

An Approach for Interoperable Service Mediation in Diverse Telecommunication Networks

Andreas Diehl

Diehl-Develop.com, University of Plymouth
Stuttgart, Germany
andreas.diehl@diehl-develop.de

Kishore Angrishi

Hamburg University of Technology
Hamburg, Germany
kishore.angrishi@tu-harburg.de

Mobile telecommunication networks consist of several co-existing, independent domains. Communication protocols in these diverse domains can be broadly classified into IP-based and SS7-based protocols. Modern IP-based network nodes already rely on Service-oriented Architectures (SOA) while SS7 based system is based on switching offices and a specialised service control. Service-oriented mediation between those networks is a challenging task. This paper addresses interoperable service-mediation by combining service descriptions, protocols and the integration of application data. The service mediation approach aims to combine performance-oriented interoperability with SOA concepts.

ASN.1, Service Mediation, SOA, Next Generation Networks, Web Services

I. INTRODUCTION

The evolution of mobile network causes a large number of diverse co-existing networks. The maintenance cost of these diverse networks (for example 2nd and 3rd generation mobile networks, UMTS Rel. 5) is comparatively high, because of the additional bridge components. In the 2nd generation (2G) mobile network (GSM), the deployed core network nodes interact using SS7 based protocols [16], while the 3rd generation (3G) mobile network (UMTS) uses predominantly IP-based communication protocols. In order to inter-work between these two networks, there is a strong need for the integration technology connecting IP-based and SS7-based networks. For example, one of the major problems in a diverse network is the handling of distributed subscriber and services data. Therefore an efficient approach to share subscriber data between 2G and 3G networks is required.

II. RELATED WORK

In a mobile network, several database identities administrate data of a single subscriber in a telecommunications network. For example, the optional Service Control Point (SCP), the Home Location Register (HLR) and Visitor Location Register (VLR) for GSM and the Home Subscriber Server (HSS) for UMTS stores service and subscriber information related to the mobile network. Additional subscriber information is stored in the Customer Care and Billing System (CCBS), the Customer Relationship Management node (CRM) and Network Management node of the Operation Subsystem (OSS, refer to Figure 1.).

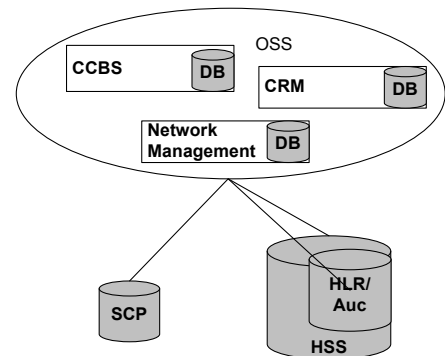


Figure 1. Operation Subsystem Overview

The main subscriber profile in current mobile networks is physically distributed in several Home Location Register (HLR) and Home Subscriber Server (HSS) respectively. The multiple main subscriber databases store predefined blocks of subscribers. In order to access a single subscriber profile the correct database has to be addressed. If the subscriber profile is accessed by the mobile station ISDN number (MSISDN) large providers use usually two digits after the Network Destination Code (NDC) of the MSISDN to identify the correct HLR. Database investigation for network specific services (e.g. Mobile Terminating Call) generates additional network traffic or processing time (refer to Figure 2.).

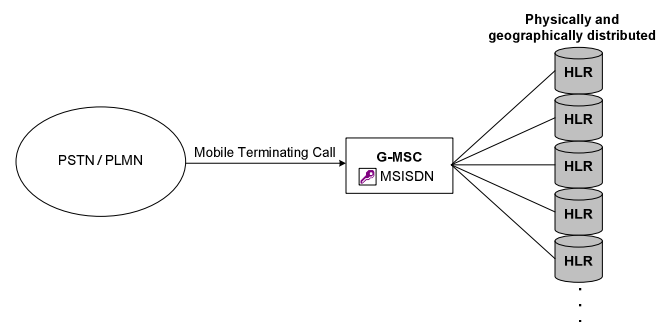


Figure 2. HLR distribution

Most of the subscriber profiles are distributed and managed only in subsets of the total subscriber information within the telecommunication network (TN). There are several approaches outlined in [5] [6] [7] [8], for restructuring subscriber data using centralized subscriber profile registers.

