ASN2TXT v2.3

User's Manual

Objective Systems, Inc. — February 2013

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Revision History

- August 2012 — Initial release of ASN2TXT documentation (version 2.3.0)
- September 2012 — Updates for command-line options (version 2.3.0)
- February 2013 — Document conversion in response to notes that the PDFs were corrupted on some systems (version 2.3.0).

Overview of ASN2TXT

ASN2TXT is a command-line tool that translates ASN.1 data encoded in the Basic, Canonical, Distinguished, or Packed encoding rules into various text formats suitable for ingestion into spreadsheets, databases, or other text processing tools. At the time of initial release, ASN2TXT supports converting ASN.1 data to XML and comma-separated value (CSV) data formats.

Conversions to XML support both an Objective Systems custom format as well as the XML Encoding Rules standard as described in ITU-T standard X.693. Conversions from all ASN.1 binary encodings (BER, CER, DER, PER) are supported by ASN2TXT.

Conversions to CSV are done by a custom transformation, since no standard for converting ASN.1-encoded data to CSV exists. Conversions from BER, CER, and DER are supported at the time of this release; PER is not supported.

Using ASN2TXT

Installation

ASN2TXT comes packaged as an executable installation program for Windows or a `.tar.gz` archive for UNIX systems. The package is comprised of the following directory tree:

```
asn2txt_v23x
|
+-asn1specs
|
+-bin
|
+-doc
|
+-sample
|
+-sample_per
```

The `bin` subdirectory contains the `asn2txt` executable. The `asn1specs` directory contains specifications used by the sample programs in the `sample` directory. This document is found in the `doc` directory.

Installing on a Windows System

To install ASN2TXT on a Windows system, simply double-click the executable installer program. Selecting the default installation options will install ASN2TXT in `c:\asn2txt_v23x`.

Installing on a UNIX System

To install ASN2TXT on a UNIX system, simply unzip and untar the `.tar.gz` archive. The program may be unpacked in any directory in which the user has permissions. No installation program is available to install ASN2TXT to `/usr/local` or other common installation paths, but it is not difficult to manually add links if needed.

Command-line Options

Invoking `asn2txt` without any options will show a usage message that contains the command-line options:

```
ASN2TXT, version 2.3.x
ASN.1 to text formatter
Copyright (c) 2012 Objective Systems, Inc.  All Rights Reserved.

Usage: asn2txt <input files> options

  <input files>          ASN.1 message file name (wildcards are okay)

  options:
    -xml                   Output to XML
    -csv                   Output to CSV

  Common options:
    -schema <filename>     ASN.1 definition file name(s)
    -I <directory>         Import ASN.1 files from <directory>
    -ber                   Use basic encoding rules (BER)
    -pdu <typename>        Message PDU type name
    -bcdhandling <default|none|bcd|tbcd>
                           Define handling of OCTET STRINGs declared to be
                             binary coded decimal (BCD) strings
    -noopentype            Disable automatic open type decoding
    -paddingbyte <hexbyte> Additional padding byte
    -bitsfmt <hex|bin>     BIT STRING content output format
    -inputFileType <binary|hextext|base64>
                           Format of data in input file
    -skip <num>            Skip <num> bytes between messages
    -headerOffset <num>    Skip the first <num> bytes in a data file
    -lickey <key>          License key to activate

  XML options:
    -per                  Use aligned packed encoding rules (PER)
    -uper                 Use unaligned packed encoding rules (U-PER)
    -xer                  Output XML in ASN.1 XER format
```

```
    -o <filename>          Output XML filename (use "<base>.xml" for batch output)
    -ascii                 Print out ASCII for printable hex values
    -emptyoptionals        Insert empty XML elements in place of
                             missing optional elements
    -emptydefault          Insert XML elements with default values in place
                             of missing elements with default values
    -nowhitespace          Remove all whitespace between elements
    -rootElement <element> Root Element Name

  CSV options:
    -s <separator>         Field separator
    -minLevel <num>        Set the minimum output depth
    -maxLevel <num>        Set the maximum output depth
    -outdir <directory>    Specify the output directory
    -noquotes              Do not quote strings in output file
    -padFields             Pad fields with data that would otherwise be empty
    -prefix                Prefix output filenames with input filenames
    -q                     Turn off all output except errors
```

The following sections summarize the command-line options.

