أكاديمية الحكومة الإلكترونية الفلسطينية

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Tutorial III:

Process Integration and Service Oriented Architectures

Session 7
SOAP

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About

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- Birzeit University, Palestine (**Coordinator**)
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- Palestine Technical University, Palestine
- Ministry of Telecom and IT, Palestine
- Ministry of Interior, Palestine
- Ministry of Local Government, Palestine
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Tutorial Map

Intended Learning Objectives
A: Knowledge and Understanding
3a1: Demonstrate knowledge of the fundamentals of middleware.
3a2: Describe the concept behind web service protocols.
3a3: Explain the concept of service oriented architecture.
3a4: Explain the concept of enterprise service bus.
3a5: Understanding WSDL service interfaces in UDDI.
B: Intellectual Skills
3b1: Design, develop, and deploy applications based on Service Oriented Architecture (SOA).
3b2: use Business Process Execution Language (BPEL).
3b3: using WSDL to describe web services.
C: Professional and Practical Skills
3c1: setup, Invoke, and deploy web services using integrated development environment.
3c2: construct and use REST and SOAP messages for web services communication.
D: General and Transferable Skills
d1: Working with team.
d2: Presenting and defending ideas.
d3: Use of creativity and innovation in problem solving.
d4: Develop communication skills and logical reasoning abilities.

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Session 7: SOAP protocol

Session ILOs

After completing this module students will be able to discuss the:

1. Construction of SOAP messages for web services communication
2. Use SOAP messages for web services communication

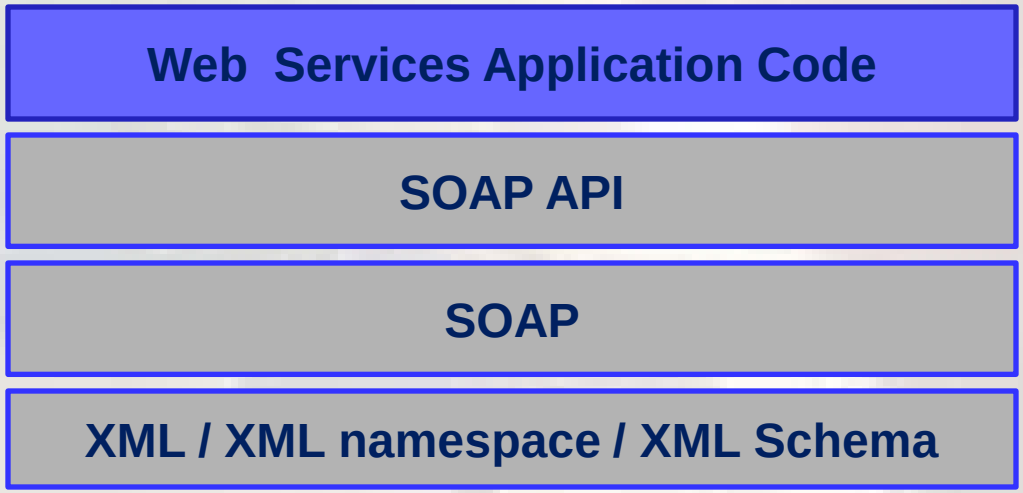
Session Outlines

- **Introduction**
  - **History, definition and basic role**
  - **characteristics**
- SOAP Message format
- SOAP section 5 encoding
- SOAP communication styles
- Summary

Introduction: History

- Microsoft started thinking about XML-based distributed computing in 1997 to enable applications to communicate via RPCs [1].
- In 2000, the XML Protocol working group at the W3C was formed to design the XML protocol “core of XML-based distributed computing”.
- The group started with SOAP 1.1 as a first working draft, then SOAP 1.2 in 2003

SOAP is based on XML concepts



Source, [6]

Introduction: Definition

- Simple Object Access Protocol (SOAP):
  - An XML-based protocol specification for exchanging structured information in the implementation of Web Services [2].
- SOAP relies on other Application Layer protocols, most notably **RPC** and **HTTP** for message negotiation and transmission.
- SOAP can form the foundation layer of a web services protocol stack
- It provides a basic messaging framework upon which web services can be built.

