YAZ User’s Guide and Reference
# COLLABORATORS

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# REVISION HISTORY

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Abstract

This document is the programmer’s guide and reference to the YAZ package version 5.28.0. YAZ is a compact toolkit that provides access to the Z39.50 and SRU/Solr protocols, as well as a set of higher-level tools for implementing the server and client roles, respectively. The documentation can be used on its own, or as a reference when looking at the example applications provided with the package.
Chapter 1

Introduction

YAZ is a C/C++ library for information retrieval applications using the Z39.50/SRU/Solr protocols for information retrieval.

Properties of YAZ:

- Complete Z39.50 version 3 support. Amendments and Z39.50-2002 revision is supported.
- Supports SRU GET/POST/SOAP version 1.1, 1.2 and 2.0 (over HTTP and HTTPS).
- Includes BER encoders/decoders for the ISO ILL protocol.
- Supports Apache Solr Web Service version 1.4.x (client side only)
- Supports the following transports: BER over TCP/IP (RFC1729), BER over unix local socket, and HTTP 1.1.
- Secure Socket Layer support using GnuTLS. If enabled, YAZ uses HTTPS transport (for SOAP) or "Secure BER" (for Z39.50).
- Offers ZOOM C API implementing Z39.50, SRU and Solr Web Service.
- The YAZ library offers a set of useful utilities related to the protocols, such as MARC (ISO2709) parser, CCL (ISO8777) parser, CQL parser, memory management routines, character set conversion.
- Portable code. YAZ compiles out-of-the box on most Unixes and on Windows using Microsoft Visual C++.
- Fast operation. The C based BER encoders/decoders as well as the server component of YAZ is very fast.
- Liberal license that allows for commercial use of YAZ.

1.1 Reading this Manual

Most implementors only need to read a fraction of the material in this manual, so a quick walkthrough of the chapters is in order.
Chapter 2 contains installation instructions for YAZ. You don’t need to read this if you expect to download YAZ binaries. However, the chapter contains information about how to make your application link with YAZ.

Chapter 3 describes the ZOOM API of YAZ. This is definitely worth reading if you wish to develop a Z39.50/SRU client.

Chapter 4 describes the generic frontend server and explains how to develop server Z39.50/SRU applications for YAZ. Obviously worth reading if you’re to develop a server.

yaz-client(1) describes how to use the YAZ Z39.50 client. If you’re a developer and wish to test your server or a server from another party, you might find this chapter useful.

Chapter 5 documents the most commonly used Z39.50 C data structures offered by the YAZ API. Client developers using ZOOM and non-Z39.50 implementors may skip this.

Chapter 6 describes how SRU and SOAP is used in YAZ. Only if you’re developing SRU applications this section is a must.

Chapter 7 contains sections for the various tools offered by YAZ. Scan through the material quickly and see what’s relevant to you! SRU implementors might find the CQL section particularly useful.

Chapter 8 goes through the details of the ODR module which is the work horse that encodes and decodes BER packages. Implementors using ZOOM only, do not need to read this. Most other Z39.50 implementors only need to read the first two sections (Section 8.1 and Section 8.2).

Chapter 9 describes the network layer module COMSTACK. Implementors using ZOOM or the generic frontend server may skip this. Others, presumably, handling client/server communication on their own should read this.

1.2 The API

The YAZ toolkit offers several different levels of access to the ISO23950/Z39.50, ILL and SRU protocols. The level that you need to use depends on your requirements, and the role (server or client) that you want to implement. If you’re developing a client application you should consider the ZOOM API. It is, by far, the easiest way to develop clients in C. Server implementers should consider the generic frontend server. None of those high-level APIs support the whole protocol, but they do include most facilities used in existing Z39.50 applications.

If you’re using ’exotic’ functionality (meaning anything not included in the high-level APIs), developing non-standard extensions to Z39.50 or you’re going to develop an ILL application, you’ll have to learn the lower level APIs of YAZ.

The YAZ toolkit modules are shown in figure Figure 1.1.
There are four layers.

- A client or server application (or both). This layer includes ZOOM and the generic frontend server.
- The second layer provides a C representation of the protocol units (packages) for Z39.50 ASN.1, ILL ASN.1, SRU.
- The third layer encodes and decodes protocol data units to simple packages (buffer with certain length). The ODR module encodes and decodes BER whereas the HTTP modules encodes and decodes HTTP requests/responses.
- The lowest layer is COMSTACK which exchanges the encoded packages with a peer process over a network.

The Z39.50 ASN.1 module represents the ASN.1 definition of the Z39.50 protocol. It establishes a set of type and structure definitions, with one structure for each of the top-level PDUs, and one structure or type for each of the contained ASN.1 types. For primitive types, or other types that are defined by the ASN.1 standard itself (such as the EXTERNAL type), the C representation is provided by the ODR (Open Data Representation) subsystem.

ODR is a basic mechanism for representing an ASN.1 type in the C programming language, and for implementing BER encoders and decoders for values of that type. The types defined in the Z39.50 ASN.1 module generally have the prefix `Z_`, and a suffix corresponding to the name of the type in the ASN.1 specification of the protocol (generally Z39.50-1995). In the case of base types (those originating in the ASN.1 standard itself), the prefix `Odr_` is sometimes seen. Either way, look for the actual definition in either `z-core.h` (for the types from the protocol), `odr.h` (for the primitive ASN.1 types). The Z39.50 ASN.1 library also provides functions (which are, in turn, defined using ODR primitives) for encoding and decoding data values. Their general form is
When you have created a BER-encoded buffer, you can use the COMSTACK subsystem to transmit (or receive) data over the network. The COMSTACK module provides simple functions for establishing a connection (passively or actively, depending on the role of your application), and for exchanging BER-encoded PDUs over that connection. When you create a connection endpoint, you need to specify what transport to use (TCP/IP, SSL or UNIX sockets). For the remainder of the connection’s lifetime, you don’t have to worry about the underlying transport protocol at all - the COMSTACK will ensure that the correct mechanism is used.

We call the combined interfaces to ODR, Z39.50 ASN.1, and COMSTACK the service level API. It’s the API that most closely models the Z39.50 service/protocol definition, and it provides unlimited access to all fields and facilities of the protocol definitions.

The reason that the YAZ service-level API is a conglomerate of the APIs from three different submodules is twofold. First, we wanted to allow the user a choice of different options for each major task. For instance, if you don’t like the protocol API provided by ODR/Z39.50 ASN.1, you can use SNACC or BERUtils instead, and still have the benefits of the transparent transport approach of the COMSTACK module. Secondly, we realize that you may have to fit the toolkit into an existing event-processing structure, in a way that is incompatible with the COMSTACK interface or some other part of YAZ.
Chapter 2

Compilation and Installation

2.1 Introduction

The latest version of the software will generally be found at:


We have tried our best to keep the software portable, and on many platforms, you should be able to compile everything with little or no changes.

The software is regularly tested on Debian GNU/Linux, CentOS, Ubuntu Linux, FreeBSD (i386), MAC OSX, Windows 10.

Some versions have been known to work on Windows XP, Solaris, HP/UX, DEC Unix, NetBSD, OpenBSD, IBM AIX, Data General DG/UX (with some CFLAGS tinkering), SGI/IRIX, DDE Supermax, Apple Macintosh (using the Codewarrior programming environment and the GUSI socket libraries), IBM AS/400.

If you move the software to other platforms, we’d be grateful if you’d let us know about it. If you run into difficulties, we will try to help if we can, and if you solve the problems, we would be happy to include your fixes in the next release. So far, we have mostly avoided #ifdefs for individual platforms, and we’d like to keep it that way as far as it makes sense.

We maintain a mailing-list for the purpose of announcing new releases and bug-fixes, as well as general discussion. Subscribe by filling-in the form here. General questions and problems can be directed at yaz-help@indexdata.dk, or the address given at the top of this document.

2.2 UNIX/MacOS

We provide Debian GNU/Linux (i386 and amd64), Ubuntu (i386 and amd64) and CentOS (amd64 only) packages for YAZ. You should be able to create packages for other CPUs by building them from the source package.

YAZ is also part of several packages repositories. Some of them are

- Solaris CSW: http://www.opencsw.org/packages/yaz/
• Solaris: http://unixpackages.com
• FreeBSD: http://www.freshports.org/net/yaz
• Debian: http://packages.debian.org/search?keywords=yaz
• Ubuntu: https://launchpad.net/ubuntu/+source/yaz

2.2.1 Compiling from source on Unix


If you wish to use character set conversion facilities in YAZ or if you are compiling YAZ for use with Zebra, it is a good idea to ensure that the iconv library is installed. Some Unixes today already have it - if not, we suggest GNU libiconv.

YAZ 3.0.16 and later includes a wrapper for the ICU (International Components for Unicode). In order to use this, the developer version of the ICU library must be available. ICU support is recommended for applications such as Pazpar2 and Zebra.

The libxslt, libxml2 libraries are required if YAZ is to support SRU/Solr. These libraries are very portable and should compile out-of-the box on virtually all Unix platforms. It is available in binary forms for Linux and others.

The GNU tools Autoconf, Automake and Libtool are used to generate Makefiles and configure YAZ for the system. You do not need these tools unless you’re using the Git version of YAZ.

The CQL parser for YAZ is built using GNU Bison. This tool is only needed if you’re using the Git version of YAZ.

YAZ includes a tiny ASN.1 compiler. This compiler is written in Tcl. But as for Bison you do not need it unless you’re using Git version of YAZ or you’re using the compiler to build your own codecs for private ASN.1.

If you are checking out from Git, run:

```
./buildconf.sh
```

This will create the configure script and Makefiles.

The next step is always:

```
./configure
```

The configure script attempts to use the C compiler specified by the CC environment variable. If not set, GNU C will be used if it is available. The CFLAGS environment variable holds options to be passed to the C compiler. If you’re using Bourne-compatible shell, you may pass something like this to use a particular C compiler with optimization enabled:

```
CC=/opt/ccs/bin/cc CFLAGS=-O ./configure
```
To customize YAZ, the configure script also accepts a set of options. The most important are:

`--prefix=prefix`  Specifies installation prefix for YAZ. This is only needed if you run `make install` later to perform a "system" installation. The prefix is `/usr/local` if not specified.

`--enable-tcpd`  The front end server will be built using Wietse’s TCP wrapper library. It allows you to allow/deny clients depending on IP number. The TCP wrapper library is often used in GNU/Linux and BSD distributions. See hosts_access(5) and tcpd(8).

`--enable-threads`  YAZ will be built using POSIX threads. Specifically, `_REENTRANT` will be defined during compilation.

`--disable-shared`  The make process will not create shared libraries (also known as shared objects .so). By default, shared libraries are created - equivalent to `--enable-shared`.

`--disable-shared`  The make process will not create static libraries (.a). By default, static libraries are created - equivalent to `--enable-static`.

`--with-iconv=[prefix]`  Compile YAZ with iconv library in directory `prefix`. By default configure will search for iconv on the system. Use this option if it doesn’t find iconv. Alternatively, `--without-iconv`, can be used to force YAZ not to use iconv.

`--with-xslt=[prefix]`  Compile YAZ with libxslt in directory `prefix`. Use this option if you want XSLT and XML support. By default, configure will search for libxslt on the system. Use this option if libxslt is not found automatically. Alternatively, `--without-xslt`, can be used to force YAZ not to use libxslt.

`--with-xml2=[prefix]`  Compile YAZ with libxml2 in directory `prefix`. Use this option if you want YAZ to use XML and support SRU/Solr. By default, configure will search for libxml2 on the system. Use this option if libxml2 is not found automatically. Alternatively, `--without-xml2`, can be used to force YAZ not to use libxml2.

Note that option `--with-xslt` also enables libxml2.

`--with-gnutls=[prefix]`  YAZ will be linked with the GNU TLS libraries and an SSL COMSTACK will be provided. By default configure enables SSL support for YAZ if the GNU TLS development libraries are found on the system.

`--with-icu=[prefix]`  YAZ will be linked the ICU library in the prefix if given. If prefix is not given, the libraries exposed by the script icu-config will be used if found.

`--with-memcached`  YAZ will be linked with libMemcached to allow for result-set caching for ZOOM. The prefix can not be given. Note that 0.40 of libmemcached is required.

`--with-redis`  YAZ will be linked with the hiredis C library to allow for result-set caching for ZOOM on a redis server. The prefix can not be given.

When configured, build the software by typing:

```
make
```

The following files are generated by the make process:
**src/libyaz.la** Main YAZ library. This is no ordinary library. It’s a Libtool archive. By default, YAZ creates a static library in `lib/.libs/libyaz.a`.

**src/libyaz_server.la** Generic Frontend server. This is an add-on for libyaz.la. Code in this library uses POSIX threads functions - if POSIX threads are available on the platform.

**src/libyaz_icu.la** Functions that wrap the ICU library.

**ztest/yaz-ztest** Test Z39.50 server.

**client/yaz-client** Z39.50 client for testing the protocol. See chapter YAZ client for more information.

**util/yaz-config** A Bourne-shell script, generated by configure, that specifies how external applications should compile - and link with YAZ.

**util/yaz-asncomp** The ASN.1 compiler for YAZ. Requires the Tcl Shell, tclsh, in `PATH` to operate.

**util/yaz-iconv** This program converts data in one character set to another. This command exercises the YAZ character set conversion API.

**util/yaz-marcdump** This program parses ISO2709 encoded MARC records and prints them in line-format or XML.

**util/yaz-icu** This program exposes the ICU wrapper library if that is enabled for YAZ. Only if ICU is available this program is useful.

**util/yaz-url** This program is a simple HTTP page fetcher ala wget or curl.

**zoom/zoomsh** A simple shell implemented on top of the ZOOM functions. The shell is a command line application that allows you to enter simple commands to perform ZOOM operations.

**zoom/zoomtst1, zoom/zoomtst2, ..** Several small applications that demonstrate the ZOOM API.

If you wish to install YAZ in system directories `/usr/local/bin, /usr/local/lib .. etc, you can type:

```
make install
```

You probably need to have root access in order to perform this. You must specify the `--prefix` option for configure if you wish to install YAZ in other directories than the default `/usr/local/`.

If you wish to perform an un-installation of YAZ, use:

```
make uninstall
```

This will only work if you haven’t reconfigured YAZ (and therefore changed installation prefix). Note that uninstall will not remove directories created by make install, e.g. `/usr/local/include/yaz`. 
2.2.2 Compiling from source on MacOS

Compiling from source on MacOSX requires libxml2. This can be installed with Homebrew, for instance:

```
brew install libxml2
```

Review the Caveats section (brew info libxml2) for the LDFLAGS, CPPFLAGS, and PKG_CONFIG_PATH environment variables before executing the ./compile command. For instance:

```
export LDFLAGS="-L/usr/local/opt/libxml2/lib"
export CPPFLAGS="-I/usr/local/opt/libxml2/include"
export PKG_CONFIG_PATH="/usr/local/opt/libxml2/lib/pkgconfig"
./configure
make
```

2.2.3 How to make apps using YAZ on UNIX

This section describes how to compile - and link your own applications using the YAZ toolkit. If you’re used to Makefiles this shouldn’t be hard. As for other libraries you have used before, you need to set a proper include path for your C/C++ compiler and specify the location of YAZ libraries. You can do it by hand, but generally we suggest you use the yaz-config that is generated by configure. This is especially important if you’re using the threaded version of YAZ which require you to pass more options to your linker/compiler.

The yaz-config script accepts command line options that makes the yaz-config script print options that you should use in your make process. The most important ones are: --cflags, --libs which prints C compiler flags, and linker flags respectively.

A small and complete Makefile for a C application consisting of one source file, myprog.c, may look like this:

```
YAZCONFIG=/usr/local/bin/yaz-config
CFLAGS='$(YAZCONFIG) --cflags'
LIBS='$(YAZCONFIG) --libs'
myprog: myprog.o
  $(CC) $(CFLAGS) -o myprog myprog.o $(LIBS)
```

The CFLAGS variable consists of a C compiler directive that will set the include path to the parent directory of yaz. That is, if YAZ header files were installed in /usr/local/include/yaz, then include path is set to /usr/local/include. Therefore, in your applications you should use

```
#include <yaz/proto.h>
```

and not

```
#include <proto.h>
```

For Libtool users, the yaz-config script provides a different variant of option --libs, called --lalibs that returns the name of the Libtool archive(s) for YAZ rather than the ordinary ones.

For applications using the threaded version of YAZ, specify threads after the other options. When threads is given, more flags and linker flags will be printed by yaz-config. If our previous example was using threads, you’d have to modify the lines that set CFLAGS and LIBS as follows:
CFLAGS='$(YAZCONFIG) --cflags threads'
LIBS='$(YAZCONFIG) --libs threads'

There is no need specify POSIX thread libraries in your Makefile. The LIBS variable includes that as well.

## 2.3 Windows

The easiest way to install YAZ on Windows is by downloading an installer from Index Data’s Windows support area. The installer comes with source too - in case you wish to compile YAZ with different compiler options, etc.

### 2.3.1 Compiling from Source on Windows

YAZ is shipped with "makefiles" for the NMAKE tool that comes with Microsoft Visual Studio. It has been tested with Microsoft Visual Studio 2017.

Start a command prompt and switch the sub directory WIN where the file makefile is located. Customize the installation by editing the makefile file (for example by using notepad). The following summarizes the most important settings in that file:

**DEBUG** If set to 1, the software is compiled with debugging libraries (code generation is multi-threaded debug DLL). If set to 0, the software is compiled with release libraries (code generation is multi-threaded DLL).

**HAVE_TCL, TCL** If HAVE_TCL is set to 1, nmake will use the ASN.1 compiler (Tcl based). You must set TCL to the full path of the Tcl interpreter. A Windows version of Tcl is part of Git for Windows.

If you do not have Tcl installed, set HAVE_TCL to 0.

**HAVE_BISON, BISON** If GNU Bison is present, you might set HAVE_BISON to 1 and specify the Bison executable in BISON. Bison is only required if you use the Git version of YAZ or if you modify the grammar for CQL (cql.y).

A Windows version of GNU Bison can be fetched from here: Index Data’s Windows support area.

**HAVE_ICONV, ICONV_DIR** If HAVE_ICONV is set to 1, YAZ is compiled with iconv support. In this configuration, set ICONV_DIR to the iconv source directory.

**HAVE_LIBXML2, LIBXML2_DIR** If HAVE_LIBXML2 is set to 1, YAZ is compiled with SRU support. In this configuration, set LIBXML2_DIR to the libxml2 source directory.

You can get pre-compiled Libxml2+Libxslt DLLs and headers from here. Should you wish to compile those libraries yourself, refer to to Section 2.3.3.

**HAVE_LIBXSLT, LIBXSLT_DIR** If HAVE_LIBXSLT is set to 1, YAZ is compiled with XSLT support. In this configuration, set LIBXSLT_DIR to the libxslt source directory.
**Note**
libxslt depends on libxml2.

**HAVE_ICU, ICU_DIR** If HAVE_ICU is set to 1, YAZ is compiled with ICU support. In this configuration, set ICU_DIR to the ICU source directory.

Pre-compiled ICU libraries for various versions of Visual Studio can be found [here](#) or from Index Data’s [Windows support site](#).

When satisfied with the settings in the makefile, type

```
nmake
```

**Note**
If the nmake command is not found on your system you probably haven’t defined the environment variables required to use that tool. To fix that, find and run the batch file vcvarsall.bat. You need to run it from within the command prompt or set the environment variables "globally"; otherwise it doesn’t work.

If you wish to recompile YAZ - for example if you modify settings in the makefile you can delete object files, etc by running.

```
nmake clean
```

The following files are generated upon successful compilation:

`bin/yaz5.dll / bin/yaz5d.dll` YAZ Release/Debug DLL.

`lib/yaz5.lib / lib/yaz5d.lib` Import library for yaz5.dll/yaz5d.dll.

`bin/yaz_cond5.dll / bin/yaz_cond5d.dll` Release/Debug DLL for condition variable utilities (condvar.c).

`lib/yaz Cond5.lib / lib/yaz Cond5d.lib` Import library for yaz_cond5.dll/yaz_cond5d.dll.

`bin/yaz_icu5.dll / bin/yaz_icu5d.dll` Release/Debug DLL for the ICU wrapper utility. Only build if HAVE_ICU is 1.

`lib/yaz_icu5.lib / lib/yaz_icu5d.lib` Import library for yaz_icu5.dll/yaz_icu5d.dll.

`bin/yaz-ztest.exe` Z39.50 multi-threaded test/example server. It’s a WIN32 console application.

`bin/yaz-client.exe` YAZ Z39.50 client application. It’s a WIN32 console application. See chapter YAZ client for more information.

`bin/yaz-icu.exe` This program exposes the ICU wrapper library if that is enabled for YAZ. Only if ICU is available this program is built.
bin/zoomsh.exe Simple console application implemented on top of the ZOOM functions. The application is a command line shell that allows you to enter simple commands to perform ZOOM operations.

bin/zoomtst1.exe, bin/zoomtst2.exe, .. Several small applications that demonstrate the ZOOM API.

2.3.2 How to make apps using YAZ on Windows

This section will go though the process of linking your Windows applications with YAZ. Some people are confused by the fact that we use the nmake tool to build YAZ. They think they have to do that too - in order to make their Windows applications work with YAZ. The good news is that you don’t have to. You can use the integrated environment of Visual Studio if desired for your own application.

When setting up a project or Makefile you have to set the following:

`include path` Set it to the include directory of YAZ.

`import library yaz5.lib` You must link with this library. It’s located in the sub directory lib of YAZ. If you want to link with the debug version of YAZ, you must link against yaz5d.lib instead.

`dynamic link library yaz5.dll` This DLL must be in your execution path when you invoke your application. Specifically, you should distribute this DLL with your application.

2.3.3 Compiling Libxml2 and Libxslt on Windows

Download libxml2 and Libxslt source and unpack it. In the example below we install Libxml2 2.9.2 and Libxslt 1.1.28 for 32-bit, so we use the destination directories libxml2.2.9.2.win32 and libxslt-1.1.28.win32 to reflect both version and architecture.

```
cd win32
cscript configure.js prefix=c:\libxml2-2.9.2.win32 iconv=no
nmake
nmake install
```

**Note**

There’s an error in `configure.js` for Libxml2 2.9.2. Line 17 should be assigned to `configure.ac` rather than `configure.in`.

For Libxslt it is similar. We must ensure that compilation of Libxslt links against the already installed libxml2.

```
cd win32
cscript configure.js prefix=c:\libxslt-1.1.28.win32 iconv=no \   lib=c:\libxml2-2.9.2.win32\lib \   include=c:\libxml2-2.9.2.win32\include\libxml2
nmake
nmake install
```
ZOOM

ZOOM is an acronym for 'Z39.50 Object-Orientation Model' and is an initiative started by Mike Taylor (Mike is from the UK, which explains the peculiar name of the model). The goal of ZOOM is to provide a common Z39.50 client API not bound to a particular programming language or toolkit.

From YAZ version 2.1.12, SRU is supported. You can make SRU ZOOM connections by specifying scheme http:// for the hostname for a connection. The dialect of SRU used is specified by the value of the connection’s sru option, which may be SRU over HTTP GET (get), SRU over HTTP POST (post), (SRU over SOAP) (soap) or solr (Solr Web Service). Using the facility for embedding options in target strings, a connection can be forced to use SRU rather the SRW (the default) by prefixing the target string with sru=get,, like this: sru=get,http://sru.miketaylor.org.uk:80/sru.pl

Solr protocol support was added to YAZ in version 4.1.0, as a dialect of a SRU protocol, since both are HTTP based protocols.

The lack of a simple Z39.50 client API for YAZ has become more and more apparent over time. So when the first ZOOM specification became available, an implementation for YAZ was quickly developed. For the first time, it is now as easy (or easier!) to develop clients as it is to develop servers with YAZ. This chapter describes the ZOOM C binding. Before going further, please reconsider whether C is the right programming language for the job. There are other language bindings available for YAZ, and still more are in active development. See the ZOOM web-site for more information.

In order to fully understand this chapter you should read and try the example programs zoomtst1.c, zoomtst2.c,.. in the zoom directory.

The C language misses features found in object oriented languages such as C++, Java, etc. For example, you’ll have to manually, destroy all objects you create, even though you may think of them as temporary. Most objects have a _create_and a _destroy variant. All objects are in fact pointers to internal stuff, but you don’t see that because of typedefs. All destroy methods should gracefully ignore a NULL pointer.

In each of the sections below you’ll find a sub section called protocol behavior, that describes how the API maps to the Z39.50 protocol.

### 3.1 Connections

The Connection object is a session with a target.
#include <yaz/zoom.h>

ZOOM_connection ZOOM_connection_new(const char *host, int portnum);
ZOOM_connection ZOOM_connection_create(ZOOM_options options);

void ZOOM_connection_connect(ZOOM_connection c, const char *host, int portnum);
void ZOOM_connection_destroy(ZOOM_connection c);

Connection objects are created with either function ZOOM_connection_new or ZOOM_connection_create. The former creates and automatically attempts to establish a network connection with the target. The latter doesn’t establish a connection immediately, thus allowing you to specify options before establishing network connection using the function ZOOM_connection_connect. If the port number, portnum, is zero, the host is consulted for a port specification. If no port is given, 210 is used. A colon denotes the beginning of a port number in the host string. If the host string includes a slash, the following part specifies a database for the connection.

You can prefix the host with a scheme followed by colon. The default scheme is tcp (Z39.50 protocol). The scheme http selects SRU/SOAP over HTTP by default, but can be changed with option sru.

You can prefix the scheme-qualified host-string with one or more comma-separated key=value sequences, each of which represents an option to be set into the connection structure before the protocol-level connection is forged and the initialization handshake takes place. This facility can be used to provide authentication credentials, as in host-strings such as: user=admin,password=halfAm4n,tcp:localhost:8017/db

Connection objects should be destroyed using the function ZOOM_connection_destroy.

void ZOOM_connection_option_set(ZOOM_connection c, const char *key, const char *val);

void ZOOM_connection_option_setl(ZOOM_connection c, const char *key, const char *val, int len);

const char *ZOOM_connection_option_get(ZOOM_connection c, const char *key);
const char *ZOOM_connection_option_getl(ZOOM_connection c, const char *key, int *lenp);

The functions ZOOM_connection_option_set and ZOOM_connection_option_setl allows you to set an option given by key to the value value for the connection. For ZOOM_connection_option_set, the value is assumed to be a 0-terminated string. Function ZOOM_connection_option_setl specifies a value of a certain size (len).

Functions ZOOM_connection_option_get and ZOOM_connection_option_getl returns the value for an option given by key.
<table>
<thead>
<tr>
<th><strong>Option</strong></th>
<th><strong>Description</strong></th>
<th><strong>Default</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>implementationName</td>
<td>Name of your client</td>
<td>none</td>
</tr>
<tr>
<td>user</td>
<td>Authentication user name</td>
<td>none</td>
</tr>
<tr>
<td>group</td>
<td>Authentication group name</td>
<td>none</td>
</tr>
<tr>
<td>password</td>
<td>Authentication password</td>
<td>none</td>
</tr>
<tr>
<td>authenticationMode</td>
<td>How authentication is encoded</td>
<td>basic</td>
</tr>
<tr>
<td>host</td>
<td>Target host. This setting is &quot;read-only&quot;. It's automatically set internally when connecting to a target.</td>
<td>none</td>
</tr>
<tr>
<td>proxy</td>
<td>Proxy host. If set, the logical host is encoded in the otherInfo area of the Z39.50 Init PDU with OID 1.2.840.10003.10.1000.81.1.</td>
<td>none</td>
</tr>
<tr>
<td>clientIP</td>
<td>Client IP. If set, is encoded in the otherInfo area of a Z39.50 PDU with OID 1.2.840.10003.10.1000.81.3. Holds the original IP addresses of a client. Is used if ZOOM is used in a gateway of some sort.</td>
<td>none</td>
</tr>
<tr>
<td>timeout</td>
<td>Idle timeout which specifies how long ZOOM will wait for network I/O before giving up. Thus, the actual waiting time might be longer than this value if the target makes a chunked response and the time between each chunk arrive is less this value. For the connect+init, this is the time ZOOM will wait until receiving first byte from Init response.</td>
<td>30</td>
</tr>
<tr>
<td>async</td>
<td>If true (1) the connection operates in asynchronous operation which means that all calls are non-blocking except ZOOM_event.</td>
<td>0</td>
</tr>
<tr>
<td>maximumRecordSize</td>
<td>Maximum size of single record</td>
<td>1 MB</td>
</tr>
<tr>
<td>preferredMessageSize</td>
<td>Maximum size of multiple records</td>
<td>1 MB</td>
</tr>
<tr>
<td>lang</td>
<td>Language for negotiation</td>
<td>none</td>
</tr>
<tr>
<td>charset</td>
<td>Character set for negotiation</td>
<td>none</td>
</tr>
<tr>
<td>serverImplementationId</td>
<td>Implementation ID of server. (The old targetImplementationId option is also supported for the benefit of old applications.)</td>
<td>none</td>
</tr>
<tr>
<td>targetImplementationName</td>
<td>Implementation Name of server. (The old targetImplementationName option is also supported for the benefit of old applications.)</td>
<td>none</td>
</tr>
<tr>
<td>serverImplementationVersion</td>
<td>Implementation Version of server. (The old targetImplementationVersion option is also supported for the benefit of old applications.)</td>
<td>none</td>
</tr>
<tr>
<td>databaseName</td>
<td>One or more database names separated by character plus (+), which is to be used by subsequent search requests on this Connection.</td>
<td>Default</td>
</tr>
<tr>
<td>piggyback</td>
<td>True (1) if piggyback should be used in searches; false (0) if not.</td>
<td>1</td>
</tr>
<tr>
<td>smallSetUpperBound</td>
<td>If hits is less than or equal to this value, then target will return all records using small element set name</td>
<td>0</td>
</tr>
<tr>
<td>largeSetLowerBound</td>
<td>If hits is greater than this value, the target will return no records.</td>
<td>1</td>
</tr>
<tr>
<td>persistence</td>
<td>This value represents the number of records to be returned as part of a search when hits is less than or equal to the lower bound of the persistence range.</td>
<td>0</td>
</tr>
</tbody>
</table>
If either option `lang` or `charset` is set, then **Character Set and Language Negotiation** is in effect.

```c
int ZOOM_connection_error(ZOOM_connection c, const char **cp,
                           const char **addinfo);
int ZOOM_connection_error_x(ZOOM_connection c, const char **cp,
                            const char **addinfo, const char **dset);
```

Function `ZOOM_connection_error` checks for errors for the last operation(s) performed. The function returns zero if no errors occurred; non-zero otherwise indicating the error. Pointers `cp` and `addinfo` holds messages for the error and additional-info if passed as non-NULL. Function `ZOOM_connection_error_x` is an extended version of `ZOOM_connection_error` that is capable of returning name of diagnostic set in `dset`.

### 3.1.1 Z39.50 Protocol behavior

The calls `ZOOM_connection_new` and `ZOOM_connection_connect` establishes a TCP/IP connection and sends an Initialize Request to the target if possible. In addition, the calls wait for an Initialize Response from the target and the result is inspected (OK or rejected).

If `proxy` is set then the client will establish a TCP/IP connection with the peer as specified by the `proxy` host and the hostname as part of the connect calls will be set as part of the Initialize Request. The proxy server will then "forward" the PDUs transparently to the target behind the proxy.

For the authentication parameters, if option `user` is set and both options `group` and `pass` are unset, then Open style authentication is used (Version 2/3) in which case the username is usually followed by a slash, then by a password. If either `group` or `pass` is set then idPass authentication (Version 3 only) is used. If none of the options are set, no authentication parameters are set as part of the Initialize Request (obviously).

When option `async` is 1, it really means that all network operations are postponed (and queued) until the function `ZOOM_event` is invoked. When doing so it doesn’t make sense to check for errors after `ZOOM_connection_new` is called since that operation "connecting - and init" is still incomplete and the API cannot tell the outcome (yet).

### 3.1.2 SRU/Solr Protocol behavior

The HTTP based protocols (SRU, SRW, Solr) do not feature an Initialize Request, so the connection phase merely establishes a TCP/IP connection with the HTTP server.

Most of the ZOOM connection options do not affect SRU/Solr and they are ignored. However, future versions of YAZ might honor `implementationName` and put that as part of User-Agent header for HTTP requests.

The `charset` is used in the Content-Type header of HTTP requests.

Setting `authenticationMode` specifies how authentication parameters are encoded for HTTP. The default is "basic" where `user` and `password` are encoded by using HTTP basic authentication.

If `authenticationMode` is "url", then user and password are encoded in the URL by parameters `x-username` and `x-password` as given by the SRU standard.
3.2 Queries

Query objects represents queries.

\[ \text{ZOOM_query} \text{ ZOOM_query_create}(\text{void}); \]
\[ \text{void ZOOM_query_destroy(ZOOM_query q);} \]
\[ \text{int ZOOM_query_prefix(ZOOM_query q, const char *str);} \]
\[ \text{int ZOOM_query_cql(ZOOM_query s, const char *str);} \]
\[ \text{int ZOOM_query_sortby(ZOOM_query q, const char *criteria);} \]
\[ \text{int ZOOM_query_sortby2(ZOOM_query q, const char *strategy, const char *criteria);} \]

Create query objects using ZOOM_query_create and destroy them by calling ZOOM_query_destroy. RPN-queries can be specified in PQF notation by using the function ZOOM_query_prefix. The ZOOM_query specifies a CQL query to be sent to the server/target. More query types will be added in future versions of YAZ, such as CCL to RPN-mapping, native CCL query, etc. In addition to a search, a sort criteria may be set. Function ZOOM_query_sortby enables Z39.50 sorting and it takes sort criteria using the same string notation as yaz-client’s sort command.

ZOOM_query_sortby2 is similar to ZOOM_query_sortby but allows a strategy for sorting. The reason for the strategy parameter is that some protocols offer multiple ways of performing sorting. For example, Z39.50 has the standard sort, which is performed after search on an existing result set. It’s also possible to use CQL in Z39.50 as the query type and use CQL’s SORTBY keyword. Finally, Index Data’s Zebra server also allows sorting to be specified as part of RPN (Type 7).

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>z39.50</td>
<td>Z39.50 resultset sort</td>
</tr>
<tr>
<td>type7</td>
<td>Sorting embedded in RPN(Type-7)</td>
</tr>
<tr>
<td>cql</td>
<td>CQL SORTBY</td>
</tr>
<tr>
<td>sru11</td>
<td>SRU sortKeys parameter</td>
</tr>
<tr>
<td>solr</td>
<td>Solr sort</td>
</tr>
<tr>
<td>embed</td>
<td>type7 for Z39.50, cql for SRU, solr for Solr protocol</td>
</tr>
</tbody>
</table>

Table 3.2: ZOOM sort strategy

3.3 Result sets

The result set object is a container for records returned from a target.
Function `ZOOM_connection_search` creates a result set, given a connection and query. Destroy a result set by calling `ZOOM_resultset_destroy`. Simple clients using PQF only, may use the function `ZOOM_connection_search_pqf` in which case creating query objects is not necessary.

```
void ZOOM_resultset_option_set(ZOOM_resultset r, const char *key, const char *val);
const char *ZOOM_resultset_option_get(ZOOM_resultset r, const char *key);
size_t ZOOM_resultset_size(ZOOM_resultset r);
```

Functions `ZOOM_resultset_options_set` and `ZOOM_resultset_get` sets and gets an option for a result set similar to `ZOOM_connection_option_get` and `ZOOM_connection_option_set`. The number of hits, also called result-count, is returned by function `ZOOM_resultset_size`.

For servers that support Search Info report, the following options may be read using `ZOOM_resultset_get`. This detailed information is read after a successful search has completed.

This information is a list of of items, where each item is information about a term or subquery. All items in the list are prefixed by `SearchResult.no` where `no` presents the item number (0=first, 1=second). Read `searchresult.size` to determine the number of items.

### 3.3.1 Z39.50 Result-set Sort

```
void ZOOM_resultset_sort(ZOOM_resultset r, const char *sort_type, const char *sort_spec);
int ZOOM_resultset_sort1(ZOOM_resultset r, const char *sort_type, const char *sort_spec);
```

`ZOOM_resultset_sort` and `ZOOM_resultset_sort1` both sort an existing result-set. The `sort_type` parameter is not used. Set it to "yaz". The `sort_spec` is same notation as `ZOOM_query_sortby` and identical to that offered by yaz-client’s `sort command`.