Common Options

The following options are common to both CSV and XML transformations.

Option	Arguments	Description
-csv		Selects CSV output.
-xml		Selects XML output.
<filename>		<filename> is the name of the input message to decode. This element is *required*. The use of wildcards (*e.g.* * and ?) is supported.
-schema	<filename>	This option is *required* when using CSV or decoding PER data. When converting BER data to XML, a schema is not required; ASN2TXT will convert the data using tag names.
-bitsfmt	<hex | bin>	-bitsfmt may be used to specify how BIT STRING items are formatted. By default they are expressed as hexadecimal strings; use bin to express them as binary strings instead.

Option	Arguments	Description
-inputFileType	<binary | hextext | base64>	-inputFileType may be used to tell ASN2TXT how the input data are formatted. By default ASN2TXT will assume that the input data are binary, but it can also decode hexadecimal or base64 encoded data. Whitespace in the input is ignored when hextext is specified.
-lickey	<key>	In Linux, Macintosh, and Windows systems, license checking is performed by the Reprise License Manager. This option permits command-line license activation. This option is compiled out for operating systems that do not support the RLM license.
-noopentype		This option disables the conversion of open types in the output. This is the default behavior when converting BER to CSV.
-paddingbyte	<hexbyte>	<hexbyte> is the hexadecimal value of a padding byte that may appear in the input message. Call data records (CDRs) are commonly continuously dumped to files by telephony equipment. If no information is available, the records are often padded by 0x00 or 0xFF bytes. The default padding byte is 0x00. <hexbyte> may be formatted with or without a 0x prefix.
-pdu	<typename>	<typename> is the name of the PDU data type to be decoded. This option is necessary when the top-level data type is ambiguous. It is also required when converting PER data.

XML Options

The following options can be used when converting to XML.

Option	Arguments	Description
-ber		Selects the use of Basic Encoding Rules for decoding.
-per		Selects the use of the Packed Encoding Rules (aligned) for decoding.
-uper		Selects the use of the Packed Encoding Rules (unaligned) for decoding.
-ascii		Scan data in untyped fields and if all bytes contain values within the ASCII character range,

Option	Arguments	Description
		display as standard text. Otherwise display as formatted hexadecimal text. Note that this option only has meaning if BER/DER/CER data is being decoded and no schema file is specified.
-emptyDefault		Insert an element with a default value as specified in the schema at the location of a missing element in the instance.
-emptyOptionals		Insert an empty element at the location of a missing element in the schema that was declared to be optional.
-nowhitespace		Do not generate any whitespace (blanks and newline characters) between elements. This makes the generated XML document more compact at the expense of readability.
-o	<filename>	Specify the output XML <filename> instead of writing output to standard out. Set <filename> to "<base>.xml" to specify batch output when converting multiple files.
-rootElement	<name>	Specify the root element <name> used to wrap the entire XML message at the outer level. This makes it possible to create an XML document for an ASN.1 file containing multiple individually encoded binary messages (a common feature of many Call Detail Record ASN.1 formats).

CSV Options

The following options can be used when converting to CSV.

