technologies such as JSON that may be used
Definitions and principles

“The term Web Services refers to an architecture that allows applications (on the Web) to talk to each other. Period. End of statement”

Adam Bobsworth in ACM Queue, Vol1, No1
The three fundamental principles, still according to Adam Bobsworth:

1. Coarse grained approach (i.e. high level interface)
2. Loose coupling (e.g. application A which talks to application B should not necessarily be re-written if application B is modified)
3. Synchronous mode of communication, but also asynchronous mode
Business model

Broker
(Human + agent)

Requestor
(Human + agent)

Provider
(Human + agent)
Business model

Requestor
- Person or organization that wishes to make use of a Web service.
- Uses an agent (i.e. requestor agent) to exchange messages with both broker agent and provider agent.

Provider
- Person or organization that owns a Web service it wants to make available for usage
- Use an agent (i.e. provider agent) to exchange messages with broker agent and requestor agent.
- The provider agent is also the software piece which implements the Web service (e.g. mapping towards legacy)

Broker
- Person or organization that puts requestors and providers in contact
  - Providers use brokers to publish Web services
  - Requestors use brokers to discover Web services
- Use an agent (i.e. broker agent) to exchange messages with requestor agent and provider agent
Business model
Some of the technologies are mandatory for some Web services while optional for other Web services:

**HTTP**
- Mandatory for RESTful Web services but “optional” for SOAP Based Web services
- Note: In practice HTTP is also used for SOAP Based Web Services

**XML**
- Mandatory for SOAP Based Web Services but optional for RESTful Web services
HTTP

HTTP (HyperText Transfer Protocol)

- Is an application-level protocol for distributed, collaborative, hypermedia information systems
  - HTTP has been in use since 1990
  - HTTP is a request-response protocol
  - HTTP requests relates to resources
    - A resource is any object or service network that can be identified by a URI (Universal Resource Identifier)
HTTP

Client
- A program that establishes connections for the purpose of sending requests

User Agent
- The client which initiates a request (e.g. browser)

- Note
  - A request may pass through several servers
HTTP

Server

- An application program that accepts connections in order to service requests by sending back responses
- A given program may be capable of being both a client and a server
- The role depends on connections
HTTP

- **Origin server**
  - The server on which a given resource resides or is to be created

- **Proxy server**
  - An intermediary program which acts as both a server and a client for the purpose of making requests on behalf of other clients

- **Gateway server**
  - receives requests as if it were the origin server for the requested resource, and forwards the request to another server
  - Is transparent to the client
HTTP-message = Request | Response

generic-message = start-line
*(message-header CRLF)
CRLF
[ message-body ]

start-line = Request-Line | Status-Line
HTTP

HEAD
- retrieve meta-information about a web page, without retrieving the page content (ex: get the date for last modification)

GET
- retrieve the page content

PUT
- store the enclosed content under the supplied Request-URI

POST
- add the entity enclosed in the request as a new subordinate of the resource identified by the Request-URI
  - E.g.
    - Post a message to a mailinglist
    - Extend a database by appending information
    - Transfer a form data
HTTP

DELETE
- Deletes the page

TRACE
- Debug

OPTIONS
- Allows the client to discover the options supported by the server

CONNECT
- Not used currently
The built-in HTTP request methods.

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GET</td>
<td>Request to read a Web page</td>
</tr>
<tr>
<td>HEAD</td>
<td>Request to read a Web page’s header</td>
</tr>
<tr>
<td>PUT</td>
<td>Request to store a Web page</td>
</tr>
<tr>
<td>POST</td>
<td>Append to a named resource (e.g., a Web page)</td>
</tr>
<tr>
<td>DELETE</td>
<td>Remove the Web page</td>
</tr>
<tr>
<td>TRACE</td>
<td>Echo the incoming request</td>
</tr>
<tr>
<td>CONNECT</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>OPTIONS</td>
<td>Query certain options</td>
</tr>
</tbody>
</table>
The status code response groups.

