

The gSOAP Stub and Skeleton Compiler for C and C++ 2.2.1

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1 Introduction

The gSOAP toolkit provides a unique SOAP-to-C/C++ language binding for the development of SOAP Web Services and clients. Other SOAP C++ implementations adopt a SOAP-centric view and offer SOAP APIs for C++ that require the use of class libraries for SOAP-like data structures. This often forces a user to adapt the application logic to these libraries. In contrast, gSOAP provides a C/C++ transparent SOAP API through the use of compiler technology that hides irrelevant SOAP-specific details from the user. The gSOAP stub and skeleton compiler automatically maps native and user-defined C and C++ data types to semantically equivalent SOAP data types and vice-versa. As a result, full SOAP interoperability is achieved with a simple API relieving the user from the burden of SOAP details and enables him or her to concentrate on the application-essential logic. The compiler enables the integration of (legacy) C/C++ and Fortran codes (through a Fortran-to-C interface), embedded systems, and real-time software in SOAP applications that share computational resources and information with other SOAP applications, possibly across different platforms, language environments, and disparate organizations located behind firewalls.

gSOAP minimizes application adaptation for building SOAP clients and Web Services. The gSOAP compiler generates SOAP marshalling routines that (de)serialize application-specific C/C++ data structures. gSOAP includes a WSDL generator to generate Web service descriptions for your Web services. The gSOAP WSDL importer "closes the circle" in that it enables client development without the need for users to analyze Web service details to implement a client.

Some of the highlights of gSOAP are:

- Unique interoperability features: the gSOAP compiler generates SOAP marshalling routines that (de)serialize native and user-defined C/C++ data structures. gSOAP is also one of the few SOAP toolkits that support the full range of SOAP 1.1 features including multi-dimensional arrays and polymorphic types. For example, a remote method with a base class parameter may accept derived class instances from a client. Derived class instances keep their identity through dynamic binding.
- gSOAP includes a WSDL generator for convenient Web Service publishing.
- gSOAP includes a WSDL importer for automated client development.
- Generates source code for stand-alone Web Services and clients.
- Ideal for building web services that are compute-intensive and are therefore best written in C and C++.
- Platform independent: Windows, Unix, Linux, Mac OS X, Pocket PC, etc.
- Fast *in situ* serialization and deserialization with SOAP encoding of arbitrary user-defined and built-in C and C++ data structures.
- Fully SOAP 1.1 compliant data encoding and decoding. Also SOAP 1.2 compliant, but the SOAP 1.2 specification is in a drafting stage.
- DIME compliant attachments.
- Zlib compression.

- Includes HTTP, TCP/IP, XML, and DIME stacks.
- Supports one-way messaging, including asynchronous send and receive operations.
- Supports the saving and loading of XML serialized C/C++ data structures to/from files.
- The schema-specific XML pull parser is fast and efficient and does not require intermediate data storage for demarshalling to save space and time.
- Selective input and output buffering is used to increase efficiency, but full message buffering to determine HTTP message length is not used. Instead, a three-phase serialization method is used to determine message length. As a result, large data sets such as base64-encoded images can be transmitted with or without DIME attachments by small-memory devices such as PDAs.
- Supports C++ single class inheritance, dynamic binding, overloading, arbitrary pointer structures such as lists, trees, graphs, cyclic graphs, fixed-size arrays, (multi-dimensional) dynamic arrays, enumerations, built-in XML schema types including base64Binary encoding, and hexBinary encoding.
- No need to rewrite existing C/C++ applications for Web service deployment. However, parts of an application that use unions, pointers to sequences of elements in memory, and **void*** need to be modified, but **only** if the data structures that adopt them are required to be serialized or deserialized as part of a remote method invocation.
- Three-phase marshalling: 1) analysis of pointers, single-reference, multi-reference, and cyclic data structures, 2) HTTP message-length determination, and 3) serialization as per SOAP 1.1 encoding style or user-defined encoding styles.
- Two-phase demarshalling: 1) SOAP parsing and decoding, which involves the reconstruction of multi-reference and cyclic data structures from the payload, and 2) resolution of "forward" pointers (i.e. resolution of the forward **href** attributes in SOAP).
- Full and customizable SOAP Fault processing (client receive and service send).
- Customizable SOAP Header processing (send and receive), which for example enables easy transaction processing for the service to keep state information.

2 Notational Conventions

The typographical conventions used by this document are:

Sans serif or italics font denotes C and C++ source code, file names, and shell/batch commands.

Bold font denotes C and C++ keywords.

Courier font denotes HTTP header content, HTML, XML, XML schema content and WSDL content.

[Optional] denotes an optional construct.

The keywords "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC-2119.

3 Differences Between gSOAP Versions 2.1 (and Earlier) and 2.2

Run-time options and flags have been changed to enable separate recv/send settings for transport, content encodings, and mappings. The flags are divided into four classes: transport (IO), content encoding (ENC), XML marshalling (XML), and C/C++ data mapping (C). The old-style flags `soap_disable_X` and `soap_enable_X`, where X is a particular feature, are deprecated. See Section 7.10 for more details.

4 Differences Between gSOAP Versions 1.X and 2.X

gSOAP versions 2.0 and higher have been rewritten based on versions 1.X. gSOAP 2.0 and higher is thread-safe, while 1.X is not. All files in the gSOAP 2.X distribution are renamed to avoid confusion with gSOAP version 1.X files:

<u>gSOAP 1.X</u>	<u>gSOAP 2.X</u>
<code>soapcpp</code>	<code>soapcpp2</code>
<code>soapcpp.exe</code>	<code>soapcpp2.exe</code>
<code>stdsoap.h</code>	<code>stdsoap2.h</code>
<code>stdsoap.c</code>	<code>stdsoap2.c</code>
<code>stdsoap.cpp</code>	<code>stdsoap2.cpp</code>

Changing the version 1.X application codes to accomodate gSOAP 2.X does not require a significant amount of recoding. The change to gSOAP 2.X affects all functions defined in `stdsoap2.c[pp]` (the gSOAP runtime environment API) and the functions in the sources generated by the gSOAP compiler (the gSOAP RPC+marshalling API). Therefore, clients and services developed with gSOAP 1.X need to be modified to accomodate a change in the calling convention used in 2.X: In 2.X, **all** gSOAP functions (including the remote method proxy routines) take an additional parameter which is an instance of the gSOAP runtime environment that includes file descriptors, tables, buffers, and flags. This additional parameter is **always** the first parameter of any gSOAP function.

The gSOAP runtime environment is stored in a **struct** `soap` type. A **struct** was chosen to support application development in C without the need for a separate gSOAP implementation. An object-oriented approach with a class for the gSOAP runtime environment would have prohibited the implementation of pure C applications. Before a client can invoke remote methods or before a service can accept requests, a runtime environment need to be allocated and initialized. Three new functions are added to gSOAP 2.X:

Function	Description
<code>soap_init(struct soap *soap)</code>	Initializes a runtime environment (required only once)
<code>struct soap *soap_new()</code>	Allocates, initializes, and returns a pointer to a runtime environment
<code>struct soap *soap_copy(struct soap *soap)</code>	Allocates a new runtime environment and copies contents of the argument environment such that the new environment does not share any data with the original environment

An environment can be reused as many times as necessary and does not need to be reinitialized in doing so. A new environment is only required for each new thread to guarantee exclusive access to a new runtime environment by each thread. For example, the following code stack-allocates the runtime environment which is used for multiple remote method calls:

```
int main()
{
    struct soap soap;
    ...
    soap_init(&soap); // initialize runtime environment
    ...
    soap_call_ns_method1(&soap, ...); // make a remote call
    ...
    soap_call_ns_method2(&soap, ...); // make another remote call
    ...
    soap_end(&soap); // clean up
    ...
}
```

The runtime environment can also be heap allocated:

```
int main()
{
    struct soap *soap;
    ...
    soap = soap_new(); // allocate and initialize runtime environment
    if (!soap) // couldn't allocate: stop
    ...
    soap_call_ns_method1(soap, ...); // make a remote call
    ...
    soap_call_ns_method2(soap, ...); // make another remote call
    ...
    soap_end(soap); // clean up
    ...
    free(soap); // deallocate runtime environment
}
```

A service need to allocate and initialize an environment before calling `soap_serve`:

```
int main()
{
    struct soap soap;
    soap_init(&soap);
```



```

    soap_serve(&soap);
}

```

Or alternatively:

```

int main()
{
    soap_serve(soap_new());
}

```

A service can use multi-threading to handle requests while running some other code that invokes remote methods:

```

int main()
{
    struct soap soap1, soap2;
    pthread_t tid;
    ...
    soap_init(&soap1);
    if (soap_bind(&soap1, host, port, backlog) < 0) exit(1);
    if (soap_accept(&soap1) < 0) exit(1);
    pthread_create(&tid, NULL, (void*)(*)(void*))soap_serve, (void*)&soap1];
    ...
    soap_init(&soap2);
    soap_call_ns_..._method(&soap2, ...); // make a remote call
    ...
    soap_end(&soap2);
    ...
    pthread_join(tid); // wait for thread to terminate
    soap_end(&soap1); // release its data
}

```

In the example above, two runtime environments are required. In comparison, gSOAP 1.X statically allocates the runtime environment, which prohibits multi-threading (only one thread can invoke remote methods and/or accept requests due to the single runtime environment).

Section 6.2.3 presents a multi-threaded stand-alone Web Service that handles multiple SOAP requests by spawning a thread for each request.

5 Interoperability

gSOAP interoperability has been verified with the following SOAP implementations and toolkits:

Apache 2.2

Apache Axis

ASP.NET

Cape Connect

Delphi

easySOAP++

eSOAP

Frontier

GLUE

Iona XMLBus

kSOAP

MS SOAP

Phalanx

SIM

SOAP::Lite

SOAP4R

Spray

SQLData

Wasp Adv.

Wasp C++

White Mesa

xSOAP

ZSI

4S4C

6 Quick User Guide

This user guide offers a quick way to get started with gSOAP. This section requires a basic understanding of the SOAP 1.1 protocol and some familiarity with C and/or C++. In principle, SOAP clients and SOAP Web services can be developed in C and C++ with the gSOAP compiler without a detailed understanding of the SOAP protocol when gSOAP client-server applications are build as an ensemble and only communicate within this group (i.e. meaning that you don't have to worry about interoperability with other SOAP implementations). This section is intended to illustrate the implementation of gSOAP Web services and clients that connect to and interoperate with other SOAP implementations such as Apache Axis, SOAP::Lite, and .NET. This requires some details of the SOAP and WSDL protocols to be understood.

6.1 How to Use the gSOAP Stub and Skeleton Compiler to Build SOAP Clients

In general, the implementation of a SOAP client application requires a **stub** routine for each remote method that the client application needs to invoke. The primary stub's responsibility is to marshal the input data, send the request to the designated SOAP service over the wire, to wait for the response, and to demarshal the output data when it arrives. The client application invokes the stub routine for a remote method as if it would invoke a local method. To write a stub routine in C or C++ by hand is a tedious task, especially if the input and/or output parameters of a remote method contain elaborate data structures such as records, arrays, and graphs.

The generation of stub routines for a SOAP client is fully automated with gSOAP. The gSOAP stub and skeleton compiler is a **preprocessor** that generates the necessary C++ sources to build SOAP C++ clients. The input to the gSOAP stub and skeleton compiler consists of a standard C/C++ **header file**. The header file can be generated from a WSDL (Web Service Description Language) documentation of a service with the gSOAP WSDL importer, see 6.2.7. The SOAP remote methods are specified in this header file as **function prototypes**. Stub routines in C/C++ source form are automatically generated by the gSOAP compiler for these function prototypes of remote methods. The resulting stub routines allow C and C++ client applications to seamlessly interact with existing SOAP Web services.

The gSOAP stub and skeleton compiler also generates **skeleton** routines for each of the remote methods specified in the header file. The skeleton routines can be readily used to implement one or more of the remote methods in a new SOAP Web service. These skeleton routines are not used for building SOAP clients in C++, although they can be used to build mixed SOAP client/server applications (peer applications).

The input and output parameters of a SOAP remote method may be simple data types or compound data types. The necessary **type declarations** of C/C++ user-defined data structures such as structs, classes, enumerations, arrays, and pointer-based data structures (graphs) are to be provided in the header file. The gSOAP stub and skeleton compiler automatically generates **serializers** and **deserializers** for the data types to enable the generated stub routines to encode and decode the contents of the parameters of the remote methods in XML.

The remote method name and its parameterization can be found with a SOAP Web service description, typically in the form of an XML schema. For SOAP 1.1 RPC encoding, there is a one-to-one correspondence between the XML schema description of a SOAP remote method and the C/C++ type declarations required to build a client application for the Web service. There is also an almost one-to-one correspondence between the schemas and the C/C++ type declarations for SOAP literal encoding. The schemas are typically part of the WSDL specification of a SOAP Web service. The gSOAP WSDL importer converts WSDL service descriptions into header files.

6.1.1 Example

The `getQuote` remote method of XMethods Delayed Stock Quote service provides a delayed stock quote for a given ticker name. The WSDL description of the XMethods Delayed Stock Quote service provides the following details:

Endpoint URL:	<code>http://services.xmethods.net:80/soap</code>
SOAP action:	<code>""</code> (2 quotes)
Remote method namespace:	<code>urn:xmethods-delayed-quotes</code>
Remote method name:	<code>getQuote</code>
Input parameter:	symbol of type <code>xsd:string</code>
Output parameter:	Result of type <code>xsd:float</code>

The following `getQuote.h` **header file** is created from the WSDL description with the WSDL importer:

```
// Content of file "getQuote.h":
int ns1_ _getQuote(char *symbol, float &Result);
```

The header file essentially specifies the service details in C/C++ with directives for the gSOAP compiler. The remote method is declared as a `ns1_ _getQuote` **function prototype** which specifies all of the necessary details for the gSOAP compiler to generate the stub routine for a client application to interact with the Delayed Stock Quote service.

The Delayed Stock Quote service description requires that the **input parameter** of the `getQuote` remote method is a **symbol** parameter of type string. The description also indicates that the **Result output parameter** is a floating point number that represents the current unit price of the stock in dollars. The gSOAP compiler uses the convention the **last parameter** of the function prototype must be the output parameter of the remote method, which is required to be passed by reference using the reference operator (&) or by using a pointer type. All other parameters except the last are input parameters of the remote method, which are required to be passed by value or passed using a pointer to a value (by reference is not allowed). The function prototype associated with a remote method is required to return an **int**, whose value indicates to the caller whether the connection to a SOAP Web service was successful or resulted in an exception, see Section 8.2 for the error codes.

The use of the namespace prefix `ns1_` in the remote method name in the function prototype declaration is discussed in detail in 6.1.2. Basically, a namespace prefix is distinguished by a **pair of underscores** in the function name, as in `ns1_ _getQuote` where `ns1` is the namespace prefix and `getQuote` is the remote method name. (A single underscore in an identifier name will be translated into a dash in XML, because dashes are more frequently used in XML compared to underscores, see Section 8.3.)

The gSOAP compiler is invoked from the command line with:

```
soapcpp2 getQuote.h
```

The compiler generates the stub routine for the `getQuote` remote method specified in the `getQuote.h` header file. This stub routine can be called by a client program at any time to request a stock quote from the Delayed Stock Quote service. The interface to the generated stub routine is the following function prototype generated by the gSOAP compiler:

```
int soap_call_ns1_ _getQuote(struct soap *soap, char *URL, char *action, char *symbol, float
&Result);
```

The stub routine is saved in `soapClient.cpp`. The file `soapC.cpp` contains the **serializer** and **deserializer** routines for the data types used by the stub.

Note that the parameters of the `soap_call_ns1_getQuote` function are identical to the `ns1_getQuote` function prototype with three additional input parameters: `soap` must be a valid pointer to a gSOAP runtime environment, `URL` is the SOAP Web service **endpoint URL** passed as a string, and `action` is a string that denotes the **SOAP action** required by the Web service.

The following example C++ client program invokes the stub to retrieve the latest AOL stock quote from the XMethods Delayed Stock Quote service:

```
#include "soapH.h" // obtain the generated stub
int main()
{
    struct soap soap; // gSOAP runtime environment
    float quote;
    soap_init(&soap); // initialize runtime environment (only once)
    if (soap_call_ns1_getQuote(&soap, "http://services.xmethods.net:80/soap", "", "AOL",
quote) == SOAP_OK)
        cout << "Current AOL Stock Quote = " << quote;
    else // an error occurred
        soap_print_fault(&soap, stderr); // display the SOAP fault message on the stderr stream
    soap_end(&soap); // clean up
}
```

The XMethods Delayed Stock Quote service endpoint URL is `http://services.xmethods.net/soap` port 80 and the SOAP action required is `""` (two quotes). If successful, the stub returns `SOAP_OK` and `quote` contains the latest stock quote. Otherwise, an error occurred and the SOAP fault is displayed with the `soap_print_fault` function.

The following functions can be used to setup a gSOAP runtime environment (**struct soap**):

Function	Description
<code>soap_init(struct soap *soap)</code>	Initializes a runtime environment (required only once)
<code>soap_init2(struct soap *soap, int imode, int omode)</code>	Initializes a runtime environment and set in/out mode flags
<code>struct soap *soap_new()</code>	Allocates, initializes, and returns a pointer to a runtime environment
<code>struct soap *soap_copy(struct soap *soap)</code>	Allocates a new runtime environment and copies contents of the argument environment such that the new environment does not share data with the argument environment
<code>soap_done(struct soap *soap)</code>	Reset, close communications, and remove callbacks

An environment can be reused as many times as necessary for client-side remote calls and does not need to be reinitialized in doing so. A new environment is required for each new thread to guarantee exclusive access to runtime environments by threads. Also the use of any client calls within an active service method requires a new environment.

When the example client application is invoked, the SOAP request is performed by the stub routine `soap_call_ns1_getQuote`, which generates the following SOAP RPC request message:

```
POST /soap HTTP/1.1
Host: services.xmethods.net
Content-Type: text/xml
Content-Length: 529
SOAPAction: ""
```

```

<?xml version="1.0" encoding="UTF-8"?>
<SOAP-ENV:Envelope xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
  xmlns:SOAP-ENC="http://schemas.xmlsoap.org/soap/encoding/"
  xmlns:xsi="http://www.w3.org/1999/XMLSchema-instance"
  xmlns:xsd="http://www.w3.org/1999/XMLSchema"
  xmlns:ns1="urn:xmethods-delayed-quotes"
  SOAP-ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
<SOAP-ENV:Body>
<ns1:getQuote>
<symbol>AOL</symbol>
</ns1:getQuote>
</SOAP-ENV:Body>
</SOAP-ENV:Envelope>

```

The XMethods Delayed Stock Quote service responds with the SOAP response message:

```

HTTP/1.1 200 OK
Date: Sat, 25 Aug 2001 19:28:59 GMT
Content-Type: text/xml
Server: Electric/1.0
Connection: Keep-Alive
Content-Length: 491

<?xml version='1.0' encoding='UTF-8'?>
<soap:Envelope xmlns:soap='http://schemas.xmlsoap.org/soap/envelope/'
  xmlns:xsi='http://www.w3.org/1999/XMLSchema-instance'
  xmlns:xsd='http://www.w3.org/1999/XMLSchema'
  xmlns:soapenc='http://schemas.xmlsoap.org/soap/encoding/'
  soap:encodingStyle='http://schemas.xmlsoap.org/soap/encoding/'>
<soap:Body>
<n:getQuoteResponse xmlns:n='urn:xmethods-delayed-quotes'>
<Result xsi:type='xsd:float'>41.81</Result>
</n:getQuoteResponse>
</soap:Body>
</soap:Envelope>

```

The server's SOAP RPC response is parsed by the stub. The stub routine further demarshalls the data of `Result` element of the SOAP response and stores it in the `quote` parameter of `soap_call_ns1__getQuote`.

A client program can invoke a remote method at any time and multiple times if necessary. Consider for example:

```

...
struct soap soap;
float quotes[3]; char *myportfolio[] = {"IBM", "AOL", "MSDN"};
soap_init(&soap); // need to initialize only once
for (int i = 0; i < 3; i++)
  if (soap_call_ns1__getQuote(&soap, "http://services.xmethods.net:80/soap", "", myport-
folio[i], quotes[i]) != SOAP_OK)
    break;
if (soap.error) // an error occurred
  soap_print_fault(&soap, stderr);

```

```

    soap_end(&soap); // clean up all deserialized data
    ...

```

This client composes an array of stock quotes by calling the `ns1._getQuote` stub routine for each symbol in a portfolio array.

This example demonstrated how easy it is to build a SOAP client with gSOAP once the details of a Web service are available in the form of a WSDL document.

6.1.2 Namespace Considerations

The declaration of the `ns1._getQuote` function prototype (discussed in the previous section) uses the namespace prefix `ns1_` of the remote method namespace, which is distinguished by a **pair of underscores** in the function name to separate the namespace prefix from the remote method name. The purpose of a namespace prefix is to associate a remote method name with a service in order to prevent naming conflicts, e.g. to distinguish identical remote method names used by different services.

Note that the XML response of the XMethods Delayed Stock Quote service example uses the **namespace prefix** `n` which is bound to the **namespace name** `urn:xmethods-delayed-quotes` through the `xmlns:n="urn:xmethods-delayed-quotes"` binding. The use of namespace prefixes and namespace names is also required to enable SOAP applications to validate the content of SOAP messages. The namespace name in the service response is verified by the stub routine by using the information supplied in a **namespace mapping table** that is required to be part of gSOAP client and service application codes. The table is accessed at run time to resolve namespace bindings, both by the generated stub's data structure serializer for encoding the client request and by the generated stub's data structure deserializer to decode and validate the service response. The namespace mapping table should **not** be part of the header file input to the gSOAP stub and skeleton compiler. Service details including namespace bindings may be provided with gSOAP directives in a header file, see Section 13.2.

The namespace mapping table for the Delayed Stock Quote client is:

```

struct Namespace namespaces[] =
{
    // {"ns-prefix", "ns-name"}
    {"SOAP-ENV", "http://schemas.xmlsoap.org/soap/envelope/"}, // MUST be first
    {"SOAP-ENC", "http://schemas.xmlsoap.org/soap/encoding/"}, // MUST be second
    {"xsi", "http://www.w3.org/2001/XMLSchema-instance"}, // MUST be third
    {"xsd", "http://www.w3.org/2001/XMLSchema"}, // 2001 XML schema
    {"ns1", "urn:xmethods-delayed-quotes"}, // given by the service description
    {NULL, NULL} // end of table
};

```

The first four namespace entries in the table consist of the standard namespaces used by the SOAP 1.1 protocol. In fact, the namespace mapping table is explicitly declared to enable a programmer to specify the SOAP encoding style and to allow the inclusion of namespace-prefix with namespace-name bindings to comply to the namespace requirements of a specific SOAP service. For example, the namespace prefix `ns1`, which is bound to `urn:xmethods-delayed-quotes` by the namespace mapping table shown above, is used by the generated stub routine to encode the `getQuote` request. This is performed automatically by the gSOAP compiler by using the `ns1` prefix of the `ns1._getQuote`

method name specified in the `getQuote.h` header file. In general, if a function name of a remote method, **struct** name, **class** name, **enum** name, or field name of a **struct** or **class** has a pair of underscores, the name has a namespace prefix that must be defined in the namespace mapping table.

The namespace mapping table will be output as part of the SOAP Envelope by the stub routine. For example:

```
...
<SOAP-ENV:Envelope xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
  xmlns:SOAP-ENC="http://schemas.xmlsoap.org/soap/encoding/"
  xmlns:xsi="http://www.w3.org/1999/XMLSchema-instance"
  xmlns:xsd="http://www.w3.org/1999/XMLSchema"
  xmlns:ns1="urn:xmethods-delayed-quotes"
  SOAP-ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
...
```

The namespace bindings will be used by a SOAP service to validate the SOAP request.

6.1.3 Example

The incorporation of namespace prefixes into C++ identifier names is necessary to distinguish remote methods that share the same name but are provided by separate Web services and/or organizations. Consider for example:

```
// Contents of file "getQuote.h":
int ns1_ _getQuote(char *symbol, float &Result);
int ns2_ _getQuote(char *ticker, char *&quote);
```

Recall that the namespace prefix is always separated from the name of a remote method by a pair of underscores (--).

This example enables a client program to connect to a (hypothetical) Stock Quote service with remote methods that can only be distinguished by their namespaces. Consequently, two different namespace prefixes had to be used as part of the remote method names.

The namespace prefix convention can also be applied to **class** declarations that contain SOAP compound values that share the same name but have different namespaces that refer to different XML schemas. For example:

```
class e_ _Address // an electronic address
{
    char *email;
    char *url;
};
class s_ _Address // a street address
{
    char *street;
    int number;
    char *city;
};
```


The namespace prefix is separated from the name of a data type by a pair of underscores (-).

An instance of `e_Address` is encoded by the generated serializer for this type as an `Address` element with namespace prefix `e`:

```
<e:Address xsi:type="e:Address">
<email xsi:type="string">me@home</email>
<url xsi:type="string">www.me.com</url>
</e:Address>
```

While an instance of `s_Address` is encoded by the generated serializer for this type as an `Address` element with namespace prefix `s`:

```
<s:Address xsi:type="s:Address">
<street xsi:type="string">Technology Drive</street>
<number xsi:type="int">5</number>
<city xsi:type="string">Softcity</city>
</s:Address>
```

The namespace mapping table of the client program must have entries for `e` and `s` that refer to the XML schemas of the data types:

```
struct Namespace namespaces[] =
{ ...
  {"e", "http://www.me.com/schemas/electronic-address"},
  {"s", "http://www.me.com/schemas/street-address"},
  ...
}
```

This table is required to be part of the client application to allow access by the serializers and deserializers of the data types at run time.

6.1.4 How to Generate C++ Client Proxy Classes

Proxy classes for C++ client applications are automatically generated by the gSOAP compiler provided that the WSDL importer is used or sufficient server details are given in the header file in the form of `//gsoap` directives, see Section 13.2 for more details on these directives.

To illustrate the generation of a proxy class, the `getQuote.h` header file example of the previous section is augmented with the appropriate directives to enable the gSOAP compiler to generate the proxy class. Similar directives are included in the header file by the WSDL importer.

```
// Content of file "getQuote.h":
//gsoap ns1 service name: Quote
//gsoap ns1 service location: http://services.xmethods.net/soap
//gsoap ns1 schema namespace: urn:xmethods-delayed-quotes
//gsoap ns1 service method-action: getQuote ""
int ns1_getQuote(char *symbol, float &Result);
```

The first three directives provide the service name which is used to name the proxy class, the service location (endpoint), and the schema. The fourth directive defines the optional SOAPAction, which is a string associated with SOAP 1.1 operations. This directive must be provided for each remote method when the SOAPAction is required. Compilation of this header file with the gSOAP compiler `soapcpp2` creates a new file `soapQuoteProxy.h` with the following contents:

```

#include "soapH.h"
class Quote
{ public:
    struct soap *soap;
    const char *endpoint;
    Quote() { soap = soap_new(); endpoint = "http://services.xmethods.net/soap"; };
    ~Quote() { if (soap) { soap_destroy(soap); soap_end(soap); soap_done(soap); free((void*)soap);
    }};
    int getQuote(char *symbol, float &result) { return soap ? soap_call_ns_.getQuote(soap, end-
point, "", symbol, result) : SOAP_EOM; };
};

```

The gSOAP environment and endpoint are declared public to enable access for run-time customization.

This generated proxy class can be included into a client application together with the generated namespace table as shown in this example: Quote.nsmmap:

```

#include <iostream.h>
#include "soapQuoteProxy.h" // get proxy
#include "Quote.nsmmap" // get namespace bindings
int main()
{
    Quote q;
    float r;
    if (q.getQuote("AOL", r) == SOAP_OK)
        cout << r << endl;
    else
        soap_print_fault(q.soap, stderr);
}

```

The Quote constructor allocates and initializes a gSOAP environment for the instance. All the HTTP and SOAP/XML processing is hidden and performed on the background.

6.1.5 XSD Type Encoding Considerations

Many SOAP services require the explicit use of XML schema types in the SOAP payload. The default encoding, which is also adopted by the gSOAP compiler, assumes SOAP RPC encoding which only requires the use of types to handle polymorphic cases. Nevertheless, the use of XSD typed messages is advised to improve interoperability. XSD types are introduced with **typedef** definitions in the header file input to the gSOAP compiler. The type name defined by a **typedef** definition corresponds to an XML schema type (XSD type). For example, the following **typedef** declarations define various built-in XSD types implemented as primitive C/C++ types:

```

// Contents of header file:
...
typedef char *xsd__string; // encode xsd__string value as the xsd:string schema type
typedef char *xsd__anyURI; // encode xsd__anyURI value as the xsd:anyURI schema type
typedef float xsd__float; // encode xsd__float value as the xsd:float schema type
typedef long xsd__int; // encode xsd__int value as the xsd:int schema type
typedef bool xsd__boolean; // encode xsd__boolean value as the xsd:boolean schema type

```

```

typedef unsigned long long xsd__positiveInteger; // encode xsd__positiveInteger value as the
xsd:positiveInteger schema type
...

```

This simple mechanism informs the gSOAP compiler to generate serializers and deserializers that explicitly encode and decode the primitive C++ types as built-in primitive XSD types when the typedefed type is used in the parameter signature of a remote method (or when used nested within structs, classes, and arrays). At the same time, the use of **typedef** does not force any recoding of a C++ client or Web service application as the internal C++ types used by the application are not required to be changed (but still have to be primitive C++ types, see Section 9.2.2 for alternative class implementations of primitive XSD types which allows for the marshalling of polymorphic primitive types).

6.1.6 Example

Reconsider the getQuote example, now rewritten with explicit XSD types to illustrate the effect:

```

// Contents of file "getQuote.h":
typedef char *xsd__string;
typedef float xsd__float;
int ns1__getQuote(xsd__string symbol, xsd__float &Result);

```

This header file is compiled by the gSOAP stub and skeleton compiler and the compiler generates source code for the function soap_call_ns1__getQuote, which is identical to the “old” proxy:

```

int soap_call_ns1__getQuote(struct soap *soap, char *URL, char *action, char *symbol, float
&Result);

```

The client application does not need to be rewritten and can still call the proxy using the “old” parameter signature. In contrast to the previous implementation of the stub however, the encoding and decoding of the data types by the stub has been changed to explicitly use the XSD types in the message payload.

For example, when the client application calls the proxy, the proxy produces a SOAP request with an xsd:string:

```

...
<SOAP-ENV:Body>
<ns1:getQuote><symbol xsi:type="xsd:string">AOL</symbol>
</ns1:getQuote>
</SOAP-ENV:Body>
...

```

The service response is:

```

...
<soap:Body>
<n:getQuoteResponse xmlns:n='urn:xmethods-delayed-quotes'>
<Result xsi:type='xsd:float'>41.81</Result>
</n:getQuoteResponse>
</soap:Body>
...

```

The validation of this service response by the stub routine takes place by matching the namespace names (URIs) that are bound to the `xsd` namespace prefix. The stub also expects the `getQuoteResponse` element to be associated with URI `urn:xmethods-delayed-quotes` through the binding of the namespace prefix `ns1` in the namespace mapping table. The service response uses namespace prefix `n` for the `getQuoteResponse` element. This namespace prefix is bound to the same URI `urn:xmethods-delayed-quotes` and therefore the service response is assumed to be valid. The response is rejected and a SOAP fault is generated when the URIs do not match.

6.1.7 How to Change the Response Element Name

There is no standardized convention for the response element name in a SOAP response message, although it is recommended that the response element name is the method name ending with “Response”. For example, the response element of `getQuote` is `getQuoteResponse`.

The response element name can be specified explicitly using a **struct** or **class** declaration in the header file. The **struct** or **class** name represents the SOAP response element name used by the service. Consequently, the output parameter of the remote method must be declared as a field of the **struct** or **class**. The use of a **struct** or a **class** for the service response is fully SOAP 1.1 compliant. In fact, the absence of a **struct** or **class** indicates to the gSOAP compiler to automatically generate a struct for the response which is internally used by a stub.

6.1.8 Example

Reconsider the `getQuote` remote method specification which can be rewritten with an explicit declaration of a SOAP response element as follows:

```
// Contents of "getQuote.h":
typedef char *xsd__string;
typedef float xsd__float;
struct ns1__getQuoteResponse {xsd__float Result;};
int ns1__getQuote(xsd__string symbol, struct ns1__getQuoteResponse &r);
```

The SOAP request is the same as before:

```
...
<SOAP-ENV:Body>
<ns1:getQuote><symbol xsi:type="xsd:string">AOL</symbol>
</ns1:getQuote>
</SOAP-ENV:Body>
...
```

The difference is that the service response is required to match the specified `getQuoteResponse` name and its namespace URI:

```
...
<soap:Body>
<n:getQuoteResponse xmlns:n='urn:xmethods-delayed-quotes'>
<Result xsi:type='xsd:float'>41.81</Result>
</n:getQuoteResponse>
</soap:Body>
...
```

This use of a **struct** or **class** enables the adaptation of the default SOAP response element name and/or namespace URI when required.

Note that the **struct** (or **class**) declaration may appear within the function prototype declaration. For example:

```
// Contents of "getQuote.h":
typedef char *xsd__string;
typedef float xsd__float;
int ns1__getQuote(xsd__string symbol, struct ns1__getQuoteResponse {xsd__float Result;} &r);
```

This example combines the declaration of the response element of the remote method with the function prototype of the remote method.

6.1.9 How to Specify Multiple Output Parameters

The gSOAP stub and skeleton compiler uses the convention that the **last parameter** of the function prototype declaration of a remote method in a header file is also the **only single output parameter** of the method. All other parameters are considered input parameters of the remote method. To specify a remote method with **multiple output parameters**, a **struct** or **class** must be declared for the remote method response, see also 6.1.7. The fields of the **struct** or **class** are the output parameters of the remote method. Both the order of the input parameters in the function prototype and the order of the output parameters (the fields in the **struct** or **class**) is not significant. However, the SOAP 1.1 specification states that input and output parameters may be treated as having anonymous parameter names which requires a particular ordering, see Section 6.1.13.

6.1.10 Example

As an example, consider a hypothetical remote method `getNames` with a single input parameter `SSN` and two output parameters `first` and `last`. This can be specified as:

```
// Contents of file "getNames.h":
int ns3__getNames(char *SSN, struct ns3__getNamesResponse {char *first; char *last;} &r);
```

The gSOAP stub and skeleton compiler takes this header file as input and generates source code for the function `soap_call_ns3__getNames`. When invoked by a client application, the proxy produces the SOAP request:

```
...
<SOAP-ENV:Envelope ... xmlns:ns3="urn:names" ...>
...
<ns3:getNames>
<SSN>999 99 9999</SSN>
</ns3:getNames>
...
```

The response by a SOAP service could be:

```
...
<m:getNamesResponse xmlns:m="urn:names">
```

```

<first>John</first>
<last>Doe</last>
</m:getNamesResponse>
...

```

where `first` and `last` are the output parameters of the `getNames` remote method of the service.

As another example, consider a remote method `copy` with an input parameter and an output parameter with identical parameter names (this is not prohibited by the SOAP 1.1 protocol). This can be specified as well using a response **struct**:

```

// Contente of file "copy.h":
int X_rox__copy_name(char *name, struct X_rox__copy_nameResponse {char *name;} &r);

```

The use of a **struct** or **class** for the remote method response enables the declaration of remote methods that have parameters that are passed both as input and output parameters.

The gSOAP compiler takes the `copy.h` header file as input and generates the `soap_call_X_rox__copy_name` proxy. When invoked by a client application, the proxy produces the SOAP request:

```

...
<SOAP-ENV:Envelope ... xmlns:X-rox="urn:copy" ...>
...
<X-rox:copy-name>
<name>SOAP</name>
</X-rox:copy-name>
...

```

The response by a SOAP `copy` service could be something like:

```

...
<m:copy-nameResponse xmlns:m="urn:copy">
<name>SOAP</name>
</m:copy-nameResponse>
...

```

The name will be parsed and decoded by the proxy and returned in the `name` field of the **struct** `X_rox__copy_nameResponse &r` parameter.

6.1.11 How to Specify Output Parameters With struct/class Compound Data Types

If the single output parameter of a remote method is a complex data type such as a **struct** or **class** it is necessary to specify the response element of the remote method as a **struct** or **class at all times**. Otherwise, the output parameter will be considered the response element (!), because of the response element specification convention used by gSOAP, as discussed in 6.1.7.