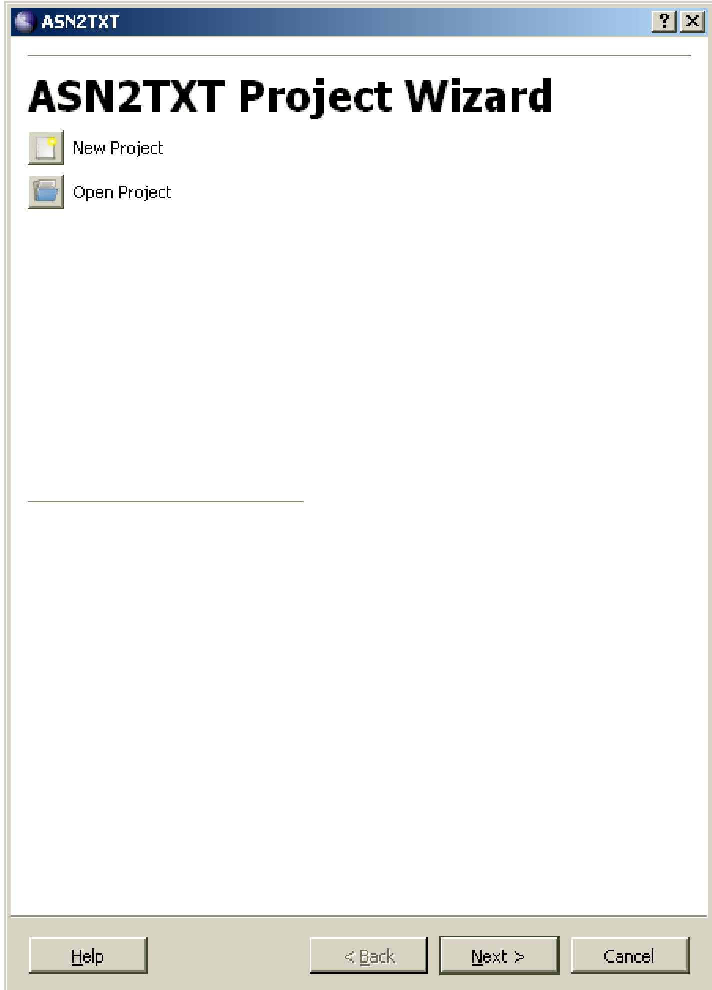
Option	Arguments	Description
-maxLevel	<level>	By default, all entries in the input file will be dumped to the output file. Deeply nested types may result in excessive output, however. The -maxLevel switch causes ASN2TXT to skip outputting data after <level> levels have been processed.
-minLevel	<level>	Similar to the -maxLevel option, the-minLevel option will cause ASN2TXT to skip outputting top-level data types <level> levels deep.
-noquotes		By default, ASN2TXT will quote all of the fields to ensure that they are processed as text by

Option	Arguments	Description
		spreadsheet programs to avoid converting numeric fields into scientific notation. Using this option suppresses that behavior.
-padfields		ASN2TXT will omit fields that would normally be duplicated in output files. Using this option will output these fields. It produces larger files, but is more explicit and may simplify ingesting the data.
-prefix		ASN2TXT will normally output all records to a predetermined filename based on the module name and PDU. When the -prefix option is selected, the output filenames will be prefixed with the input message filename.
-q		This option causes ASN2TXT to operate in a "quiet" mode more suitable for batch processing. Informational messages are limited and only error output will be reported.
-s	<separator>	By default, ASN2TXT assumes the record separator will be a comma. When this conflicts with output data (e.g., a field may consist of City, State), users may use the -s switch to specify a different separator such as a tab or a pipe. Enclosing the separator in quotation marks is necessary when using a tab or other whitespace character.