These functions only work for Z39.50. Use the more generic utility `ZOOM_query_sortby2` for other protocols (and even Z39.50).
<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>start</td>
<td>Offset of first record to be retrieved from target. First record has offset 0 unlike the protocol specifications where first record has position 1. This option affects ZOOM_resultset_search and ZOOM_resultset_search_pqf and must be set before any of these functions are invoked. If a range of records must be fetched manually after search, function ZOOM_resultset_records should be used.</td>
<td>0</td>
</tr>
<tr>
<td>count</td>
<td>Number of records to be retrieved. This option affects ZOOM_resultset_search and ZOOM_resultset_search_pqf and must be set before any of these functions are invoked.</td>
<td>0</td>
</tr>
<tr>
<td>presentChunk</td>
<td>The number of records to be requested from the server in each chunk (present request). The value 0 means to request all the records in a single chunk. (The old step option is also supported for the benefit of old applications.)</td>
<td>0</td>
</tr>
<tr>
<td>elementSetName</td>
<td>Element-Set name of records. Most targets should honor element set name B and F for brief and full respectively.</td>
<td>none</td>
</tr>
<tr>
<td>preferredRecordSyntax</td>
<td>Preferred Syntax, such as USMARC, SUTRS, etc.</td>
<td>none</td>
</tr>
<tr>
<td>schema</td>
<td>Schema for retrieval, such as Gils-schema, Geo-schema, etc.</td>
<td>none</td>
</tr>
<tr>
<td>setname</td>
<td>Name of Result Set (Result Set ID). If this option isn’t set, the ZOOM module will automatically allocate a result set name.</td>
<td>default</td>
</tr>
<tr>
<td>rpnCharset</td>
<td>Character set for RPN terms. If this is set, ZOOM C will assume that the ZOOM application is running UTF-8. Terms in RPN queries are then converted to the rpnCharset. If this is unset, ZOOM C will not assume any encoding of RPN terms and no conversion is performed.</td>
<td>none</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>searchresult.size</td>
<td>number of search result entries. This option is non-existent if no entries are returned by the server.</td>
</tr>
<tr>
<td>searchresult.no.id</td>
<td>sub query ID</td>
</tr>
<tr>
<td>searchresult.no.count</td>
<td>result count for item (number of hits)</td>
</tr>
<tr>
<td>searchresult.no.subquery.term</td>
<td>subquery term</td>
</tr>
<tr>
<td>searchresult.no.interpretation.term</td>
<td>interpretation term</td>
</tr>
<tr>
<td>searchresult.no.recommendation.term</td>
<td>recommendation term</td>
</tr>
</tbody>
</table>

Table 3.3: ZOOM Result set Options

Table 3.4: Search Info Report Options
3.3.2 Z39.50 Protocol behavior

The creation of a result set involves at least a SearchRequest - SearchResponse protocol handshake. Following that, if a sort criteria was specified as part of the query, a SortRequest - SortResponse handshake takes place. Note that it is necessary to perform sorting before any retrieval takes place, so no records will be returned from the target as part of the SearchResponse because these would be unsorted. Hence, piggyback is disabled when sort criteria are set. Following Search - and a possible sort - Retrieval takes place - as one or more Present Requests/Response pairs being transferred.

The API allows for two different modes for retrieval. A high level mode which is somewhat more powerful and a low level one. The low level is enabled when searching on a Connection object for which the settings smallSetUpperBound, mediumSetPresentNumber and largeSetLowerBound are set. The low level mode thus allows you to precisely set how records are returned as part of a search response as offered by the Z39.50 protocol. Since the client may be retrieving records as part of the search response, this mode doesn’t work well if sorting is used.

The high-level mode allows you to fetch a range of records from the result set with a given start offset. When you use this mode the client will automatically use piggyback if that is possible with the target, and perform one or more present requests as needed. Even if the target returns fewer records as part of a present response because of a record size limit, etc. the client will repeat sending present requests. As an example, if option start is 0 (default) and count is 4, and piggyback is 1 (default) and no sorting criteria is specified, then the client will attempt to retrieve the 4 records as part the search response (using piggyback). On the other hand, if either start is positive or if a sorting criteria is set, or if piggyback is 0, then the client will not perform piggyback but send Present Requests instead.

If either of the options mediumSetElementSetName and smallSetElementSetName are unset, the value of option elementSetName is used for piggyback searches. This means that for the high-level mode you only have to specify one elementSetName option rather than three.

3.3.3 SRU Protocol behavior

Current version of YAZ does not take advantage of a result set id returned by the SRU server. Future versions might do, however. Since the ZOOM driver does not save result set IDs, any present (retrieval) is transformed to a SRU SearchRetrieveRequest with same query but, possibly, different offsets.

Option schema specifies SRU schema for retrieval. However, options elementSetName and preferredRecordSyntax are ignored.

Options start and count are supported by SRU. The remaining options piggyback, smallSetUpperBound, largeSetLowerBound, mediumSetPresentNumber, mediumSetElementSetName, smallSetElementSetName are unsupported.

SRU supports CQL queries, not PQF. If PQF is used, however, the PQF query is transferred anyway using non-standard element pQuery in SRU SearchRetrieveRequest.

Solr queries need to be done in Solr query format.

Unfortunately, SRU and Solr do not define a database setting. Hence, databaseName is unsupported and ignored. However, the path part in host parameter for functions ZOOM_connection_new and ZOOM_connectionConnect acts as a database (at least for the YAZ SRU server).
3.4 Records

A record object is a retrieval record on the client side - created from result sets.

```c
void ZOOM_resultset_records(ZOOM_resultset r,
    ZOOM_record *recs,
    size_t start, size_t count);
ZOOM_record ZOOM_resultset_record(ZOOM_resultset s, size_t pos);
const char *ZOOM_record_get(ZOOM_record rec, const char *type,
    size_t *len);
int ZOOM_record_error(ZOOM_record rec, const char **msg,
    const char **addinfo, const char **diagset);
ZOOM_record ZOOM_record_clone(ZOOM_record rec);
void ZOOM_record_destroy(ZOOM_record rec);
```

References to temporary records are returned by functions `ZOOM_resultset_records` or `ZOOM_resultset_record`.

If a persistent reference to a record is desired `ZOOM_record_clone` should be used. It returns a record reference that should be destroyed by a call to `ZOOM_record_destroy`.

A single record is returned by function `ZOOM_resultset_record` that takes a position as argument. First record has position zero. If no record could be obtained `NULL` is returned.

Error information for a record can be checked with `ZOOM_record_error` which returns non-zero (error code) if record is in error, called Surrogate Diagnostics in Z39.50.

Function `ZOOM_resultset_records` retrieves a number of records from a result set. Parameter `start` and `count` specifies the range of records to be returned. Upon completion, the array `recs[0]`, `..recs[count-1]` holds record objects for the records. The array of records `recs` should be allocated prior the call `ZOOM_resultset_records`. Note that for those records that couldn’t be retrieved from the target, `recs[ ..]` is set to `NULL`.

In order to extract information about a single record, `ZOOM_record_get` is provided. The function returns a pointer to certain record information. The nature (type) of the pointer depends on the parameter, `type`.

The `type` is a string of the format:

```
format[:charset=from[/opacfrom][,to]][:format=v][:base64=xpath]
```

If `charset` is given, then `from` specifies the character set of the record in its original form (as returned by the server), `to` specifies the output (returned) character set encoding. If `to` is omitted, then UTF-8 is assumed. If charset is not given, then no character set conversion takes place. OPAC records may be returned in a different set from the bibliographic MARC record. If this is this the case, `opacfrom` should be set to the character set of the OPAC record part.

The `format` is generic but can only be used to specify XML indentation when the value `v` is 1 (`format=1`). The `base64` allows a full record to be extracted from base64-encoded string in an XML document.
Note
Specifying the OPAC record character set requires YAZ 4.1.5 or later.
Specifying the base64 parameter requires YAZ 4.2.35 or later.

The format argument controls whether record data should be XML pretty-printed (post process operation). It is enabled only if format value v is 1 and the record content is XML well-formed.

In addition, for certain types, the length len passed will be set to the size in bytes of the returned information.

The following are the supported values for form.

database The Database of the record is returned as a C null-terminated string. Return type const char *.
syntax The transfer syntax of the record is returned as a C null-terminated string containing the symbolic name of the record syntax, e.g. Usmarc. Return type is const char *.
schema The schema of the record is returned as a C null-terminated string. Return type is const char *.
render The record is returned in a display friendly format. Upon completion, buffer is returned (type const char *) and length is stored in *len.
raw The record is returned in the internal YAZ specific format. For GRS-1, Explain, and others, the raw data is returned as type Z_External * which is just the type for the member retrievalRecord in type NamePlusRecord. For SUTRS and octet aligned record (including all MARCs) the octet buffer is returned and the length of the buffer.
xml The record is returned in XML if possible. SRU, Solr and Z39.50 records with transfer syntax XML are returned verbatim. MARC records are returned in MARCXML (converted from ISO2709 to MARCXML by YAZ). OPAC records are also converted to XML and the bibliographic record is converted to MARCXML (when possible). GRS-1 records are not supported for this form. Upon completion, the XML buffer is returned (type const char *) and length is stored in *len.
opac OPAC information for record is returned in XML if an OPAC record is present at the position given. If no OPAC record is present, a NULL pointer is returned.
txml The record is returned in TurboMARC if possible. SRU and Z39.50 records with transfer syntax XML are returned verbatim. MARC records are returned in TurboMARC (converted from ISO2709 to TurboMARC by YAZ). Upon completion, the XML buffer is returned (type const char *) and length is stored in *len.
json Like xml, but MARC records are converted to MARC-in-JSON.

Most MARC21 records uses the MARC-8 character set encoding. An application that wishes to display in Latin-1 would use

render; charset=marc8,iso-8859-1
3.4.1 Z39.50 Protocol behavior

The functions \texttt{ZOOM\_resultset\_record} and \texttt{ZOOM\_resultset\_records} inspects the client-side record cache. Records not found in cache are fetched using Present. The functions may block (and perform network I/O) - even though option \texttt{async} is 1, because they return records objects. (And there’s no way to return records objects without retrieving them!)

There is a trick, however, in the usage of function \texttt{ZOOM\_resultset\_records} that allows for delayed retrieval (and makes it non-blocking). By using a null pointer for \texttt{recs} you’re indicating you’re not interested in getting records objects \textit{now}.

3.4.2 SRU/Solr Protocol behavior

The ZOOM driver for SRU/Solr treats records returned by a SRU/Solr server as if they were Z39.50 records with transfer syntax XML and no element set name or database name.

3.5 ZOOM Facets

Facets are only supported for a few Z39.50 targets. It is a relatively new non-standard Z39.50 extension (see facets.asn in the YAZ source). However, facets are usually supported for Solr and SRU 2.0 targets.

Facets may be specified by the \texttt{facets} option before a search is sent. See Section 7.8 for the notation. For inspection of the returned facets, the following functions are available:

\begin{verbatim}
ZOOM_facet_field *ZOOM_resultset_facets(ZOOM_resultset r);
size_t ZOOM_resultset_facets_size(ZOOM_resultset r);
ZOOM_facet_field ZOOM_resultset_get_facet_field(ZOOM_resultset r,
const char *facet_name);
ZOOM_facet_field ZOOM_resultset_get_facet_field_by_index(ZOOM_resultset r,
int pos);
const char *ZOOM_facet_field_name(ZOOM_facet_field facet_field);
size_t ZOOM_facet_field_term_count(ZOOM_facet_field facet_field);
const char *ZOOM_facet_field_get_term(ZOOM_facet_field facet_field,
size_t idx, int *freq);
\end{verbatim}

References to temporary structures are returned by all functions. They are only valid as long the Result set is valid.

All facet fields may be returned by a call to \texttt{ZOOM\_resultset\_facets}. The length of the array is
given by ZOOM_resultset_facets_size. The array is zero-based and the last entry will be at
ZOOM_resultset_facets_size(result_set)-1.

Facet fields can also be fetched via its name using ZOOM_resultset_get_facet_field. Or by
its index (starting from 0) by a call to ZOOM_resultset_get_facet_field_by_index. Both of
these functions return NULL if name is not found or index is out of bounds.

Function ZOOM_facet_field_name gets the request facet name from a returned facet field.

Function ZOOM_facet_field_get_term returns the idx’th term and term count for a facet field. Idx
must between 0 and ZOOM_facet_field_term_count-1, otherwise the returned reference will be
NULL. On a valid idx, the value of the freq reference will be the term count. The freq parameter must be
valid pointer to integer.

3.6 Scan

This section describes an interface for Scan. Scan is not an official part of the ZOOM model yet. The result
of a scan operation is the ZOOM_scanset which is a set of terms returned by a target.

The Scan interface is supported for both Z39.50, SRU and Solr.

```c
ZOOM_scanset ZOOM_connection_scan(ZOOM_connection c,
       const char *startpqf);

ZOOM_scanset ZOOM_connection_scan1(ZOOM_connection c,
       ZOOM_query q);

size_t ZOOM_scanset_size(ZOOM_scanset scan);

const char *ZOOM_scanset_term(ZOOM_scanset scan, size_t pos,
       size_t *occ, size_t *len);

const char *ZOOM_scanset_display_term(ZOOM_scanset scan, size_t pos,
       size_t *occ, size_t *len);

void ZOOM_scanset_destroy(ZOOM_scanset scan);

const char *ZOOM_scanset_option_get(ZOOM_scanset scan,
       const char *key);

void ZOOM_scanset_option_set(ZOOM_scanset scan, const char *key,
       const char *val);
```

The scan set is created by function ZOOM_connection_scan which performs a scan operation on the
connection using the specified startpqf. If the operation was successful, the size of the scan set can
be retrieved by a call to ZOOM_scanset_size. Like result sets, the items are numbered 0..size-1.
To obtain information about a particular scan term, call function `ZOOM_scanset_term`. This function takes a scan set offset `pos` and returns a pointer to a raw term or `NULL` if non-present. If present, the `occ` and `len` are set to the number of occurrences and the length of the actual term respectively. `ZOOM_scanset_display_term` is similar to `ZOOM_scanset_term` except that it returns the display term rather than the raw term. In a few cases, the term is different from display term. Always use the display term for display and the raw term for subsequent scan operations (to get more terms, next scan result, etc).

A scan set may be freed by a call to function `ZOOM_scanset_destroy`. Functions `ZOOM_scanset_option_get` and `ZOOM_scanset_option_set` retrieves and sets an option respectively.

The `startpqf` is a subset of PQF, namely the Attributes+Term part. Multiple `@attr` can be used. For example to scan in title (complete) phrases:

```plaintext
@attr 1=4 @attr 6=2 "science o"
```

The `ZOOM_connection_scan1` is a newer and more generic alternative to `ZOOM_connection_scan` which allows to use both CQL and PQF for Scan.

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>Number of Scan Terms requested in next scan. After scan it holds the actual number of terms returned.</td>
<td>20</td>
</tr>
<tr>
<td>position</td>
<td>Preferred Position of term in response in next scan; actual position after completion of scan.</td>
<td>1</td>
</tr>
<tr>
<td>stepSize</td>
<td>Step Size</td>
<td>0</td>
</tr>
<tr>
<td>scanStatus</td>
<td>An integer indicating the Scan Status of last scan.</td>
<td>0</td>
</tr>
<tr>
<td>rpnCharset</td>
<td>Character set for RPN terms. If this is set, ZOOM C will assume that the ZOOM application is running UTF-8. Terms in RPN queries are then converted to the rpnCharset. If this is unset, ZOOM C will not assume any encoding of RPN terms and no conversion is performed.</td>
<td>none</td>
</tr>
</tbody>
</table>

Table 3.5: ZOOM Scan Set Options

### 3.7 Extended Services

ZOOM offers an interface to a subset of the Z39.50 extended services as well as a few privately defined ones:

- Z39.50 Item Order (ILL). See Section 3.7.1.
- Record Update. This allows a client to insert, modify or delete records. See Section 3.7.2.
- Database Create. This a non-standard feature. Allows a client to create a database. See Section 3.7.3.
• Database Drop. This a non-standard feature. Allows a client to delete/drop a database. See Section 3.7.4.
• Commit operation. This a non-standard feature. Allows a client to commit operations. See Section 3.7.5.

To create an extended service operation, a ZOOM_package must be created. The operation is a five step operation. The package is created, package is configured by means of options, the package is sent, result is inspected (by means of options), the package is destroyed.

```c
ZOOM_package ZOOM_connection_package(ZOOM_connection c,
                                   ZOOM_options options);

const char *ZOOM_package_option_get(ZOOM_package p,
                                   const char *key);
void ZOOM_package_option_set(ZOOM_package p, const char *key,
                                   const char *val);
void ZOOM_package_send(ZOOM_package p, const char *type);
void ZOOM_package_destroy(ZOOM_package p);
```

The ZOOM_connection_package creates a package for the connection given using the options specified.

Functions ZOOM_package_option_get and ZOOM_package_option_set gets and sets options. ZOOM_package_send sends the package the via connection specified in ZOOM_connection_package. The type specifies the actual extended service package type to be sent.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>itemorder</td>
<td>Item Order</td>
</tr>
<tr>
<td>update</td>
<td>Record Update</td>
</tr>
<tr>
<td>create</td>
<td>Database Create</td>
</tr>
<tr>
<td>drop</td>
<td>Database Drop</td>
</tr>
<tr>
<td>commit</td>
<td>Commit Operation</td>
</tr>
</tbody>
</table>

Table 3.6: Extended Service Type

### 3.7.1 Item Order

For Item Order, type must be set to itemorder in ZOOM_package_send.

There are two variants of item order: ILL-variant and XML document variant. In order to use the XML variant the setting doc must hold the XML item order document. If that setting is unset, the ILL-variant is used.

### 3.7.2 Record Update

For Record Update, type must be set to update in ZOOM_package_send.
<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>package-name</td>
<td>Extended Service Request package name. Must be specified as part of a request.</td>
<td>none</td>
</tr>
<tr>
<td>user-id</td>
<td>User ID of Extended Service Package. Is a request option.</td>
<td>none</td>
</tr>
<tr>
<td>function</td>
<td>Function of package - one of create, delete, modify. Is a request option.</td>
<td>create</td>
</tr>
<tr>
<td>waitAction</td>
<td>Wait action for package. Possible values: wait, waitIfPossible, dontWait or</td>
<td>waitIfPossible</td>
</tr>
<tr>
<td></td>
<td>dontReturnPackage.</td>
<td></td>
</tr>
<tr>
<td>operationStatus</td>
<td>Read after response. One of: done, accepted or failure. Inspect with</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>ZOOM_pacakage_option_get.</td>
<td></td>
</tr>
<tr>
<td>targetReference</td>
<td>Target Reference. This is part of the response as returned by the target.</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>Read it after a successful operation. Inspect with ZOOM_pacakage_option_get.</td>
<td></td>
</tr>
<tr>
<td>taskStatus</td>
<td>Read after response: One of: pending, active, complete, aborted.</td>
<td>none</td>
</tr>
<tr>
<td>esError</td>
<td>Read after response: is set to diagnostic code for response.</td>
<td>none</td>
</tr>
<tr>
<td>esAddinfo</td>
<td>Read after response: is set to additional info for response.</td>
<td>none</td>
</tr>
</tbody>
</table>

Table 3.7: Extended Service Common Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>contact-name</td>
<td>ILL contact name</td>
<td>none</td>
</tr>
<tr>
<td>contact-phone</td>
<td>ILL contact phone</td>
<td>none</td>
</tr>
<tr>
<td>contact-email</td>
<td>ILL contact email</td>
<td>none</td>
</tr>
<tr>
<td>itemorder-setname</td>
<td>Name of result set for record</td>
<td>default</td>
</tr>
<tr>
<td>itemorder-item</td>
<td>Position for item (record) requested. An integer</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3.8: Item Order Options
<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>protocol-version-num</td>
</tr>
<tr>
<td>transaction-id,initial-requester-id,person-or-institution-symbol,person</td>
</tr>
<tr>
<td>transaction-id,initial-requester-id,person-or-institution-symbol,institution</td>
</tr>
<tr>
<td>transaction-id,initial-requester-id,name-of-person-or-institution,name-of-person</td>
</tr>
<tr>
<td>transaction-id,initial-requester-id,name-of-person-or-institution,name-of-institution</td>
</tr>
<tr>
<td>transaction-id,transaction-group-qualifier</td>
</tr>
<tr>
<td>transaction-id,transaction-qualifier</td>
</tr>
<tr>
<td>transaction-id,sub-transaction-qualifier</td>
</tr>
<tr>
<td>service-date-time,this,date</td>
</tr>
<tr>
<td>service-date-time,this,time</td>
</tr>
<tr>
<td>service-date-time,original,date</td>
</tr>
<tr>
<td>service-date-time,original,time</td>
</tr>
<tr>
<td>requester-id,person-or-institution-symbol,person</td>
</tr>
<tr>
<td>requester-id,person-or-institution-symbol,institution</td>
</tr>
<tr>
<td>requester-id,name-of-person-or-institution,name-of-person</td>
</tr>
<tr>
<td>requester-id,name-of-person-or-institution,name-of-institution</td>
</tr>
<tr>
<td>responder-id,person-or-institution-symbol,person</td>
</tr>
<tr>
<td>responder-id,person-or-institution-symbol,institution</td>
</tr>
<tr>
<td>responder-id,name-of-person-or-institution,name-of-person</td>
</tr>
<tr>
<td>responder-id,name-of-person-or-institution,name-of-institution</td>
</tr>
<tr>
<td>transaction-type</td>
</tr>
<tr>
<td>delivery-address,postal-address,name-of-person-or-institution,name-of-person</td>
</tr>
<tr>
<td>delivery-address,postal-address,name-of-person-or-institution,name-of-institution</td>
</tr>
<tr>
<td>delivery-address,postal-address,extended-postal-delivery-address</td>
</tr>
<tr>
<td>delivery-address,postal-address,street-and-number</td>
</tr>
<tr>
<td>delivery-address,postal-address,post-office-box</td>
</tr>
<tr>
<td>delivery-address,postal-address,city</td>
</tr>
<tr>
<td>delivery-address,postal-address,region</td>
</tr>
<tr>
<td>delivery-address,postal-address,country</td>
</tr>
<tr>
<td>delivery-address,postal-address,postal-code</td>
</tr>
<tr>
<td>delivery-address,electronic-address,telecom-service-identifier</td>
</tr>
<tr>
<td>delivery-address,electronic-address,telecom-service-address</td>
</tr>
<tr>
<td>billing-address,postal-address,name-of-person-or-institution,name-of-person</td>
</tr>
<tr>
<td>billing-address,postal-address,name-of-person-or-institution,name-of-institution</td>
</tr>
<tr>
<td>billing-address,postal-address,extended-postal-delivery-address</td>
</tr>
<tr>
<td>billing-address,postal-address,street-and-number</td>
</tr>
<tr>
<td>billing-address,postal-address,post-office-box</td>
</tr>
<tr>
<td>billing-address,postal-address,city</td>
</tr>
<tr>
<td>billing-address,postal-address,region</td>
</tr>
<tr>
<td>billing-address,postal-address,country</td>
</tr>
<tr>
<td>billing-address,postal-address,postal-code</td>
</tr>
<tr>
<td>billing-address,electronic-address,telecom-service-identifier</td>
</tr>
<tr>
<td>billing-address,electronic-address,telecom-service-address</td>
</tr>
<tr>
<td>ill-service-type</td>
</tr>
<tr>
<td>requester-optional-messages,can-send-RECEIVED</td>
</tr>
<tr>
<td>requester-optional-messages,can-send-RETURNED</td>
</tr>
<tr>
<td>requester-optional-messages,requester-SHIPPED</td>
</tr>
<tr>
<td>requester-optional-messages,requester-CHECKED-IN</td>
</tr>
<tr>
<td>search-type,level-of-service</td>
</tr>
<tr>
<td>search-type,need-before-date</td>
</tr>
<tr>
<td>search-type,expiry-date</td>
</tr>
<tr>
<td>search-type,transaction-flag</td>
</tr>
<tr>
<td>Option</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>action</td>
</tr>
<tr>
<td>recordIdOpaque</td>
</tr>
<tr>
<td>recordIdNumber</td>
</tr>
<tr>
<td>recordIdString</td>
</tr>
<tr>
<td>record</td>
</tr>
<tr>
<td>recordOpaque</td>
</tr>
<tr>
<td>syntax</td>
</tr>
<tr>
<td>databaseName</td>
</tr>
<tr>
<td>correlationInfo.note</td>
</tr>
<tr>
<td>correlationInfo.id</td>
</tr>
<tr>
<td>elementSetName</td>
</tr>
<tr>
<td>updateVersion</td>
</tr>
</tbody>
</table>

Table 3.10: Record Update Options
3.7.3 Database Create

For Database Create, `type` must be set to `create` in `ZOOM_package_send`.

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>databaseName</td>
<td>Database from connection object</td>
<td>Default</td>
</tr>
</tbody>
</table>

Table 3.11: Database Create Options

3.7.4 Database Drop

For Database Drop, `type` must be set to `drop` in `ZOOM_package_send`.

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>databaseName</td>
<td>Database from connection object</td>
<td>Default</td>
</tr>
</tbody>
</table>

Table 3.12: Database Drop Options

3.7.5 Commit Operation

For Commit, `type` must be set to `commit` in `ZOOM_package_send`.

3.7.6 Protocol behavior

All the extended services are Z39.50-only.

**Note**
The database create, drop, and commit services are privately defined operations. Refer to `esadmin.asn` in YAZ for the ASN.1 definitions.

3.8 Options

Most ZOOM objects provide a way to specify options to change behavior. From an implementation point of view, a set of options is just like an associative array / hash.

```c
ZOOM_options ZOOM_options_create(void);

ZOOM_options ZOOM_options_create_with_parent(ZOOM_options parent);

void ZOOM_options_destroy(ZOOM_options opt);
```
const char *ZOOM_options_get(ZOOM_options opt, const char *name);

void ZOOM_options_set(ZOOM_options opt, const char *name, const char *v);

typedef const char *(*ZOOM_options_callback)(void *handle, const char *name);

ZOOM_options_callback
ZOOM_options_set_callback(ZOOM_options opt, ZOOM_options_callback c, void *handle);

3.9 Query conversions

int ZOOM_query_cql2rpn(ZOOM_query s, const char *cql_str, ZOOM_connection conn);

int ZOOM_query_ccl2rpn(ZOOM_query s, const char *ccl_str, const char *config, int *ccl_error, const char **error_string, int *error_pos);

ZOOM_query_cql2rpn translates the CQL string, client-side, into RPN which may be passed to the server. This is useful for servers that don’t themselves support CQL, for which ZOOM_query_cql is useless. 'conn' is used only as a place to stash diagnostics if compilation fails; if this information is not needed, a null pointer may be used. The CQL conversion is driven by option cqlfile from connection conn. This specifies a conversion file (e.g. pqf.properties) which must be present.

ZOOM_query_ccl2rpn translates the CCL string, client-side, into RPN which may be passed to the server. The conversion is driven by the specification given by config. Upon completion 0 is returned on success; -1 is returned on failure. On failure error_string and error_pos hold the error message and position of first error in original CCL string.

3.10 Events

If you’re developing non-blocking applications, you have to deal with events.

int ZOOM_event(int no, ZOOM_connection *cs);
The `ZOOM_event` executes pending events for a number of connections. Supply the number of connections in `no` and an array of connections in `cs` (cs[0] ... cs[no-1]). A pending event could be sending a search, receiving a response, etc. When an event has occurred for one of the connections, this function returns a positive integer `n` denoting that an event occurred for connection `cs[n-1]`. When no events are pending for the connections, a value of zero is returned. To ensure that all outstanding requests are performed, call this function repeatedly until zero is returned.

If `ZOOM_event` returns, and returns non-zero, the last event that occurred can be expected.

```c
int ZOOM_connection_last_event(ZOOM_connection cs);
```

`ZOOM_connection_last_event` returns an event type (integer) for the last event.

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZOOM_EVENT_NONE</td>
<td>No event has occurred</td>
</tr>
<tr>
<td>ZOOM_EVENT_CONNECT</td>
<td>TCP/IP connect has initiated</td>
</tr>
<tr>
<td>ZOOM_EVENT_SEND_DATA</td>
<td>Data has been transmitted (sending)</td>
</tr>
<tr>
<td>ZOOM_EVENT_RECV_DATA</td>
<td>Data has been received</td>
</tr>
<tr>
<td>ZOOM_EVENT_TIMEOUT</td>
<td>Timeout</td>
</tr>
<tr>
<td>ZOOM_EVENT_UNKNOWN</td>
<td>Unknown event</td>
</tr>
<tr>
<td>ZOOM_EVENT_SEND_APDU</td>
<td>An APDU has been transmitted (sending)</td>
</tr>
<tr>
<td>ZOOM_EVENT_RECV_APDU</td>
<td>An APDU has been received</td>
</tr>
<tr>
<td>ZOOM_EVENT_RECV_RECORD</td>
<td>A result-set record has been received</td>
</tr>
<tr>
<td>ZOOM_EVENT_RECV_SEARCH</td>
<td>A search result has been received</td>
</tr>
</tbody>
</table>

Table 3.13: ZOOM Event IDs
Chapter 4

Generic server

4.1 Introduction

If you aren’t into documentation, a good way to learn how the back end interface works is to look at the `backend.h` file. Then, look at the small dummy-server in `ztest/ztest.c`. The `backend.h` file also makes a good reference, once you’ve chewed your way through the prose of this file.

If you have a database system that you would like to make available by means of Z39.50 or SRU, YAZ basically offers two options. You can use the APIs provided by the Z39.50 ASN.1, ODR, and COMSTACK modules to create and decode PDUs, and exchange them with a client. Using this low-level interface gives you access to all fields and options of the protocol, and you can construct your server as close to your existing database as you like. It is also a fairly involved process, requiring you to set up an event-handling mechanism, protocol state machine, etc. To simplify server implementation, we have implemented a compact and simple, but reasonably full-functioned server-frontend that will handle most of the protocol mechanics, while leaving you to concentrate on your database interface.

---

**Note**

The backend interface was designed in anticipation of a specific integration task, while still attempting to achieve some degree of generality. We realize fully that there are points where the interface can be improved significantly. If you have specific functions or parameters that you think could be useful, send us a mail (or better, sign on to the mailing list referred to in the top-level README file). We will try to fit good suggestions into future releases, to the extent that it can be done without requiring too many structural changes in existing applications.

---

**Note**

The YAZ server does not support XCQL.

---

4.2 The Database Frontend

We refer to this software as a generic database frontend. Your database system is the *backend database*, and the interface between the two is called the *backend API*. The backend API consists of a small number of
function handlers and structure definitions. You are required to provide the main() routine for the server (which can be quite simple), as well as a set of handlers to match each of the prototypes. The interface functions that you write can use any mechanism you like to communicate with your database system: You might link the whole thing together with your database application and access it by function calls; you might use IPC to talk to a database server somewhere; or you might link with third-party software that handles the communication for you (like a commercial database client library). At any rate, the handlers will perform the tasks of:

- Initialization.
- Searching.
- Fetching records.
- Scanning the database index (optional - if you wish to implement SCAN).
- Extended Services (optional).
- Result-Set Delete (optional).
- Result-Set Sort (optional).
- Return Explain for SRU (optional).

(more functions will be added in time to support as much of Z39.50-1995 as possible).

### 4.3 The Backend API

The header file that you need to use the interface are in the include/yaz directory. It’s called backend.h. It will include other files from the include/yaz directory, so you’ll probably want to use the -I option of your compiler to tell it where to find the files. When you run make in the top-level YAZ directory, everything you need to create your server is to link with the lib/libyaz.la library.

### 4.4 Your main() Routine

As mentioned, your main() routine can be quite brief. If you want to initialize global parameters, or read global configuration tables, this is the place to do it. At the end of the routine, you should call the function

```c
int statserv_main(int argc, char **argv,
                   bend_initresult *(bend_init)(bend_initrequest *r),
                   void *(bend_close)(void *handle));
```
The third and fourth arguments are pointers to handlers. Handler `bend_init` is called whenever the server receives an Initialize Request, so it serves as a Z39.50 session initializer. The `bend_close` handler is called when the session is closed.

`statserv_main` will establish listening sockets according to the parameters given. When connection requests are received, the event handler will typically `fork()` and create a sub-process to handle a new connection. Alternatively the server may be setup to create threads for each connection. If you do use global variables and forking, you should be aware, then, that these cannot be shared between associations, unless you explicitly disable forking by command line parameters.

The server provides a mechanism for controlling some of its behavior without using command-line options. The function

```c
statserv_options_block *statserv_getcontrol(void);
```

will return a pointer to a `struct statserv_options_block` describing the current default settings of the server. The structure contains these elements:

- `int dynamic` A boolean value, which determines whether the server will fork on each incoming request (TRUE), or not (FALSE). Default is TRUE. This flag is only read by UNIX-based servers (WIN32-based servers do not fork).

- `int threads` A boolean value, which determines whether the server will create a thread on each incoming request (TRUE), or not (FALSE). Default is FALSE. This flag is only read by UNIX-based servers that offer POSIX Threads support. WIN32-based servers always operate in threaded mode.

- `int inetd` A boolean value, which determines whether the server will operate under a UNIX INET daemon (inetd). Default is FALSE.


- `char apdunfile[ODR_MAXNAME+1]` Name of file for logging incoming and outgoing APDUs ("": don’t log APDUs, ":" : stderr).

- `char default_listen[1024]` Same form as the command-line specification of listener address. ":" : no default listener address. Default is to listen at "tcp:@:9999". You can only specify one default listener address in this fashion.

- `enum oid_proto default_proto;` Either `PROTO_Z3950` or `PROTO_SR`. Default is `PROTO_Z39_50`.

- `int idle_timeout;` Maximum session idle-time, in minutes. Zero indicates no (infinite) timeout. Default is 15 minutes.

- `int maxrecordsize;` Maximum permissible record (message) size. Default is 64 MB. This amount of memory will only be allocated if a client requests a very large amount of records in one operation (or a big record). Set it to a lower number if you are worried about resource consumption on your host system.

- `char configname[ODR_MAXNAME+1]` Passed to the backend when a new connection is received.
char setuid[ODR_MAXNAME+1] Set user id to the user specified, after binding the listener addresses.

void (*bend_start)(struct statserv_options_block *p) Pointer to function which is called after the command line options have been parsed - but before the server starts listening. For forked UNIX servers, this handler is called in the mother process; for threaded servers, this handler is called in the main thread. The default value of this pointer is NULL in which case it isn’t invoked by the frontend server. When the server operates as an NT service, this handler is called whenever the service is started.

void (*bend_stop)(struct statserv_options_block *p) Pointer to function which is called whenever the server has stopped listening for incoming connections. This function pointer has a default value of NULL in which case it isn’t called. When the server operates as an NT service, this handler is called whenever the service is stopped.

void *handle User defined pointer (default value NULL). This is a per-server handle that can be used to specify "user-data". Do not confuse this with the session-handle as returned by bend_init.

The pointer returned by statserv_getcontrol points to a static area. You are allowed to change the contents of the structure, but the changes will not take effect until you call

void statserv_setcontrol(statserv_options_block *block);

**Note**
You should generally update this structure before calling statserv_main().

### 4.5 The Backend Functions

For each service of the protocol, the backend interface declares one or two functions. You are required to provide implementations of the functions representing the services that you wish to implement.

#### 4.5.1 Init

bend_initresult (*bend_init)(bend_initrequest *r);  

This handler is called once for each new connection request, after a new process/thread has been created, and an Initialize Request has been received from the client. The pointer to the bend_init handler is passed in the call to statserv_start.  

This handler is also called when operating in SRU mode - when a connection has been made (even though SRU does not offer this service).

Unlike previous versions of YAZ, the bend_init also serves as a handler that defines the Z39.50 services that the backend intends to support. Pointers to all service handlers, including search - and fetch must be specified here in this handler.