6.1.12 Example

This is best illustrated with an example. The Flighttracker service by ObjectSpace provides real time flight information for flights in the air. It requires an airline code and flight number as

parameters. The remote method name is `getFlightInfo` and the method has two string parameters: the airline code and flight number, both of which must be encoded as `xsd:string` types. The method returns a `getFlightResponse` response element with a `return` output parameter that is of complex type `FlightInfo`. The type `FlightInfo` is represented by a **class** in the header file, whose field names correspond to the `FlightInfo` accessors:

```
// Contents of file "flight.h":
typedef char *xsd_string;
class ns2_FlightInfo
{
    public:
    xsd_string airline;
    xsd_string flightNumber;
    xsd_string altitude;
    xsd_string currentLocation;
    xsd_string equipment;
    xsd_string speed;
};
struct ns1_getFlightInfoResponse {ns2_FlightInfo _return;};
int ns1_getFlightInfo(xsd_string param1, xsd_string param2, struct ns1_getFlightInfoResponse
&r);
```

The response element `ns1_getFlightInfoResponse` is explicitly declared and it has one field: `return_` of type `ns2_FlightInfo`. Note that `return_` has a trailing underscore to avoid a name clash with the **return** keyword, see Section 8.3 for details on the translation of C++ identifiers to XML element names.

The gSOAP compiler generates the `soap_call_ns1_getFlightInfo` proxy. Here is an example fragment of a client application that uses this proxy to request flight information:

```
struct soap soap;
...
soap_init(&soap);
...
soap_call_ns1_getFlightInfo(&soap, "testvger.objectspace.com/soap/servlet/rpcrouter",
    "urn:galdemo:flighttracker", "UAL", "184", r);
...
struct Namespace namespaces[] =
{
    {"SOAP-ENV", "http://schemas.xmlsoap.org/soap/envelope/"},
    {"SOAP-ENC", "http://schemas.xmlsoap.org/soap/encoding/"},
    {"xsi", "http://www.w3.org/1999/XMLSchema-instance"},
    {"xsd", "http://www.w3.org/1999/XMLSchema"},
    {"ns1", "urn:galdemo:flighttracker"},
    {"ns2", "http://galdemo.flighttracker.com"},
    {NULL, NULL}
};
```

When invoked by a client application, the proxy produces the SOAP request:

```
POST /soap/servlet/rpcrouter HTTP/1.1
Host: testvger.objectspace.com
Content-Type: text/xml
```

```

Content-Length: 634
SOAPAction: "urn:galdemo:flighttracker"

<?xml version="1.0" encoding="UTF-8"?>
<SOAP-ENV:Envelope xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
  xmlns:SOAP-ENC="http://schemas.xmlsoap.org/soap/encoding/"
  xmlns:xsi="http://www.w3.org/1999/XMLSchema-instance"
  xmlns:xsd="http://www.w3.org/1999/XMLSchema"
  xmlns:ns1="urn:galdemo:flighttracker"
  xmlns:ns2="http://galdemo.flighttracker.com"
  SOAP-ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
<SOAP-ENV:Body>
<ns1:getFlightInfo xsi:type="ns1:getFlightInfo">
<param1 xsi:type="xsd:string">UAL</param1>
<param2 xsi:type="xsd:string">184</param2>
</ns1:getFlightInfo>
</SOAP-ENV:Body>
</SOAP-ENV:Envelope>

```

The Flighttracker service responds with:

```

HTTP/1.1 200 ok
Date: Thu, 30 Aug 2001 00:34:17 GMT
Server: IBM_HTTP_Server/1.3.12.3 Apache/1.3.12 (Win32)
Set-Cookie: sesessionid=2GFVTOGC30DOLGRGU2L4HFA;Path=/
Cache-Control: no-cache="set-cookie,set-cookie2"
Expires: Thu, 01 Dec 1994 16:00:00 GMT
Content-Length: 861
Content-Type: text/xml; charset=utf-8
Content-Language: en

<?xml version='1.0' encoding='UTF-8'?>
<SOAP-ENV:Envelope xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
  xmlns:xsi="http://www.w3.org/1999/XMLSchema-instance"
  xmlns:xsd="http://www.w3.org/1999/XMLSchema">
<SOAP-ENV:Body>
<ns1:getFlightInfoResponse xmlns:ns1="urn:galdemo:flighttracker"
  SOAP-ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
<return xmlns:ns2="http://galdemo.flighttracker.com" xsi:type="ns2:FlightInfo">
<equipment xsi:type="xsd:string">A320</equipment>
<airline xsi:type="xsd:string">UAL</airline>
<currentLocation xsi:type="xsd:string">188 mi W of Lincoln, NE</currentLocation>
<altitude xsi:type="xsd:string">37000</altitude>
<speed xsi:type="xsd:string">497</speed>
<flightNumber xsi:type="xsd:string">184</flightNumber>
</return>
</ns1:getFlightInfoResponse>
</SOAP-ENV:Body>
</SOAP-ENV:Envelope>

```

The proxy returns the service response in variable `r` of type **struct** `ns1._getFlightInfoResponse` and this information can be displayed by the client application with the following code fragment:


```
cout << r.return_.equipment << " flight " << r.return_.airline << r.return_.flightNumber
    << " traveling " << r.return_.speed << " mph " << " at " << r.return_.altitude
    << " ft, is located " << r.return_.currentLocation jj endl;
```

This code displays the service response as:

```
A320 flight UAL184 traveling 497 mph at 37000 ft, is located 188 mi W of Lincoln,
NE
```

Note: the flight tracker service is no longer available since 9/11/2001. It is kept in the documentation as an example to illustrate the use of structs/classes and response types.

6.1.13 How to Specify Anonymous Parameter Names

The SOAP 1.1 protocol allows parameter names to be anonymous. That is, the name(s) of the output parameters of a remote method are not strictly required to match a client's view of the parameters names. Also, the input parameter names of a remote method are not strictly required to match a service's view of the parameter names. Although this convention is likely to be deprecated in SOAP 1.2, the gSOAP compiler can generate stub and skeleton routines that support anonymous parameters. Parameter names are implicitly anonymous by omitting the parameter names in the function prototype of the remote method. For example:

```
// Contents of "getQuote.h":
typedef char *xsd_string;
typedef float xsd_float;
int ns1_getQuote(xsd_string, xsd_float&);
```

To make parameter names explicitly anonymous on the receiving side (client or service), the parameter names should start with an underscore (_) in the function prototype in the header file.

For example:

```
// Contents of "getQuote.h":
typedef char *xsd_string;
typedef float xsd_float;
int ns1_getQuote(xsd_string symbol, xsd_float &_return);
```

Or, alternatively with a response **struct**:

```
// Contents of "getQuote.h":
typedef char *xsd_string;
typedef float xsd_float;
struct ns1_getQuoteResponse {xsd_float _return;};
int ns1_getQuote(xsd_string symbol, struct ns1_getQuoteResponse &r);
```

In this example, `_return` is an anonymous output parameter. As a consequence, the service response to a request made by a client created with gSOAP using this header file specification may include any name for the output parameter in the SOAP payload. The input parameters may also be anonymous. This affects the implementation of Web services in gSOAP and the matching of parameter names by the service.

Caution: when anonymous parameter names are used, the order of the parameters in the function prototype of a remote method is significant.

6.1.14 How to Specify a Method with No Input Parameters

To specify a remote method that has no input parameters, just provide a function prototype with one parameter which is the output parameter. However, some C/C++ compilers (notably Visual C++TM) will not compile and complain about an empty **struct**. This **struct** is generated by gSOAP to contain the SOAP request message. To fix this, provide one input parameter of type **void*** (gSOAP can not serialize **void*** data). For example:

```
struct ns3_ _SOAPService
{
    public:
    int ID;
    char *name;
    char *owner;
    char *description;
    char *homepageURL;
    char *endpoint;
    char *SOAPAction;
    char *methodNameNamespaceURI;
    char *serviceStatus;
    char *methodName;
    char *dateCreated;
    char *downloadURL;
    char *wsdlURL;
    char *instructions;
    char *contactEmail;
    char *serverImplementation;
};
struct ArrayOfSOAPService {struct ns3_ _SOAPService *_ptr; int _size;};
int ns_ _getAllSOAPServices(void *_ , struct ArrayOfSOAPService &_return);
```

The `ns_ _getAllSOAPServices` method has one **void*** input parameter which is ignored by the serializer to produce the request message.

Most C/C++ compilers allow empty **structs** and therefore the **void*** parameter is not required.

6.1.15 How to Specify a Method with No Output Parameters

To specify a remote method that has no output parameters, just provide a function prototype with a response struct that is empty. For example:

```
enum ns_ _event { off, on, stand_by };
int ns_ _signal(enum ns_ _event in, struct ns_ _signalResponse { } *out);
```

Since the response struct is empty, no output parameters are specified. Most C/C++ compilers allow empty **structs**. For those that don't, use a **void*** parameter in the struct. This parameter is not (de)serialized.

Some SOAP resources refer to SOAP RPC with empty responses as **one way** SOAP messaging. However, we refer to one-way messaging by asynchronous explicit send and receive operations as described in Section 6.3. We found this view of one-way SOAP messaging more useful by providing a message passing alternative to SOAP RPC.

6.2 How to Use the gSOAP Stub and Skeleton Compiler to Build SOAP Web Services

The gSOAP stub and skeleton compiler generates **skeleton** routines in C++ source form for each of the remote methods specified as function prototypes in the header file processed by the gSOAP compiler. The skeleton routines can be readily used to implement the remote methods in a new SOAP Web service. The compound data types used by the input and output parameters of SOAP remote methods must be declared in the header file, such as structs, classes, arrays, and pointer-based data structures (graphs) that are used as the data types of the parameters of a remote method. The gSOAP compiler automatically generates serializers and deserializers for the data types to enable the generated skeleton routines to encode and decode the contents of the parameters of the remote methods. The gSOAP compiler also generates a remote method request dispatcher routine that will serve requests by calling the appropriate skeleton when the SOAP service application is installed as a CGI application on a Web server.

6.2.1 Example

The following example specifies three remote methods to be implemented by a new SOAP Web service:

```
// Contents of file "calc.h":  
typedef double xsd__double;  
int ns__add(xsd__double a, xsd__double b, xsd__double &result);  
int ns__sub(xsd__double a, xsd__double b, xsd__double &result);  
int ns__sqrt(xsd__double a, xsd__double &result);
```

The add and sub methods are intended to add and subtract two double floating point numbers stored in input parameters a and b and should return the result of the operation in the result output parameter. The sqrt method is intended to take the square root of input parameter a and to return the result in the output parameter result. The xsd__double type is recognized by the gSOAP compiler as the xsd:double XML schema data type. The use of **typedef** is a convenient way to associate primitive C types with primitive XML schema data types.

To generate the skeleton routines, the gSOAP compiler is invoked from the command line with:

```
soapcpp2 calc.h
```

The compiler generates the skeleton routines for the add, sub, and sqrt remote methods specified in the calc.h header file. The skeleton routines are respectively, soap_serve_ns__add, soap_serve_ns__sub, and soap_serve_ns__sqrt and saved in the file soapServer.cpp. The generated file soapC.cpp contains serializers and deserializers for the skeleton. The compiler also generates a service dispatcher: the soap_serve function handles client requests on the standard input stream and dispatches the remote method requests to the appropriate skeletons to serve the requests. The skeleton in turn calls the remote method implementation function. The function prototype of the remote method implementation function is specified in the header file that is input to the gSOAP compiler.

Here is an example Calculator service application that uses the generated soap_serve routine to handle client requests:

```

// Contents of file "calc.cpp":
#include "soapH.h"
#include <math.h> // for sqrt()
main()
{
    soap_serve(soap_new()); // use the remote method request dispatcher
}
// Implementation of the "add" remote method:
int ns_add(struct soap *soap, double a, double b, double &result)
{
    result = a + b;
    return SOAP_OK;
}
// Implementation of the "sub" remote method:
int ns_sub(struct soap *soap, double a, double b, double &result)
{
    result = a - b;
    return SOAP_OK;
}
// Implementation of the "sqrt" remote method:
int ns_sqrt(struct soap *soap, double a, double &result);
{
    if (a >= 0)
    {
        result = sqrt(a);
        return SOAP_OK;
    }
    else
        return soap_receiver_fault(soap, "Square root of negative number", "I can only take the square
root of a non-negative number");
}
// As always, a namespace mapping table is needed:
struct Namespace namespaces[] =
{ // {"ns-prefix", "ns-name"}
  {"SOAP-ENV", "http://schemas.xmlsoap.org/soap/envelope/"},
  {"SOAP-ENC", "http://schemas.xmlsoap.org/soap/encoding/"},
  {"xsi", "http://www.w3.org/1999/XMLSchema-instance"},
  {"xsd", "http://www.w3.org/1999/XMLSchema"},
  {"ns", "urn:simple-calc"}, // bind "ns" namespace prefix
  {NULL, NULL}
};

```

Note that the remote methods have an extra input parameter which is a pointer to the gSOAP runtime environment. The implementation of the remote methods MUST return a SOAP error code. The code SOAP_OK denotes success, while SOAP_FAULT denotes an exception with details that can be defined by the user. The exception description can be assigned to the soap->fault->faultstring string and details can be assigned to the soap->fault->detail string. This is SOAP 1.1 specific. SOAP 1.2 requires the soap->fault->SOAP_ENV_Reason and the soap->fault->SOAP_ENV_Detail strings to be assigned. Better is to use the soap_receiver_fault function that allocates a fault struct and sets the SOAP Fault string and details regardless of the SOAP 1.1 or SOAP 1.2 version used. The soap_receiver_fault function returns SOAP_FAULT, i.e. an application-specific fault. The fault exception will be passed on to the client of this service.

This service application can be readily installed as a CGI application. The service description would be:

Endpoint URL:	the URL of the CGI application
SOAP action:	"" (2 quotes)
Remote method namespace:	urn:simple-calc
Remote method name:	add
Input parameters:	a of type xsd:double and b of type xsd:double
Output parameter:	result of type xsd:double
Remote method name:	sub
Input parameters:	a of type xsd:double and b of type xsd:double
Output parameter:	result of type xsd:double
Remote method name:	sqrt
Input parameter:	a of type xsd:double
Output parameter:	result of type xsd:double or a SOAP Fault

The `soapcpp2` compile generates a WSDL file for this service, see Section 6.2.5.

Unless the CGI application inspects and checks the environment variable `SOAPAction` which contains the SOAP action request by a client, the SOAP action is ignored by the CGI application. SOAP actions are specific to the SOAP protocol and provide a means for routing requests and for security reasons (e.g. firewall software can inspect SOAP action headers to grant or deny the SOAP request. Note that this requires the SOAP service to check the SOAP action header as well to match it with the remote method.)

The header file input to the gSOAP compiler does not need to be modified to generate client stubs for accessing this service. Client applications can be developed by using the same header file as for which the service application was developed. For example, the `soap_call_ns__add` proxy is available from the `soapClient.cpp` file after invoking the gSOAP compiler on the `calc.h` header file. As a result, client and service applications can be developed without the need to know the details of the SOAP encoding used.

6.2.2 How to Create a Stand-Alone gSOAP Service

The deployment of a Web service as a CGI application is an easy means to provide your service on the Internet. gSOAP services can also run as stand-alone services on any port by utilizing the built-in HTTP and TCP/IP stacks. The stand-alone services can be run on port 80 thereby providing Web server capabilities restricted to SOAP RPC.

To create a stand-alone service, only the main routine of the service needs to be modified as follows. Instead of just calling the `soap_serve` routine, the main routine is changed into:

```
int main()
{
    struct soap soap;
    int m, s; // master and slave sockets
    soap_init(&soap);
    m = soap_bind(&soap, "machine.cs.fsu.edu", 18083, 100);
    if (m < 0)
        soap_print_fault(&soap, stderr);
    else
    {
```

```

fprintf(stderr, "Socket connection successful: master socket = %d\n", m);
for (int i = 1; ; i++)
{
    s = soap_accept(&soap);
    if (s < 0)
    {
        soap_print_fault(&soap, stderr);
        break;
    }
    fprintf(stderr, "%d: accepted connection from IP=%d.%d.%d.%d socket=%d", i,
        (soap.ip<<24)&0xFF, (soap.ip<<16)&0xFF, (soap.ip<<8)&0xFF, soap.ip&0xFF, s);
    soap_serve(&soap); // process RPC request
    fprintf(stderr, "request served\n");
    soap_destroy(&soap); // clean up class instances
    soap_end(&soap); // clean up everything and close socket
}
}
soap_done(&soap); // close master socket
}

```

The gSOAP functions that can be used are:

Function	Description
<code>soap_init(struct soap *soap)</code>	Initializes gSOAP runtime environment (required once)
<code>soap_bind(struct soap *soap, char *host, int port, int backlog)</code>	Returns master socket (backlog = max. queue size for requests). When <code>host==NULL</code> : host is the machine on which the service runs
<code>soap_accept(struct soap *soap)</code>	Returns slave socket
<code>soap_end(struct soap *soap)</code>	Clean up deserialized data (except class instances) and temporary data
<code>soap_free(struct soap *soap)</code>	Clean up temporary data only
<code>soap_destroy(struct soap *soap)</code>	Clean up deserialized class instances
<code>soap_done(struct soap *soap)</code>	Reset: close master/slave sockets and remove call-backs (see Section 13.7)

The *host* name in `soap_bind` may be `NULL` to indicate that the current host should be used.

The `soap.accept_timeout` attribute of the gSOAP run-time environment specifies the timeout value for a non-blocking `soap_accept(&soap)` call. See Section 13.14 for more details on timeout management.

See Section 7.11 for more details on memory management.

A client application connects to this stand-alone service with the endpoint `machine.cs.fsu.edu:18083`. A client may use the `http://` prefix. When absent, no HTTP header is send and no HTTP-based information will be communicated to the service.

6.2.3 How to Create a Multi-Threaded Stand-Alone Service

Multi-threading a Web Service is essential when the response times for handling requests by the service are (potentially) long or when keep-alive is enabled, see Section 13.9. In case of long response

times, the latencies introduced by the unrelated requests may become prohibitive for a successful deployment of a stand-alone service. When HTTP keep-alive is enabled, a client may not close the socket on time, thereby preventing other clients from connecting.

gSOAP 2.0 and higher is thread safe and supports the implementation of multi-threaded stand-alone services in which a thread is used to handle a request.

Here is an example of a multi-threaded Web Service:

```
#include "soapH.h"
#include <pthread.h>
#define BACKLOG (100) // Max. request backlog
#define MAX_THR (8) // Max. threads to serve requests
int main(int argc, char **argv)
{
    struct soap soap;
    soap_init(&soap);
    if (argc < 3) // no args: assume this is a CGI application
    {
        soap_serve(&soap); // serve request, one thread, CGI style
        soap_end(&soap); // cleanup
    }
    else
    {
        struct soap *soap_thr[MAX_THR]; // each thread needs a runtime environment
        pthread_t tid[MAX_THR];
        char *host = argv[1];
        int port = atoi(argv[2]);
        int m, s, i;
        m = soap_bind(&soap, host, port, BACKLOG);
        if (m < 0)
            exit(1);
        fprintf(stderr, "Socket connection successful %d\n", m);
        for (i = 0; i < MAX_THR; i++)
            soap_thr[i] = NULL;
        for (;;)
        {
            for (i = 0; i < MAX_THR; i++)
            {
                s = soap_accept(&soap);
                if (s < 0)
                    break;
                fprintf(stderr, "Thread %d accepts socket %d connection from IP %d.%d.%d.%d\n",
                    i, s, (soap.ip>>24)&0xFF, (soap.ip>>16)&0xFF, (soap.ip>>8)&0xFF, soap.ip&0xFF);
                if (!soap_thr[i]) // first time around
                {
                    soap_thr[i] = soap_new();
                    if (!soap_thr[i])
                        exit(1); // could not allocate
                }
                else // recycle soap environment
                {
                    pthread_join(tid[i], NULL);
                    fprintf(stderr, "Thread %d completed\n", i);
                }
            }
        }
    }
}
```

```

        soap_end(soap_thr[i]); // deallocate data of old thread
    }
    soap_thr[i]->socket = s;
    pthread_create(&tid[i], NULL, (void*)(*)(void*))soap_serve, (void*)soap_thr[i]);
}
}
}
return 0;
}

```

The example illustrates the use of threads to improve the quality of service by handling new requests in separate threads. Each thread needs a separate runtime environment. The example above requires threads to synchronize at some point, so runaway processes can be halted (not shown in the code). The next example detaches threads. No attempt is made to synchronize threads.

```

#include "soapH.h"
#include <pthread.h>
#define BACKLOG (100) // Max. request backlog
int main(int argc, char **argv)
{
    struct soap soap;
    soap_init(&soap);
    if (argc < 3) // no args: assume this is a CGI application
    {
        soap_serve(&soap); // serve request, one thread, CGI style
        soap_end(&soap); // cleanup
    }
    else
    {
        void *process_request(void*);
        struct soap *tsoap;
        pthread_t tid;
        char *host = argv[1];
        int port = atoi(argv[2]);
        int m, s;
        m = soap_bind(&soap, host, port, BACKLOG);
        if (m < 0)
            exit(1);
        fprintf(stderr, "Socket connection successful %d\n", m);
        for (;;)
        {
            s = soap_accept(&soap);
            if (s < 0)
                break;
            fprintf(stderr, "Thread %d accepts socket %d connection from IP %d.%d.%d.%d\n",
i, s, (soap.ip>>24)&0xFF, (soap.ip>>16)&0xFF, (soap.ip>>8)&0xFF, soap.ip&0xFF);
            tsoap = soap_copy(&soap); // make a safe copy
            if (!tsoap)
                break;
            pthread_create(&tid, NULL, (void*)(*)(void*))process_request, (void*)tsoap);
        }
    }
    return 0;
}

```



```

}
void *process_request(void *soap)
{
    pthread_detach(pthread_self());
    soap_serve((struct soap*)soap);
    soap_end((struct soap*)soap);
    free(soap);
    return NULL;
}

```

The following functions can be used to setup a gSOAP runtime environment (**struct** soap):

Function	Description
soap_init(struct soap *soap)	Initializes a runtime environment (required only once)
struct soap *soap_new()	Allocates, initializes, and returns a pointer to a runtime environment
struct soap *soap_copy(struct soap *soap)	Allocates a new runtime environment and copies contents of the argument environment such that the new environment does not share data with the argument environment
soap_done(struct soap *soap)	Reset, close communications, and remove callbacks

A new environment is required for each new thread to guarantee exclusive access to runtime environments by threads.

For clean termination of the server, the master socket can be closed and callbacks removed with soap_done(**struct** soap *soap).

6.2.4 Some Web Service Implementation Issues

The same client header file specification issues apply to the specification and implementation of a SOAP Web service. Refer to

- 6.1.2 for namespace considerations.
- 6.1.5 for an explanation on how to change the encoding of the primitive types.
- 6.1.7 for a discussion on how the response element format can be controlled.
- 6.1.9 for details on how to pass multiple output parameters from a remote method.
- 6.1.11 for passing complex data types as output parameters.
- 6.1.13 for anonymizing the input and output parameter names.

6.2.5 How to Generate WSDL Service Descriptions

The gSOAP stub and skeleton compiler soapcpp2 generates WSDL (Web Service Description Language) service descriptions and XML schema files when processing a header file. The compiler produces one WSDL file for a set of remote methods. The names of the function prototypes of the remote methods must use the same namespace prefix and the namespace prefix is used to name the

WSDL file. If multiple namespace prefixes are used to define remote methods, multiple WSDL files will be created and each file describes the set of remote methods belonging to a namespace prefix. In addition to the generation of the `ns.wsdl` file, a file with a namespace mapping table is generated by the gSOAP compiler. An example mapping table is shown below:

```
struct Namespace namespaces[] =
{
    {"SOAP-ENV", "http://schemas.xmlsoap.org/soap/envelope/"},
    {"SOAP-ENC", "http://schemas.xmlsoap.org/soap/encoding/"},
    {"xsi", "http://www.w3.org/2001/XMLSchema-instance", "http://www.w3.org/*/XMLSchema-
instance"},
    {"xsd", "http://www.w3.org/2001/XMLSchema", "http://www.w3.org/*/XMLSchema"},
    {"ns", "http://tempuri.org"},
    {NULL, NULL}
};
```

This file can be incorporated in the client/service application, see Section 8.4 for details on namespace mapping tables.

To deploy a Web service, copy the compiled CGI service application to the designated CGI directory of your Web server. Make sure the proper file permissions are set (`chmod 755 calc.cgi` for Unix/Linux). You can then publish the WSDL file on the Web by placing it in the appropriate Web server directory.

The gSOAP compiler also generates XML schema files for all C/C++ complex types (e.g. **structs** and **classes**) when declared with a namespace prefix. These files are named `ns.xsd`, where `ns` is the namespace prefix used in the declaration of the complex type. The XML schema files do not have to be published as the WSDL file already contains the appropriate XML schema definitions.

6.2.6 Example

For example, suppose the following methods are defined in the header file:

```
typedef double xsd_double;
int ns_add(xsd_double a, xsd_double b, xsd_double &result);
int ns_sub(xsd_double a, xsd_double b, xsd_double &result);
int ns_sqrt(xsd_double a, xsd_double &result);
```

Then, one WSDL file will be created with the file name `ns.wsdl` that describes all three remote methods:

```
<?xml version="1.0" encoding="UTF-8"?>
<definitions name="Service"
  xmlns="http://schemas.xmlsoap.org/wsdl/"
  targetNamespace="http://location/Service.wsdl"
  xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
  xmlns:SOAP-ENC="http://schemas.xmlsoap.org/soap/encoding/"
  xmlns:SOAP="http://schemas.xmlsoap.org/wsdl/soap/"
  xmlns:WSDL="http://schemas.xmlsoap.org/wsdl/"
  xmlns:xsd="http://www.w3.org/2000/10/XMLSchema"
```

```

    xmlns:tns="http://location/Service.wsdl"
    xmlns:ns="http://tempuri.org">
<types>
  <schema
    xmlns="http://www.w3.org/2000/10/XMLSchema"
    targetNamespace="http://tempuri.org"
    xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
    xmlns:SOAP-ENC="http://schemas.xmlsoap.org/soap/encoding/">
    <complexType name="addResponse">
      <all>
        <element name="result" type="double" minOccurs="0" maxOccurs="1"/>
      </all>
      <anyAttribute namespace="##other"/>
    </complexType>
    <complexType name="subResponse">
      <all>
        <element name="result" type="double" minOccurs="0" maxOccurs="1"/>
      </all>
      <anyAttribute namespace="##other"/>
    </complexType>
    <complexType name="sqrtResponse">
      <all>
        <element name="result" type="double" minOccurs="0" maxOccurs="1"/>
      </all>
      <anyAttribute namespace="##other"/>
    </complexType>
  </schema>
</types>
<message name="addRequest">
  <part name="a" type="xsd:double"/>
  <part name="b" type="xsd:double"/>
</message>
<message name="addResponse">
  <part name="result" type="xsd:double"/>
</message>
<message name="subRequest">
  <part name="a" type="xsd:double"/>
  <part name="b" type="xsd:double"/>
</message>
<message name="subResponse">
  <part name="result" type="xsd:double"/>
</message>
<message name="sqrtRequest">
  <part name="a" type="xsd:double"/>
</message>
<message name="sqrtResponse">
  <part name="result" type="xsd:double"/>
</message>
<portType name="ServicePortType">
  <operation name="add">
    <input message="tns:addRequest"/>
    <output message="tns:addResponse"/>
  </operation>

```

```

    <operation name="sub">
      <input message="tns:subRequest"/>
      <output message="tns:subResponse"/>
    </operation>
    <operation name="sqrt">
      <input message="tns:sqrtRequest"/>
      <output message="tns:sqrtResponse"/>
    </operation>
  </portType>
  <binding name="ServiceBinding" type="tns:ServicePortType">
    <SOAP:binding style="rpc" transport="http://schemas.xmlsoap.org/soap/http"/>
    <operation name="add">
      <SOAP:operation soapAction="http://tempuri.org#add"/>
      <input>
        <SOAP:body use="encoded" namespace="http://tempuri.org"
          encodingStyle="http://schemas.xmlsoap.org/soap/encoding"/>
      </input>
      <output>
        <SOAP:body use="encoded" namespace="http://tempuri.org"
          encodingStyle="http://schemas.xmlsoap.org/soap/encoding"/>
      </output>
    </operation>
    <operation name="sub">
      <SOAP:operation soapAction="http://tempuri.org#sub"/>
      <input>
        <SOAP:body use="encoded" namespace="http://tempuri.org"
          encodingStyle="http://schemas.xmlsoap.org/soap/encoding"/>
      </input>
      <output>
        <SOAP:body use="encoded" namespace="http://tempuri.org"
          encodingStyle="http://schemas.xmlsoap.org/soap/encoding"/>
      </output>
    </operation>
    <operation name="sqrt">
      <SOAP:operation soapAction="http://tempuri.org#sqrt"/>
      <input>
        <SOAP:body use="encoded" namespace="http://tempuri.org"
          encodingStyle="http://schemas.xmlsoap.org/soap/encoding"/>
      </input>
      <output>
        <SOAP:body use="encoded" namespace="http://tempuri.org"
          encodingStyle="http://schemas.xmlsoap.org/soap/encoding"/>
      </output>
    </operation>
  </binding>
  <service name="Service">
    <port name="ServicePort" binding="tns:ServiceBinding">
      <SOAP:address location="http://location/Service.cgi"/>
    </port>
  </service>
</definitions>

```

6.2.7 How to Import WSDL Service Descriptions

Note: see README.txt in the wsdlcpp directory for installation instructions for the importer.

The creation of SOAP Web Service clients from a WSDL service description is a two-step process.

First, execute `java wsdlcpp file.wsdl` which generates the a header file `file.h` and a C-source file `file.c` with an example client program template. Modify the client program template to your needs. Use `java wsdlcpp -c file.wsdl` to generate C-only code.

Second, the header file `file.h` is to be processed by the gSOAP compiler by executing `soapcpp2 file.h`. This creates the C/C++ source files to build a client application, see 6.1. In addition, this generates a client proxy object declared in `soapServiceProxy.h`, where `Service` is the name of the service defined in the WSDL. To use this object, include the `soapServiceProxy.h` and `Service.nsmmap` files in your C++ client application. The `Service` class provides the remote Web service methods as class members.

6.2.8 How to Use Client Functionalities Within a Service

A gSOAP service may make client calls to other services from within its remove methods. This is best illustrated with an example. The following example is a more sophisticated example that combines the functionality of two Web services into one new SOAP Web service. The service provides a currency-converted stock quote. To serve a request, the service in turn requests the stock quote and the currency-exchange rate from two XMethods services.

In addition to being a client of two XMethods services, this service application can also be used as a client of itself to test the implementation. As a client invoked from the command-line, it will return a currency-converted stock quote by connecting to a copy of itself installed as a CGI application on the Web to retrieve the quote after which it will print the quote on the terminal.

The header file input to the gSOAP compiler is given below:

```
// Contents of file "quotex.h":
int ns1_ _getQuote(char *symbol, float &result); // XMethods delayed stock quote service remote
method
int ns2_ _getRate(char *country1, char *country2, float &result); // XMethods currency-exchange
service remote method
int ns3_ _getQuote(char *symbol, char *country, float &result); // the new currency-converted
stock quote service
```

The quotex.cpp client/service application source is:

```
// Contents of file "quotex.cpp":
#include "soapH.h" // include generated proxy and SOAP support
int main(int argc, char **argv)
{
    struct soap soap;
    float q;
    soap_init(&soap);
    if (argc != 2)
        soap_serve();
    else if (soap_call_ns3_ _getQuote(&soap, "http://www.cs.fsu.edu/~engelen/quotex.cgi",
    NULL, argv[1], argv[2], q))
```

```

        soap_print_fault(&soap, stderr);
    else
        printf("\nCompany %s: %f (%s)\n", argv[1], q, argv[2]);
    return 0;
}
int ns3_.getQuote(struct soap *soap, char *symbol, char *country, float &result)
{
    float q, r;
    if (soap_call_ns1_.getQuote(soap, "http://services.xmethods.net/soap", NULL, symbol, q)
    == 0 &&
        soap_call_ns2_.getRate(soap, "http://services.xmethods.net/soap", NULL, "us", coun-
    try, r) == 0)
    {
        result = q*r;
        return SOAP_OK;
    }
    else
        return SOAP_FAULT; // pass soap fault messages on to the client of this app
}
/* Since this app is a combined client-server, it is put together with
one header file that describes all remote methods. However, as a consequence we
have to implement the methods that are not ours. Since these implementations are
never called (this code is client-side), we can make them dummies as below.
/
int ns1_.getQuote(struct soap *soap, char *symbol, float &result)
{ return SOAP_NO_METHOD; } // dummy: will never be called
int ns2_.getRate(struct soap *soap, char *country1, char *country2, float &result)
{ return SOAP_NO_METHOD; } // dummy: will never be called

struct Namespace namespaces[] =
{
    {"SOAP-ENV", "http://schemas.xmlsoap.org/soap/envelope/"},
    {"SOAP-ENC", "http://schemas.xmlsoap.org/soap/encoding/"},
    {"xsi", "http://www.w3.org/2001/XMLSchema-instance", "http://www.w3.org/XMLSchema-
instance"},
    {"xsd", "http://www.w3.org/2001/XMLSchema", "http://www.w3.org/XMLSchema"},
    {"ns1", "urn:xmethods-delayed-quotes"},
    {"ns2", "urn:xmethods-CurrencyExchange"},
    {"ns3", "urn:quotex"},
    {NULL, NULL}
};
};

```

To compile:

```

soapcpp2 quotex.h
g++ -o quotex.cgi quotex.cpp soapC.cpp soapClient.cpp soapServer.cpp stdsoap2.cpp -lsocket -lnet
-lnsl

```

Note: under Linux and Mac OS X you can often omit the `-l` libraries.

The `quotex.cgi` executable is installed as a CGI application on the Web by copying it in the designated directory specific to your Web server. After this, the executable can also serve to test the service. For example

quotex.cgi AOL uk

returns the quote of AOL in uk pounds by communicating the request and response quote from the CGI application. See <http://xmethods.com/detail.html?id=5> for details on the currency abbreviations.

When combining clients and service functionalities, it is required to use one header file input to the compiler. As a consequence, however, stubs and skeletons are available for **all** remote methods, while the client part will only use the stubs and the service part will use the skeletons. Thus, dummy implementations of the unused remote methods need to be given which are never called.

Three WSDL files are created by gSOAP: `ns1.wsdl`, `ns2.wsdl`, and `ns3.wsdl`. Only the `ns3.wsdl` file is required to be published as it contains the description of the combined service, while the others are generated as a side-effect (and in case you want to develop these separate services).

6.3 How to Use gSOAP for Asynchronous One-Way Message Passing

SOAP RPC client-server interaction is synchronous: the client blocks until the server responds to the request. gSOAP also supports asynchronous one-way message passing. SOAP messaging routines are declared as function prototypes, just like remote methods for SOAP RPC. However, the output parameter is a **void** type to indicate the absence of a return value.

For example, the following header file specifies a event message for SOAP messaging:

```
int ns_._event(int eventNo, void dummy);
```

The gSOAP stub and skeleton compiler generates the following functions in `soapClient.cpp`:

```
int soap_send_ns_._event(struct soap *soap, const char URL, const char action, int event);  
int soap_rcv_ns_._event(struct soap *soap, struct ns_._event *dummy);
```

The `soap_send_ns_._event` function transmits the message to the destination URL by opening a socket and sending the SOAP encoded message. The socket will remain open after the send and has to be closed with `soap_closesock()`. The open socket connection can also be used to obtain a service response, e.g. with a `soap_rcv` function call.

The `soap_rcv_ns_._event` function waits for a SOAP message on the currently open socket (`soap.socket`) and fills the **struct** `ns_._event` with the `ns_._event` parameters (e.g. **int** `eventNo`). The **struct** `ns_._event` is automatically created by gSOAP and is a mirror image of the `ns_._event` parameters:

```
struct ns_._event  
{ int eventNo;  
}
```

The gSOAP generated `soapServer.cpp` code includes a skeleton routine to accept the message. (The skeleton routine does not respond with a SOAP response message.)

```
int soap_serve_ns_._event(struct soap *soap);
```

The skeleton routine calls the user-implemented `ns__event(struct soap *soap, int eventNo)` routine (note the absence of the void parameter!).

