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www.cs.stir.ac.uk

Web Services

Introduction

Some Logistics

- **Dr. Mario Kolberg**, 4B123, mko@cs.stir.ac.uk
- **Lectures and labs:**
  - Labs and lectures alternate weeks. (details follow …)

Logistics cont.

- **Tutorials**
  - No formal tutorials
  - Use the labs to ask questions
- **Assignments & Examination**
  - Lab Checkpoints (10%)
  - Assignment: (40%)
  - Examination: (50%)
- **On line @ CANVAS**

Resources for private study

- Internet: lectures & lab sheets will be available on webpage
- Books
  - Java Web Services, Martin Kalin, O'Reilly (recommended)
  - Restful Java with JAX-RS 2.0, Bill Burke, O'Reilly (recommended)
  - Building RESTful Web Services with Java EE 8, Mario-Leander Reimer, Packt Publishing (background)
- Emails are welcome
  - mko@cs.stir.ac.uk

Origins

- Distributed computing for
  - Linking networked computers and applications
  - Sharing computation
  - Sharing data
- Previous approaches
  - Java RMI (Remote Method Invocation)
  - OMG CORBA (Common Object Request Broker Architecture)
  - Microsoft DCOM (Distributed Component Object Model)
  - ODP (Open Distributed Model)
- Web was rapidly adopted as a means to share information, initially through static web pages, later dynamic and interactive web pages
- Web focussed on accessing information
- Web services focus on B2B communication

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Characteristics

- Jeff Bezos (CEO Amazon), Tech. Review 01/2005
  - "Web 1.0 was making the Internet for people; Web 2.0 is making the Internet better for computers"
- Gartner Research,
  - "Web services are loosely coupled software components delivered over Internet standard technologies"

- emphasise communication among applications rather than users
- follow open standards that are widely supported by industry
- architecture is loosely coupled, so web services can be designed in isolation
- can interwork even if they were not explicitly designed to do so
- supported by three classes of system: service consumers (clients), service providers (servers), and service brokers (registries)

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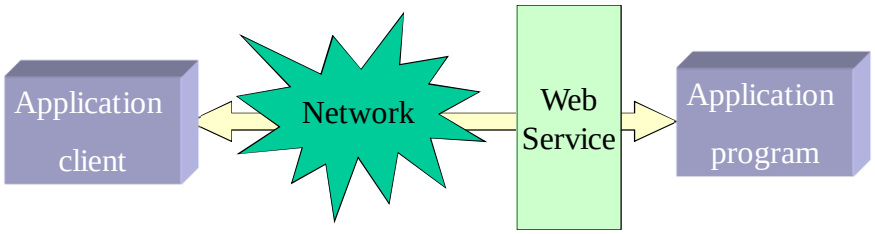
What is a Web Service?

- A web service is a network accessible interface to application programs, built using standard Internet technologies.
- Clients of web services do NOT need to know how it is implemented.
- A Web Service is a URL-addressable software resource that performs functions (or a function).



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What is a Web Service?

- "Web services are a new breed of Web application. They are self-contained, self-describing, modular applications that can be published, located, and invoked across the Web. Web services perform functions, which can be anything from simple requests to complicated business processes. … Once a Web service is deployed, other applications (and other Web services) can discover and invoke the deployed service." *IBM web service tutorial*