The request - and result structures are defined as
typedef struct bend_initrequest
{
    /** \brief user/name/password to be read */
    Z_IdAuthentication *auth;
    /** \brief encoding stream (for results) */
    ODR stream;
    /** \brief printing stream */
    ODR print;
    /** \brief decoding stream (use stream for results) */
    ODR decode;
    /** \brief reference ID */
    Z_ReferenceId *referenceId;
    /** \brief peer address of client */
    char *peer_name;

    /** \brief character set and language negotiation
     
     see include/yaz/z-charneg.h */
    Z_CharSetandLanguageNegotiation *charneg_request;

    /** \brief character negotiation response */
    Z_External *charneg_response;

    /** \brief character set (encoding) for query terms
     
     This is NULL by default. It should be set to the native character
     set that the backend assumes for query terms */
    char *query_charset;

    /** \brief whether query_charset also applies to records
     
     Is 0 (No) by default. Set to 1 (yes) if records is in the same
     character set as queries. If in doubt, use 0 (No). */
    int records_in_same_charset;

    char *implementation_id;
    char *implementation_name;
    char *implementation_version;

    /** \brief Z39.50 sort handler */
    int (*bend_sort)(void *handle, bend_sort_rr *rr);

    /** \brief SRU/Z39.50 search handler */
    int (*bend_search)(void *handle, bend_search_rr *rr);

    /** \brief SRU/Z39.50 fetch handler */
    int (*bend_fetch)(void *handle, bend_fetch_rr *rr);
}
/** rief SRU/Z39.50 present handler */
int (*bend_present)(void *handle, bend_present_rr *rr);
/** rief Z39.50 extended services handler */
int (*bend_esrequest) (void *handle, bend_esrequest_rr *rr);
/** rief Z39.50 delete result set handler */
int (*bend_delete)(void *handle, bend_delete_rr *rr);
/** rief Z39.50 scan handler */
int (*bend_scan)(void *handle, bend_scan_rr *rr);
/** rief Z39.50 segment facility handler */
int (*bend_segment)(void *handle, bend_segment_rr *rr);
/** rief SRU explain handler */
int (*bend_explain)(void *handle, bend_explain_rr *rr);
/** rief SRU scan handler */
int (*bend_srw_scan)(void *handle, bend_scan_rr *rr);
/** rief SRU record update handler */
int (*bend_srw_update)(void *handle, bend_update_rr *rr);

/** rief whether named result sets are supported (0=disable, 1=enable) */
int named_result_sets;
}

typedef struct bend_initrequest
{
  int errcode;     /* 0==OK */
  char *errstring; /* system error string or NULL */
  void *handle;   /* private handle to the backend module */
} bend_initrequest;

typedef struct bend_initresult
{
  int errcode;     /* 0==OK */
  char *errstring; /* system error string or NULL */
  void *handle;   /* private handle to the backend module */
} bend_initresult;

In general, the server frontend expects that the bend_*result pointer that you return is valid at least until the next call to a bend_* function. This applies to all of the functions described herein. The parameter structure passed to you in the call belongs to the server frontend, and you should not make assumptions about its contents after the current function call has completed. In other words, if you want to retain any of the contents of a request structure, you should copy them.

The errcode should be zero if the initialization of the backend went well. Any other value will be interpreted as an error. The errstring isn’t used in the current version, but one option would be to stick it in the initResponse as a VisibleString. The handle is the most important parameter. It should be set to some value that uniquely identifies the current session to the backend implementation. It is used by the frontend server in any future calls to a backend function. The typical use is to set it to point to a dynamically allocated state structure that is private to your backend module.

The auth member holds the authentication information part of the Z39.50 Initialize Request. Interpret this if your server requires authentication.

The members peer_name, implementation_id, implementation_name and implementation_version holds DNS of client, ID of implementor, name of client (Z39.50) implementation - and version.

The bend_* members are set to NULL when bend_init is called. Modify the pointers by setting them to point to backend functions.
4.5.2 Search and Retrieve

We now describe the handlers that are required to support search - and retrieve. You must support two functions - one for search - and one for fetch (retrieval of one record). If desirable you can provide a third handler which is called when a present request is received which allows you to optimize retrieval of multiple-records.

```c
int (*bend_search) (void *handle, bend_search_rr *rr);
```

typedef struct {
    char *setname;    /* name to give to this set */
    int replace_set; /* replace set, if it already exists */
    int num_bases;   /* number of databases in list */
    char **basenames; /* databases to search */
    Z_ReferenceId *referenceId; /* reference ID */
    Z_Query *query;    /* query structure */
    ODR stream;       /* encode stream */
    ODR decode;       /* decode stream */
    ODR print;        /* print stream */
    bend_request request;
    bend_association association;
    int *fd;
    int hits;         /* number of hits */
    int errcode;      /* 0==OK */
    char *errstring;  /* system error string or NULL */
    Z_OtherInformation *search_info; /* additional search info */
    char *srw_sortKeys;    /* holds SRU/SRW sortKeys info */
    char *srw_setname;    /* holds SRU/SRW generated resultsetID */
    int *srw_setnameIdleTime; /* holds SRU/SRW life-time */
    int estimated_hit_count; /* if hit count is estimated */
    int partial_resultset; /* if result set is partial */
} bend_search_rr;
```

The `bend_search` handler is a fairly close approximation of a protocol Z39.50 Search Request - and Response PDUs. The `setname` is the `resultSetName` from the protocol. You are required to establish a mapping between the set name and whatever your backend database likes to use. Similarly, the `replace_set` is a boolean value corresponding to the `resultSetIndicator` field in the protocol. `num_bases/basenames` is a length of/array of character pointers to the database names provided by the client. The `query` is the full query structure as defined in the protocol ASN.1 specification. It can be either of the possible query types, and it’s up to you to determine if you can handle the provided query type. Rather than reproduce the C interface here, we’ll refer you to the structure definitions in the file `include/yaz/z-core.h`. If you want to look at the `attributeSetId` OID of the RPN query, you can either match it against your own internal tables, or you can use the `OID tools`.

The structure contains a number of hits, and an `errcode/errstring` pair. If an error occurs during the search, or if you’re unhappy with the request, you should set the `errcode` to a value from the BIB-
1 diagnostic set. The value will then be returned to the user in a nonsurrogate diagnostic record in the response. The errstring, if provided, will go in the addinfo field. Look at the protocol definition for the defined error codes, and the suggested uses of the addinfo field.

The bend_search handler is also called when the frontend server receives a SRU SearchRetrieveRequest. For SRU, a CQL query is usually provided by the client. The CQL query is available as part of Z_Query structure (note that CQL is now part of Z39.50 via an external). To support CQL in existing implementations that only do Type-1, we refer to the CQL-to-PQF tool described here.

To maintain backwards compatibility, the frontend server of yaz always assume that error codes are BIB-1 diagnostics. For SRU operation, a Bib-1 diagnostic code is mapped to SRU diagnostic.

```c
int (*bend_fetch) (void *handle, bend_fetch_rr *rr);

typedef struct bend_fetch_rr {
    char *setname;          /* set name */
    int number;             /* record number */
    Z_ReferenceId *referenceId; /* reference ID */
    Odr_oid *request_format; /* format, transfer syntax (OID) */
    Z_RecordComposition *comp; /* Formatting instructions */
    ODR stream;             /* encoding stream - memory source if req */
    ODR print;              /* printing stream */
    char *basename;         /* name of database that provided record */
    int len;                /* length of record or -1 if structured */
    char *record;           /* record */
    int last_in_set;        /* is it? */
    Odr_oid *output_format; /* response format/syntax (OID) */
    int errcode;            /* 0==success */
    char *errstring;        /* system error string or NULL */
    int surrogate_flag;     /* surrogate diagnostic */
    char *schema;           /* string record schema input/output */
} bend_fetch_rr;
```

The frontend server calls the bend_fetch handler when it needs database records to fulfill a Z39.50 Search Request, a Z39.50 Present Request or a SRU SearchRetrieveRequest. The setname is simply the name of the result set that holds the reference to the desired record. The number is the offset into the set (with 1 being the first record in the set). The format field is the record format requested by the client (See Section 7.2). A value of NULL for format indicates that the client did not request a specific format. The stream argument is an ODR stream which should be used for allocating space for structured data records. The stream will be reset when all records have been assembled, and the response package has been transmitted. For unstructured data, the backend is responsible for maintaining a static or dynamic buffer for the record between calls.

If a SRU SearchRetrieveRequest is received by the frontend server, the referenceId is NULL and the format (transfer syntax) is the OID for XML. The schema for SRU is stored in both the Z_RecordComposition structure and schema (simple string).
In the structure, the basename is the name of the database that holds the record. len is the length of the record returned, in bytes, and record is a pointer to the record. last_in_set should be nonzero only if the record returned is the last one in the given result set. errcode and errstring, if given, will be interpreted as a global error pertaining to the set, and will be returned in a non-surrogate-diagnostic. If you wish to return the error as a surrogate-diagnostic (local error) you can do this by setting surrogate_flag to 1 also.

If the len field has the value -1, then record is assumed to point to a constructed data type. The format field will be used to determine which encoder should be used to serialize the data.

**Note**
If your backend generates structured records, it should use odr_malloc() on the provided stream for allocating data: This allows the frontend server to keep track of the record sizes.

The format field is mapped to an object identifier in the direct reference of the resulting EXTERNAL representation of the record.

**Note**
The current version of YAZ only supports the direct reference mode.

```c
int (*bend_present) (void *handle, bend_present_rr *rr);
```

```c
typedef struct {
    char *setname;     /* set name */
    int start;
    int number;        /* record number */
    Odr_oid *format;   /* format, transfer syntax (OID) */
    Z_ReferenceId *referenceId; /* reference ID */
    Z_RecordComposition *comp; /* Formatting instructions */
    ODR stream;       /* encoding stream - memory source if required */
    ODR print;        /* printing stream */
    bend_request request;
    bend_association association;

    int hits;        /* number of hits */
    int errcode;     /* 0==OK */
    char *errstring; /* system error string or NULL */
} bend_present_rr;
```

The bend_present handler is called when the server receives a Z39.50 Present Request. The setname, start and number is the name of the result set - start position - and number of records to be retrieved respectively. format and comp is the preferred transfer syntax and element specifications of the present request.

Note that this is handler serves as a supplement for bend_fetch and need not to be defined in order to support search - and retrieve.
4.5.3 Delete

For back-ends that supports delete of a result set, only one handler must be defined.

```c
int (*bend_delete)(void *handle, bend_delete_rr *rr);

typedef struct bend_delete_rr {
    int function;
    int num_setnames;
    char **setnames;
    Z_ReferenceId *referenceId;
    int delete_status;    /* status for the whole operation */
    int *statuses;        /* status each set - indexed as setnames */
    ODR stream;
    ODR print;
} bend_delete_rr;
```

**Note**
The delete set function definition is rather primitive, mostly because we have had no practical need for it as of yet. If someone wants to provide a full delete service, we'd be happy to add the extra parameters that are required. Are there clients out there that will actually delete sets they no longer need?

4.5.4 Scan

For servers that wish to offer the scan service one handler must be defined.

```c
int (*bend_scan)(void *handle, bend_scan_rr *rr);

typedef enum {
    BEND_SCAN_SUCCESS,    /* ok */
    BEND_SCAN_PARTIAL    /* not all entries could be found */
} bend_scan_status;

typedef struct bend_scan_rr {
    int num_bases;    /* number of elements in databaselist */
    char **basenames;    /* databases to search */
    Odr_oid *attributeset;
    Z_ReferenceId *referenceId;    /* reference ID */
    Z_AttributesPlusTerm *term;
    ODR stream;    /* encoding stream - memory source if required */
    ODR print;    /* printing stream */
    int *step_size;    /* step size */
    int term_position;    /* desired index of term in result list/returned */
```
int num_entries;    /* number of entries requested/returned */

/* scan term entries. The called handler does not have
   to allocate this. Size of entries is num_entries (see above) */
struct scan_entry *entries;
bend_scan_status status;
int errcode;
char *errstring;
char *scanClause;    /* CQL scan clause */
char *setname;       /* Scan in result set (NULL if omitted) */
} bend_scan_rr;

This backend server handles both Z39.50 scan and SRU scan. In order for a handler to distinguish between
SRU (CQL) scan Z39.50 Scan, it must check for a non-NULL value of scanClause.

---

**Note**

If designed today, it would be a choice using a union or similar, but that would break binary compatibility
with existing servers.

---

### 4.6 Application Invocation

The finished application has the following invocation syntax (by way of statserv_main()):

```bash
[-w dir] [-p pidfile] [-r kilobytes] [-ziDSTV1] [listener-spec...]
```

The options are:

- **-a** file Specify a file for dumping PDUs (for diagnostic purposes). The special name - (dash) sends output to stderr.
- **-S** Don’t fork or make threads on connection requests. This is good for debugging, but not recommended for real operation: Although the server is asynchronous and non-blocking, it can be nice to keep a software malfunction (okay then, a crash) from affecting all current users.
- **-l** Like -S but after one session the server exits. This mode is for debugging only.
- **-T** Operate the server in threaded mode. The server creates a thread for each connection rather than fork a process. Only available on UNIX systems that offer POSIX threads.
- **-s** Use the SR protocol (obsolete).
- **-z** Use the Z39.50 protocol (default). This option and -s complement each other. You can use both multiple times on the same command line, between listener-specifications (see below). This way, you can set up the server to listen for connections in both protocols concurrently, on different local ports.
-l file The logfile.

-c config A user option that serves as a specifier for some sort of configuration, usually a filename. The argument to this option is transferred to member configname of the statserv_options_block.

-f vconfig This specifies an XML file that describes one or more YAZ frontend virtual servers.

-C fname Sets SSL certificate file name for server (PEM).

-v level The log level. Use a comma-separated list of members of the set {fatal,debug,warn,log,malloc,all,none}.

-u uid Set user ID. Sets the real UID of the server process to that of the given user. It’s useful if you aren’t comfortable with having the server run as root, but you need to start it as such to bind a privileged port.

-w dir The server changes to this directory before listening to incoming connections. This option is useful when the server is operating from the inetd daemon (see -i).

-p pidfile Specifies that the server should write its Process ID to the file given by pidfile. A typical location would be /var/run/yaz-ztest.pid.

-i Use this to make the server run from the inetd server (UNIX only).

-D Use this to make the server put itself in the background and run as a daemon. If neither -i nor -D is given, the server starts in the foreground.

-install Use this to install the server as an NT service (Windows NT/2000/XP only). Control the server by going to the Services in the Control Panel.

-install Use this to install the server as an NT service and mark it as "auto-start. Control the server by going to the Services in the Control Panel.

-remove Use this to remove the server from the NT services (Windows NT/2000/XP only).

-t minutes Idle session timeout, in minutes.

-k size Maximum record size/message size, in kilobytes.

-K Forces no-keepalive for HTTP sessions. By default GFS will keep sessions alive for HTTP 1.1 sessions (as defined by the standard). Using this option will force GFS to close the connection for each operation.

-r size Maximum size of log file before rotation occurs, in kilobytes. Default size is 1048576 k (=1 GB).

-d daemon Set name of daemon to be used in hosts access file. See hosts_access(5) and tcpd(8).

-m time-format Sets the format of time-stamps in the log-file. Specify a string in the input format to strftime().

-V Display YAZ version and exit.
A listener specification consists of a transport mode followed by a colon (:) followed by a listener address. The transport mode is either tcp, unix: or ssl.

For TCP and SSL, an address has the form

```
hostname | IP-number [: portnumber]
```

The port number defaults to 210 (standard Z39.50 port).

For UNIX, the address is the filename of a socket.

For TCP/IP and SSL, the special hostnames @, maps to IN6ADDR_ANY_INIT with IPv4 binding as well (bindv6only=0). The special hostname @4 binds to INADDR_ANY (IPv4 only listener). The special hostname @6 binds to IN6ADDR_ANY_INIT with bindv6only=1 (IPv6 only listener).

**Example 4.1 Running the GFS on Unix**

Assuming the server application `appname` is started as root, the following will make it listen on port 210. The server will change identity to `nobody` and write its log to `/var/log/app.log`.

```
application -l /var/log/app.log -u nobody tcp:@:210
```

The server will accept Z39.50 requests and offer SRU service on port 210.

**Example 4.2 Setting up Apache as SRU Frontend**

If you use Apache as your public web server and want to offer HTTP port 80 access to the YAZ server on 210, you can use the `ProxyPass` directive. If you have virtual host `srw.mydomain` you can use the following directives in Apache's `httpd.conf`:

```
<VirtualHost *>
ErrorLog /home/srw/logs/error_log
TransferLog /home/srw/logs/access_log
ProxyPass / http://srw.mydomain:210/
</VirtualHost>
```

The above is for the Apache 1.3 series.

**Example 4.3 Running a server with local access only**

A server that is only being accessed from the local host should listen on UNIX file socket rather than an Internet socket. To listen on `/tmp/mysocket` start the server as follows:

```
application unix:/tmp/mysocket
```

### 4.7 GFS Configuration and Virtual Hosts

The Virtual hosts mechanism allows a YAZ frontend server to support multiple backends. A backend is selected on the basis of the TCP/IP binding (port+listening address) and/or the virtual host.
A backend can be configured to execute in a particular working directory. Or the YAZ frontend may perform CQL to RPN conversion, thus allowing traditional Z39.50 backends to be offered as a SRW/SRU service. SRW/SRU Explain information for a particular backend may also be specified.

For the HTTP protocol, the virtual host is specified in the Host header. For the Z39.50 protocol, the virtual host is specified as in the Initialize Request in the OtherInfo, OID 1.2.840.10003.10.1000.81.1.

---

**Note**
Not all Z39.50 clients allow the VHOST information to be set. For those, the selection of the backend must rely on the TCP/IP information alone (port and address).

---

The YAZ frontend server uses XML to describe the backend configurations. Command-line option `-f` specifies filename of the XML configuration.

The configuration uses the root element `yazgfs`. This element includes a list of `listen` elements, followed by one or more `server` elements.

The `listen` describes listener (transport end point), such as TCP/IP, Unix file socket or SSL server. Content for a listener:

- **CDATA (required)** The CDATA for the `listen` element holds the listener string, such as `tcp:@:210`, `tcp:server1:2100`, etc.

- **attribute id (optional)** Identifier for this listener. This may be referred to from server sections.

---

**Note**
We expect more information to be added for the listen section in a future version, such as CERT file for SSL servers.

---

The `server` describes a server and the parameters for this server type. Content for a server:

- **attribute id (optional)** Identifier for this server. Currently not used for anything, but it might be for logging purposes.

- **attribute listenref (optional)** Specifies one or more listeners for this server. Each server ID is separated by a comma. If this attribute is not given, the server is accessible from all listeners. In order for the server to be used for real, however, the virtual host must match if specified in the configuration.

- **element config (optional)** Specifies the server configuration. This is equivalent to the config specified using command line option `-c`.

- **element directory (optional)** Specifies a working directory for this backend server. If specified, the YAZ frontend changes current working directory to this directory whenever a backend of this type is started (backend handler `bend_start`), stopped (backend handler `hand_stop`) and initialized (`bend_init`).

- **element host (optional)** Specifies the virtual host for this server. If this is specified a client must specify this host string in order to use this backend.
element **cql2rpn (optional)** Specifies a filename that includes CQL to RPN conversion for this backend server. See Section 7.1.3.4. If given, the backend server will only "see" a Type-1/RPN query.

element **ccl2rpn (optional)** Specifies a filename that includes CCL to RPN conversion for this backend server. See Section 7.1.2.2. If given, the backend server will only "see" a Type-1/RPN query.

element **stylesheet (optional)** Specifies the stylesheet reference to be part of SRU HTTP responses when the client does not specify one. If none is given, then if the client does not specify one, then no stylesheet reference is part of the SRU HTTP response.

element **client_query_charset (optional)** If specified, a conversion from the character set given to UTF-8 is performed by the generic frontend server. It is only executed for Z39.50 search requests (SRU/Solr are assumed to be UTF-8 encoded already).

element **docpath (optional)** Specifies a path for local file access using HTTP. All URLs with a leading prefix (/ excluded) that matches the value of docpath are used for file access. For example, if the server is to offer access in directory xsl, the docpath would be xsl and all URLs of the form http://host/xsl will result in a local file access.

element **explain (optional)** Specifies SRW/SRU ZeeRex content for this server. Copied verbatim to the client. As things are now, some of the Explain content seem redundant because host information, etc. is also stored elsewhere.

element **maximumrecordsize (optional)** Specifies maximum record size/message size, in bytes. This value also serves as the maximum size of incoming packages (for Record Updates etc). It’s the same value as that given by the -k option.

element **retrievalinfo (optional)** Enables the retrieval facility to support conversions and specifications of record formats/types. See Section 7.6 for more information.

The XML below configures a server that accepts connections from two ports, TCP/IP port 9900 and a local UNIX file socket. We name the TCP/IP server public and the other server internal.

```xml
<yazgfs>
  <listen id="public">tcp:0:9900</listen>
  <listen id="internal">unix:/var/tmp/socket</listen>
  <server id="server1">
    <host>server1.mydomain</host>
    <directory>/var/www/s1</directory>
    <config>config.cfg</config>
  </server>
  <server id="server2" listenref="public,internal">
    <host>server2.mydomain</host>
    <directory>/var/www/s2</directory>
    <config>config.cfg</config>
    <cql2rpn>../etc/pqf.properties</cql2rpn>
    <explain xmlns="http://explain.z3950.org/dtd/2.0/">
      <serverInfo>
        <host>server2.mydomain</host>
        <port>9900</port>
      </serverInfo>
```
There are three configured backend servers. The first two servers, "server1" and "server2", can be reached by both listener addresses. "server1" is reached by all (two) since no listenref attribute is specified. "server2" is reached by the two listeners specified. In order to distinguish between the two, a virtual host has been specified for each server in the host elements.

For "server2" elements for CQL to RPN conversion is supported and explain information has been added (a short one here to keep the example small).

The third server, "server3" can only be reached via listener "internal".
Chapter 5

The Z39.50 ASN.1 Module

5.1 Introduction

The Z39.50 ASN.1 module provides you with a set of C struct definitions for the various PDUs of the Z39.50 protocol, as well as for the complex types appearing within the PDUs. For the primitive data types, the C representation often takes the form of an ordinary C language type, such as Odr_int which is equivalent to an integral C integer. For ASN.1 constructs that have no direct representation in C, such as general octet strings and bit strings, the ODR module (see section The ODR Module) provides auxiliary definitions.

The Z39.50 ASN.1 module is located in sub directory z39.50. There you’ll find C files that implement encoders and decoders for the Z39.50 types. You’ll also find the protocol definitions: z3950v3.asn, esupdate.asn, and others.

5.2 Preparing PDUs

A structure representing a complex ASN.1 type doesn’t in itself contain the members of that type. Instead, the structure contains pointers to the members of the type. This is necessary, in part, to allow a mechanism for specifying which of the optional structure (SEQUENCE) members are present, and which are not. It follows that you will need to somehow provide space for the individual members of the structure, and set the pointers to refer to the members.

The conversion routines don’t care how you allocate and maintain your C structures - they just follow the pointers that you provide. Depending on the complexity of your application, and your personal taste, there are at least three different approaches that you may take when you allocate the structures.

You can use static or automatic local variables in the function that prepares the PDU. This is a simple approach, and it provides the most efficient form of memory management. While it works well for flat PDUs like the InitRequest, it will generally not be sufficient for say, the generation of an arbitrarily complex RPN query structure.

You can individually create the structure and its members using the malloc(2) function. If you want to ensure that the data is freed when it is no longer needed, you will have to define a function that individually releases each member of a structure before freeing the structure itself.
You can use the `odr_malloc()` function (see Section 8.2 for details). When you use `odr_malloc()`, you can release all of the allocated data in a single operation, independent of any pointers and relations between the data. The `odr_malloc()` function is based on a "nibble-memory" scheme, in which large portions of memory are allocated, and then gradually handed out with each call to `odr_malloc()`. The next time you call `odr_reset()`, all of the memory allocated since the last call is recycled for future use (actually, it is placed on a free-list).

You can combine all of the methods described here. This will often be the most practical approach. For instance, you might use `odr_malloc()` to allocate an entire structure and some of its elements, while you leave other elements pointing to global or per-session default variables.

The Z39.50 ASN.1 module provides an important aid in creating new PDUs. For each of the PDU types (say, `Z_InitRequest`), a function is provided that allocates and initializes an instance of that PDU type for you. In the case of the InitRequest, the function is simply named `zget_InitRequest()`, and it sets up reasonable default value for all of the mandatory members. The optional members are generally initialized to null pointers. This last aspect is very important: it ensures that if the PDU definitions are extended after you finish your implementation (to accommodate new versions of the protocol, say), you won’t get into trouble with uninitialized pointers in your structures. The functions use `odr_malloc()` to allocate the PDUs and its members, so you can free everything again with a single call to `odr_reset()`.

We strongly recommend that you use the `zget_*` functions whenever you are preparing a PDU (in a C++ API, the `zget_*` functions would probably be promoted to constructors for the individual types).

The prototype for the individual PDU types generally look like this:

```
Z_<type> *zget_<type>(ODR o);
```

E.g.:

```
Z_InitRequest *zget_InitRequest(ODR o);
```

The ODR handle should generally be your encoding stream, but it needn’t be.

As well as the individual PDU functions, a function `zget_APDU()` is provided, which allocates a top-level `Z-APDU` of the type requested:

```
Z_APDU *zget_APDU(ODR o, int which);
```

The `which` parameter is (of course) the discriminator belonging to the `Z-APDU CHOICE` type. All of the interface described here is provided by the Z39.50 ASN.1 module, and you access it through the `proto.h` header file.
5.3 EXTERNAL Data

In order to achieve extensibility and adaptability to different application domains, the new version of the protocol defines many structures outside of the main ASN.1 specification, referencing them through ASN.1 EXTERNAL constructs. To simplify the construction and access to the externally referenced data, the Z39.50 ASN.1 module defines a specialized version of the EXTERNAL construct, called Z_External. It is defined thus:

```c
typedef struct Z_External {
    Odr_oid *direct_reference;
    int *indirect_reference;
    char *descriptor;
    enum {
        /* Generic types */
        Z_External_single = 0,
        Z_External_octet,
        Z_External_arbitrary,
        /* Specific types */
        Z_External_SUTRS,
        Z_External_explainRecord,
        Z_External_resourceReport1,
        Z_External_resourceReport2
    } which;
    union {
        /* Generic types */
        Odr_any *single_ASN1_type;
        Odr_oct *octet_aligned;
        Odr_bitmask *arbitrary;
        /* Specific types */
        Z_SUTRS *sutrs;
        Z_ExplainRecord *explainRecord;
        Z_ResourceReport1 *resourceReport1;
        Z_ResourceReport2 *resourceReport2;
        ...
    } u;
} Z_External;
```

When decoding, the Z39.50 ASN.1 module will attempt to determine which syntax describes the data by looking at the reference fields (currently only the direct-reference). For ASN.1 structured data, you need only consult the which field to determine the type of data. You can access the data directly through
the union. When constructing data for encoding, you set the union pointer to point to the data, and set the which field accordingly. Remember also to set the direct (or indirect) reference to the correct OID for the data type. For non-ASN.1 data such as MARC records, use the octet_aligned arm of the union.

Some servers return ASN.1 structured data values (e.g. database records) as BER-encoded records placed in the octet-aligned branch of the EXTERNAL CHOICE. The ASN-module will not automatically decode these records. To help you decode the records in the application, the function

```
z_ext_typeent *z_ext_gettypebyref(const oid *oid);
```

can be used to retrieve information about the known, external data types. The function returns a pointer to a static area, or NULL, if no match for the given direct reference is found. The `z_ext_typeent` is defined as:

```c
typedef struct Z_ext_typeent
{
    int oid[OID_SIZE]; /* the direct-reference OID. */
    int what; /* discriminator value for the external CHOICE */
    Odr_fun fun; /* decoder function */
} Z_ext_typeent;
```

The `what` member contains the `Z_External` union discriminator value for the given type: For the SUTRS record syntax, the value would be `Z_External_sutrs`. The `fun` member contains a pointer to the function which encodes/decodes the given type. Again, for the SUTRS record syntax, the value of `fun` would be `z_SUTRS` (a function pointer).

If you receive an EXTERNAL which contains an octet-string value that you suspect of being an ASN.1-structured data value, you can use `z_ext_gettypebyref` to look for the provided direct-reference. If the return value is different from NULL, you can use the provided function to decode the BER string (see Section 8.2).

If you want to send EXTERNALs containing ASN.1-structured values in the octet-aligned branch of the CHOICE, this is possible too. However, on the encoding phase, it requires a somewhat involved juggling around of the various buffers involved.

If you need to add new, externally defined data types, you must update the struct above, in the source file `prt-ext.h`, as well as the encoder/decoder in the file `prt-ext.c`. When changing the latter, remember to update both the arm array and the list `type_table`, which drives the CHOICE biasing that is necessary to tell the different, structured types apart on decoding.

---

**Note**

Eventually, the EXTERNAL processing will most likely automatically insert the correct OIDs or indirect-refs. First, however, we need to determine how application-context management (specifically the presentation-context-list) should fit into the various modules.

---

### 5.4 PDU Contents Table

We include, for reference, a listing of the fields of each top-level PDU, as well as their default settings.
### Table 5.1: Default settings for PDU Initialize Request

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
<tr>
<td>protocolVersion</td>
<td>Odr_bitmask</td>
<td>Empty bitmask</td>
</tr>
<tr>
<td>options</td>
<td>Odr_bitmask</td>
<td>Empty bitmask</td>
</tr>
<tr>
<td>preferredMessageSize</td>
<td>Odr_int</td>
<td>30*1024</td>
</tr>
<tr>
<td>maximumRecordSize</td>
<td>Odr_int</td>
<td>30*1024</td>
</tr>
<tr>
<td>idAuthentication</td>
<td>Z_IdAuthentication</td>
<td>NULL</td>
</tr>
<tr>
<td>implementationId</td>
<td>char*</td>
<td>&quot;81&quot;</td>
</tr>
<tr>
<td>implementationName</td>
<td>char*</td>
<td>&quot;YAZ&quot;</td>
</tr>
<tr>
<td>implementationVersion</td>
<td>char*</td>
<td>YAZ_VERSION</td>
</tr>
<tr>
<td>userInformationField</td>
<td>Z_UserInformation</td>
<td>NULL</td>
</tr>
<tr>
<td>otherInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
</tbody>
</table>

### Table 5.2: Default settings for PDU Initialize Response

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
<tr>
<td>protocolVersion</td>
<td>Odr_bitmask</td>
<td>Empty bitmask</td>
</tr>
<tr>
<td>options</td>
<td>Odr_bitmask</td>
<td>Empty bitmask</td>
</tr>
<tr>
<td>preferredMessageSize</td>
<td>Odr_int</td>
<td>30*1024</td>
</tr>
<tr>
<td>maximumRecordSize</td>
<td>Odr_int</td>
<td>30*1024</td>
</tr>
<tr>
<td>result</td>
<td>Odr_bool</td>
<td>TRUE</td>
</tr>
<tr>
<td>implementationId</td>
<td>char*</td>
<td>&quot;id)&quot;</td>
</tr>
<tr>
<td>implementationName</td>
<td>char*</td>
<td>&quot;YAZ&quot;</td>
</tr>
<tr>
<td>implementationVersion</td>
<td>char*</td>
<td>YAZ_VERSION</td>
</tr>
<tr>
<td>userInformationField</td>
<td>Z_UserInformation</td>
<td>NULL</td>
</tr>
<tr>
<td>otherInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
<tr>
<td>Field</td>
<td>Type</td>
<td>Default Value</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
<tr>
<td>smallSetUpperBound</td>
<td>Odr_int</td>
<td>0</td>
</tr>
<tr>
<td>largeSetLowerBound</td>
<td>Odr_int</td>
<td>1</td>
</tr>
<tr>
<td>mediumSetPresentNumber</td>
<td>Odr_int</td>
<td>0</td>
</tr>
<tr>
<td>replaceIndicator</td>
<td>Odr_bool</td>
<td>TRUE</td>
</tr>
<tr>
<td>resultSetName</td>
<td>char *</td>
<td>&quot;default&quot;</td>
</tr>
<tr>
<td>num_databaseNames</td>
<td>Odr_int</td>
<td>0</td>
</tr>
<tr>
<td>databaseNames</td>
<td>char **</td>
<td>NULL</td>
</tr>
<tr>
<td>smallSetElementSetNames</td>
<td>Z_ElementSetNames</td>
<td>NULL</td>
</tr>
<tr>
<td>mediumSetElementSetNames</td>
<td>Z_ElementSetNames</td>
<td>NULL</td>
</tr>
<tr>
<td>preferredRecordSyntax</td>
<td>Odr_oid</td>
<td>NULL</td>
</tr>
<tr>
<td>query</td>
<td>Z_Query</td>
<td>NULL</td>
</tr>
<tr>
<td>additionalSearchInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
<tr>
<td>otherInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
</tbody>
</table>

Table 5.3: Default settings for PDU Search Request

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
<tr>
<td>resultCount</td>
<td>Odr_int</td>
<td>0</td>
</tr>
<tr>
<td>numberOfRecordsReturned</td>
<td>Odr_int</td>
<td>0</td>
</tr>
<tr>
<td>nextResultSetPosition</td>
<td>Odr_int</td>
<td>0</td>
</tr>
<tr>
<td>searchStatus</td>
<td>Odr_bool</td>
<td>TRUE</td>
</tr>
<tr>
<td>resultSetStatus</td>
<td>Odr_int</td>
<td>NULL</td>
</tr>
<tr>
<td>presentStatus</td>
<td>Odr_int</td>
<td>NULL</td>
</tr>
<tr>
<td>records</td>
<td>Z_Records</td>
<td>NULL</td>
</tr>
<tr>
<td>additionalSearchInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
<tr>
<td>otherInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
</tbody>
</table>

Table 5.4: Default settings for PDU Search Response
<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
<tr>
<td>resultSetId</td>
<td>char*</td>
<td>&quot;default&quot;</td>
</tr>
<tr>
<td>resultSetStartPoint</td>
<td>Odr_int</td>
<td>1</td>
</tr>
<tr>
<td>numberOfRecordsRequested</td>
<td>Odr_int</td>
<td>10</td>
</tr>
<tr>
<td>num_ranges</td>
<td>Odr_int</td>
<td>0</td>
</tr>
<tr>
<td>additionalRanges</td>
<td>Z_Range</td>
<td>NULL</td>
</tr>
<tr>
<td>recordComposition</td>
<td>Z_RecordComposition</td>
<td>NULL</td>
</tr>
<tr>
<td>preferredRecordSyntax</td>
<td>Odr_oid</td>
<td>NULL</td>
</tr>
<tr>
<td>maxSegmentCount</td>
<td>Odr_int</td>
<td>NULL</td>
</tr>
<tr>
<td>maxRecordSize</td>
<td>Odr_int</td>
<td>NULL</td>
</tr>
<tr>
<td>maxSegmentSize</td>
<td>Odr_int</td>
<td>NULL</td>
</tr>
<tr>
<td>otherInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
</tbody>
</table>

Table 5.5: Default settings for PDU Present Request

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
<tr>
<td>numberOfRecordsReturned</td>
<td>Odr_int</td>
<td>0</td>
</tr>
<tr>
<td>nextResultSetPosition</td>
<td>Odr_int</td>
<td>0</td>
</tr>
<tr>
<td>presentStatus</td>
<td>Odr_int</td>
<td>Z_PresentStatus_success</td>
</tr>
<tr>
<td>records</td>
<td>Z_Records</td>
<td>NULL</td>
</tr>
<tr>
<td>otherInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
</tbody>
</table>

Table 5.6: Default settings for PDU Present Response

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
<tr>
<td>deleteFunction</td>
<td>Odr_int</td>
<td>Z_DeleteResultSetRequest_list</td>
</tr>
<tr>
<td>num_ids</td>
<td>Odr_int</td>
<td>0</td>
</tr>
<tr>
<td>resultSetList</td>
<td>char**</td>
<td>NULL</td>
</tr>
<tr>
<td>otherInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
</tbody>
</table>

Table 5.7: Default settings for Delete Result Set Request
### Default settings for Delete Result Set Response

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
<tr>
<td>deleteOperationStatus</td>
<td>Odr_int</td>
<td>Z_DeleteStatus_success</td>
</tr>
<tr>
<td>num_statuses</td>
<td>Odr_int</td>
<td>0</td>
</tr>
<tr>
<td>deleteListStatuses</td>
<td>Z_ListStatus**</td>
<td>NULL</td>
</tr>
<tr>
<td>numberNotDeleted</td>
<td>Odr_int</td>
<td>NULL</td>
</tr>
<tr>
<td>num_bulkStatuses</td>
<td>Odr_int</td>
<td>0</td>
</tr>
<tr>
<td>bulkStatuses</td>
<td>Z_ListStatus</td>
<td>NULL</td>
</tr>
<tr>
<td>deleteMessage</td>
<td>char*</td>
<td>NULL</td>
</tr>
<tr>
<td>otherInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
</tbody>
</table>

Table 5.8: Default settings for Delete Result Set Response

### Default settings for Scan Request

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
<tr>
<td>stepSize</td>
<td>Odr_int</td>
<td>NULL</td>
</tr>
<tr>
<td>scanStatus</td>
<td>Odr_int</td>
<td>Z_Scan_success</td>
</tr>
<tr>
<td>numberOfEntriesReturned</td>
<td>Odr_int</td>
<td>0</td>
</tr>
<tr>
<td>positionOfTerm</td>
<td>Odr_int</td>
<td>NULL</td>
</tr>
<tr>
<td>entries</td>
<td>Z_ListEntries</td>
<td>NULL</td>
</tr>
<tr>
<td>attributeSet</td>
<td>Odr_oid</td>
<td>NULL</td>
</tr>
<tr>
<td>otherInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
</tbody>
</table>

Table 5.9: Default settings for Scan Request

### Default settings for Scan Response

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
<tr>
<td>requestedAction</td>
<td>Odr_int</td>
<td>Z_TriggerResourceCtrl_resou..</td>
</tr>
<tr>
<td>prefResourceReportFormat</td>
<td>Odr_oid</td>
<td>NULL</td>
</tr>
<tr>
<td>resultSetWanted</td>
<td>Odr_bool</td>
<td>NULL</td>
</tr>
<tr>
<td>otherInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
</tbody>
</table>

Table 5.10: Default settings for Scan Response

### Default settings for Trigger Resource Control Request

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
</tbody>
</table>

Table 5.11: Default settings for Trigger Resource Control Request
<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
<tr>
<td>suspendedFlag</td>
<td>Odr_bool</td>
<td>NULL</td>
</tr>
<tr>
<td>resourceReport</td>
<td>Z_External</td>
<td>NULL</td>
</tr>
<tr>
<td>partialResultsAvailable</td>
<td>Odr_int</td>
<td>NULL</td>
</tr>
<tr>
<td>responseRequired</td>
<td>Odr_bool</td>
<td>FALSE</td>
</tr>
<tr>
<td>triggeredRequestFlag</td>
<td>Odr_bool</td>
<td>NULL</td>
</tr>
<tr>
<td>otherInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
</tbody>
</table>

Table 5.12: Default settings for Resource Control Request

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
<tr>
<td>continueFlag</td>
<td>bool_t</td>
<td>TRUE</td>
</tr>
<tr>
<td>resultSetWanted</td>
<td>bool_t</td>
<td>NULL</td>
</tr>
<tr>
<td>otherInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
</tbody>
</table>

Table 5.13: Default settings for Resource Control Response

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
<tr>
<td>which</td>
<td>enum</td>
<td>Z_AccessRequest_simpleForm;</td>
</tr>
<tr>
<td>u</td>
<td>union</td>
<td>NULL</td>
</tr>
<tr>
<td>otherInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
</tbody>
</table>

Table 5.14: Default settings for Access Control Request

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
<tr>
<td>which</td>
<td>enum</td>
<td>Z_AccessResponse_simpleForm</td>
</tr>
<tr>
<td>u</td>
<td>union</td>
<td>NULL</td>
</tr>
<tr>
<td>diagnostic</td>
<td>Z_DiagRec</td>
<td>NULL</td>
</tr>
<tr>
<td>otherInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
</tbody>
</table>

Table 5.15: Default settings for Access Control Response

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
<tr>
<td>numberOfRecordsReturned</td>
<td>Odr_int</td>
<td>value=0</td>
</tr>
<tr>
<td>num_segmentRecords</td>
<td>Odr_int</td>
<td>0</td>
</tr>
<tr>
<td>segmentRecords</td>
<td>Z_NamePlusRecord</td>
<td>NULL</td>
</tr>
<tr>
<td>otherInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
</tbody>
</table>

Table 5.16: Default settings for Segment
<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>referenceId</td>
<td>Z_ReferenceId</td>
<td>NULL</td>
</tr>
<tr>
<td>closeReason</td>
<td>Odr_int</td>
<td>Z_Close_finished</td>
</tr>
<tr>
<td>diagnosticInfo</td>
<td>char*</td>
<td>NULL</td>
</tr>
<tr>
<td>resourceReportFormat</td>
<td>Odr_oid</td>
<td>NULL</td>
</tr>
<tr>
<td>resourceFormat</td>
<td>Z_External</td>
<td>NULL</td>
</tr>
<tr>
<td>otherInfo</td>
<td>Z_OtherInformation</td>
<td>NULL</td>
</tr>
</tbody>
</table>

Table 5.17: Default settings for Close
Chapter 6

SOAP and SRU

6.1 Introduction

YAZ uses a very simple implementation of SOAP that only (currently) supports what is sufficient to offer SRU SOAP functionality. The implementation uses the tree API of libxml2 to encode and decode SOAP packages.

Like the Z39.50 ASN.1 module, the YAZ SRU implementation uses simple C structs to represent SOAP packages as well as HTTP packages.

6.2 HTTP

YAZ only offers HTTP as transport carrier for SOAP, but it is relatively easy to change that.

The following definition of \texttt{Z\_GDU} (Generic Data Unit) allows for both HTTP and Z39.50 in one packet.