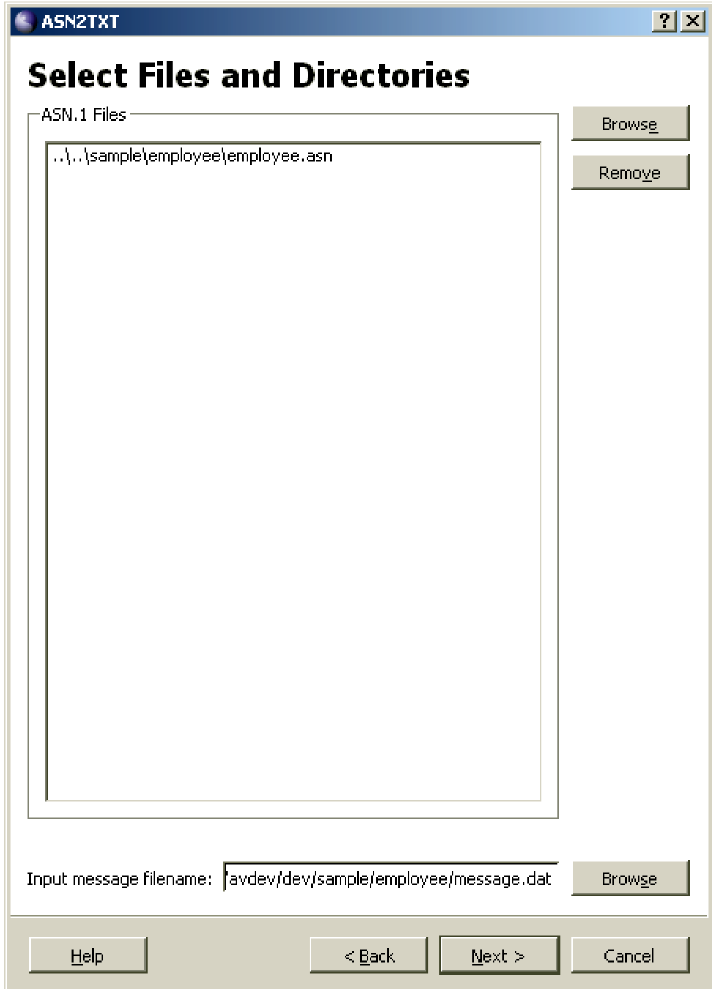
Using the GUI

ASN2TXT for Windows is provided with a graphical user interface that can be used to invoke the command-line tool from a windowed environment. The GUI supports a project file format so that commonly used specifications and messages can be transformed to XML or CSV as needed.

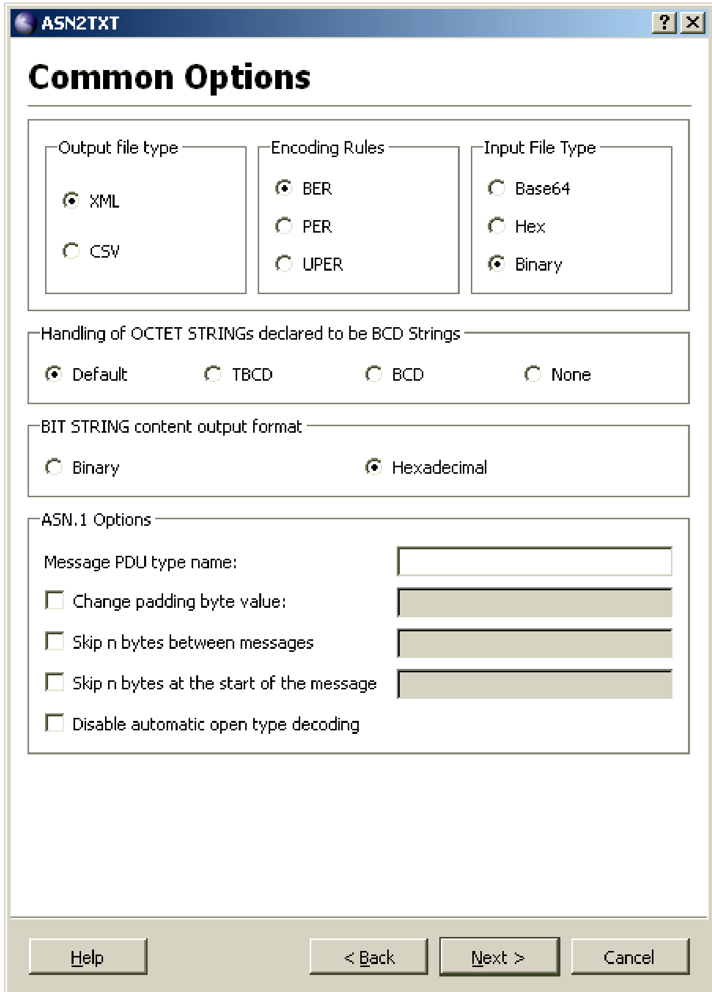
The opening screen follows:



The initial screen contains options for users who wish to open or create a new project, but this is not necessary to use the software. The next screen is used to select the input specifications and message data used for decoding.