SOAP basic Role

- The role of SOAP [1]:
  - A Web service is a software system designed to support interoperable machine-to-machine interaction.
  - A Web service has an interface described in a machine processable format (specifically WSDL).
  - Other systems interact with the Web service in a manner prescribed by its description *using SOAP-messages*, *typically* conveyed using HTTP with an XML serialization in conjunction with other Web related standards.

SOAP Characteristics

- Provides a mechanism for defining the unit of communication using identifiable SOAP message.
- Provides a processing model:
  - A set of rules for dealing with SOAP messages in software which is the key to use the protocol successfully.
- Provides an extensibility model: using any number of SOAP headers to implement arbitrary extensions on top of SOAP.

SOAP Characteristics, cont.

- Provides a mechanism for error handling
- Provides a flexible mechanism for data representation (text, XML, …)
- Provides a convention for representing Remote Procedure Calls (RPCs) and responses as SOAP messages
- Provides a protocol binding framework: an architecture for building bindings to send and receive SOAP messages over arbitrary underlying transports, HTTP, TCP, UDP, ….

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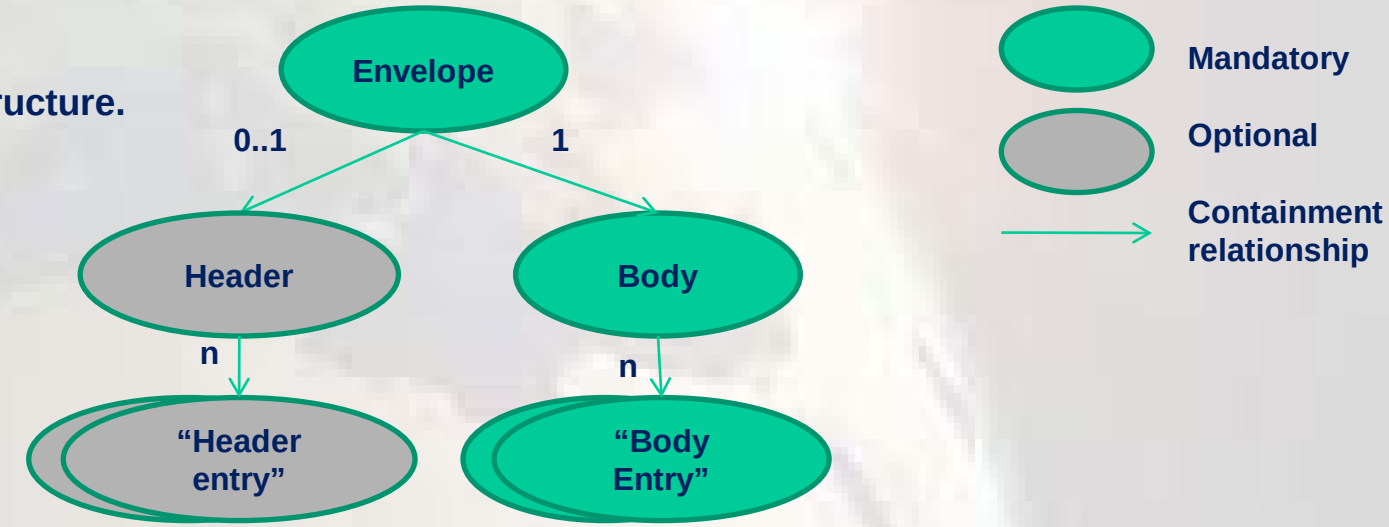
SOAP Message format

- SOAP messages are XML instances consisting of [6]:
  - *Envelope*: a mandatory top element represents the SOAP message and provide a container for header and body.
  - *Header*: an optional element offers a way to pass additional processing or control info.
    - Could convey authentication, QoS and service billing data, and extra *header entries.*
    - If present, it must be the first immediate child.
  - *Body*: a mandatory element carries all mandatory info "*body entries*" for the final recipient

SOAP Message format

SOAP message Containment Structure. Source, [6]