```c
#include <yaz/zgdu.h>

#define Z_GDU_Z3950 1
#define Z_GDU_HTTP_Request 2
#define Z_GDU_HTTP_Response 3

typedef struct {
    int which;
    union {
        Z_APDU *z3950;
        Z_HTTP_Request *HTTP_Request;
        Z_HTTP_Response *HTTP_Response;
    } u;
} Z_GDU;
```

The corresponding \texttt{Z\_GDU} encoder/decoder is \texttt{z\_GDU}. The \texttt{z3950} is any of the known BER encoded Z39.50 APDUs. \texttt{HTTP\_Request} and \texttt{HTTP\_Response} is the HTTP Request and Response respectively.
6.3 SOAP Packages

Every SOAP package in YAZ is represented as follows:

```c
#include <yaz/soap.h>

typedef struct {
    char *fault_code;
    char *fault_string;
    char *details;
} Z_SOAP_Fault;

typedef struct {
    int no;
    char *ns;
    void *p;
} Z_SOAP_Generic;

#define Z_SOAP_fault 1
#define Z_SOAP_generic 2
#define Z_SOAP_error 3

typedef struct {
    int which;
    union {
        Z_SOAP_Fault *fault;
        Z_SOAP_Generic *generic;
        Z_SOAP_Fault *soap_error;
    } u;
    const char *ns;
} Z_SOAP;
```

The `fault` and `soap_error` arms both represent a SOAP fault - struct `Z_SOAP_Fault`. Any other generic (valid) package is represented by `Z_SOAP_Generic`.

The `ns` as part of `Z_SOAP` is the namespace for SOAP itself and reflects the SOAP version. For version 1.1 it is `http://schemas.xmlsoap.org/soap/envelope/`, for version 1.2 it is `http://www.w3.org/2001/06/soap-envelope`.

```c
int z_soap_codec(ODR o, Z_SOAP **pp, 
    char **content_buf, int *content_len, 
    Z_SOAP_Handler *handlers);
```

The `content_buf` and `content_len` is XML buffer and length of buffer respectively.

The `handlers` is a list of SOAP codec handlers - one handler for each service namespace. For SRU SOAP, the namespace would be `http://www.loc.gov/zing/srw/v1.0/`. 
When decoding, the `z_soap_codec` inspects the XML content and tries to match one of the services namespaces of the supplied handlers. If there is a match, a handler function is invoked which decodes that particular SOAP package. If successful, the returned `Z_SOAP` package will be of type `Z_SOAP_Generic`. Member `no` is set the offset of the handler that matched; `ns` is set to namespace of the matching handler; the void pointer `p` is set to the C data structure associated with the handler.

When a NULL namespace is met (member `ns` below), that specifies end-of-list.

Each handler is defined as follows:

```c
typedef struct {
    char *ns;
    void *client_data;
    Z_SOAP_fun f;
} Z_SOAP_Handler;
```

The `ns` is the namespace of the service associated with handler `f`. The `client_data` is user-defined data which is passed to the handler.

The prototype for a SOAP service handler is:

```c
int handler(ODR o, void * ptr, void **handler_data,
            void *client_data, const char *ns);
```

The `o` specifies the mode (decode/encode) as usual. The second argument, `ptr`, is a libxml2 tree node pointer (`xmlNodePtr`) and is a pointer to the `Body` element of the SOAP package. The `handler_data` is an opaque pointer to C definitions associated with the SOAP service. The `client_data` is the pointer which was set as part of the `Z_SOAP_handler`. Finally, `ns` is the service namespace.

### 6.4 SRU

SRU SOAP is just one implementation of a SOAP handler as described in the previous section. The encoder/decoder handler for SRU is defined as follows:

```c
#include <yaz/srw.h>

int yaz_srw_codec(ODR o, void * pp, Z_SRW_GDU **handler_data,
                   void *client_data, const char *ns);
```

Here, `Z_SRW_GDU` is either `searchRetrieveRequest` or a `searchRetrieveResponse`. 
Note
The xQuery and xSortKeys are not handled yet by the SRW implementation of YAZ. Explain is also missing. Future versions of YAZ will include these features.

The definition of searchRetrieveRequest is:

typedef struct {
    #define Z_SRW_query_type_cql  1
    #define Z_SRW_query_type_xcql 2
    #define Z_SRW_query_type_pqf  3
    int query_type;
    union {
        char *cql;
        char *xcql;
        char *pqf;
    } query;

    #define Z_SRW_sort_type_none 1
    #define Z_SRW_sort_type_sort 2
    #define Z_SRW_sort_type_xSort 3
    int sort_type;
    union {
        char *none;
        char *sortKeys;
        char *xSortKeys;
    } sort;
    int *startRecord;
    int *maximumRecords;
    char *recordSchema;
    char *recordPacking;
    char *database;
} Z_SRW_searchRetrieveRequest;

Please observe that data of type xsd:string is represented as a char pointer (char *). A null pointer means that the element is absent. Data of type xsd:integer is represented as a pointer to an int (int *). Again, a null pointer is used for absent elements.

The SearchRetrieveResponse has the following definition.

typedef struct {
    int * numberOfRecords;
    char * resultSetId;
    int * resultSetIdleTime;
} Z_SRW_searchRetrieveResponse;
Z_SRW_record *records;
int num_records;

Z_SRW_diagnostic *diagnostics;
int num_diagnostics;
int *nextRecordPosition;
} Z_SRW_searchRetrieveResponse;

The num_records and num_diagnostics is number of returned records and diagnostics respectively, and also correspond to the "size of" arrays records and diagnostics.

A retrieval record is defined as follows:

typedef struct {
    char *recordSchema;
    char *recordData_buf;
    int recordData_len;
    int *recordPosition;
} Z_SRW_record;

The record data is defined as a buffer of some length so that data can be of any type. SRW 1.0 currently doesn’t allow for this (only XML), but future versions might do.

And, a diagnostic as:

typedef struct {
    int *code;
    char *details;
} Z_SRW_diagnostic;
Chapter 7

Supporting Tools

In support of the service API - primarily the ASN module, which provides the programmatic interface to the Z39.50 APDUs, YAZ contains a collection of tools that support the development of applications.

7.1 Query Syntax Parsers

Since the type-1 (RPN) query structure has no direct, useful string representation, every origin application needs to provide some form of mapping from a local query notation or representation to a Z_RPNQuery structure. Some programmers will prefer to construct the query manually, perhaps using `odr_malloc()` to simplify memory management. The YAZ distribution includes three separate, query-generating tools that may be of use to you.

7.1.1 Prefix Query Format

Since RPN or reverse polish notation is really just a fancy way of describing a suffix notation format (operator follows operands), it would seem that the confusion is total when we now introduce a prefix notation for RPN. The reason is one of simple laziness - it’s somewhat simpler to interpret a prefix format, and this utility was designed for maximum simplicity, to provide a baseline representation for use in simple test applications and scripting environments (like Tcl). The demonstration client included with YAZ uses the PQF.

Note

The PQF has been adopted by other parties developing Z39.50 software. It is often referred to as Prefix Query Notation - PQN.

The PQF is defined by the pquery module in the YAZ library. There are two sets of functions that have similar behavior. First set operates on a PQF parser handle, second set doesn’t. First set of functions are more flexible than the second set. Second set is obsolete and is only provided to ensure backwards compatibility.

First set of functions all operate on a PQF parser handle:
A PQF parser is created and destructed by functions yaz_pqf_create and yaz_pqf_destroy respectively. Function yaz_pqf_parse parses the query given by string qbuf. If parsing was successful, a Z39.50 RPN Query is returned which is created using ODR stream o. If parsing failed, a NULL pointer is returned. Function yaz_pqf_scan takes a scan query in qbuf. If parsing was successful, the function returns attributes plus term pointer and modifies attributeSetId to hold attribute set for the scan request - both allocated using ODR stream o. If parsing failed, yaz_pqf_scan returns a NULL pointer. Error information for bad queries can be obtained by a call to yaz_pqf_error which returns an error code and modifies *msg to point to an error description, and modifies *off to the offset within the last query where parsing failed.

The second set of functions are declared as follows:

```
#include <yaz/pquery.h>

Z_RPNQuery *p_query_rpn(ODR o, oid_proto proto, const char *qbuf);

Z_AttributesPlusTerm *p_query_scan(ODR o, oid_proto proto,
     Odr_oid **attributeSetP, const char *qbuf);

int p_query_attset(const char *arg);
```

The function p_query_rpn() takes as arguments an ODR stream (see section The ODR Module) to provide a memory source (the structure created is released on the next call to odr_reset() on the stream), a protocol identifier (one of the constants PROTO_Z3950 and PROTO_SR), an attribute set reference, and finally a null-terminated string holding the query string.

If the parse went well, p_query_rpn() returns a pointer to a Z_RPNQuery structure which can be placed directly into a Z_SearchRequest. If parsing failed, due to syntax error, a NULL pointer is returned.

The p_query_attset specifies which attribute set to use if the query doesn’t specify one by the @attrset operator. The p_query_attset returns 0 if the argument is a valid attribute set specifier; otherwise the function returns -1.

The grammar of the PQF is as follows:
You will note that the syntax above is a fairly faithful representation of RPN, except for the Attribute, which has been moved a step away from the term, allowing you to associate one or more attributes with an entire query structure. The parser will automatically apply the given attributes to each term as required.

The @attr operator is followed by an attribute specification (attr-spec above). The specification consists of an optional attribute set, an attribute type-value pair and a sub-query. The attribute type-value pair is packed in one string: an attribute type, an equals sign, and an attribute value, like this: @attr 1=1003. The type is always an integer, but the value may be either an integer or a string (if it doesn’t start with a digit character). A string attribute-value is encoded as a Type-1 “complex” attribute with the list of values containing the single string specified, and including no semantic indicators.
Version 3 of the Z39.50 specification defines various encoding of terms. Use `@term` `type string`, where type is one of: `general`, `numeric` or `string` (for `InternationalString`). If no term type has been given, the `general` form is used. This is the only encoding allowed in both versions 2 and 3 of the Z39.50 standard.

### 7.1.1.1 Using Proximity Operators with PQF

**Note**
This is an advanced topic, describing how to construct queries that make very specific requirements on the relative location of their operands. You may wish to skip this section and go straight to the example PQF queries.

**Warning**
Most Z39.50 servers do not support proximity searching, or support only a small subset of the full functionality that can be expressed using the PQF proximity operator. Be aware that the ability to express a query in PQF is no guarantee that any given server will be able to execute it.

The proximity operator `@prox` is a special and more restrictive version of the conjunction operator `@and`. Its semantics are described in section 3.7.2 (Proximity) of Z39.50 the standard itself, which can be read on-line at [https://www.loc.gov/z3950/agency/markup/09.html#3.7.2](https://www.loc.gov/z3950/agency/markup/09.html#3.7.2)

In PQF, the proximity operation is represented by a sequence of the form

```
@prox exclusion distance ordered relation which-code unit-code
```

in which the meanings of the parameters are as described in the standard, and they can take the following values:

- **exclusion** 0 = false (i.e. the proximity condition specified by the remaining parameters must be satisfied) or 1 = true (the proximity condition specified by the remaining parameters must not be satisfied).

- **distance** An integer specifying the difference between the locations of the operands: e.g. two adjacent words would have distance=1 since their locations differ by one unit.

- **ordered** 1 = ordered (the operands must occur in the order the query specifies them) or 0 = unordered (they may appear in either order).

- **relation** Recognised values are 1 (lessThan), 2 (lessThanOrEqual), 3 (equal), 4 (greaterThanOrEqual), 5 (greaterThan) and 6 (notEqual).

- **which-code** known or k (the unit-code parameter is taken from the well-known list of alternatives described below) or private or p (the unit-code parameter has semantics specific to an out-of-band agreement such as a profile).

- **unit-code** If the which-code parameter is known then the recognised values are 1 (character), 2 (word), 3 (sentence), 4 (paragraph), 5 (section), 6 (chapter), 7 (document), 8 (element), 9 (subelement), 10 (elementType) and 11 (byte). If which-code is private then the acceptable values are determined by the profile.
(The numeric values of the relation and well-known unit-code parameters are taken straight from the ASN.1 of the proximity structure in the standard.)

7.1.1.2 PQF queries

**Example 7.1** PQF queries using simple terms

```
dylan
"bob dylan"
```

**Example 7.2** PQF boolean operators

```
@or "dylan" "zimmerman"

@and @or dylan zimmerman when

@and when @or dylan zimmerman
```

**Example 7.3** PQF references to result sets

```
@set Result-1

@and @set seta @set setb
```

**Example 7.4** Attributes for terms

```
@attr 1=4 computer

@attr 1=4 @attr 4=1 "self portrait"

@attrset expl @attr 1=1 CategoryList

@attr gils 1=2008 Copenhagen

@attr 1=/book/title computer
```

**Example 7.5** PQF Proximity queries

```
@prox 0 3 1 2 k 2 dylan zimmerman
```

Here the parameters 0, 3, 1, 2, k and 2 represent exclusion, distance, ordered, relation, which-code and unit-code, in that order. So:

- exclusion = 0: the proximity condition must hold
- distance = 3: the terms must be three units apart
- ordered = 1: they must occur in the order they are specified
• relation = 2: lessThanOrEqual (to the distance of 3 units)

• which-code is "known", so the standard unit-codes are used

• unit-code = 2: word.

So the whole proximity query means that the words dylan and zimmerman must both occur in the record, in that order, differing in position by three or fewer words (i.e. with two or fewer words between them.) The query would find "Bob Dylan, aka. Robert Zimmerman", but not "Bob Dylan, born as Robert Zimmerman" since the distance in this case is four.

**Example 7.6** PQF specification of search term type

@term string "a UTF-8 string, maybe?"

**Example 7.7** PQF mixed queries

@or @and bob dylan @set Result-1

@attr 4=1 @and @attr 1=1 "bob dylan" @attr 1=4 "slow train coming"

@and @attr 2=4 @attr gils 1=2038 -114 @attr 2=2 @attr gils 1=2039 -109

The last of these examples is a spatial search: in the GILS attribute set, access point 2038 indicates West Bounding Coordinate and 2030 indicates East Bounding Coordinate, so the query is for areas extending from -114 degrees longitude to no more than -109 degrees longitude.

**7.1.2 CCL**

Not all users enjoy typing in prefix query structures and numerical attribute values, even in a minimalistic test client. In the library world, the more intuitive Common Command Language - CCL (ISO 8777) has enjoyed some popularity - especially before the widespread availability of graphical interfaces. It is still useful in applications where you for some reason or other need to provide a symbolic language for expressing boolean query structures.

**7.1.2.1 CCL Syntax**

The CCL parser obeys the following grammar for the FIND argument. The syntax is annotated using lines prefixed by `--`.

```
CCL-Find ::= CCL-Find Op Elements
          | Elements.

Op ::= "and" | "or" | "not"
     -- The above means that Elements are separated by boolean operators.

Elements ::= '(' CCL-Find ')
           | Set
           | Terms
           | Qualifiers Relation Terms
```
| Qualifiers Relation ‘(‘ CCL-Find ‘)’ |
| Qualifiers ‘=’ string ‘-’ string |
-- Elements is either a recursive definition, a result set reference, a list of terms, qualifiers followed by terms, qualifiers followed by a recursive definition or qualifiers in a range (lower - upper).

Set ::= 'set' = string
-- Reference to a result set

Terms ::= Terms Prox Term
   | Term
-- Proximity of terms.

Term ::= Term string
   | string
-- This basically means that a term may include a blank

Qualifiers ::= Qualifiers ',' string
   | string
-- Qualifiers is a list of strings separated by comma

Relation ::= ‘=’ | ‘>=’ | ‘<=’ | ‘<’ | ‘>' | '<'
-- Relational operators. This really doesn’t follow the ISO8777 standard.

Prox ::= ‘%’ | ‘!’
-- Proximity operator

---

**Example 7.8 CCL queries**
The following queries are all valid:

```
dylan
"bob dylan"
dylan or zimmerman
set=1
(dylan and bob) or set=1
righttrunc?
"notrunc?"
singlechar#mask```

---
Assuming that the qualifiers \texttt{ti} and \texttt{au} and \texttt{date} are defined, we may use:

\begin{verbatim}
  ti=self portrait
  au=(bob dylan and slow train coming)
  date>1980 and (ti=((self portrait)))
\end{verbatim}

### 7.1.2.2 CCL Qualifiers

Qualifiers are used to direct the search to a particular searchable index, such as title (\texttt{ti}) and author indexes (\texttt{au}). The CCL standard itself doesn’t specify a particular set of qualifiers, but it does suggest a few shorthand notations. You can customize the CCL parser to support a particular set of qualifiers to reflect the current target profile. Traditionally, a qualifier would map to a particular use-attribute within the BIB-1 attribute set. It is also possible to set other attributes, such as the structure attribute.

A CCL profile is a set of predefined CCL qualifiers that may be read from a file or set in the CCL API. The YAZ client reads its CCL qualifiers from a file named \texttt{default.bib}. There are four types of lines in a CCL profile: qualifier specification, qualifier alias, comments and directives.

#### 7.1.2.2.1 Qualifier specification

A qualifier specification is of the form:

\texttt{qualifier-name\[attributeset,\]type=val[attributeset,\]type=val...}

where \texttt{qualifier-name} is the name of the qualifier to be used (e.g. \texttt{ti}), \texttt{type} is attribute type in the attribute set (Bib-1 is used if no attribute set is given) and \texttt{val} is attribute value. The \texttt{type} can be specified as an integer, or as a single-letter: \texttt{u} for use, \texttt{r} for relation, \texttt{p} for position, \texttt{s} for structure, \texttt{t} for truncation, or \texttt{c} for completeness. The attributes for the special qualifier name \texttt{term} are used when no CCL qualifier is given in a query.

Refer to Bib-1 Attribute Set\cite{bib1_2023} or the complete list of Bib-1 attributes

It is also possible to specify non-numeric attribute values, which are used in combination with certain types. The special combinations are:

**Example 7.9 CCL profile**

Consider the following definition:

\begin{verbatim}
  ti         u=4 s=1
  au         u=1 s=1
  term       s=105
  ranked     r=102
  date       u=30 r=o
\end{verbatim}

\texttt{ti} and \texttt{au} both set structure attribute to phrase (\texttt{s=1}). \texttt{ti} sets the use-attribute to 4. \texttt{au} sets the use-attribute to 1. When no qualifiers are used in the query, the structure-attribute is set to free-form-text (105) (rule for \texttt{term}). The \texttt{date} sets the relation attribute to the relation used in the CCL query and sets the use attribute to 30 (Bib-1 Date).

You can combine attributes. To Search for "ranked title" you can do
<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>u=value</td>
<td>Use attribute (1). Common use attributes are 1 Personal-name, 4 Title, 7 ISBN, 8 ISSN, 30 Date, 62 Subject, 1003 Author, 1016 Any. Specify value as an integer.</td>
</tr>
<tr>
<td>r=value</td>
<td>Relation attribute (2). Common values are 1 &lt;, 2 &lt;=, 3 =, 4 &gt;=, 5 &gt;, 6 &lt;&gt;, 100 phonetic, 101 stem, 102 relevance, 103 always matches.</td>
</tr>
<tr>
<td>p=value</td>
<td>Position attribute (3). Values: 1 first in field, 2 first in any subfield, 3 any position in field.</td>
</tr>
<tr>
<td>s=value</td>
<td>Structure attribute (4). Values: 1 phrase, 2 word, 3 key, 4 year, 5 date, 6 word list, 100 date (un), 101 name (norm), 102 name (un), 103 structure, 104 urx, 105 free-form-text, 106 document-text, 107 local-number, 108 string, 109 numeric string.</td>
</tr>
<tr>
<td>t=value</td>
<td>Truncation attribute (5). Values: 1 right, 2 left, 3 left and right, 100 none, 101 process #, 102 regular-1, 103 regular-2, 104 CCL.</td>
</tr>
<tr>
<td>c=value</td>
<td>Completeness attribute (6). Values: 1 incomplete subfield, 2 complete subfield, 3 complete field.</td>
</tr>
</tbody>
</table>

Table 7.1: Common Bib-1 attributes

```
ti,ranked=knuth computer
```

which will set relation=ranked, use=title, structure=phrase.

Query
```
date > 1980
```

is a valid query. But
```
ti > 1980
```

is invalid.

### 7.1.2.2 Qualifier alias

A qualifier alias is of the form:
```
q q1 q2 ..
```

which declares q to be an alias for q1, q2... such that the CCL query \( q=x \) is equivalent to \( q1=x \) or \( q2=x \) or ....

### 7.1.2.3 Comments

Lines with white space or lines that begin with character # are treated as comments.

### 7.1.2.4 Directives

Directive specifications takes the form

```
@directive value
```
<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>s=pw</td>
<td>The structure is set to either word or phrase depending on the number of tokens in a term (phrase-word).</td>
</tr>
<tr>
<td>s=al</td>
<td>Each token in the term is ANDed (and-list). This does not set the structure at all.</td>
</tr>
<tr>
<td>s=ol</td>
<td>Each token in the term is ORed (or-list). This does not set the structure at all.</td>
</tr>
<tr>
<td>s=ag</td>
<td>Tokens that appears as phrases (with blank in them) gets structure phrase attached (4=1). Tokens that appear to be words gets structure word attached (4=2). Phrases and words are ANDed. This is a variant of s=al and s=pw, with the main difference that words are not split (with operator AND) but instead kept in one RPN token. This facility appeared in YAZ 4.2.38.</td>
</tr>
<tr>
<td>s=sl</td>
<td>Tokens are split into sub-phrases of all combinations - in order. This facility appeared in YAZ 5.14.0.</td>
</tr>
<tr>
<td>r=o</td>
<td>Allows ranges and the operators greater-than, less-than, ... equals. This sets Bib-1 relation attribute accordingly (relation ordered). A query construct is only treated as a range if dash is used and that is surrounded by white-space. So -1980 is treated as term &quot;-1980&quot; not &lt;= 1980. If – 1980 is used, however, that is treated as a range.</td>
</tr>
<tr>
<td>r=r</td>
<td>Similar to r=o but assumes that terms are non-negative (not prefixed with –). Thus, a dash will always be treated as a range. The construct 1980-1990 is treated as a range with r=r but as a single term &quot;1980-1990&quot; with r=o. The special attribute r=r is available in YAZ 2.0.24 or later.</td>
</tr>
<tr>
<td>r=omiteq</td>
<td>This will omit relation=equals (@attr 2=3) when r=o / r=r is used. This is useful for servers that somehow break when an explicit relation=equals is used. Omitting the relation is usually safe because &quot;equals&quot; is the default behavior. This tweak was added in YAZ version 5.1.2.</td>
</tr>
<tr>
<td>t=l</td>
<td>Allows term to be left-truncated. If term is of the form ?x, the resulting Type-1 term is x and truncation is left.</td>
</tr>
<tr>
<td>t=r</td>
<td>Allows term to be right-truncated. If term is of the form x?, the resulting Type-1 term is x and truncation is right.</td>
</tr>
<tr>
<td>t=n</td>
<td>If term is does not include ?, the truncation attribute is set to none (100).</td>
</tr>
<tr>
<td>t=b</td>
<td>Allows term to be both left-and-right truncated. If term is of the form ?x?, the resulting truncation is set to both left and right.</td>
</tr>
<tr>
<td>t=x</td>
<td>Allows masking anywhere in a term, thus fully supporting # (mask one character) and ? (zero or more of any). If masking is used, truncation is set to 102 (regexp-1 in term) and the term is converted accordingly to a regular expression.</td>
</tr>
<tr>
<td>t=z</td>
<td>Allows masking anywhere in a term, thus fully supporting # (mask one character) and ? (zero or more of any). If masking is used, truncation is set to 104 (Z39.58 in term) and the term is converted accordingly to Z39.58 masking term - actually the same truncation as CCL itself.</td>
</tr>
</tbody>
</table>

Table 7.2: Special attribute combos
Table 7.3: CCL directives

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>truncation</td>
<td>Truncation character</td>
<td>?</td>
</tr>
<tr>
<td>mask</td>
<td>Masking character. Requires YAZ 4.2.58 or later</td>
<td>#</td>
</tr>
<tr>
<td>field</td>
<td>Specifies how multiple fields are to be combined. There are two modes: or: multiple qualifier fields are ORed, merge: attributes for the qualifier fields are merged and assigned to one term.</td>
<td>merge</td>
</tr>
<tr>
<td>case</td>
<td>Specifies if CCL operators and qualifiers should be compared with case sensitivity or not. Specify 1 for case sensitive; 0 for case insensitive.</td>
<td>1</td>
</tr>
<tr>
<td>and</td>
<td>Specifies token for CCL operator AND.</td>
<td>and</td>
</tr>
<tr>
<td>or</td>
<td>Specifies token for CCL operator OR.</td>
<td>or</td>
</tr>
<tr>
<td>not</td>
<td>Specifies token for CCL operator NOT.</td>
<td>not</td>
</tr>
<tr>
<td>set</td>
<td>Specifies token for CCL operator SET.</td>
<td>set</td>
</tr>
</tbody>
</table>

7.1.2.3 CCL API

All public definitions can be found in the header file `ccl.h`. A profile identifier is of type `CCL_bibset`. A profile must be created with the call to the function `ccl_qual_mk` which returns a profile handle of type `CCL_bibset`.

To read a file containing qualifier definitions the function `ccl_qual_file` may be convenient. This function takes an already opened `FILE` handle pointer as argument along with a `CCL_bibset` handle.

To parse a simple string with a FIND query use the function

```c
struct ccl_rpn_node *ccl_find_str(CCL_bibset bibset, const char *str, int *error, int *pos);
```

which takes the CCL profile (bibset) and query (str) as input. Upon successful completion the RPN tree is returned. If an error occurs, such as a syntax error, the integer pointed to by error holds the error code and pos holds the offset inside query string in which the parsing failed.

An English representation of the error may be obtained by calling the `ccl_err_msg` function. The error codes are listed in `ccl.h`.

To convert the CCL RPN tree (type `struct ccl_rpn_node *`) to the `Z_RPNQuery` of YAZ the function `ccl_rpn_query` must be used. This function which is part of YAZ is implemented in `yaz-ccl.c`. After calling this function the CCL RPN tree is probably no longer needed. The `ccl_rpn_delete` destroys the CCL RPN tree.

A CCL profile may be destroyed by calling the `ccl_qual_rm` function.

The token names for the CCL operators may be changed by setting the globals (all type `char *`) `ccl_token_and`, `ccl_token_or`, `ccl_token_not` and `ccl_token_set`. An operator may have aliases, i.e. there may be more than one name for the operator. To do this, separate each alias with a space character.

7.1.3 CQL

CQL - Common Query Language - was defined for the SRU protocol. In many ways CQL has a similar
syntax to CCL. The objective of CQL is different. Where CCL aims to be an end-user language, CQL is the protocol query language for SRU.

Tip
If you are new to CQL, read the Gentle Introduction.

The CQL parser in YAZ provides the following:

- It parses and validates a CQL query.
- It generates a C structure that allows you to convert a CQL query to some other query language, such as SQL.
- The parser converts a valid CQL query to PQF, thus providing a way to use CQL for both SRU servers and Z39.50 targets at the same time.
- The parser converts CQL to XCQL. XCQL is an XML representation of CQL. XCQL is part of the SRU specification. However, since SRU supports CQL only, we don’t expect XCQL to be widely used. Furthermore, CQL has the advantage over XCQL that it is easy to read.

7.1.3.1 CQL parsing

A CQL parser is represented by the `cql_parser` handle. Its contents should be considered YAZ internal (private).

```c
#include <yaz/cql.h>

typedef struct cql_parser *CQL_parser;

CQL_parser cql_parser_create(void);
void cql_parser_destroy(CQL_parser cp);
```

A parser is created by `cql_parser_create` and is destroyed by `cql_parser_destroy`.

To parse a CQL query string, the following function is provided:

```c
int cql_parser_string(CQL_parser cp, const char *str);
```

A CQL query is parsed by the `cql_parser_string` which takes a query `str`. If the query was valid (no syntax errors), then zero is returned; otherwise -1 is returned to indicate a syntax error.
The functions `cql_parser_stream` and `cql_parser_stdio` parse a CQL query—just like `cql_parser_string`. The only difference is that the CQL query can be fed to the parser in different ways. The `cql_parser_stream` uses a generic byte stream as input. The `cql_parser_stdio` uses a `FILE` handle which is opened for reading.

### 7.1.3.2 CQL tree

If the query string is valid, the CQL parser generates a tree representing the structure of the CQL query.

```c
struct cql_node *cql_parser_result(CQL_parser cp);
```

cql_parser_result returns a pointer to the root node of the resulting tree.

Each node in a CQL tree is represented by a `struct cql_node`. It is defined as follows:

```c
#define CQL_NODE_ST 1
#define CQL_NODE_BOOL 2
#define CQL_NODE_SORT 3
struct cql_node {
    int which;
    union {
        struct {
            char *index;
            char *index_uri;
            char *term;
            char *relation;
            char *relation_uri;
            struct cql_node *modifiers;
        } st;
        struct {
            char *value;
            struct cql_node *left;
            struct cql_node *right;
            struct cql_node *modifiers;
        } boolean;
        struct {
            char *index;
```
There are three node types: search term (ST), boolean (BOOL) and sortby (SORT). A modifier is treated as a search term too.

The search term node has five members:

- `index`: index for search term. If an index is unspecified for a search term, `index` will be NULL.
- `index_uri`: index URI for search term or NULL if none could be resolved for the index.
- `term`: the search term itself.
- `relation`: relation for search term.
- `modifiers`: relation modifiers for search term. The `modifiers` list itself of `cql_node` each of type ST.

The boolean node represents `and`, `or`, `not` + proximity.

- `left` and `right`: left - and right operand respectively.
- `modifiers`: proximity arguments.

The sort node represents both the SORTBY clause.

### 7.1.3.3 CQL to PQF conversion

Conversion to PQF (and Z39.50 RPN) is tricky by the fact that the resulting RPN depends on the Z39.50 target capabilities (combinations of supported attributes). In addition, the CQL and SRU operates on index prefixes (URI or strings), whereas the RPN uses Object Identifiers for attribute sets.