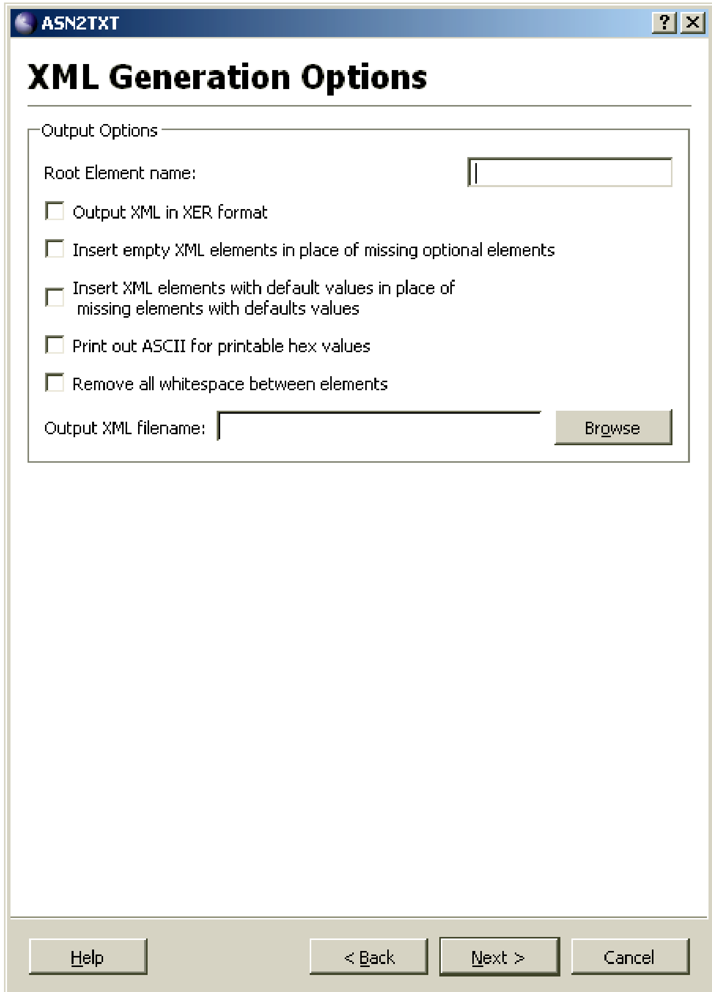


The next button in the file selection window will not activate until both the input message and input specification have been provided. After this is done, the following common options can be set:



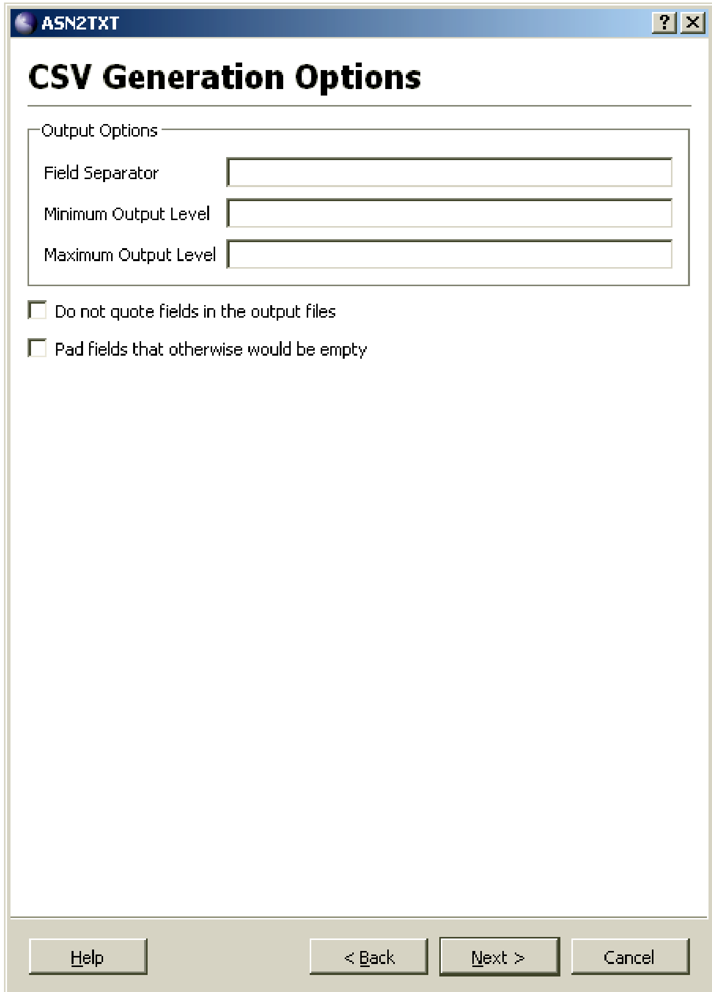
The options are described in detail in the User's Guide. When selecting CSV output, the GUI will automatically disable the PER input options and open type decoding. Conversions to CSV do not support either PER or open type decoding at this time.