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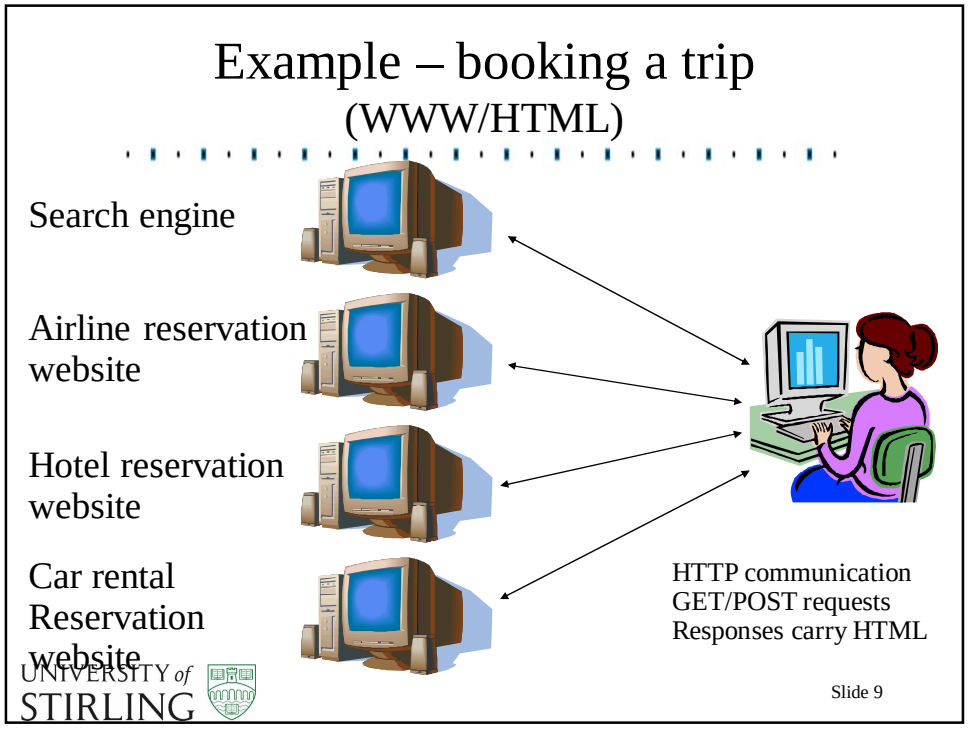
Example – booking a trip
(WWW/HTML)
Search engine
Airline reservation website
Hotel reservation website
Car rental Reservation website
HTTP communication
GET/POST requests
Responses carry HTML
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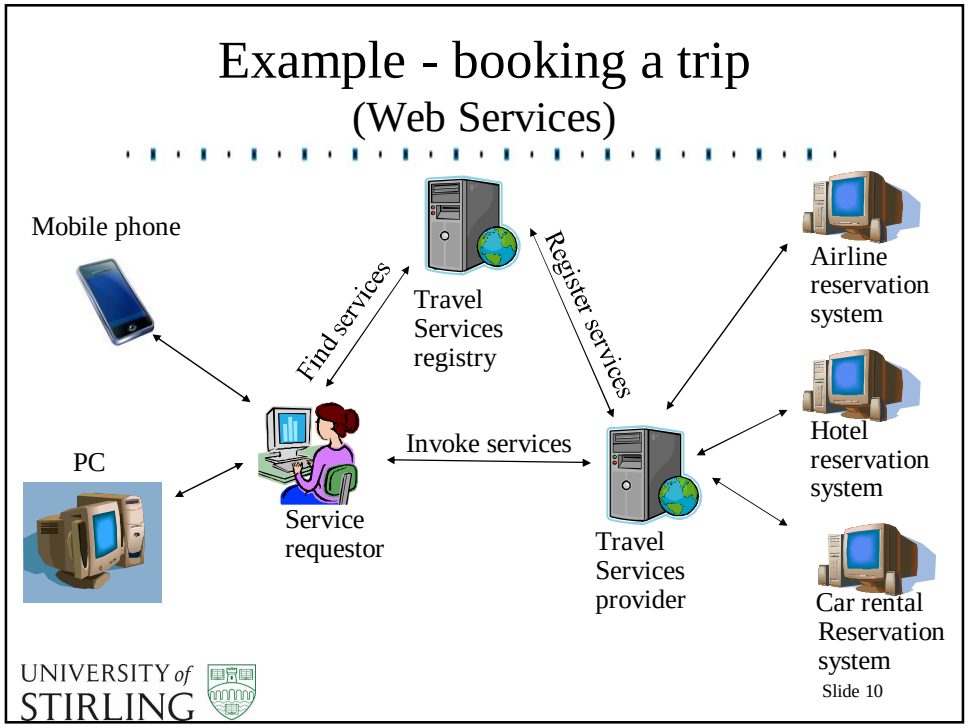
Example - booking a trip
(Web Services)
Mobile phone
PC
Find services
Travel Services registry
Register services
Invoke services
Service requestor
Travel Services provider
Airline reservation system
Hotel reservation system
Car rental Reservation system
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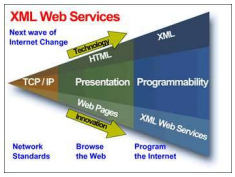
Evolution