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1xx</td>
<td>Information</td>
<td>100 = server agrees to handle client’s request</td>
</tr>
<tr>
<td>2xx</td>
<td>Success</td>
<td>200 = request succeeded; 204 = no content present</td>
</tr>
<tr>
<td>3xx</td>
<td>Redirection</td>
<td>301 = page moved; 304 = cached page still valid</td>
</tr>
<tr>
<td>4xx</td>
<td>Client error</td>
<td>403 = forbidden page; 404 = page not found</td>
</tr>
<tr>
<td>5xx</td>
<td>Server error</td>
<td>500 = internal server error; 503 = try again later</td>
</tr>
</tbody>
</table>
XML

XML documents
Data objects made of elements
- `<element> content </element>`

Well-formed Documents
- If it obeys to the XML syntax
  - Exp: - All XML elements must have a closing tag
    - The name in an element's end-tag MUST match the element type in the start-tag.
    - All XML elements must be properly nested
XML

XML processor

- Read XML documents
- Provide access to the content and the structure
- Behaviour described in the XML specifications
- Navigate XML document structure and add, modify, or delete its elements.

- Most popular programming APIs
  - Document Object Model (DOM) from W3C
  - Simple API for XML (SAX) – From XML-DEV mailing list
RESTful Web Services

1. Introduction
2. Resource Oriented Architecture
3. Resources
4. Properties
5. Tool kits
6. Examples of RESTful Web services
Introduction

- What about using the Web’s basic technologies (e.g. HTTP) as a platform for distributed services?
  
  - This is what is REST about.
Introduction

- REST was first coined by Roy Fielding in his Ph.D. dissertation in 2000

- It is a network architectural style for distributed hypermedia systems.
Introduction

- REST is a way to reunite the programmable web with the human web.

- It is simple
  - Uses existing web standards
  - The necessary infrastructure has already become pervasive
  - RESTFull web services are lightweight
  - HTTP traverse firewall
Introduction

- RESTFul web services are easy for clients to use

- Relies on HTTP and inherits its advantages, mainly
  - Statelessness
  - Addressability
  - Unified interface
Resource-Oriented Architecture

- The Resource-Oriented Architecture (ROA)
  - Is a RESTful architecture
  - Provides a commonsense set of rules for designing RESTful web services
Resource-Oriented Architecture

- Concepts
  - Resources
    - Resources names (Unified Resource Identifiers-URIs)
    - Resources representations
    - Links between resources

- Key properties:
  - Addressability
  - Statelessness
  - Uniform interface
Resources

What’s a Resource?
- A resource is any information that
  - can be named
  - Is important enough to be referenced as a thing in itself
- A resource may be a physical object or an abstract concept
- e.g.
  - a document
  - a row in a database
  - the result of running an algorithm.
Resources

- Naming:
  - Unified Resource Identifier (URI)
    - The URI is the name and address of a resource
    - Each resource should have at least one URI
    - URIs should have a structure and should vary in predictable ways
Resource

Representation

- A representation is any useful information about the state of a resource

- Different representation formats can be used (Unlike SOAP based Web services)
  - *plain-text*
  - *JSON*
  - *XML*
  - *XHTML*
  - ....
Resource

...  

- In most RESTful web services, representations are hypermedia
  - i.e. documents that contain data, and links to other resources.
Properties

- **Addressability**
  - An application is addressable if it exposes a URI for every piece of information it serves
  - This may be an infinite number of URIs
    - e.g. for search results
      - [http://www.google.com/search?q=jellyfish](http://www.google.com/search?q=jellyfish)
Properties

- **Statelessness**
  - The state should stay on the client side, and be transmitted to the server for every request that needs it.
    - Makes the protocol simpler
    - Ease load balancing
Properties

- Uniform interface
  - **HTTP GET:**
    - Retrieve a representation of a resource
  - **HTTP PUT**
    - Create a new resource, where the client is in charge of creating the resource URI: **HTTP PUT** to the new URI
    - Modify an existing resource: **HTTP PUT** to an existing URI
  - **HTTP POST:**
    - Create a new resource, where the server is in charge of creating the resource URI: **HTTP POST** to the URI of the superordinate of the new resource
  - **HTTP DELETE:**
    - Delete an existing resource:
  - **HTTP HEAD:**
    - Fetch metadata about a resource
  - **HTTP OPTIONS:**
    - Lets the client discover what it’s allowed to do with a resource.
Examples of tool kits