SOAP message Embedded in HTTP Request for `GetMyAgeInDays` Service

```
POST /WebSite2/Service.asmx HTTP/1.1
Host: localhost
Content-Type: text/xml; charset=utf-8
Content-Length: length
SOAPAction: "http://tempuri.org/GetMyAgeInDays"
<?xml version="1.0" encoding="utf-8"?>
 <soap:Envelope
   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
   xmlns:xsd="http://www.w3.org/2001/XMLSchema"
   xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/">
 <soap:Body>
 <GetMyAgeInDays xmlns="http://tempuri.org/">
   <day>int</day>
   <month>int</month>
   <year>int</year>
   </GetMyAgeInDays>
 </soap:Body>
</soap:Envelope>
```

SOAP Message Embedded in HTTP Response for `GetMyAgeInDays` Service

```
HTTP/1.1 200 OK
Content-Type: text/xml; charset=utf-8
Content-Length: length
<?xml version="1.0" encoding="utf-8"?>
<soap:Envelope
 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 xmlns:xsd="http://www.w3.org/2001/XMLSchema"
 xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/">
 <soap:Body>
   <GetMyAgeInDaysResponse xmlns="http://tempuri.org/">
     <GetMyAgeInDaysResult>int</GetMyAgeInDaysResult>
   </GetMyAgeInDaysResponse>
 </soap:Body>
</soap:Envelope>
```

SOAP message Example

```
<soap-env:Envelope
    xmlns:soap-env="http://schemas.xmlsoap.org/soap/envelope/"
    xmlns:xsd="http://www.w3.org/2001/Schema"
    xmlns:xsi="http://www.w3.org/2001/Schema-instance">
    <soap-env:Header> <!-- optional -->
        <cXP:priority
        xmlns:cXP="http://companyx.com/ns/priority"
        soap-env:mustUnderstand="1">
        high
        </cXP:priority>
    </soap-env:Header>
    <soap-env:Body>
    <cX:getPhoneNumebr
    xmlns:cX="http://companyx.com/ns/employees"
    soap-env:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
        <first-name xsi:type="xsd:string">Ahmad</first-name>
        <last-name xsi:type="xsd:string">Ahmad</last-name>
    </cX:getPhoneNumber>
    </soap-env:Body>
</soap-env:Envelope>
```

Header Entry

Header Must be processed

Method invocation

Use SOAP encoding

Body Entry

Method Parameters

Method Parameter type

Method Parameter value

Source, [6]

SOAP Message Delivery

- SOAP messages may be handed over from a WS requester to a service provider via *intermediaries*.
- Similar to service providers, intermediaries are identified also via URI value.
- For example, when embedding SOAP into HTTP, the URI maps to the HTTP request URL.

SOAP Message Attributes

- `encodingStyle`: indicates the serialization rules used in the message.
  - Serialization is converting from an application-specific data representation to the wire format.
  - While, deserialization is converting back to the original format.
  - Also, called **marshalling** and **unmarshalling**.
  - Identified through URI in a body entry and applied until another `encodingStyle` attribute appears in the body element e.g. `http://schemas.xmlsoap.org/soap/encoding/`

SOAP Message Attributes, cont.

- `actor`: identifies the application that should process the header entry.

  e.g. `http://schemas.xmlsoap.org/soap/actor/next`
- `mustUnderstand`: identifies whether a SOAP message receiver “target actor” must understand ,value ‘1’, the content of a header entry.

SOAP Message Body Entries

- Recipient must understand and process all body entries.
- Body entries are specific to the application exchanging SOAP messages.
- Recall the phone number request in the example.
- One SOAP-defined body entry exists, is the `Fault` element.
  - Optional child that must not appear more than once within the `body` element.
  - Comprises error and status information.

SOAP Message `Fault` Body Entry Subordinates

- `faultcode`: fault identification
  - `VersionMismatch`: namespace qualification is not identical to: `http://schemas.xmlsoap.org/soap/envelope/`
  - `MustUnderstand`: SOAP application could not process a header entry containing "`MustUnderstand`" with value '1'.
  - `Client`: a SOAP message is not appropriately formed.
  - `Server`: a SOAP message could not be processed
- `faultstring`: human readable fault explanation
- `faultactor`: carries a URI value that identifies the fault originator.
- `detail`: application-specific error info related the body element.