As usual, the skeleton will be automatically called by the remote method request dispatcher that handles both the remote method requests (RPCs) and messages:

```
main()
{ soap_serve(soap_new());
}
int ns__event(struct soap *soap, int eventNo)
{
    ... // handle event
    return SOAP_OK;
}
```

6.4 How to Use the SOAP Serializers and Deserializers to Save and Load Application Data

The gSOAP stub and skeleton compiler generates serializers and deserializers for all user-defined data structures that are specified in the header file input to the compiler. The serializers and deserializers can be found in the generated `soapC.cpp` file. These serializers and deserializers can be used separately by an application without the need to build a full client or service application. This is useful for applications that need to save or export their data in XML or need to import or load data stored in XML format.

The following attributes can be set to control the destination and source for serialization and deserialization:

Variable	Description
<code>soap.socket</code>	socket file descriptor for input and output or -1
<code>soap.sendfd</code>	when <code>soap_socket<0</code> this is the file descriptor for send operations
<code>soap.rcvfd</code>	when <code>soap_socket<0</code> this is the file descriptor for receive operations

The following initializing and finalizing functions can be used:

Function	Description
void <code>soap_begin_send(struct soap*)</code>	start a send/write phase
int <code>soap_end_send(struct soap*)</code>	flush the buffer
int <code>soap_begin_recv(struct soap*)</code>	start a rec/read phase (if an HTTP header is present, parse it first)
int <code>soap_end_recv(struct soap*)</code>	perform a id/href consistency check on deserialized data

See also Section 7.10 to control the I/O buffering and content encoding such as compression and DIME encoding with flags.

6.4.1 Serializing a Data Type

To serialize a data type, two functions need to be called to process the data. The first function (`soap_serialize`) analyzes pointers and determines if multi-references are required to encode the data and if the data contains cycles. The second function (`soap_put`) generates the SOAP encoding output for that data type.

The function names are specific to a data type. For example, `soap_serialize_float(&soap, &d)` is called to serialize an **float** value and `soap_put_float(&soap, &d, "number", NULL)` is called to output the floating point value in SOAP tagged with the name `<number>`. To initialize data, the `soap_default` function of a data type can be used. For example, `soap_default_float(&soap, &d)` initializes the float to 0.0. The `soap_default` functions are useful to initialize complex data types such as arrays, **structs**, and **class** instances. Note that the `soap_default` functions do not need the gSOAP runtime environment as a first parameter.

The following table lists the type naming conventions used:

Type	Type Name
char*	string
wchar_t*	wstring
char	byte
bool	bool
double	double
int	int
float	float
long	long
LONG64	LONG64 (Win32)
long long	LONG64 (Unix/Linux)
short	short
time_t	time
unsigned char	unsignedByte
unsigned int	unsignedInt
unsigned long	unsignedLong
ULONG64	unsignedLONG64 (Win32)
unsigned long long	unsignedLONG64 (Unix/Linux)
unsigned short	unsignedShort
<u>T</u>[<u>N</u>]	Array <u>N</u> Of <u>Type</u> where <u>Type</u> is the type name of <u>T</u>
<u>T</u>*	PointerTo <u>Type</u> where <u>Type</u> is the type name of <u>T</u>
struct Name	Name
class Name	Name
enum Name	Name

Consider for example the following declaration of `p` as a pointer to a **struct** `ns._Person`:

```
struct ns._Person { char *name; } *p;
```

To serialize `p`, its address is passed to the function `soap_serialize_PointerTons._Person` generated for this type by the gSOAP compiler:

```
soap_serialize_PointerTons._Person(&soap, &p);
```

The **address of** `p` is passed, so the serializer can determine whether `p` was already serialized and to discover cycles in graph data structures. To generate the output, the address of `p` is passed to the function `soap_put_PointerTons._Person` together with the name of an XML element and an optional type string (to omit a type, use `NULL`):

```
soap_put_PointerTons._Person(&soap, &p, "ns:element-name", "ns:type-name");
```

This produces:

```

<ns:element-name xmlns:SOAP-ENV="..." xmlns:SOAP-ENC="..." xmlns:ns="..."
... xsi:type="ns:type-name">
<name xsi:type="xsd:string">...</name>
</ns:element-name>

```

The serializer is initialized with the `soap_begin` function. All temporary data structures and data structures deserialized on the heap are destroyed with the `soap_end()` function. The `soap_free()` function can be used to remove the temporary data only and keep the deserialized data on the heap. Temporary data structures are only created if the encoded data uses pointers. Each pointer in the encoded data has an internal hash table entry to determine all multi-reference parts and cyclic parts of the complete data structure.

If more than one data structure is to be serialized and parts of those data structures are shared through pointers, then the `soap_serialize` functions **MUST** to be called first before any of the `soap_put` functions. This is necessary to ensure that multi-reference data shared by the data structures is encoded as multi-reference.

For example, to encode the contents of two variables `var1` and `var2` the serializers are called before the output routines:

```

T1 var1;
T2 var2;
struct soap soap;
...
soap_init(&soap); // initialize
[soap_omode(&soap, flags);] // set output-mode flags
soap_begin(&soap); // start new (de)serialization phase
soap_set_omode(&soap, SOAP_XML_GRAPH);
soap_serialize_Type1(&soap, &var1);
soap_serialize_Type2(&soap, &var2);
...
[soap.socket = a_socket_file_descriptor;]
[soap.sendfd = an_output_file_descriptor;]
soap_begin_send(&soap);
soap_put_Type1(&soap, &var1, "[namespace-prefix:]element-name1", "[namespace-prefix:]type-name1");
soap_put_Type2(&soap, &var2, "[namespace-prefix:]element-name2", "[namespace-prefix:]type-name2");
...
soap_end_send(&soap); // flush
soap_end(&soap); // remove temporary data structures after phase
soap_done(&soap); // finalize last use of this environment
...

```

where `Type1` is the type name of `T1` and `Type2` is the type name of `T2` (see table above). The strings `[namespace-prefix:]type-name1` and `[namespace-prefix:]type-name2` describe the schema types of the elements. Use `NULL` to omit this type information. The output stream is set by the assignment to `soap.sendfd`.

For serializing class instances, method invocations **MUST** be used instead of function calls, for example `var.soap_serialize(&soap)` and `var.soap_put(&soap, "elt", "type")`. This ensures that the proper serializers are used for serializing instances of derived classes.

In principle, encoding **MAY** take place without calling the `soap_serialize` functions. However, as the following example demonstrates the resulting encoding is not SOAP 1.1 compliant. However, the

messages can still be used with gSOAP to save and restore data.

Consider the following **struct**:

```
// Contents of file "tricky.h":
struct Tricky
{
    int *p;
    int n;
    int *q;
};
```

The following fragment initializes the pointer fields **p** and **q** to the value of field **n**:

```
struct soap soap;
struct Tricky X;
X.n = 1;
X.p = &X.n;
X.q = &X.n;
soap_init(&soap);
soap_begin(&soap);
soap_serialize_Tricky(&soap, &X);
soap_put_Tricky(&soap, &X, "Tricky", NULL);
soap_end(&soap); // Clean up temporary data used by the serializer
```

The resulting output is:

```
<Tricky xsi:type="Tricky">
<p href="#2"/> <n xsi:type="int">1</n> <q href="#2"/> <r xsi:type="int">2</r> </Tricky>
<id id="2" xsi:type="int">1</id>
```

which uses an independent element at the end to represent the multi-referenced integer.

To preserve the exact structure of the data, use the `SOAP_XML_GRAPH` flag to serialize the data in XML (see Section 7.10) to serialize multi-referenced data embedded in the structure which assures the preservation of structure but is not SOAP 1.1 compliant. For example, the resulting output is:

```
<Tricky xsi:type="Tricky">
<p href="#2"/> <n id="2" xsi:type="int">1</n> <q href="#2"/> </Tricky>
```

In this case, the XML is self-contained and multi-referenced data is accurately serialized. The gSOAP generated deserializer for this data type will be able to accurately reconstruct the data from the XML (on the heap).

6.4.2 Deserializing a Data Type

To deserialize a data type, its `soap_get` function is used. The outline of a program that deserializes two variables `var1` and `var2` is for example:

```
T1 var1;
T2 var2;
```

```

struct soap soap;
...
soap_init(&soap); // initialize at least once
[soap_imode(&soap, flags);] // set input-mode flags
soap_begin(&soap); // begin new decoding phase
[soap_recvfd = an_input_stream;]
soap_begin_recv(&soap); // if HTTP header is present, parse it
soap_get_Type1(&soap, &var1, "[namespace-prefix:]element-name1", "[namespace-prefix:]type-name1");
soap_get_Type2(&soap, &var2, "[namespace-prefix:]element-name2", "[namespace-prefix:]type-name1");
...
soap_end_recv(&soap); // check consistency of id/hrefs
soap_destroy(&soap); // remove deserialized class instances
soap_end(&soap); // remove temporary data, including the decoded data on the heap
soap_done(&soap); // finalize last use of the environment

```

The strings `[namespace-prefix:]type-name1` and `[namespace-prefix:]type-name2` are the schema types of the elements and should match the `xsi:type` attribute of the receiving message. To omit the match, use `NULL` as the type. For class instances, method invocation can be used instead of a function call if the object is already instantiated, i.e. `var.soap_get(&soap, "...", "...")`.

The `soap_begin` call resets the deserializers. The `soap_destroy` and `soap_end` calls remove the temporary data structures **and** the decoded data that was placed on the heap.

To remove temporary data while retaining the deserialized data on the heap, the function `soap_free` should be called instead of `soap_destroy` and `soap_end`.

6.4.3 Example

As an example, consider the following data type declarations:

```

// Contents of file "person.h":
typedef char *xsd_ _string;
typedef char *xsd_ _Name;
typedef unsigned int xsd_ _unsignedInt;
enum ns_ _Gender {male, female};
class ns_ _Address
{
    public:
    xsd_ _string street;
    xsd_ _unsignedInt number;
    xsd_ _string city;
};
class ns_ _Person
{
    public:
    xsd_ _Name name;
    enum ns_ _Gender gender;
    ns_ _Address address;
    ns_ _Person *mother;
    ns_ _Person *father;
};

```

The following program uses these data types to write to standard output a data structure that contains the data of a person named "John" living at Dowling st. 10 in London. He has a mother "Mary" and a father "Stuart". After initialization, the class instance for "John" is serialized and encoded in XML to the standard output stream using Zlib-compression:

```
// Contents of file "person.cpp":
#include "soapH.h"
int main()
{
    struct soap soap;
    ns_1Person mother, father, john;
    mother.name = "Mary";
    mother.gender = female;
    mother.address.street = "Dowling st.";
    mother.address.number = 10;
    mother.address.city = "London";
    mother.mother = NULL;
    mother.father = NULL;
    father.name = "Stuart";
    father.gender = male;
    father.address.street = "Main st.";
    father.address.number = 5;
    father.address.city = "London";
    father.mother = NULL;
    father.father = NULL;
    john.name = "John";
    john.gender = male;
    john.address = mother.address;
    john.mother = &mother;
    john.father = &father;
    soap_init(&soap);
    soap_omode(&soap, SOAP_ENC_ZLIB|SOAP_XML_GRAPH); // see 7.10
    soap_begin(&soap);
    soap_begin_send(&soap);
    john.soap_serialize(&soap);
    john.soap_put(&soap, "johnnie", NULL);
    soap_end_send(&soap);
    soap_end(&soap);
    soap_done(&soap);
}
struct Namespace namespaces[] =
{
    {"SOAP-ENV", "http://schemas.xmlsoap.org/soap/envelope/"},
    {"SOAP-ENC", "http://schemas.xmlsoap.org/soap/encoding/"},
    {"xsi", "http://www.w3.org/1999/XMLSchema-instance"},
    {"xsd", "http://www.w3.org/1999/XMLSchema"},
    {"ns", "urn:person"}, // Namespace URI of the "Person" data type
    {NULL, NULL}
};
```

The header file is processed and the application compiled on Linux/Unix with:

```
soapcpp2 person.h
g++ -DWITH_ZLIB -o person person.cpp soapC.cpp stdsoap2.cpp -lsocket -lnet -lnsl -lzlib
```

(Depending on your system configuration, the libraries libsocket.a, libxnet.a, libnsl.a are required. Compiling on Linux typically does not require the inclusion of those libraries.) See 13.19 for details in Zlib compression with gSOAP.

Running the person application results in the compressed XML output:

```
<johnnie xsi:type="ns:Person" xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
  xmlns:SOAP-ENC="http://schemas.xmlsoap.org/soap/encoding/"
  xmlns:xsi="http://www.w3.org/1999/XMLSchema-instance"
  xmlns:xsd="http://www.w3.org/1999/XMLSchema"
  xmlns:ns="urn:person"
  SOAP-ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
<name xsi:type="xsd:Name">John</name>
<gender xsi:type="ns:Gender">male</gender>
<address xsi:type="ns:Address">
<street id="3" xsi:type="xsd:string">Dowling st.</street>
<number xsi:type="unsignedInt">10</number>
<city id="4" xsi:type="xsd:string">London</city>
</address>
<mother xsi:type="ns:Person">
<name xsi:type="xsd:Name">Mary</name>
<gender xsi:type="ns:Gender">female</gender>
<address xsi:type="ns:Address">
<street href="#3"/>
<number xsi:type="unsignedInt">5</number>
<city href="#4"/>
</address>
</mother>
<father xsi:type="ns:Person">
<name xsi:type="xsd:Name">Stuart</name>
<gender xsi:type="ns:Gender">male</gender>
<address xsi:type="ns:Address">
<street xsi:type="xsd:string">Main st.</street>
<number xsi:type="unsignedInt">13</number>
<city href="#4"/>
</address>
</father>
</johnnie>
```

The following program fragment decodes this content from standard input and reconstructs the original data structure on the heap:

```
#include "soapH.h"
int main()
{
  struct soap soap;
  ns__Person *mother, *father, *john = NULL;
  soap_init(&soap);
  soap_imode(&soap, SOAP_ENC_ZLIB);
  soap_begin(&soap);
```

```

    soap_begin_rcv(&soap);
    if (soap_get_ns._Person(&soap, john, "johnnie", NULL))
        ... error ...
    mother = john->mother;
    father = john->father;
    ...
    soap_end_rcv(&soap);
    soap_free(&soap); // Clean up temporary data but keep deserialized data
}
struct Namespace namespaces[] =
{
    {"SOAP-ENV", "http://schemas.xmlsoap.org/soap/envelope/"},
    {"SOAP-ENC", "http://schemas.xmlsoap.org/soap/encoding/"},
    {"xsi", "http://www.w3.org/1999/XMLSchema-instance"},
    {"xsd", "http://www.w3.org/1999/XMLSchema"},
    {"ns", "urn:person"}, // Namespace URI of the "Person" data type
    {NULL, NULL}
};

```

It is REQUIRED to either pass NULL to the soap_get routine, or a valid pointer to a data structure that can hold the decoded content. The following example explicitly passes NULL:

```
john = soap_get_ns._Person(&soap, NULL, "johnnie", NULL);
```

Note: the second NULL parameter indicates that the schema type attribute of the receiving message can be ignored. The deserializer stores the SOAP contents on the heap, and returns the address. The allocated storage is released with the soap_end call, which removes all temporary and deserialized data from the heap, or with the soap_free call, which removes all temporary data only.

Alternatively, the XML content can be decoded within an existing allocated data structure. The following program fragment decodes the SOAP content in a **struct** ns._Person allocated on the stack:

```

#include "soapH.h"
main()
{
    struct soap soap;
    ns._Person *mother, *father, john;
    soap_init(&soap);
    soap_imode(&soap, SOAP_ENC_ZLIB);
    soap_begin(&soap);
    soap_begin_rcv(&soap);
    soap_default_ns._Person(&soap, &john);
    if (soap_get_ns._Person(&soap, &john, "johnnie", NULL))
        ... error ...
    ...
}
struct Namespace namespaces[] =
...

```

Note the use of soap_default_ns._Person. This routine is generated by the gSOAP stub and skeleton compiler and assigns default values to the fields of john.

6.4.4 How to Specify Default Values for Omitted Data

The gSOAP compiler generates `soap_default` functions for all data types. The default values of the primitive types can be easily changed by defining any of the following macros in the `stdsoap2.h` file:

```
#define SOAP_DEFAULT_bool
#define SOAP_DEFAULT_byte
#define SOAP_DEFAULT_double
#define SOAP_DEFAULT_float
#define SOAP_DEFAULT_int
#define SOAP_DEFAULT_long
#define SOAP_DEFAULT_LONG64
#define SOAP_DEFAULT_short
#define SOAP_DEFAULT_string
#define SOAP_DEFAULT_time
#define SOAP_DEFAULT_unsignedByte
#define SOAP_DEFAULT_unsignedInt
#define SOAP_DEFAULT_unsignedLong
#define SOAP_DEFAULT_unsignedLONG64
#define SOAP_DEFAULT_unsignedShort
#define SOAP_DEFAULT_wstring
```

Instead of adding these to `stdsoap2.h`, you can also compile with option `-DWITH_USERDEFS_H` and include your definitions in file `userdefs.h`. The absence of a data value in a receiving SOAP message will result in the assignment of a default value to a primitive type upon deserialization.

Default values can also be assigned to individual **struct** and **class** fields of primitive type. For example,

```
struct MyRecord
{
    char *name = "Unknown";
    int value = 9999;
    enum Status { active, passive } status = passive;
}
```

Default values are assigned to the fields on receiving a SOAP/XML message in which the data values are absent.

Because method requests and responses are essentially structs, default values can also be assigned to method parameters. The default parameter values do not control the parameterization of C/C++ function calls, i.e. all actual parameters must be present when calling a function. The default parameter values are used in case an inbound request or response message lacks the XML elements with parameter values. For example, a Web service can use default values to fill-in absent parameters in a SOAP/XML request:

```
int ns_login(char *username = "anonymous", char *password = "guest", bool granted);
```

When the request message lacks username and password parameters, e.g.:

```
<?xml version="1.0" encoding="UTF-8"?>
<SOAP-ENV:Envelope
```



```

xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
xmlns:SOAP-ENC="http://schemas.xmlsoap.org/soap/encoding/"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:ns="http://tempuri.org">
<SOAP-ENV:Body encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
  <ns:login>
  </ns:login>
</SOAP-ENV:Body>
</SOAP-ENV:Envelope>

```

then the service uses the default values. In addition, the default values will show up in the SOAP/XML request and response message examples generated by the gSOAP compiler.

7 Using the gSOAP Stub and Skeleton Compiler

The gSOAP stub and skeleton compiler is invoked from the command line and optionally takes the name of a header file as an argument or, when the file name is absent, parses the standard input:

```
soapcpp2 [aheaderfile.h]
```

where `aheaderfile.h` is a standard C++ header file. The compiler acts as a preprocessor and produces C++ source files that can be used to build SOAP client and Web service applications in C++. The files generated by the compiler are:

File Name	Description
<code>soapH.h</code>	Main header file to be included by all client and service sources
<code>soapC.cpp</code>	Serializers and deserializers for the specified data structures
<code>soapClient.cpp</code>	Client stub routines and proxies for all remote methods
<code>soapServer.cpp</code>	Service skeleton routines
<code>soapStub.h</code>	A modified header file produced from the compiler input header file
<code>.xsd</code>	An <code>ns.xsd</code> file is generated with an XML schema for each namespace prefix <code>ns</code> used by a data structure in the header file input to the compiler, see Section 6.2.5
<code>.wsdl</code>	A <code>ns.wsdl</code> file is generated with an WSDL description for each namespace prefix <code>ns</code> used by a remote method in the header file input to the compiler, see Section 6.2.5
<code>.xml</code>	Several SOAP/XML request and response files are generated. These are example message files are valid provided that sufficient schema namespace directives are added to the header file or the generated <code>.nsmap</code> namespace table for the client/service is not modified by hand
<code>.nsmap</code>	A <code>ns.nsmap</code> file is generated for each namespace prefix <code>ns</code> used by a remote method in the header file input to the compiler, see Section 6.2.5. The file contains a namespace mapping table that can be used in the client/service sources

Both client and service applications are developed from a header file that specifies the remote methods. If client and service applications are developed with the same header file, the applications are guaranteed to be compatible because the stub and skeleton routines use the same serializers and deserializers to encode and decode the parameters. Note that when client and service applications are developed together, an application developer does not need to know the details of the internal SOAP encoding used by the client and service.

The following files are part of the gSOAP package and are required to build client and service applications:

File Name	Description
stdsoap2.h	Header file of stdsoap2.cpp runtime library
stdsoap2.c	Runtime C library with XML parser and run-time support routines
stdsoap2.cpp	Runtime C++ library identical to stdsoap2.c

7.1 Compiler Options

The compiler supports the following options:

Option	Description
-1	Use SOAP 1.1 namespaces and encodings (default)
-2	Use SOAP 1.2 namespaces and encodings
-h	Print a brief usage message
-c	Save files using extension .c instead of .cpp
-i	Interpret #include and #define directives
-m	Generate code that requires array/binary classes to explicitly free malloced array (to be deprecated since soap_unlink should be used to keep specific data)
-d <path>	Save sources in directory specified by <path>
-p <name>	Save sources with file name prefix <name> instead of "soap"

For example

```
soapcpp2 -cd '../projects' -pmy file.h
```

Saves the sources:

```
../projects/myH.h
../projects/myC.c
../projects/myClient.c
../projects/myServer.c
../projects/myStub.h
```

MS Windows users can use the usual "/" for options, for example:

```
soapcpp2 /cd '..\projects' /pmy file.h
```

7.2 SOAP 1.1 Versus SOAP 1.2

gSOAP supports SOAP 1.1 by default. SOAP 1.2 support is automatically turned on when the appropriate SOAP 1.2 namespace is used in the namespace mapping table:

```
struct Namespace namespaces[] =
{
    {"SOAP-ENV", "http://www.w3.org/2002/06/soap-envelope"},
    {"SOAP-ENC", "http://www.w3.org/2002/06/soap-encoding"},
    {"xsi", "http://www.w3.org/2001/XMLSchema-instance", "http://www.w3.org/XMLSchema-instance"},
    {"xsd", "http://www.w3.org/2001/XMLSchema", "http://www.w3.org/XMLSchema"}, ...
}
```

gSOAP Web services and clients can automatically switch from SOAP 1.1 to SOAP 1.2 by providing the SOAP 1.2 namespace as a pattern in the third column of a namespace table:

```
struct Namespace namespaces[] =
{
    {"SOAP-ENV", "http://schemas.xmlsoap.org/soap/envelope/", "http://www.w3.org/2002/06/soap-encoding"},
    {"SOAP-ENC", "http://schemas.xmlsoap.org/soap/encoding/", "http://www.w3.org/2002/06/soap-envelope"},
    {"xsi", "http://www.w3.org/2001/XMLSchema-instance", "http://www.w3.org/*/XMLSchema-instance"},
    {"xsd", "http://www.w3.org/2001/XMLSchema", "http://www.w3.org/*/XMLSchema"}, ...
}
```

This way, gSOAP Web services can respond to either SOAP 1.1 or SOAP 1.2 requests.

The gSOAP soapcpp2 compiler generates a .nsmap file with SOAP-ENV and SOAP-ENC namespace patterns similar to the above. Since clients issue a send first, they will always use SOAP 1.1 for requests when the namespace table is similar as shown above. Clients can accept SOAP 1.2 responses by inspecting the response message. To restrict gSOAP services and clients to SOAP 1.2 and to generate SOAP 1.2 service WSDLs, use soapcpp2 compiler option -2 to generate SOAP 1.2 conformant .nsmap and .wsdl files.

Caution: SOAP 1.2 does not support partially transmitted arrays. So the `_offset` field of a dynamic array is meaningless.

Caution: SOAP 1.2 requires the use of `SOAP_ENV__Code`, `SOAP_ENV__Reason`, and `SOAP_ENV__Detail` fields in a `SOAP_ENV__Fault` fault struct, while SOAP 1.1 uses `faultcode`, `faultstring`, and `detail` fields. Use `soap_receiver_fault(struct soap *soap, const char *faultstring, const char *detail)` to set a SOAP 1.1/1.2 fault at the server-side. Use `soap_sender_fault(struct soap *soap, const char *faultstring, const char *detail)` to set a SOAP 1.1/1.2 unrecoverable Bad Request fault at the server-side.

7.3 The soapdefs.h Header File

The `soapdefs.h` header file is included in `stdsoap2.h` when compiling with option `-DWITH_SOAPDEFS_H`:

```
g++ -DWITH_SOAPDEFS_H -c stdsoap2.cpp
```

The `soapdefs.h` file allows users to include definitions and add includes without requiring changes to `stdsoap2.h`. For example,

```
// Contents of soapdefs.h
#include <ostream>
#define SOAP_BUFLLEN 20480 // use large send/recv buffer
```

The following header file can now refer to `ostream`:

```
extern class ostream; // ostream can't be (de)serialized, but need to be declared to make it visible to gSOAP
class ns__myClass
```

```

{ ...
    virtual void print(ostream &s) const; // need ostream here
    ...
};

```

See also Section 13.4.

7.4 The gSOAP #import Directive

The `#import` directive can be used to include gSOAP header files into other gSOAP header files for processing with `soapcpp2`. The C `#include` directive cannot be used to include gSOAP header files. The `#include` directive is reserved to control the post-gSOAP compilation process, see 7.5.

An example of the `#import` directive:

```

#import "mydefs.gsoap"
int ns._mymethod(xsd._string in, xsd._int *out);

```

where "mydefs.gsoap" is a gSOAP header file that defines `xsd._string` and `xsd._int`:

```

typedef char *xsd._string;
typedef int xsd._int;

```

7.5 How to Use #include and #define Directives

The `#include` and `#define` directives are normally ignored by the gSOAP compiler. The use of the directives is enabled with the `-i` option of the gSOAP compiler, see Section 7.1. However, the gSOAP compiler will not actually parse the contents of the header files provided by the `#include` directives in a header file. Instead, the `#include` and `#define` directives will be added to the generated `soapH.h` header file **before** any other header file is included. Therefore, `#include` and `#define` directives can be used to control the C/C++ compilation process of the sources of an application.

The following example header file refers to `ostream` by including `<ostream>`:

```

#include <ostream>
#define WITH_COOKIES // use HTTP cookie support (you must compile stdsoap2.cpp with -
-DWITH_COOKIES)
#define WITH_OPENSSL // use HTTP OpenSSL support (you must compile stdsoap2.cpp with
-DWITH_OPENSSL)
#define SOAP_DEFAULT_float FLT_NAN // use NaN instead of 0.0
extern class ostream; // ostream can't be (de)serialized, but need to be declared to make it visible
to gSOAP
class ns._myClass
{ ...
    virtual void print(ostream &s) const; // need ostream here
    ...
};

```

This example also uses `#define` directives for various settings.

Caution: Note that the use of `#define` in the header file does not automatically result in compiling `stdsoap2.cpp` with these directives. You **MUST** use the `-DWITH_COOKIES` and `-DWITH_OPENSSL`

options when compiling `stdsoap2.cpp` before linking the object file with your codes. As an alternative, you can use `#define WITH_SOAPDEFS_H` and put the `#define` directives in the `soapdefs.h` file.

7.6 Compiling a gSOAP Client

After invoking the gSOAP stub and skeleton compiler on a header file description of a service, the client application can be compiled on a Linux machine as follows:

```
g++ -o myclient myclient.cpp stdsoap2.cpp soapC.cpp soapClient.cpp
```

Or on a Unix machine:

```
g++ -o myclient myclient.cpp stdsoap2.cpp soapC.cpp soapClient.cpp -lsocket -lnet -lnsl
```

(Depending on your system configuration, the libraries `libsocket.a`, `libxnet.a`, `libnsl.a` or dynamic `*.so` versions of those libraries are required.)

The `myclient.cpp` file must include `soapH.h` and must define a global namespace mapping table. A typical client program layout with namespace mapping table is shown below:

```
// Contents of file "myclient.cpp"
#include "soapH.h";
...
// A remote method invocation:
soap_call_some_remote_method(...);
...
struct Namespace namespaces[] =
{ // {"ns-prefix", "ns-name"}
  {"SOAP-ENV", "http://schemas.xmlsoap.org/soap/envelope/"},
  {"SOAP-ENC", "http://schemas.xmlsoap.org/soap/encoding/"},
  {"xsi", "http://www.w3.org/1999/XMLSchema-instance"},
  {"xsd", "http://www.w3.org/1999/XMLSchema"},
  {"ns1", "urn:my-remote-method"},
  {NULL, NULL}
};
...
```

A mapping table is generated by the gSOAP compiler that can be used in the source, see Section 6.2.5.

7.7 Compiling a gSOAP Web Service

After invoking the gSOAP stub and skeleton compiler on a header file description of the service, the server application can be compiled on a Linux machine as follows:

```
g++ -o myserver myserver.cpp stdsoap2.cpp soapC.cpp soapServer.cpp
```

Or on a Unix machine:

```
g++ -o myserver myserver.cpp stdsoap2.cpp soapC.cpp soapServer.cpp -lsocket -lnet -lnsl
```

(Depending on your system configuration, the libraries libsocket.a, libxnet.a, libnsl.a or dynamic *.so versions of those libraries are required.)

The myserver.cpp file must include soapH.h and must define a global namespace mapping table. A typical service program layout with namespace mapping table is shown below:

```
// Contents of file "myserver.cpp"
#include "soapH.h";
int main()
{
    soap_serve(soap_new());
}
...
// Implementations of the remote methods as C++ functions
...
struct Namespace namespaces[] =
{ // {"ns-prefix", "ns-name"}
  {"SOAP-ENV", "http://schemas.xmlsoap.org/soap/envelope/"},
  {"SOAP-ENC", "http://schemas.xmlsoap.org/soap/encoding/"},
  {"xsi", "http://www.w3.org/1999/XMLSchema-instance"},
  {"xsd", "http://www.w3.org/1999/XMLSchema"},
  {"ns1", "urn:my-remote-method"},
  {NULL, NULL}
};
...
```

When the gSOAP service is compiled and installed as a CGI application, the soap_serve function acts as a service dispatcher. It listens to standard input and invokes the method via a skeleton routine to serve a SOAP client request. After the request is served, the response is encoded in SOAP and send to standard output. The method must be implemented in the server application and the type signature of the method must be identical to the remote method specified in the header file. That is, the function prototype in the header file must be a valid prototype of the method implemented as a C/C++ function.

7.8 Using gSOAP for Creating Web Services and Clients in Pure C

The gSOAP compiler can be used to create pure C Web services and clients. The gSOAP stub and skeleton compiler soapcpp2 generates .cpp files by default. The compiler generates .c files with the -c option. However, these files only use C syntax and data types **if** the header file input to soapcpp2 uses C syntax and data types. For example:

```
soapcpp2 -c quote.h
gcc -o quote quote.c stdsoap2.c soapC.c soapClient.c
```

Warnings will be issued by the compiler when C++ class declarations occur in the header file.

7.9 Limitations of gSOAP

gSOAP is fully SOAP 1.1 (and mostly SOAP 1.2) compliant and supports all SOAP RPC and most SOAP LIT features.

From the perspective of the C/C++ language, a few C++ language features are not supported by gSOAP and these features cannot be used in the specification of SOAP remote methods.

The following C++ language constructs cannot be used by the header file input to the gSOAP stub and skeleton compiler:

Templates The gSOAP stub and skeleton compiler is a preprocessor and cannot predict the template instantiations used by the main program, nor can it generate templated code.

Multiple inheritance Single class inheritance is supported. Multiple inheritance cannot be supported due to limitations of the SOAP protocol.

Abstract methods A class must be instantiatable to allow decoding of instances of the class.

Directives Directives and pragmas such as `#include` and `#define` are interpreted by the gSOAP compiler. However, the interpretation is different compared to the usual handling of directives, see Section 7.5. If necessary, a traditional C++ preprocessor can be used for the interpretation of directives. For example, Unix and Linux users can use “`cpp -B`” to expand the header file, e.g. `cpp -B myfile.h | soapcpp2`. Use the gSOAP `#import` directive to import gSOAP header files, see 7.4.

C and C++ programming statements All class methods of a class should be declared within the class declaration in the header file, but the methods should not be implemented in code. All class method implementations must be defined within another C++ source file and linked to the application.

In addition, the following data types cannot be used in the header file (they can, however be used as a class method return type and as class method parameter types of a class declared in the header file):

union types Because the run-time value of a **union** data type cannot be determined by the compiler, the data type cannot be encoded. An alternative is to use a **struct** with a pointer type for each field. Because NULL pointers are not encoded, the resulting encoding will appear as a union type if only one pointer field is valid (i.e. non-NULL) at the time that the data type is encoded.

void and void* types The **void** data type cannot be encoded. The **void*** data type is typically used to point to some object or to some array of some type of objects at run-time. The compiler cannot determine the type of data pointed to and the size of the array pointed to.

Pointers to sequences of elements in memory Any pointer, except for C strings which are pointers to a sequence of characters, are treated by the compiler as if the pointer points to **only one element in memory** at run-time. Consequently, the encoding and decoding routines will ignore any subsequent elements that follow the first in memory. For the same reason, arrays of undetermined length, e.g. `float a[]` cannot be used. gSOAP supports dynamic arrays using a special type convention, see Section 9.8.

Uninitialized pointers Obviously, all pointers that are part of a data structure must be valid or NULL to enable serialization of the data structure at run time.

There are a number of programming solutions that can be adopted to circumvent these limitations. Instead of using **void***, a program can in some cases be modified to use a pointer to a known type. If the pointer is intended to point to different types of objects, a generic base class can be declared and the pointer is declared to point to the base class. All the other types are declared to be derived classes of this base class. For pointers that point to a sequence of elements in memory dynamic arrays should be used instead, see 9.8.

7.10 Runtime Flags

gSOAP provides flags to control the input and output mode settings at runtime. These flags are divided into four categories: transport (IO), content encoding (ENC), XML marshalling (XML), and C/C++ data mapping (C).

Although gSOAP is fully SOAP 1.1 compliant, some SOAP implementations may have trouble accepting multi-reference data and/or require explicit nil data so these flags can be used to put gSOAP in “safe mode”. In addition, the embedding (or inlining) of multi-reference data is adopted in the SOAP 1.2 specification, which gSOAP automatically supports when handling with SOAP 1.2 messages. The flags are:

Flag	Description
SOAP_IO_FLUSH	Disable buffering and flush output (default for all file-based output)
SOAP_IO_BUFFER	Enable buffering (default for all socket-oriented connections)
SOAP_IO_STORE	Store entire message to calculate HTTP content length
SOAP_IO_CHUNK	Use HTTP chunking
SOAP_IO_LENGTH	Require apriori calculation of content length (this is automatic)
SOAP_IO_KEEPALIVE	Attempt to keep socket connections alive (open)
SOAP_ENC_XML	Use plain XML encoding without HTTP headers
SOAP_ENC_DIME	Use DIME encoding (automatic when DIME attachments are used)
SOAP_ENC_SSL	Encrypt encoding with SSL (automatic with “https:” endpoints)
SOAP_ENC_ZLIB	Compress encoding with Zlib
SOAP_XML_STRICT	XML strict validation (fault on unknown XML elements rather than omitting them)
SOAP_XML_TREE	Serialize data as XML trees (no multi-ref, duplicate data when necessary)
SOAP_XML_GRAPH	Serialize data as an XML graph with inline multi-ref (SOAP 1.2 default)
SOAP_XML_NIL	Serialize NULL data as XML nil elements (omit by default)
SOAP_C_NOIOB	Do not fault with SOAP_IOB when an array is received that does not fit in a fixed-size array
SOAP_C_UTFSTRING	(De)serialize 8-bit strings “as is” (strings MUST have UTF-8 encoded content)

The flags can be selectively turned on/off at any time, for example when multiple Web services are accessed by a client that require special treatment.

All flags are orthogonal, except SOAP_IO_FLUSH, SOAP_IO_BUFFER, SOAP_IO_STORE, and SOAP_IO_CHUNK which are enumerations and only one of these I/O flags can be used. Also the XML serialization flags SOAP_XML_TREE and SOAP_XML_GRAPH should not be mixed.