Centralized subscriber databases offer a unified access for the OSS, the different network domains and the distributed main subscriber profiles. Centralized subscriber databases have to support a common subscriber profile based on a centralized subscriber model mentioned in [2] [3].

In respect to the network and service mediation the major challenges faced in these systems are:

- Interoperability – common access interface for the diverse network,
- Performance – fast (real-time) access of the centralized, subscriber profile [4],
- Service-oriented data access.

The EU project Flexinet (Flexinet [7]) addresses mainly interoperability and service orientation of a centralized subscriber database. Flexinet uses Web Services (WS) concepts to interoperate between IP Multimedia Subsystems (IMS), PS Domain and a Wireless LAN domain.

Another approach supporting a common subscriber profile has been standardized by the 3GPP. In this application model, the Generic User Profile (GUP) [14] [15] uses a proxy server to request the defined XML model out of specific subscriber profiles located in diverse databases.

In this paper we like to address all of the three challenges mentioned above, by applying an enhanced web services paradigm.

III. CONCEPT

The enhanced web services (E-WS) paradigm is based on the idea of using ASN.1 instead of XML in WS communication architecture to achieve a better performance [9]. It combines service-oriented technologies with real-time access criteria. Service Oriented Architecture (SOA) suits to the diverse TNs with a centralized database, because of the transparent “service-on-demand” paradigm. When most people speak of a SOA, they speak of a set of services residing on the Internet or an intranet using WS. The WS are widely used in IP networks, but don’t satisfy the performance requirements of the TN. One of the performance influencing factors in web services is the processing and validation of data in XML format [10].

The idea of using ASN.1 fits coherently for the ASN.1 based messages, especially in the telecommunication industry. Existing and well-defined interface definitions can be re-used for building the E-WS. E-WS definitions shall be mapped to XML schemes [11], so that E-WS can also be accessed by traditional WS clients using SOAP/XML messages. ASN.1 definitions shall be used to define both character encoded XML messages (using E-XER) [12] [13] and binary encoded ASN.1 messages.

In general, data is always transferred between a Service Requestor and Service Provider residing in two different domains. In order to achieve interoperability between the two domains, a bridging component is necessary. For example, in a restructured modern mobile network [5], [6], messages encoded as BER [18] or PER format [19] are exchanged between the standard telecommunication nodes such as Mobile Switching Centre (MSC) and the centralized subscriber

database that is named here Next Generation Profile Register (NGPR, refer to section II). In this case the bridging component, Negotiation Gateway (NG) is responsible for message translation and efficient data transmission between the diverse network nodes (refer to Figure 3.).

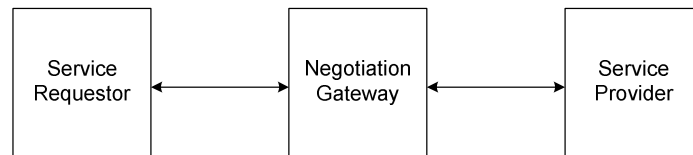


Figure 3. Service Mediation using Negotiation Gateway

In this paper we explain how a centralized IP based NGPR can be accessed by the traditional telecommunication network nodes (TNN) based on a service-oriented architecture using a Negotiation Gateway (NG).

IV. AN APPLICATION

In general the TNN communicates with the NGPR using the bridging component, NG (refer to Figure 4.). If the users subscriber information stored in the NGPR are exposed to the external domain entities as web services, the NG translates the SS7 message from the TNN to appropriate web service requests to the NGPR. The architecture (shown in Figure 4) consists of interfaces handling two different protocols. The interface between TNN and NG handles the traditional SS7 protocol carrying application specific message using the MAP/TCAP/SCCP [17] [20]. On the other interface between the NG and the NGPR messages are transmitted over HTTP/TCP/IP.

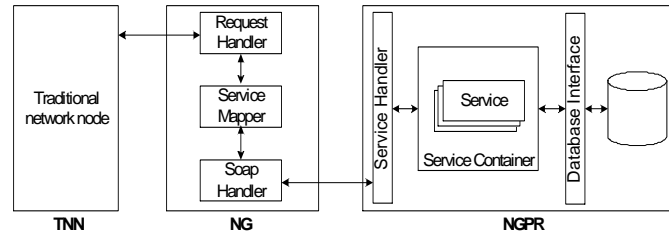


Figure 4. Overview of the NGPR interface with NG

The NG consists of three components

- Request Handler,
- Service Mapper, and
- SOAP Handler.

