MAP-SOAP Interworking
in Future Service-Oriented Wireless Networks

Andreas Diehl[1], Woldemar Fuhrmann[2] and Gerd Siegmund[3]

[1]Alcatel, Stuttgart, Germany, [2]University of Applied Sciences, Darmstadt, [3]TZ Technik der Netze, Stuttgart, Germany

Abstract

Modern telecommunication systems evolve from transport-centric to service-oriented systems which enable efficient development and implementation of new applications. This paper investigates the application of principles of the service-oriented architecture on a functionally layered wireless network, such as the UMTS.

Keywords

Service-Oriented Architecture, Layers architectural pattern, UMTS, Third Generation Partnership Project (3GPP), ASN.1, XML, Web Service architecture, SOAP, Fast Web Services, Home Location Register (HLR), Data Model

1. Introduction

Future wireless networks are characterized by an open architecture that supports integration of legacy telecommunication services, such as telephony, and Internet applications, and is independent on the access technology. This approach had been discussed in many fora and was also put into Third Generation Partnership Project (3GPP) which has the mandate for Universal Mobile Telecommunications System (UMTS) standardization. A Layered Functional Architecture was formulated by the Mobile Wireless Internet Forum (MWIF) [All-IP Workshop, 2000] showing three separate functional layers: services/applications, control and transport.

Looking at the development of application platforms, a pattern emerged which was called Service-Oriented Architecture. This pattern stresses two attributes: implementation transparency and location transparency. Location transparency is the ability to locate and use a component that may exist anywhere in a network. Implementation transparency is the ability to use a component without regard to the language or mechanisms used to fulfil the component's public interface or behaviour specification. There are multiple techniques known to implement the Service-Oriented Architecture pattern. To achieve a common communication mechanism between services above a particular platform and implementation of service logic, the architecture should rely on standardized TCP/IP protocols and Extensible Markup Language (XML).

The approach of a Service-Oriented Architecture seems to fit well into the concept of the layered functional architecture of future networks: This architecture could be used to model the two upper layers of layered networks, control and services. Therefore, in this paper we consider one possible approach for the implementation of the control and services layer using the Service-Oriented Architecture pattern. We consider, as an example the Home Location Register (HLR) of a cellular network, for example the UMTS. The HLR is the central node in a cellular network providing on the one hand, control and service logic, such as interrogation of location information for routing a mobile terminating call, and on the other hand persistent storage of subscription data and other information, such as the location of active mobile users [Rupp et al 1, 2004]. We adopt another pattern broadly used in application development (Layers architectural pattern) and separate control and service logic and the persistent storage of data. This leads to a new generic implementation of network nodes, consisting of application servers and databases [Rupp et. al 1 and 2, 2004, Siegmund et al, 2004]. In our study the HLR is modelled as an application server and an object-oriented database.

The Web Service architecture is the most accepted implementation of the Service-Oriented Architecture pattern. A client interacts with Web Services over an XML communication mechanism provided by the Simple Object Application Protocol (SOAP) [Nilo Mitra et al, 2003]. In our model, we investigate the signalling exchange and processing of an IP-based HLR necessary to set up a mobile terminated call. The legacy signalling information defined by the Mobile Application Part [3GPP, 1998] is converted to XML and carried on SOAP messages. We show a possible implementation for the separation of control and service logic and data persistence and consider several variants of the XML data transport.

2. SOAP MAP Interworking in future mobile communication systems

We consider the Mobile-Terminating Call procedure used in a cellular network, for example the UMTS, for establishing a call to a mobile user. The procedure is shown in Fig. 1. The Gateway-Mobile Services Switching Centre (G-MSC) initiates the MAP operation sendRoutingInformation to get a temporary address for routing the pending incoming call to the visited Mobile Services Switching Centre (MSC)/Visitor Location Register (VLR) of the mobile user. The HLR controlling the mobile user knows the visited MSC/VLR and initiates the MAP operation provideRoamingNumber. The MSC/VLR returns a temporary address, the roaming number, to the HLR and the G-MSC which is then used to complete the connection between the G-MSC and the visited MSC/VLR.