A failing intermediary

- Recall the example of requesting the phone number of Ahmad M. Ahmad.
- Enforced by means of `mustUnderstand`, suppose the intermediary does not understand the header, it responds with fault element:

```
<soap-env:Envelope
   xmlns:soap-
   env="http://schemas.xmlsoap.org/soap/envelope/">
    <soap-env:Body>
     <soap-env:Fault>
      <faultcode>soap-env: MustUnderstand</faultcode>
      <faultstring>
       SOAP MustUnderstand Error </faultstring>
      <faultactor>
        http://companyx.com/messageHub_71</faultactor>
    </soap-env:Fault>
   </soap-env:Body>
</soap-env:Envelope>
```

Visit to see the envelope schema!

http://schemas.xmlsoap.org/soap/envelope/

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- Introduction
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- **SOAP section 5 encoding**
- SOAP communication styles
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SOAP section 5 Encoding

- Connecting heterogeneous applications typically introduces the data-type compatibility problem
- Solution is often based on a common intermediate transfer data format for exchanging information between applications
- SOAP section 5 encoding rules provide a built in mechanism to do that, with appropriate programming languages mappings.
- Using SOAP section 5 encoding is optional, and other encodings may be used as well.

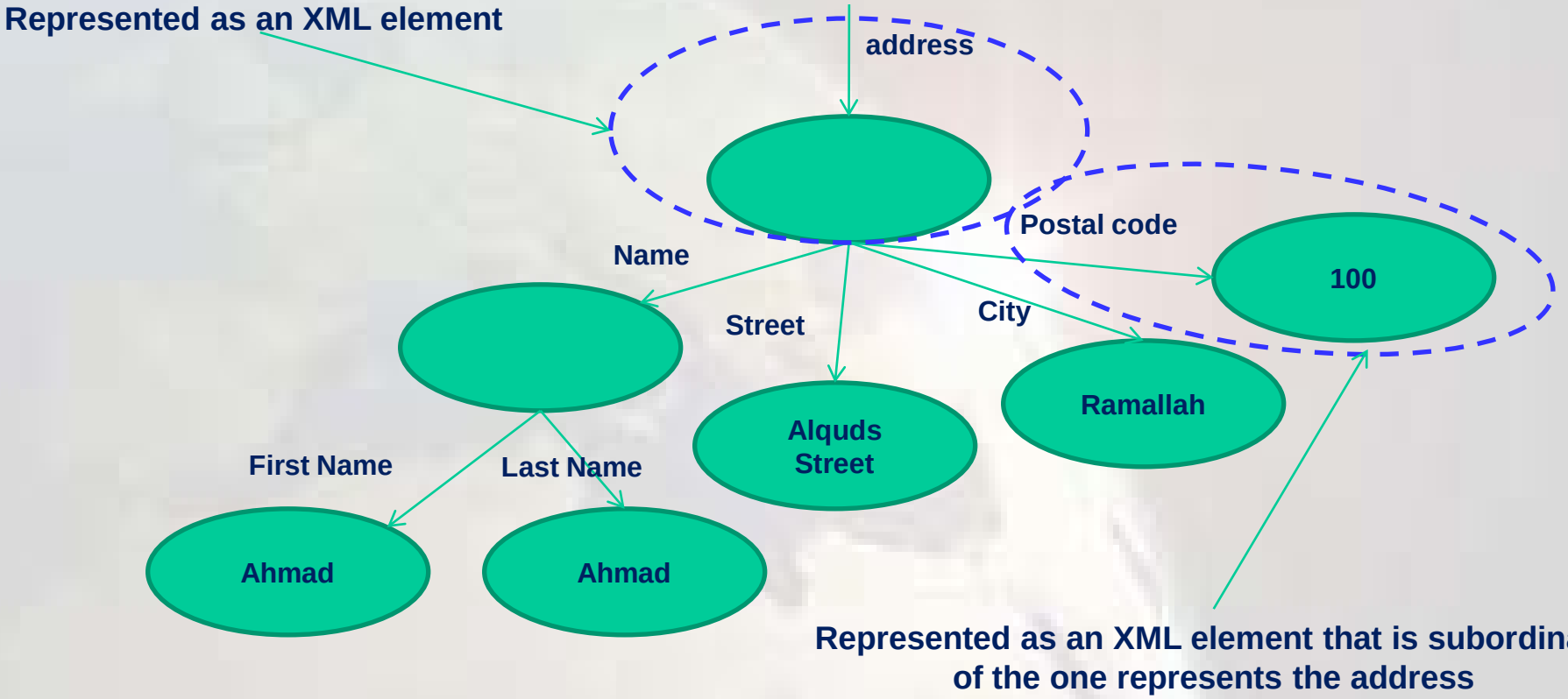
SOAP Values and Data Types

- The SOAP encoding data model consists of simple types and compound types.
- Compound types are based on simple types or other compound types.
- Any application-specific data is represented in terms of a directed graph.