Technology	TCP/IP	HTML	XML
Purpose	Connectivity	Presentation	Programmability
Applications	E-Mail, FTP…	Web Pages	Web Services
Outcome	Create the Web	Browse the Web	Program the Web

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Usage

- Web services are used by business for managing partnerships
  - supply chains (e.g. a brake manufacturer automatically maintains stock levels of parts for a car manufacturer)
  - outsourcing (e.g. an electronics manufacturer has its web pages managed by an IT company)
  - contracting (e.g. an Internet shop goes to tender for management of online purchases)
  - combined services (e.g. a travel agent uses the services of airlines, hotel chains and car rental companies to offer a complete travel booking service)
- Web services support virtual organisations across the boundaries of conventional organisations

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Web Services Standards

- standards for web services are defined by a number of organisations such as:
  - IETF (Internet Engineering Task Force, www.ietf.org)
  - OASIS (Organization for The Advancement of Structured Information Standards, www.oasis-open.org)
  - W3C (World Wide Web Consortium, www.w3.org)
- web services share certain communication mechanisms with conventional use of the Web:
  - HTTP (HyperText Transfer Protocol, IETF RFC 2616) to support message exchange between web services
  - TCP (Transmission Control Protocol, IETF RFC 793) for reliable transfer of data across a collection of subnetworks (e.g. the Internet)
  - IP (Internet Protocol, IETF RFC 791) for routing across a collection of subnetworks

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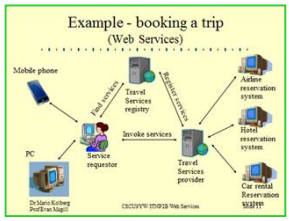
Web Services Standards

- many web service aspects have been (or are being) standardised in areas such as:
  - service description
  - service discovery
  - service addressing
  - security and authentication
  - reliable messaging and transaction
  - service orchestration and choreography
  - service policies