The Request Handler receives the SS7 message from the TNN and filters out TCAP/MAP section. For example, TCAP/MAP message for “UpdateLocation” request is shown in figure 5. The Service Mapper receives the filtered TCAP/MAP message from the Request Handler. It pre-processes the TCAP/MAP message, decoding only the TCAP “header”, to identify the MAP request it contains and to remove the MAP message from TCAP/MAP message. The content of the field “basicROS.argument” in TCAP/MAP message which contains the MAP request wouldn’t be decoded (and all other

open types defined) at first pass. For the received MAP request, it identifies the service type to be enquired from the NGPR. The unprocessed MAP message from the Service Mapper is encapsulated within ASN.1 PER [19] encoded SOAP Envelope/Body. This is done by the SOAP Handler. In a simple case the SOAP Handler uses a predefined SOAP template without a SOAP Header (shown in figure 6). For more complex cases SOAP templates with Header shall be used.

```

TCMessage CHOICE
{
  begin SEQUENCE
  {
    otid OrigTransactionID = 00.2c.53.f0
    dialoguePortion DialoguePortion
    {
      direct-reference OBJECT_IDENTIFIER = {itu-t(0) recommendation(0)
q(17) 773 1 1 1}
      encoding CHOICE
      {
        single-ASN1-type OPEN_TYPE
        {
          = 60.0b.a1.09.06.07.04.00.00.01.00.01.03
        }
      }
    }
    components SEQUENCE_OF
    {
      CHOICE
      {
        basicROS CHOICE
        {
          invoke SEQUENCE
          {
            invokeId InvokeId
            {
              present INTEGER = -128
            }
            opcode Code
            {
              local INTEGER = 2
            }
          }
          argument OPEN_TYPE
          {
            UpdateLocationArg SEQUENCE
            {
              imsi IMSI = 52.90.79.08.00.00.00.f0
              msc-Number ISDN-AddressString = 91.97.30.07.41.00.00
              vlr-Number ISDN-AddressString = 91.97.30.07.41.00.00
              lmsi LMSI = 00.00.6d.0c
              vlr-Capability VLR-Capability
              {
                supportedCamelPhases SupportedCamelPhases =
{phase1(0)|phase2(1)}
              }
            }
          }
        }
      }
    }
  }
}

```

Figure 5. Traditional TCAP/MAP message for "UpdateLocation" request

The SOAP Handler provides template information to the NGPR by the parameter templateInfo of the HTTP Header

SOAP Action. This information about the service type is also transmitted by the parameter serviceType of the SOAP Action. These parameters are used by the NGPR to properly identify and decode the SOAP request from NG. The encoded, document type style SOAP messages are transmitted between NG and NGPR asynchronously. The NGPR service interface consists of

- Service Handler,
- Service Container and
- Database interface

The Service Handler checks the two SOAP Action parameters of all incoming requests. Based on the template type the template repository is queried to select the appropriate template.

The selected template and the service type information is used by the service handler to decode the incoming message. Afterwards the appropriate service object in the service container is instantiated. In the case of the unknown or unavailable service type parameter or template parameter an error message is sent back to the service requestor.

```

AsnSoap DEFINITIONS XER INSTRUCTIONS ::= BEGIN
  MAP_Messages ::= SEQUENCE {
    ...
  }
  Body ::= SET OF MAP_Messages
  Envelope ::= SEQUENCE {
    xmlSchema [NAMESPACE AS
"http://www.w3.org/2001/XMLSchema" PREFIX "xsd"] [ATTRIBUTE]
BOOLEAN,
    xmlSchema-Instance [NAMESPACE AS
"http://www.w3.org/2001/XMLSchema-instance" PREFIX "xsi"]
[ATTRIBUTE] BOOLEAN,
    body [NAMESPACE AS "http://schemas.xmlsoap.org/soap/envelope/"
PREFIX "soapenv"] [NAME AS "Body"] Body,
    encodingStyle [NAMESPACE AS
"http://schemas.xmlsoap.org/soap/envelope/" PREFIX "soapenv"]
[ATTRIBUTE] IA5String (FROM ("a".."z"|":"|"|"|"."))
  }
  ENCODING-CONTROL XER
  GLOBAL-DEFAULTS MODIFIED-ENCODINGS
  NAMESPACE Envelope AS
"http://schemas.xmlsoap.org/soap/envelope" PREFIX "soapenv"
END

```

Figure 6. SOAP ASN.1 Definition

The service container is the administration and management platform for service objects of the NGPR. All service objects inside the service container shall communicate with the centralized database using the database interface.