SOAP Values and Data Types, cont.

- Simple value: e.g. string, integer or Boolean, is represented as a node without outgoing edges.
- Compound value: e.g. structure or array, is represented with outgoing edges.
- A simple or compound values may be single-referenced “has only one incoming edge” or multi-referenced “has multiple incoming edge”.
- The SOAP data model is shown in the next slide!

The SOAP Data Model



The SOAP data model, Source, [6] with modification.

SOAP Data Types I

- SOAP encoding adopts all XML schema built-in types.
- But, compound types differ fundamentally from XML schema complex types.
- SOAP types extending the XML schema types are defined in the separate namespace:

http://schemas.xmlsoap.org/soap/encoding/

SOAP Data Types II

- Sender could explicitly assert the type street element content to be a string:
  `<street xsi:type="xsd:string">Alquds Street</street>`
- Or, may not contain the type attribute:
  `<street>Alquds Street</street>`
- SOAP simple values: represented as element content.
  - For each element containing a value, the type is made via XML schema instance `type` attribute.
  - e.g. `<last-name xsi:type="xsd:string">Ahmad</last-name>`

SOAP Data Types III

- SOAP compound values: represented as an element containing a sequence of subordinate elements.
  - SOAP encoding supports two compound types: `structs` and `arrays`
  - e.g. XML encoding for an array in the SOAP object model looks like this:

```
<nameArray xsi:type="SOAP-ENC:array" SOAP-
ENC:arrayType="xsd:string[3]">
    <member>First Name</member>
    <member>Med. Name</member>
    <member>Last Name</member>
</nameArray>
```

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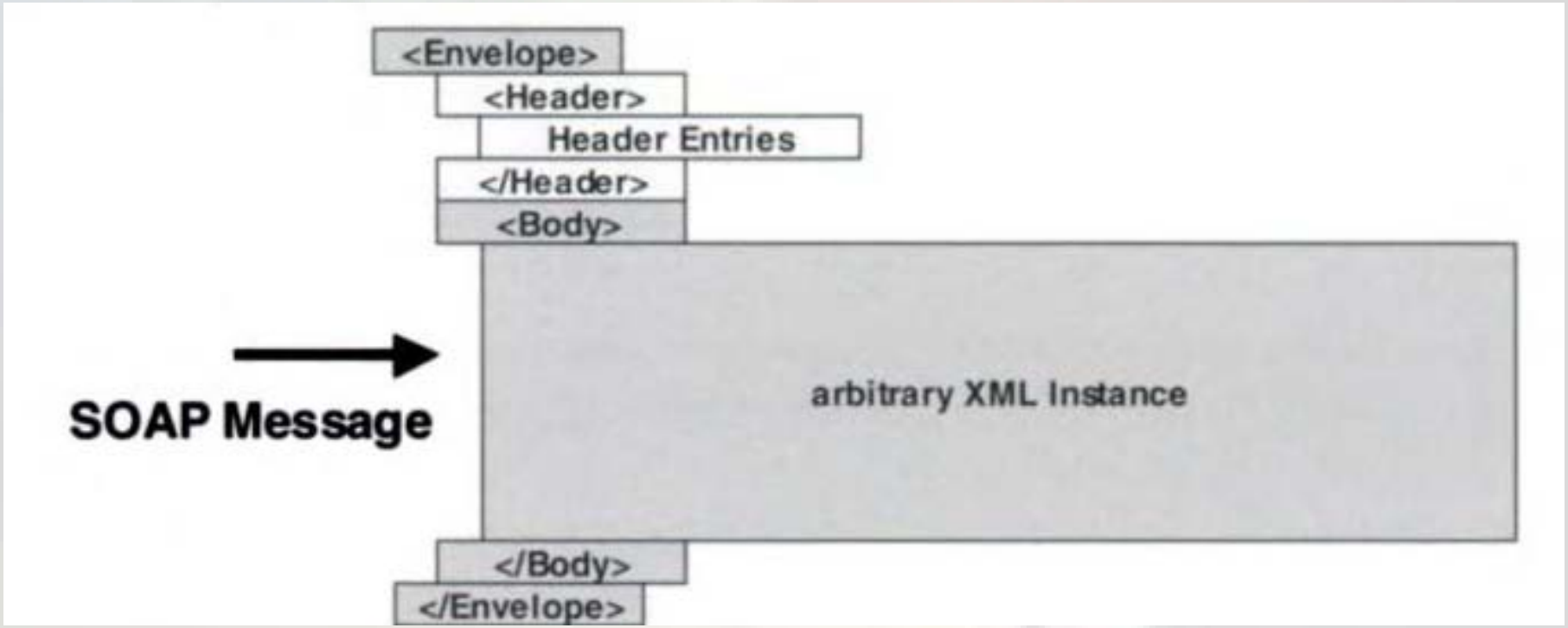
SOAP Communication style