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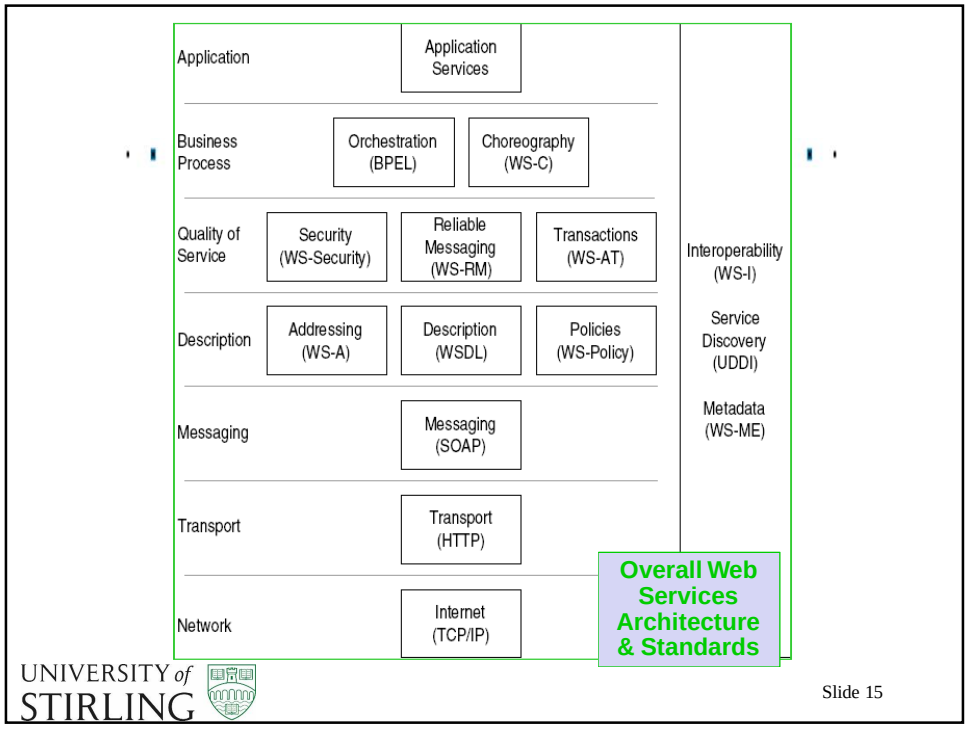
Application
Application Services
Business Process
Orchestration (BPEL)
Choreography (WS-C)
Quality of Service
Security (WS-Security)
Reliable Messaging (WS-RM)
Transactions (WS-AT)
Description
Addressing (WS-A)
Description (WSDL)
Policies (WS-Policy)
Messaging
Messaging (SOAP)
Transport
Transport (HTTP)
Network
Internet (TCP/IP)
Interoperability (WS-I)
Service Discovery (UDDI)
Metadata (WS-ME)
Overall Web Services Architecture & Standards
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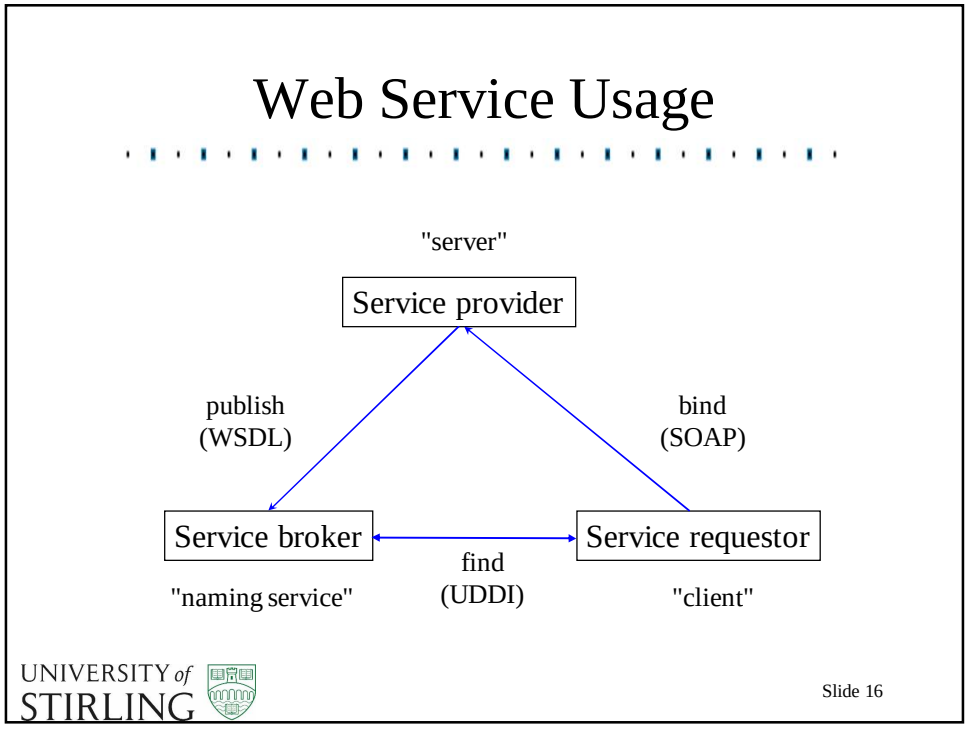
Web Service Usage
"server"
Service provider
publish (WSDL)
bind (SOAP)
Service broker
Service requestor
find (UDDI)
"naming service"
"client"
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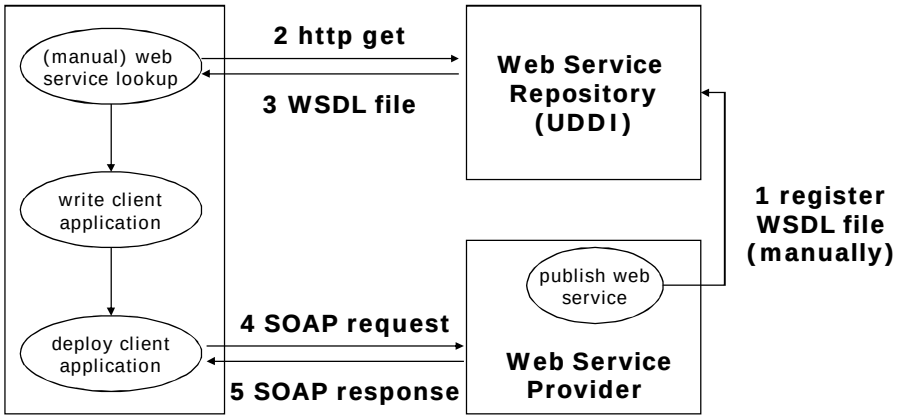
Web Services Usage Example