The flags control the inbound and outbound message transport, encoding, and (de)serialization. The following functions are used to set and reset the flags for input and output modes:

Function	Description
<code>soap_init2(struct soap *soap, int imode, int omode)</code>	Initialize the runtime and set flags
<code>soap_imode(struct soap *soap, int imode)</code>	Set all input mode flags
<code>soap_omode(struct soap *soap, int omode)</code>	Set all output mode flags
<code>soap_set_imode(struct soap *soap, int imode)</code>	Enable input mode flags
<code>soap_set_omode(struct soap *soap, int omode)</code>	Enable output mode flags
<code>soap_clr_imode(struct soap *soap, int imode)</code>	Disable input mode flags
<code>soap_clr_omode(struct soap *soap, int omode)</code>	Disable output mode flags

The default setting is SOAP_IO_DEFAULT for both input and output modes.

In many cases, setting the input mode will have no effect, especially with HTTP transport because gSOAP will determine the optimal input buffering and the encoding used for an inbound message. The flags that do have an effect on handling inbound messages are SOAP_IO_KEEPALIVE, SOAP_ENC_SSL (but automatic when "https:" endpoints are used or `soap_ssl_accept`), SOAP_ENC_ZLIB (but automatic when HTTP transport is used), SOAP_XML_NIL will fault on receiving nil elements for non-nillable data, SOAP_C_NOIOB, and SOAP_C_UTFSTRING.

For example

```

struct soap soap;
soap_init2(&soap, SOAP_IO_KEEPALIVE, SOAP_IO_KEEPALIVE|SOAP_ENC_ZLIB|SOAP_XML_TREE);
if (soap_call_ns_...myMethod(&soap, ...))
...

```

sends a Zlib compressed client request with keep-alive enabled and all data serialized as XML trees.

Caution: The SOAP_XML_TREE serialization flag can be used to improve interoperability with SOAP implementations that are not fully SOAP 1.1 compliant. However, a tree serialization will duplicate data when necessary and will crash the serializer for cyclic data structures.

7.11 Memory Management

Understanding gSOAP's run-time memory management is important to optimize client and service applications by eliminating memory leaks and/or dangling references.

There are two forms of dynamic (heap) allocations made by gSOAP's runtime for serialization and deserialization of data. Temporary data is created by the runtime such as hash tables to keep pointer reference information for serialization and hash tables to keep XML id/href information for multi-reference object deserialization. Deserialized data is created upon receiving SOAP messages. This data is stored on the heap and requires several calls to the `malloc` library function to allocate space for the data and **new** to create class instances. All such allocations are tracked by gSOAP's runtime by linked lists for later deallocation. The linked list for `malloc` allocations uses some extra space in each malloced block to form a chain of pointers through the malloced blocks. A separate malloced linked list is used to keep track of class instance allocations.

gSOAP does not enforce a deallocation policy and the user can adopt a deallocation policy that works best for a particular application. As a consequence, deserialized data is never deallocated by the gSOAP runtime unless the user explicitly forces deallocation by calling functions to deallocate data collectively or individually.

The deallocation functions are:

Function Call	Description
<code>soap_end(struct soap *soap)</code>	Remove temporary data and deserialized data except class instances
<code>soap_free(struct soap *soap)</code>	Remove temporary data only
<code>soap_destroy(struct soap *soap)</code>	Remove all dynamically allocated class instances. Need to be called before <code>soap_end()</code>
<code>soap_dealloc(struct soap *soap, void *p)</code>	Remove malloced data at <code>p</code> . When <code>p==NULL</code> : remove all dynamically allocated (deserialized) data except class instances
<code>soap_delete(struct soap *soap, void *p)</code>	Remove class instance at <code>p</code> . When <code>p==NULL</code> : remove all dynamically allocated (deserialized) class instances (this is identical to calling <code>soap_destroy(struct soap *soap)</code>)
<code>soap_unlink(struct soap *soap, void *p)</code>	Unlink data/object at <code>p</code> from gSOAP's deallocation chain so gSOAP won't deallocate it
<code>soap_done(struct soap *soap)</code>	Reset: close master/slave sockets and remove callbacks (see Section 13.7)

Temporary data (i.e. the hash tables) are automatically removed with calls to the `soap_free` function which is made within `soap_end` and `soap_done` or when the next call to a stub or skeleton routine is made to send a message or receive a message. Deallocation of non-class based data is straightforward: `soap_end` removes all dynamically allocated deserialized data (data allocated with `soap_malloc`. That is, when the client/service application does not use any class instances that are (de)marshalled, but uses structs, arrays, etc., then calling the `soap_end` function is safe to remove all deserialized data. The function can be called after processing the deserialized data of a remote method call or after a number of remote method calls have been made. The function is also typically called after `soap_serve`, when the service finished sending the response to a client and the deserialized client request data can be removed.

Individual data objects can be unlinked from the deallocation chain if necessary, to prevent deallocation by the collective `soap_end` or `soap_destroy` functions.

7.11.1 Memory Management Policies

There are three situations to consider for memory deallocation policies for class instances:

1. the program code deletes the class instances and the class destructors in turn SHOULD delete and free any dynamically allocated data (deep deallocation) without calling the `soap_end` and `soap_destroy` functions,
2. or the class destructors SHOULD NOT deallocate any data and the `soap_end` and `soap_destroy` functions can be called to remove the data.
3. or the class destructors SHOULD mark their own deallocation and mark the deallocation of any other data deallocated by it's destructors by calling the `soap_unlink` function. This allows `soap_destroy` and `soap_end` to remove the remaining instances and data without causing duplicate deallocations.

With the `-m` option of `soapcpp2` enabled (to be deprecated), there is one exception which requires explicit deallocation of malloced data in the destructors of classes for array binary types:

- A dynamic array class with non-class elements SHOULD delete the contents of the array it points to as part of its destructor's operations (this includes classes for `hexBinary` and `base64Binary` schema types).

It is advised to use pointers to class instances that are used within other structs and classes to avoid the creation of temporary class instances. The problem with temporary class instances is that the destructor of the temporary may affect data used by other instances through the sharing of data parts accessed with pointers. Temporaries and even whole copies of class instances can be created when deserializing SOAP multi-referenced objects. A dynamic array of class instances is similar: temporaries may be created to fill the array upon deserialization. To avoid problems, use dynamic arrays of pointers to class instances. This also enables the exchange of polymorphic arrays when the elements are instances of classes in an inheritance hierarchy. In addition, allocate data and class instances with `soap_malloc` and `soap_new_X` functions (more details below).

To summarize, it is advised to pass class data types by pointer to a remote method. For example:

```
class X { ... };
ns_remoteMethod(X *in, ...);
```

Response elements that are class data types can be passed by reference, as in:

```
class X { ... };
class ns_remoteMethodResponse { ... };
ns_remoteMethod(X *in, ns_remoteMethodResponse &out);
```

But dynamic arrays declared as class data types should use a pointer to a valid object that will be overwritten when the function is called, as in:

```
typedef int xsd_int;
class X { ... };
class ArrayOfint { xsd_int *_ptr; int _size; };
ns_remoteMethod(X *in, ArrayOfint *out);
```

Or a reference to a valid or NULL pointer, as in:

```
typedef int xsd_int;
class X { ... };
class ArrayOfint { xsd_int *_ptr; int _size; };
ns_remoteMethod(X *in, ArrayOfint *&out);
```

The gSOAP memory allocation functions can be used in client and/or service code to allocate temporary data that will be automatically deallocated. These functions are:

Function Call	Description
void *soap_malloc(struct soap *soap, size_t n)	return pointer to n bytes
<u>Class</u> *soap_new_ <u>Class</u> (struct soap *soap, int n)	instantiate n <u>Class</u> objects

The `soap_new_X` functions are generated by the gSOAP compiler for every class X in the header file. Parameter n MUST be -1 to instantiate a single object or ≥ 0 to instantiate an array of n objects.

Space allocated with `soap_malloc` will be released with the `soap_end` and `soap_dealloc` functions. Objects instantiated with `soap_new_X(struct soap*)` are removed altogether with `soap_destroy(struct soap*)`. Individual objects instantiated with `soap_new_X` are removed with `soap_delete_X(struct soap*, X*)`. For example, the following service uses temporary data in the remote method implementation:

```

int main()
{ ...
    struct soap soap;
    soap_init(&soap);
    soap_serve(&soap);
    soap_end(&soap);
    ...
}

```

An example remote method that allocates a temporary string is:

```

int ns_itoa(struct soap *soap, int i, char **a)
{
    *a = (char*)soap_malloc(soap, 11);
    sprintf(*a, "%d", i);
    return SOAP_OK;
}

```

This temporary allocation can also be used to allocate strings for the SOAP Fault data structure. For example:

```

int ns_mymethod(...)
{ ...
    if (exception)
    {
        char *msg = (char*)soap_malloc(soap, 1024); // allocate temporary space for detailed message
        sprintf(msg, "...", ...); // produce the detailed message
        return soap_receiver_fault(soap, "An exception occurred", msg); // return the server-side fault
    }
    ...
}

```

Use `soap_receiver_fault(struct soap *soap, const char *faultstring, const char *detail)` to set a SOAP 1.1/1.2 fault at the server-side. Use `soap_sender_fault(struct soap *soap, const char *faultstring, const char *detail)` to set a SOAP 1.1/1.2 unrecoverable Bad Request fault at the server-side.

7.11.2 Intra-Class Memory Management

When a class declaration has a **struct** soap * field, this field will be set to point to the current gSOAP run-time environment by gSOAP's deserializers and by the `soap_new_Class` functions. This simplifies memory management for class instances. The **struct** soap* pointer is implicitly set by the gSOAP deserializer for the class or explicitly by calling the `soap_new_X` function for class X. For example:

```

class Sample
{ public:
    struct soap *soap; // reference to gSOAP's run-time
    ...
    Sample();
    ~Sample();
};

```

The constructor and destructor for class `Sample` are:

```
Sample::Sample()
{ this->soap = NULL;
}
Sample::~Sample()
{ soap_unlink(this->soap, this);
}
```

The `soap_unlink()` call removes the object from gSOAP's deallocation chain. In that way, `soap_destroy` can be safely called to remove all class instances. The following code illustrates the explicit creation of a `Sample` object and cleanup:

```
struct soap *soap = soap_new(); // new gSOAP runtime
Sample *obj = soap_new_Sample(soap, -1); // new Sample object with obj->soap set to runtime
...
delete obj; // also calls soap_unlink to remove obj from the deallocation chain
soap_destroy(soap); // deallocate all (other) class instances
soap_end(soap); // clean up
```

Here is another example:

```
class ns_._myClass
{ ...
    struct soap *soap; // set by soap_new_ns_._myClass()
    char *name;
    void setName(const char *s);
    ...
};
```

Calls to `soap_new_ns_._myClass(soap, n)` will set the `soap` field in the class instance to the current gSOAP environment. Because the deserializers invoke the `soap_new` functions, the `soap` field of the `ns_._myClass` instances are set as well. This mechanism is convenient when Web Service methods need to return objects that are instantiated in the methods. For example

```
int ns_._myMethod(struct soap *soap, ...)
{
    ns_._myClass *p = soap_new_ns_._myClass(soap, -1);
    p->setName(" SOAP");
    return SOAP_OK;
}
void ns_._myClass::ns_._setName(const char *s)
{
    if (soap)
        name = (char*)soap_malloc(soap, strlen(s)+1);
    else
        name = (char*)malloc(strlen(s)+1);
    strcpy(name, s);
}
ns_._myClass::ns_._myClass()
{
    soap = NULL;
}
```

```

    name = NULL;
}
ns_myClass::~~ns_myClass()
{
    if (!soap && name) free(name);
    soap_unlink(soap, this);
}

```

Calling `soap_destroy` right after `soap_serve` in the Web Service will destroy all dynamically allocated class instances.

7.12 Debugging

To activate message logging for debugging, un-comment the `#define DEBUG` directive in `stdsoap2.h`. Compile the client and/or server applications as described above (or simply use `g++ -DDEBUG ...` to compile with debugging activated). When the client and server applications run, they will log their activity in three separate files:

File	Description
SENT.log	The SOAP content transmitted by the application
RECV.log	The SOAP content received by the application
TEST.log	A log containing various activities performed by the application

Caution: The client and server applications may run slow due to the logging activity.

Caution: When installing a CGI application on the Web with debugging activated, the log files may sometimes not be created due to file access permission restrictions imposed on CGI applications. To get around this, create empty log files with universal write permissions. Be careful about the security implication of this.

You can test a service CGI application without deploying it on the Web. To do this, create a client application for the service and activate message logging by this client. Remove any old `SENT.log` file and run the client (which connects to the Web service or to another dummy, but valid address) and copy the `SENT.log` file to another file, e.g. `SENT.tst`. Then redirect the `SENT.tst` file to the service CGI application. For example,

```
myservice.cgi < SENT.tst
```

This should display the service response on the terminal.

The file names of the log files and the logging activity can be controlled at the application level. This allows the creation of separate log files by separate services, clients, and threads. For example, the following service logs all SOAP messages (but no debug messages) in separate directories:

```

struct soap soap;
soap_init(&soap);
...
soap_set_recv_logfile(&soap, "logs/recv/service12.log"); // append all messages received in /logs/recv/service12.log
soap_set_sent_logfile(&soap, "logs/sent/service12.log"); // append all messages sent in /logs/sent/service12.log
soap_set_test_logfile(&soap, NULL); // no file name: do not save debug messages
...
soap_serve(&soap);
...

```

Likewise, messages can be logged for individual client-side remote method calls.

7.13 Libraries

- The socket library is essential and requires the inclusion of the appropriate libraries with the compile command for Sun Solaris systems:

```
g++ -o myclient myclient.cpp stdsoap2.cpp soapC.cpp soapClient.cpp -lsocket -lnet -lnsl
```

These library loading options are not required with Linux.

- The gSOAP runtime uses the math library for the NaN, INF, and -INF floating point representations. The library is not strictly necessary and the `<math.h>` header file import can be commented out from the `stdsoap2.h` header file. The application can be linked without the `-lm` math library e.g. under Sun Solaris:

```
g++ -o myclient myclient.cpp stdsoap2.cpp soapC.cpp soapClient.cpp -lsocket -lnet -lnsl
```

8 The gSOAP Remote Method Specification Format

A SOAP remote method is specified as a C/C++ function prototype in a header file. The function is REQUIRED to return **int**, which is used to represent a SOAP error code, see Section 8.2. Multiple remote methods MAY be declared together in one header file.

The general form of a SOAP remote method specification is:

```
[int] [namespace_prefix_]method_name([inparam1, inparam2, ...,] outparam);
```

where

`namespace_prefix_` is the optional namespace prefix of the method (see identifier translation rules 8.3)

`method_name` is the remote method name (see identifier translation rules 8.3)

`inparam` is the declaration of an input parameter of the remote method

`outparam` is the declaration of the output parameter of the remote method

This simple form can only pass a single, non-**struct** and non-**class** type output parameter. See 8.1 for passing multiple output parameters. The name of the declared function `namespace_prefix_.method_name` must be unique and cannot match the name of a **struct**, **class**, or **enum** declared in the same header file.

The method request is encoded in SOAP as an XML element and the namespace prefix, method name, and input parameters are encoded using the format:

```
<[namespace-prefix:]method_name xsi:type="[namespace-prefix:]method_name">
<inparam-name1 xsi:type="...">...</inparam-name1>
<inparam-name2 xsi:type="...">...</inparam-name2>
...
</[namespace-prefix:]method_name>
```

where the `inparam-name` accessors are the element-name representations of the `inparam` parameter name declarations, see Section 8.3. (The optional parts are shown enclosed in `[]`.)

The XML response by the Web service is of the form:

```
<[namespace-prefix:]method-nameResponse xsi:type="[namespace-prefix:]method-nameResponse">
  <outparam-name xsi:type="...">...</outparam-name>
</[namespace-prefix:]method-nameResponse>
```

where the `outparam-name` accessor is the element-name representation of the `outparam` parameter name declaration, see Section 8.3. By convention, the response element name is the method name ending in `Response`. See 8.1 on how to change the declaration if the service response element name is different.

The gSOAP stub and skeleton compiler generates a stub routine for the remote method. This stub is of the form:

```
int soap_call_[namespace_prefix_]method_name(struct soap *soap, char *URL, char *action, [inparam1,
inparam2, ...,] outparam);
```

This proxy can be called by a client application to perform the remote method call.

The gSOAP stub and skeleton compiler generates a skeleton routine for the remote method. The skeleton function is:

```
int soap_serve_[namespace_prefix_]method_name(struct soap *soap);
```

The skeleton routine, when called by a service application, will attempt to serve a request on the standard input. If no request is present or if the request does not match the method name, `SOAP_NO_METHOD` is returned. The skeleton routines are automatically called by the generated `soap_serve` routine that handles all requests.

8.1 Remote Method Parameter Passing

The input parameters of a remote method **MUST** be passed by value. Input parameters cannot be passed by reference with the `&` reference operator, but an input parameter value **MAY** be passed by a pointer to the data. Of course, passing a pointer to the data is preferred when the size of the data of the parameter is large. Also, to pass instances of (derived) classes, pointers to the instance need to be used to avoid passing the instance by value which requires a temporary and prohibits passing derived class instances. When two input parameter values are identical, passing them using a pointer has the advantage that the value will be encoded only once as multi-reference (hence, the parameters are aliases). When input parameters are passed using a pointer, the data pointed to will not be modified by the remote method and returned to the caller.

The output parameter **MUST** be passed by reference using `&` or by using a pointer. Arrays are passed by reference by default and do not require the use of the reference operator `&`.

The input and output parameter types have certain limitations, see Section 7.9

If the output parameter is a **struct** or **class** type, it is considered a SOAP remote method response element instead of a simple output parameter value. That is, the name of the **struct** or **class** is the name of the response element and the **struct** or **class** fields are the output parameters of the

remote method, see also 6.1.7. Hence, if the output parameter has to be a **struct** or **class**, a response **struct** or **class** MUST be declared as well. In addition, if a remote method returns multiple output parameters, a response **struct** or **class** MUST be declared. By convention, the response element is the remote method name ending with “Response”.

The general form of a response element declaration is:

```
struct [namespace_prefix_]response_element_name
{
    outparam1;
    outparam2;
    ...
};
```

where

`namespace_prefix_` is the optional namespace prefix of the response element (see identifier translation rules 8.3)

`response_element_name` is the name of the response element (see identifier translation rules 8.3)

`outparam` is the declaration of an output parameter of the remote method

The general form of a remote method specification with a response element declaration for (multiple) output parameters is:

```
[int] [namespace_prefix_]method_name([inparam1, inparam2, ...,] struct [namespace_prefix_]response_element_name
{outparam1[, outparam2, ...]} &anyparam);
```

The choice of name for `anyparam` has no effect on the SOAP encoding and decoding and is only used as a place holder for the response.

The method request is encoded in SOAP as an independent element and the namespace prefix, method name, and input parameters are encoded using the format:

```
<[namespace-prefix:]method-name xsi:type="[namespace-prefix:]method-name">
<inparam-name1 xsi:type="...">...</inparam-name1>
<inparam-name2 xsi:type="...">...</inparam-name2>
...
</[namespace-prefix:]method-name>
```

where the `inparam-name` accessors are the element-name representations of the `inparam` parameter name declarations, see Section 8.3. (The optional parts resulting from the specification are shown enclosed in [].)

The method response is expected to be of the form:

```
<[namespace-prefix:]response-element-name xsi:type="[namespace-prefix:]response-element-name">
<outparam-name1 xsi:type="...">...</outparam-name1>
<outparam-name2 xsi:type="...">...</outparam-name2>
...
</[namespace-prefix:]response-element-name>
```

where the `outparam-name` accessors are the element-name representations of the `outparam` parameter name declarations, see Section 8.3. (The optional parts resulting from the specification are shown enclosed in `[]`.)

The input and/or output parameters can be made anonymous, which allows the deserialization of requests/responses with different parameter names as is endorsed by the SOAP 1.1 specification, see Section 6.1.13.

8.2 Stub and Skeleton Routine Error Codes

The error codes returned by the stub and skeleton routines are listed below.

#	Code	Description
0	SOAP_OK	No error
1	SOAP_CLI_FAULT*	The service returned a client fault (SOAP 1.2 Sender fault)
2	SOAP_SVR_FAULT*	The service returned a server fault (SOAP 1.2 Receiver fault)
3	SOAP_TAG_MISMATCH	An XML element didn't correspond to anything expected
4	SOAP_TYPE_MISMATCH	An XML schema type mismatch
5	SOAP_SYNTAX_ERROR	An XML syntax error occurred on the input
6	SOAP_NO_TAG	Begin of an element expected, but not found
7	SOAP_IOB	Array index out of bounds
8	SOAP_MUSTUNDERSTAND*	An element needs to be ignored that need to be understood
9	SOAP_NAMESPACE	Namespace name mismatch (validation error)
10	SOAP_OBJ_MISMATCH	Mismatch in the size and/or shape of an object
11	SOAP_FATAL_ERROR	Internal error
12	SOAP_FAULT	An exception raised by the service
13	SOAP_NO_METHOD	Skeleton error: the skeleton cannot serve the method
14	SOAP_GET_METHOD	Unsupported HTTP GET
15	SOAP_EOM	Out of memory
16	SOAP_NULL	An element was null, while it is not supposed to be null
17	SOAP_MULTI_ID	Multiple occurrences of the same element ID on the input
18	SOAP_MISSING_ID	Element ID missing for an HREF on the input
19	SOAP_HREF	Reference to object is incompatible with the object referred to
20	SOAP_TCP_ERROR	A TCP connection error occurred
21	SOAP_HTTP_ERROR	An HTTP error occurred
22	SOAP_SSL_ERROR	An SSL error occurred
23	SOAP_ZLIB_ERROR	A Zlib error occurred
24	SOAP_DIME_ERROR	DIME parsing error
25	SOAP_EOD	End of DIME error
26	SOAP_VERSIONMISMATCH*	SOAP version mismatch or no SOAP message
27	SOAP_DIME_MISMATCH	DIME version mismatch
28	SOAP_PLUGIN_ERROR	Failed to register plugin
-1	SOAP_EOF	Unexpected end of file, no input, or timeout receiving data

The error codes that are returned by a stub routine (proxy) upon receiving a SOAP Fault from the server are marked (*). The remaining error codes are generated by the proxy itself as a result of problems with a SOAP payload. The error code is `SOAP_OK` when the remote method call was successful (the `SOAP_OK` predefined constant is guaranteed to be 0). The error code is also stored in `soap.error`, where `soap` is a variable that contains the current runtime environment. The function `soap_print_fault(struct soap *soap, FILE *fd)` can be called to display an error message on `fd` where current value of the `soap.error` variable is used by the function to display the error. The function

`soap_print_fault_location(struct soap *soap, FILE *fd)` prints the location of the error if the error is a result from parsing XML.

A remote method implemented in a SOAP service **MUST** return an error code as the function's return value. `SOAP_OK` denotes success and `SOAP_FAULT` denotes an exception. The exception details can be assigned with the `soap_receiver_fault(struct soap *soap, const char *faultstring, const char *detail)` which sets the strings `soap.fault->faultstring` and `soap.fault->detail` for SOAP 1.1, and `soap.fault->SOAP_ENV__Reason` and `soap.fault->SOAP_ENV__Detail` for SOAP 1.2, where `soap` is a variable that contains the current runtime environment, see Section 10.

8.3 C/C++ Identifier Name to XML Name Translations

One of the “secrets” behind the power and flexibility of gSOAP's encoding and decoding of remote method names, class names, type identifiers, and struct or class fields is the ability to specify namespace prefixes with these names that are used to denote their encoding style. More specifically, a C/C++ identifier name of the form

`[namespace_prefix_]element_name`

will be encoded in XML as

`<[namespace-prefix:]element-name ...>`

The **underscore pair** (`_.`) separates the namespace prefix from the element name. Each namespace prefix has a namespace URI specified by a namespace mapping table 8.4, see also Section 6.1.2. The namespace URI is a unique identification that can be associated with the remote methods and data types. The namespace URI disambiguates potentially identical remote method names and data type names used by disparate organizations.

XML element names are NCNames (restricted strings) that **MAY** contain **hypens**, **dots**, and **underscores**. The special characters in the XML element names of remote methods, structs, classes, typedefs, and fields can be controlled using the following conventions: A **single underscore** in a namespace prefix or identifier name is replaced by a hyphen (`-`) in the XML element name. For example, the identifier name `SOAP_ENC_.ur.type` is represented in XML as `SOAP-ENC:ur-type`. The sequence `_.DOT_` is replaced by a dot (`.`), and the sequence `_.USCORE_` is replaced by an underscore (`_`) in the corresponding XML element name. For example:

```
class n_s_.biz_DOT_com
{
    char *n_s_.biz_USCORE_name;
};
```

is encoded in XML as:

```
<n-s:biz.com xsi:type="n-s:biz.com">
  <n-s:biz_name xsi:type="string">Bizybiz</n-s:biz_name>
</n-s:biz.com>
```

Trailing underscores of an identifier name are not translated into the XML representation. This is useful when an identifier name clashes with a C++ keyword. For example, `return` is often used

as an accessor name in a SOAP response element. The `return` element can be specified as `return_` in the C++ source code. Note that XML should be treated as case sensitive, so the use of e.g. `Return` may not always work to avoid a name clash with the `return` keyword. The use of trailing underscores also allows for defining **structs** and **classes** with essentially the same XML schema type name, but that have to be distinguished as separate C/C++ types.

For decoding, the underscores in identifier names act as wildcards. An XML element is parsed and matches the name of an identifier if the name is identical to the element name (case insensitive) and the underscores in the identifier name are allowed to match any character in the element name. For example, the identifier name `I_want_soap_fun_the_bea_...DOT_com` matches the element name `I-want:SOAP4fun@the-beach.com`.

8.4 Namespace Mapping Table

A namespace mapping table **MUST** be defined by clients and service applications. The mapping table is used by the serializers and deserializers of the stub and skeleton routines to produce a valid SOAP payload and to validate an incoming SOAP payload. A typical mapping table is shown below:

```
struct Namespace namespaces[] =
{ // {"ns-prefix", "ns-name"}
  {"SOAP-ENV", "http://schemas.xmlsoap.org/soap/envelope/"}, // MUST be first
  {"SOAP-ENC", "http://schemas.xmlsoap.org/soap/encoding/"}, // MUST be second
  {"xsi", "http://www.w3.org/1999/XMLSchema-instance"}, // MUST be third
  {"xsd", "http://www.w3.org/1999/XMLSchema"}, // Required for XML schema types
  {"ns1", "urn:my-service-URI"}, // The namespace URI of the remote methods
  {NULL, NULL} // end of table
};
```

Each namespace prefix used by a identifier name in the header file specification (see Section 8.3) **MUST** have a binding to a namespace URI in the mapping table. The end of the namespace mapping table **MUST** be indicated by the `NULL` pair. The namespace URI matching is case insensitive. A namespace prefix is distinguished by the occurrence of a pair of underscores (`..`) in an identifier.

An optional namespace pattern **MAY** be provided with each namespace mapping table entry. The patterns provide an alternative namespace matching for the validation of decoded SOAP messages. In this pattern, dashes (`-`) are single-character wildcards and asterisks (`*`) are multi-character wildcards. For example, to decode different versions of XML Schema type with different authoring dates, four dashes can be used in place of the specific dates in the namespace mapping table pattern:

```
struct Namespace namespaces[] =
{ // {"ns-prefix", "ns-name", "ns-name validation pattern"}
...
  {"xsi", "http://www.w3.org/1999/XMLSchema-instance", "http://www.w3.org/----/XMLSchema-
instance"},
  {"xsd", "http://www.w3.org/1999/XMLSchema", "http://www.w3.org/----/XMLSchema"},
...
};
```

Or alternatively, asterisks can be used as wildcards for multiple characters:

```

struct Namespace namespaces[] =
{ // {"ns-prefix", "ns-name", "ns-name validation pattern"}
...
{"xsi", "http://www.w3.org/1999/XMLSchema-instance", "http://www.w3.org/*/XMLSchema-
instance"},
{"xsd", "http://www.w3.org/1999/XMLSchema", "http://www.w3.org/*/XMLSchema"},
...

```

A namespace mapping table is automatically generated together with a WSDL file for each namespace prefix that is used for a remote method in the header file. This namespace mapping table has entries for all namespace prefixes. The namespace URIs need to be filled in. These appear as `http://tempuri.org` in the table. See Section 13.2 on how to specify the namespace URIs in the header file.

For decoding elements with namespace prefixes, the namespace URI associated with the namespace prefix (through the `xmlns` attribute of an XML element) is searched from the beginning to the end in a namespace mapping table, and for every row the following tests are performed as part of the validation process:

1. the string in the second column matches the namespace URI (case insensitive)
2. the string in the optional third column matches the namespace URI (case insensitive), where - is a one-character wildcard and * is a multi-character wildcard

When a match is found, the namespace prefix in the first column of the table is considered semantically identical to the namespace prefix used by the XML element to be decoded, though the prefix names may differ. A service will respond with the namespace that it received from a client in case it matches a pattern in the third column.

For example, let's say we have the following structs:

```

struct a_elt { ... };
struct b_elt { ... };
struct k_elt { ... };

```

and a namespace mapping table in the program:

```

struct Namespace namespaces[] =
{ // {"ns-prefix", "ns-name", "ns-name validation pattern"}
...
{"a", "some uri"},
{"b", "other uri"},
{"c", "his uri", "* uri"},
...

```

Then, the following XML elements will match the structs:

```

<n:elt xmlns:n="some URI">      matches the struct name a_elt
...
<m:elt xmlns:m="other URI">    matches the struct name b_elt
...

```

```
<k:elt xmlns:k="my URI">      matches the struct name c__elt
...
```

The response of a service to a client request that uses the namespaces listed above, will include my URI for the name space of element k.

It is possible to use a number of different namespace tables and select the one that is appropriate. For example, an application might contact many different Web services all using different namespace URIs. If all the URIs are stored in one table, each remote method invocation will dump the whole namespace table in the SOAP payload. There is no technical problem with that, but it can be ugly when the table is large. To use different namespace tables, declare a pointer to a table and set the pointer to a particular table before remote method invocation. For example:

```
struct Namespace namespacesTable1[] = { ... };
struct Namespace namespacesTable2[] = { ... };
struct Namespace namespacesTable3[] = { ... };
struct Namespace *namespaces;
...
struct soap soap;
...
soap_init(&soap);
soap.namespaces = namespacesTable1;
soap_call_remote_method(&soap, URL, Action, ...);
...
```

9 gSOAP Serialization and Deserialization Rules

This section describes the serialization and deserialization of C and C++ data types for SOAP 1.1 and 1.2 compliant encoding and decoding.

9.1 Primitive Type Encoding

The default encoding rules for the primitive C and C++ data types are given in the table below:

Type	Schema Type	Example Encoding
bool	boolean	<boolean xsi:type="boolean">...</boolean>
char* (C string)	string	<string xsi:type="string">...</string>
char	byte	<byte xsi:type="byte">...</byte>
double	double	<double xsi:type="double">...</double>
float	float	<float xsi:type="float">...</float>
int	int	<int xsi:type="int">...</int>
long	long	<long xsi:type="long">...</long>
LONG64	long	<long xsi:type="long">...</long>
long long	long	<long xsi:type="long">...</long>
short	short	<short xsi:type="short">...</short>
time_t	dateTime	<dateTime xsi:type="dateTime">...</dateTime>
unsigned char	unsignedByte	<unsignedByte xsi:type="unsignedByte">...</unsignedByte>
unsigned int	unsignedInt	<unsignedInt xsi:type="unsignedInt">...</unsignedInt>
unsigned long	unsignedLong	<unsignedLong xsi:type="unsignedLong">...</unsignedLong>
ULONG64	unsignedLong	<unsignedLong xsi:type="unsignedLong">...</unsignedLong>
unsigned long long	unsignedLong	<unsignedLong xsi:type="unsignedLong">...</unsignedLong>
unsigned short	unsignedShort	<unsignedShort xsi:type="unsignedShort">...</unsignedShort>
wchar_t*	string	<string xsi:type="string">...</string>

Objects of type **void** and **void*** cannot be encoded.

9.2 How to Encode and Decode Primitive Types as XSD Types

By default, encoding of the primitive types will take place as per SOAP encoding style. The encoding can be changed to any XML schema type (XSD type) with an optional namespace prefix by using a **typedef** in the header file input to the gSOAP stub and skeleton compiler. The declaration enables the implementation of built-in XML schema types (also known as XSD types) such as `positiveInteger`, `xsd:anyURI`, and `xsd:date` for which no built-in data structures in C and C++ exist but which can be represented using standard data structures such as strings, integers, and floats.

The **typedef** declaration is frequently used for convenience in C. A **typedef** declares a type name for a (complex) type expression. The type name can then be used in other declarations in place of the more complex type expression, which often improves the readability of the program code.

The gSOAP compiler interprets **typedef** declarations the same way as a regular C compiler interprets them, i.e. as types in declarations. In addition however, the gSOAP compiler will also use the type name in the encoding of the data in SOAP. The **typedef** name will appear as the XML element name of an independent element and as the value of the `xsi:type` attribute in the SOAP payload.

Many built-in primitive and derived XSD types such as `xsd:anyURI`, `positiveInteger`, and `decimal` can be stored by standard primitive data structures in C++ as well such as strings, integers, floats, and doubles. To serialize strings, integers, floats, and doubles as built-in primitive and derived XSD types. To this end, a **typedef** declaration can be used to declare an XSD type.

For example, the declaration

```
typedef unsigned int positiveInteger;
```

creates a named type `positiveInteger` which is represented by **unsigned int** in C++. For example, the encoding of a `positiveInteger` value 3 is

```
<positiveInteger xsi:type="positiveInteger">3</positiveInteger>
```

The built-in primitive and derived numerical XML Schema types are listed below together with their recommended **typedef** declarations. Note that the SOAP encoding schemas for primitive types are derived from the built-in XML schema types, so SOAP_ENC_... can be used as a namespace prefix instead of xsd_...

xsd:anyURI Represents a Uniform Resource Identifier Reference (URI). Each URI scheme imposes specialized syntax rules for URIs in that scheme, including restrictions on the syntax of allowed fragment identifiers. It is recommended to use strings to store **xsd:anyURI** XML schema types. The recommended type declaration is:

```
typedef char *xsd__anyURI;
```

xsd:base64Binary Represents Base64-encoded arbitrary binary data. For using the **xsd:base64Binary** XML schema type, the use of the base64Binary representation of a dynamic array is **strongly** recommended, see Section 9.9. However, the type can also be declared as a string and the encoding will be string-based:

```
typedef char *xsd__base64Binary;
```

With this approach, it is solely the responsibility of the application to make sure the string content is according to the Base64 Content-Transfer-Encoding defined in Section 6.8 of RFC 2045.

xsd:boolean For declaring an **xsd:boolean** XML schema type, the use of a **bool** is **strongly** recommended. If a pure C compiler is used that does not support the **bool** type, see Section 9.3.5. The corresponding type declaration is:

```
typedef bool xsd__boolean;
```

Type **xsd__boolean** declares a Boolean (0 or 1), which is encoded as

```
<xsd:boolean xsi:type="xsd:boolean">...</xsd:boolean>
```

xsd:byte Represents a byte (-128...127). The corresponding type declaration is:

```
typedef char xsd__byte;
```

Type **xsd__byte** declares a byte which is encoded as

```
<xsd:byte xsi:type="xsd:byte">...</xsd:byte>
```

xsd:dateTime Represents a date and time. The lexical representation is according to the ISO 8601 extended format CCYY-MM-DDThh:mm:ss where "CC" represents the century, "YY" the year, "MM" the month and "DD" the day, preceded by an optional leading "-" sign to indicate a negative number. If the sign is omitted, "+" is assumed. The letter "T" is the date/time separator and "hh", "mm", "ss" represent hour, minute and second respectively. It is recommended to use the **time_t** type to store **xsd:dateTime** XML schema types and the type declaration is:

```
typedef time_t xsd__dateTime;
```


However, note that calendar times before the year 1902 or after the year 2037 cannot be represented. Upon receiving a date outside this range, the `time_t` value will be set to -1.

Strings (**char***) can be used to store `xsd:dateTime` XML schema types. The type declaration is:

```
typedef char *xsd__dateTime;
```

In this case, it is up to the application to read and set the `dateTime` representation.