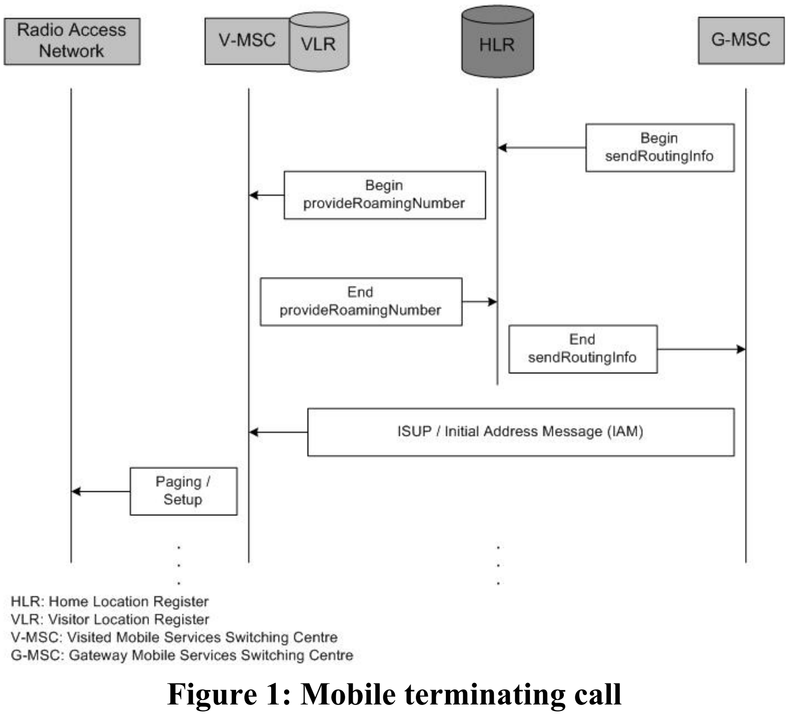

Figure 1: Mobile terminating call

Our model includes a Gateway and an IP-based HLR and implements the MAP operations sendRoutingInformation and provideRoamingNumber (refer to Fig.2). Web Services and IP transport are used on the interface between the Gateway and the HLR. The gateway performs the necessary conversions between MAP messages carried on top of Signalling System No.7 (SS7) protocols on the MSC/VLR side and MAP messages carried on top of SOAP and IP on the HLR side. In this model MAP messages are always encapsulated by Transaction Capabilities Application Part (TCAP) [ITU-T Q.771, 1997]. The MAP messages on top of SOAP can use one of two encodings: native XML or Abstract Syntax Notation One (ASN.1)/Basic Encoding Rule (BER) [ITU-T X.690, 2003]. The encoding can be specified in the request (refer to Fig. 3).