The CQL library of YAZ defines a `cql_transform_t` type. It represents a particular mapping between CQL and RPN. This handle is created and destroyed by the functions:

```c
#include <cql.h>

cql_transform_t cql_transform_open_FILE (FILE *f);
cql_transform_t cql_transform_open_fname(const char *fname);
void cql_transform_close(cql_transform_t ct);
```
The first two functions create a transformation handle from either an already open FILE or from a filename respectively.

The handle is destroyed by `cql_transform_close` in which case no further reference of the handle is allowed.

When a `cql_transform_t` handle has been created you can convert to RPN.

```c
int cql_transform_buf(cql_transform_t ct, 
    struct cql_node *cn, char *out, int max);
```

This function converts the CQL tree `cn` using handle `ct`. For the resulting PQF, you supply a buffer `out` which must be able to hold at least `max` characters.

If conversion failed, `cql_transform_buf` returns a non-zero SRU error code; otherwise zero is returned (conversion successful). The meanings of the numeric error codes are listed in the SRU specification somewhere (no direct link anymore).

If conversion fails, more information can be obtained by calling

```c
int cql_transform_error(cql_transform_t ct, char **addinfop);
```

This function returns the most recently returned numeric error-code and sets the string-pointer at `*addinfop` to point to a string containing additional information about the error that occurred: for example, if the error code is 15 ("Illegal or unsupported context set"), the additional information is the name of the requested context set that was not recognised.

The SRU error-codes may be translated into brief human-readable error messages using

```c
const char *cql_strerror(int code);
```

If you wish to be able to produce a PQF result in a different way, there are two alternatives.

```c
void cql_transform_pr(cql_transform_t ct, 
    struct cql_node *cn, 
    void (*pr)(const char *buf, void *client_data),
    void *client_data);
```

```c
int cql_transform_FILE(cql_transform_t ct, 
    struct cql_node *cn, FILE *f);
```

The former function produces output to a user-defined output stream. The latter writes the result to an already open FILE.
7.1.3.4 Specification of CQL to RPN mappings

The file supplied to functions cql_transform_open_FILE, cql_transform_open_fname follows a structure found in many Unix utilities. It consists of mapping specifications - one per line. Lines starting with # are ignored (comments).

Each line is of the form

\[ \text{CQL pattern} = \text{RPN equivalent} \]

An RPN pattern is a simple attribute list. Each attribute pair takes the form:

\[ [\text{set}] \text{ type}=\text{value} \]

The attribute set is optional. The type is the attribute type, value the attribute value.

The character * (asterisk) has special meaning when used in the RPN pattern. Each occurrence of * is substituted with the CQL matching name (index, relation, qualifier etc). This facility can be used to copy a CQL name verbatim to the RPN result.

The following CQL patterns are recognized:

**index.set.name** This pattern is invoked when a CQL index, such as dc.title is converted. set and name are the context set and index name respectively. Typically, the RPN specifies an equivalent use attribute.

For terms not bound by an index, the pattern index.cql.serverChoice is used. Here, the prefix cql is defined as http://www.loc.gov/zing/cql/cql-indexes/v1.0/. If this pattern is not defined, the mapping will fail.

The pattern, index.set.* is used when no other index pattern is matched.

**qualifier.set.name** (DEPRECATED) For backwards compatibility, this is recognised as a synonym of index.set.name

**relation.relation** This pattern specifies how a CQL relation is mapped to RPN. The pattern is name of relation operator. Since = is used as separator between CQL pattern and RPN, CQL relations including = cannot be used directly. To avoid a conflict, the names ge, eq, le, must be used for CQL operators, greater-than-or-equal, equal, less-than-or-equal respectively. The RPN pattern is supposed to include a relation attribute.

For terms not bound by a relation, the pattern relation.scr is used. If the pattern is not defined, the mapping will fail.

The special pattern, relation.* is used when no other relation pattern is matched.

**relationModifier.mod** This pattern specifies how a CQL relation modifier is mapped to RPN. The RPN pattern is usually a relation attribute.

**structure.type** This pattern specifies how a CQL structure is mapped to RPN. Note that this CQL pattern is somewhat similar to CQL pattern relation. The type is a CQL relation.

The pattern, structure.* is used when no other structure pattern is matched. Usually, the RPN equivalent specifies a structure attribute.
position.type  This pattern specifies how the anchor (position) of CQL is mapped to RPN. The type is one of first, any, last, firstAndLast.

The pattern, position.* is used when no other position pattern is matched.

set.prefix  This specification defines a CQL context set for a given prefix. The value on the right hand side is the URI for the set - not RPN. All prefixes used in index patterns must be defined this way.

set  This specification defines a default CQL context set for index names. The value on the right hand side is the URI for the set.

Example 7.10 CQL to RPN mapping file
This simple file defines two context sets, three indexes and three relations, a position pattern and a default structure.

<table>
<thead>
<tr>
<th>set.cql</th>
<th><a href="http://www.loc.gov/zing/cql/context-sets/cql/v1.1/">http://www.loc.gov/zing/cql/context-sets/cql/v1.1/</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>set.dc</td>
<td><a href="http://www.loc.gov/zing/cql/dc-indexes/v1.0/">http://www.loc.gov/zing/cql/dc-indexes/v1.0/</a></td>
</tr>
<tr>
<td>index.cql.serverChoice</td>
<td>1=1016</td>
</tr>
<tr>
<td>index.dc.title</td>
<td>1=4</td>
</tr>
<tr>
<td>index.dc.subject</td>
<td>1=21</td>
</tr>
<tr>
<td>relation.&lt;</td>
<td>2=1</td>
</tr>
<tr>
<td>relation.eq</td>
<td>2=3</td>
</tr>
<tr>
<td>relation.scr</td>
<td>2=3</td>
</tr>
<tr>
<td>position.any</td>
<td>3=3 6=1</td>
</tr>
<tr>
<td>structure.*</td>
<td>4=1</td>
</tr>
</tbody>
</table>

With the mappings above, the CQL query

```
computer
```

is converted to the PQF:

```
@attr 1=1016 @attr 2=3 @attr 4=1 @attr 3=3 @attr 6=1 "computer"
```

by rules index.cql.serverChoice, relation.scr, structure.*, position.any. CQL query

```
computer^                
```

is rejected, since position.right is undefined. CQL query

```
>my = "http://www.loc.gov/zing/cql/dc-indexes/v1.0/" my.title = x
```

is converted to

```
@attr 1=4 @attr 2=3 @attr 4=1 @attr 3=3 @attr 6=1 "x"
```
Example 7.11 CQL to RPN string attributes

In this example we allow any index to be passed to RPN as a use attribute.

```
# Identifiers for prefixes used in this file. (index.*)
set.cql = info:srw/cql-context-set/1/cql-v1.1
set.rpn = http://bogus/rpn
set = http://bogus/rpn

# The default index when none is specified by the query
index.cql.serverChoice = 1=any
index.rpn.* = 1=* 
relation.eq = 2=3
structure.* = 4=1
position.any = 3=3
```

The http://bogus/rpn context set is also the default so we can make queries such as

```
title = a
```

which is converted to

```
@attr 2=3 @attr 4=1 @attr 3=3 @attr 1=title "a"
```

Example 7.12 CQL to RPN using Bath Profile

The file etc/pqf.properties has mappings from the Bath Profile and Dublin Core to RPN. If YAZ is installed as a package it's usually located in /usr/share/yaz/etc and part of the development package, such as libyaz-dev.

7.1.3.5 CQL to XCQL conversion

Conversion from CQL to XCQL is trivial and does not require a mapping to be defined. There are three functions to choose from depending on the way you wish to store the resulting output (XML buffer containing XCQL).

```
int cql_to_xml_buf(struct cql_node *cn, char *out, int max);
void cql_to_xml(struct cql_node *cn, 
    void (*pr)(const char *buf, void *client_data),
    void *client_data);
void cql_to_xml_stdio(struct cql_node *cn, FILE *f);
```

Function cql_to_xml_buf converts to XCQL and stores the result in a user-supplied buffer of a given max size.

cql_to_xml writes the result in a user-defined output stream. cql_to_xml_stdio writes to a file.
7.1.3.6 PQF to CQL conversion

Conversion from PQF to CQL is offered by the two functions shown below. The former uses a generic stream for result. The latter puts result in a WRBUF (string container).

```c
#include <yaz/rpn2cql.h>

int cql_transform_rpn2cql_stream(cql_transform_t ct,
                               void (*pr)(const char *buf, void *client_data),
                               void *client_data,
                               Z_RPNQuery *q);

int cql_transform_rpn2cql_wrbuf(cql_transform_t ct,
                                WRBUF w,
                                Z_RPNQuery *q);
```

The configuration is the same as used in CQL to PQF conversions.

7.2 Object Identifiers

The basic YAZ representation of an OID is an array of integers, terminated with the value -1. This integer is of type `Odr_oid`.

Fundamental OID operations and the type `Odr_oid` are defined in `yaz/oid_util.h`.

An OID can either be declared as an automatic variable or it can be allocated using the memory utilities or ODR/NMEM. It’s guaranteed that an OID can fit in `OID_SIZE` integers.

**Example 7.13 Create OID on stack**

We can create an OID for the Bib-1 attribute set with:

```c
Odr_oid bib1[OID_SIZE];
bib1[0] = 1;
bib1[1] = 2;
bib1[2] = 840;
bib1[3] = 10003;
bib1[4] = 3;
bib1[5] = 1;
bib1[6] = -1;
```

And OID may also be filled from a string-based representation using dots (.). This is achieved by the function

```c
int oid_dotstring_to_oid(const char *name, Odr_oid *oid);
```

This functions returns 0 if name could be converted; -1 otherwise.
Example 7.14 Using oid_oiddotstring_to_oid
We can fill the Bib-1 attribute set OID more easily with:

```c
Odr_oid bib1[OID_SIZE];
oid_oiddotstring_to_oid("1.2.840.10003.3.1", bib1);
```

We can also allocate an OID dynamically on an ODR stream with:

```c
Odr_oid *odr_getoidbystr(ODR o, const char *str);
```

This creates an OID from a string-based representation using dots. This function takes an ODR stream as parameter. This stream is used to allocate memory for the data elements, which is released on a subsequent call to odr_reset() on that stream.

Example 7.15 Using odr_getoidbystr
We can create an OID for the Bib-1 attribute set with:

```c
Odr_oid *bib1 = odr_getoidbystr(odr, "1.2.840.10003.3.1");
```

The function

```c
char *oid_oid_to_dotstring(const Odr_oid *oid, char *oidbuf)
```

does the reverse of oid_oiddotstring_to_oid. It converts an OID to the string-based representation using dots. The supplied char buffer oidbuf holds the resulting string and must be at least OID_STR_MAX in size.

OIDs can be copied with oid_oidcpy which takes two OID lists as arguments. Alternatively, an OID copy can be allocated on an ODR stream with:

```c
Odr_oid *odr_oiddup(ODR odr, const Odr_oid *o);
```

OIDs can be compared with oid_oidcmp which returns zero if the two OIDs provided are identical; non-zero otherwise.

### 7.2.1 OID database

From YAZ version 3 and later, the oident system has been replaced by an OID database. OID database is a misnomer .. the old oident system was also a database.

The OID database is really just a map between named Object Identifiers (string) and their OID raw equivalents. Most operations either convert from string to OID or other way around.

Unfortunately, whenever we supply a string we must also specify the OID class. The class is necessary because some strings correspond to multiple OIDs. An example of such a string is Bib-1 which may either be an attribute-set or a diagnostic-set.

Applications using the YAZ database should include yaz/oid_db.h.

A YAZ database handle is of type yaz_oid_db_t. Actually that’s a pointer. You need not deal with that. YAZ has a built-in database which can be considered "constant" for most purposes. We can get hold of that by using function yaz_oid_std.
All functions with prefix `yaz_string_to_oid` converts from class + string to OID. We have variants of this operation due to different memory allocation strategies.

All functions with prefix `yaz_oid_to_string` converts from OID to string + class.

**Example 7.16** Create OID with YAZ DB

We can create an OID for the Bib-1 attribute set on the ODR stream `odr` with:

```c
Odr_oid *bib1 = yaz_string_to_oid_odr(yaz_oid_std(), CLASS_ATTSET, "Bib-1", odr);
```

This is more complex than using `odr_getoidbystr`. You would only use `yaz_string_to_oid_odr` when the string (here Bib-1) is supplied by a user or configuration.

### 7.2.2 Standard OIDs

All the object identifiers in the standard OID database as returned by `yaz_oid_std` can be referenced directly in a program as a constant OID. Each constant OID is prefixed with `yaz_oid_` - followed by OID class (lowercase) - then by OID name (normalized and lowercase).

See Appendix A for list of all object identifiers built into YAZ. These are declared in `yaz/oid_std.h` but are included by `yaz/oid_db.h` as well.

**Example 7.17** Use a built-in OID

We can allocate our own OID filled with the constant OID for Bib-1 with:

```c
Odr_oid *bib1 = odr_oiddup(o, yaz_oid_attset_bib1);
```

### 7.3 Nibble Memory

Sometimes when you need to allocate and construct a large, interconnected complex of structures, it can be a bit of a pain to release the associated memory again. For the structures describing the Z39.50 PDUs and related structures, it is convenient to use the memory-management system of the ODR subsystem (see Section 8.2). However, in some circumstances where you might otherwise benefit from using a simple nibble-memory management system, it may be impractical to use `odr_malloc()` and `odr_reset()`.

For this purpose, the memory manager which also supports the ODR streams is made available in the NMEM module. The external interface to this module is given in the `nmem.h` file.

The following prototypes are given:

```c
NMEM nmem_create(void);
void nmem_destroy(NMEM n);
void *nmem_malloc(NMEM n, size_t size);
void nmem_reset(NMEM n);
size_t nmem_total(NMEM n);
void nmem_init(void);
void nmem_exit(void);
```
The `nmem_create()` function returns a pointer to a memory control handle, which can be released again by `nmem_destroy()` when no longer needed. The function `nmem_malloc()` allocates a block of memory of the requested size. A call to `nmem_reset()` or `nmem_destroy()` will release all memory allocated on the handle since it was created (or since the last call to `nmem_reset()`). The function `nmem_total()` returns the number of bytes currently allocated on the handle.

The nibble-memory pool is shared amongst threads. POSIX mutexes and WIN32 Critical sections are introduced to keep the module thread safe. Function `nmem_init()` initializes the nibble-memory library and it is called automatically the first time the `YAZ.DLL` is loaded. YAZ uses function `DllMain` to achieve this. You should not call `nmem_init` or `nmem_exit` unless you’re absolute sure what you’re doing. Note that in previous YAZ versions you’d have to call `nmem_init` yourself.

### 7.4 Log

YAZ has evolved a fairly complex log system which should be useful both for debugging YAZ itself, debugging applications that use YAZ, and for production use of those applications.

The log functions are declared in header `yaz/log.h` and implemented in `src/log.c`. Due to name clash with syslog and some math utilities the logging interface has been modified as of YAZ 2.0.29. The obsolete interface is still available in header file `yaz/log.h`. The key points of the interface are:

```c
void yaz_log(int level, const char *fmt, ...)
void yaz_log_init(int level, const char *prefix, const char *name);
void yaz_log_init_file(const char *fname);
void yaz_log_init_level(int level);
void yaz_log_init_prefix(const char *prefix);
void yaz_log_time_format(const char *fmt);
void yaz_log_init_max_size(int mx);
int yaz_log_mask_str(const char *str);
int yaz_log_module_level(const char *name);
```

The reason for the whole log module is the `yaz_log` function. It takes a bitmask indicating the log levels, a `printf`-like format string, and a variable number of arguments to log.

The log level is a bit mask, that says on which level(s) the log entry should be made, and optionally set some behaviour of the logging. In the most simple cases, it can be one of `YLOG_FATAL`, `YLOG_DEBUG`, `YLOG_WARN`, `YLOG_LOG`. Those can be combined with bits that modify the way the log entry is written: `YLOG_ERRNO`, `YLOG_NOTIME`, `YLOG_FLUSH`. Most of the rest of the bits are deprecated, and should not be used. Use the dynamic log levels instead.

Applications that use YAZ, should not use the LOG_LOG for ordinary messages, but should make use of the dynamic loglevel system. This consists of two parts, defining the loglevel and checking it.

To define the log levels, the (main) program should pass a string to `yaz_log_mask_str` to define which log levels are to be logged. This string should be a comma-separated list of log level names, and can contain both hard-coded names and dynamic ones. The log level calculation starts with `YLOG_DEFAULT_LEVEL` and adds a bit for each word it meets, unless the word starts with a '-', in which case it clears the bit. If the string ‘none’ is found, all bits are cleared. Typically this string comes from the command-line, often identified by `-v`. The `yaz_log_mask_str` returns a log level that should be passed to `yaz_log_init_level` for it to take effect.
Each module should check what log bits should be used, by calling `yaz_log_module_level` with a suitable name for the module. The name is cleared of a preceding path and an extension, if any, so it is quite possible to use `__FILE__` for it. If the name has been passed to `yaz_log_mask_str`, the routine returns a non-zero bitmask, which should then be used in consequent calls to `yaz_log`. (It can also be tested, so as to avoid unnecessary calls to `yaz_log`, in time-critical places, or when the log entry would take time to construct.)

Yaz uses the following dynamic log levels: server, session, request, requestdetail for the server functionality. zoom for the zoom client API. ztest for the simple test server. malloc, nmem, odr, eventl for internal debugging of yaz itself. Of course, any program using yaz is welcome to define as many new ones as it needs.

By default the log is written to stderr, but this can be changed by a call to `yaz_log_init_file` or `yaz_log_init`. If the log is directed to a file, the file size is checked at every write, and if it exceeds the limit given in `yaz_log_init_max_size`, the log is rotated. The rotation keeps one old version (with a .1 appended to the name). The size defaults to 1GB. Setting it to zero will disable the rotation feature.

A typical yaz-log looks like this

<table>
<thead>
<tr>
<th>Time</th>
<th>Program</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>13:23:14-23/11</td>
<td>yaz-ztest(1)</td>
<td>[session] Starting session from tcp:127.0.0.1 &lt;- (pid=30968)</td>
</tr>
<tr>
<td>13:23:14-23/11</td>
<td>yaz-ztest(1)</td>
<td>[request] Init from 'YAZ' (81) (ver 2.0.28) &lt;- OK</td>
</tr>
<tr>
<td>13:23:17-23/11</td>
<td>yaz-ztest(1)</td>
<td>[request] Search Z: @attrset Bib-1 foo OK:7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[request] Present: [1] 2+2 OK 2 records &lt;- returned</td>
</tr>
</tbody>
</table>

The log entries start with a time stamp. This can be omitted by setting the `YLOG_NOTIME` bit in the loglevel. This way automatic tests can be hoped to produce identical log files, that are easy to diff. The format of the time stamp can be set with `yaz_log_time_format`, which takes a format string just like `strftime`.

Next in a log line comes the prefix, often the name of the program. For yaz-based servers, it can also contain the session number. Then comes one or more logbits in square brackets, depending on the logging level set by `yaz_log_init_level` and the loglevel passed to `yaz_log_init_level`. Finally comes the format string and additional values passed to `yaz_log`.

The log level `YLOG_LOGLEVEL`, enabled by the string `loglevel`, will log all the log-level affecting operations. This can come in handy if you need to know what other log levels would be useful. Grep the logfile for `[loglevel]`.

The log system is almost independent of the rest of YAZ, the only important dependence is of `nmem`, and that only for using the semaphore definition there.

The dynamic log levels and log rotation were introduced in YAZ 2.0.28. At the same time, the log bit names were changed from `LOG_something` to `YLOG_something`, to avoid collision with `syslog.h`. 
7.5 MARC

YAZ provides a fast utility for working with MARC records. Early versions of the MARC utility only allowed decoding of ISO2709. Today the utility may both encode - and decode to a variety of formats.

```c
#include <yaz/marcdisp.h>

/* create handler */
yaz_marc_t yaz_marc_create(void);
/* destroy */
void yaz_marc_destroy(yaz_marc_t mt);

/* set XML mode YAZ_MARC_LINE, YAZ_MARC_SIMPLEXML, ... */
void yaz_marc_xml(yaz_marc_t mt, int xmlmode);
#define YAZ_MARC_LINE 0
#define YAZ_MARC_SIMPLEXML 1
#define YAZ_MARC_OAIMARC 2
#define YAZ_MARC_MARCXML 3
#define YAZ_MARC_ISO2709 4
#define YAZ_MARC_XCHANGE 5
#define YAZ_MARC_CHECK 6
#define YAZ_MARC_TURBOMARC 7
#define YAZ_MARC_JSON 8

/* supply iconv handle for character set conversion .. */
void yaz_marc_iconv(yaz_marc_t mt, yaz_iconv_t cd);

/* set debug level, 0=none, 1=more, 2=even more, .. */
void yaz_marc_debug(yaz_marc_t mt, int level);

/* decode MARC in buf of size bsize. Returns >0 on success; <=0 on failure.
On success, result in *result with size *rsize. */
int yaz_marc_decode_buf(yaz_marc_t mt, const char *buf, int bsize,
const char **result, size_t *rsize);

/* decode MARC in buf of size bsize. Returns >0 on success; <=0 on failure.
On success, result in WRBUF */
int yaz_marc_decode_wrbuf(yaz_marc_t mt, const char *buf,
int bsize, WRBUF wrbuf);
```

**Note**
The synopsis is just a basic subset of all functionality. Refer to the actual header file marcdisp.h for details.
A MARC conversion handle must be created by using `yaz_marc_create` and destroyed by calling `yaz_marc_destroy`.

All other functions operate on a `yaz_marc_t` handle. The output is specified by a call to `yaz_marc_xml`. The `xmlmode` must be one of

- **YAZ_MARC_LINE** A simple line-by-line format suitable for display but not recommended for further (machine) processing.
- **YAZ_MARC_MARCXML** MARCXML.
- **YAZ_MARC_ISO2709** ISO2709 (sometimes just referred to as "MARC").
- **YAZ_MARC_XCHANGE** MarcXchange.
- **YAZ_MARC_CHECK** Pseudo format for validation only. Does not generate any real output except diagnostics.
- **YAZ_MARC_TURBOMARC** XML format with same semantics as MARCXML but more compact and geared towards fast processing with XSLT. Refer to Section 7.5.1 for more information.
- **YAZ_MARC_JSON** MARC-in-JSON format.

The actual conversion functions are `yaz_marc_decode_buf` and `yaz_marc_decode_wrbuf` which decodes and encodes a MARC record. The former function operates on simple buffers, and stores the resulting record in a WRBUF handle (WRBUF is a simple string type).

**Example 7.18 Display of MARC record**

The following program snippet illustrates how the MARC API may be used to convert a MARC record to the line-by-line format:

```c
void print_marc(const char *marc_buf, int marc_buf_size)
{
    char *result; /* for result buf */
    size_t result_len; /* for size of result */
    yaz_marc_t mt = yaz_marc_create();
    yaz_marc_xml(mt, YAZ_MARC_LINE);
    yaz_marc_decode_buf(mt, marc_buf, marc_buf_size,
                        &result, &result_len);
    fwrite(result, result_len, 1, stdout);
    yaz_marc_destroy(mt); /* note that result is now freed... */
}
```

### 7.5.1 TurboMARC

 TurboMARC is yet another XML encoding of a MARC record. The format was designed for fast processing with XSLT.
Applications like Pazpar2 uses XSLT to convert an XML encoded MARC record to an internal representation. This conversion mostly checks the tag of a MARC field to determine the basic rules in the conversion. This check is costly when that tag is encoded as an attribute in MARCXML. By having the tag value as the element instead, makes processing many times faster (at least for Libxslt).

TurboMARC is encoded as follows:

- **Record elements is part of namespace** "http://www.indexdata.com/turbomarc".
- A record is enclosed in element \texttt{r}.
- A collection of records is enclosed in element \texttt{collection}.
- The leader is encoded as element \texttt{l} with the leader content as its (text) value.
- A control field is encoded as element \texttt{c} concatenated with the tag value of the control field if the tag value matches the regular expression \[a-zA-Z0-9]*\. If the tag value does not match the regular expression \[a-zA-Z0-9]*\ the control field is encoded as element \texttt{c} and attribute \texttt{code} will hold the tag value. This rule ensures that in the rare cases where a tag value might result in a non-well-formed XML, then YAZ will encode it as a coded attribute (as in MARCXML).
- The control field content is the text value of this element. Indicators are encoded as attribute names \texttt{i1}, \texttt{i2}, etc. and corresponding values for each indicator.
- A data field is encoded as element \texttt{d} concatenated with the tag value of the data field or using the attribute \texttt{code} as described in the rules for control fields. The children of the data field element are subfield elements. Each subfield element is encoded as \texttt{s} concatenated with the sub field code. The text of the subfield element is the contents of the subfield. Indicators are encoded as attributes for the data field element, similar to the encoding for control fields.

### 7.6 Retrieval Facility

YAZ version 2.1.20 or later includes a Retrieval facility tool which allows a SRU/Z39.50 to describe itself and perform record conversions. The idea is the following:

- An SRU/Z39.50 client sends a retrieval request which includes a combination of the following parameters: syntax (format), schema (or element set name).
- The retrieval facility is invoked with parameters in a server/proxy. The retrieval facility matches the parameters a set of "supported" retrieval types. If there is no match, the retrieval signals an error (syntax and / or schema not supported).
- For a successful match, the backend is invoked with the same or altered retrieval parameters (syntax, schema). If a record is received from the backend, it is converted to the frontend name / syntax.
- The resulting record is sent back the client and tagged with the frontend syntax / schema.

The Retrieval facility is driven by an XML configuration. The configuration is neither Z39.50 ZeeRex or SRU ZeeRex. But it should be easy to generate both of them from the XML configuration. (Unfortunately the two versions of ZeeRex differ substantially in this regard.)
7.6.1 Retrieval XML format

All elements should be covered by namespace `http://indexdata.com/yaz`. The root element node must be `retrievalinfo`.

The `retrievalinfo` must include one or more `retrieval` elements. Each `retrieval` defines specific combination of syntax, name and identifier supported by this retrieval service.

The `retrieval` element may include any of the following attributes:

- `syntax` (REQUIRED) Defines the record syntax. Possible values is any of the names defined in YAZ' OID database or a raw OID in (n.n ... n).
- `name` (OPTIONAL) Defines the name of the retrieval format. This can be any string. For SRU, the value is equivalent to schema (short-hand); for Z39.50 it’s equivalent to simple element set name. For YAZ 3.0.24 and later this name may be specified as a glob expression with operators * and ?.
- `identifier` (OPTIONAL) Defines the URI schema name of the retrieval format. This can be any string. For SRU, the value is equivalent to URI schema. For Z39.50, there is no equivalent.

The `retrieval` may include one `backend` element. If a `backend` element is given, it specifies how the records are retrieved by some backend and how the records are converted from the backend to the "frontend".

The attributes, `name` and `syntax` may be specified for the `backend` element. The semantics of these attributes is equivalent to those for the `retrieval`. However, these values are passed to the "backend".

The `backend` element may include one or more conversion instructions (as children elements). The supported conversions are:

- `marc` The `marc` element specifies a conversion to - and from ISO2709 encoded MARC and MARCXML/MarcXchange. The following attributes may be specified:
  - `inputformat` (REQUIRED) Format of input. Supported values are `marc` (for ISO2709), `xml` (MARCXML/MarcXchange) and `json` (MARC-in-JSON).
  - `outputformat` (REQUIRED) Format of output. Supported values are `line` (MARC line format); `marcxml` (for MARCXML), `marc` (ISO2709), `turbomarc`, `marcxchange` (for MarcXchange), or `json` (MARC-in-JSON).
  - `inputcharset` (OPTIONAL) Encoding of input. For XML input formats, this need not be given, but for ISO2709 based input formats, this should be set to the encoding used. For MARC21 records, a common inputcharset value would be `marc-8`.
  - `outputcharset` (OPTIONAL) Encoding of output. If outputformat is XML based, it is strongly recommended to use `utf-8`.
- `select` The `select` selects one or more text nodes and decodes them as XML. The following attributes may be specified:
  - `path` (REQUIRED) X-Path expression for selecting text nodes.

This conversion is available in YAZ 5.8.0 and later.
**solrmarc** The solrmarc decodes solrmarc records. It assumes that the input is pure solrmarc text (no escaping) and will convert all sequences of the form #XX; to a single character of the hexadecimal value as given by XX. The output, presumably, is a valid ISO2709 buffer.

This conversion is available in YAZ 5.0.21 and later.

**xslt** The xslt element specifies a conversion via XSLT. The following attributes may be specified:

- **stylesheet (REQUIRED)** Stylesheet file.

In addition, the element can be configured as follows:

- **param (OPTIONAL)** A param tag configures a parameter to be passed to the XSLT stylesheet. Multiple param tags may be defined.

**rdf-lookup** The rdf-lookup element looks up BIBFRAME elements in some suitable service, for example http://id.loc.gov/authorities/names and replaces the URIs for specified elements with URIs it finds at that service. Its configuration consists of:

- **debug (OPTIONAL)** Attribute to the rdf-lookup tag to enable debug output. A value of "1" makes the filter to add a XML comment next to each key it tried to look up, showing the URL, the result, and timing. This is useful for debugging the configuration. The default is not to add any comments.

- **timeout (OPTIONAL)** Attribute of the rdf-lookup tag which defines timeout in seconds for the HTTP based rdf-lookup.

- **namespace (OPTIONAL)** A namespace tag declares a namespace to be used in the xpath below. The tag requires two attributes: prefix and href.

- **lookup (REQUIRED)** A section that defines one tag to be looked up, for example an author. The xpath attribute (REQUIRED) specifies the path to the element(s).

- **key (REQUIRED)** A tag withing the lookup tag specifies the value to be used in the lookup, for example a name or an ID. It is a relative Xpath starting from the tag specified in the lookup.

- **server (OPTIONAL)** Specifies the URL for server to use for the lookup. A %s is replaced by the key value to be looked up. If not specified, defaults to the same as the previous lookup section, or lacking one, to http://id.loc.gov/authorities/names(label/%s). The method attribute can be used to specify the HTTP method to be used in this lookup. The default is GET, and the useful alternative is HEAD.

See the example below.

This conversion is available in YAZ 5.19.0 and later.

### 7.6.2 Retrieval Facility Examples
Example 7.19 MARC21 backend
A typical way to use the retrieval facility is to enable XML for servers that only supports ISO2709 encoded MARC21 records.

```xml
<retrievalinfo>
  <retrieval syntax="usmarc" name="F"/>
  <retrieval syntax="usmarc" name="B"/>
  <retrieval syntax="xml" name="marcxml"
    identifier="info:srw/schema/1/marcxml-v1.1">
    <backend syntax="usmarc" name="F">
      <marc inputformat="marc" outputformat="marcxml"
        inputcharset="marc-8"/>
    </backend>
  </retrieval>
  <retrieval syntax="xml" name="marcxml">
    <backend syntax="xml" name="marcxml">
      <marc inputformat="xml" outputformat="marc"
        outputcharset="marc-8"/>
      <xslt stylesheet="MARC21slim2DC.xsl"/>
    </backend>
  </retrieval>
</retrievalinfo>
```

This means that our frontend supports:

- MARC21 F(ull) records.
- MARC21 B(rief) records.
- MARCXML records.
- Dublin core records.

Example 7.20 MARCXML backend
SRW/SRU and Solr backends return records in XML. If they return MARCXML or MarcXchange, the retrieval module can convert those into ISO2709 formats, most commonly USMARC (AKA MARC21). In this example, the backend returns MARCXML for schema="marcxml".

```xml
<retrievalinfo>
  <retrieval syntax="usmarc">
    <backend syntax="xml" name="marcxml">
      <marc inputformat="xml" outputformat="marc"
        outputcharset="marc-8"/>
    </backend>
  </retrieval>
  <retrieval syntax="xml" name="marcxml"
    identifier="info:srw/schema/1/marcxml-v1.1">
    <backend syntax="xml" name="marcxml">
      <retrieval syntax="xml" name="dc">
        <backend syntax="xml" name="marcxml">
          <marc inputformat="marc" outputformat="marcxml"
            inputcharset="marc-8"/>
          <backend>
            <retrieval syntax="xml" name="marcxml">
              <backend>
                <retrieval syntax="xml" name="marcxml">
                  <backend>
                    <retrieval syntax="xml" name="marcxml">
                      <backend>
                        <retrieval syntax="xml" name="marcxml">
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                                                                                                                                   <retrieval syntax="xml" name="marcxml">
                                                                                                                                      <backend>
                                                                                                                                   <retrieval syntax="xml" name="marcxml">
                                                                                                                                      <backend>
                                                                                                                                   <retrieval syntax="xml" name="marcxml">
This means that our frontend supports:

- MARC21 records (any element set name) in MARC-8 encoding.
- MARCXML records for element-set=marcxml
- Dublin core records for element-set=dc.

### Example 7.21 RDF-lookup backend

This is a minimal example of the backend configuration for the rdf-lookup. It could well be used with some heavy xslt transforms that make BIBFRAME records out of MarxXml.