V. COMPARISONS

There are several methods available for inter-working between the IP based networks and SS7 based networks. One of them described in [4] also helps to model the subscriber information access from the NGPR based on the web service paradigm. The major difference between the two approaches arises from the performance characteristics. The encapsulation of the payload MAP message from TCAP/MAP message into ASN.1 encoded SOAP envelope, eliminate the necessity for MAP message validation and XML conversion. This saves a considerable amount of time at the NG. At the NGPR, the received ASN.1 messages are validated and transformed accordingly instead of XML validation and transformations, which contributes to approximately 15% of processing [10]. The PER encoded SOAP message with encapsulated MAP part is shown in figure 7 and the XML equivalent of the message is shown in figure 8. The bold text part of the message refers in both figures to the telecommunication message whereas the normal text is referring to SOAP.

```
01247873643d687474703a2f2f777777e77332e6f72672f3
23030312f584d4c536368656d610100d54a41e42000003
c1a465cc01d040001a465cc01d040000001b4301402428
005adb6e380
```

Figure 7. SOAP/MAP message PER

From the test results found in [21], it can be observed that the usage of ASN.1 representation for signed or unsigned complex attribute provides significant performance gain than their XML counterpart. While the same cannot be said for the signed simple or semi-complex attribute. The information exchanged between TNN and NGPR are mostly made of unsigned complex attribute, which justifies the use of ASN.1 representation. Moreover, the observed performance gain in the recipient decoding time is also found to be greater than that of sender encoding times. This supports our argument, because NGPR represents a central database which provides subscriber user information for many TNs. Hence, usage of ASN.1 format in service requests messages instead of XML provides a better service capacity at NGPR.

```
<? xml version='1.0' ?>
<SOAP-ENV:Envelope
xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/">
  <SOAP-ENV:Body>
    <UpdateLocationArg>
      <imsi>5290790800000f0</imsi>
      <msc-Number>91973007410000</msc-Number>
      <vlr-Number>91973007410000</vlr-Number>
      <lmsi>00006d0c</lmsi>
      <vlr-Capability>
        <supportedCamelPhases>01
        </supportedCamelPhases>
      </vlr-Capability>
    </UpdateLocationArg>
  </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

Figure 8. SOAP/MAP message XML (Extended XER)

VI. SIGNIFICANCE

The service interface of the NGPR together with NG is a novel approach adopting the service-oriented architecture to

the diverse telecommunication networks. Interoperability to the TNN is guaranteed through enhanced web services concepts. The enhanced web services concept uses ASN.1 encoding, which is a default method for message encoding in the telecommunication world. The ASN.1 PER encoding utilized in the test implementation provides the highest message compression (refer to the comparison presented in figure 9) and is employed in the UMTS network. E-XER builds the bridge between the XML and ASN.1 world. ASN.1 Definitions found in telecommunication networks are standardised and can be reused in the service-oriented architecture by combining them with the ASN.1 definition of SOAP. This architecture inherits the portability, interoperability and service-orientation of the web services world and the performance characteristics of the ASN.1 world. Figure 9 shows a brief comparison of message length of a MAP message e.g. "UpdateLocation" encoded in different ASN.1 encoding schemes.