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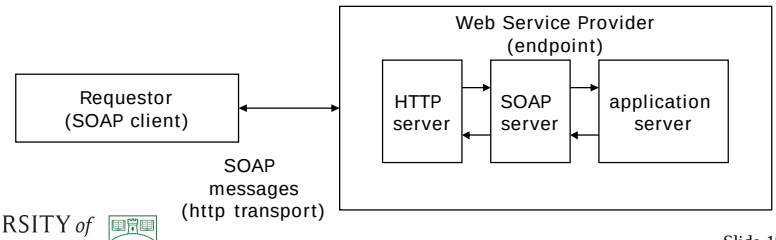
Web Services Implementation

- Drastically simplified!
- Application Server (web service-enabled)
  - provides implementation of services and exposes it through WSDL/SOAP
  - implementation in Java, as EJB, as .NET (C#) etc.
- SOAP server, implements the SOAP protocol
- HTTP server, standard Web server
- SOAP client, implements the SOAP protocol on the client site



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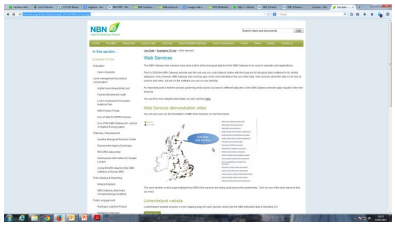
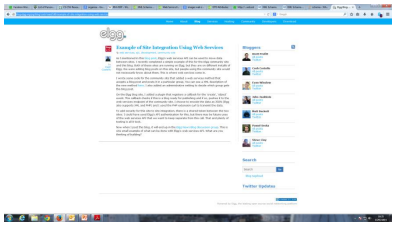
Examples

- http://aws.amazon.com/
  - Exposes world's largest product database through Web Services
  - Idea: let others figure out how to sell products for us
  - Associates program enables Web sites to link to Amazon.com and earn referral fees
- Some other interesting examples:
  - http://www.nbn.org.uk/Use-Data/Examples-Of-Use/Web-services.aspx
  - http://blog.elgg.org/pg/blog/cash/read/149/example-of-site-integration-using-web-services





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SOA/SOC

- web services support what is generically called SOA (Service Oriented Architecture) in support of SOC (Service Oriented Computing)
- SOC views a distributed system from the perspective of the services it offers and how these relate to each other
- previous work on distributed computing was object oriented, but this describes the (close) coupling among distributed objects
- instead, web services maintain a loose coupling – only the services offered by a distributed application are exposed:
  - legacy applications can easily be given a web service wrapping
  - the internal design of a web service can readily be changed
  - new services can be created by combining existing services

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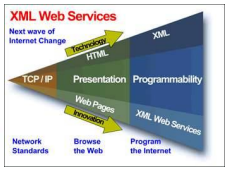
Background: XML



- Meta-language
- XML uses **markup** to describe data.
  - So it is used to develop **our own** markup languages.
- Text files
- XML and HTML are for different purposes.
  - HTML is concerned with display (e.g. <body>, <p>, <ul>)
  - XML is concerned with data representation
- The markup facilities in HTML are **predefined**
- In XML **we define our own!**

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Background: XML cont.

- Some XML:

```
<pets>
  <animal>
    <type>Dog</type>
    <name>Jasper</name>
    <disposition>Enthusiastic</disposition>
  </animal>
  <animal>
    <type>Cat</type>
    <name>Barney</name>
    <disposition>Cynical</disposition>
  </animal>
</pets>
```

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Background XML cont.