`xsd:date` Represents a date. The lexical representation for date is the reduced (right truncated) lexical representation for `dateTime`: CCYY-MM-DD. It is recommended to use strings (**char***) to store `xsd:date` XML schema types. The type declaration is:

```
typedef char *xsd__date;
```

`xsd:decimal` Represents arbitrary precision decimal numbers. It is recommended to use the **double** type to store `xsd:decimal` XML schema types and the type declaration is:

```
typedef double xsd__decimal;
```

Type `xsd__decimal` declares a double floating point number which is encoded as

```
<xsd:double xsi:type="xsd:decimal">...</xsd:double>
```

`xsd:double` Corresponds to the IEEE double-precision 64-bit floating point type. The type declaration is:

```
typedef double xsd__double;
```

Type `xsd__double` declares a double floating point number which is encoded as

```
<xsd:double xsi:type="xsd:double">...</xsd:double>
```

`xsd:duration` Represents a duration of time. The lexical representation for duration is the ISO 8601 extended format `PnYn MnDTnH nMnS`, where `nY` represents the number of years, `nM` the number of months, `nD` the number of days, `T` is the date/time separator, `nH` the number of hours, `nM` the number of minutes and `nS` the number of seconds. The number of seconds can include decimal digits to arbitrary precision. It is recommended to use strings (**char***) to store `xsd:duration` XML schema types. The type declaration is:

```
typedef char *xsd__duration;
```

`xsd:float` Corresponds to the IEEE single-precision 32-bit floating point type. The type declaration is:

```
typedef float xsd__float;
```

Type `xsd__float` declares a floating point number which is encoded as

```
<xsd:float xsi:type="xsd:float">...</xsd:float>
```

xsd:hexBinary Represents arbitrary hex-encoded binary data. It has a lexical representation where each binary octet is encoded as a character tuple, consisting of two hexadecimal digits ([0-9a-fA-F]) representing the octet code. For example, "0FB7" is a hex encoding for the 16-bit integer 4023 (whose binary representation is 111110110111). For using the **xsd:hexBinary** XML schema type, the use of the hexBinary representation of a dynamic array is **strongly** recommended, see Section 9.10. However, the type can also be declared as a string and the encoding will be string-based:

```
typedef char *xsd_hexBinary;
```

With this approach, it is solely the responsibility of the application to make sure the string content consists of a sequence of octets.

xsd:int Corresponds to a 32-bit integer in the range -2147483648 to 2147483647. If the C++ compiler supports 32-bit **int** types, the type declaration can use the **int** type:

```
typedef int xsd_int;
```

Otherwise, the C++ compiler supports 16-bit **int** types and the type declaration should use the **long** type:

```
typedef long xsd_int;
```

Type **xsd_int** declares a 32-bit integer which is encoded as

```
<xsd:int xsi:type="xsd:int">...</xsd:int>
```

xsd:integer Corresponds to an unbounded integer. Since C++ does not support unbounded integers as a standard feature, the recommended type declaration is:

```
typedef long long xsd_integer;
```

Type **xsd_integer** declares a 64-bit integer which is encoded as an unbounded **xsd:integer**:

```
<xsd:integer xsi:type="xsd:integer">...</xsd:integer>
```

Another possibility is to use strings to represent unbounded integers and do the translation in code.

xsd:long Corresponds to a 64-bit integer in the range -9223372036854775808 to 9223372036854775807. The type declaration is:

```
typedef long long xsd_long;
```

Or in Visual C++:

```
typedef LONG64 xsd_long;
```

Type **xsd_long** declares a 64-bit integer which is encoded as

```
<xsd:long xsi:type="xsd:long">...</xsd:long>
```

xsd:negativeInteger Corresponds to a negative unbounded integer (< 0). Since C++ does not support unbounded integers as a standard feature, the recommended type declaration is:

```
typedef long long xsd_negativeInteger;
```

Type `xsd::negativeInteger` declares a 64-bit integer which is encoded as a `xsd:negativeInteger`:

```
<xsd:negativeInteger xsi:type="xsd:negativeInteger">...</xsd:negativeInteger>
```

Another possibility is to use strings to represent unbounded integers and do the translation in code.

`xsd:nonNegativeInteger` Corresponds to a non-negative unbounded integer (> 0). Since C++ does not support unbounded integers as a standard feature, the recommended type declaration is:

```
typedef unsigned long long xsd::_nonNegativeInteger;
```

Type `xsd::_nonNegativeInteger` declares a 64-bit unsigned integer which is encoded as a non-negative unbounded `xsd:nonNegativeInteger`:

```
<xsd:nonNegativeInteger xsi:type="xsd:nonNegativeInteger">...</xsd:nonNegativeInteger>
```

Another possibility is to use strings to represent unbounded integers and do the translation in code.

`xsd:nonPositiveInteger` Corresponds to a non-positive unbounded integer (≤ 0). Since C++ does not support unbounded integers as a standard feature, the recommended type declaration is:

```
typedef long long xsd::_nonPositiveInteger;
```

Type `xsd::_nonPositiveInteger` declares a 64-bit integer which is encoded as a `xsd:nonPositiveInteger`:

```
<xsd:nonPositiveInteger xsi:type="xsd:nonPositiveInteger">...</xsd:nonPositiveInteger>
```

Another possibility is to use strings to represent unbounded integers and do the translation in code.

`xsd:normalizedString` Represents normalized character strings. Normalized character strings do not contain the carriage return (`#xD`), line feed (`#xA`) nor tab (`#x9`) characters. It is recommended to use strings to store `xsd:normalizedString` XML schema types. The type declaration is:

```
typedef char *xsd::_normalizedString;
```

Type `xsd::_normalizedString` declares a string type which is encoded as

```
<xsd:normalizedString xsi:type="xsd:normalizedString">...</xsd:normalizedString>
```

It is solely the responsibility of the application to make sure the strings do not contain carriage return (`#xD`), line feed (`#xA`) and tab (`#x9`) characters.

`xsd:positiveInteger` Corresponds to a positive unbounded integer (≥ 0). Since C++ does not support unbounded integers as a standard feature, the recommended type declaration is:

```
typedef unsigned long long xsd::_positiveInteger;
```

Type `xsd::_positiveInteger` declares a 64-bit unsigned integer which is encoded as a `xsd:positiveInteger`:

```
<xsd:positiveInteger xsi:type="xsd:positiveInteger">...</xsd:positiveInteger>
```

Another possibility is to use strings to represent unbounded integers and do the translation in code.

xsd:short Corresponds to a 16-bit integer in the range -323768 to 323767. The type declaration is:

```
typedef short xsd__short;
```

Type `xsd__short` declares a short 16-bit integer which is encoded as

```
<xsd:short xsi:type="xsd:short">...</xsd:short>
```

xsd:string Represents character strings. The type declaration is:

```
typedef char *xsd__string;
```

Type `xsd__string` declares a string type which is encoded as

```
<xsd:string xsi:type="xsd:string">...</xsd:string>
```

The type declaration for wide character strings is:

```
typedef wchar_t *xsd__string;
```

Both type of strings can be used at the same time, but requires one typedef name to be changed by appending an underscore which is invisible in XML. For example:

```
typedef wchar_t *xsd__string_;
```

xsd:time Represents a time. The lexical representation for time is the left truncated lexical representation for `dateTime`: `hh:mm:ss.sss` with optional following time zone indicator. It is recommended to use strings (**char***) to store `xsd:time` XML schema types. The type declaration is:

```
typedef char *xsd__time;
```

xsd:token Represents tokenized strings. Tokens are strings that do not contain the line feed (`#xA`) nor tab (`#x9`) characters, that have no leading or trailing spaces (`#x20`) and that have no internal sequences of two or more spaces. It is recommended to use strings to store `xsd:token` XML schema types. The type declaration is:

```
typedef char *xsd__token;
```

Type `xsd__token` declares a string type which is encoded as

```
<xsd:token xsi:type="xsd:token">...</xsd:token>
```

It is solely the responsibility of the application to make sure the strings do not contain the line feed (`#xA`) nor tab (`#x9`) characters, that have no leading or trailing spaces (`#x20`) and that have no internal sequences of two or more spaces.

xsd:unsignedByte Corresponds to an 8-bit unsigned integer in the range 0 to 255. The type declaration is:

```
typedef unsigned char xsd__unsignedByte;
```

Type `xsd_unsignedByte` declares a unsigned 8-bit integer which is encoded as

```
<xsd:unsignedByte xsi:type="xsd:unsignedByte">...</xsd:unsignedByte>
```

`xsd_unsignedInt` Corresponds to a 32-bit unsigned integer in the range 0 to 4294967295. If the C++ compiler supports 32-bit **int** types, the type declaration can use the **int** type:

```
typedef unsigned int xsd_unsignedInt;
```

Otherwise, the C++ compiler supports 16-bit **int** types and the type declaration should use the **long** type:

```
typedef unsigned long xsd_unsignedInt;
```

Type `xsd_unsignedInt` declares an unsigned 32-bit integer which is encoded as

```
<xsd:unsignedInt xsi:type="xsd:unsignedInt">...</xsd:unsignedInt>
```

`xsd_unsignedLong` Corresponds to a 64-bit unsigned integer in the range 0 to 18446744073709551615. The type declaration is:

```
typedef unsigned long long xsd_unsignedLong;
```

Or in Visual C++:

```
typedef ULONG64 xsd_unsignedLong;
```

Type `xsd_unsignedLong` declares an unsigned 64-bit integer which is encoded as

```
<xsd:unsignedLong xsi:type="xsd:unsignedLong">...</xsd:unsignedLong>
```

`xsd_unsignedShort` Corresponds to a 16-bit unsigned integer in the range 0 to 65535. The type declaration is:

```
typedef unsigned short xsd_unsignedShort;
```

Type `xsd_unsignedShort` declares an unsigned short 16-bit integer which is encoded as

```
<xsd:unsignedShort xsi:type="xsd:unsignedShort">...</xsd:unsignedShort>
```

Other XML schema types such as `gYearMonth`, `gYear`, `gMonthDay`, `gDay`, `xsd:gMonth`, `QName`, `NOTATION`, etc., can be encoded similarly using a **typedef** declaration.

9.2.1 How to Use Multiple C/C++ Types for a Single Primitive XSD Type

Trailing underscores (see Section 8.3) can be used in the type name in a **typedef** to enable the declaration of multiple storage formats for a single XML schema type. For example, one part of a C/C++ application's data structure may use plain strings while another part may use wide character strings. To enable this simultaneous use, declare:

```
typedef char *xsd_string;  
typedef wchar_t *xsd_string_;
```

Now, the `xsd_string` and `xsd_string_` types will both be encoded and decoded as XML string types and the use of trailing underscores allows multiple declarations for a single XML schema type.

9.2.2 How to use Wrapper Classes to Specify Polymorphic Primitive Types

SOAP 1.1 supports polymorphic types, because XML schema types form a hierarchy. The root of the hierarchy is called `xsd:anyType` (`xsd:ur-type` in the older 1999 schema). So, for example, an array of `xsd:anyType` in SOAP may actually contain any mix of element types that are the derived types of the root type. The use of polymorphic types is indicated by the WSDL and schema descriptions of a Web service and can therefore be predicted/expected for each particular case.

On the one hand, the **typedef** construct provides a convenient way to associate C/C++ types with XML schema types and makes it easy to incorporate these types in a (legacy) C/C++ application. However, on the other hand the **typedef** declarations cannot be used to support polymorphic XML schema types. Most SOAP clients and services do not use polymorphic types. In case they do, the primitive polymorphic types can be declared as a hierarchy of C++ **classes** that can be used simultaneously with the **typedef** declarations.

The general form of a primitive type declaration that is derived from a super type is:

```
class xsd_._type_name: [public xsd_._super_type_name]
{ public: Type _item;
  [public:] [private] [protected:]
  method1;
  method2;
  ...
};
```

where Type is a primitive C type. The `_item` field MUST be the first field in this wrapper class.

For example, the XML schema type hierarchy can be copied to C++ with the following declarations:

```
class xsd_._anyType { };
class xsd_._anySimpleType: public xsd_._anyType { };
typedef char *xsd_._anyURI;
class xsd_._anyURI_: public xsd_._anySimpleType { public: xsd_._anyURI _item; };
typedef bool xsd_._boolean;
class xsd_._boolean_: public xsd_._anySimpleType { public: xsd_._boolean _item; };
typedef char *xsd_._date;
class xsd_._date_: public xsd_._anySimpleType { public: xsd_._date _item; };
typedef time_t xsd_._dateTime;
class xsd_._dateTime_: public xsd_._anySimpleType { public: xsd_._dateTime _item; };
typedef double xsd_._double;
class xsd_._double_: public xsd_._anySimpleType { public: xsd_._double _item; };
typedef char *xsd_._duration;
class xsd_._duration_: public xsd_._anySimpleType { public: xsd_._duration _item; };
typedef float xsd_._float;
class xsd_._float_: public xsd_._anySimpleType { public: xsd_._float _item; };
typedef char *xsd_._time;
class xsd_._time_: public xsd_._anySimpleType { public: xsd_._time _item; };
typedef char *xsd_._decimal;
class xsd_._decimal_: public xsd_._anySimpleType { public: xsd_._decimal _item; };
typedef char *xsd_._integer;
class xsd_._integer_: public xsd_._decimal_ { public: xsd_._integer _item; };
typedef LONG64 xsd_._long;
class xsd_._long_: public xsd_._integer_ { public: xsd_._long _item; };
```

```

typedef long xsd__int;
class xsd__int_: public xsd__long_ { public: xsd__int __item; };
typedef short xsd__short;
class xsd__short_: public xsd__int_ { public: xsd__short __item; };
typedef char xsd__byte;
class xsd__byte_: public xsd__short_ { public: xsd__byte __item; };
typedef char *xsd__nonPositiveInteger;
class xsd__nonPositiveInteger_: public xsd__integer_ { public: xsd__nonPositiveInteger __item; };
typedef char *xsd__negativeInteger;
class xsd__negativeInteger_: public xsd__nonPositiveInteger_ { public: xsd__negativeInteger __item; };
};
typedef char *xsd__nonNegativeInteger;
class xsd__nonNegativeInteger_: public xsd__integer_ { public: xsd__nonNegativeInteger __item; };
typedef char *xsd__positiveInteger;
class xsd__positiveInteger_: public xsd__nonNegativeInteger_ { public: xsd__positiveInteger __item; };
};
typedef ULONG64 xsd__unsignedLong;
class xsd__unsignedLong_: public xsd__nonNegativeInteger_ { public: xsd__unsignedLong __item; };
};
typedef unsigned long xsd__unsignedInt;
class xsd__unsignedInt_: public xsd__unsingedLong_ { public: xsd__unsignedInt __item; };
typedef unsigned short xsd__unsignedShort;
class xsd__unsignedShort_: public xsd__unsignedInt_ { public: xsd__unsignedShort __item; };
typedef unsigned char xsd__unsignedByte;
class xsd__unsignedByte_: public xsd__unsignedShort_ { public: xsd__unsignedByte __item; };
typedef char *xsd__string;
class xsd__string_: public xsd__anySimpleType { public: xsd__string __item; };
typedef char *xsd__normalizedString;
class xsd__normalizedString_: public xsd__string_ { public: xsd__normalizedString __item; };
typedef char *xsd__token;
class xsd__token_: public xsd__normalizedString_ { public: xsd__token __item; };

```

Note the use of the trailing underscores for the **class** names to distinhuish the **typedef** type names from the **class** names. Only the most frequently used built-in schema types are shown. It is also allowed to include the xsd:base64Binary and xsd:hexBinary types in the hierarchy:

```

class xsd__base64Binary: public xsd__anySimpleType { public: unsigned char *_ptr; int __size; };
class xsd__hexBinary: public xsd__anySimpleType { public: unsigned char *_ptr; int __size; };

```

See Sections 9.9 and 9.10.

Methods are allowed to be added to the classes above, such as constructors and getter/setter methods.

Wrapper structs are supported as well, similar to wrapper classes. But thay cannot be used to implement polymorphism. Rather, the wrapper structs facilitate the use of XML attributes with a primitive typed object, see 9.5.5.

9.2.3 XML Schema Type Decoding Rules

The decoding rules for the primitive C and C++ data types is given in the table below:

Type	Allows Decoding of	Precision Lost?
bool	[xsd:] boolean	no
char* (C string)	any type, see 9.2.5	no
wchar_t * (wide string)	any type, see 9.2.5	no
double	[xsd:] double	no
	[xsd:] float	no
	[xsd:] long	no
	[xsd:] int	no
	[xsd:] short	no
	[xsd:] byte	no
	[xsd:] unsignedLong	no
	[xsd:] unsignedInt	no
	[xsd:] unsignedShort	no
	[xsd:] unsignedByte	no
	[xsd:] decimal	possibly
	[xsd:] integer	possibly
	[xsd:] positiveInteger	possibly
	[xsd:] negativeInteger	possibly
	[xsd:] nonPositiveInteger	possibly
	[xsd:] nonNegativeInteger	possibly
float	[xsd:] float	no
	[xsd:] long	no
	[xsd:] int	no
	[xsd:] short	no
	[xsd:] byte	no
	[xsd:] unsignedLong	no
	[xsd:] unsignedInt	no
	[xsd:] unsignedShort	no
	[xsd:] unsignedByte	no
	[xsd:] decimal	possibly
	[xsd:] integer	possibly
	[xsd:] positiveInteger	possibly
	[xsd:] negativeInteger	possibly
	[xsd:] nonPositiveInteger	possibly
	[xsd:] nonNegativeInteger	possibly
long long	[xsd:] long	no
	[xsd:] int	no
	[xsd:] short	no
	[xsd:] byte	no
	[xsd:] unsignedLong	possibly
	[xsd:] unsignedInt	no
	[xsd:] unsignedShort	no
	[xsd:] unsignedByte	no
	[xsd:] integer	possibly
	[xsd:] positiveInteger	possibly
	[xsd:] negativeInteger	possibly
	[xsd:] nonPositiveInteger	possibly
	[xsd:] nonNegativeInteger	possibly

Type	Allows Decoding of	Precision Lost?
long	<div> <div>xsd:long</div> <div>xsd:int</div> <div>xsd:short</div> <div>xsd:byte</div> <div>xsd:unsignedLong</div> <div>xsd:unsignedInt</div> <div>xsd:unsignedShort</div> <div>xsd:unsignedByte</div> </div>	<div>possibly, if long is 32 bit</div> <div>no</div> <div>no</div> <div>no</div> <div>possibly</div> <div>no</div> <div>no</div> <div>no</div>
int	<div> <div>xsd:int</div> <div>xsd:short</div> <div>xsd:byte</div> <div>xsd:unsignedInt</div> <div>xsd:unsignedShort</div> <div>xsd:unsignedByte</div> </div>	<div>no</div> <div>no</div> <div>no</div> <div>possibly</div> <div>no</div> <div>no</div>
short	<div> <div>xsd:short</div> <div>xsd:byte</div> <div>xsd:unsignedShort</div> <div>xsd:unsignedByte</div> </div>	<div>no</div> <div>no</div> <div>no</div> <div>no</div>
char	<div> <div>xsd:byte</div> <div>xsd:unsignedByte</div> </div>	<div>no</div> <div>possibly</div>
unsigned long long	<div> <div>xsd:unsignedLong</div> <div>xsd:unsignedInt</div> <div>xsd:unsignedShort</div> <div>xsd:unsignedByte</div> <div>xsd:positiveInteger</div> <div>xsd:nonNegativeInteger</div> </div>	<div>no</div> <div>no</div> <div>no</div> <div>no</div> <div>possibly</div> <div>possibly</div>
unsigned long	<div> <div>xsd:unsignedLong</div> <div>xsd:unsignedInt</div> <div>xsd:unsignedShort</div> <div>xsd:unsignedByte</div> </div>	<div>possibly, if long is 32 bit</div> <div>no</div> <div>no</div> <div>no</div>
unsigned int	<div> <div>xsd:unsignedInt</div> <div>xsd:unsignedShort</div> <div>xsd:unsignedByte</div> </div>	<div>no</div> <div>no</div> <div>no</div>
unsigned short	<div> <div>xsd:unsignedShort</div> <div>xsd:unsignedByte</div> </div>	<div>no</div> <div>no</div>
unsigned char	<div> <div>xsd:unsignedByte</div> </div>	<div>no</div>
time_t	<div> <div>xsd:dateTime</div> </div>	<div>no(?)</div>

Due to limitations in representation of certain primitive C++ types, a possible loss of accuracy may occur with the decoding of certain XML schema types as is indicated in the table. The table does

not indicate the possible loss of precision of floating point values due to the textual representation of floating point values in SOAP.

All explicitly declared XML schema encoded primitive types adhere to the same decoding rules. For example, the following declaration:

```
typedef unsigned long long xsd:_nonNegativeInteger;
```

enables the encoding and decoding of `xsd:nonNegativeInteger` XML schema types (although decoding takes place with a possible loss of precision). The declaration also allows decoding of `xsd:positiveInteger` XML schema types, because of the storage as a **unsigned long long** data type.

9.2.4 Multi-Reference Strings

If more than one **char** pointer points to the same string, the string is encoded as a multi-reference value. Consider for example

```
char *s = "hello", *t = s;
```

The `s` and `t` variables are assigned the same string, and when serialized, `t` refers to the content of `s`:

```
<string id="123" xsi:type="string">hello</string>
...
<string href="#123"/>
```

The example assumed that `s` and `t` are encoded as independent elements.

Note: the use of **typedef** to declare a string type such as `xsd:_string` will not affect the multi-reference string encoding. However, strings declared with different **typedefs** will never be considered multi-reference even when they point to the same string. For example

```
typedef char *xsd:_string;
typedef char *xsd:_anyURI;
xsd:_anyURI *s = "http://www.myservice.com";
xsd:_string *t = s;
```

The variables `s` and `t` point to the same string, but since they are considered different types their content will not be shared in the SOAP payload through a multi-referenced string.

9.2.5 “Smart String” Mixed-Content Decoding

The implementation of string decoding in gSOAP allows for mixed content decoding. If the SOAP payload contains a complex data type in place of a string, the complex data type is decoded in the string as plain XML text.

For example, suppose the `getInfo` remote method returns some detailed information. The remote method is declared as:

```
// Contents of header file "getInfo.h":
getInfo(char *detail);
```

The proxy of the remote method is used by a client to request a piece of information and the service responds with:

```
HTTP/1.1 200 OK
Content-Type: text/xml
Content-Length: nnn

<SOAP-ENV:Envelope xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
  xmlns:SOAP-ENC="http://schemas.xmlsoap.org/soap/encoding/"
  xmlns:xsi="http://www.w3.org/1999/XMLSchema-instance"
  xmlns:xsd="http://www.w3.org/1999/XMLSchema"
<SOAP-ENV:Body>
<getInfoResponse>
<detail>
<picture>Mona Lisa by <i>Leonardo da Vinci</i></picture>
</detail>
</getInfoResponse>
</SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

As a result of the mixed content decoding, the detail string contains “<picture>Mona Lisa by <i>Leonardo da Vinci</i></picture>”.

9.2.6 Changing the Encoding Precision of float and double Types

The double encoding format is by default set to “%.18G” (see a manual on printf text formatting in C), i.e. at most 18 digits of precision to limit a loss in accuracy. The float encoding format is by default “%.9G”, i.e. at most 9 digits of precision.

The encoding format of a double type can be set by assigning a format string to `soap.double_format`, where `soap` is a variable that contains the current runtime environment. For example:

```
struct soap soap;
soap_init(&soap); // sets double_format = "%.18G"
soap.double_format = "%e"; // redefine
```

which causes all doubles to be encoded in scientific notation. Likewise, the encoding format of a float type can be set by assigning a format string to the static `soap.float_format` string variable. For example:

```
struct soap soap;
soap_init(&soap); // sets float_format = "%.9G"
soap.float_format = "%.4F"; // redefine
```

which causes all floats to be encoded with four digits precision.

Caution: The format strings are not automatically reset before or after SOAP communications. An error in the format string may result in the incorrect encoding of floating point values.

9.2.7 INF, -INF, and NaN Values of float and double Types

The gSOAP runtime `stdsoap2.cpp` and header file `stdsoap2.h` support the marshalling of IEEE INF, -INF, and NaN representations. Under certain circumstances this may break if the hardware and/or C/C++ compiler does not support these representations. To remove the representations, remove the inclusion of the `math.h` header file from the `stdsoap2.h` file. You can control the representations as well, which are defined by the macros:

```
#define FLT_NAN
#define FLT_PINFTY
#define FLT_NINFTY
#define DBL_NAN
#define DBL_PINFTY
#define DBL_NINFTY
```

9.3 Enumeration Type Encoding and Decoding

Enumerations are generally useful for the declaration of named integer-valued constants, also called enumeration constants.

9.3.1 Symbolic Encoding of Enumeration Constants

The gSOAP stub and skeleton compiler encodes the constants of enumeration-typed variables in symbolic form using the names of the constants when possible to comply to SOAP's XML schema enumeration encoding style. Consider for example the following enumeration of weekdays:

```
enum weekday {Mon, Tue, Wed, Thu, Fri, Sat, Sun};
```

The enumeration-constant `Mon`, for example, is encoded as

```
<weekday xsi:type="weekday">Mon</weekday>
```

The value of the `xsi:type` attribute is the enumeration-type identifier's name. If the element is independent as in the example above, the element name is the enumeration-type identifier's name.

The encoding of complex types such as enumerations requires a reference to an XML schema through the use of a namespace prefix. The namespace prefix can be specified as part of the enumeration-type identifier's name, with the usual namespace prefix conventions for identifiers. This can be used to explicitly specify the encoding style. For example:

```
enum ns1:_weekday {Mon, Tue, Wed, Thu, Fri, Sat, Sun};
```

The enumeration-constant `Sat`, for example, is encoded as:

```
<ns1:weekday xsi:type="ns1:weekday">Sat</ns1:weekday>
```

The corresponding XML schema for this enumeration data type would be:

```

<xsd:element name="weekday" type="tns:weekday"/>
<xsd:simpleType name="weekday">
  <xsd:restriction base="xsd:string">
    <xsd:enumeration value="Mon"/>
    <xsd:enumeration value="Tue"/>
    <xsd:enumeration value="Wed"/>
    <xsd:enumeration value="Thu"/>
    <xsd:enumeration value="Fri"/>
    <xsd:enumeration value="Sat"/>
    <xsd:enumeration value="Sun"/>
  </xsd:restriction>
</xsd:simpleType>

```

9.3.2 Literal Encoding of Enumeration Constants

If the value of an enumeration-typed variable has no corresponding named constant, the value is encoded as a signed integer literal. For example, the following declaration of a `workday` enumeration type lacks named constants for Saturday and Sunday:

```
enum ns1:_workday {Mon, Tue, Wed, Thu, Fri};
```

If the constant 5 (Saturday) or 6 (Sunday) is assigned to a variable of the `workday` enumeration type, the variable will be encoded with the integer literals 5 and 6, respectively. For example:

```
<ns1:workday xsi:type="ns1:workday">5</ns1:workday>
```

Since this is legal in C++ and SOAP allows enumeration constants to be integer literals, this method ensures that non-symbolic enumeration constants are correctly communicated to another party if the other party accepts literal enumeration constants (as with the gSOAP stub and skeleton compiler).

Both symbolic and literal enumeration constants can be decoded.

To enforce the literal enumeration constant encoding and to get the literal constants in the WSDL file, use the following trick:

```
enum ns1:_nums { _1 = 1, _2 = 2, _3 = 3 };
```

The difference with an enumeration type without a list of values and the enumeration type above is that the enumeration constants will appear in the WSDL service description.

9.3.3 Initialized Enumeration Constants

The gSOAP compiler supports the initialization of enumeration constants, as in:

```
enum ns1:_relation {LESS = -1, EQUAL = 0, GREATER = 1};
```

The symbolic names `LESS`, `EQUAL`, and `GREATER` will appear in the SOAP payload for the encoding of the `ns1:_relation` enumeration values -1, 0, and 1, respectively.

9.3.4 How to “Reuse” Symbolic Enumeration Constants

A well-known deficiency of C and C++ enumeration types is the lack of support for the reuse of symbolic names by multiple enumerations. That is, the names of all the symbolic constants defined by an enumeration cannot be reused by another enumeration. To force encoding of the same symbolic name by different enumerations, the identifier of the symbolic name can end in an underscore (_) or any number of underscores to distinguish it from other symbolic names in C++. This guarantees that the SOAP encoding will use the same name, while the symbolic names can be distinguished in C++. Effectively, the underscores are removed from a symbolic name prior to encoding.

Consider for example:

```
enum ns1__workday {Mon, Tue, Wed, Thu, Fri};
enum ns1__weekday {Mon_, Tue_, Wed_, Thu_, Fri_, Sat_, Sun_};
```

which will result in the encoding of the constants of `enum ns1__weekday` without the underscore, for example as `Mon`.

Caution: The following declaration:

```
enum ns1__workday {Mon, Tue, Wed, Thu, Fri};
enum ns1__weekday {Sat = 5, Sun = 6};
```

will not properly encode the `weekday` enumeration, because it lacks the named constants for `workday` in its enumeration list.

9.3.5 Boolean Enumeration Type Encoding and Decoding for C Compilers

When a pure C compiler is used to create SOAP clients and services, the `bool` type may not be supported by the compiler and in that case an enumeration type should be used. The C enumeration-type encoding adopted by the gSOAP stub and skeleton compiler can be used to encode boolean values according to the SOAP encoding style. The namespace prefix can be specified with the usual namespace prefix convention for identifiers to explicitly specify the encoding style. For example, the built-in `boolean` XML schema type supports the mathematical concept of binary-valued logic. The `boolean` XML schema encoding style can be specified by using the `xsd` prefix. For example:

```
enum xsd__boolean {false_, true_};
```

The value `false_`, for example, is encoded as:

```
<xsd:boolean xsi:type="xsd:boolean">false</xsd:boolean>
```

Peculiar of the SOAP boolean type encoding is that it only defines the values 0 and 1, while the built-in XML schema boolean type also defines the `false` and `true` symbolic constants as valid values. The following example declaration of an enumeration type lacks named constants altogether to force encoding of the enumeration values as literal constants:

```
enum SOAP_ENC__boolean {};
```

The value 0, for example, is encoded with an integer literal:

```
<SOAP-ENC:boolean xsi:type="SOAP-ENC:boolean">0<SOAP-ENC:boolean>
```

9.3.6 Bitmask Enumeration Encoding and Decoding

A bitmask is an enumeration of flags such as declared with C#'s [Flags] **enum** annotation. gSOAP supports bitmask encoding and decoding for interoperability. However, bitmask types are not standardized with SOAP RPC.

A special syntactic convention is used in the header file input to the gSOAP compiler to indicate the use of bitmasks with an asterisk:

```
enum * name { enum-constant, enum-constant, ... };
```

The gSOAP compiler will encode the enumeration constants as flags, i.e. as a series of powers of 2 starting with 1. The enumeration constants can be or-ed to form a bitvector (bitmask) which is encoded and decoded as a list of symbolic values in SOAP. For example:

```
enum * ns__machineStatus { ON, BELT, VALVE, HATCH};
int ns__getMachineStatus(char *name, char *enum ns__machineStatus result);
```

Note that the use of the **enum** does not require the asterisk, only the definition. The gSOAP compiler generates the enumeration:

```
enum ns__machineStatus { ON=1, BELT=2, VALVE=4, HATCH=8};
```

A remote method implementation in a Web service can return:

```
int ns__getMachineStatus(struct soap *soap, char *name, enum ns__machineStatus result)
{ ...
  *result = BELT — HATCH;
  return SOAP_OK;
}
```

9.4 Struct Encoding and Decoding

A **struct** data type is encoded as a SOAP compound data type such that the **struct** name forms the data type's element name and schema type and the fields of the **struct** are the data type's accessors. This encoding is identical to the **class** instance encoding without inheritance and method declarations, see Section 9.5 for further details. However, the encoding and decoding of **structs** is more efficient compared to **class** instances due to the lack of inheritance and the requirement by the marshalling routines to check inheritance properties at run time.

Certain fields of a **struct** can be (de)serialized as XML attributes. See 9.5.5 for more details.

9.5 Class Instance Encoding and Decoding

A **class** instance is encoded as a SOAP compound data type such that the **class** name forms the data type's element name and schema type and the data member fields are the data type's accessors. Only the data member fields are encoded in the SOAP payload. Class methods are not encoded.

The general form of a **class** declaration is:

```
class [namespace_prefix_]class_name1 [:[public:] [private:] [protected:] [namespace_prefix_]class_name2]
{
    [public:] [private:] [protected:]
    field1;
    field2;
    ...
    [public:] [private:] [protected:]
    method1;
    method2;
    ...
};
```

where

`namespace_prefix_` is the optional namespace prefix of the compound data type (see identifier translation rules 8.3)

`class_name1` is the element name of the compound data type (see identifier translation rules 8.3).

`class_name2` is an optional base class.

`field` is a field declaration (data member). A field MAY be declared **static** and **const** and MAY be initialized.

`method` is a method declaration. A method MAY be declared **virtual**, but abstract methods are not allowed. The method parameter declarations are REQUIRED to have parameter identifier names.

[**public**:] [**private**:] [**protected**:] are OPTIONAL and have no effect on the declaration and MAY therefore be omitted. All access permissions are converted to **public** by the gSOAP stub and skeleton compiler.

A class name is REQUIRED to be unique and cannot have the same name as a **struct**, **enum**, or remote method name specified in the header file input to the gSOAP compiler. The reason is that remote method requests are encoded similarly to class instances in SOAP and they are in principle undistinguishable (the method parameters are encoded just as the fields of a **class**).

Only single inheritance is supported by the gSOAP compiler. Multiple inheritance is not supported, because of the limitations of the SOAP protocol.

If a constructor method is present, there MUST also be a constructor declaration with empty parameter list.

Templates are not supported by the gSOAP compiler.

Certain fields of a **class** can be (de)serialized as XML attributes. See 9.5.5 for more details.

A **class** instance is encoded as:

```
<[namespace-prefix:]class-name xsi:type="[namespace-prefix:]class-name">
<basefield-name1 xsi:type="...">...</basefield-name1>
<basefield-name2 xsi:type="...">...</basefield-name2>
...
<field-name1 xsi:type="...">...</field-name1>
<field-name2 xsi:type="...">...</field-name2>
...
</[namespace-prefix:]class-name>
```

where the **field-name** accessors have element-name representations of the class fields and the **basefield-name** accessors have element-name representations of the base class fields. (The optional parts resulting from the specification are shown enclosed in [].)

The decoding of a class instance allows any ordering of the accessors in the SOAP payload. However, if a base class field name is identical to a derived class field name because the field is overloaded, the base class field name **MUST** precede the derived class field name in the SOAP payload for decoding. gSOAP guarantees this, but interoperability with other SOAP implementations is cannot be guaranteed.

9.5.1 Example

The following example declares a base class **ns_._Object** and a derived class **ns_._Shape**:

```
// Contents of file "shape.h":
class ns_._Object
{
    public:
    char *name;
};
class ns_._Shape : public ns_._Object
{
    public:
    int sides;
    enum ns_._Color {Red, Green, Blue} color;
    ns_._Shape();
    ns_._Shape(int sides, enum ns_._Color color);
    ~ns_._Shape();
};
```

The implementation of the methods of **class** **ns_._Shape** must not be part of the header file and need to be defined elsewhere.

An instance of **class** **ns_._Shape** with name Triangle, 3 sides, and color Green is encoded as:

```
<ns:Shape xsi:type="ns:Shape">
<name xsi:type="string">Triangle</name>
<sides xsi:type="int">3</sides>
<color xsi:type="ns:Color">Green</color>
</ns:shape>
```

The namespace URI of the namespace prefix **ns** must be defined by a namespace mapping table, see Section 8.4.

9.5.2 Initialized static const Fields

A data member field of a class declared as **static const** is initialized with a constant value at compile time. This field is encoded in the serialization process, but is not decoded in the deserialization process. For example:

```
// Contents of file "triangle.h":
class ns_::Triangle : public ns_::Object
{
    public:
    int size;
    static const int sides = 3;
};
```

An instance of **class** `ns_::Triangle` is encoded in SOAP as:

```
<ns:Triangle xsi:type="ns:Triangle">
<name xsi:type="string">Triangle</name>
<size xsi:type="int">15</size>
<sides xsi:type="int">3</sides>
</ns:Triangle>
```

Decoding will ignore the `sides` field's value.

Caution: The current gSOAP implementation does not support encoding **static const** fields, due to C++ compiler compatibility differences. This feature may be provided the future.

9.5.3 Class Methods

A **class** declaration in the header file input to the gSOAP compiler MAY include method declarations. The method implementations MUST NOT be part of the header file but are required to be defined in another C++ source that is externally linked with the application. This convention is also used for the constructors and destructors of the **class**.

Dynamic binding is supported, so a method MAY be declared **virtual**.

9.5.4 Polymorphism, Derived Classes, and Dynamic Binding

Interoperability between client and service applications developed with gSOAP is established even when clients and/or services use derived classes instead of the base classes used in the declaration of the remote method parameters. A client application MAY use pointers to instances of derived classes for the input parameters of a remote method. If the service was compiled with a declaration and implementation of the derived class, the remote method base class input parameters are demarshalled and a derived class instance is created instead of a base class instance. If the service did not include a declaration of the derived class, the derived class fields are ignored and a base class instance is created. Therefore, interoperability is guaranteed even when the client sends an instance of a derived classes and when a service returns an instance of a derived class.

The following example declares Base and Derived classes and a remote method that takes a pointer to a Base class instance and returns a Base class instance:

```
// Contents of file "derived.h"
class Base
{
    public:
    char *name;
    Base();
    virtual void print();
};
class Derived : public Base
{
    public:
    int num;
    Derived();
    virtual void print();
};
int method(Base *in, struct methodResponse { Base *out; } &result);
```

This header file specification is processed by the gSOAP compiler to produce the stub and skeleton routines which are used to implement a client and service. The pointer of the remote method is also allowed to point to Derived class instances and these instances will be marshalled as Derived class instances and send to a service, which is in accord to the usual semantics of parameter passing in C++ with dynamic binding.

The Base and Derived class method implementations are:

```
// Method implementations of the Base and Derived classes:
#include "soapH.h"
...
Base::Base()
{
    cout << "created a Base class instance" << endl;
}
Derived::Derived()
{
    cout << "created a Derived class instance" << endl;
}
Base::print()
{
    cout << "print(): Base class instance " << name << endl;
}
Derived::print()
{
    cout << "print(): Derived class instance " << name << " " << num << endl;
}
```

Below is an example CLIENT application that creates a Derived class instance that is passed as the input parameter of the remote method:

```
// CLIENT
#include "soapH.h"
```

```

int main()
{
    struct soap soap;
    soap_init(&soap);
    Derived obj1;
    Base *obj2;
    struct methodResponse r;
    obj1.name = "X";
    obj1.num = 3;
    soap_call_method(&soap, url, action, &obj1, r);
    r.obj2->print();
}
...

```

The following example SERVER1 application copies a class instance (Base or Derived class) from the input to the output parameter:

```

// SERVER1
#include "soapH.h"
int main()
{
    soap_serve(soap_new());
}
int method(struct soap *soap, Base *obj1, struct methodResponse &result)
{
    obj1->print();
    result.obj2 = obj1;
    return SOAP_OK;
}
...

```

The following messages are produced by the CLIENT and SERVER1 applications:

```

CLIENT: created a Derived class instance
SERVER1: created a Derived class instance
SERVER1: print(): Derived class instance X 3
CLIENT: created a Derived class instance
CLIENT: print(): Derived class instance X 3

```

Which indicates that the derived class kept its identity when it passed through SERVER1. Note that instances are created both by the CLIENT and SERVER1 by the demarshalling process.

Now suppose a service application is developed that only accepts Base class instances. The header file is:

```

// Contents of file "base.h":
class Base
{
    public:
    char *name;
    Base();
    virtual void print();
};
int method(Base *in, Base *out);

```

This header file specification is processed by the gSOAP stub and skeleton compiler to produce skeleton routine which is used to implement a service (so the client will still use the derived classes).

The method implementation of the Base class are:

```
// Method implementations of the Base class:
#include "soapH.h"
...
Base::Base()
{
    cout << "created a Base class instance" << endl;
}
Base::print()
{
    cout << "print(): Base class instance " << name << endl;
}
```

And the SERVER2 application is that uses the Base class is:

```
// SERVER2
#include "soapH.h"
int main()
{
    soap_serve(soap_new());
}
int method(struct soap *soap, Base *obj1, struct methodResponse &result)
{
    obj1->print();
    result.obj2 = obj1;
    return SOAP_OK;
}
...
```

Here are the messages produced by the CLIENT and SERVER2 applications:

```
CLIENT: created a Derived class instance
SERVER2: created a Base class instance
SERVER2: print(): Base class instance X
CLIENT: created a Base class instance
CLIENT: print(): Base class instance X
```

In this example, the object was passed as a Derived class instance to SERVER2. Since SERVER2 only implements the Base class, this object is converted to a Base class instance and send back to CLIENT.

9.5.5 Struct/Class Encoding With XML Attributes

The SOAP RPC/LIT and SOAP DOC/LIT encoding styles support XML attributes in SOAP messages while SOAP RPC with “Section 5” encoding does not support XML attributes other than the SOAP and XSD specific attributes. SOAP RPC “Section 5” encoding has advantages for

cross-language interoperability and data encodings such as graph serialization. However, RPC/LIT and DOC/LIT enables direct exchange of XML documents, which may include encoded application data structures. Language interoperability is compromised, because no mapping between XML and the typical language data types is defined. The meaning of the RPC/LIT and DOC/LIT XML content is Schema driven rather than application/language driven.

gSOAP supports XML attribute (de)serialization for structs and classes. Attributes are primitive XSD types, such as strings, enumerations, boolean, and numeric types. To declare an XML attribute in a struct/class, the qualifier `@` is used with the type of the attribute. The type must be primitive type (including enumerations and strings), which can be declared with or without a **typedef** to associate a XSD type with the C/C+ type. For example

```
typedef char *xsd__string;
typedef bool *xsd__boolean;
enum ns__state { _0, _1, _2 };
struct ns__myStruct
{
    @ xsd__string ns__type; // encode as XML attribute 'ns:type' of type 'xsd:string'
    @ xsd__boolean ns__flag = false; // encode as XML attribute 'ns:flag' of type 'xsd:boolean'
    @ enum ns__state ns__state = _2; // encode as XML attribute 'ns:state' of type 'ns:state'
    struct ns__myStruct *next;
};
```

The `@` qualifier indicates XML attribute encoding for the `ns__type`, `ns__flag`, and `ns__state` fields. Note that the namespace prefix `ns` is used to distinguish these attributes from any other attributes such as `xsi:type` (`ns:type` is not to be confused with `xsi:type`).

Default values can be associated with any field that has a primitive type in a struct/class, as is illustrated in this example. The default values are used when the receiving message does not contain the corresponding values.

The XSD type `QName` plays a special role in gSOAP to ensure the decoding of the appropriate namespace information from the XML message inbound. An attribute with type `QName` (Qualified Name) contains an optional prefix and a local name. When declaring a `QName` XSD type as a string with a **typedef**, the `QName` values are serialized as strings and the user is responsible to ensure proper formatting of the string as a `QName`. For deserialization however, the `QName` string is changed by replacing the namespace prefix with the namespace prefix defined in the namespace mapping table. If the namespace mapping table has not entry for the namespace name (URI), then the entire URI replaces the namespace prefix in the `QName` to ensure that this information is not lost. For example

```
typedef char *xsd__QName;
struct ns__myStruct
{
    @ xsd__QName ns__name = "ns:abc";
};
```

When the field `ns__name` is serialized, the string contents are just send. Suppose that the inbound value for the `ns__name` is `x:def`, where the namespace name associated with the prefix `x` matches the namespace name of the prefix `ns` (as defined in the namespace mapping table). Then, the value is converted into `ns:def` to ensure proper mapping. If the namespace name is not in the table,

then `x:def` is converted to `"URI":def` where `"URI"` is the namespace URI bound to `x` in the message received.

Because a remote method request and response is essentially a struct, XML attributes can also be associated with method requests and responses. For example

```
typedef char *xsd__string;
int ns__myMethod(@ xsd__string ns__name, ...);
```

Attributes can also be attached to the dynamic arrays, binary types, and wrapper classes/structs of primitive types. Wrapper classes are described in Section 9.2.2. For example

```
struct xsd__string
{
    char *__item;
    @ xsd__boolean flag;
};
```

and

```
struct xsd__base64Binary
{
    unsigned char *__ptr;
    int __size;
    @ xsd__boolean flag;
};
```

The attribute declarations MUST follow the `__item`, `__ptr`, and `__size` fields which define the characteristics of wrapper structs/classes and dynamic arrays.

Caution: Do not use XML attributes with SOAP RPC encoding, unless RPC/LIT is required.

9.6 Pointer Encoding and Decoding

The serialization of a pointer to a data type amounts to the serialization of the data type in SOAP and the SOAP encoded representation of a pointer to the data type is indistinguishable from the encoded representation of the data type pointed to.

9.6.1 Multi-Reference Data

A data structure pointed to by more than one pointer is serialized as SOAP multi-reference data. This means that the data will be serialized only once and identified with a unique `id` attribute. The encoding of the pointers to the shared data is done through the use of `href` attributes to refer to the multi-reference data (also see Section 7.10 on options to control the serialization of multi-reference data). Cyclic C/C++ data structures are encoded with multi-reference SOAP encoding. Consider for example the following a linked list data structure:

```
typedef char *xsd__string;
struct ns__list
{
```

```

    xsd__string value;
    struct ns__list *next;
};

```

Suppose a cyclic linked list is created. The first node contains the value "abc" and points to a node with value "def" which in turn points to the first node. This is encoded as:

```

<ns:list id="1" xsi:type="ns:list">
  <value xsi:type="xsd:string">abc</value>
  <next xsi:type="ns:list">
    <value xsi:type="xsd:string">def</value>
    <next href="#1"/>
  </next>
</ns:list>

```

In case multi-referenced data is received that "does not fit in a pointer-based structure", the data is copied. For example, the following two **structs** are similar, except that the first uses pointer-based fields while the other uses non-pointer-based fields:

```

typedef long xsd__int;
struct ns__record
{
    xsd__int *a;
    xsd__int *b;
} P;
struct ns__record
{
    xsd__int a;
    xsd__int b;
} R;
...
P.a = &n;
P.b = &n;
...

```

Since both a and b fields of P point to the same integer, the encoding of P is multi-reference:

```

<ns:record xsi:type="ns:record">
  <a href="#1"/>
  <b href="#1"/>
</ns:record>
<id id="1" xsi:type="xsd:int">123</id>

```

Now, the decoding of the content in the R data structure that does not use pointers to integers results in a copy of each multi-reference integer. Note that the two **structs** resemble the same XML data type because the trailing underscore will be ignored in XML encoding and decoding.

9.6.2 NULL Pointers and Nil Elements

A NULL pointer is **not** serialized, unless the pointer itself is pointed to by another pointer (but see Section 7.10 to control the serialization of NULLs). For example:


```

struct X
{
    int *p;
    int **q;
}

```

Suppose pointer q points to pointer p and suppose p=NULL. In that case the p pointer is serialized as

```
<... id="123" xsi:nil="true"/>
```

and the serialization of q refers to href="#123". Note that SOAP 1.1 does not support pointer to pointer types (!), so this encoding is specific to gSOAP. The pointer to pointer encoding is rarely used in codes anyway. More common is a pointer to a data type such as a **struct** with pointer fields.

Caution: When the deserializer encounters an XML element that has a `xsi:nil="true"` attribute but the corresponding C++ data is not a pointer or reference, the deserializer will terminate with a SOAP_NULL fault when the SOAP_XML_NIL flag is set. The types section of a WSDL description contains information on the “nilability” of data.

9.7 Fixed-Size Arrays

Fixed size arrays are encoded as per SOAP 1.1 one-dimensional array types. Multi-dimensional fixed size arrays are encoded by gSOAP as nested one-dimensional arrays in SOAP. Encoding of fixed size arrays supports partially transmitted and sparse array SOAP formats.

The decoding of (multi-dimensional) fixed-size arrays supports the SOAP multi-dimensional array format as well as partially transmitted and sparse array formats.

An example:

```

// Contents of header file "fixed.h":
struct Example
{
    float a[2][3];
};

```

This specifies a fixed-size array part of the **struct** Example. The encoding of array a is:

```

<a xsi:type="SOAP-ENC:Array" SOAP-ENC:arrayType="float [] [2]">
<SOAP-ENC:Array xsi:type="SOAP-ENC:Array" SOAP-ENC:arrayType="float [3]"
<float xsi:type="float">...</float>
<float xsi:type="float">...</float>
<float xsi:type="float">...</float>
</SOAP-ENC:Array>
<SOAP-ENC:Array xsi:type="SOAP-ENC:Array" SOAP-ENC:arrayType="float [3]"
<float xsi:type="float">...</float>
<float xsi:type="float">...</float>
<float xsi:type="float">...</float>
</SOAP-ENC:Array>
</a>

```

Caution: Any decoded parts of a (multi-dimensional) array that do not “fit” in the fixed size array are ignored by the deserializer.

9.8 Dynamic Arrays

As the name suggests, dynamic arrays are much more flexible than fixed-size arrays and dynamic arrays are better adaptable to the SOAP encoding and decoding rules for arrays. In addition, a typical C application allocates a dynamic array using `malloc`, assigns the location to a pointer variable, and deallocates the array later with `free`. A typical C++ application allocates a dynamic array using `new`, assigns the location to a pointer variable, and deallocates the array later with `delete`. Such dynamic allocations are flexible, but pose a problem for the serialization of data: how does the array serializer know the length of the array to be serialized given only a pointer to the sequence of elements? The application stores the size information somewhere. This information is crucial for the array serializer and has to be made explicitly known to the array serializer by packaging the pointer and array size information within a **struct** or **class**.

9.8.1 One-Dimensional Dynamic Arrays

A special form of **struct** or **class** is used for one-dimensional dynamic arrays that contains a pointer variable and a field that records the number of elements the pointer points to in memory.

The general form of the **struct** declaration for one-dimensional dynamic arrays is:

```
struct some_name
{
    Type * _ptr;
    int _size;
    [[static const] int _offset [= ...];]
    ... // anything that follows here will be ignored
};
```

where Type MUST be a type associated with an XML schema or MUST be a primitive type. If these conditions are not met, a list/vector (de)serialization is used (see Section 9.8.6). A primitive type can be used with or without a **typedef**. If the array elements are structs or classes, then the struct/class type names should have a namespace prefix for schema association, or they should be other (nested) dynamic arrays.

An alternative to a **struct** is to use a **class** with optional methods that MUST appear after the `_ptr` and `_size` fields:

```
class some_name
{
    public:
    Type * _ptr;
    int _size;
    [[static const] int _offset [= ...];]
    method1;
    method2;
    ... // any fields that follow will be ignored
};
```

To encode the data type as an array, the name of the **struct** or **class** SHOULD NOT have a namespace prefix, otherwise the data type will be encoded and decoded as a SOAP list/vector, see Section 9.8.6.

The deserializer of a dynamic array can decode partially transmitted and/or SOAP sparse arrays, and even multi-dimensional arrays which will be collapsed into a one-dimensional array with row-major ordering.

Caution: SOAP 1.2 does not support partially transmitted arrays. So the `__offset` field of a dynamic array is ignored.

9.8.2 Example

The following example header file specifies the XMethods Service Listing service `getAllSOAPServices` remote method and an array of `SOAPService` data structures:

```
// Contents of file "listing.h":
class ns3_ SOAPService
{
public:
    int ID;
    char *name;
    char *owner;
    char *description;
    char *homepageURL;
    char *endpoint;
    char *SOAPAction;
    char *methodNameNamespaceURI;
    char *serviceStatus;
    char *methodName;
    char *dateCreated;
    char *downloadURL;
    char *wsdlURL;
    char *instructions;
    char *contactEmail;
    char *serverImplementation;
};
class ServiceArray
{
public:
    ns3_ SOAPService *__ptr; // points to array elements
    int __size; // number of elements pointed to
    ServiceArray();
    ~ServiceArray();
    void print();
};
int ns_ getAllSOAPServices(ServiceArray &return_);
```

An example client application:

```
#include "soapH.h" ...
// ServiceArray class method implementations:
ServiceArray::ServiceArray()
{
    __ptr = NULL;
    __size = 0;
```

```

}
ServiceArray::~ServiceArray()
{
    if (!_ptr)
        free(_ptr);
    _size = 0;
}
void ServiceArray::print()
{
    for (int i = 0; i < _size; i++)
        cout << _ptr[i].name << ": " << _ptr[i].homepage << endl;
}
...
// Request a service listing and display results:
{
    struct soap soap;
    ServiceArray result;
    const char *endpoint = "www.xmethods.net:80/soap/servlet/rpcrouter";
    const char *action = "urn:xmethodsServicesManager#getAllSOAPServices";
    ...
    soap_init(&soap);
    soap_call_ns_getAllSOAPServices(&soap, endpoint, action, result);
    result.print();
    ...
}

```

9.8.3 One-Dimensional Dynamic Arrays With Non-Zero Offset

The declaration of a dynamic array as described in 9.8 MAY include an **int** `_offset` field. When set to an integer value, the serializer of the dynamic array will use this field as the start index of the array and the SOAP array offset attribute will be used in the SOAP payload.

For example, the following header file declares a mathematical `Vector` class, which is a dynamic array of floating point values with an index that starts at 1:

```

// Contents of file "vector.h":
typedef float xsd_float;
class Vector
{
    xsd_float *_ptr;
    int _size;
    int _offset;
    Vector();
    Vector(int n);
    float& operator[](int i);
}

```

The implementations of the `Vector` methods are:

```

Vector::Vector()
{
    _ptr = NULL;
}

```

```

    _size = 0;
    _offset = 1;
}
Vector::Vector(int n)
{
    _ptr = (float*)malloc(n*sizeof(float));
    _size = n;
    _offset = 1;
}
Vector::~Vector()
{
    if (_ptr)
        free(_ptr);
}
float& Vector::operator[](int i)
{
    return _ptr[i-_offset];
}

```

An example program fragment that serializes a vector of 3 elements:

```

struct soap soap;
soap_init(&soap);
Vector v(3);
v[1] = 1.0;
v[2] = 2.0;
v[3] = 3.0;
soap_begin(&soap);
v.serialize(&soap);
v.put("vec");
soap_end(&soap);

```

The output is a partially transmitted array:

```

<vec xsi:type="SOAP-ENC:Array" SOAP-ENC:arrayType="xsd:float[4]" SOAP-ENC:offset="[1]">
<item xsi:type="xsd:float">1.0</item>
<item xsi:type="xsd:float">2.0</item>
<item xsi:type="xsd:float">3.0</item>
</vec>

```

Note that the size of the encoded array is necessarily set to 4 and that the encoding omits the non-existent element at index 0.

The decoding of a dynamic array with an `_offset` field is more efficient than decoding a dynamic array without an `_offset` field, because the `_offset` field will be assigned the value of the `SOAP-ENC:offset` attribute instead of padding the initial part of the array with default values.

9.8.4 Nested One-Dimensional Dynamic Arrays

One-dimensional dynamic arrays MAY be nested. For example, using `class` `Vector` declared in the previous section, `class` `Matrix` is declared:

```
// Contents of file "matrix.h":
class Matrix
{
    public:
    Vector *_ptr;
    int _size;
    int _offset;
    Matrix();
    Matrix(int n, int m);
    ~Matrix();
    Vector& operator[](int i);
};
```

The Matrix type is essentially an array of pointers to arrays which make up the rows of a matrix. The encoding of the two-dimensional dynamic array in SOAP will be in nested form.

9.8.5 Multi-Dimensional Dynamic Arrays

The general form of the **struct** declaration for K-dimensional ($K \geq 1$) dynamic arrays is:

```
struct some_name
{
    Type *_ptr;
    int _size[K];
    int _offset[K];
    ... // anything that follows here will be ignored
};
```

where Type MUST be a type associated with an XML schema, which means that it must be a **typedefed** type in case of a primitive type, or a **struct/class** name with a namespace prefix for schema association, or another dynamic array. If these conditions are not met, a list/vector (de)serialization is used (see Section 9.8.6).

An alternative is to use a **class** with optional methods:

```
class some_name
{
    public:
    Type *_ptr;
    int _size[K];
    int _offset[K];
    method1;
    method2;
    ... // any fields that follow will be ignored
};
```

In the above, K is a constant denoting the number of dimensions of the multi-dimensional array.

To encode the data type as an array, the name of the **struct** or **class** SHOULD NOT have a namespace prefix, otherwise the data type will be encoded and decoded as a SOAP list/vector, see Section 9.8.6.

The deserializer of a dynamic array can decode partially transmitted multi-dimensional arrays.

For example, the following declaration specifies a matrix class:

```
typedef double xsd_._double;
class Matrix
{
    public:
    xsd_._double *_._ptr;
    int _._size[2];
    int _._offset[2];
};
```

In contrast to the matrix class of Section 9.8.4 that defined a matrix as an array of pointers to matrix rows, this class has one pointer to a matrix stored in row-major order. The size of the matrix is determined by the `._size` field: `._size[0]` holds the number of rows and `._size[1]` holds the number of columns of the matrix. Likewise, `._offset[0]` is the row offset and `._offset[1]` is the columns offset.

9.8.6 Dynamic Array as List Encoding

In case the name of the **struct** or **class** of a dynamic array has a namespace prefix, the data type is considered a list (a.k.a. vector) and will be serialized as a SOAP list and not encoded as a SOAP array.

For example:

```
struct ns_._Map
{
    struct ns_._Binding {char *key; char *val;} *_._ptr;
    int _._size;
};
```

This declares a dynamic array, but the array will be serialized and deserialized as a list. For example:

```
<ns:Map xsi:type="ns:Map">
<ns:Binding xsi:type="ns:Binding">
<key>Joe</key>
<val>555 77 1234</val>
</ns:Binding>
<ns:Binding xsi:type="ns:Binding">
<key>Susan</key>
<val>555 12 6725</val>
</ns:Binding>
<ns:Binding xsi:type="ns:Binding">
<key>Pete</key>
<val>555 99 4321</val>
</ns:Binding>
</ns:Map>
```

Deserialization is less efficient compared to an array, because the size of the list is not part of the SOAP encoding. Internal buffering is used by the deserializer to collect the elements. When the

end of the list is reached, the buffered elements are copied to a newly allocated space on the heap for the dynamic array.

A list (de)serialization is also in affect for dynamic arrays when the pointer field does not refer to a type that is associated with a schema. For example:

```
struct vector
{
    int * _ptr;
    int _size;
};
```

Since **int** has no association with a schema, a vector structure X is serialized as:

```
<X>
<item>1</item>
<item>-2</item>
...
</X>
```

9.8.7 Polymorphic Dynamic Arrays and Lists

An array of pointers to class instances allows the encoding of polymorphic arrays (arrays of polymorphic element types) and lists. For example:

```
class ns_Object
{
    public:
    ...
};
class ns_Data: public ns_Object
{
    public:
    ...
};
class ArrayOfObject
{
    public:
    ns_Object ** _ptr;
    int _size;
    int _offset;
};
```

The pointers in the array can point to the `ns_Object` base class or `ns_Data` derived class instances which will be serialized and deserialized accordingly in SOAP. That is, the array elements are polymorphic.

9.8.8 How to Change the Tag Names of the Elements of a SOAP Array or List

The `_ptr` field in a **struct** or **class** declaration of a dynamic array may have an optional suffix part that describes the name of the tags of the SOAP array XML elements. The suffix is part of the field name:

Type *__ptrarray_elt_name

The suffix describes the tag name to be used for all array elements. The usual identifier to XML translations apply, see Section 8.3. The default XML element tag name for array elements is `item` (which corresponds to the use of field name `__ptritem`).

Consider for example:

```
struct ArrayOfstring
{
    xsd_string *__ptrstring;    int __size; };
```

The array is serialized as:

```
<array xsi:type="SOAP-ENC:Array" SOAP-ENC:arrayType="xsd:string[2]">
<string xsi:type="xsd:string">Hello</string>
<string xsi:type="xsd:string">World</string>
</array>
```

SOAP 1.1 and 1.2 do not require the use of a specific tag name for array elements. gSOAP will deserialize a SOAP array while ignoring the tag names. Certain XML schemas used in doc/literal encoding may require the declaration of array element tag names.

9.8.9 Embedded Arrays and Lists

An array (or list) can be embedded in a struct/class without the need to declare a separate array data type. When a struct or class type declaration contains a **int** `__size` field and the next field below is a pointer type, gSOAP assumes the pointer type points to an array of values where the `__size` field holds the number of values at run time. Multiple arrays can be embedded in a struct/class by using `__size` field names that end with a unique name suffix.

The general convention for embedding arrays is:

```
struct ns_SomeStruct
{
    ...
    int __sizename1; // number of elements pointed to
    Type1 *field1; // by this field
    ...
    int __sizename2; // number of elements pointed to
    Type2 *field2; // by this field
    ...
};
```

where name1 and name2 are identifiers used as a suffix to distinguish the `__size` field. These names can be arbitrary and are not visible in XML.

For example, the following struct has two embedded arrays:

```
struct ns_Contact
{
```

```

    char *firstName;
    char *lastName;
    int __sizePhones;
    ULONG64 *phoneNumber; // array of phone numbers
    int __sizeEmails;
    char **emailAddress; // array of email addresses
    char *socSecNumber;
};

```

The XML serialization of an example `ns__Contact` is:

```

<mycontact xsi:type="ns:Contact">
  <firstName>Joe</firstName>
  <lastName>Smith</lastName>
  <phoneNumber>5551112222</phoneNumber>
  <phoneNumber>5551234567</phoneNumber>
  <phoneNumber>5552348901</phoneNumber>
  <emailAddress>Joe.Smith@mail.com</emailAddress>
  <emailAddress>Joe@Smith.com</emailAddress>
  <socSecNumber>999999999</socSecNumber>
</mycontact>

```

9.9 Base64Binary XML Schema Type Encoding

The `base64Binary` XML schema type is a special form of dynamic array declared with a pointer (`__ptr`) to an **unsigned char** array.

For example using a **struct**:

```

struct xsd__base64Binary
{
    unsigned char *__ptr;
    int __size;
};

```

Or with a **class**:

```

class xsd__base64Binary
{
public:
    unsigned char *__ptr;
    int __size;
};

```

When compiled by the gSOAP stub and skeleton compiler, this header file specification will generate `base64Binary` serializers and deserializers.

The `SOAP_ENC:base64` encoding is another type for base 64 binary encoding specified by the SOAP data type schema and some SOAP applications may use this form (as indicated by their WSDL descriptions). It is declared by:

```

struct SOAP_ENC__base64
{

```

```

    unsigned char *_ptr;
    int _size;
};

```

Or with a **class**:

```

class SOAP_ENC_base64
{
    unsigned char *_ptr;
    int _size;
};

```

When compiled by the gSOAP stub and skeleton compiler, this header file specification will generate SOAP-ENC:base64 serializers and deserializers.

The advantage of using a **class** is that methods can be used to initialize and manipulate the `_ptr` and `_size` fields. The user can add methods to this class to do this. For example:

```

class xsd_base64Binary
{
    public:
    unsigned char *_ptr;
    int _size;
    xsd_base64Binary(); // Constructor
    xsd_base64Binary(struct soap *soap, int n); // Constructor
    ~xsd_base64Binary(); // Destructor
    unsigned char *location(); // returns the memory location
    int size(); // returns the number of bytes
};

```

Here are example method implementations:

```

xsd_base64Binary::xsd_base64Binary()
{
    _ptr = NULL;
    _size = 0;
}
xsd_base64Binary::xsd_base64Binary(struct soap *soap, int n)
{
    _ptr = (unsigned int*)soap_malloc(soap, n);
    _size = n;
}
xsd_base64Binary::~xsd_base64Binary()
{ }
unsigned char *xsd_base64Binary::location()
{
    return _ptr;
}
int xsd_base64Binary::size()
{
    return _size;
}

```

The following example in C/C++ reads from a raw image file and encodes the image in SOAP using the `base64Binary` type:

```
...
FILE *fd = fopen("image.jpg", "r");
xsd_base64Binary image(filesize(fd));
fread(image.location(), image.size(), 1, fd);
fclose(fd);
soap_begin(&soap);
image.soap_serialize(&soap);
image.soap_put(&soap, "jpegimage", NULL);
soap_end(&soap);
...
```

where `filesize` is a function that returns the size of a file given a file descriptor.

Reading the `xsd:base64Binary` encoded image.

```
...
xsd_base64Binary image;
soap_begin(&soap);
image.get(&soap, "jpegimage");
soap_end(&soap);
...
```

The **struct** or **class** name `soap_enc_base64` should be used for `SOAP-ENC:base64` schema type instead of `xsd_base64Binary`.

9.10 hexBinary XML Schema Type Encoding

The `hexBinary` XML schema type is a special form of dynamic array declared with the name `xsd_hexBinary` and a pointer (`_ptr`) to an **unsigned char** array.

For example, using a **struct**:

```
struct xsd_hexBinary
{
    unsigned char *_ptr;
    int _size;
};
```

Or using a **class**:

```
class xsd_hexBinary
{
    public:
    unsigned char *_ptr;
    int _size;
};
```

When compiled by the gSOAP stub and skeleton compiler, this header file specification will generate `base64Binary` serializers and deserializers.

9.11 Doc/Literal XML Encoding Style

gSOAP supports doc/literal SOAP encoding of request and/or response messages. However, the XML schema of the message data must be known in order for the gSOAP compiler to generate the (de)serialization routines. In addition, arbitrary XML documents can be (de)serialized into regular C strings or wide character strings (`wchar_t*`) by gSOAP. Because XML documents are stored in strings, an application may need a “plug-in” XML parser to decode XML content stored in strings. For details on (de)serialization XML into strings, see Section 9.11.1.

gSOAP supports doc/literal SOAP encoding either manually by setting the values of `soap.encodingStyle`, `soap.defaultNamespace`, and by using the flag `SOAP_XML_TREE` for output mode in your code, or automatically by using a gSOAP directive in the header file. In most doc/literal cases, the `SOAP-ENV:encodingStyle` attribute needs to be absent. To do this, set `soap.encodingStyle=NULL`. Furthermore, a default namespace needs to be defined by setting `soap.defaultNamespace`. Finally, doc/literal is a limited form of serialization and does not support graphs. So setting the flag `SOAP_XML_TREE` will produce tree-structured output preventing multi-reference data. Note that cyclic data will crash the doc/literal serializer because of this setting. Also polymorphic data may cause deserialization problems due to the absense of type information in the SOAP payload (which makes us wonder why doc/literal is the default in .NET).

The `LocalTimeByZipCode` remote method of the `LocalTime` service provides the local time given a zip code and uses doc/literal SOAP encoding (using MS .NET). The following header file declares the method:

```
int LocalTimeByZipCode(char *ZipCode, char **LocalTimeByZipCodeResult);
```

Note that none of the data types need to be namespace qualified using namespace prefixes. The use of namespace prefixes is optional for doc/literal in gSOAP. When used, the XML document will include `xsi:type` attributes.

To illustrate the manual doc/literal setting, the following client program sets the required properties before the call:

```
#include "soapH.h"
int main()
{
    struct soap soap;
    char *t;
    soap_init(&soap);
    soap.encodingStyle = NULL; // don't use SOAP encoding
    soap.defaultNamespace = "http://alethea.net/webservices/"; // use the service's namespace
    soap_set_omode(&soap, SOAP_XML_TREE); // don't produce multi-ref data (but can accept)
    if (soap_call_LocalTimeByZipCode(&soap, "http://alethea.net/webservices/LocalTime.asmx", "http://alethea.net/w
    "32306", &t))
        soap_print_fault(&soap, stderr);
    else
        printf("Time = %s\n", t);
    return 0;
}
struct Namespace namespaces[] =
{
    {"SOAP-ENV", "http://schemas.xmlsoap.org/soap/envelope/"},

```

```

    {"SOAP-ENC", "http://schemas.xmlsoap.org/soap/encoding/"},
    {"xsi", "http://www.w3.org/2001/XMLSchema-instance", "http://www.w3.org/*/XMLSchema-
instance"},
    {"xsd", "http://www.w3.org/2001/XMLSchema", "http://www.w3.org/*/XMLSchema"},
    {NULL, NULL}
};

```

The SOAP request is:

```

POST /webservises/LocalTime.asmx HTTP/1.0
Host: alethea.net
Content-Type: text/xml; charset=utf-8
Content-Length: 479
SOAPAction: "http://alethea.net/webservises/LocalTimeByZipCode"

<?xml version="1.0" encoding="UTF-8"?>
<SOAP-ENV:Envelope
  xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
  xmlns:SOAP-ENC="http://schemas.xmlsoap.org/soap/encoding/"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  xmlns="http://alethea.net/webservises/">
  <SOAP-ENV:Body>
    <LocalTimeByZipCode><ZipCode>32306</ZipCode></LocalTimeByZipCode>
  </SOAP-ENV:Body>
</SOAP-ENV:Envelope>

```

Alternatively, the settings can be automatically set by including gSOAP directives in the header file:

```

//gsoap ns service name: localtime
//gsoap ns service encoding: literal
//gsoap ns service namespace: http://alethea.net/webservises/
int ns_ _LocalTimeByZipCode(char *ZipCode, char **LocalTimeByZipCodeResult);

```

In this case, the method name requires to be associated with a schema through a namespace prefix, e.g. ns is used in this example. See Section 13.2 for more details on gSOAP directives. With these directives, the gSOAP compiler generates client and server sources with the specified settings. The directives are required to produce a WSDL file for a new service that uses doc/literal encoding.

The example client program can be simplified into:

```

#include "soapH.h"
#include "localtime.nsmap" // include generated map file
int main()
{
  struct soap soap;
  char *t;
  soap_init(&soap);
  if (soap_call_ns_ _LocalTimeByZipCode(&soap, "http://alethea.net/webservises/LocalTime.asmx",
    "http://alethea.net/webservises/LocalTimeByZipCode", "32306", &t))
    soap_print_fault(&soap, stderr);
}

```

```

    else
        printf("Time = %s\n", t);
    return 0;
}

```

9.11.1 Serializing and Deserializing XML Into Strings

To declare a literal XML “type” to hold XML documents in regular strings, use:

```
typedef char *XML;
```

To declare a literal XML “type” to hold XML documents in wide character strings, use:

```
typedef wchar_t *XML;
```

Note: only one of the two storage formats can be used. The differences between the use of regular strings versus wide character strings for XML documents are:

- Regular strings for XML documents **MUST** hold UTF-8 encoded XML documents. That is, the string **MUST** contain the proper UTF-8 encoding to exchange the XML document in SOAP messages.
- Wide character strings for XML documents **SHOULD NOT** hold UTF-8 encoded XML documents. Instead, the UTF-8 translation is done automatically by the gSOAP runtime marshalling routines.

Literal XML encoding should only use one input parameter and one output parameter. Here is an example of a remote method specification in which the parameters of the remote method uses literal XML encoding to pass an XML document to a service and back:

```
typedef char *XML;
ns_._GetDocument(XML m_._XMLDoc, XML &m_._XMLDoc_);
```

The `ns_._Document` is essentially a **struct** that forms the root of the XML document. The use of the underscore in the `ns_._Document` response part of the message avoids the name clash between the **structs**. Assuming that the namespace mapping table contains the binding of `ns` to `http://my.org/` and the binding of `m` to `http://my.org/mydoc.xsd`, the XML message is:

```

<?xml version="1.0" encoding="UTF-8"?>
<SOAP-ENV:Envelope
  xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
  xmlns:SOAP-ENC="http://schemas.xmlsoap.org/soap/encoding/"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  xmlns:ns="http://my.org/"
  xmlns:m="http://my.org/mydoc.xsd"
  SOAP-ENV:encodingStyle="">
  <SOAP-ENV:Body>
    <ns:GetDocument>

```

```

        <XMLDoc xmlns="http://my.org/mydoc.xsd">
            ...
        </XMLDoc>
    </ns:Document>
</SOAP-ENV:Body>
</SOAP-ENV:Envelope>

```

Important: the literal XML encoding style MUST be specified by setting `soap.encodingStyle`, where `soap` is a variable that contains the current runtime environment. For example, to specify no constraints on the encoding style (which is typical) use `NULL`:

```

struct soap soap;
soap_init(&soap);
soap.encodingStyle = NULL;

```

As a result, the `SOAP-ENV:encodingStyle` attribute will not appear in the SOAP payload.

For interoperability with Apache SOAP, use

```

struct soap soap;
soap_init(&soap);
soap.encodingStyle = "http://xml.apache.org/xml-soap/literalxml";

```

The name of the response element can be changed (default is the remote method name ending with `Response`). For example:

```

typedef char *XML;
ns_._GetDocument(struct soap *soap, XML m_._XMLDoc, struct ns_._Document { XML m_._XMLDoc;
} &result);

```

10 SOAP Fault Processing

A predeclared standard SOAP Fault data structure is generated by the gSOAP stub and skeleton compiler for exchanging exception messages. This predeclared data structure is:

```

struct SOAP_ENV_._Fault
{
    char *faultcode;
    char *faultstring;
    char *faultactor;
    char *detail;
    char *SOAP_ENV_._Code;
    char *SOAP_ENV_._Reason;
    char *SOAP_ENV_._Detail;
};

```

The first four fields are SOAP 1.1 specific. The last three fields are SOAP 1.2 specific. The data structure can be changed to the need of an application. To do this, include a new declaration of a `struct SOAP_ENV_._Fault` in the header file input to the gSOAP compiler to replace the built-in data structure. For example:


```

struct SOAP_ENV__Fault
{
    char *faultcode; // MUST be string
    char *faultstring; // MUST be string
    char *faultactor;
    Detail *detail; // new detail field
    char *SOAP_ENV__Code; // MUST be string
    char *SOAP_ENV__Reason; // MUST be string
    char *SOAP_ENV__Detail; // MUST be string
    Detail SOAP_ENVB Detail; // new SOAP 1.2 detail field
};

```

where Detail is some data type that holds application specific data such as a stack dump.

When the skeleton of a remote method returns an error (see Section 8.2), then `soap.fault` contains the SOAP Fault data at the receiving side (client).

When a remote method wants to raise an exception, it does so by assigning the `fault` field of the current reference to the runtime environment with appropriate data associated with the exception and by returning the error `SOAP_FAULT`. For example:

```

soap_receiver_fault(soap, "Stack dump", NULL);
if (soap->version == 2)
    soap->fault->SOAP_ENV__Detail = sp; // SOAP 1.2: point to stack
else
    soap->fault->detail = sp; // SOAP 1.1: point to stack
return SOAP_Fault; // return from remote method call

```

When `soap_fault` allocates a fault struct, this data is removed with the `soap_end` call (or `soap_dealloc`). Note that the `soap_receiver_fault` function is called to allocate the fault struct and set the fault string and detail fields, i.e. `soap_receiver_fault(soap, "Stack dump", NULL)`. The advantage is that this is independent of SOAP 1.1 and SOAP 1.2. However, setting the custom detail fields requires inspecting the SOAP version used, using the `soap->version` attribute which is 1 for SOAP 1.1 and 2 for SOAP 1.2.

Each remote method implementation in a service application can return a SOAP Fault upon an exception by returning an error code, see Section 6.2.1 for details and an example. In addition, a SOAP Fault can be returned by a service application through calling the `soap_send_fault` function. This is useful in case the initialization of the application fails, as illustrated in the example below:

```

int main()
{
    struct soap soap;
    soap_init(&soap);
    some initialization code
    if (initialization failed)
    {
        soap.error = soap_receiver_fault(&soap, "Init failed", "..."); // set the error condition (SOAP_FAULT)
        soap_send_fault(&soap); // Send SOAP Fault to client
        return 0; // Terminate
    }
}

```

11 SOAP Header Processing

A predeclared standard SOAP Header data structure is generated by the gSOAP stub and skeleton compiler for exchanging SOAP messages with SOAP Headers. This predeclared data structure is:

```
struct SOAP_ENV__Header
{ void *dummy;
};
```

which declares an empty header (some C and C++ compilers don't accept empty structs so a transient dummy field is provided).

To adapt the data structure to a specific need for SOAP Header processing, a new **struct** `SOAP_ENV__Header` can be added to the header file input to the gSOAP compiler. A **class** for the SOAP Header data structure can be used instead of a **struct**.

For example, the following header can be used for transaction control:

```
struct SOAP_ENV__Header
{ char *t__transaction;
};
```

with client-side code:

```
struct soap soap;
soap_init(&soap);
...
soap.header = NULL; // do not use a SOAP Header for the request (as set with soap_init)
soap.actor = NULL; // do not use an actor (receiver is actor)
soap_call_method(&soap, ...);
if (soap.header) // a SOAP Header was received
    cout << soap.header->t__transaction;
// Can reset, modify, or set soap.header here before next call
soap_call_method(&soap, ...); // reuse the SOAP Header of the service response for the request
...
```

The SOAP Web service response can include a SOAP Header with a transaction number that the client is supposed to use for the next remote method invocation to the service. Therefore, the next request includes a transaction number:

```
...
<SOAP-ENV:Envelope ...>
<SOAP-ENV:Header>
<t:transaction xsi:type="int">12345</t:transaction>
</SOAP-ENV:Header>
<SOAP-ENV:Body>
...
</SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

This is just an example and the transaction control is not a feature of SOAP but can be added on by the application layer to implement stateful transactions between clients and services. At the

client side, the `soap.actor` attribute can be set to indicate the recipient of the header (the SOAP `SOAP-ENV:actor` attribute).