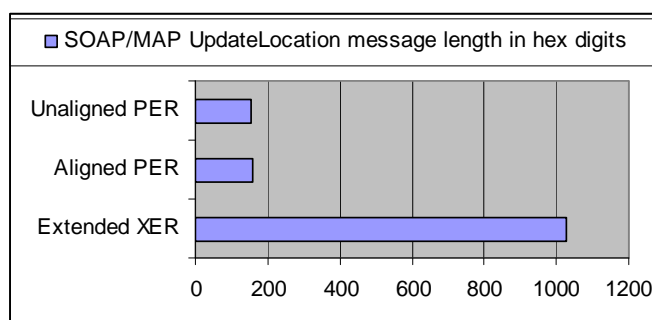


Figure 9. SOAP/MAP message length comparison

However, message length and network bandwidth do not play a significant role in core network. Therefore performance tests of the introduced application (refer to section 4) were conducted. The prototype used for conducting performance tests is based on Java 5.0 and compares standard Apache Axis [22] RPC style services with the ASN.1 PER messages over the application layer protocol HTTP. ASN.1 PER messages are translated into Java objects by an appropriate ASN.1 compiler [24]. On the server side both solutions provide a completely equivalent Java or XML based interface. The Jakarta Apache Tomcat Servlet Container [23] is used for ASN.1 and Apache Axis services. In order to build an equivalent interface all mobility services defined by ASN.1 definitions were translated into a XML schema. In the following the schema definition was embedded into the WSDL. The WSDL was used to generate appropriate Java Web Services Stubs and Skeletons.

Performance tests were fulfilled by 200-4000 requests in 1 to 20 parallel threads.

The tests within the NGPR architecture have shown that the ASN.1 solution is under heavy load 3 to 4 times faster than the standard web services approach. This performance gain is realized in the service processing and parsing. Especially XML parsing and validation is more expensive than decoding and parsing ASN.1 binary data. Figure 10 shows the performance achieved by using ASN.1 instead of XML for web service data definitions and data encoding. The parameter average (Figure 10) refers to the average response

time in ms for the Web Services and ASN.1 approach. Deviation (Figure 10) describes the standard deviation time between all requests in ms. The performance test measures parallel UpdateLocation requests without transaction information (as presented in Figure 5, 7 and 8).

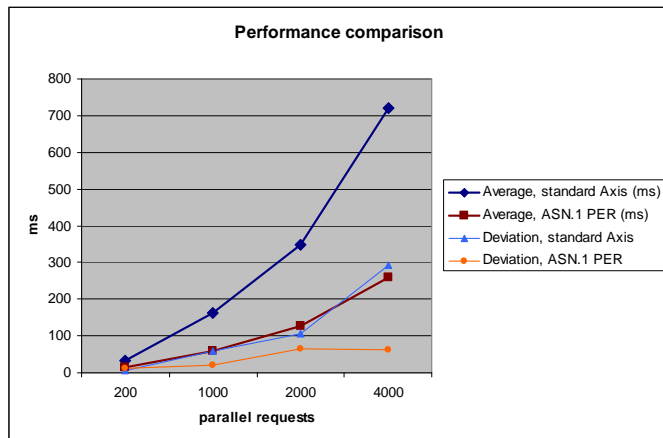


Figure 10. Performance comparison

VII. CONCLUSION AND FUTURE WORK

In this approach we deploy the NG between TNN and the NGPR to enable inter-working of two different technologies. NG takes advantage of partial pre-processing of TCAP/MAP message together with the PER encoded SOAP message. The NG transmits the encoded SOAP messages identified by SOAP Action parameters to the NGPR over HTTP. HTTP can be replaced by any application layer protocol above TCP/IP. SOAP messages with SOAP Header shall be used for secure transactions.

This work makes an attempt to apply the service-oriented architecture using the fast web services concept [9] in telecommunication networks. High message compression and minimum message processing achieves an efficient integration. Using this architecture the NGPR can be accessed as web services or by real-time traditional network interfaces. The prototype combines interoperability, performance and service-oriented access.

ACKNOWLEDGMENT

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REFERENCES

- [1] Diehl A., Bleimann U., Fuhrmann W., Reynolds P., Rupp S „Service Architecture for an Object-Oriented Next Generation Profile Register” International Network Conference 2005, Samos Island, Greece
- [2] Andreas Diehl, Franz-Josef Banet, Gerd Siegmund, Stephan Rupp, Woldemar Fuhrmann, „A Flexible Object-Oriented Data Model for a Centralized Subscriber Database” 14th IST Mobile and Wireless Communications Summit, Dresden 19 - 23 June 2005, Germany.
- [3] Asma Alazeib and Andreas Diehl, “An Ontology for Generic Wireless Authentication Data” 8th International Protege Conference - July 18-21, 2005 - Madrid, Spain