- XML *attributes* further define *elements*:
  - `<price currency="GBP">1.15</price>`
  - `<price currency="USD">1.75</price>`
- #Required vs #Implied
- Well formed *vs* valid XML
- Two ways to specify the structure of XML documents:
  - Document Type Definitions (DTDs)
  - XML Schemas
- We need to specify
  - what elements (tags) will be used
  - how the various elements may be nested
  - what attributes they may contain
  - what types of data an element can contain

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DTD vs Schemas

- DTDs are rather limited in how they describe the content of data (e.g. it cannot be stated that a particular element contains integers or strings)
- **XSD** (**XML Schema Definition**, W3C version 1.0) is now the preferred way to define applications of XML, giving:
  - the structural elements in the data, defining the types of data they contain
  - definitions of data types, including sophisticated constraints on their contents
  - the relationships among the structural elements
  - the attributes of elements
- **XSI** (**XML Schema Instance**, W3C version 1.0) defines XML documents as instances of their schemas

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Namespaces

- a namespace is essentially just a unique string, though namespaces typically take the form of a URI (Uniform Resource Indicator)
- a namespace URI is typically a URL (Uniform Resource Locator) for where a schema is defined (e.g. www.cs.stir.ac.uk/schemas/mustard.xsd)
- a namespace URI may simply be a URN (Uniform Resource Name) that gives a (relatively) unique identifier (e.g. urn:MustardDefinition)
- since a namespace URI may be lengthy, it is commonly referred to by a short prefix – a string that is unique only within a document (e.g. mstd)

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Defining a Namespace

- namespace prefixes are defined and used as follows (xmlns means XML NameSpace):
  - xmlns:mstd="www.cs.stir.ac.uk/schemas/mustard.xsd"
  - ...
  - mstd:sequence
- mstd:sequence is an example of using a namespace prefix
- a document may declare a default namespace (xmlns on its own) for elements and attributes that are used without an explicit namespace prefix
- a document may also declare a target namespace (targetNamespace) that applies to all elements and attributes that it defines
- it is often convenient to have a prefix corresponding to the target namespace; this is typically, but need not be, named tns
- the namespace prefix for XML Schema Definition is usually xsd (though sometimes xs), while that for XML Schema Instance is usually xsi

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XML Schema

- With a schema, instead of having a definition in a file such as **note.dtd**, it is held in a file **note.xsd**
- When the XML file is specified by an XSD document held in **note.xsd**, the attributes within the **note** element in the XML file are:

```
<note xmlns="http://www.w3schools.com"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation="http://www.w3schools.com note.xsd">
```

- The notation is therefore in XML.
- We have also defined namespaces.
- The default namespace in this example is: **http://www.w3schools.com**

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XML Schema

- Let us now look at the structure of the XSD document.
- The <schema> element is the root element of every XML Schema and it normally has attributes.
- The following specifies that elements and data types used in the schema (schema, element, complexType, sequence, string, boolean, etc.) come from the namespace: **http://www.w3.org/2001/XMLSchema**

and that the elements and data types from that namespace should be prefixed with xs:

```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
   targetNamespace="http://www.w3schools.com"
   xmlns="http://www.w3schools.com"
   elementFormDefault="qualified">
```

elements used by a XML document which are declared in this schema must be namespace **qualified**

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An example …

The root element in our XML is `note`. Suppose that it is composed of a sequence of four elements `to`, `from`, `heading` and `body`, it is an example of a ***complex element*** and its definition has the structure:

```
<xs:element name="note">
  <xs:complexType>
    <xs:sequence>
      ...
    </xs:sequence>
  </xs:complexType>
</xs:element>
```

- The term `sequence` indicates that the inner elements must appear in the specified order.

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XML Schema Datatypes

- XML Schema have a lot of built-in data types. Examples are:
  - **`xs:string`**
  - **`xs:decimal`**
  - **`xs:integer`**
  - **`xs:boolean`**
  - **`xs:date`**
  - **`xs:time`**
- This gives us a lot more control than we had with DTDs to specify what can go into our XML document. If the XML document contains a value of the wrong type then it will not validate.