```xml
<backend syntax="xml" name="rdf-lookup">
  <rdf-lookup debug="1" timeout="10">
    <namespace prefix="bf" href="http://id.loc.gov/ontologies/bibframe"/>
    <namespace prefix="bflc" href="http://id.loc.gov/ontologies/bibframe/lc-extensions"/>
    <lookup xpath="/bf:contribution/bf:Contribution/bf:agent/bf:Agent">
      <key field="bflc:name00MatchKey"/>
      <key field="bflc:name01MatchKey"/>
      <key field="bflc:name11MatchKey"/>
      <server url="http://id.loc.gov/authorities/names/label/%s" method="HEAD"/>
    </lookup>
  </rdf-lookup>
</backend>
```

The `debug=1` attribute tells the filter to add XML comments to the key nodes that indicate what lookup it tried to do, how it went, and how long it took.

The namespace prefix `bf:` is defined in the `namespace` tags. These namespaces are used in the xpath expressions in the lookup sections.

The `lookup` tag specifies one tag to be looked up. The `xpath` attribute defines which node to modify. It may make use of the namespace definitions above.

The `server` tag gives the URL to be used for the lookup. A `%s` in the string will get replaced by the key value. If there is no `server` tag, the one from the preceding `lookup` section is used, and if there is no previous section, the id.loc.gov address is used as a default. The default is to make a GET request, this example uses HEAD.

### 7.6.3 API

It should be easy to use the retrieval systems from applications. Refer to the headers `yaz/retrieval.h` and `yaz/record_conv.h`. 
7.7 Sorting

This chapter describes sorting and how it is supported in YAZ. Sorting applies to a result-set. The Z39.50 sorting facility takes one or more input result-sets and one result-set as output. The most simple case is that the input-set is the same as the output-set.

Z39.50 sorting has a separate APDU (service) that is, thus, performed following a search (two phases).

In SRU/Solr, however, the model is different. Here, sorting is specified during the search operation. Note, however, that SRU might perform sort as separate search, by referring to an existing result-set in the query (result-set reference).

7.7.1 Using the Z39.50 sort service

yaz-client and the ZOOM API support the Z39.50 sort facility. In any case the sort sequence or sort criteria is using a string notation. This notation is a one-line notation suitable for being manually entered or generated, and allows for easy logging (one liner). For the ZOOM API, the sort is specified in the call to ZOOM_query_sortby function. For yaz-client the sort is performed and specified using the sort and sort+ commands. For description of the sort criteria notation refer to the sort command in the yaz-client manual.

The ZOOM API might choose one of several sort strategies for sorting. Refer to Table 3.2.

7.7.2 Type-7 sort

Type-7 sort is an extension to the Bib-1 based RPN query where the sort specification is embedded as an Attribute-Plus-Term.

The objectives for introducing Type-7 sorting is that it allows a client to perform sorting even if it does not implement/support Z39.50 sort. Virtually all Z39.50 client software supports RPN queries. It also may improve performance because the sort criteria is specified along with the search query.

The sort is triggered by the presence of type 7, and the value of type 7 specifies the sortRelation. The value for type 7 is 1 for ascending and 2 for descending. For the sortElement only the generic part is handled. If generic sortKey is of type sortField, then attribute type 1 is present and the value is sortField (InternationalString). If generic sortKey is of type sortAttributes, then the attributes in the list are used. Generic sortKey of type elementSpec is not supported.

The term in the sorting Attribute-Plus-Term combo should hold an integer. The value is 0 for primary sorting criteria, 1 for second criteria, etc.

7.8 Facets

YAZ supports facets in the Solr, SRU 2.0 and Z39.50 protocols.

Like Type-1/RPN, YAZ supports a string notation for specifying facets. This notataion maps straight to facets.asn. The notation is parsed by function yaz_pqf_parse_facet_list defined in header yaz/pquery.h.
For ZOOM C the facets are specified by option "facets". For yaz-client, the 'facets' command is used.

The grammar of this specification is as follows:

\[
\text{facet-spec ::= facet-list}
\]

\[
\text{facet-list ::= facet-list ',', attr-spec | attr-spec}
\]

\[
\text{attr-spec ::= attr-spec '@attr' string | '@attr' string}
\]

The notation is inspired by PQF. The string following '@attr' must not include blanks and is of the form 
\text{type}=value, where type is an integer and value is a string or an integer.

There is no formal facets attribute set (it is not given in the protocol by the facets, although it could). The following types apply:

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Field-name. This is often a string, e.g. &quot;Author&quot;, &quot;Year&quot;, etc.</td>
</tr>
<tr>
<td>2</td>
<td>Sort order. Value should be an integer. Value 0: count descending (frequency). Value 1: alpha ascending.</td>
</tr>
<tr>
<td>3</td>
<td>Number of terms requested.</td>
</tr>
<tr>
<td>4</td>
<td>Start offset (starting from 1)</td>
</tr>
</tbody>
</table>

Table 7.4: Facet attributes
Chapter 8

The ODR Module

8.1 Introduction

ODR is the BER-encoding/decoding subsystem of YAZ. Care has been taken to isolate ODR from the rest of the package - specifically from the transport interface. ODR may be used in any context where basic ASN.1/BER representations are used.

If you are only interested in writing a Z39.50 implementation based on the PDUs that are already provided with YAZ, you only need to concern yourself with the section on managing ODR streams (Section 8.2). Only if you need to implement ASN.1 beyond that which has been provided, should you worry about the second half of the documentation (Section 8.3). If you use one of the higher-level interfaces, you can skip this section entirely.

This is important, so we’ll repeat it for emphasis: You do not need to read Section 8.3 to implement Z39.50 with YAZ.

If you need a part of the protocol that isn’t already in YAZ, you should contact the authors before going to work on it yourself: We might already be working on it. Conversely, if you implement a useful part of the protocol before us, we’d be happy to include it in a future release.

8.2 Using ODR

8.2.1 ODR Streams

Conceptually, the ODR stream is the source of encoded data in the decoding mode; when encoding, it is the receptacle for the encoded data. Before you can use an ODR stream it must be allocated. This is done with the function

    ODR odr_createmem(int direction);

The odr_createmem() function takes as argument one of three manifest constants: ODR_ENCODE, ODR_DECODE, or ODR_PRINT. An ODR stream can be in only one mode - it is not possible to change its
mode once it’s selected. Typically, your program will allocate at least two ODR streams - one for decoding, and one for encoding.

When you’re done with the stream, you can use

```c
void odr_destroy(ODR o);
```

to release the resources allocated for the stream.

### 8.2.2 Memory Management

Two forms of memory management take place in the ODR system. The first one, which has to do with allocating little bits of memory (sometimes quite large bits of memory, actually) when a protocol package is decoded, and turned into a complex of interlinked structures. This section deals with this system, and how you can use it for your own purposes. The next section deals with the memory management which is required when encoding data - to make sure that a large enough buffer is available to hold the fully encoded PDU.

The ODR module has its own memory management system, which is used whenever memory is required. Specifically, it is used to allocate space for data when decoding incoming PDUs. You can use the memory system for your own purposes, by using the function

```c
void *odr_malloc(ODR o, size_t size);
```

You can’t use the normal `free(2)` routine to free memory allocated by this function, and ODR doesn’t provide a parallel function. Instead, you can call

```c
void odr_reset(ODR o);
```

when you are done with the memory: Everything allocated since the last call to `odr_reset()` is released. The `odr_reset()` call is also required to clear up an error condition on a stream.

The function

```c
size_t odr_total(ODR o);
```

returns the number of bytes allocated on the stream since the last call to `odr_reset()`.

The memory subsystem of ODR is fairly efficient at allocating and releasing little bits of memory. Rather than managing the individual, small bits of space, the system maintains a free-list of larger chunks of memory, which are handed out in small bits. This scheme is generally known as a `nibble-memory` system. It is very useful for maintaining short-lived constructions such as protocol PDUs.

If you want to retain a bit of memory beyond the next call to `odr_reset()`, you can use the function
ODR_MEM odr_extract_mem(ODR o);

This function will give you control of the memory recently allocated on the ODR stream. The memory will live (past calls to `odr_reset()`), until you call the function

```c
void odr_release_mem(ODR_MEM p);
```

The opaque `ODR_MEM` handle has no other purpose than referencing the memory block for you until you want to release it.

You can use `odr_extract_mem()` repeatedly between allocating data, to retain individual control of separate chunks of data.

### 8.2.3 Encoding and Decoding Data

When encoding data, the ODR stream will write the encoded octet string in an internal buffer. To retrieve the data, use the function

```c
char *odr_getbuf(ODR o, int *len, int *size);
```

The integer pointed to by `len` is set to the length of the encoded data, and a pointer to that data is returned. `*size` is set to the size of the buffer (unless `size` is null, signaling that you are not interested in the size). The next call to a primitive function using the same ODR stream will overwrite the data, unless a different buffer has been supplied using the call

```c
void odr_setbuf(ODR o, char *buf, int len, int can_grow);
```

which sets the encoding (or decoding) buffer used by `o` to `buf`, using the length `len`. Before a call to an encoding function, you can use `odr_setbuf()` to provide the stream with an encoding buffer of sufficient size (length). The `can_grow` parameter tells the encoding ODR stream whether it is allowed to use `realloc(2)` to increase the size of the buffer when necessary. The default condition of a new encoding stream is equivalent to the results of calling

```c
odr_setbuf(stream, 0, 0, 1);
```

In this case, the stream will allocate and reallocate memory as necessary. The stream reallocates memory by repeatedly doubling the size of the buffer - the result is that the buffer will typically reach its maximum, working size with only a small number of reallocation operations. The memory is freed by the stream when the latter is destroyed, unless it was assigned by the user with the `can_grow` parameter set to zero (in this case, you are expected to retain control of the memory yourself).
To assume full control of an encoded buffer, you must first call `odr_getbuf()` to fetch the buffer and its length. Next, you should call `odr_setbuf()` to provide a different buffer (or a null pointer) to the stream. In the simplest case, you will reuse the same buffer over and over again, and you will just need to call `odr_getbuf()` after each encoding operation to get the length and address of the buffer. Note that the stream may reallocate the buffer during an encoding operation, so it is necessary to retrieve the correct address after each encoding operation.

It is important to realize that the ODR stream will not release this memory when you call `odr_reset()`: It will merely update its internal pointers to prepare for the encoding of a new data value. When the stream is released by the `odr_destroy()` function, the memory given to it by `odr_setbuf` will be released only if the `can_grow` parameter to `odr_setbuf()` was nonzero. The `can_grow` parameter, in other words, is a way of signaling who is to own the buffer, you or the ODR stream. If you never call `odr_setbuf()` on your encoding stream, which is typically the case, the buffer allocated by the stream will belong to the stream by default.

When you wish to decode data, you should first call `odr_setbuf()`, to tell the decoding stream where to find the encoded data, and how long the buffer is (the `can_grow` parameter is ignored by a decoding stream). After this, you can call the function corresponding to the data you wish to decode (e.g. `odr_integer()` or `z_APDU()`).

Example 8.1 Encoding and decoding functions

```c
int odr_integer(ODR o, Odr_int **p, int optional, const char *name);
int z_APDU(ODR o, Z_APDU **p, int optional, const char *name);
```

If the data is absent (or doesn’t match the tag corresponding to the type), the return value will be either 0 or 1 depending on the `optional` flag. If `optional` is 0 and the data is absent, an error flag will be raised in the stream, and you’ll need to call `odr_reset()` before you can use the stream again. If `optional` is nonzero, the pointer pointed to by `p` will be set to the null value, and the function will return 1. The `name` argument is used to pretty-print the tag in question. It may be set to `NULL` if pretty-printing is not desired.

If the data value is found where it’s expected, the pointer pointed to by the `p` argument will be set to point to the decoded type. The space for the type will be allocated and owned by the ODR stream, and it will live until you call `odr_reset()` on the stream. You cannot use `free(2)` to release the memory. You can decode several data elements (by repeated calls to `odr_setbuf()` and your decoding function), and new memory will be allocated each time. When you do call `odr_reset()`, everything decoded since the last call to `odr_reset()` will be released.

Example 8.2 Encoding and decoding of an integer

The use of the double indirection can be a little confusing at first (its purpose will become clear later on, hopefully), so an example is in order. We’ll encode an integer value, and immediately decode it again using a different stream. A useless, but informative operation.

```c
void do_nothing_useful(Odr_int value)
{
    ODR encode, decode;
    Odr_int *valp, *resvalp;
    char *bufferp;
```
int len;

/* allocate streams */
if (!(encode = odr_createmem(ODR_ENCODE)))
    return;
if (!(decode = odr_createmem(ODR_DECODE)))
    return;

valp = &value;
if (odr_integer(encode, &valp, 0, 0) == 0)
{
    printf("encoding went bad\n");
    return;
}
bufferp = odr_getbuf(encode, &len, 0);
printf("length of encoded data is %d\n", len);

/* now let's decode the thing again */
odr_setbuf(decode, bufferp, len, 0);
if (odr_integer(decode, &resvalp, 0, 0) == 0)
{
    printf("decoding went bad\n");
    return;
}
/* ODR_INT_PRINTF format for printf (such as %d) */
printf("the value is " ODR_INT_PRINTF "\n", *resvalp);

/* clean up */
odr_destroy(encode);
odr_destroy(decode);

This looks like a lot of work, offhand. In practice, the ODR streams will typically be allocated once, in the
beginning of your program (or at the beginning of a new network session), and the encoding and decoding
will only take place in a few, isolated places in your program, so the overhead is quite manageable.

8.2.4 Printing

When an ODR stream is created of type ODR_PRINT the ODR module will print the contents of a PDU
in a readable format. By default output is written to the stderr stream. This behavior can be changed,
however, by calling the function

    odr_setprint(ODR o, FILE *file);

before encoders or decoders are being invoked. It is also possible to direct the output to a buffer (or indeed
another file), by using the more generic mechanism:
```c
void odr_set_stream(ODR o, void *handle,
    void (*stream_write)(ODR o, void *handle, int type,
        const char *buf, int len),
    void (*stream_close)(void *handle));
```

Here the user provides an opaque handle and two handlers, `stream_write` for writing, and `stream_close` which is supposed to close/free resources associated with handle. The `stream_close` handler is optional and if NULL for the function is provided, it will not be invoked. The `stream_write` takes the ODR handle as parameter, the user-defined handle, a type `ODR_OCTETSTRING`, `ODR_VISIBLESTRING` which indicates the type of contents being written.

Another utility useful for diagnostics (error handling) or as part of the printing facilities is:

```c
const char **odr_get_element_path(ODR o);
```

which returns a list of current elements that ODR deals with at the moment. For the returned array, say `ar`, then `ar[0]` is the top level element, `ar[n]` is the last. The last element has the property that `ar[n+1] == NULL`.

**Example 8.3 Element Path for record**

For a database record part of a PresentResponse the array returned by `odr_get_element` is `presentResponse, databaseOrSurDiagnostics, ?, record, ?, databaseRecord`. The question mark appears due to unnamed constructions.

### 8.2.5 Diagnostics

The encoding/decoding functions all return 0 when an error occurs. Until you call `odr_reset()`, you cannot use the stream again, and any function called will immediately return 0.

To provide information to the programmer or administrator, the function

```c
void odr_perror(ODR o, char *message);
```

is provided, which prints the `message` argument to `stderr` along with an error message from the stream. You can also use the function

```c
int odr_geterror(ODR o);
```

to get the current error number from the screen. The number will be one of these constants:

The character string array

```c
char *odr_errlist[]
```

can be indexed by the error code to obtain a human-readable representation of the problem.
<table>
<thead>
<tr>
<th>code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OMEMORY</td>
<td>Memory allocation failed.</td>
</tr>
<tr>
<td>OSYSERR</td>
<td>A system- or library call has failed. The standard diagnostic variable errno should be examined to determine the actual error.</td>
</tr>
<tr>
<td>OSPACE</td>
<td>No more space for encoding. This will only occur when the user has explicitly provided a buffer for an encoding stream without allowing the system to allocate more space.</td>
</tr>
<tr>
<td>OREQUIRED</td>
<td>This is a common protocol error; A required data element was missing during encoding or decoding.</td>
</tr>
<tr>
<td>OUNEXPECTED</td>
<td>An unexpected data element was found during decoding.</td>
</tr>
<tr>
<td>OOTHER</td>
<td>Other error. This is typically an indication of misuse of the ODR system by the programmer, and also that the diagnostic system isn’t as good as it should be, yet.</td>
</tr>
</tbody>
</table>

Table 8.1: ODR Error codes

### 8.2.6 Summary and Synopsis

```c
#include <yaz/odr.h>

ODR odr_createmem(int direction);
void odr_destroy(ODR o);
void odr_reset(ODR o);
char *odr_getbuf(ODR o, int *len, int *size);
void odr_setbuf(ODR o, char *buf, int len, int can_grow);
void *odr_malloc(ODR o, int size);
NMEM odr_extract_mem(ODR o);
int odr_geterror(ODR o);
void odr_perror(ODR o, const char *message);
extern char *odr_errlist[];
```
8.3 Programming with ODR

The API of ODR is designed to reflect the structure of ASN.1, rather than BER itself. Future releases may be able to represent data in other external forms.

Tip
There is an ASN.1 tutorial available at this site. This site also has standards for ASN.1 (X.680) and BER (X.690) online.

The ODR interface is based loosely on that of the Sun Microsystems XDR routines. Specifically, each function which corresponds to an ASN.1 primitive type has a dual function. Depending on the settings of the ODR stream which is supplied as a parameter, the function may be used either to encode or decode data. The functions that can be built using these primitive functions, to represent more complex data types, share this quality. The result is that you only have to enter the definition for a type once - and you have the functionality of encoding, decoding (and pretty-printing) all in one unit. The resulting C source code is quite compact, and is a pretty straightforward representation of the source ASN.1 specification.

In many cases, the model of the XDR functions works quite well in this role. In others, it is less elegant. Most of the hassle comes from the optional SEQUENCE members which don’t exist in XDR.

8.3.1 The Primitive ASN.1 Types

ASN.1 defines a number of primitive types (many of which correspond roughly to primitive types in structured programming languages, such as C).

8.3.1.1 INTEGER

The ODR function for encoding or decoding (or printing) the ASN.1 INTEGER type looks like this:

```c
int odr_integer(ODR o, Odr_int **p, int optional, const char *name);
```

The `Odr_int` is just a simple integer.

This form is typical of the primitive ODR functions. They are named after the type of data that they encode or decode. They take an ODR stream, an indirect reference to the type in question, and an optional flag (corresponding to the OPTIONAL keyword of ASN.1) as parameters. They all return an integer value of either one or zero. When you use the primitive functions to construct encoders for complex types of your own, you should follow this model as well. This ensures that your new types can be reused as elements in yet more complex types.

The `o` parameter should obviously refer to a properly initialized ODR stream of the right type (encoding/decoding/printing) for the operation that you wish to perform.

When encoding or printing, the function first looks at `* p`. If `* p` (the pointer pointed to by `p`) is a null pointer, this is taken to mean that the data element is absent. If the `optional` parameter is nonzero, the
function will return one (signifying success) without any further processing. If the optional is zero, an internal error flag is set in the ODR stream, and the function will return 0. No further operations can be carried out on the stream without a call to the function odr_reset().

If *p is not a null pointer, it is expected to point to an instance of the data type. The data will be subjected to the encoding rules, and the result will be placed in the buffer held by the ODR stream.

The other ASN.1 primitives have similar functions that operate in similar manners:

### 8.3.1.2 BOOLEAN

```c
int odr_bool(ODR o, Odr_bool **p, int optional, const char *name);
```

### 8.3.1.3 REAL

Not defined.

### 8.3.1.4 NULL

```c
int odr_null(ODR o, Odr_null **p, int optional, const char *name);
```

In this case, the value of **p is not important. If *p is different from the null pointer, the null value is present, otherwise it’s absent.

### 8.3.1.5 OCTET STRING

```c
typedef struct odr_oct {
    unsigned char *buf;
    int len;
} Odr_oct;
```

```c
int odr_octetstring(ODR o, Odr_oct **p, int optional, const char *name);
```

The buf field should point to the character array that holds the octetstring. The len field holds the actual length. The character array need not be null-terminated.

To make things a little easier, an alternative is given for string types that are not expected to contain embedded NULL characters (e.g. VisibleString):

```c
int odr_cstring(ODR o, char **p, int optional, const char *name);
```
which encodes or decodes between OCTETSTRING representations and null-terminated C strings.

Functions are provided for the derived string types, e.g.:

```c
int odr_visiblestring(ODR o, char **p, int optional,
                      const char *name);
```

### 8.3.1.6 BIT STRING

```c
int odr_bitstring(ODR o, Odr_bitmask **p, int optional,
                  const char *name);
```

The opaque type `Odr_bitmask` is only suitable for holding relatively brief bit strings, e.g. for options fields, etc. The constant `ODR_BITMASK_SIZE` multiplied by 8 gives the maximum possible number of bits.

A set of macros are provided for manipulating the `Odr_bitmask` type:

```c
void ODR_MASK_ZERO(Odr_bitmask *b);
void ODR_MASK_SET(Odr_bitmask *b, int bitno);
void ODR_MASK_CLEAR(Odr_bitmask *b, int bitno);
int ODR_MASK_GET(Odr_bitmask *b, int bitno);
```

The functions are modeled after the manipulation functions that accompany the `fd_set` type used by the `select(2)` call. `ODR_MASK_ZERO` should always be called first on a new bitmask, to initialize the bits to zero.

### 8.3.1.7 OBJECT IDENTIFIER

```c
int odr_oid(ODR o, Odr oid **p, int optional, const char *name);
```

The C OID representation is simply an array of integers, terminated by the value -1 (the `Odr_oid` type is synonymous with the `short` type). We suggest that you use the OID database module (see Section 7.2.1) to handle object identifiers in your application.
8.3.2 Tagging Primitive Types

The simplest way of tagging a type is to use the `odr_implicit_tag()` or `odr_explicit_tag()` macros:

```c
int odr_implicit_tag(ODR o, Odr_fun fun, int class, int tag,
    int optional, const char *name);
int odr_explicit_tag(ODR o, Odr_fun fun, int class, int tag,
    int optional, const char *name);
```

To create a type derived from the integer type by implicit tagging, you might write:

```
MyInt ::= [210] IMPLICIT INTEGER
```

In the ODR system, this would be written like:

```c
int myInt(ODR o, Odr_int **p, int optional, const char *name)
{
    return odr_implicit_tag(o, odr_integer, p,
        ODR_CONTEXT, 210, optional, name);
}
```

The function `myInt()` can then be used like any of the primitive functions provided by ODR. Note that the behavior of `odr_explicit_tag()` and `odr_implicit_tag()` macros act exactly the same as the functions they are applied to - they respond to error conditions, etc, in the same manner - they simply have three extra parameters. The class parameter may take one of the values: `ODR_CONTEXT`, `ODR_PRIVATE`, `ODR_UNIVERSAL`, or `/ODR_APPLICATION`.

8.3.3 Constructed Types

Constructed types are created by combining primitive types. The ODR system only implements the `SEQUENCE` and `SEQUENCE OF` constructions (although adding the rest of the container types should be simple enough, if the need arises).

For implementing `SEQUENCEs`, the functions

```c
int odr_sequence_begin(ODR o, void *p, int size, const char *name);
int odr_sequence_end(ODR o);
```

are provided.

The `odr_sequence_begin()` function should be called in the beginning of a function that implements a `SEQUENCE` type. Its parameters are the ODR stream, a pointer (to a pointer to the type you’re implementing), and the size of the type (typically a C structure). On encoding, it returns 1 if *p is a null pointer. The size parameter is ignored. On decoding, it returns 1 if the type is found in the data stream. size bytes of memory are allocated, and *p is set to point to this space. The `odr_sequence_end()` is called at the end of the complex function. Assume that a type is defined like this:
MySequence ::= SEQUENCE {
    intval INTEGER,
    boolval BOOLEAN OPTIONAL
}

The corresponding ODR encoder/decoder function and the associated data structures could be written like this:

typedef struct MySequence {
    Odr_int *intval;
    Odr_bool *boolval;
} MySequence;

int mySequence(ODR o, MySequence **p, int optional, const char *name)
{
    if (odr_sequence_begin(o, p, sizeof(**p), name) == 0)
        return optional && odr_ok(o);
    return
        odr_integer(o, &(*p)->intval, 0, "intval") &&
        odr_bool(o, &(*p)->boolval, 1, "boolval") &&
        odr_sequence_end(o);
}

Note the 1 in the call to odr_bool(), to mark that the sequence member is optional. If either of the member types had been tagged, the macros odr_implicit_tag() or odr_explicit_tag() could have been used. The new function can be used exactly like the standard functions provided with ODR. It will encode, decode or pretty-print a data value of the MySequence type. We like to name types with an initial capital, as done in ASN.1 definitions, and to name the corresponding function with the first character of the name in lower case. You could, of course, name your structures, types, and functions any way you please - as long as you’re consistent, and your code is easily readable. odr_ok is just that - a predicate that returns the state of the stream. It is used to ensure that the behavior of the new type is compatible with the interface of the primitive types.

### 8.3.4 Tagging Constructed Types

**Note**
See Section 8.3.2 for information on how to tag the primitive types, as well as types that are already defined.

#### 8.3.4.1 Implicit Tagging

Assume the type above had been defined as

MySequence ::= [10] IMPLICIT SEQUENCE {
    intval INTEGER,
...
You would implement this in ODR by calling the function

```c
int odr_implicit_settag(ODR o, int class, int tag);
```

which overrides the tag of the type immediately following it. The macro `odr_implicit_tag()` works by calling `odr_implicit_settag()` immediately before calling the function pointer argument. Your type function could look like this:

```c
int mySequence(ODR o, MySequence **p, int optional, const char *name)
{
    if (odr_implicit_settag(o, ODR_CONTEXT, 10) == 0 \\
        || odr_sequence_begin(o, p, sizeof(**p), name) == 0)
        return optional && odr_ok(o);
    return
        odr_integer(o, &(*p)->intval, 0, "intval") &&
        odr_bool(o, &(*p)->boolval, 1, "boolval") &&
        odr_sequence_end(o);
}
```

The definition of the structure `MySequence` would be the same.

### 8.3.4.2 Explicit Tagging

Explicit tagging of constructed types is a little more complicated, since you are in effect adding a level of construction to the data.

Assume the definition:

```
MySequence ::= [10] IMPLICIT SEQUENCE {
    intval INTEGER,
    boolval BOOLEAN OPTIONAL
}
```

Since the new type has an extra level of construction, two new functions are needed to encapsulate the base type:

```c
int odr_constructed_begin(ODR o, void *p, int class, int tag, 
        const char *name);

int odr_constructed_end(ODR o);
```

Assume that the IMPLICIT in the type definition above were replaced with EXPLICIT (or that the IMPLICIT keyword was simply deleted, which would be equivalent). The structure definition would look the same, but the function would look like this:
int mySequence(ODR o, MySequence **p, int optional, const char *name)
{
    if (odr_constructed_begin(o, p, ODR_CONTEXT, 10, name) == 0)
        return optional && odr_ok(o);
    if (o->direction == ODR_DECODE)
        *p = odr_malloc(o, sizeof(**p));
    if (odr_sequence_begin(o, p, sizeof(**p), 0) == 0)
        {
            *p = 0; /* this is almost certainly a protocol error */
            return 0;
        }
    return
            odr_integer(o, &(*p)->intval, 0, "intval") &&
            odr_bool(o, &(*p)->boolval, 1, "boolval") &&
            odr_sequence_end(o) &&
            odr_constructed_end(o);
}

Notice that the interface here gets kind of nasty. The reason is simple: Explicitly tagged, constructed types are fairly rare in the protocols that we care about, so the aesthetic annoyance (not to mention the dangers of a cluttered interface) is less than the time that would be required to develop a better interface. Nevertheless, it is far from satisfying, and it’s a point that will be worked on in the future. One option for you would be to simply apply the odr_explicit_tag() macro to the first function, and not have to worry about odr_constructed_* yourself. Incidentally, as you might have guessed, the odr_sequence_ functions are themselves implemented using the /odr_constructed_ functions.

8.3.5 SEQUENCE OF

To handle sequences (arrays) of a specific type, the function

    int odr_sequence_of(ODR o, int (*fun)(ODR o, void *p, int optional),
                        void *p, int *num, const char *name);

The fun parameter is a pointer to the decoder/encoder function of the type. p is a pointer to an array of pointers to your type. num is the number of elements in the array.

Assume a type

MyArray ::= SEQUENCE OF INTEGER

The C representation might be

typedef struct MyArray
{
    int num_elements;
    Odr_int **elements;
} MyArray;
And the function might look like

```c
int myArray(ODR o, MyArray **p, int optional, const char *name)
{
    if (o->direction == ODR_DECODE)
        *p = odr_malloc(o, sizeof(**p));
    if (odr_sequence_of(o, odr_integer, &(*p)->elements,
                        &(*p)->num_elements, name))
        return 1;
    *p = 0;
    return optional && odr_ok(o);
}
```

### 8.3.6 CHOICE Types

The choice type is used fairly often in some ASN.1 definitions, so some work has gone into streamlining its interface.

CHOICE types are handled by the function:

```c
int odr_choice(ODR o, Odr_arm arm[], void *p, void *whichp,
               const char *name);
```

The `arm` array is used to describe each of the possible types that the CHOICE type may assume. Internally in your application, the CHOICE type is represented as a discriminated union. That is, a C union accompanied by an integer (or enum) identifying the active 'arm' of the union. `whichp` is a pointer to the union discriminator. When encoding, it is examined to determine the current type. When decoding, it is set to reference the type that was found in the input stream.

The Odr_arm type is defined thus:

```c
typedef struct odr_arm
{
    int tagmode;
    int class;
    int tag;
    int which;
    Odr_fun fun;
    char *name;
} Odr_arm;
```

The interpretation of the fields are:

- **tagmode** Either `ODR_IMPLICIT`, `ODR_EXPLICIT`, or `ODR_NONE` (-1) to mark no tagging.

- **which** The value of the discriminator that corresponds to this CHOICE element. Typically, it will be a #defined constant, or an enum member.
fun A pointer to a function that implements the type of the CHOICE member. It may be either a standard ODR type or a type defined by yourself.

name Name of tag.

A handy way to prepare the array for use by the odr_choice() function is to define it as a static, initialized array in the beginning of your decoding/encoding function. Assume the type definition:

MyChoice ::= CHOICE {
   untagged INTEGER,
   tagged [99] IMPLICIT INTEGER,
   other BOOLEAN
}

Your C type might look like

typedef struct MyChoice {
   enum {
      MyChoice_untagged,
      MyChoice_tagged,
      MyChoice_other
   } which;
   union {
      Odr_int *untagged;
      Odr_int *tagged;
      Odr_bool *other;
   } u;
};

And your function could look like this:

int myChoice(ODR o, MyChoice **p, int optional, const char *name) {
   static Odr_arm arm[] = {
      {-1, -1, -1, MyChoice_untagged, odr_integer, "untagged"},
      {ODR_IMPLICIT, ODR_CONTEXT, 99, MyChoice_tagged, odr_integer, "tagged"},
      {-1, -1, -1, MyChoice_other, odr_boolean, "other"},
      {-1, -1, -1, -1, 0}
   };
   if (o->direction == ODR_DECODE)
      *p = odr_malloc(o, sizeof(**p));
   else if (!*p)
      return optional && odr_ok(o);
   return odr_choice(o, arm, &(*p)->u, &(*p)->which), name)
return 1;
*p = 0;
return optional && odr_ok(o);
}

In some cases (say, a non-optional choice which is a member of a sequence), you can "embed" the union and its discriminator in the structure belonging to the enclosing type, and you won’t need to fiddle with memory allocation to create a separate structure to wrap the discriminator and union.

The corresponding function is somewhat nicer in the Sun XDR interface. Most of the complexity of this interface comes from the possibility of declaring sequence elements (including CHOICEs) optional.

The ASN.1 specifications naturally require that each member of a CHOICE have a distinct tag, so they can be told apart on decoding. Sometimes it can be useful to define a CHOICE that has multiple types that share the same tag. You’ll need some other mechanism, perhaps keyed to the context of the CHOICE type. In effect, we would like to introduce a level of context-sensitiveness to our ASN.1 specification. When encoding an internal representation, we have no problem, as long as each CHOICE member has a distinct discriminator value. For decoding, we need a way to tell the choice function to look for a specific arm of the table. The function

void odr_choice_bias(ODR o, int what);

provides this functionality. When called, it leaves a notice for the next call to odr_choice() to be called on the decoding stream o, that only the arm entry with a which field equal to what should be tried.

The most important application (perhaps the only one, really) is in the definition of application-specific EXTERNAL encoders/decoders which will automatically decode an ANY member given the direct or indirect reference.

8.4 Debugging

The protocol modules are suffering somewhat from a lack of diagnostic tools at the moment. Specifically ways to pretty-print PDUs that aren’t recognized by the system. We’ll include something to this end in a not-too-distant release. In the meantime, what we do when we get packages we don’t understand is to compile the ODR module with ODR_DEBUG defined. This causes the module to dump tracing information as it processes data units. With this output and the protocol specification (Z39.50), it is generally fairly easy to see what goes wrong.
Chapter 9

The COMSTACK Module

9.1 Synopsis (blocking mode)

```c
COMSTACK stack;
char *buf = 0;
int size = 0, length_incoming;
char server_address_str[] = "localhost:9999";
void *server_address_ip;
int status;

char *protocol_package = "GET / HTTP/1.0\r\n\n";
int protocol_package_length = strlen(protocol_package);

stack = cs_create(tcpip_type, 1, PROTO_HTTP);
if (!stack) {
    perror("cs_create"); /* use perror() here since we have no stack ←
    yet */
    return -1;
}

server_address_ip = cs_straddr(stack, server_address_str);
if (!server_address_ip) {
    fprintf(stderr, "cs_straddr: address could not be resolved\n");
    return -1;
}

status = cs_connect(stack, server_address_ip);
if (status) {
    fprintf(stderr, "cs_connect: %s\n", cs_strerror(stack));
    return -1;
}

status = cs_rcvconnect(stack);
if (status) {
    fprintf(stderr, "cs_rcvconnect: %s\n", cs_strerror(stack));
}
```
return -1;
}

status = cs_put(stack, protocol_package, protocol_package_length);
if (status) {
    fprintf(stderr, "cs_put: %s\n", cs_strerror(stack));
    return -1;
}

/* Now get a response */
length_incoming = cs_get(stack, &buf, &size);
if (!length_incoming) {
    fprintf(stderr, "Connection closed\n");
    return -1;
} else if (length_incoming < 0) {
    fprintf(stderr, "cs_get: %s\n", cs_strerror(stack));
    return -1;
}

/* Print result */
fwrite(buf, length_incoming, 1, stdout);

/* clean up */
.cs_close(stack);
if (buf)
    xfree(buf);
return 0;

9.2 Introduction

The COMSTACK subsystem provides a transparent interface to different types of transport stacks for the exchange of BER-encoded data and HTTP packets. At present, the RFC1729 method (BER over TCP/IP), local UNIX socket and an experimental SSL stack are supported, but others may be added in time. The philosophy of the module is to provide a simple interface by hiding unused options and facilities of the underlying libraries. This is always done at the risk of losing generality, and it may prove that the interface will need extension later on.

Note
There hasn't been interest in the XTImOSI stack for some years. Therefore, it is no longer supported.

The interface is implemented in such a fashion that only the sub-layers constructed to the transport methods that you wish to use in your application are linked in.

You will note that even though simplicity was a goal in the design, the interface is still orders of magnitudes more complex than the transport systems found in many other packages. One reason is that the interface
needs to support the somewhat different requirements of the different lower-layer communications stacks; another important reason is that the interface seeks to provide a more or less industrial-strength approach to asynchronous event-handling. When no function is allowed to block, things get more complex - particularly on the server side. We urge you to have a look at the demonstration client and server provided with the package. They are meant to be easily readable and instructive, while still being at least moderately useful.

9.3 Common Functions

9.3.1 Managing Endpoints

```c
COMSTACK cs_create(CS_TYPE type, int blocking, int protocol);
```

Creates an instance of the protocol stack - a communications endpoint. The `type` parameter determines the mode of communication. At present the following values are supported:

- `tcpip_type` TCP/IP (BER over TCP/IP or HTTP over TCP/IP)
- `ssl_type` Secure Socket Layer (SSL). This COMSTACK is experimental and is not fully implemented. If HTTP is used, this effectively is HTTPS.
- `unix_type` Unix socket (unix only). Local Transfer via file socket. See `unix(7)`.

The `cs_create` function returns a null-pointer if a system error occurs. The `blocking` parameter should be '1' if you wish the association to operate in blocking mode, and '0' otherwise. The `protocol` field should be `PROTO_Z3950` or `PROTO_HTTP`. Protocol `PROTO_SR` is no longer supported.

```c
void cs_close(COMSTACK handle);
```

Closes the connection (as elegantly as the lower layers will permit), and releases the resources pointed to by the `handle` parameter. The `handle` should not be referenced again after this call.

---

**Note**

We really need a soft disconnect, don’t we?

9.3.2 Data Exchange

```c
int cs_put(COMSTACK handle, char *buf, int len);
```

---
Sends buf down the wire. In blocking mode, this function will return only when a full buffer has been written, or an error has occurred. In nonblocking mode, it’s possible that the function will be unable to send the full buffer at once, which will be indicated by a return value of 1. The function will keep track of the number of octets already written; you should call it repeatedly with the same values of buf and len, until the buffer has been transmitted. When a full buffer has been sent, the function will return 0 for success. The return value -1 indicates an error condition (see below).

```c
int cs_get(COMSTACK handle, char **buf, int *size);
```

Receives a PDU or HTTP Response from the peer. Returns the number of bytes read. In nonblocking mode, it is possible that not all of the packet can be read at once. In this case, the function returns 1. To simplify the interface, the function is responsible for managing the size of the buffer. It will be reallocated if necessary to contain large packages, and will sometimes be moved around internally by the subsystem when partial packages are read. Before calling `cs_get` for the first time, the buffer can be initialized to the null pointer, and the length should also be set to 0 (`cs_get` will perform a `malloc(2)` on the buffer for you). When a full buffer has been read, the size of the package is returned (which will always be greater than 1). The return value -1 indicates an error condition.

See also the `cs_more()` function below.

```c
int cs_more(COMSTACK handle);
```

The `cs_more()` function should be used in conjunction with `cs_get` and `select(2)`. The `cs_get()` function will sometimes (notably in the TCP/IP mode) read more than a single protocol package off the network. When this happens, the extra package is stored by the subsystem. After calling `cs_get()`, and before waiting for more input, You should always call `cs_more()` to check if there’s a full protocol package already read. If `cs_more()` returns 1, `cs_get()` can be used to immediately fetch the new package. For the mOSI subsystem, the function should always return 0, but if you want your stuff to be protocol independent, you should use it.

**Note**
The `cs_more()` function is required because the RFC1729-method does not provide a way of separating individual PDUs, short of partially decoding the BER. Some other implementations will carefully nibble at the packet by calling `read(2)` several times. This was felt to be too inefficient (or at least clumsy) - hence the call for this extra function.