- SOAP supports two communication styles:
  - Document style: SOAP message body is an arbitrary XML instance.
    - The document style is referred to as message-oriented style.
  - RPC style: represents a remote procedure call.
    - A client invoking a remote procedure expects a result back from the server.
    - Recall our example, it was an RPC style SOAP message
    - The client invoked the method `getPhoneNumber`.

A document style SOAP message

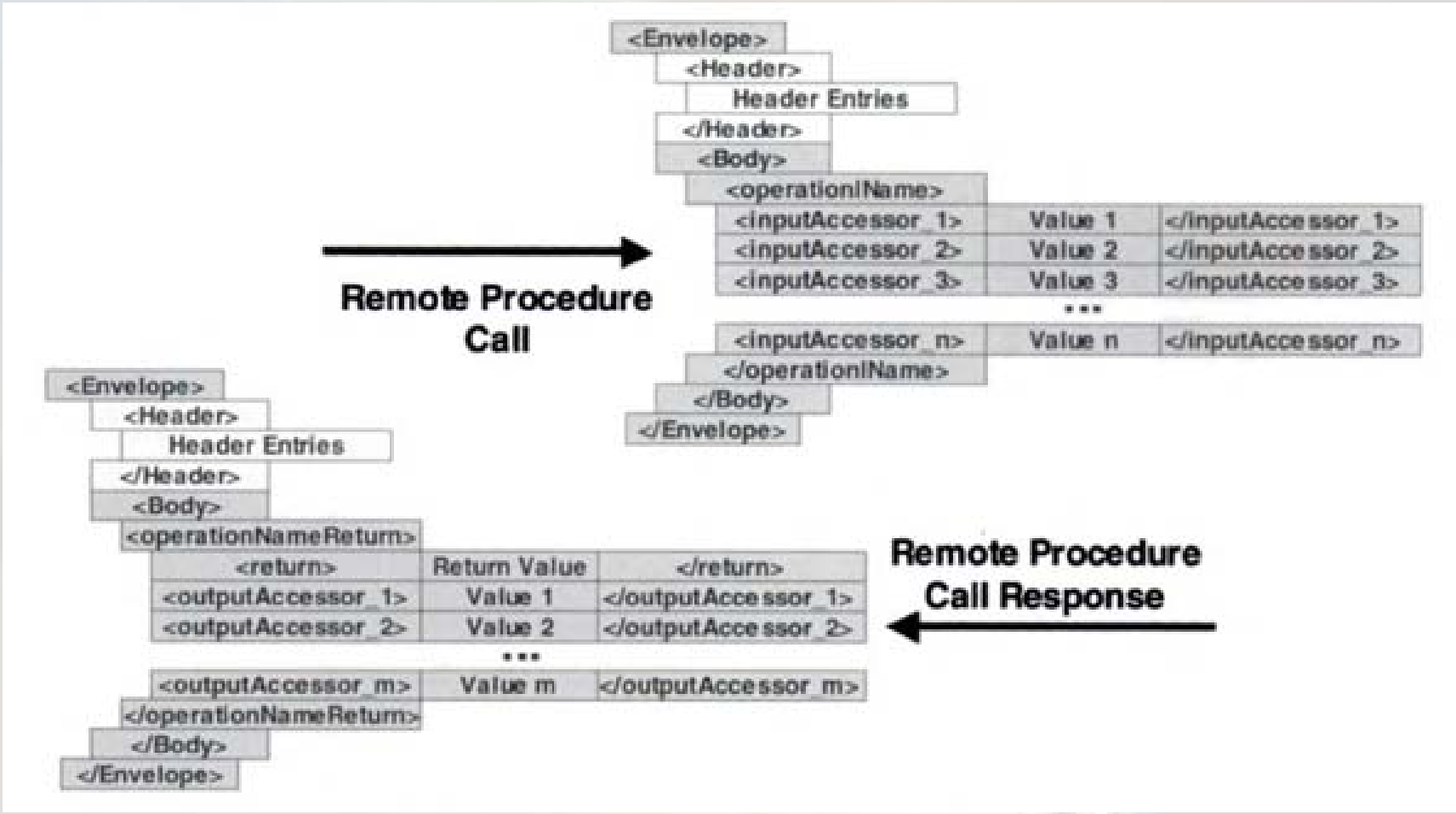


Source, [6]

A document style SOAP message example

```
<SOAP-ENV:Envelope
 xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/">
  <SOAP-ENV:Body>
    <ph:phoneOwner xmlns:ph="http://companyx.com/ns/phoneBook">
      <cX:address xmlns:cX="http://companyx.com/ns/employees"
       targetAddress="PS">
        <cX:name>
          <cX:title selectedTitle="Mr"/>
          <cX:first-name>Ahmad M.<cX:first-name>
          <cX:last-name>Ahmad</cX:last-name>
        </cX:name>
        <cX:street>Alquds Street</cX:street>
        <cX:city>Ramallah<cX:city>
        <cX:postal-code>100</cX:postal-code>
        <cX:country>Palestine</cX:country>
      </cX:address>
      <ph:phonebook>
        <ph:location>Ramallah Office</ph:location>
        <ph:roomNumber>03.04</ph:roomNumber>
        <ph:officePhone>*2900000</ph:officePhone>
      </ph:phone>
    </ph:phoneOwner>
  </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

A SOAP RPC style request and the associated response



Source, [6]

Response on the phone number request from the earlier example (slide 18)

```
<SOAP-ENV:Envelope
 xmlns:SOAP-
ENV="http://schemas.xmlsoap.org/soap/envelope/"
 xmlns:xsd="http://www.w3.org/2001/schema"