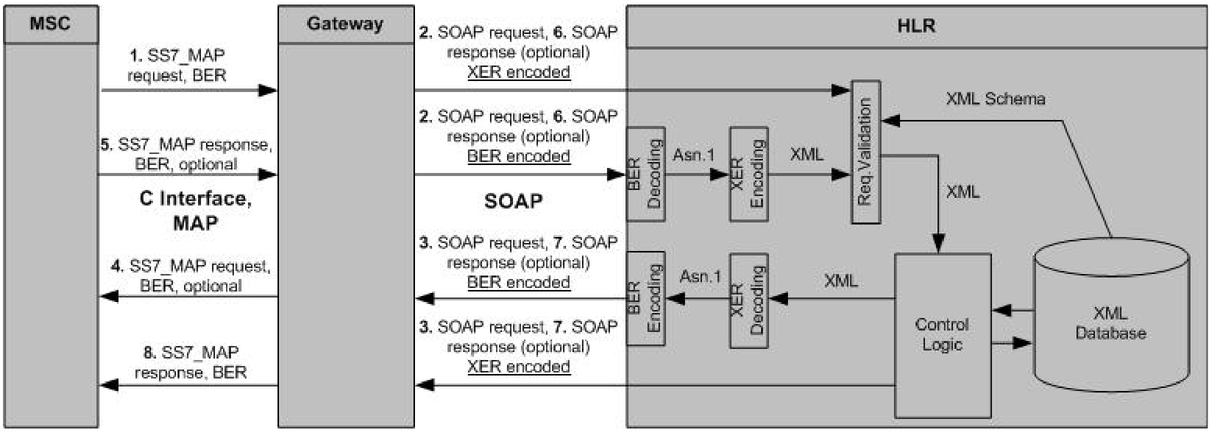

Figure 2: MAP-SOAP interworking

The following messages are exchanged on the interfaces between MSC/VLR and Gateway and between Gateway and HLR:

1. SS7_MAP SendRoutingInformation request to the Gateway
2. SOAP SendRoutingInformation request to the HLR
3. SOAP ProvideRoamingNumber request to the Gateway
4. SS7_MAP ProvideRoamingNumber request to the MSC/VLR
5. SS7_MAP ProvideRoamingNumber response to the Gateway
6. SOAP SendRoutingInformation response to the Gateway
7. SS7_MAP SendRoutingInformation response to the G-MSC

The HLR may receive native XML-encoded data or ASN.1/BER encoded data of the signalling system. In the second case it converts the data into an ASN.1 presentation view. This presentation view can then be translated by the standardized XML Encoding Rule (XER, [ITU-T X.693, 2003]) to XML. The XML input stream is red into a XML object (Document Object Model) and after that the validation of the request against the XML schemas stored in the database (DB) is started. If the validation has been successful, the particular control logic for the MAP operation is initiated. The control logic also handles database accesses/updates and returns responses. The XML database stores all data required for handling the mobile terminating call. The response is first translated from XML encoding to the ASN.1 presentation view and then to ASN.1/BER.

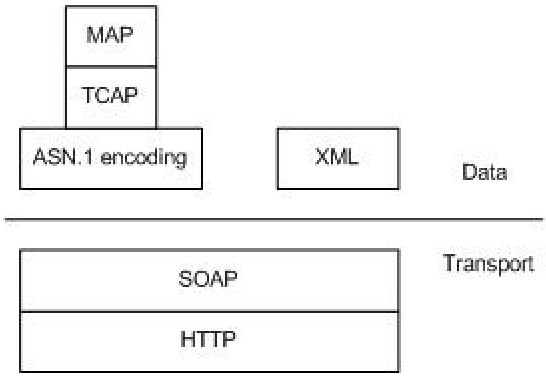

Figure 3: MAP-on-SOAP protocol stack

In this paper, we investigate the mobile terminating call procedure as an example. However, the model open to all MAP operations.

3. Message format

Between the Gateway and the HLR a defined message format is used. A request to the HLR contains the following information element including:

- The transferred SS7 layer
  - Element name: tcapService for a TCAP/MAP request
  - Element name: mapService for a MAP request
- An identifier for the particular MAP operation (attribute name: name)
- A message identifier (attribute name: id)
- The encoding type for the request (attribute name: reqEncoding)
- The required response encoding (attribute name: resEncoding)

Correspondingly the response contains the information element including:

- The transferred SS7 layer with the addition Res (for example, tcapServiceRes, mapServiceRes)
- An identifier for the MAP operation
- A message identifier
- The applied response encoding.

The different codings of a TCAP/MAP message are illustrated by the example of SendRoutingInformation request. Figure 4 and 5 show the BER and XER encoded message. The example messages give a first impression on the different message lengths. The length of the BER encoded SendRoutingInformation request message is 473 characters and the message length using XER encoding is 1348 characters.

The information element is used for the dynamic selection of the ASN.1 compiler method and the control logic.

The control logic is implemented by a particular service class for each MAP operation. The service class is called by a reference which is defined in an XML configuration file. The reference key is the service name specified in the information element of the request.