If XML is the selected output format, the following screen will appear:



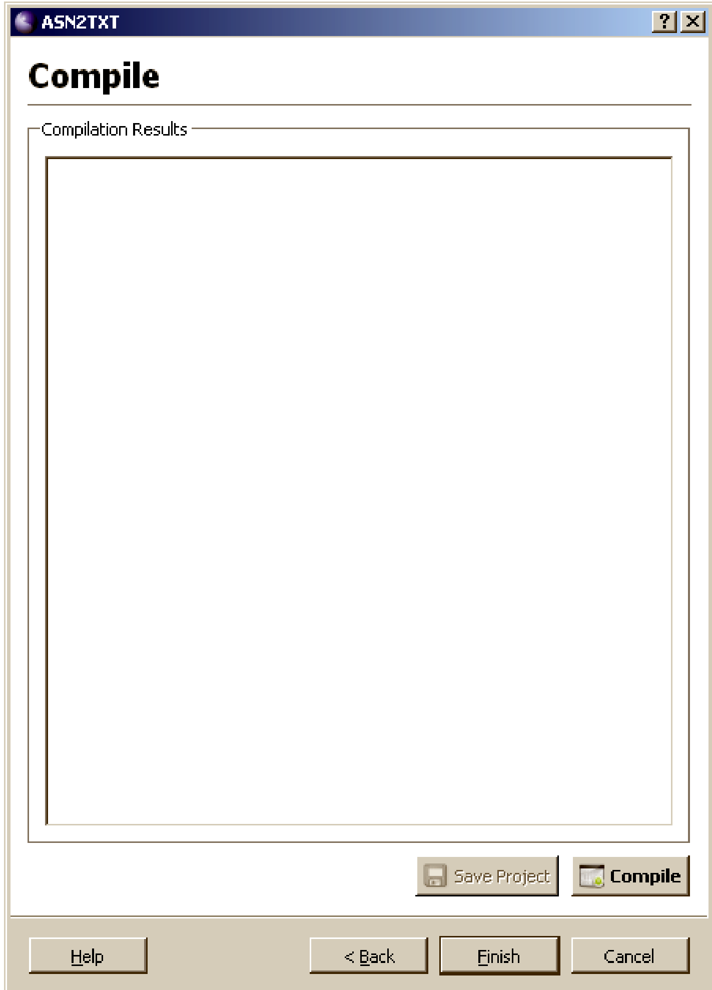
Users have two options for how to direct their XML output: it can be dumped to the GUI directly or else to a file. When the XML output filename is not provided, users will see the decoded XML output in the compilation window.

If output to CSV is requested, the following screen will appear instead:



Unlike XML output, CSV output is always directed to a file (or, more likely, several files). The output in the compilation window is therefore a little different than what is seen when XML output is selected without an output filename. This behavior is normal.

When the appropriate options for either type have been selected, the following screen is presented for compilation:


ASN2TXT
Compile
Compilation Results
Save Project
Compile
Help
< Back
Finish
Cancel

ASN.1 to XML Type Mappings

This chapter defines the mapping between ASN.1 encoded data values and XML for each of the ASN.1 types defined in the X.680 standard.