A Web service can read and set the SOAP Header as follows:

```
int main()
{
    struct soap soap;
    soap.actor = NULL; // use this to accept all headers (default)
    soap.actor = "http://some/actor"; // accept headers destined for "http://some/actor" only
    soap_serve(&soap);
}
...
int method(struct soap *soap, ...)
{
    if (soap->header) // a Header was received
        ... = soap->header->t._transaction;
    else
        soap->header = soap_malloc(sizeof(struct SOAP_ENV__Header)); // alloc new header
    ... soap->header->t._transaction = ...;
    return SOAP_OK;
}
```

See Section 13.2 on how to generate WSDL with the proper method-to-header-part bindings.

The `SOAP-ENV:mustUnderstand` attribute indicates the requirement that the recipient of the SOAP Header (who must correspond to the `SOAP-ENV:actor` attribute when present or when the attribute has the value `SOAP-ENV:actor="http://schemas.xmlsoap.org/soap/actor/next"`) MUST handle the Header part that carries the attribute. gSOAP handles this automatically on the background. However, an application still needs to inspect the header part's value and handle it appropriately. If a remote method in a Web service is not able to do this, it should return `SOAP_MUSTUNDERSTAND` to indicate this failure.

The syntax for the header file input to the gSOAP compiler is extended with a special storage qualifier `mustUnderstand`. This qualifier can be used in the SOAP Header declaration to indicate which parts should carry a `SOAP-ENV:mustUnderstand="1"` attribute. For example:

```
struct SOAP_ENV__Header
{
    char *t._transaction;
    mustUnderstand char *t._authentication;
};
```

When both fields are set and `soap.actor="http://some/actor"` then the message contains:

```
<SOAP-ENV:Envelope ...>
<SOAP-ENV:Header>
<t:transaction>5</t:transaction>
<t:authentication SOAP-ENV:actor="http://some/actor" SOAP-ENV:mustUnderstand="1">XX</t:authentication>
</SOAP-ENV:Header>
<SOAP-ENV:Body>
...
</SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

12 DIME Attachment Processing

gSOAP can transmit binary data with DIME attachments with or without streaming. With DIME output streaming, the binary data is retrieved from an application's data source at run time in parts without storing the entire content. With DIME input streaming, the binary data will be handed to the application in parts. DIME streaming is implemented with function callbacks. See Section 12.2 for more details.

12.1 Non-Streaming DIME

Without streaming, the binary data is stored in augmented `xsd:base64Binary` and `xsd:hexBinary` structs/classes. These structs/classes have three additional fields: an `id` field for attachment referencing (typically a content id (CID) or UUID), a `type` field to specify the MIME type of the binary data, and an `options` field to piggy-back additional information with a DIME attachment. DIME attachment support is fully automatic, which means that gSOAP will test for the presence of attachments at run time and use SOAP in DIME accordingly.

A `xsd:base64Binary` type with DIME attachment support is declared by

```
struct xsd__base64Binary
{
    unsigned char *_ptr;
    int _size;
    char *id;
    char *type;
    char *options;
};
```

The specification order of the fields is significant. In addition, no other fields or methods may be declared before any of these fields in the struct/class, but additional fields and methods can appear after the field declarations. A `xsd:hexBinary` declaration is similar. When the `id` field and/or `type` field is non-NULL during run-time serialization of the data, DIME attachment transmission is used for the *entire* SOAP message, as per SOAP in DIME specifications. When only the `type` field is set, gSOAP will assign a default DIME id to the attachment (see also below). The `options` field is an optional string with a special layout: the first two bytes are reserved for the option type, the next two bytes store the size of the option data, followed by the option data. The function

```
char *soap_option(struct soap *soap, unsigned short type, const char *option)
```

returns a string with this encoding. For example

```
struct xsd__base64Binary image;
image._ptr = ...;
image._size = ...;
image.id = "uuid:09233523-345b-4351-b623-5dsf35sgs5d6";
image.type = "image/jpeg";
image.options = soap_option(soap, 0, "My wedding picture");
```

When receiving DIME attachments, the fields will be set according to the DIME attachment content. If binary data is received without attachments, the `id`, `type`, `options` fields are all NULL. Note

that SOAP messages may contain binary data that references external resources not provided as attachments. In that case, the `_ptr` field is NULL and the `id` field refers to the external data source. Non-augmented binary data types `xsd:base64Binary` and `xsd:hexBinary` can be used to receive DIME attachments, but the `id`, `type`, and `options` information are absent. Also DIME attachments can be received and stored in strings, but not send from strings.

When necessary, the `xsd:base64Binary` schema type and its attachment-based counterpart can be specified with class inheritance. For example:

```
class xsd__base64Binary
{
    unsigned char *_ptr;
    int _size;
};
class xsd__base64Binary_ : xsd__base64Binary
{
    char *id;
    char *type;
    char *options;
};
```

The `dime_id_format` attribute of the current gSOAP run-time environment can be set to the default format of DIME id fields. The format string MUST contain a `%d` format specifier (or any other **int**-based format specifier). The value of this specifier is a non-negative integer, with zero being the value of the DIME attachment id for the SOAP message. For example,

```
struct soap soap;
soap_init(&soap);
soap.dime_id_format = "uuid:09233523-345b-4351-b623-5dsf35sgs5d6-%x";
```

As a result, all attachments with a NULL `id` field will use a gSOAP-generated id value based on the format string.

12.2 Streaming DIME

Three function callbacks for streaming DIME output and three callbacks for streaming DIME input are available. These callbacks are used to access application data resources during transmission.

Callback (function pointer)

void *(*)(soap.fdimereadopen)(**struct** soap *soap, **void** *handle, **const** **char** *id, **const** **char** *type, **const** **char** *options)*

Called from the gSOAP run-time DIME attachment sender to start reading from a (binary) data source for outbound transmission. The content will be read from the application's data source in chunks using the `fdimeread` callback and streamed into the SOAP/XML/DIME output stream. The `handle` contains the value of the `__ptr` field of an attachment struct/class, which could be a pointer to specific information such as a file descriptor or a pointer to a string to be passed to this callback. Both `__ptr` and `__size` fields should have been set by the application prior to the serialization of the content. The `id`, `type`, and `options` arguments are the DIME id, type, and options, respectively. The callback should return `handle`, or another pointer value which will be passed as a handle to `fdimeread` and `fdimereadclose`. The callback should return `NULL` and set `soap->error` when an error occurred. The callback should return `NULL` (and not set `soap->error`) when this particular DIME attachment is not to be streamed.

size_t *(*)(soap.fdimeread)(**struct** soap *soap, **void** *handle, **char** *buf, **size_t** len)*

Called from the gSOAP run-time DIME attachment sender to read more data from a (binary) data source for streaming into the output stream. The `handle` contains the value returned by the `fdimereadopen` callback. The `buf` argument is the buffer of length `len` into which a chunk of data should be stored. The actual amount of data stored in the buffer might be less than `len` and the amount should be returned by the application. A return value of 0 indicates an error. The `__size` field of the attachment struct/class should have been set by the application prior to the serialization of the content. The value of `__size` indicates the total size of the content to be transmitted.

void *(*)(soap.fdimereadclose)(**struct** soap *soap, **void** *handle)*

Called from the gSOAP run-time DIME attachment sender at the end of the streaming process to close the data source. The `handle` contains the value returned by the `fdimereadopen` callback. The `fdimewriteclose` callback is called after successfully transmitting the data or when an error occurred.

void *(*)(soap.fdimewriteopen)(**struct** soap *soap, **const** **char** *id, **const** **char** *type, **const** **char** *options)*

Called from the gSOAP run-time DIME attachment receiver to start writing an inbound DIME attachment to an application's data store. The content is streamed into an application data store through multiple `fdimewrite` calls from the gSOAP attachment receiver. The `id`, `type`, and `options` arguments are the DIME id, type, and options, respectively. The callback should return a handle which is passed to the `fdimewrite` and `fdimewriteclose` callbacks. The `__ptr` field of the attachment struct/class is set to the value of this handle. The `__size` field is set to the total size of the attachment after receiving the entire content. The size is unknown in advance because a DIME attachment may be chunked.

int *(*)(soap.fdimewrite)(**struct** soap *soap, **void** *handle, **const** **char** *buf, **size_t** len)*

Called from the gSOAP run-time DIME attachment receiver to write part of an inbound DIME attachment to an application's data store. The `handle` contains the value returned by the `fdimewriteopen` callback. The `buf` argument contains the data of length `len`. The callback should return a gSOAP error code (e.g. `SOAP_OK` when no error occurred).

void *(*)(soap.fdimewriteclose)(**struct** soap *soap, **void** *handle)*

Called from the gSOAP run-time DIME attachment receiver at the end of the streaming process to close the data store. The `handle` contains the value returned by the `fdimewriteopen` callback. The `fdimewriteclose` callback is called after successfully receiving the data or when an error occurred.

In addition, a **void***`user` field in the **struct** `soap` data structure is available to pass user-defined data to the callbacks.

The following example illustrates the client-side initialization of an image attachment struct to stream a file into a DIME attachment:

```

int main()
{
    struct soap soap;
    struct xsd__base64Binary image;
    FILE *fd;
    struct stat sb;
    soap_init(&soap);
    if (!fstat(fileno(fd), &sb) && sb.st_size > 0)
    { // because we can get the length of the file, we can stream it
        soap.fdimereadopen = dime_read_open;
        soap.fdimereadclose = dime_read_close;
        soap.fdimeread = dime_read;
        image._ptr = (unsigned char*)fd; // must set to non-NULL (this is our fd handle which we
need in the callbacks)
        image._size = sb.st_size; // must set size
    }
    else
    { // don't know the size, so buffer it
        size_t i;
        int c;
        image._ptr = (unsigned char*)soap_malloc(&soap, MAX_FILE_SIZE);
        for (i = 0; i < MAX_FILE_SIZE; i++)
        {
            if ((c = fgetc(fd)) == EOF)
                break;
            image._ptr[i] = c;
        }
        fclose(fd);
        image._size = i;
    }
    image.type = "image/jpeg";
    image.options = soap_dime_option(&soap, 0, "My picture");
    soap_call_ns__method(&soap, ...);
    ...
}

void *dime_read_open(struct soap *soap, void *handle, const char *id, const char *type, const
char *options)
{ return handle;
}

void dime_read_close(struct soap *soap, void *handle)
{ fclose((FILE*)handle);
}

size_t dime_read(struct soap *soap, void *handle, char *buf, size_t len)
{ return fread(buf, 1, len, (FILE*)handle);
}

```

The following example illustrates the streaming of a DIME attachment into a file by a client:

```

int main()
{ struct soap soap;
  soap_init(&soap);
  soap.fdimewriteopen = dime_write_open;
  soap.fdimewriteclose = dime_write_close;

```

```

    soap.fdimewrite = dime_write;
    soap_call_ns_._method(&soap, ...);
    ...
}
void *dime_write_open(struct soap *soap, const char *id, const char *type, const char *options)
{
    FILE *handle = fopen("somefile", "wb");
    if (!handle)
    {
        soap->error = SOAP_EOF;
        soap->errnum = errno; // get reason
    }
    return (void*)handle;
}
void dime_write_close(struct soap *soap, void *handle)
{ fclose((FILE*)handle);
}
int dime_write(struct soap *soap, void *handle, const char *buf, size_t len)
{
    size_t nwritten;
    while (len)
    {
        nwritten = fwrite(buf, 1, len, (FILE*)handle);
        if (!nwritten)
        {
            soap->errnum = errno; // get reason
            return SOAP_EOF;
        }
        len -= nwritten;
        buf += nwritten;
    }
    return SOAP_OK;
}

```

13 Advanced Features

13.1 Internationalization

The use of wide-character strings (`wchar_t*`) in C and C++ clients and services suffices for internationalization. In contrast, when strings with wide characters are received and stored in regular strings, only the lower 8 bits of the wide characters are retained. The `SOAP_C_UTFSTRING` flag can be set to enable send and/or receive of wide-characters with regular strings. With this flag set, text will be stored in UTF8 format in the strings directly, which means that character codes 1 to 127 are treated as plain ASCII. Codes with the MSB set are UTF8-encoded characters. Please consult the UTF8 specification for details.

13.2 Customizing the WSDL and Namespace Mapping Table File Contents

A header file can be augmented with directives for the gSOAP Stub and Skeleton compiler to automatically generate customized WSDL and namespace mapping tables contents. The WSDL

and namespace mapping table files do not need to be modified by hand (Sections 6.2.5 and 8.4). In addition, the sample SOAP/XML request and response files generated by the compiler are valid provided that XML schema namespace information is added to the header file with directives so that the gSOAP compiler can produce example SOAP/XML messages that are correctly namespace qualified. These compiler directives are specified as `//-comments`.

Three directives are currently supported that can be used to specify details associated with namespace prefixes used by the remote method names in the header file. To specify the name of a Web Service in the header file, use:

```
//gsoap namespace-prefix service name: service-name
```

where *namespace-prefix* is a namespace prefix used by identifiers in the header file and *service-name* is the name of a Web Service (only required to create new Web Services). The name may be followed by text up to the end of the line which is incorporated into the WSDL service documentation. Alternatively, the service documentation can be provided with the directive below.

To specify the documentation of a Web Service in the header file, use:

```
//gsoap namespace-prefix service documentation: text
```

where *namespace-prefix* is a namespace prefix used by identifiers in the header file and *text* is the documentation text up to the end of the line. The text is incorporated into the WSDL service documentation.

To specify the portType of a Web Service in the header file, use:

```
//gsoap namespace-prefix service portType: portType
```

where *namespace-prefix* is a namespace prefix used by identifiers in the header file and *portType* is the portType name of the WSDL service portType.

To specify the location (or port endpoint) of a Web Service in the header file, use:

```
//gsoap namespace-prefix service location: URL
```

or alternatively

```
//gsoap namespace-prefix service port: URL
```

where *URL* is the location of the Web Service (only required to create new Web Services). The *URL* specifies the path to the service executable (so *URL/service-executable* is the actual location of the executable when declared).

To specify the name of the executable of a Web Service in the header file, use:

```
//gsoap namespace-prefix service executable: executable-name
```

where *executable-name* is the name of the executable of the Web Service.

To specify the namespace URI of a Web Service in the header file, use:

```
//gsoap namespace-prefix service namespace: namespace-URI
```

where *namespace-URI* is the URI associated with the namespace prefix.

In addition, the schema namespace URI can be specified in the header file:

```
//gsoap namespace-prefix schema namespace: namespace-URI
```

where *namespace-URI* is the schema URI associated with the namespace prefix. If present, it defines the schema-part of the generated WSDL file and the URI in the namespace mapping table. This declaration is useful when the service declares its own data types that need to be associated with a namespace. Furthermore, the header file for client applications do not need the full service details and the specification of the schema namespaces for namespace prefixes suffices.

To document a method, use:

```
//gsoap namespace-prefix service method-documentation: method-name //text
```

where *method-name* is the unqualified name of the method and *text* is a line of text terminated by a newline. Do not use any XML reserved characters in *text* such as < and >. Use XML and XHTML markup instead. For example:

```
//gsoap ns service method-documentation: getQuote This method returns a stock quote
int ns._getQuote(char *symbol, float &_result);
```

To specify the SOAPAction for a method, use:

```
//gsoap namespace-prefix service method-action: method-name action
```

where *method-name* is the unqualified name of the method and *action* is a quoted or non-quoted string (spaces and blanks are not allowed). For example:

```
//gsoap ns service method-action: getQuote ""
int ns._getQuote(char *symbol, float &_result);
```

When header processing is required, each method declared in the WSDL should provide a binding to the parts of the header that may appear as part of a method request message. Such a binding is given by:

```
//gsoap namespace-prefix service method-header-part: method-name header-part
```

For example:

```
struct SOAP_ENV__Header
{
    char *h._transaction;
    struct UserAuth *h._authentication;
};
```

Suppose method `ns._login` uses both header parts (at most), then this is declared as:

```
//gsoap ns service method-header-part: login transaction
//gsoap ns service method-header-part: login authentication
int ns._login(...);
```

Suppose method `ns_`search uses only the first header part (at most), then this is declared as:

```
//gsoap ns service method-header-part: search transaction
int ns_
```

Note that the method name and header part names in the directive are left unqualified.

To specify the header parts for the method input (method request message), use:

```
//gsoap namespace-prefix service method-input-header-part: method-name header-part
```

Similarly, to specify the header parts for the method output (method response message), use:

```
//gsoap namespace-prefix service method-output-header-part: method-name header-part
```

The declarations above only affect the WSDL. It's the application's responsibility to set and reset the header messages.

When doc/literal encoding is required, the service encoding can be specified in the header file:

```
//gsoap namespace-prefix service encoding: literal
```

or when the `SOAP-ENV:encodingStyle` attribute is different from the SOAP 1.1 encoding style:

```
//gsoap namespace-prefix service encoding: encoding-style
```

(Note: blanks can be used anywhere in the directive, except between `//` and `gsoap`.)

The use of these directive is best illustrated with an example. The `quotex.h` header file of the `quotex` example in the gSOAP distribution for Unix/Linux is:

```
//gsoap ns1 service namespace: urn:xmethods-delayed-quotes
int ns1_
```

The `quotex` example is a new Web Service created by combining two existing Web Services: the XMethods Delayed Stock Quote service and XMethods Currency Exchange service.

Namespace prefix `ns3` is used for the new `quotex` Web Service with namespace URI `urn:quotex`, service name `quotex`, and location `http://www.cs.fsu.edu/~engelen`. Since the new Web Service invokes the `ns1_`getQuote and `ns2_`getRate remote methods, the service namespaces of these methods are given. The service names and locations of these methods are not given because they are only required for setting up a new Web Service for these methods (but may also be provided in the header file for documentation purposes). After invoking the gSOAP Stub and Skeleton compiler on the `quotex.h` header file:

soapcpp2 quotex.h

the WSDL of the new quotex Web Service is saved as quotex.wsdl. Since the service name (quotex), location (<http://www.cs.fsu.edu/~engelen>), and namespace URI (urn:quotex) were provided in the header file, the generated WSDL file does not need to be changed by hand and can be published immediately together with the compiled Web Service installed as a CGI application at the designated URL (<http://www.cs.fsu.edu/~engelen/quotex.cgi> and <http://www.cs.fsu.edu/~engelen/quotex.wsdl>).

The namespace mapping table for the quotex.cpp Web Service implementation is saved as quotex.nsmmap. This file can be directly included in quotex.cpp instead of specified by hand in the source of quotex.cpp:

```
#include "quotex.nsmmap"
```

The automatic generation and inclusion of the namespace mapping table requires compiler directives for **all** namespace prefixes to associate each namespace prefix with a namespace URI. Otherwise, namespace URIs have to be manually added to the table (they appear as <http://tempuri.org>).

13.3 How to Specify minOccurs and maxOccurs Schema Attributes

By default, gSOAP generates WSDL and schemas with minOccurs=1 and maxOccurs=1 for non-array types, and minOccurs=0 and maxOccurs=unbounded for array types. The minOccurs and maxOccurs attribute values of fields in **struct** and **class** types are specified as

Type fieldname [minOccurs[:maxOccurs]] [= value]

The minOccurs and maxOccurs values must be integer literals.

For example

```
struct ns_..MyRecord
{
    int n;
    int m 0;
    int _size 0:10;
    int *item;
}
```

gSOAP generates:

```
<complexType name="MyRecord">
  <all>
    <element name="n" type="xsd:int" minOccurs="1" maxOccurs="1"/>
    <element name="m" type="xsd:int" minOccurs="0" maxOccurs="1"/>
    <element name="item" type="xsd:int" minOccurs="0" maxOccurs="10"/>
  </all>
</complexType>
```

13.4 Transient Data Types

There are situations when certain data types have to be ignored by gSOAP for the compilation of (de)marshalling routines. For example, in certain cases the fields in a class or struct need not be (de)serialized, or the base class of a derived class should not be (de)serialized, and certain built-in classes such as `ostream` cannot be (de)serialized. These data types (including fields) are called “transient” and can be declared outside of gSOAP’s compilation window. Transient data type and transient fields are declared with the **extern** keyword or are declared within [and] blocks in the header file input to the gSOAP compiler. The **extern** keyword has a special meaning to the gSOAP compiler and won’t affect the generated codes. The special [and] block construct can be used with data type declarations and within **struct** and **class** declarations. The use of **extern** or [] achieve the same effect, but [] may be more convenient to encapsulate transient types in a larger part of the header file. The use of **extern** with **typedef** is reserved for the declaration of user-defined external (de)serializers for data types, see Section 13.5.

First example:

```
extern class ostream; // ostream can't be (de)serialized, but need to be declared to make it visible
                        to gSOAP
class ns_::myClass
{ ...
    virtual void print(ostream &s) const; // need ostream here
    ...
};
```

Second example:

```
[
    class myBase // base class need not be (de)serialized
    { ... };
]
class ns_::myDerived : myBase
{ ... };
```

Third example:

```
[ typedef int transientInt; ]
class ns_::myClass
{
    int a; // will be (de)serialized
    [
        int b; // transient field
        char s[256]; // transient field
    ]
    extern float d; // transient field
    char *t; // will be (de)serialized
    transientInt *n; // transient field
    [
        virtual void method(char buf[1024]); // does not create a char[1024] (de)serializer
    ]
};
```

In this example, **class** `ns._myClass` has three transient fields: `b`, `s`, and `n` which will not be (de)serialized in SOAP. Field `n` is transient because the type is declared within a transient block. Pointers, references, and arrays of transient types are transient. The single class method is encapsulated within `[and]` to prevent gSOAP from creating (de)serializers for the **char**[1024] type. gSOAP will generate (de)serializers for all types that are not declared within a `[and]` transient block.

Functions prototypes of remote methods cannot be declared transient and will result in errors when attempted.

13.5 How to Declare User-Defined Serializers and Deserializers

Users can declare their own (de)serializers for specific data types instead of relying on the gSOAP-generated (de)serializers. To declare a external (de)serializer, declare a type with **extern typedef**. gSOAP will not generate the (de)serializers for the type name that is declared. For example:

```
extern typedef char *MyData;
struct Sample
{
    MyData s; // use user-defined (de)serializer for this field
    char *t; // use gSOAP (de)serializer for this field
};
```

The user is required to supply the following routines for each **extern typedef**'ed name T:

```
void soap_mark_T(struct soap *soap, const T *a)
void soap_default_T(struct soap *soap, T *a)
void soap_out_T(struct soap *soap, const char *tag, int id, const T *a, const char *type)
T *soap_in_T(struct soap *soap, const char *tag, T *a, const char *type)
```

The function prototypes can be found in `soapH.h`.

For example, the (de)serialization of `MyData` can be done with the following code:

```
void soap_mark_MyData(struct soap *soap, MyData *const*a)
{ } // no need to mark this node (for multi-ref and cycle detection)
void soap_default_MyData(&soap, MyData **a)
{ *a = NULL }
void soap_out_MyData(struct soap *soap, const char *tag, int id, MyData *const*a, const char *type)
{
    soap_element_begin_out(soap, tag, id, type); // print XML beginning tag
    soap_send(soap, *a); // just print the string (no XML conversion)
    soap_element_end_out(soap, tag); // print XML ending tag
}
MyData **soap_in_MyData(struct soap *soap, const char *tag, MyData **a, const char *type)
{
    if (soap_element_begin_in(soap, tag))
        return NULL;
    if (!a)
        a = (MyData**)soap_malloc(soap, sizeof(MyData*));
    if (soap->null)
        *a = NULL; // xsi:nil element
```

```

if (*soap->type && soap_match_tag(soap, soap->type, type))
{
    soap->error = SOAP_TYPE_MISMATCH;
    return NULL; // type mismatch
}
if (*soap->href)
    a = (MyData**)soap_id_forward(soap, soap->href, a, SOAP_MyData, sizeof(MyData*))
else if (soap->body)
{
    char *s = soap_value(soap); // fill buffer
    *a = (char*)soap_malloc(soap, strlen(s)+1);
    strcpy(*a, s);
}
if (soap->body && soap_element_end_in(soap, tag))
    return NULL;
return a;

```

More information on custom (de)serialization will be provided in this document or in a separate document in the future. The writing of the (de)serializer code requires the use of the low-level gSOAP API.

13.6 How to Serialize Data Without XSD Type Attributes

gSOAP serializes data in XML with `xsi:type` attributes when the types are declared with namespace prefixes to indicate the type of the data contained in the elements. SOAP 1.1 and 1.2 requires `xsi:type` attributes in the presence of polymorphic data or when the type of the data cannot be deduced from the SOAP payload.

To omit the generation of `xsi:type` attributes in the serialization, simply use type declarations that do not include namespace prefixes. The only remaining issue is the (de)serialization of lists/vectors with typed elements. To declare a list/vector with typed elements, use a leading underscore for type names of the **struct** or **class**. The leading underscores in type names makes type anonymous (invisible in XML).

13.7 Function Callbacks for Customized I/O and HTTP Handling

gSOAP provides five callback functions for customized I/O and HTTP handling:

Callback (function pointer)

int (*soap.fopen)(struct soap *soap, const char *endpoint, const char *host, int port)

Called from a client proxy to open a connection to a Web Service located at `endpoint`. Input parameters `host` and `port` are micro-parsed from `endpoint`. Should return a valid file descriptor, or -1 and `soap->error` set to an error code. Built-in gSOAP function: `tcp_connect`

int (*soap.fpost)(struct soap *soap, const char *endpoint, const char *host, const char *path, const char *action, size_t count)

Called from a client proxy to generate the HTTP header to connect to `endpoint`. Input parameters `host` and `path` are micro-parsed from `endpoint`, `action` is the SOAP action, and `count` is the length of the SOAP message or 0 when `SOAP_ENC_XML` is set or when `SOAP_IO_LENGTH` is reset. Use function `soap_send(struct soap *soap, char *s)` to write the header contents. Should return `SOAP_OK`, or a gSOAP error code. Built-in gSOAP function: `http_post`.

int (*soap.fposthdr)(struct soap *soap, const char *key, const char *val)

Called by `http_post` and `http_response` (through the callbacks). Emits HTTP key: val header entries. Should return `SOAP_OK`, or a gSOAP error code. Built-in gSOAP function: `http_post_header`.

int (*soap.fresponse)(struct soap *soap, int soap_error_code, size_t count)

Called from a service to generate the response HTTP header. Input parameter `soap_error_code` is a gSOAP error code (see Section 8.2 and `count` is the length of the SOAP message or 0 when `SOAP_ENC_XML` is set or when `SOAP_IO_LENGTH` is reset. Use function `soap_send(struct soap *soap, char *s)` to write the header contents. Should return `SOAP_OK`, or a gSOAP error code. Built-in gSOAP function: `http_response`

int (*soap.fparse)(struct soap *soap)

Called by client proxy and service to parse an HTTP header (if present). When user-defined, this routine must at least skip the header. Use function `int soap_getline(struct soap *soap, char *buf, int len)` to read HTTP header lines into a buffer `buf` of length `len` (returns empty line at end of HTTP header). Should return `SOAP_OK`, or a gSOAP error code. Built-in gSOAP function: `http_parse`

int (*soap.fparsehdr)(struct soap *soap, const char *key, const char *val)

Called by `http_parse` (through the `fparse` callback). Handles HTTP key: val header entries to set gSOAP's internals. Should return `SOAP_OK`, or a gSOAP error code. Built-in gSOAP function: `http_parse_header`

int (*soap.fclose)(struct soap *soap)

Called by client proxy **multiple times**, to close a socket connection before a new socket connection is established and at the end of communications when the `SOAP_IO_KEEPALIVE` flag is not set and `soap.keep_alive` \neq 0 (indicating that the other party supports keep alive). Should return `SOAP_OK`, or a gSOAP error code. Built-in gSOAP function: `tcp_disconnect`

int (*soap.fsend)(struct soap *soap, const char *s, size_t n)

Called for all send operations to emit contents of `s` of length `n`. Should return `SOAP_OK`, or a gSOAP error code. Built-in gSOAP function: `fsend`

size_t (*soap.frecv)(struct soap *soap, char *s, size_t n)

Called for all receive operations to fill buffer `s` of maximum length `n`. Should return the number of bytes read or 0 in case of an error, e.g. EOF. Built-in gSOAP function: `frecv`

int (*soap.fignore)(struct soap *soap, const char *tag)

Called when an unknown XML element was encountered on the input and `tag` is the offending XML element tag name. Should return `SOAP_OK`, or a gSOAP error code such as `SOAP_MUSTUNDERSTAND` to throw an exception. Built-in gSOAP function: `ignore`

In addition, a `void*user` field in the `struct soap` data structure is available to pass user-defined data to the callbacks.

The following example uses I/O function callbacks for customized serialization of data into a buffer and deserialization back into a datastructure:


```

char buf[10000]; // XML buffer
int len1 = 0; // #chars written
int len2 = 0; // #chars read
// mysend: put XML in buf[]
int mysend(struct soap *soap, const char *s, size_t n)
{
    if (len1 + n > sizeof(buf))
        return SOAP_EOF;
    strcpy(buf + len1, s);
    len1 += n;
    return SOAP_OK;
}
// myrecv: get XML from buf[]
size_t myrecv(struct soap *soap, char *s, size_t n)
{
    if (len2 + n > len1)
        n = len1 - len2;
    strncpy(s, buf + len2, n);
    len2 += n;
    return n;
}
main()
{
    struct soap soap;
    struct ns__person p;
    soap_init(&soap);
    len1 = len2 = 0; // reset buffer pointers
    p.name = "John Doe";
    p.age = 25;
    soap.fsend = mysend; // assign callback
    soap.frecv = myrecv; // assign callback
    soap_begin(&soap);
    soap_set_omode(&soap, SOAP_XML_GRAPH);
    soap_serialize_ns__person(&soap, &p);
    soap_put_ns__person(&soap, &p, "ns:person", NULL);
    if (soap.error)
    {
        soap_print_fault(&soap, stdout);
        exit(1);
    }
    soap_end(&soap);
    soap_begin(&soap);
    soap_get_ns__person(&soap, &p, "ns:person", NULL);
    if (soap.error)
    {
        soap_print_fault(&soap, stdout);
        exit(1);
    }
    soap_end(&soap);
    soap_init(&soap); // disable callbacks
}

```

The `soap_done` function can be called to reset the callback to the default internal gSOAP I/O and HTTP handlers.

The following example illustrates customized I/O and (HTTP) header handling. The SOAP request is saved to a file. The client proxy then reads the file contents as the service response. To perform this trick, the service response has exactly the same structure as the request. This is declared by the **struct** `ns__test` output parameter part of the remote method declaration. This struct resembles the service request (see the generated `soapStub.h` file created from the header file).

The header file is:

```
//gsoap ns service name: callback
//gsoap ns service namespace: urn:callback
struct ns__person
{
    char *name;
    int age;
};
int ns__test(struct ns__person in, struct ns__test &out);
```

The client program is:

```
#include "soapH.h"
...
int myopen(struct soap *soap, const char *endpoint, const char *host, int port)
{
    if (strncmp(endpoint, "file:", 5))
    {
        printf(" File name expected\n");
        return SOAP_EOF;
    }
    if ((soap->sendfd = soap->recvfd = open(host, O_RDWR|O_CREAT, S_IWUSR|S_IRUSR)) < 0)
        return SOAP_EOF;
    return SOAP_OK;
}
void myclose(struct soap *soap)
{
    if (soap->sendfd > 2) // still open?
        close(soap->sendfd); // then close it
    soap->recvfd = 0; // set back to stdin
    soap->sendfd = 1; // set back to stdout
}
int mypost(struct soap *soap, const char *endpoint, const char *host, const char *path, const char *action, size_t count)
{
    return soap_send(soap, "Custom-generated file\n"); // writes to soap->sendfd
}
int myparse(struct soap *soap)
{
    char buf[256];
    if (lseek(soap->recvfd, 0, SEEK_SET) < 0 — soap_getline(soap, buf, 256)) // go to begin and
skip custom header
        return SOAP_EOF;
    return SOAP_OK;
}
```