- RestLet
- Jersey
Examples of RESTful Web Services

- Examples of existing RESTful web services include:
  - Amazon’s Simple Storage Service (S3) ([http://aws.amazon.com/s3](http://aws.amazon.com/s3))
  - Twitter is a popular blogging site that uses RESTful Web services extensively.
# Examples of RESTful Web Services

<table>
<thead>
<tr>
<th>Resources</th>
<th>URL</th>
<th>HTTP action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outbound SMS message requests</strong></td>
<td><code>/outbound/{senderAddress}/requests</code></td>
<td>GET: read pending outbound message requests&lt;br&gt;POST: create new outbound messages request</td>
</tr>
<tr>
<td><strong>Outbound SMS message request and delivery status</strong></td>
<td><code>/outbound/{senderAddress}/requests/{requestId}</code></td>
<td>GET: read a given sent message, along with its delivery status</td>
</tr>
<tr>
<td><strong>Inbound SMS message subscriptions</strong></td>
<td><code>/inbound/subscriptions</code></td>
<td>GET: read all active subscriptions&lt;br&gt;POST: create new message subscription</td>
</tr>
<tr>
<td><strong>Individual inbound SMS message subscription</strong></td>
<td><code>/inbound/subscriptions/{subscriptionId}</code></td>
<td>GET: read individual subscription&lt;br&gt;DELETE: remove subscription and stop corresponding notifications</td>
</tr>
</tbody>
</table>

Table 2. A subset of ParlayREST SMS resources.
Examples of RESTful Web Services

Figure 4. Sample scenario for SMS handling.
Virtualization
1. Systems virtualization
2. Network virtualization
Systems Virtualization

1. On operating systems
2. Brief history of systems virtualization
3. Key concepts (virtual machine, virtual machine monitor/hypervisor)
4. Examples of benefits
On operating systems

Some of the motivations

- Only one single thread of CPU can run at a time on any single core consumer machine
- Machine language is tedious
On operating systems

Operating systems bring a level of abstraction on which multiple processes can run at a time – Deal among other things with:

- Multiplexing
- Hardware management issues

However only one operating system can run on a bare single core consumer machine
Brief history

- Systems virtualization dates back to the 60s
- IBM experimentation with “time sharing systems”
  - Need for virtual machines to test how applications / users can time share a real machine
Key concepts

Virtual machine (VM) (sometimes called virtual hardware)
- Software that provides same inputs / outputs and behaviour expected from hardware (i.e. real machine) and that supports operations such as:
  - Create
  - Delete
  - Migrate
  - Increase resources

Virtual machine monitor (also called hypervisor)
- Software environment that enables operations on virtual machines (e.g. XEN, VMWare) and ensures isolation
Key concepts

From reference [6] – Note: There is a small in the figure
Key concepts

Types of hypervisor

- Type I – bare metal
- Type 2 - hosted
Key concepts

Types of hypervisor/virtual machine monitor

[Sugerman et al. 2001]
Key concepts

Full virtualization vs. para-virtualization

- Full virtualization
  - No need to modify guest operating system before installing it on top of hypervisor

- Para virtualization
  - Operating system needs to be modified
  - Note: Some hardware (e.g. X86) are not fully virtualisable
Examples of Benefits

All benefits are due to the possibility to manipulate virtual machine (e.g. create, delete, increase resources, migrate), e.g.

- Co-existence of operating systems
- Operating systems research
- Software testing and run-time debugging
- Optimization of hardware utilization
- Job migration
Network virtualization

1. Motivations

2. Basic components
Motivations

Bring the benefits of systems virtualization to the networking world, e.g.

- Co-existence of virtual networks on top of a same real network
  - Note: Virtual Private Networks (VPNs) do not rely on virtualization and have several limitations
    - Different technologies and protocol stacks cannot be used for instance
- Networking research
- Optimization of networking resources utilization
  - Nodes
  - Links
Basic components

From reference 9
Basic components

From reference 9
The End