```c
int cs_look(COMSTACK handle);
```

This function is useful when you’re operating in nonblocking mode. Call it when `select(2)` tells you there’s something happening on the line. It returns one of the following values:

- **CS_NONE** No event is pending. The data found on the line was not a complete package.
CS_CONNECT A response to your connect request has been received. Call `cs_rcvconnect` to process the event and to finalize the connection establishment.

CS_DISCON The other side has closed the connection (or maybe sent a disconnect request - but do we care? Maybe later). Call `cs_close` to close your end of the association as well.

CS_LISTEN A connect request has been received. Call `cs_listen` to process the event.

CS_DATA There’s data to be found on the line. Call `cs_get` to get it.

Note
You should be aware that even if `cs_look()` tells you that there’s an event pending, the corresponding function may still return and tell you there was nothing to be found. This means that only part of a package was available for reading. The same event will show up again, when more data has arrived.

```c
int cs_fileno(COMSTACK h);
```
returns the file descriptor of the association. Use this when file-level operations on the endpoint are required (select(2) operations, specifically).

### 9.4 Client Side

```c
int cs_connect(COMSTACK handle, void *address);
```
Initiate a connection with the target at address (more on addresses below). The function will return 0 on success, and 1 if the operation does not complete immediately (this will only happen on a nonblocking endpoint). In this case, use `cs_rcvconnect` to complete the operation, when `select(2)` or `poll(2)` reports input pending on the association.

```c
int cs_rcvconnect(COMSTACK handle);
```
Complete a connect operation initiated by `cs_connect()`. It will return 0 on success; 1 if the operation has not yet completed (in this case, call the function again later); -1 if an error has occurred.

### 9.5 Server Side

To establish a server under the inetd server, you can use

```c
COMSTACK cs_createbysocket(int socket, CS_TYPE type, int blocking,
                          int protocol);
```
The `socket` parameter is an established socket (when your application is invoked from inetd, the socket will typically be 0. The following parameters are identical to the ones for `cs_create`.

```c
int cs_bind(COMSTACK handle, void *address, int mode)
```

Binds a local address to the endpoint. Read about addresses below. The `mode` parameter should be either `CS_CLIENT` or `CS_SERVER`.

```c
int cs_listen(COMSTACK handle, char *addr, int *addrlen);
```

Call this to process incoming events on an endpoint that has been bound in listening mode. It will return 0 to indicate that the connect request has been received, 1 to signal a partial reception, and -1 to indicate an error condition.

```c
COMSTACK cs_accept(COMSTACK handle);
```

This finalizes the server-side association establishment, after `cs_listen` has completed successfully. It returns a new connection endpoint, which represents the new association. The application will typically wish to fork off a process to handle the association at this point, and continue listen for new connections on the old handle.

You can use the call

```c
const char *cs_addrstr(COMSTACK);
```

on an established connection to retrieve the host-name of the remote host.

---

**Note**

You may need to use this function with some care if your name server service is slow or unreliable.

### 9.6 Addresses

The low-level format of the addresses are different depending on the mode of communication you have chosen. A function is provided by each of the lower layers to map a user-friendly string-form address to the binary form required by the lower layers.

```c
void *cs_straddr(COMSTACK handle, const char *str);
```
The format for TCP/IP and SSL addresses is:

\[ <\text{host}> \ [ ': ' \ <\text{portnum}> \ ] \]

The hostname can be either a domain name or an IP address. The port number, if omitted, defaults to 210.

For TCP/IP and SSL, the special hostnames @, maps to IN6ADDR_ANY_INIT with IPV4 binding as well (bindv6only=0), The special hostname @4 binds to INADDR_ANY (IPV4 only listener). The special hostname @6 binds to IN6ADDR_ANY_INIT with bindv6only=1 (IPV6 only listener).

For UNIX sockets, the format of an address is the socket filename.

When a connection has been established, you can use

\[
\text{const char *cs_addrstr(COMSTACK h);}\]


to retrieve the host name of the peer system. The function returns a pointer to a static area, which is overwritten on the next call to the function.

A fairly recent addition to the COMSTACK module is the utility function

\[
\text{COMSTACK cs_create_host (const char *str, int blocking, void **vp);}\]

which is just a wrapper for cs_create and cs_straddr. The str is similar to that described for cs_straddr but with a prefix denoting the COMSTACK type. Prefixes supported are tcp: and unix: and ssl: for TCP/IP and UNIX and SSL respectively. If no prefix is given, then TCP/IP is used. The blocking is passed to function cs_create. The third parameter vp is a pointer to COMSTACK stack type specific values. Parameter vp is reserved for future use. Set it to NULL.

### 9.7 SSL

\[
\text{void *cs_get_ssl(COMSTACK cs);}\]

Returns the SSL handle, SSL * for comstack. If comstack is not of type SSL, then NULL is returned.

\[
\text{int cs_set_ssl_ctx(COMSTACK cs, void *ctx);}\]

Sets SSL context for comstack. The parameter is expected to be of type SSL_CTX *. This function should be called just after comstack has been created (before connect, bind, etc). This function returns 1 for success; 0 for failure.
int cs_set_ssl_certificate_file(COMSTACK cs, const char *fname);

Sets SSL certificate for comstack as a PEM file. This function returns 1 for success; 0 for failure.

int cs_get_ssl_peer_certificate_x509(COMSTACK cs, char **buf, int *len);

This function returns the peer certificate. If successful, *buf and *len holds X509 buffer and length respectively. Buffer should be freed with xfree. This function returns 1 for success; 0 for failure.

9.8 Diagnostics

All functions return -1 if an error occurs. Typically, the functions will return 0 on success, but the data exchange functions (cs_get, cs_put, cs_more) follow special rules. Consult their descriptions.

The error code for the COMSTACK can be retrieved using C macro cs_errno which will return one of the error codes CSYSERR, CSOUTSTATE, CSNODATA, ...

int cs_errno(COMSTACK handle);

You can the textual representation of the error code by using cs_errmsg, which works like strerror(3).

const char *cs_errmsg(int n);

It is also possible to get straight to the textual representation without the error code, by using cs_strerror.

const char *cs_strerror(COMSTACK h);

9.9 Summary and Synopsis

#include <yaz/comstack.h>

#include <yaz/tcpip.h>  /* this is for TCP/IP and SSL support */
#include <yaz/unix.h>  /* this is for UNIX socket support */

COMSTACK cs_create(CS_TYPE type, int blocking, int protocol);

COMSTACK cs_createbysocket(int s, CS_TYPE type, int blocking, int protocol);
COMSTACK cs_create_host(const char *str, int blocking, void **vp);

int cs_bind(COMSTACK handle, int mode);

int cs_connect(COMSTACK handle, void *address);

int cs_rcvconnect(COMSTACK handle);

int cs_listen(COMSTACK handle);

COMSTACK cs_accept(COMSTACK handle);

int cs_put(COMSTACK handle, char *buf, int len);

int cs_get(COMSTACK handle, char **buf, int *size);

int cs_more(COMSTACK handle);

void cs_close(COMSTACK handle);

int cs_look(COMSTACK handle);

void *cs_straddr(COMSTACK handle, const char *str);

const char *cs_addrstr(COMSTACK h);
Chapter 10

Future Directions

We have a new and better version of the front-end server on the drawing board. Resources and external commitments will govern when we’ll be able to do something real with it. Features should include greater flexibility, greater support for access/resource control, and easy support for Explain (possibly with Zebra as an extra database engine).

YAZ is a BER toolkit and as such should support all protocols out there based on that. We’d like to see running ILL applications. It shouldn’t be that hard. Another thing that would be interesting is LDAP. Maybe a generic framework for doing IR using both LDAP and Z39.50 transparently.

The SOAP implementation is incomplete. In the future we hope to add more features to it. Perhaps make a WSDL/XML Schema compiler. The authors of libxml2 are already working on XML Schema and RELAX NG compilers so this may not be too hard.

It would be neat to have a proper module mechanism for the Generic Frontend Server so that backend would be dynamically loaded (as shared objects / DLLs).

Other than that, YAZ generally moves in the directions which appear to make the most people happy (including ourselves, as prime users of the software). If there’s something you’d like to see in here, then drop us a note and let’s see what we can come up with.
Chapter 11

Reference

The material in this chapter is drawn directly from the individual manual entries.

11.1 yaz-client

yaz-client — Z39.50/SRU client for implementors

Synopsis


DESCRIPTION

yaz-client is a Z39.50/SRU client (origin) with a simple command line interface that allows you to test behavior and performance of Z39.50 targets and SRU servers.

From YAZ version 4.1.0 yaz-client may also operate as a Solr Web Service client.

If the server-addr is specified, the client creates a connection to the Z39.50/SRU target at the address given.

When yaz-client is started it tries to read commands from one of the following files:

- Command file if it is given by option -f.
- .yazclientrc in current working directory.
- .yazclientrc in the user’s home directory. The value of the $HOME environment variable is used to determine the home directory. Normally, $HOME is only set on POSIX systems such as Linux, FreeBSD, Solaris.
OPTIONS

-a filename If specified, logging of protocol packages will be appended to the file given. If filename is specified as -, the output is written to stdout.

-b filename If specified, YAZ will dump BER data in readable notation to the file specified. If filename is specified as -, the output is written to stdout.

-c filename If specified, CCL configuration will be read from the file given.

-d dump If specified, YAZ will dump BER data for all PDUs sent and received to individual files, named dump.DDD.raw, where DDD is 001, 002, 003, ...

-f cmdfile Reads commands from cmdfile. When this option is used, YAZ client does not read .yazclientrc from current directory or home directory.

-k size Sets preferred messages and maximum record size for Initialize Request in kilobytes. Default value is 65536 (64 MB).

-m filename If specified, retrieved records will be appended to the file given.

-p proxy-addr If specified, the client will use the proxy at the address given. YAZ client will connect to a proxy on the address and port given. The actual target will be specified as part of the InitRequest to inform the proxy about the actual target.

-q filename If specified, CQL configuration will be read from the file given.

-t displaycharset If displaycharset is given, it specifies name of the character set of the output (on the terminal on which YAZ client is running).

-u auth If specified, the auth string will be used for authentication.

-v level Sets the LOG level to level. Level is a sequence of tokens separated by comma. Each token is a integer or a named LOG item - one of fatal, debug, warn, log, malloc, all, none.

-V Prints YAZ version.

-x Makes the YAZ client print hex dumps of packages sent and received on standard output.

COMMANDS

The YAZ client accepts the following commands.

open zurl Opens a connection to a server. The syntax for zurl is the same as described above for connecting from the command line.

Syntax:

[(tcp|ssl|unix|http)’’:’']host[:port][/base]

quit Quits YAZ client
**find query** Sends a Search Request using the *query* given. By default the query is assumed to be PQF. See command **querytype** for more information.

**delete setname** Deletes result set with name *setname* on the server.

**base base1 base2 ...** Sets the name(s) of the database(s) to search. One or more databases may be specified, separated by blanks. This command overrides the database given in zurl.

**show [start [+number] [+resultset]]** Fetches records by sending a Present Request from the start position given by *start* and a number of records given by *number*, from the result set *resultset*. If *start* is not given, then the client will fetch from the position of the last retrieved record plus 1. If *number* is not given, then one record will be fetched at a time. If *resultset* is not given, the most recently retrieved result set is used.

**scan term** Scans database index for a term. The syntax resembles the syntax for **find**. If you want to scan for the word *water* you could write

```
scan water
```

but if you want to scan only in, say the title field, you would write

```
scan @attr 1=4 water
```

**setscan set term** Scans database index for a term within a result set. This is similar to the scan command but has a result set as its first argument.

**scanpos pos** Sets preferred position for scan. This value is used in the next scan. By default, position is 1.

**scansize size** Sets number of entries to be returned by scan. Default number of entries is 20.

**scanstep step** Set step-size for scan. This value is used in the next scan sent to the target. By default step-size is 0.

**sort sortspecs** Sorts a result set. The sort command takes a sequence of space-separated sort specifications, with each sort specification consisting of two space-separated words (so that the whole specification list is made up of an even number of words). The first word of each specification holds a field (sort criterion) and the second holds flags. If the sort criterion includes = it is assumed that the SortKey is of type sortAttributes using Bib-1: in this case the integer before = is the attribute type and the integer following = is the attribute value. If no = character is in the criterion, it is treated as a sortfield of type InternationalString. The flags word of each sort specification must consist of s for case sensitive or i for case insensitive, and < for ascending order or > for descending order.

**sort+** Same as **sort** but stores the sorted result set in a new result set.

**authentication openauth** Sets up an authentication string if a server requires authentication (v2 OpenStyle). The authentication string is first sent to the server when the **open** command is issued and the Z39.50 Initialize Request is sent, so this command must be used before **open** in order to be effective. A common convention for the authopen string is that the username - and password is separated by a slash, e.g. myusername/mysecret.
**srumethodversion** Selects Web Service method and version. Must be one of post, get, soap (default) or solr. Version should be either 1.1, 1.2 or 2.0 for SRU. Other versions are allowed - for testing purposes (version negotiation with SRU server). The version is currently not used for Solr Web Services.

**list_all** This command displays status and values for many settings.

**lslbn** Sets the limit for when no records should be returned together with the search result. See the Z39.50 standard on set bounds for more details.

**ssubn** Sets the limit for when all records should be returned with the search result. See the Z39.50 standard on set bounds for more details.

**mspn n** Sets the number of records that should be returned if the number of records in the result set is between the values of lslb and ssub. See the Z39.50 standard on set bounds for more details.

**status** Displays the values of lslb, ssub and mspn.

**setname** Switches named result sets on and off. Default is on.

**cancel** Sends a Trigger Resource Control Request to the target.

**facets spec** Specifies requested facets to be used in search. The notation is specified in Section 7.8.

**format oid** Sets the preferred transfer syntax for retrieved records. yaz-client supports all the record syntaxes that currently are registered. See Z39.50 Record Syntax Identifiers for more details. Commonly used records syntaxes include usmarc, sutrs and xml.

**elements e** Sets the element set name for the records. Many targets support element sets B (for brief) and F (for full).

**close** Sends a Z39.50 Close APDU and closes connection with the peer.

**querytype type** Sets the query type as used by command find. The following is supported: prefix for Prefix Query Notation (Type-1 Query); ccl for CCL search (Type-2 Query), cql for CQL (Type-104 search with CQL OID), ccl2rpn for CCL to RPN conversion (Type-1 Query), cql2rpn for CQL to RPN conversion (Type-1 Query).

**attributeset set** Sets attribute set OID for prefix queries (RPN, Type-1).

**refid id** Sets reference ID for Z39.50 Request(s).

**itemorder type no** Sends an Item Order Request using the ILL External. type is either 1 or 2 which corresponds to ILL-Profile 1 and 2 respectively. The no is the Result Set position of the record to be ordered.

**update action recid doc** Sends Item Update Request. The action argument must be the action type: one of insert, replace, delete and update. The second argument, recid, is the record identifier (any string). Third argument which is optional is the record document for the request. If doc is preceded with "<", then the following characters are treated as a filename with the records to be updated. Otherwise doc is treated as a document itself. The doc may also be quoted in double quotes. If doc is omitted, the last received record (as part of present response or piggybacked search response) is used for the update.
source filename  Executes list of commands from file filename, just like 'source' on most UNIX shells. A single dot (.) can be used as an alternative.

! args  Executes command args in subshell using the system call.

push_command command  The push_command takes another command as its argument. That command is then added to the history information (so you can retrieve it later). The command itself is not executed. This command only works if you have GNU readline/history enabled.

set_apdufile filename  Sets that APDU should be logged to file filename. Another way to achieve APDU log is by using command-line option -a.

set_auto_reconnect flag  Specifies whether YAZ client automatically reconnects if the target closes connection (Z39.50 only).

flag must be either on or off.

set_auto_wait flag  Specifies whether YAZ client should wait for response protocol packages after a request. By default YAZ client waits (on) for response packages immediately after a command (find, show) has been issued. If off is used, YAZ client does not attempt to receive packages automatically. These will have to be manually received when command wait_response is used.

flag must be either on or off.

set_marcdump filename  Specifies that all retrieved records should be appended to file filename. This command does the same thing as option -m.

schema schemaid  Specifies schema for retrieval. Schema may be specified as an OID for Z39.50. For SRU, schema is a simple string URI.

charset negotiationcharset [displaycharset] [[marccharset]]  Specifies character set (encoding) for Z39.50 negotiation / SRU encoding and/or character set for output (terminal).

negotiationcharset is the name of the character set to be negotiated by the server. The special name - for negotiationcharset specifies no character set to be negotiated.

If displaycharset is given, it specifies name of the character set of the output (on the terminal on which YAZ client is running). To disable conversion of characters to the output encoding, the special name - (dash) can be used. If the special name auto is given, YAZ client will convert strings to the encoding of the terminal as returned by nl_langinfo call.

If marccharset is given, it specifies name of the character set of retrieved MARC records from server. See also marccharset command.

Note
Since character set negotiation takes effect in the Z39.50 Initialize Request you should issue this command before command open is used.

Note
MARC records are not covered by Z39.50 character set negotiation, so that's why there is a separate character that must be known in order to do meaningful conversion(s).
negcharset charset  Specifies character set for negotiation (Z39.50). The argument is the same as second argument for command charset.

displaycharset charset  Specifies character set for output (display). The argument is the same as second argument for command charset.

marccharset charset  Specifies character set for retrieved MARC records so that YAZ client can display them in a character suitable for your display. See charset command. If auto is given, YAZ will assume that MARC21/USMARC is using MARC8/UTF8 and ISO-8859-1 for all other MARC variants. The charset argument is the same as third argument for command charset.

querycharset charset  Specifies character set for query terms for Z39.50 RPN queries and Z39.50 Scan Requests (termListAndStartPoint). This is a pure client-side conversion which converts from displayCharset to queryCharset.

set_cclfile filename  Specifies that CCL fields should be read from file file filename. This command does the same thing as option -c.

set_cqlfile filename  Specifies that CQL fields should be read from file file filename. This command does the same thing as option -q.

register_oid name class OID  This command allows you to register your own object identifier - so that instead of entering a long dot-notation you can use a short name instead. The name is your name for the OID, class is the class, and OID is the raw OID in dot notation. Class is one of: appctx, absyn, attet, transyn, diagset, recsyn, resform, accform, extserv, userinfo, elemspec, varset, schema, tagset, general. If you're in doubt use the general class.

register_tab command string  This command registers a TAB completion string for the command given.

sleep seconds  This command makes YAZ client sleep (be idle) for the number of seconds given.

wait_response [ number]  This command makes YAZ client wait for a number of response packages from target. If number is omitted, 1 is assumed.

This command is rarely used and is only useful if command set_auto_wait is set to off.

xmles OID doc  Sends XML Extended Services request using the OID and doc given.

zversion ver  This command sets Z39.50 version for negotiation. Should be used before open. By default 3 (version 3) is used.

options opi op2..  This command sets Z39.50 options for negotiation. Should be used before open.

The following options are supported: search, present, delSet, resourceReport, triggerResourceCtrl, accessCtrl, scan, sort, extendedServices, level_1Segmentation, level_2Segmentation, concurrentOperations, namedResultSets, encapsulation, resultCount, negotiationModel, duplicationDetection, queryType104, pQESCorrection, stringSchema.
EXAMPLE

The simplest example of a Prefix Query would be something like

```
f knuth
```

or

```
f "donald knuth"
```

In those queries, no attributes were specified. This leaves it up to the server what fields to search but most servers will search in all fields. Some servers do not support this feature though, and require that some attributes are defined. To add one attribute you could do:

```
f @attr 1=4 computer
```

where we search in the title field, since the use(1) is title(4). If we want to search in the author field and in the title field, and in the title field using right truncation it could look something like this:

```
f @and @attr 1=1003 knuth @attr 1=4 @attr 5=1 computer
```

Finally using a mix of Bib-1 and GILS attributes could look something like this:

```
f @attrset Bib-1 @and @attr GILS 1=2008 Washington @attr 1=21 weather
```

FILES

```
yaz-<version>/client/client.c
$HOME/.yazclientrc
$HOME/.yazclient.history
```

SEE ALSO

```
yaz(7) bib1-attr(7)
```

11.2 yaz-ztest

yaz-ztest — Z39.50/SRU Test Server

Synopsis

```
application[-install][-installa][-remove][-a file][-v level][-l file][-u uid][-c config][-f vconfig][-C fname][-t minutes][-k kilobytes][-K][-d daemon][-w dir][-p pidfile][-r kilobytes][-ziDSTV] [listener-spec...]
```
DESCRIPTION

**yaz-ztest** is a Z39.50/SRU test server that uses the YAZ generic frontend server (GFS) API. The server acts as a real Z39.50/SRU server but does not use a database. It returns a random hit count and returns a subset of a few built-in records.

The **listener-spec** consists of a transport mode followed by a colon, followed by a listener address. The transport mode is either tcp, unix, or ssl.

For TCP and SSL, an address has the form:

```
hostname | IP-number [ : portnumber ]
```

For UNIX local socket, the address is the filename of the local socket.

OPTIONS

- `a file` Specify a file for dumping PDUs (for diagnostic purposes). The special name `-(dash)` sends output to stderr.

- `S` Don’t fork or make threads on connection requests. This is good for debugging, but not recommended for real operation: Although the server is asynchronous and non-blocking, it can be nice to keep a software malfunction (okay then, a crash) from affecting all current users.

- `1` Like `S` but after one session the server exits. This mode is for debugging only.

- `T` Operate the server in threaded mode. The server creates a thread for each connection rather than fork a process. Only available on UNIX systems that offer POSIX threads.

- `s` Use the SR protocol (obsolete).

- `z` Use the Z39.50 protocol (default). This option and `s` complement each other. You can use both multiple times on the same command line, between listener-specifications (see below). This way, you can set up the server to listen for connections in both protocols concurrently, on different local ports.

- `l file` The logfile.

- `c config` A user option that serves as a specifier for some sort of configuration, usually a filename. The argument to this option is transferred to member `configname` of the `statserv_options_block`.

- `f vconfig` This specifies an XML file that describes one or more YAZ frontend virtual servers.

- `C fname` Sets SSL certificate file name for server (PEM).

- `v level` The log level. Use a comma-separated list of members of the set {fatal, debug, warn, log, malloc, all, none}.

- `u uid` Set user ID. Sets the real UID of the server process to that of the given user. It’s useful if you aren’t comfortable with having the server run as root, but you need to start it as such to bind a privileged port.

- `w dir` The server changes to this directory before listening to incoming connections. This option is useful when the server is operating from the inetd daemon (see `−i`).
-p pidfile Specifies that the server should write its Process ID to the file given by pidfile. A typical location would be /var/run/yaz-ztest.pid.

-i Use this to make the server run from the inetd server (UNIX only).

-D Use this to make the server put itself in the background and run as a daemon. If neither -i nor -D is given, the server starts in the foreground.

-install Use this to install the server as an NT service (Windows NT/2000/XP only). Control the server by going to the Services in the Control Panel.

-install Use this to install the server as an NT service and mark it as "auto-start. Control the server by going to the Services in the Control Panel.

-remov Use this to remove the server from the NT services (Windows NT/2000/XP only).

-t minutes Idle session timeout, in minutes.

-k size Maximum record size/message size, in kilobytes.

-K Forcing no-keepalive for HTTP sessions. By default GFS will keep sessions alive for HTTP 1.1 sessions (as defined by the standard). Using this option will force GFS to close the connection for each operation.

-r size Maximum size of log file before rotation occurs, in kilobytes. Default size is 1048576 k (=1 GB).

-d daemon Set name of daemon to be used in hosts access file. See hosts_access(5) and tcpd(8).

-m time-format Sets the format of time-stamps in the log-file. Specify a string in the input format to strftime().

-V Display YAZ version and exit.

**TESTING**

yaz-ztest normally returns a random hit count between 0 and 24. However, if a query term includes leading digits, then the integer value of that term is used as hit count. This allows testers to return any number of hits. yaz-ztest includes 24 MARC records for testing. Hit counts exceeding 24 will make yaz-ztest return the same record batch over and over. So record at position 1, 25, 49, etc. are equivalent.

For XML, if no element set is given or element has value "marcxml", MARCXML is returned (each of the 24 dummy records converted from ISO2709 to XML). For element set OP, then OPAC XML is returned.

yaz-ztest may also return predefined XML records (for testing). This is enabled if YAZ_ZTEST_XML_FETCH environment variable is defined. A record is fetched from a file (one record per file). The path for the filename is $FE.d.xml where $F is the YAZ_ZTEST_XML_FETCH value (possibly empty), $E is element-set, $d is record position (starting from 1).

The following databases are honored by yaz-ztest: Default, slow and db.* (all databases with prefix "db"). Any other database will make yaz-ztest return diagnostic 109: "Database unavailable".

---
Options for search may be included in the form or URL get arguments included as part of the Z39.50 database name. The following database options are present: `search-delay`, `present-delay`, `fetch-delay` and `seed`.

The former, delay type options, specify a fake delay (sleep) that `yaz-ztest` will perform when searching, presenting, fetching records respectively. The value of the delay may either be a fixed floating point value which specifies the delay in seconds. Alternatively the value may be given as two floating point numbers separated by colon, which will make `yaz-ztest` perform a random sleep between the first and second number.

The database parameter `seed` takes an integer as value. This will call `srand` with this integer to ensure that the random behavior can be re-played.

Suppose we want searches to take between 0.1 and 0.5 seconds and a fetch to take 0.2 second. To access test database Default we’d use: `Default?search-delay=0.1:0.5&fetch-delay=0.2`.

**GFS Configuration and Virtual Hosts**

The Virtual hosts mechanism allows a YAZ frontend server to support multiple backends. A backend is selected on the basis of the TCP/IP binding (port+listening address) and/or the virtual host.

A backend can be configured to execute in a particular working directory. Or the YAZ frontend may perform CQL to RPN conversion, thus allowing traditional Z39.50 backends to be offered as a SRW/SRU service. SRW/SRU Explain information for a particular backend may also be specified.

For the HTTP protocol, the virtual host is specified in the Host header. For the Z39.50 protocol, the virtual host is specified as in the Initialize Request in the OtherInfo, OID 1.2.840.10003.10.1000.81.1.

**Note**  
Not all Z39.50 clients allow the VHOST information to be set. For those, the selection of the backend must rely on the TCP/IP information alone (port and address).

The YAZ frontend server uses XML to describe the backend configurations. Command-line option `-f` specifies filename of the XML configuration.

The configuration uses the root element `yazgfs`. This element includes a list of `listen` elements, followed by one or more `server` elements.

The `listen` describes listener (transport end point), such as TCP/IP, Unix file socket or SSL server. Content for a listener:

**CDATA (required)** The CDATA for the `listen` element holds the listener string, such as `tcp:@:210`, `tcp:server1:2100`, etc.

**attribute id (optional)** Identifier for this listener. This may be referred to from server sections.

**Note**  
We expect more information to be added for the listen section in a future version, such as CERT file for SSL servers.
The server describes a server and the parameters for this server type. Content for a server:

**attribute id (optional)** Identifier for this server. Currently not used for anything, but it might be for logging purposes.

**attribute listenref (optional)** Specifies one or more listeners for this server. Each server ID is separated by a comma. If this attribute is not given, the server is accessible from all listeners. In order for the server to be used for real, however, the virtual host must match if specified in the configuration.

**element config (optional)** Specifies the server configuration. This is equivalent to the config specified using command line option -c.

**element directory (optional)** Specifies a working directory for this backend server. If specified, the YAZ frontend changes current working directory to this directory whenever a backend of this type is started (backend handler bend_start), stopped (backend handler hand_stop) and initialized (bend_init).

**element host (optional)** Specifies the virtual host for this server. If this is specified a client must specify this host string in order to use this backend.

**element cql2rpn (optional)** Specifies a filename that includes CQL to RPN conversion for this backend server. See Section 7.1.3.4. If given, the backend server will only "see" a Type-1/RPN query.

**element ccl2rpn (optional)** Specifies a filename that includes CCL to RPN conversion for this backend server. See Section 7.1.2.2. If given, the backend server will only "see" a Type-1/RPN query.

**element stylesheet (optional)** Specifies the stylesheet reference to be part of SRU HTTP responses when the client does not specify one. If none is given, then if the client does not specify one, then no stylesheet reference is part of the SRU HTTP response.

**element client_query_charset (optional)** If specified, a conversion from the character set given to UTF-8 is performed by the generic frontend server. It is only executed for Z39.50 search requests (SRU/Solr are assumed to be UTF-8 encoded already).

**element docpath (optional)** Specifies a path for local file access using HTTP. All URLs with a leading prefix (/ excluded) that matches the value of docpath are used for file access. For example, if the server is to offer access in directory xsl, the docpath would be xsl and all URLs of the form http://host/xsl will result in a local file access.

**element explain (optional)** Specifies SRW/SRU ZeeRex content for this server. Copied verbatim to the client. As things are now, some of the Explain content seem redundant because host information, etc. is also stored elsewhere.

**element maximumrecordsize (optional)** Specifies maximum record size/message size, in bytes. This value also serves as the maximum size of incoming packages (for Record Updates etc). It's the same value as that given by the -k option.

**element retrievalinfo (optional)** Enables the retrieval facility to support conversions and specifications of record formats/types. See Section 7.6 for more information.

The XML below configures a server that accepts connections from two ports, TCP/IP port 9900 and a local UNIX file socket. We name the TCP/IP server public and the other server internal.
<yazgfs>
<listen id="public">tcp:@:9900</listen>
<listen id="internal">unix:/var/tmp/socket</listen>
<server id="server1">
  <host>server1.mydomain</host>
  <directory>/var/www/s1</directory>
  <config>config.cfg</config>
</server>
<server id="server2" listenref="public,internal">
  <host>server2.mydomain</host>
  <directory>/var/www/s2</directory>
  <config>config.cfg</config>
  <cql2rpn>../etc/pqf.properties</cql2rpn>
  <explain xmlns="http://explain.z3950.org/dtd/2.0/">
    <serverInfo>
      <host>server2.mydomain</host>
      <port>9900</port>
      <database>a</database>
    </serverInfo>
  </explain>
</server>
<server id="server3" listenref="internal">
  <directory>/var/www/s3</directory>
  <config>config.cfg</config>
</server>
</yazgfs>

There are three configured backend servers. The first two servers, "server1" and "server2", can be reached by both listener addresses. "server1" is reached by all (two) since no listenref attribute is specified. "server2" is reached by the two listeners specified. In order to distinguish between the two, a virtual host has been specified for each server in the host elements.

For "server2" elements for CQL to RPN conversion is supported and explain information has been added (a short one here to keep the example small).

The third server, "server3" can only be reached via listener "internal".

FILES

yaz-<version>/ztest/yaz-ztest.c
yaz-<version>/include/yaz/backend.h

SEE ALSO

yaz(7) yaz-log(7)
11.3 yaz-config

yaz-config — Script to get information about YAZ.

Synopsis


DESCRIPTION

yaz-config is a script that returns information that your own software should use to build software that uses YAZ.

The following libraries are supported:

threads Use the threaded version of YAZ.

OPTIONS

--prefix=DIR Returns prefix of YAZ or assume a different one if DIR is specified.
--version Returns version of YAZ.
--libs Library specification be used when using YAZ.
--lalibs Return library specification.
--cflags Return C Compiler flags.
--include Return C compiler includes for YAZ header files (-Ipath).
--comp Returns full path to YAZ’ ASN.1 compiler: yaz-asncomp.
-V Returns YAZ SHA1 ID (from Git) and version.

FILES

/usr/bin/yaz-config
/usr/lib/libyaz*.a
/usr/include/yaz/*.h

SEE ALSO

yaz(7)
Section "How to make apps using YAZ on UNIX" in the YAZ manual.
11.4 yaz

yaz — Z39.50 toolkit.

DESCRIPTION

YAZ is a C/C++ programmer’s toolkit supporting the development of Z39.50v3 clients and servers. The YAZ toolkit offers several different levels of access to the ISO23950/Z39.50, SRU Solr (client only) and ILL protocols. The level that you need to use depends on your requirements, and the role (server or client) that you want to implement.

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SEE ALSO

yaz-client(1), yaz-ztest(8), yaz-config(8), zoomsh(1) bib1-attr(7)

YAZ manual (/usr/share/doc/yaz)

YAZ home page.
Z39.50 Maintenance Agency Page.
11.5 zoomsh

zoomsh — ZOOM shell

Synopsis

```
zoomsh [-a apdufile] [-e] [-v loglevel] [commands...]
```

DESCRIPTION

`zoomsh` is a ZOOM client with a simple command line interface. The client demonstrates the ZOOM API and is useful for testing targets.

You may pass one or more commands to `zoomsh`. These commands are invoked first.

OPTIONS

- `-a apdufile` Logs protocol packages into apdufile (APDU log).
- `-e` Makes `zoomsh` stop processing commands as soon as an error occur. The exit code of `zoomsh` is 1 if error occurs; 0 otherwise.
- `-v loglevel` Sets YAZ log level to `loglevel`.

EXAMPLES

If you start the `yaz-ztest` in one console you can use the ZOOM shell as follows:

```
$ zoomsh
ZOOM>connect localhost:9999
ZOOM>search computer
localhost:9999: 7 hits
ZOOM>show 0 1
 1 Default USmarc
  001 11224466
  003 DLC
  005 00000000000000.0
  008 910710c19910701nju 00010 eng
  010 $a 11224466
  040 $a DLC $c DLC
  050 00 $a 123-xyz
  100 10 $a Jack Collins
  245 10 $a How to program a computer
  260 1 $a Penguin
  263 $a 8710
  300 $a p. cm.
```
You can also achieve the same result by passing the commands as arguments on a single command line:

```
$ zoomsh "connect localhost:9999" "search computer" "show 0 1" quit
```

**COMMANDS**

`connect zurl` Connects to the target given by `zurl`.

`close [zurl]` Closes connection to target given by `zurl` or all targets if `zurl` was omitted.

`show [start [count]]` Displays `count` records starting at offset given by `start`. First records has offset 0 (unlike the Z39.50 protocol).

`quit` Quits `zoomsh`.

`set name [value]` Sets option `name` to `value`.

`get name` Prints value of option `name`.

`help` Prints list of available commands.

**SEE ALSO**

yaz(7), yaz-ztest(8).

Section "Building clients with ZOOM" in the YAZ manual.

ZOOM home page.

### 11.6 yaz-asncomp

yaz-asncomp — YAZ ASN.1 compiler

**Synopsis**