 xmlns:xsi="http://www.w3.org/2001/schema-instance">
  <SOAP-ENV:Body>
    <companyx:getPhoneNumberReturn
     xmlns:companyx="http://companyx/employees"
     SOAP=ENV:encodingStyle=
     "http://schemas.xmlsoap.org/soap/encoding/">
      <return xsi:type="xsd:string">
        *2900000</return>
    </companyx:getPhoneNumberReturn>
  </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

Practices

- Using WCF test client in Visual Studio to test `AgeInDays` service and view the SOAP messages.

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Summary

During this session we have explained the SOAP message construction for web services communication. The following subjects have been covered:

1. SOAP definition and characteristics
2. SOAP Message format
3. SOAP section 5 encoding
4. SOAP communication styles

In the following session we will introduce how to describe a web service using WSDL.

Further reading on SOAP 1.1 can be found at the following link: http://www.w3.org/TR/2000/NOTE-SOAP-20000508/

References

1. Steve Graham, Doug Davis, Simeon Simeonov,Glen Daniels, Peter Brittenham, Yuichi Nakamura, Paul Fremantle,Dieter König and Claudia Zentner, Building Web Services with Java, M A K I N G S E N S E O F X M L , S O A P , W S D L , A N D U D D I, Second Edition, Sams Publishing, 800 East 96th Street, Indianapolis, Indiana 46240, 2005.
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6. Olaf Zimmermann, Mark Tomlinson, Stefan Peuser, “Perspectives on Web services-Applying SOAP, WSDL and UDDI to real-world projects, 2nd edition, Springer, 2005
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Thanks

Mohammed Aldasht