```

}
main()
{
    struct soap soap;
    struct ns__test r;
    struct ns__person p;
    soap_init(&soap); // reset
    p.name = "John Doe";
    p.age = 99;
    soap.fopen = myopen; // use custom open
    soap.fpost = mypost; // use custom post
    soap.fparse = myparse; // use custom response parser
    soap.fclose = myclose; // use custom close
    soap_call_ns__test(&soap, "file://test.xml", "", p, r);
    if (soap.error)
    {
        soap_print_fault(&soap, stdout);
        exit(1);
    }
    soap_end(&soap);
    soap_init(&soap); // reset to default callbacks
}

```

SOAP 1.1 and 1.2 specify that XML elements may be ignored when present in a SOAP payload on the receiving side. gSOAP ignores XML elements that are unknown, unless the XML attribute `mustUnderstand="true"` is present in the XML element. It may be undesirable for elements to be ignored when the outcome of the omission is uncertain. The `soap.ignore` callback can be set to a function that returns `SOAP_OK` in case the element can be safely ignored, or `SOAP_MUSTUNDERSTAND` to throw an exception, or to perform some application-specific action. For example, to throw an exception as soon as an unknown element is encountered on the input, use:

```

int myignore(struct soap *soap, const char *tag)
{
    return SOAP_MUSTUNDERSTAND; // never skip elements (secure)
}
...
soap.ignore = myignore;
soap_call_ns__method(&soap, ...); // or soap_serve(&soap);

```

To selectively throw an exception as soon as an unknown element is encountered but element `ns:xyz` can be safely ignored, use:

```

int myignore(struct soap *soap, const char *tag)
{
    if (soap_match_tag(soap, tag, "ns:xyz") != SOAP_OK)
        return SOAP_MUSTUNDERSTAND;
    return SOAP_OK;
}
...
soap.ignore = myignore;
soap_call_ns__method(&soap, ...); // or soap_serve(&soap)
...

```

```

struct Namespace namespaces[] =
{
    {"SOAP-ENV", "http://schemas.xmlsoap.org/soap/envelope/"},
    {"SOAP-ENC", "http://schemas.xmlsoap.org/soap/encoding/"},
    {"xsi", "http://www.w3.org/1999/XMLSchema-instance"},
    {"xsd", "http://www.w3.org/1999/XMLSchema"},
    {"ns", "some-URI"}, // the namespace of element ns:xyz
    {NULL, NULL}
}

```

Function `soap_match_tag` compares two tags. The third parameter may be a pattern where `*` is a wildcard and `-` is a single character wildcard. So for example `soap_match_tag(tag, "ns:*")` will match any element in namespace `ns` or when no namespace prefix is present in the XML message.

The callback can also be used to keep track of unknown elements in an internal data structure such as a list:

```

struct Unknown
{
    char *tag;
    struct Unknown *next;
};
int myignore(struct soap *soap, const char *tag)
{
    char *s = (char*)soap_malloc(soap, strlen(tag)+1);
    struct Unknown *u = (struct Unknown*)soap_malloc(soap, sizeof(struct Unknown));
    if (s && u)
    {
        strcpy(s, tag);
        u->tag = s;
        u->next = u;
        u->next = u;
    }
}
...
struct soap *soap;
struct Unknown *ulist = NULL;
soap_init(&soap);
soap_ignore = myignore;
soap_call_ns_method(&soap, ...); // or soap_serve(&soap)
// print the list of unknown elements
soap_end(&soap); // clean up

```

13.8 HTTP 1.0 and 1.1

gSOAP uses HTTP 1.0 by default. gSOAP supports HTTP 1.1, but does not support all HTTP 1.1 transfer encodings such as gzipped encodings. gSOAP does support HTTP 1.1 chunked-transfer encoding. Nevertheless, the the HTTP version used can be changed by setting the attribute:

```

struct soap soap;
soap_init(&soap);
...
soap.http_version = "1.1";

```

13.9 HTTP Keep-Alive

gSOAP supports keep-alive socket connections. To activate keep-alive support, set the SOAP_IO_KEEPAIVE flag for both input and output modes, see Section 7.10. For example

```
struct soap soap;
soap_init2(&soap, SOAP_IO_KEEPAIVE, SOAP_IO_KEEPAIVE);
```

When a client or a service communicates with another client or service that supports keep alive, the attribute `soap.keep_alive` will be set to 1, otherwise it is reset to 0 (indicating that the other party will close the connection). The connection maybe terminated on either end before the communication completed, for example when the server keep-alive connection has timed out. This generates a "Broken Pipe" signal on Unix/Linux platforms. This signal can be caught with a signal handler:

```
signal(SIGPIPE, sigpipe_handle);
```

where, for example:

```
void sigpipe_handle(int x) { }
```

Alternatively, broken pipes can be kept silent by setting:

```
soap.socket_flags = MSG_NOSIGNAL;
```

This setting will not generate a sigpipe but read/write operations return SOAP_EOF instead. Note that Win32 systems do not support signals and lack the MSG_NOSIGNAL flag. The sigpipe handling and flags are not very portable.

A connection will be kept open only if the request contains an HTTP 1.0 header with "Connection: Keep-Alive" or an HTTP 1.1 header that does not contain "Connection: close". This means that a gSOAP client method call should use "http://" in the endpoint URL of the request to the stand-alone service to ensure HTTP headers are used.

If the client does not close the connection, the server will wait forever when no `recv_timeout` is specified. In addition, other clients will be denied service as long as a client keeps the connection to the server open. To prevent this from happening, the service should be multi-threaded such that each thread handles the client connection:

```
int main(int argc, char **argv)
{
    struct soap soap, *tsoap;
    pthread_t tid;
    int m, s;
    soap_init2(&soap, SOAP_IO_KEEPAIVE, SOAP_IO_KEEPAIVE);
    soap.accept_timeout = 600; // optional: let server time out after ten minutes of inactivity
    m = soap_bind(&soap, NULL, 18000, BACKLOG); // use port 18000 on the current machine
    if (m < 0)
    {
        soap_print_fault(&soap, stderr);
        exit(1);
    }
}
```

```

    }
    fprintf(stderr, "Socket connection successful %d\n", m);
    for (count = 0; count >= 0; count++)
    {
        soap.socket_flags = MSG_NOSIGNAL; // use this
        soap.accept_flags = SO_NOSIGPIPE; // or this to prevent sigpipe
        s = soap_accept(&soap);
        if (s < 0)
        {
            if (soap.errnum)
                soap_print_fault(&soap, stderr);
            else
                fprintf(stderr, "Server timed out\n"); // Assume timeout is long enough for threads to
complete serving requests
            break;
        }
        fprintf(stderr, "Accepts socket %d connection from IP %d.%d.%d.%d\n", s, (int)(soap.ip>>24)&0xFF,
(int)(soap.ip>>16)&0xFF, (int)(soap.ip>>8)&0xFF, (int)soap.ip&0xFF);
        tsoap = soap_copy(&soap);
        pthread_create(&tid, NULL, (void*)(*)(void*))process_request, (void*)tsoap);
    }
    return 0;
}
void *process_request(void *soap)
{
    pthread_detach(pthread_self());
    ((struct soap*)soap)->recv_timeout = 300; // Timeout after 5 minutes stall on recv
    ((struct soap*)soap)->send_timeout = 60; // Timeout after 1 minute stall on send
    soap_serve((struct soap*)soap);
    soap_destroy((struct soap*)soap);
    soap_end((struct soap*)soap);
    soap_done((struct soap*)soap);
    free(soap);
    return NULL;
}

```

To prevent a malicious client from keeping a thread waiting forever by keeping the connection open, timeouts are set in the `process_request` routine. See Section 13.14 for more details on timeout settings.

A gSOAP client call will automatically attempt to re-establish a connection to a server when the server has terminated the connection for any reason. This way, a sequence of calls can be made to the server while keeping the connection open. Client stubs will poll the server to check if the connection is still open. When the connection was terminated by the server, the client will automatically reconnect.

A client should reset `SOAP_IO_KEEPAIVE` just before the last call to a server to close the connection after this last call. This will close the socket after the call and also informs the server to gracefully close the connection.

13.10 HTTP Chunked Transfer Encoding

gSOAP supports HTTP chunked transfer encoding. Un-chunking of inbound messages takes place automatically. Outbound messages are never chunked, except when the SOAP_IO_CHUNK flag is set for the output mode. Most Web services, however, will not accept chunked inbound messages.

13.11 HTTP Buffered Sends

The entire outbound message can be stored to determine the HTTP content length rather than the two-phase encoding used by gSOAP which requires a separate pass over the data to determine the length of the outbound message. Setting the flag SOAP_IO_STORE for the output mode will buffer the entire message. This can speed up the transmission of messages, depending on the content, but may require significant storage space to hold the verbose XML message.

Zlib compressed transfers require buffering. The SOAP_IO_STORE flag is set when the SOAP_ENC_ZLIB flag is set by the user. The use of chunking may speed up the transmission of compressed SOAP/XML messages which is accomplished by setting the SOAP_IO_CHUNK flag with SOAP_ENC_ZLIB for the output mode.

13.12 HTTP Authentication

HTTP authentication (basic) is enabled at the client-side by setting the soap.userid and soap.passwd strings to a username and password, respectively. For example, a server may request user authentication. Otherwise, access is denied (HTTP 401 error). Example client code fragment to set username and password:

```
struct soap soap;
soap_init(&soap);
soap.userid = "guest";
soap.passwd = "guest";
...
```

A client SOAP request will have the following HTTP header:

```
POST /XXX HTTP/1.0
Host: YYY
User-Agent: gSOAP/2.2
Content-Type: text/xml; charset=utf-8
Content-Length: nnn
Authorization: Basic Z3Vlc3Q6Z3Vlc3Q=
...
```

13.13 HTTP Proxy Authentication

HTTP proxy authentication (basic) is enabled at the client-side by setting the soap.proxy_userid and soap.proxy_passwd strings to a username and password, respectively. For example, a proxy server may request user authentication. Otherwise, access is denied by the proxy (HTTP 407 error). Example client code fragment to set proxy server, username, and password:

```

struct soap soap;
soap_init(&soap);
soap.proxy_host = "xx.xx.xx.xx"; // IP
soap.proxy_port = 8080;
soap.proxy_userid = "guest";
soap.proxy_passwd = "guest";
...

```

A client SOAP request will have the following HTTP header:

```

POST /XXX HTTP/1.0
Host: YYY
User-Agent: gSOAP/2.2
Content-Type: text/xml; charset=utf-8
Content-Length: nnn
Proxy-Authorization: Basic Z3Vlc3Q6Z3Vlc3Q=
...

```

13.14 Timeout Management for Non-Blocking Operations

Socket connect, accept, send, and receive timeout values can be set to manage socket communication timeouts. The `soap.connect.timeout`, `soap.accept.timeout`, `soap.send.timeout`, and `soap.recv.timeout` attributes of the current gSOAP runtime environment `soap` can be set to the appropriate user-defined socket send, receive, and accept timeout values. A positive value measures the timeout in seconds. A negative timeout value measures the timeout in microseconds (10^{-6} sec).

The `soap.connect.timeout` specifies the timeout value for `soap_call_ns_*` method calls.

The `soap.accept.timeout` specifies the timeout value for `soap_accept(&soap)` calls.

The `soap.send.timeout` and `soap.recv.timeout` specify the timeout values for non-blocking socket I/O operations.

Example:

```

struct soap soap;
soap_init(&soap);
soap.send_timeout = 10;
soap.recv_timeout = 10;

```

This will result in a timeout if no data can be send in 10 seconds and no data is received within 10 seconds after initiating a send or receive operation over the socket. A value of zero disables timeout, for example:

```

soap.send_timeout = 0;
soap.recv_timeout = 0;

```

When a timeout occurs in send/receive operations, a `SOAP_EOF` exception will be raised ("end of file or no input"). Negative timeout values measure timeouts in microseconds, for example:

```

#define uSec *-1
#define mSec *-1000

```



```
soap.accept_timeout = 10 uSec;  
soap.send_timeout = 20 mSec;  
soap.recv_timeout = 20 mSec;
```

The macros improve readability.

Caution: Many Linux versions do not support non-blocking connect(). Therefore, setting soap.connect_timeout for non-blocking soap_call_ns_...method calls may not work under Linux.

13.15 Socket Options and Flags

gSOAP's socket communications can be controlled with socket options and flags. The gSOAP runtime environment **struct** soap flags are: **int** soap.socket.flags to control socket send() and recv() calls, **int** soap.connect.flags to set client connection socket options, **int** soap.bind.flags to set server-side port bind socket options, **int** soap.accept.flags to set server-side request message accept socket options. See the manual pages of send and recv for soap.socket.flags values and see the manual pages of setsockopt for soap.connect.flags, soap.bind.flags, and soap.accept.flags (SOL_SOCKET) values. These SO_ socket option flags (see setsockopt manual pages) can be bit-wise or-ed to set multiple socket options at once.

For example, to disable sigpipe signals on Unix/Linux platforms use: soap.socket.flags=MSG_NOSIGNAL and/or soap.connect.flags=SO_NOSIGPIPE (i.e. client-side connect) depending on your platform.

Use soap.bind.flags=SO_REUSEADDR to enable server-side port reuse and local port sharing (but be aware of the security issues when the port is not blocked by a firewall and open to the Internet).

13.16 Secure SOAP Clients with HTTPS/SSL

You need to install the OpenSSL library on your platform to enable secure SOAP clients to utilize HTTPS/SSL. After installation, compile all the sources of your application with option -DWITH_OPENSSL. For example on Linux:

```
g++ -DWITH_OPENSSL myclient.cpp stdsoap.cpp soapC.cpp soapClient.cpp -lssl -lcrypto
```

or Unix:

```
g++ -DWITH_OPENSSL myclient.cpp stdsoap.cpp soapC.cpp soapClient.cpp -lnet -lsocket -lnsl  
-lssl -lcrypto
```

or you can add the following line to soapdefs.h:

```
#define WITH_OPENSSL
```

and compile with option -DWITH_SOAPDEFS_H to include soapdefs.h in your project. A client program simply uses the prefix https: instead of http: in the endpoint URL of a remote method call to a Web Service to use encrypted transfers (if the service supports HTTPS). For example:

```
soap_call_ns_...mymethod(&soap, "https://domain/path/secure.cgi", "", ...);
```

By default, server authentication is disabled. To enable server authentication, set the require_server_auth attribute of the current gSOAP runtime environment (**struct** soap) before a call is made:

```
soap.require_server_auth = 1;
```

This will force server authentication for all calls over HTTPS.

Make sure you have signal handlers set in your application to catch broken connections (SIGPIPE):

```
signal(SIGPIPE, sigpipe_handle);
```

where, for example:

```
void sigpipe_handle(int x) { }
```

13.17 Secure SOAP Web Services with HTTPS/SSL

When a Web Service is installed as CGI, it uses standard I/O that is encrypted/decrypted by the Web server that runs the CGI application. Therefore, HTTPS/SSL support must be configured for the Web server (not Web Service).

SSL support for stand-alone gSOAP Web services is accomplished by calling `soap_ssl_accept` after `soap_accept`. In addition, a key file, CA file, DH file (if RSA is not used), and password need to be supplied. Instructions on how to do this can be found in the OpenSSL documentation <http://www.openssl.org>. See also Section 13.18. To enable OpenSSL, first install OpenSSL and use option `-DWITH_OPENSSL` to compile the sources with your C or C++ compiler, for example:

```
g++ -DWITH_OPENSSL -o myprog myprog.cpp stdsoap2.cpp soapC.cpp soapServer.cpp -lssl -lcrypto
```

Let's take a look at an example SSL secure multi-threaded stand-alone SOAP Web Service:

```
int main()
{
    int m, s;
    pthread_t tid;
    struct soap soap, *tsoap;
    soap_init(&soap);
    // soap.rsa = 1; // use RSA (or use DH which requires a DH file: see below)
    soap.keyfile = "server.pem"; // must be resident key file
    soap.cafile = "cacert.pem"; // must be resident CA file
    soap.dhfile = "dh512.pem"; // if soap.rsa == 0, use DH with resident DH file
    soap.password = "password"; // password
    soap.randfile = "random.rnd"; // (optional) some file with random data to seed PRNG
    m = soap_bind(&soap, "linprog2.cs.fsu.edu", 18000, 100);
    if (m < 0)
    {
        soap_print_fault(&soap, stderr);
        exit(1);
    }
    fprintf(stderr, "Socket connection successful: master socket = %d\n", m);
    for (;;)
    {
        s = soap_accept(&soap);
        fprintf(stderr, "Socket connection successful: slave socket = %d\n", s);
```

```

    if (s < 0)
    {
        soap_print_fault(&soap, stderr);
        exit(1);
    }
    if (soap_ssl_accept(&soap))
    {
        soap_print_fault(&soap, stderr);
        exit(1);
    }
    tsoap = soap_copy(&soap);
    if (!tsoap)
        exit(1);
    pthread_create(&tid, NULL, &process_request, (void*)tsoap);
}
return 0;
}
void *process_request(void *soap)
{
    pthread_detach(pthread_self());
    soap_serve((struct soap*)soap);
    soap_end((struct soap*)soap);
    free(soap);
    return NULL;
}

```

In case Web services have to verify clients, use a key file, CA file, a file with random data, and password in an SSL-enabled client:

```

...
soap_init(&soap);
soap.keyfile = "client.pem";
soap.password = "password";
soap.cacert = "cacert.pem";
soap.randfile = "random.rnd";
if (soap_call_ns_method(&soap, "https://linprog2.cs.fsu.edu:18000", "", ...))
...

```

Make sure you have signal handlers set in your service and/or client applications to catch broken connections (SIGPIPE):

```
signal(SIGPIPE, sigpipe_handle);
```

where, for example:

```
void sigpipe_handle(int x) { }
```

13.18 SSL Certificates

The .pem files in the gSOAP distribution are examples. Developers will have to generate certificates as needed (client only, server only or both). There is more than one way to generate pem files for clients and servers. Here is the simplest/quickest one:

Create a private Certificate Authority (CA). The CA is used in SSL to verify the authenticity of a given certificate. The CA acts as a trusted third party who has authenticated the user of the signed certificate as being who they say. The certificate is signed by the CA, and if the client trusts the CA, it will trust your certificate. For use within your organization, a private CA will probably serve your needs. However, if you intend use your certificates for a public service, you should probably obtain a certificate from a known CA (e.g. VeriSign). In addition to identification, your certificate is also used for encryption.

Creating a private CA:

- Go to the OpenSSL bin directory (/usr/local/ssl/misc by default).
- There should be a script called CA.sh (and a CA.pl that does the same stuff). This hides all the gruesome details of how this works. Without the script this is a very annoying process.
- su to root
- Make sure that the OpenSSL bin directory is in your path.
- ./CA.sh -newca
- When prompted for CA filename hit return.
- Answer the rest of the questions intelligently. The common name would be how this certificate might be referred to. For example, the Equifax Secure CA uses the common name of Equifax Secure Certificate Authority. Do not forget the password!

Creating certificates should be done through a certificate authority to obtain signed certificates. But you can create your own certificates for testing purposes as follows.

- ./CA.sh -newreq
- This creates an unsigned certificate request.
- The procedure is the same as creating a private CA except you'll want to use the name of the host that will use the certificate as the common name. If they don't match, the client will not like it when you set `require_server_auth=1`.
- You probably don't want to use the same passphrase for this as you did with the CA.
- ./CA.sh -sign
- It will ask for a PEM pass phrase, that's the passphrase you set for the private CA you created.
- This signs the certificate that you just created with the CA you created just moments before.
- The signed certificate is now in the current directory as newcert.pem. If you are going to create more, you should rename this or it will be overwritten by subsequent signatures.

Now do the following at the prompt:

```
cat newreq.pem newcert.pem > server.pem (or client.pem as needed)
```

You now have generated a client and a server certificate in PEM format by repeating the same process and changing the common name for the client (e.g. gSOAP client). You also need the CA certificate.

Finally you need to generate Diffie-Hellman parameters for the server. Do the following at the prompt:

```
openssl dhparam -outform PEM -out dh.pem 1024
```

File `dh.pem` is the output file and 1024 is the number of bits used (this will take a long time, you can safely use 512).

Of course the developer using your server cert on her machine will find that if `require_server_auth=1` the client will exit before doing the handshake.

13.19 Zlib Compressed Messages

To enable Zlib compression, install Zlib from <http://www.zlib.org> if not already installed on your system. Compile `stdsoap2.cpp` (and/or `stdsoap2.c`) with compiler option `-DWITH_ZLIB` and link your code with the Zlib library, e.g. `-lz` on Unix/Linux platforms.

The Zlib compression is orthogonal to all transport encodings such as HTTP, SSL, and DIME. You can also save and load compressed XML data to/from files.

To transmit compressed SOAP/XML data, set the output mode flags to `SOAP_ENC_ZLIB`. For example:

```
soap_init(&soap);
...
soap_set_omode(&soap, SOAP_ENC_ZLIB);
if (soap_call_ns_myMethod(&soap, ...))
...
```

This will send a compressed SOAP/XML request to a service, provided that Zlib is installed and linked with the application.

Receiving compressed SOAP/XML over HTTP is automatic and the flag does not have to be set. However, reading or receiving plain SOAP/XML requires the flag `SOAP_ENC_ZLIB` to be set for the input mode to decompress the data.

To control the level of compression of outbound messages, set the `soap.z_level` to a value between 1 and 9, where 1 is the best speed and 9 is the best compression (default is 6). For example

```
soap_init(&soap);
...
soap_set_omode(&soap, SOAP_ENC_ZLIB);
soap.z_level = 9; // best compression
if (soap_call_ns_myMethod(&soap, ...))
...
```

13.20 Client-Side Cookie Support

Client-side cookie support is optional. To enable cookie support, compile all sources with option `-DWITH_COOKIES`, for example:

```
g++ -DWITH_COOKIES -o myclient stdsoap2.cpp soapC.cpp soapClient.cpp
```

or add the following line to `stdsoap.h`:

```
#define WITH_COOKIES
```

Client-side cookie support is fully automatic. So just (re)compile `stdsoap2.cpp` with `-DWITH_COOKIES` to enable cookie-based session control in your client.

A database of cookies is kept and returned to the appropriate servers. Cookies are not automatically saved to a file by a client. An example cookie file manager is included as an extras in the distribution. You should explicitly remove all cookies before terminating a gSOAP environment by calling `soap_free_cookies(soap)` or by calling `soap_done(soap)`.

To avoid "cookie storms" caused by malicious servers that return an unreasonable amount of cookies, gSOAP clients/servers are restricted to a database size that the user can limit (32 cookies by default), for example:

```
struct soap soap;  
soap_init(&soap);  
soap.cookie_max = 10;
```

The cookie database is a linked list pointed to by `soap.cookies` where each node is declared as:

```
struct soap_cookie  
{  
    char *name;  
    char *value;  
    char *domain;  
    char *path;  
    long expire; /* client-side: local time to expire; server-side: seconds to expire */  
    unsigned int version;  
    short secure;  
    short session; /* server-side */  
    short env; /* server-side: 1 = got cookie from client */  
    short modified; /* server-side: 1 = client cookie was modified */  
    struct soap_cookie *next;  
};
```

Since the cookie database is linked to a `soap` struct, each thread has a local cookie database in a multi-threaded implementation.

13.21 Server-Side Cookie Support

Server-side cookie support is optional. To enable cookie support, compile all sources with option `-DWITH_COOKIES`, for example:

g++ -DWITH_COOKIES -o myserver ...

gSOAP provides the following cookie API for server-side cookie session control:

Function

struct soap_cookie *soap_set_cookie(struct soap *soap, const char *name, const char *value, const char *domain, const char *path);

Add a cookie to the database with name *name* and value *value*. *domain* and *path* may be NULL to use the current domain and path given by *soap_cookie_domain* and *soap_cookie_path*. If successful, returns pointer to a cookie node in the linked list, or NULL otherwise.

struct soap_cookie *soap_cookie(struct soap *soap, const char *name, const char *domain, const char *path);

Find a cookie in the database with name *name* and value *value*. *domain* and *path* may be NULL to use the current domain and path given by *soap_cookie_domain* and *soap_cookie_path*. If successful, returns pointer to a cookie node in the linked list, or NULL otherwise.

char *soap_cookie_value(struct soap *soap, const char *name, const char *domain, const char *path);

Get value of a cookie in the database with name *name*. *domain* and *path* may be NULL to use the current domain and path given by *soap_cookie_domain* and *soap_cookie_path*. If successful, returns the string pointer to the value, or NULL otherwise.

long soap_cookie_expire(struct soap *soap, const char *name, const char *domain, const char *path);

Get expiration value of the cookie in the database with name *name* (in seconds). *domain* and *path* may be NULL to use the current domain and path given by *soap_cookie_domain* and *soap_cookie_path*. Returns the expiration value, or -1 if cookie does not exist.

int soap_set_cookie_expire(struct soap *soap, const char *name, long expire, const char *domain, const char *path);

Set expiration value *expire* of the cookie in the database with name *name* (in seconds). *domain* and *path* may be NULL to use the current domain and path given by *soap_cookie_domain* and *soap_cookie_path*. If successful, returns SOAP_OK, or SOAP_EOF otherwise.

int soap_set_cookie_session(struct soap *soap, const char *name, const char *domain, const char *path);

Set cookie in the database with name *name* to be a session cookie. This means that the cookie will be returned to the client. (Only cookies that are modified are returned to the client). *domain* and *path* may be NULL to use the current domain and path given by *soap_cookie_domain* and *soap_cookie_path*. If successful, returns SOAP_OK, or SOAP_EOF otherwise.

int soap_clr_cookie_session(struct soap *soap, const char *name, const char *domain, const char *path);

Clear cookie in the database with name *name* to be a session cookie. *domain* and *path* may be NULL to use the current domain and path given by *soap_cookie_domain* and *soap_cookie_path*. If successful, returns SOAP_OK, or SOAP_EOF otherwise.

void soap_clr_cookie(struct soap *soap, const char *name, const char *domain, const char *path);

Remove cookie from the database with name *name*. *domain* and *path* may be NULL to use the current domain and path given by *soap_cookie_domain* and *soap_cookie_path*.

int soap_getenv_cookies(struct soap *soap);

Initializes cookie database by reading the 'HTTP_COOKIE' environment variable. This provides a means for a CGI application to read cookies send by a client. If successful, returns SOAP_OK, or SOAP_EOF otherwise.

void soap_free_cookies(struct soap *soap);

Release cookie database.

The following global variables are used to define the current domain and path:

Attribute	value
const char *cookie_domain	MUST be set to the domain (host) of the service
const char *cookie_path	MAY be set to the default path to the service
int cookie_max	maximum cookie database size (default=32)

The cookie_path value is used to filter cookies intended for this service according to the path prefix rules outlined in RFC2109.

The following example server adopts cookies for session control:

```

int main()
{
    struct soap soap;
    int m, s;
    soap_init(&soap);
    soap.cookie_domain = "...";
    soap.cookie_path = "/"; // the path which is used to filter/set cookies with this destination
    if (argc < 2)
    {
        soap_getenv_cookies(&soap); // CGI app: grab cookies from 'HTTP_COOKIE' env var
        soap_serve(&soap);
    }
    else
    {
        m = soap_bind(&soap, NULL, atoi(argv[1]), 100);
        if (m < 0)
            exit(1);
        for (int i = 1; ; i++)
        {
            s = soap_accept(&soap);
            if (s < 0)
                exit(1);
            soap_serve(&soap);
            soap_end(&soap); // clean up
            soap_free_cookies(&soap); // remove all old cookies from database so no interference occurs
            // with the arrival of new cookies
        }
        return 0;
    }
}

int ck_demo(struct soap *soap, ...)
{
    int n;
    const char *s;
    s = soap_cookie_value(soap, "demo", NULL, NULL); // cookie returned by client?
    if (!s)
        s = "init-value"; // no: set initial cookie value
    else
        ... // modify 's' to reflect session control
    soap_set_cookie(soap, "demo", s, NULL, NULL);
    soap_set_cookie_expire(soap, "demo", 5, NULL, NULL); // cookie may expire at client-side in 5
    // seconds
    return SOAP_OK;
}

```


13.22 Connecting Clients Through Proxy Servers

When a client needs to connect to a Web Service through a proxy server, set the `soap.proxy_host` string and `soap.proxy_port` integer attributes of the current `soap` runtime environment to the proxy's host name and port, respectively. For example:

```
struct soap soap;
soap_init(&soap);
soap.proxy_host = "proxyhostname";
soap.proxy_port = 8080;
if (soap_call_ns_method(&soap, "http://host:port/path", "action", ...))
    soap_print_fault(&soap, stderr);
else
    ...
```

The attributes `soap.proxy_host` and `soap.proxy_port` keep their values through the remove method calls, so they only need to be set once.

13.23 FastCGI Support

To enable FastCGI support, install FastCGI and compile with option `-DWITH_FASTCGI` or add

```
#define WITH_FASTCGI
```

to `stdsoap2.h`.

13.24 How to Create Separate Client/Server DLLs

13.24.1 Create Base `stdsoap2.dll`

The first step is to create `stdsoap2.dll` which consists of the file `stdsoap2.cpp` and `envC.cpp`. This DLL contains all common functions needed for all other clients and servers based on gSOAP. `envC.cpp` is a generated file from an *empty* input file to the `soapcpp2`:

```
Create an empty header file empty.h
(If necessary, add appropriate SOAP Header definitions used by all clients and services)
soapcpp2 -penv empty.h
Compile envC.cpp and stdsoap2.cpp into stdsoap2.dll using the compiler option -DWITH_NONNAMESPACES
```

This file contains all the envelope functions required, so that `stdsoap2.dll` includes the appropriate function definitions.

While compiling this project, use the Pre-Processor definition: `SOAP_FMAC1=_declspec(dllexport)`, or set the macro as an option `-DSOAP_FMAC1=_declspec(dllexport)`, or compile with `-DWITH_SOAPDEFS_H` and put the macro definitions in `soapdefs.h`. This exports all functions which are preceded by the macro `SOAP_FMAC1` in the source files.

13.24.2 Creating Client and Service DLLs

Client side DLL serves as the common code which all clients will use to access the server. This DLL consists of the files `soapC.cpp` and `soapClient.cpp` and other wrapper files, which if needed, to abstract the gSOAP details from the clients. (These wrapper methods are then exported. If we don't want to write the wrapper methods, we can directly export the functions in `soapClient.cpp` with using the Pre-Processor definition: `SOAP_FMAC1=_declspec(dllexport)`). Compile the DLL with option `-DWITH_NOGLOBAL`. This DLL links to `stdsoap2.dll`.

Clients MUST explicitly set the namespaces value of the gSOAP environment:

```
soap_init(&soap);
soap.namespaces = namespaces;
```

where the `namespaces[]` table is defined (static) in the client source.

A service side DLL is similar. This DLL consists of the files `soapC.cpp` and `soapServer.cpp`. Use the Pre-Processor definition: `SOAP_FMAC1=_declspec(dllexport)`. Compile the DLL with option `-DWITH_NOGLOBAL`. This DLL links to `stdsoap2.dll`. Also the namespaces table MUST be explicitly set in the service code.

13.24.3 gSOAP Plug-ins

The gSOAP plug-in feature enables a convenient extension mechanism of gSOAP capabilities. When the plug-in registers with gSOAP, it has full access to the run-time settings and the gSOAP function callbacks. Upon registry, the plug-in's local data is associated with the gSOAP run-time. By overriding gSOAP's function callbacks with the plug-in's function callbacks, the plug-in can extend gSOAP's capabilities. The local plug-in data can be accessed through a lookup function, usually invoked within a callback function to access the plug-in data. The registry and lookup functions are:

```
int soap_register_plugin_arg(struct soap *soap, int (*fcreate)(struct soap *soap, struct soap_plugin *p, void *arg), void *arg)
void* soap_lookup_plugin(struct soap*, const char*);
```

Other functions that deal with plug-ins are:

```
int soap_copy(struct soap *soap);
void soap_done(struct soap *soap);
```

The `soap_copy` function returns a new dynamically allocated gSOAP environment that is a copy of another, such that no data is shared between the copy and the original environment. The `soap_copy` function invokes the plug-in copy callbacks to copy the plug-ins' local data. The `soap_copy` function returns a gSOAP error code or `SOAP_OK`. The `soap_done` function de-registers all plugin-ins, so this function should be called to cleanly terminate a gSOAP run-time environment.

An example will be used to illustrate these functions. This example overrides the send and receive callbacks to copy all messages that are sent and received to the terminal (`stderr`).

First, we write a header file `plugin.h` to define the local plug-in data structure(s) and we define a global name to identify the plug-in:

```

#include "stdsoap2.h"
#define PLUGIN_ID "PLUGIN-1.0" // some name to identify plugin
struct plugin_data // local plugin data
{
    int (*fsend)(struct soap*, const char*, size_t); // to save and use send callback
    size_t (*frecv)(struct soap*, char*, size_t); // to save and use recv callback
};
int plugin(struct soap *soap, struct soap_plugin *plugin, void *arg);

```

Then, we write the plugin registry function and the callbacks:

```

#include "plugin.h"
static const char plugin_id[] = PLUGIN_ID; // the plugin id
static int plugin_init(struct soap *soap, struct plugin_data *data);
static int plugin_copy(struct soap *soap, struct soap_plugin *dst, struct soap_plugin *src);
static void plugin_delete(struct soap *soap, struct soap_plugin *p);
static int plugin_send(struct soap *soap, const char *buf, size_t len);
static size_t plugin_recv(struct soap *soap, char *buf, size_t len);
// the registry function:
int plugin(struct soap *soap, struct soap_plugin *p, void *arg)
{
    p->id = plugin_id;
    p->data = (void*)malloc(sizeof(struct plugin_data));
    p->fcopy = plugin_copy;
    p->fdelete = plugin_delete;
    if (p->data)
        if (plugin_init(soap, (struct plugin_data*)p->data))
        {
            free(p->data); // error: could not init
            return SOAP_EOM; // return error
        }
    return SOAP_OK;
}
static int plugin_init(struct soap *soap, struct plugin_data *data)
{
    data->fsend = soap->frecv; // save old recv callback
    data->frecv = soap->frecv; // save old send callback
    soap->fsend = plugin_send; // replace send callback with new
    soap->frecv = plugin_recv; // replace recv callback with new
    return SOAP_OK;
}
// copy plugin data, called by soap_copy() // This is important: we need a deep copy to avoid data
sharing by two run-time environments
static int plugin_copy(struct soap *soap, struct soap_plugin *dst, struct soap_plugin *src)
{
    *dst = *src;
}
// plugin deletion, called by soap_done()
static void plugin_delete(struct soap *soap, struct soap_plugin *p)
{
    free(p->data); // free allocated plugin data
}
// the new send callback
static int plugin_send(struct soap *soap, const char *buf, size_t len)
{

```

```

    struct plugin_data *data = (struct plugin_data*)soap_lookup_plugin(soap, plugin_id); // fetch
    plugin's local data
    fwrite(buf, len, 1, stderr); // write message to stderr
    return data->fsend(soap, buf, len); // pass data on to old send callback
}
// the new receive callback
static size_t plugin_rcv(struct soap *soap, char *buf, size_t len)
{
    struct plugin_data *data = (struct plugin_data*)soap_lookup_plugin(soap, plugin_id); // fetch
    plugin's local data
    size_t res = data->frecv(soap, buf, len); // get data from old rcv callback
    fwrite(buf, res, 1, stderr);
    return res;
}

```

The `fcopy` and `fdelete` callbacks of **struct** `soap_plugin` MUST be set to register the plugin. It is the responsibility of the plug-in to handle registry (init), copy, and deletion of the plug-in data and callbacks.

The example plug-in should be used as follows:

```

struct soap soap;
soap_init(&soap);
soap_register_plugin(&soap, plugin);
...
soap_done(&soap);

```

Note: `soap_register_plugin(...)` is an alias for `soap_register_plugin_arg(..., NULL)`. That is, it passes `NULL` as an argument to plug-in's registry callback.