```
```
DESCRIPTION

yaz-asncomp is an ASN.1 compiler that reads an ASN.1 specification in filename and produces C/C++ definitions and BER encoders/decoders for it.

The produced C/C++ code and header files uses the ODR module of YAZ which is a library that encodes/decodes/prints BER packages. yaz-asncomp allows you to specify name of resulting source via options. Alternatively, you can specify a DEFINITIONS file, which provides customized output to many output files - if the ASN.1 specification file consists of many modules.

This utility is written in Tcl. Any version of Tcl should work.

OPTIONS

-v Makes the ASN.1 compiler print more verbose about the various stages of operations.
-c cfile Specifies the name of the C/C++ file with encoders/decoders.
-h hfile Specifies the name of header file with definitions.
-p pfile Specifies the name of the a private header file with definitions. By default all definitions are put in header file (option -h).
-d dfile Specifies the name of a definitions file.
-I iout Specifies first part of directory in which header files are written.
-i idir Specifies second part of directory in which header files are written.
-m module Specifies that ASN.1 compiler should only process the module given. If this option is not specified, all modules in the ASN.1 file are processed.

DEFINITIONS FILE

The definitions file is really a Tcl script but follows traditional rules for Shell like configuration files. That is # denotes the beginning of a comment. Definitions are line oriented. The definitions files usually consist of a series of variable assignments of the form:

set name value

Available variables are:

default-prefix Sets prefix for names in the produced output. The value consists of three tokens: C function prefix, C typedef prefix and preprocessor prefix respectively.

prefix(module) This value sets prefix values for module module. The value has same form as default-prefix.

c filename(module) Specifies filename for C/header file for module module.

init(module,h) Code fragment to be put in first part of public header for module module.
**body**(module,h) Code fragment to be put in last part of public header for module module (trailer).

**init**(module,c) Code fragment to be put in first part of C based encoder/decoder for module module.

**body**(module,c) Code fragment to be put in last part of C based encoder/decoder for module module (trailer).

**map**(module,name) Maps ASN.1 type in module module of name to value.

**membermap**(module,name,member) Maps member member in SEQUENCE/CHOICE of name in module module to value. The value consists of one or two tokens. First token is name of C preprocessor part. Second token is resulting C member name. If second token is omitted the value (one token) is both preprocessor part and C struct, union.

**unionmap**(module,name,member) Maps member member in CHOICE of name in module module to value. Value consists of two or three tokens. The first token is name of the integer in the union that is used as selector for the union itself. The second token is name of the union. The third token overrides the name of the CHOICE member; if omitted the member name is used.

**FILES**

/usr/share/yaz/z39.50/z.tcl
/usr/share/yaz/z39.50/*.asn

**SEE ALSO**

yaz(7)
Section “The ODR Module” in the YAZ manual.

**11.7 yaz-marcdump**

yaz-marcdump — MARC record dump utility

**Synopsis**


**DESCRIPTION**

yaz-marcdump reads MARC records from one or more files. It parses each record and supports output in line-format, ISO2709, MARCXML, MARC-in-JSON, MarcXchange as well as Hex output. This utility parses records ISO2709(raw MARC), line format, MARC-in-JSON format as well as XML if that is structured as MARCXML/MarcXchange. MARC-in-JSON encoding/decoding is supported in YAZ 5.0.5 and later.
Note
As of YAZ 2.1.18, OAI-MARC is no longer supported. OAI-MARC is deprecated. Use MARCXML instead.

By default, each record is written to standard output in a line format with newline for each field, $x for each subfield x. The output format may be changed with option -o,

`yaz-marcdump` can also be requested to perform character set conversion of each record.

OPTIONS

-`-i format` Specifies input format. Must be one of marcxml, marc (ISO2709), marcxchange (ISO25577), line (line mode MARC), turbomarc (Turbo MARC), or json (MARC-in-JSON).

-`-o format` Specifies output format. Must be one of marcxml, marc (ISO2709), marcxchange (ISO25577), line (line mode MARC), turbomarc (Turbo MARC), or json (MARC-in-JSON).

-`-f from` Specify the character set of the input MARC record. Should be used in conjunction with option -t. Refer to the yaz-iconv man page for supported character sets.

-`-t to` Specify the character set of the output. Should be used in conjunction with option -f. Refer to the yaz-iconv man page for supported character sets.

-`-l leaderspec` Specify a simple modification string for MARC leader. The `leaderspec` is a list of pos=value pairs, where pos is an integer offset (0 - 23) for leader. Value is either a quoted string or an integer (character value in decimal). Pairs are comma separated. For example, to set leader at offset 9 to a, use 9='a'.

-`-s prefix` Writes a chunk of records to a separate file with prefix given, i.e. splits a record batch into files with only at most "chunk" ISO2709 records per file. By default chunk is 1 (one record per file). See option -C.

-`-C chunksize` Specifies chunk size; to be used conjunction with option -s.

-`-p` Makes yaz-marcdump print record number and input file offset of each record read.

-`-n` MARC output is omitted so that MARC input is only checked.

-`-v` Writes more information about the parsing process. Useful if you have ill-formatted ISO2709 records as input.

-`-V` Prints YAZ version.

EXAMPLES

The following command converts MARC21/USMARC in MARC-8 encoding to MARC21/USMARC in UTF-8 encoding. Leader offset 9 is set to ‘a’. Both input and output records are ISO2709 encoded.
The same records may be converted to MARCXML instead in UTF-8:

```
yaz-marcdump -f MARC-8 -t UTF-8 -o marcxml marc21.raw >marcxml.xml
```

Turbo MARC is a compact XML notation with same semantics as MARCXML, but which allows for faster processing via XSLT. In order to generate Turbo MARC records encoded in UTF-8 from MARC21 (ISO), one could use:

```
yaz-marcdump -f MARC8 -t UTF8 -o turbomarc -i marc marc21.raw >out.xml
```

### FILES

```
prefix/bin/yaz-marcdump
prefix/include/yaz/marcdisp.h
```

### SEE ALSO

yaz(7)
yaz-iconv(1)

#### 11.8 yaz-iconv

yaz-iconv — YAZ Character set conversion utility

### Synopsis

```
yaz-iconv [-f from] [-t to] [-v] [file...]
```

### DESCRIPTION

yaz-iconv converts data in the character set specified by `from` to output in the character set as specified by `to`.

This `yaz-iconv` utility is similar to the `iconv` found on many POSIX systems (Glibc, Solaris, etc). If no `file` is specified, `yaz-iconv` reads from standard input.
OPTIONS

-ffrom] Specify the character set from of the input file. Should be used in conjunction with option -t.

-tto] Specify the character set of of the output. Should be used in conjunction with option -f.

-v Print more information about the conversion process.

ENCODINGS

The yaz-iconv command and the API as defined in yaz/yaz-iconv.h is a wrapper for the library system call iconv. But YAZ’ iconv utility also implements conversions on its own. The table below lists characters sets (or encodings) that are supported by YAZ. Each character set is marked with either encode or decode. If an encoding is encode-enabled, YAZ may convert to the designated encoding. If an encoding is decode-enabled, YAZ may convert from the designated encoding.

marc8 (encode, decode) The MARC8 encoding as defined by the Library of Congress. Most MARC21/USMARC records use this encoding.

marc8s (encode, decode) Like MARC8 but conversion prefers non-combined characters in the Latin-1 plane over combined characters.

marc8lossy (encode) Lossy encoding of MARC-8.

marc8lossless (encode) Lossless encoding of MARC8.

utf8 (encode, decode) The most commonly used UNICODE encoding on the Internet.

iso8859-1 (encode, decode) ISO-8859-1, AKA Latin-1.

iso5426 (decode) ISO 5426. Some MARC records (UNIMARC) use this encoding.


advancegreek (encode, decode) An encoding for Greek in use by some vendors (Advance).

danmarc (decode) Danmarc (in danish) is an encoding based on UNICODE which is used for DanMARC2 records.

EXAMPLES

The following command converts from ISO-8859-1 (Latin-1) to UTF-8.

```
yaz-iconv -f ISO-8859-1 -t UTF-8 <input.lst >output.lst
```

FILES

prefix/bin/yaz-iconv
prefix/include/yaz/yaz-iconv.h
SEE ALSO

yaz(7) iconv(1)

11.9  yaz-log

yaz-log — Log handling in all yaz-based programs

Synopsis

yaz-XXXX [-v loglevel,...] [-l logfile]

DESCRIPTION

All YAZ-based programs use a common log subsystem, and should support common command line options for controlling it. This man page documents those.

OPTIONS

-\ l  logfile Specify the file where the log is to be written. If none is specified, stderr is used. The log is appended to this file. If the file grows overly large, it is silently rotated: It is renamed to logfile.1, logfile.2, ..., 9 (old such file is deleted), and a new file is opened. The limit defaults to 1GB, but can be set by the program. The rotating limit can be specified with option -r for the YAZ frontend server (yaz-ztest).

Rotation can also be implicitly enabled by using a filename which gets changed for a given date, due to substitutions as given by the strftime(3) function.

-v  loglevel Specify the logging level. The argument is a set of log level names, separated by commas (no whitespace!), optionally preceded by a '-' to negate that level. Most programs have their own default, often containing fatal, warn, log, and some application-specific values. The default list can be cleared with the word none, or individual bits can be removed by prefixing them with a dash '-' .

LOG LEVELS TO CONTROL LOGGING

Some of the log levels control the way the log is written.

flush causes the log to be flushed after every write. This can have serious implications to performance, and should not be used in production. On the other hand, when debugging a program crash, this can be extremely useful. The option debug implies flush as well.

notime prevents the writing of time stamps. This is intended for automatic test scripts, which should produce predictable log files that are easy to compare.
GENERAL LOG LEVELS IN YAZ ITSELF

YAZ itself uses the following log levels:

fatal for fatal errors, that prevent further execution of the program.

warn for warnings about things that should be corrected.

debug for debugging. This flag may be used temporarily when developing or debugging yaz, or a program that uses yaz. It is practically deprecated, you should be defining and using your own log levels (see below).

all turns on almost all hard-coded log levels.

loglevel logs information about the log levels used by the program. Every time the log level is changed, lists all bits that are on. Every time a module asks for its log bits, this is logged. This can be used for getting an idea of what log levels are available in any program that uses yaz-log. Start the program with -v none,loglevel, and do some common operations with it. Another way is to grep for yaz_log_module_level in the source code, as in

```
find . -name '.*[ch]' -print |
xargs grep yaz_log_module_level |
grep '^
' |
cut -d'' -f2 |
sort -u
```

event1, malloc, nmem, odr are used internally for debugging yaz.

LOG LEVELS FOR CLIENTS

zoom logs the calls to the zoom API, which may be useful in debugging client applications.

LOG LEVELS FOR SERVERS

server logs the server functions on a high level, starting up, listening on a port, etc.

session logs individual sessions (connections).

request logs a one-liner for each request (init, search, etc.).

requestdetail logs the details of every request, before it is passed to the back-end, and the results received from it.

Each server program (zebra, etc.) is supposed to define its own log levels in addition to these. As they depend on the server in question, they can not be described here. See above how to find out about them.

LOGGING EXAMPLES

See what log levels yaz-ztest is using:
yaz-ztest -l -v none,loglevel
14:43:29-23/11 [loglevel] Setting log level to 4096 = 0x00001000
14:43:29-23/11 [loglevel] Static log bit 00000001 'fatal' is off
14:43:29-23/11 [loglevel] Static log bit 00000002 'debug' is off
14:43:29-23/11 [loglevel] Static log bit 00000004 'warn' is off
14:43:29-23/11 [loglevel] Static log bit 00000008 'log' is off
14:43:29-23/11 [loglevel] Static log bit 00000080 'malloc' is off
14:43:29-23/11 [loglevel] Static log bit 00000800 'flush' is off
14:43:29-23/11 [loglevel] Static log bit 00001000 'loglevel' is ON
14:43:29-23/11 [loglevel] Static log bit 00002000 'server' is off
14:43:29-23/11 [loglevel] Dynamic log bit 00004000 'session' is off
14:43:29-23/11 [loglevel] Dynamic log bit 00008000 'request' is off
14:44:13-23/11 yaz-ztest [loglevel] returning log bit 0x4000 for 'session'
14:44:13-23/11 yaz-ztest [loglevel] returning NO log bit for 'event1'
14:44:20-23/11 yaz-ztest [loglevel] returning log bit 0x4000 for 'session'
14:44:20-23/11 yaz-ztest [loglevel] returning log bit 0x8000 for 'request'
14:44:20-23/11 yaz-ztest [loglevel] returning NO log bit for 'odr'
14:44:20-23/11 yaz-ztest [loglevel] returning NO log bit for 'ztst'

See the details of the requests for yaz-ztest
./yaz-ztest -l -v requestdetail
14:45:35-23/11 yaz-ztest [server] Adding static Z3950 listener on tcp:@:9999
14:45:35-23/11 yaz-ztest [server] Starting server ./yaz-ztest pid=32200
14:45:38-23/11 yaz-ztest [session] Starting session from tcp:127.0.0.1 (pid=32200)
14:45:38-23/11 yaz-ztest [requestdetail] Id: 81
14:45:38-23/11 yaz-ztest [requestdetail] Name: YAZ
14:45:38-23/11 yaz-ztest [requestdetail] Version: 2.0.28
14:45:38-23/11 yaz-ztest [requestdetail] Negotiated to v3: srch prst del extendedServices namedresults scan sort
14:45:38-23/11 yaz-ztest [request] Init from 'YAZ' (81) (ver 2.0.28) OK
14:45:39-23/11 yaz-ztest [requestdetail] ResultSet '1'
14:45:39-23/11 yaz-ztest [requestdetail] Database 'Default'
14:45:39-23/11 yaz-ztest [requestdetail] RPN query. Type: Bib-1
14:45:39-23/11 yaz-ztest [requestdetail] term 'foo' (general)
14:45:39-23/11 yaz-ztest [request] Search Z: @attrset Bib-1 foo OK:7 hits
LOG FILENAME EXAMPLES

A file with format my_YYYYMMDD.log (where Y, M, D is year, month, and day digits) is given as follows:
-1 my_%Y%m%d.log. And since the filename is depending on day, rotation will occur on midnight.
A weekly log could be specified as -1 my_%Y%U.log.

FILES

prefix/include/yaz/log.h prefix/src/log.c

SEE ALSO

yaz(7) yaz-ztest(8) yaz-client(1) strftime(3)

11.10 yaz-illclient

yaz-illclient — ILL client

Synopsis

yaz-illclient [-f filename] [-v loglevel] [-D name=value...] [-o] [-u user] [-p password] [-V] [server-addr]

DESCRIPTION

yaz-illclient is a client which sends an ISO ILL request to a remote server and decodes the response from it. Exactly one server address (server-addr) must be specified.

OPTIONS

-f [filename] Specify filename.
-v [loglevel] Specify the log level.
-D [name=value] Defines name & value pair.
Enable OCLC authentication.

Specify user.

Specify password.

Show yaz-illclient version.

EXAMPLES

None yet.

FILES

None yet.

SEE ALSO

yaz(7)

11.11 yaz-icu

yaz-icu — YAZ ICU utility

Synopsis

yaz-icu [-c config] [-p opt] [-x] [-s] [infile]

DESCRIPTION

yaz-icu is a utility which demonstrates the ICU chain module of yaz. (yaz/icu.h).

The utility can be used in two ways. It may read some text using an XML configuration for configuring ICU and show text analysis. This mode is triggered by option -c which specifies the configuration to be used. The input file is read from standard input or from a file if infile is specified.

The utility may also show ICU information. This is triggered by option -p.
OPTIONS

-c config  Specifies the file containing ICU chain configuration which is XML based.

-p type  Specifies extra information to be printed about the ICU system. If type is c then ICU converters are printed. If type is l, then available locales are printed. If type is t, then available transliterators are printed.

-s  Specifies that output should include sort key as well. Note that sort key differs between ICU versions.

-x  Specifies that output should be XML based rather than "text" based.

ICU chain configuration

The ICU chain configuration specifies one or more rules to convert text data into tokens. The configuration format is XML based.

The toplevel element must be named icu_chain. The icu_chain element has one required attribute locale which specifies the ICU locale to be used in the conversion steps.

The icu_chain element must include elements where each element specifies a conversion step. The conversion is performed in the order in which the conversion steps are specified. Each conversion element takes one attribute: rule which serves as argument to the conversion step.

The following conversion elements are available:

casemap  Converts case (and rule specifies how):

  l  Lower case using ICU function u_strToLower.
  u  Upper case using ICU function u_strToUpper.
  t  To title using ICU function u_strToTitle.
  f  Fold case using ICU function u_strFoldCase.

display  This is a meta step which specifies that a term/token is to be displayed. This term is retrieved in an application using function icu_chain_token_display (yaz/icu.h).

transform  Specifies an ICU transform rule using a transliterator Identifier. The rule attribute is the transliterator Identifier. See ICU Transforms for more information.

transliterate  Specifies a rule-based transliterator. The rule attribute is the custom transformation rule to be used. See ICU Transforms for more information.

tokenize  Breaks / tokenizes a string into components using ICU functions ubrk_open, ubrk_setText, .. . The rule is one of:

  l  Line. ICU: UBRK_LINE.
  s  Sentence. ICU: UBRK_SENTENCE.
  w  Word. ICU: UBRK_WORD.
join  Joins tokens into one string. The rule attribute is the joining string, which may be empty. The join conversion element was added in YAZ 4.2.49.

EXAMPLES

The following command analyzes text in file text using ICU chain configuration chain.xml:

```
cat text | yaz-icu -c chain.xml
```

The chain.xml might look as follows:

```xml
<icu_chain locale="en">
  <transform rule="[:Control:] Any-Remove"/>
  <tokenize rule="w"/>
  <transform rule="[:WhiteSpace:] [:Punctuation:]" Remove"/>
  <transliterate rule="xy > z;"/>
  <display/>
  <casemap rule="l"/>
</icu_chain>
```

SEE ALSO

yaz(7)
ICU Home
ICU Transforms

11.12 yaz-url

yaz-url — YAZ URL fetch utility

Synopsis

```
```

DESCRIPTION

yaz-url is utility to get web content. It is very limited in functionality compared to programs such as curl, wget.

The options must precede the URL given on the command line, to take effect.

Fetch HTTP content is written to stdout, unless option -O is given.
OPTIONS

-H name:value Specifies HTTP header content with name and value. This option can be given multiple
times (for different names, of course).

-m method Specifies the HTTP method to be used for the next URL. Default is method "GET". However,
option -p sets it to "POST".

-O fname Sets output filename for HTTP content.

-p fname Sets a file to be POSTed in the following URL.

-R num Sets maximum number of HTTP redirects to be followed. A value of zero disables follow of HTTP redirects.

-u user/password Specifies a user and a password to be used in HTTP basic authentication in the fol-
lowing URL fetch. The user and password must be separated by a slash (thus it is not possible to
specify a user with a slash in it).

-v Makes yaz-url dump each HTTP request/response to stdout.

-x proxy Specifies a proxy to be used for URL fetch.

SEE ALSO

yaz(7)

11.13 Bib-1 Attribute Set

bib1-attr — Bib-1 Attribute Set

DESCRIPTION

This reference entry lists the Bib-1 attribute set types and values.

TYPES

The Bib-1 attribute set defines six attribute types: Use (1), Relation (2), Position (3), Structure (4), Trunca-
tion (5) and Completeness (6).
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Personal-name</td>
</tr>
<tr>
<td>2</td>
<td>Corporate-name</td>
</tr>
<tr>
<td>3</td>
<td>Conference-name</td>
</tr>
<tr>
<td>4</td>
<td>Title</td>
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<td>Title-series</td>
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</tr>
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<td>BNB-card-number</td>
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<td>BGF-number</td>
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</tr>
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<td>14</td>
<td>UDC-classification</td>
</tr>
<tr>
<td>15</td>
<td>Bliss-classification</td>
</tr>
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<td>NLM-call-number</td>
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</tr>
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<td>MESH-subject</td>
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<td>26</td>
<td>PA-subject</td>
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<td>27</td>
<td>LC-subject-heading</td>
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<td>28</td>
<td>RVM-subject-heading</td>
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<td>Subject-subdivision</td>
</tr>
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<td>Number-natl-biblio</td>
</tr>
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</table>
49  Number-legal-deposit
50  Number-govt-pub
51  Number-music-publisher
52  Number-db
53  Number-local-call
54  Code-language
55  Code-geographic
56  Code-institution
57  Name-and-title
58  Name-geographic
59  Place-publication
60  CODEN
61  Microform-generation
62  Abstract
63  Note
1000 Author-title
1001 Record-type
1002 Name
1003 Author
1004 Author-name-personal
1005 Author-name-corporate
1006 Author-name-conference
1007 Identifier-standard
1008 Subject-LC-childrens
1009 Subject-name-personal
1010 Body-of-text
1011 Date/time-added-to-db
1012 Date/time-last-modified
1013 Authority/format-id
1014 Concept-text
1015 Concept-reference
1016 Any
1017 Server-choice
1018 Publisher
1019 Record-source
1020 Editor
1021 Bib-level
1022 Geographic-class
1023 Indexed-by
1024 Map-scale
1025 Music-key
1026 Related-periodical
1027 Report-number
1028 Stock-number
1030 Thematic-number
1031 Material-type
1032 Doc-id
1033 Host-item
1034 Content-type
1035 Anywhere
**RELATION (2)**

1. Less than
2. Less than or equal
3. Equal
4. Greater or equal
5. Greater than
6. Not equal
100. Phonetic
101. Stem
102. Relevance
103. AlwaysMatches

**POSITION (3)**

1. First in field
2. First in subfield
3. Any position in field

**STRUCTURE (4)**

1. Phrase
2. Word
3. Key
4. Year
5. Date (normalized)
6. Word list
100. Date (un-normalized)
101. Name (normalized)
102. Name (un-normalized)
103. Structure
104. Urx
105. Free-form-text
106. Document-text
107. Local-number
108. String
109. Numeric-string

**TRUNCATION (5)**
1 Right truncation
2 Left truncation
3 Left and right truncation
100 Do not truncate
101 Process # in search term . regular #=.*
102 RegExpr-1
103 RegExpr-2
104 Process # ?n . regular: #=., ?n={0,n} or ?=.* Z39.58

Thw 105-106 truncation attributes below are only supported by Index Data’s Zebra server.

105 Process * ! regular: *=.*, !=. and right truncate

COMPLETENESS (6)

1 Incomplete subfield
2 Complete subfield
3 Complete field

SORTING (7)

1 ascending
2 descending

Type 7 is an Index Data extension to RPN queries that allows embedding a sort critieria into a query.

SEE ALSO

Bib-1 Attribute Set
Attribute Set Bib-1 Semantics.

11.14 yaz-json-parse

yaz-json-parse — YAZ JSON parser

Synopsis

yaz-json-parse [-p]
DESCRIPTION

yaz-json-parse is a utility which demonstrates the JSON API of YAZ. (yaz/json.h).

The program attempts to parse a JSON from standard input (stdin). It will return exit code 1 if parsing fails and the parsing error message will be printed to standard error (stderr). The program returns exit code 0 if parsing succeeds, and returns no output unless -p is given (see below).

OPTIONS

-p Makes the JSON parser echo the JSON result string to standard output, if parsing from stdin was successful. If -p is given twice, then the output is a multi-line output with indentation (pretty print).

SEE ALSO

yaz(7)

11.15 yaz-record-iconv

DESCRiPTION

yaz-record-conv — YAZ Record Conversion Utility

Synopsis

yaz-record-conv [-v loglevel] [config] [fname...]

OPTIONS

-v level Sets the LOG level to level. Level is a sequence of tokens separated by comma. Each token is a integer or a named LOG item - one of fatal, debug, warn, log, malloc, all, none.

EXAMPLES

The following backend configuration converts MARC records (ISO2709) to Dublin-Core XML.
We can convert one of the sample records from YAZ’ test directory with:

```
$ ../util/yaz-record-conv record-conv-conf.xml marc6.marc

<?xml version="1.0" encoding="UTF-8"?>
  <dc:title>How to program a computer</dc:title>
  <dc:creator>Jack Collins</dc:creator>
  <dc:type>text</dc:type>
  <dc:publisher>Penguin</dc:publisher>
  <dc:language>eng</dc:language>
</dc:dc>
```

**FILES**

record_conv.h

**SEE ALSO**

yaz(7)
## Appendix A

### List of Object Identifiers

These is a list of object identifiers that are built into YAZ.

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<th>Class</th>
<th>Constant / OID</th>
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| UNIverse-Resource-Report      | RESFORM  | yaz_oid_resform_universe_resource_report  
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| exp. inv.                     | EXTSERV  | yaz_oid_extserv_exp_inv_  
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| Admin                         | EXTSERV  | yaz_oid_extserv_admin  
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Appendix B

Bib-1 diagnostics

List of Bib-1 diagnostics that are known to YAZ.

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<thead>
<tr>
<th>Code</th>
<th>Text</th>
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<tbody>
<tr>
<td>1</td>
<td>Permanent system error</td>
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<tr>
<td>2</td>
<td>Temporary system error</td>
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<tr>
<td>3</td>
<td>Unsupported search</td>
</tr>
<tr>
<td>4</td>
<td>Terms only exclusion (stop) words</td>
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<tr>
<td>5</td>
<td>Too many argument words</td>
</tr>
<tr>
<td>6</td>
<td>Too many boolean operators</td>
</tr>
<tr>
<td>7</td>
<td>Too many truncated words</td>
</tr>
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<td>8</td>
<td>Too many incomplete subfields</td>
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<tr>
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<td>Truncated words too short</td>
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<td>10</td>
<td>Invalid format for record number (search term)</td>
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<td>11</td>
<td>Too many characters in search statement</td>
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<td>12</td>
<td>Too many records retrieved</td>
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<td>13</td>
<td>Present request out of range</td>
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<td>14</td>
<td>System error in presenting records</td>
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<td>15</td>
<td>Record no authorized to be sent intersystem</td>
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<td>16</td>
<td>Record exceeds Preferred-message-size</td>
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<td>Record exceeds Maximum-record-size</td>
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<td>18</td>
<td>Result set not supported as a search term</td>
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<td>Only single result set as search term supported</td>
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<td>Only ANDing of a single result set as search term supported</td>
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<td>Result set exists and replace indicator off</td>
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<td>Result set naming not supported</td>
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<td>23</td>
<td>Combination of specified databases not supported</td>
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<td>24</td>
<td>Element set names not supported</td>
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<td>25</td>
<td>Specified element set name not valid for specified database</td>
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<td>26</td>
<td>Only a single element set name supported</td>
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<td>Result set no longer exists - unilaterally deleted by target</td>
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<td>Result set is in use</td>
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<td>One of the specified databases is locked</td>
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<td>Specified result set does not exist</td>
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<td>------</td>
<td>----------------------------------------------------------------------</td>
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<tr>
<td>31</td>
<td>Resources exhausted - no results available</td>
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<td>32</td>
<td>Resources exhausted - unpredictable partial results available</td>
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<td>33</td>
<td>Resources exhausted - valid subset of results available</td>
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<td>Security challenge required but could not be issued - record not included</td>
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<td>Security challenge failed - record not included</td>
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<td>Init/AC: Incorrect interface type (specified id valid only when used with a particular access method or client)</td>
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<td>Init/AC: System temporarily out of resources</td>
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<td>1019</td>
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<td>Init/AC: System temporarily unavailable (Addinfo: when it’s expected back up)</td>
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<td>Init/AC: Account has expired</td>
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<td>Init/AC: Password has expired so a new one must be supplied</td>
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<td>Init/AC: Password has been changed by an administrator so a new one must be supplied</td>
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<td>Duplicate Detection: Cannot dedup on requested record portion</td>
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<td>Duplicate Detection: Requested regular expression not supported</td>
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<td>Duplicate Detection: Retention criterion not supported</td>
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<td>Duplicate Detection: Requested number (or percentage) of entries</td>
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<td>Duplicate Detection: Requested sort criterion not supported</td>
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<td>CompSpec: Unknown schema, or schema not supported.</td>
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<td>Encapsulation: Encapsulated sequence of PDUs not supported</td>
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<td>1068</td>
<td>Encapsulation: Base operation (and encapsulated PDUs) not executed based on pre-screening analysis</td>
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<td>No syntaxes available for this request</td>
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<td>1070</td>
<td>user not authorized to receive record(s) in requested syntax</td>
</tr>
<tr>
<td>1071</td>
<td>preferredRecordSyntax not supplied</td>
</tr>
<tr>
<td>1072</td>
<td>Query term includes characters that do not translate into the target character set</td>
</tr>
<tr>
<td>1073</td>
<td>Database records do not contain data associated with access point</td>
</tr>
<tr>
<td>1074</td>
<td>Proxy failure</td>
</tr>
</tbody>
</table>
## Appendix C

### SRU diagnostics

List of SRU diagnostics that are known to YAZ.

<table>
<thead>
<tr>
<th>Code</th>
<th>Text</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Permanent system error</td>
</tr>
<tr>
<td>2</td>
<td>System temporarily unavailable</td>
</tr>
<tr>
<td>3</td>
<td>Authentication error</td>
</tr>
<tr>
<td>4</td>
<td>Unsupported operation</td>
</tr>
<tr>
<td>5</td>
<td>Unsupported version</td>
</tr>
<tr>
<td>6</td>
<td>Unsupported parameter value</td>
</tr>
<tr>
<td>7</td>
<td>Mandatory parameter not supplied</td>
</tr>
<tr>
<td>8</td>
<td>Unsupported parameter</td>
</tr>
<tr>
<td>10</td>
<td>Query syntax error</td>
</tr>
<tr>
<td>11</td>
<td>Unsupported query type</td>
</tr>
<tr>
<td>12</td>
<td>Too many characters in query</td>
</tr>
<tr>
<td>13</td>
<td>Invalid or unsupported use of parentheses</td>
</tr>
<tr>
<td>14</td>
<td>Invalid or unsupported use of quotes</td>
</tr>
<tr>
<td>15</td>
<td>Unsupported context set</td>
</tr>
<tr>
<td>16</td>
<td>Unsupported index</td>
</tr>
<tr>
<td>17</td>
<td>Unsupported combination of index and context set</td>
</tr>
<tr>
<td>18</td>
<td>Unsupported combination of indexes</td>
</tr>
<tr>
<td>19</td>
<td>Unsupported relation</td>
</tr>
<tr>
<td>20</td>
<td>Unsupported relation modifier</td>
</tr>
<tr>
<td>21</td>
<td>Unsupported combination of relation modifiers</td>
</tr>
<tr>
<td>22</td>
<td>Unsupported combination of relation and index</td>
</tr>
<tr>
<td>23</td>
<td>Too many characters in term</td>
</tr>
<tr>
<td>24</td>
<td>Unsupported combination of relation and term</td>
</tr>
<tr>
<td>25</td>
<td>Special characters not quoted in term</td>
</tr>
<tr>
<td>26</td>
<td>Non special character escaped in term</td>
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<tr>
<td>27</td>
<td>Empty term unsupported</td>
</tr>
<tr>
<td>28</td>
<td>Masking character not supported</td>
</tr>
<tr>
<td>29</td>
<td>Masked words too short</td>
</tr>
<tr>
<td>30</td>
<td>Too many masking characters in term</td>
</tr>
<tr>
<td>31</td>
<td>Anchoring character not supported</td>
</tr>
<tr>
<td>Code</td>
<td>Text</td>
</tr>
<tr>
<td>------</td>
<td>---------------------------------------------------------------------</td>
</tr>
<tr>
<td>32</td>
<td>Anchoring character in unsupported position</td>
</tr>
<tr>
<td>33</td>
<td>Combination of proximity/adjacency and masking characters not supported</td>
</tr>
<tr>
<td>34</td>
<td>Combination of proximity/adjacency and anchoring characters not supported</td>
</tr>
<tr>
<td>35</td>
<td>Term contains only stopwords</td>
</tr>
<tr>
<td>36</td>
<td>Term in invalid format for index or relation</td>
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<tr>
<td>37</td>
<td>Unsupported boolean operator</td>
</tr>
<tr>
<td>38</td>
<td>Too many boolean operators in query</td>
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<td>39</td>
<td>Proximity not supported</td>
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<td>40</td>
<td>Unsupported proximity relation</td>
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<td>41</td>
<td>Unsupported proximity distance</td>
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<tr>
<td>42</td>
<td>Unsupported proximity unit</td>
</tr>
<tr>
<td>43</td>
<td>Unsupported proximity ordering</td>
</tr>
<tr>
<td>44</td>
<td>Unsupported combination of proximity modifiers</td>
</tr>
<tr>
<td>45</td>
<td>Prefix assigned to multiple identifiers</td>
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<tr>
<td>46</td>
<td>Unsupported boolean modifier</td>
</tr>
<tr>
<td>47</td>
<td>Cannot process query; reason unknown</td>
</tr>
<tr>
<td>48</td>
<td>Query feature unsupported</td>
</tr>
<tr>
<td>49</td>
<td>Masking character in unsupported position</td>
</tr>
<tr>
<td>50</td>
<td>Result sets not supported</td>
</tr>
<tr>
<td>51</td>
<td>Result set does not exist</td>
</tr>
<tr>
<td>52</td>
<td>Result set temporarily unavailable</td>
</tr>
<tr>
<td>53</td>
<td>Result sets only supported for retrieval</td>
</tr>
<tr>
<td>54</td>
<td>Retrieval may only occur from an existing result set</td>
</tr>
<tr>
<td>55</td>
<td>Combination of result sets with search terms not supported</td>
</tr>
<tr>
<td>56</td>
<td>Only combination of single result set with search terms supported</td>
</tr>
<tr>
<td>57</td>
<td>Result set created but no records available</td>
</tr>
<tr>
<td>58</td>
<td>Result set created with unpredictable partial results available</td>
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<tr>
<td>59</td>
<td>Result set created with valid partial results available</td>
</tr>
<tr>
<td>60</td>
<td>Result set not created: too many matching records</td>
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<tr>
<td>61</td>
<td>First record position out of range</td>
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<tr>
<td>62</td>
<td>Negative number of records requested</td>
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<tr>
<td>63</td>
<td>System error in retrieving records</td>
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<td>64</td>
<td>Record temporarily unavailable</td>
</tr>
<tr>
<td>65</td>
<td>Record does not exist</td>
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<tr>
<td>66</td>
<td>Unknown schema for retrieval</td>
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<td>67</td>
<td>Record not available in this schema</td>
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<tr>
<td>68</td>
<td>Not authorised to send record</td>
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<tr>
<td>69</td>
<td>Not authorised to send record in this schema</td>
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<tr>
<td>70</td>
<td>Record too large to send</td>
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<tr>
<td>71</td>
<td>Unsupported record packing</td>
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<td>72</td>
<td>XPath retrieval unsupported</td>
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<tr>
<td>73</td>
<td>XPath expression contains unsupported feature</td>
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<td>74</td>
<td>Unable to evaluate XPath expression</td>
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<td>Sort not supported</td>
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<td>81</td>
<td>Unsupported sort type</td>
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<tr>
<td>82</td>
<td>Unsupported sort sequence</td>
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<tr>
<td>Code</td>
<td>Text</td>
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<tr>
<td>------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>83</td>
<td>Too many records to sort</td>
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<tr>
<td>84</td>
<td>Too many sort keys to sort</td>
</tr>
<tr>
<td>85</td>
<td>Duplicate sort keys</td>
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<tr>
<td>86</td>
<td>Cannot sort: incompatible record formats</td>
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<td>Unsupported schema for sort</td>
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<td>Unsupported path for sort</td>
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<td>Path unsupported for schema</td>
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<td>Unsupported direction value</td>
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<td>Unsupported case value</td>
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<td>92</td>
<td>Unsupported missing value action</td>
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<td>93</td>
<td>Sort ended due to missing value</td>
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<td>100</td>
<td>Explain not supported</td>
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<td>101</td>
<td>Explain request type not supported (SOAP vs GET)</td>
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<td>102</td>
<td>Explain record temporarily unavailable</td>
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<td>Stylesheets not supported</td>
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<td>Unsupported stylesheet</td>
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<td>120</td>
<td>Response position out of range</td>
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<td>121</td>
<td>Too many terms requested</td>
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<tr>
<td>235</td>
<td>Database does not exist</td>
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<tr>
<td>236</td>
<td>Access to specified database denied</td>
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<tr>
<td>1015</td>
<td>Init/AC: Maximum number of simultaneous sessions for Userid</td>
</tr>
<tr>
<td>1074</td>
<td>Proxy failure</td>
</tr>
</tbody>
</table>
Appendix D

License

D.1 Index Data Copyright

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Appendix E

About Index Data

Index Data is a consulting and software-development enterprise that specializes in library and information management systems. Our interests and expertise span a broad range of related fields, and one of our primary, long-term objectives is the development of a powerful information management system with open network interfaces and hyper-media capabilities.

We make this software available free of charge, on a fairly unrestricted license; as a service to the networking community, and to further the development of quality software for open network communication.

We’ll be happy to answer questions about the software, and about ourselves in general.

The Hacker’s Jargon File has the following to say about the use of the prefix "YA" in the name of a software product.

[?, ?]
Appendix F

Credits

This appendix lists individuals that have contributed in the development of YAZ. Some have contributed with code, while others have provided bug fixes or suggestions. If we’re missing somebody, or if you, for whatever reason, don’t like to be listed here, let us know.

• Gary Anderson
• Dimitrios Andreadis
• Morten Bøgeskov
• Rocco Carbone
• Matthew Carey
• Hans van Dalen
• Irina Dijour
• Larry E. Dixson
• Hans van den Dool
• Mads Bondo Dydensborg
• Franck Falcoz
• Kevin Gamiel
• Morten Garkier Hendriksen
• Morten Holmqvist
• Ian Ibbotson
• Shigeru Ishida
• Heiko Jansen
• David Johnson
• Oleg Kolobov
• Giannis Kosmas
• Kang-Jin Lee
• Pieter Van Lierop
• Stefan Lohrum
• Ronald van der Meer
• Thomas W. Place
• Peter Popovics
• Jacob Chr. Poulsen
• Ko van der Sloot
• Mike Taylor
• Rustam T. Usmanov
• Charles Woodfield
• Tom André Øverland