- [4] Andreas Diehl, Woldemar Fuhrmann, Gerd Siegmund, „MAP-SOAP Interworking in Future Service-Oriented Wireless Networks” International Network Conference 2004, Plymouth, UK
- [5] Rupp, S., Siegmund, G., López Aladros, R., Banet, F.-J., „FLEXINET – A Network Service Architecture”, The Journal of The Communication Network, U.K. 2003.
- [6] López Aladros, R., Banet, F.-J., Rupp, S., Winter, E.: “Restructuring the Telecommunication Networks”, Working Conference HET-NETs’03, Ikley, U.K. 2003.
- [7] Flexinet Deliverables and Contributions <http://www.ist-flexinet.org>
- [8] Apertio Apertio One-NDS (Network Directory Server) Whitepaper <http://www.apertio.co.uk/resources.html>
- [9] Fast Web Services, Sun Microsystems, <http://www.itu.int/rec/T-REC-X.892-200505-I/en>
- [10] Java Technology and XML-Part Two http://java.sun.com/developer/technicalArticles/xml/JavaTechandXML_part2/
- [11] X.694: Mapping from XML Schemas to ASN.1 modules <http://asn1.elibel.tm.fr/xml/#schema-mapping>
- [12] ITU-T X.693 (2003), „XML Encoding Rule“ X Serie: Data networks and open system communications, International Telecommunications Union, <http://www.itu.int/rec/recommendation.asp?type=items&lang=e&parent=T-REC-X.693-200112-I>
- [13] ITU-T X.680 (2003), “Amendment 1: Support for EXTENDED-XER“ X Serie: Data networks and open system communications, International Telecommunications Union, <http://www.itu.int/ITU-T/studygroups/com17/languages/X.680amd1.pdf>
- [14] ETSI TS 123 240 V6.7.0 Technical Specification (2005), “3GPP Generic User Profile (GUP) requirements; Architecture (Stage 2)”, http://webapp.etsi.org/exchangefolder/ts_123240v060700p.pdf
- [15] ETSI TR 123 941 V6.0.0 Technical Report (2004), “3GPP Generic User Profile (GUP); Stage 2; Data Description Method (DDM)”, http://webapp.etsi.org/exchangefolder/tr_123941v060000p.pdf
- [16] ITU-T Q.700 (1993), „ Introduction to CCITT Signalling System No. 7“, Q Serie: Switching and signalling, International Telecommunications Union, <http://www.itu.int/rec/recommendation.asp?type=items&lang=e&parent=T-REC-Q.700-199303-I>
- [17] ITU-T Q.771-774 (1997), „Specification signalling System No. 7 - Transaction capabilities application part“ Q Serie: Switching and signalling, International Telecommunications Union, <http://www.itu.int/rec/recommendation.asp?type=products&lang=e&parent=T-REC-Q>
- [18] ITU-T X.690 (2003), „Specification of Basic Encoding Rule, Canonical Encoding Rule and Distinguished Encoding Rule“, X Serie: Data networks and open system communications, International Telecommunications Union, <http://www.itu.int/rec/recommendation.asp?type=items&lang=e&parent=T-REC-X.690-200207-I>
- [19] ITU-T X.691 (2002) „Specification of Packed Encoding Rule“ X Serie: Data networks and opensystem communications, International Telecommunications Union <http://www.itu.int/rec/recommendation.asp?type=folders&lang=e&parent=T-REC-X.691>
- [20] ETSI TS 100 974 (2004), “Digital cellular telecommunications system (Phase 2+), Mobile Application Part (MAP) specification”, http://webapp.etsi.org/exchangefolder/ts_100974v071500p.pdf
- [21] David Chadwick, Darren Mundy “Comparing the Performance of Abstract Syntax Notation One (ASN.1) vs eXtensible Markup Language (XML)”, TERENA Networking Conference 2003, Zagreb, Croatia.
- [22] Apache Axis Web Services Project, Documentation, User’s Guide, Developer’s Guide, Integration Guide, Architecture Guide and Reference Guide, <http://ws.apache.org/axis/>
- [23] Apache Tomcat, Documentation, User’s Guide and Apache Tomcat Development, <http://tomcat.apache.org/tomcat-5.5-doc/index.html>
- [24] uniGone ASN.1 Compiler, <http://www.unigone.com/en/products/Asn1Compiler/description>