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<soapenv:Envelope xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/">
        <soapenv:Body>
                <tcapService name="SendRoutingInformation" id="10000" reqEncoding="ber"
resEncoding="ber">62614804002C45C26B1A2818060700118605010101A00D600BA1090607040000010005036C3DA1
3B0201000201163033800791973047 0301F983010086079197300741FFFF8706AE00F302002CAA0E0A010404090403
8090A37D029181AB04030206C0</tcapService>
        </soapenv:Body>
</soapenv:Envelope>
```

Figure 4: BER encoded SendRoutingInformation request

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<soapenv:Envelope xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/">
    <soapenv:Body>
        <tcapService name="SendRoutingInformation" id="10000" reqEncoding="xer" resEncoding="ber">
            <TCMessage>
                <begin>
                    <otid>002C45C2</otid>
                    <dialoguePortion>
                        <direct-reference>0.0.17.773.1.1.1</direct-reference>
                        <encoding>
                            <single-ASN1-type>600BA1090607040000010005 03</single-ASN1-type>
                        </encoding>
                    </dialoguePortion>
                    <components>
                        <basicROS>
                            <invoke>
                                <invokeId>
                                    <present>0</present>
                                </invokeId>
                                <opcode>
                                    <local>22</local>
                                </opcode>
                                <argument>
                                    <SendRoutingInfoArg>
                                        <msisdn>919730470301F9</msisdn>
                                        <interrogationType>
                                            <basicCall/>
                                        </interrogationType>
                                        <gmsc-OrGsmSCF-Address>9197300741FFFF</gmsc-OrGsmSCF-Address>
                                        <callReferenceNumber>AE00F302002C</callReferenceNumber>
                                        <networkSignalInfo>
                                            <protocolId>
                                                <ets-300102-1/>
                                            </protocolId>
                                            <signalInfo>04038090A37D029181</signalInfo>
                                        </networkSignalInfo>
                                        <camelInfo>
                                            <supportedCamelPhases>11</supportedCamelPhases>
                                        </camelInfo>
                                    </SendRoutingInfoArg>
                                </argument>
                            </invoke>
                        </basicROS>
                    </components>
                </begin>
            </TCMessage>
        </tcapService>
    </soapenv:Body>
</soapenv:Envelope>
```

Figure 5: XER encoded SendRoutingInformation request

4. Measurements

A first performance test has been carried out using a normal desktop computer environment. The gateway and the HLR are installed on separate systems. Figure 6 describes the delay times which are subject to the measurements. In the given test environment, approximately 30 ms are required on average to decode and encode an ASN.1 message, and approximately 10 ms on average are required for the parsing process using the Document Object Model. The validation of the request requires about 210 ms on average. The reason here is the size of the XML schema for the complete MAP specification. Possible alternatives for improvement are the validation on ASN.1 definition level or the usage of a MAP object library.