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Example datatypes

- Suppose that we had the following simple elements in XML:

```
<lastname>Smith</lastname>
<age>36</age>
<dateborn>1968-03-27</dateborn>
```

- Note that date is given as YYYY-MM-DD
- The corresponding simple element definitions in XSD are:

```
<xs:element name="lastname" type="xs:string"/>
<xs:element name="age" type="xs:integer"/>
<xs:element name="dateborn" type="xs:date"/>
```

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Example cont.

In our **note** example, the inner elements are built-in simple elements. Their definition has the structure:

```
<xs:element name="aname" type="atype"/>
```

In fact, they are all strings. Hence the full definition of **note** is:

```
<xs:element name="note">
 <xs:complexType>
   <xs:sequence>
    <xs:element name="to" type="xs:string"/>
    <xs:element name="from" type="xs:string"/>
    <xs:element name="heading" type="xs:string"/>
    <xs:element name="body" type="xs:string"/>
   </xs:sequence>
 </xs:complexType>
</xs:element>
```

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Defining new types

- So, here we have defined a new element called **`note`** and described its structure.
- It has an *anonymous* type.

- An alternative would be to define a new **`complexType`** (e.g. **`NoteType`**) and then define the **`note`** element as:

```
<xs:element name= "note" type= "NoteType"/>
```

This approach is much better if we are going to have several elements with the same structure (type).

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A new type

- We now define **`NoteType`** as:

```
<xs:complexType name="NoteType">
   <xs:sequence>
     <xs:element name="to" type="xs:string"/>
     <xs:element name="from" type="xs:string"/>
     <xs:element name="heading" type="xs:string"/>
     <xs:element name="body" type="xs:string"/>
   </xs:sequence>
</xs:complexType>
```

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Another new type

- We can also define a new **`simpleType`**.
- We start from an existing **`simpleType`** (the base type) and impose a ***restriction*** by means of a ***facet***.
- Example facets are:
  - `maxInclusive` and `maxExclusive`
  - `minInclusive` and `minExclusive`
  - `pattern`
  - `enumeration`

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Restrictions on types

- Suppose that we wanted to restrict the range of allowable values in our `age` element.
- Instead of defining it as:

```
<xs:element name="age" type="xs:integer"/>
```

- We can define it as:

```
<xs:element name="age">
 <xs:simpleType>
  <xs:restriction base="xs:integer">
    <xs:minInclusive value="13"/>
    <xs:maxInclusive value="19"/>
  </xs:restriction>
 </xs:simpleType>
</xs:element>
```

```
<xs:element name="car">
  <xs:simpleType>
    <xs:restriction base="xs:string">
      <xs:enumeration value="Audi"/>
      <xs:enumeration value="Golf"/>
      <xs:enumeration value="BMW"/>
    </xs:restriction>
  </xs:simpleType>
</xs:element>
```

```
<xs:element name="initials">
  <xs:simpleType>
    <xs:restriction base="xs:string">
      <xs:pattern value="[A-Z][A-Z]"/>
    </xs:restriction>
  </xs:simpleType>
</xs:element>
```

- Can also define default or fixed values for a type:

```
<xs:element name="color" type="xs:string" default="red"/>
<xs:element name="color" type="xs:string" fixed="red"/>
```

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XML Schema summary

- schema data types use the following:
  - predefined types like **boolean**, **date**, **double**, **float**, **int**, **integer** (arbitrary length), **nonNegativeInteger**, **string**, **time**
  - **element** for a field in a type
  - **complexType** for structured types

```
<complexType name="fieldCount">                          <!-- start 'fieldCount' type -->
    <sequence>                                           <!-- start fields -->
    <element name="field"   type="xsd:string"/>          <!– 'field' field -->
    <element name="count" type="xsd:nonNegativeInteger"/> <!– 'count' field -->
    </sequence>                                          <!-- end fields -->
</complexType>                                           <!-- end 'fieldCount' type -->

<complexType name="analysis">                            <!-- start 'analysis' type -->
    <sequence>                                           <!-- start fields -->
    <element name="fieldCount" type="defs:fieldCount"
    minOccurs="0" maxOccurs="unbounded"/>                <!– 'fieldCount' array -->
    </sequence>                                          <!-- end fields -->
</complexType>                                           <!-- end 'analysis' type -->
```

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