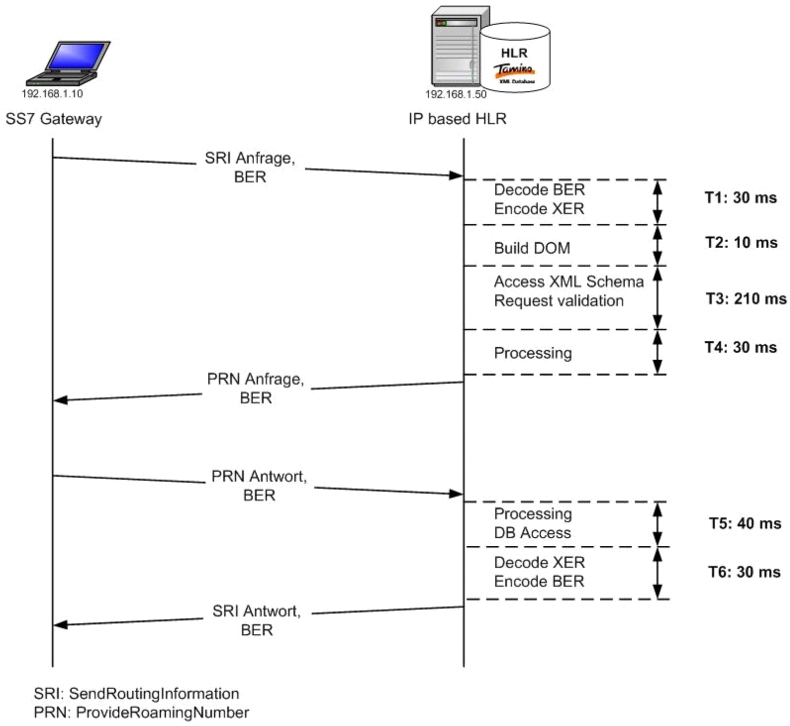

Figure 6: Delay measurements

An overview of the messages length is given in Table 1. For simplification we consider only the content of TCAP/MAP and the overhead of SOAP messages.

Encoding	**TCAP/MAP** (characters)	**SOAP** (cahracters)	**Total** (cahracters)
BER TCAP/MAP message	198	275	473
XER TCAP/MAP message	1073	275	1348

Table 1: Message length

Figure 7 shows the messages length and processing delays in the HLR. The processing delay comprises in case of SOAP/BER T1 to T6 (refer to Figure 6) and in case of SOAP/XER T2, T3, T4, and T5. For implementation there is the choice to trade off message length (transmission delay) versus processing delay. While SOAP/BER is attractive for slow transmission media, SOAP/XER is a better choice for fast transmission media.

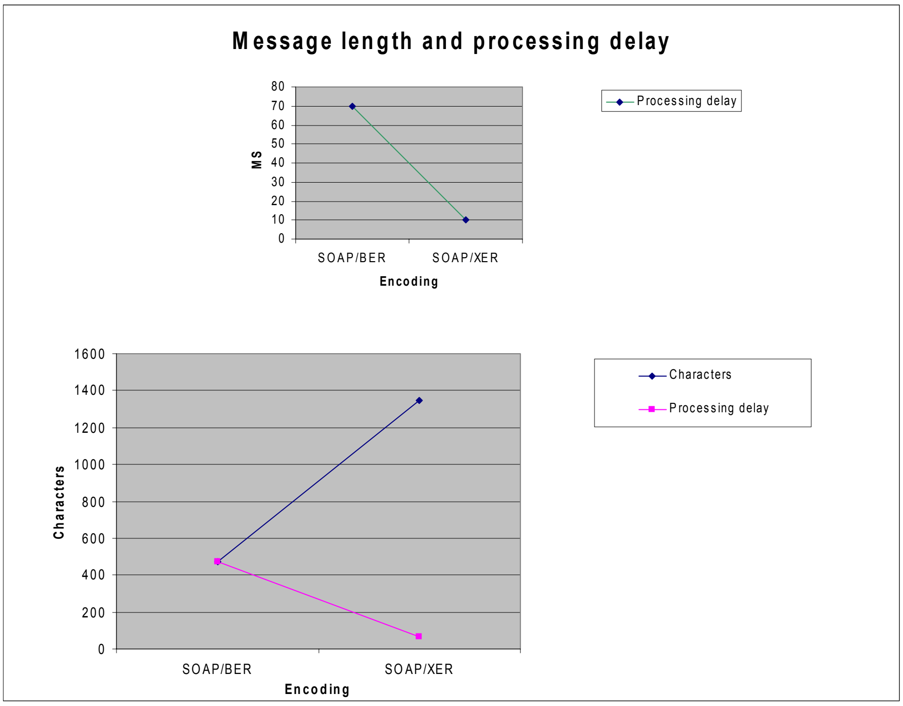

Figure 7: Message length and processing delay

5. Conclusions

The Service-Oriented Architecture pattern and the separation of control logic and data persistence provide significant benefit for future layered networks. In this paper we have shown an implementation of this pattern by means of Web Services and a Java application platform. The presented measurement results are already within performance margin which makes it worthwhile to spend more efforts for the optimization on the scheme. Possible steps for the optimization are using ASN.1 Packet Encoding Rule (PER) [Sandoz (2003)], [ITU-T X.691, 1999] and Base64 encoding [Freed and Borenstein, 1996] for message compression, and improvement of the hardware and software platform.

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