General Mapping without ASN.1 Schema Information

A BER, DER, or CER encoded data stream may be translated to XML format without providing associated ASN.1 schema information. In this case, XML element names are derived from built-in ASN.1 tag information contained within the message and values are encoded as either hexadecimal text, ASCII text, or as specific data-typed values if universal tag information is present.

XML element names derived from ASN.1 tag names for all tags except known universal tags is in the following general form:

```
<TagClass_TagValue>
```

where TagClass is the tag class name (APPLICATION, CONTEXT, or PRIVATE) and TagValue is the numeric tag value. For example, an [APPLICATION 1] tag would be printed as <APPLICATION_1> and a [0] tag (context-specific zero) would be printed as <CONTEXT_0>.

In the case of known universal tags, the tag value is derived using the name of the known type. In general, this is the type name defined in the ASN.1 standard with an underscore character used in place of embedded whitespace if it exists. The following table shows the XML tag names for the known types:

Tag	XML Element Name
UNIVERSAL 1	BOOLEAN
UNIVERSAL 2	INTEGER
UNIVERSAL 3	BIT_STRING
UNIVERSAL 4	OCTET_STRING
UNIVERSAL 5	NULL
UNIVERSAL 6	OBJECT_IDENTIFIER
UNIVERSAL 7	OBJECT_DESCRIPTOR
UNIVERSAL 8	EXTERNAL
UNIVERSAL 9	REAL
UNIVERSAL 10	ENUMERATED

Tag	XML Element Name
UNIVERSAL 12	EMBEDDED_PDV
UNIVERSAL 13	RELATIVE_OID
UNIVERSAL 16	SEQUENCE
UNIVERSAL 17	SET
UNIVERSAL 18-22, 25-30	Character string
UNIVERSAL 23	UTCTIME
UNIVERSAL 24	GENERALIZEDTIME

Element content will be formatted in one of three ways: hexadecimal text, ASCII (character) text, or specific-typed value.

Hexadecimal text is the default format for untyped content. ASCII text will be used if the `-ascii` command-line switch is specified and all byte values within a particular field are determined to be printable ASCII characters. A specific-type value encoding will be done if a known universal tag is found. The mapping in this case will be as described in the "Specific ASN.1 Type to XML Value Mapping" section below.

General Mapping with ASN.1 Schema Information

ASN.1 schema information is used if one or more ASN.1 schema files are specified on the command-line using the `-schema` command-line switch. In this case, element names as specified in the schema file are used for the XML element names and the content is decoded based on the specific type.

It is possible to use the `–pdu` command-line switch to force the association of a type within the specification to the message. This is only necessary if the ASN.1 files contain multiple types with the same start tag as the message type. Otherwise, the program will be able to determine on its own which type to use by matching tags. This is true for BER/DER/CER messages only: for PER, it is necessary to specify the PDU type along with the schema.

Specific ASN.1 Type to Value Mappings

This section defines the type-to-value mapping for each of the specific ASN.1 types. By default, these mappings are not in the form defined in the ASN.1 XML Encoding Rules (XER) standard (ITU-T X.693).

When a schema is provided using the `-schema` option, the output may be adjusted to conform to XER if desired by using the `-xer` option. XER is more verbose and less validation-friendly than our native XML export. It is provided for those occasions when strict conformance is required. Differences between the two formats are provided along with the schemaless mappings below.

BOOLEAN. An ASN.1 boolean value is transformed into the keyword 'true' or 'false'. If BER/DER/CER data is being decoded without a schema and the universal tag for this type is parsed, a <BOOLEAN> tag is added.

`b BOOLEAN ::= TRUE`	
Schemaless	`<BOOLEAN>TRUE</BOOLEAN>`
XML Mode	`<b>true</b>`
XER Mode	`<b><TRUE/></b>`

INTEGER. An ASN.1 integer value is transformed into numeric text. The one exception to this rule is if named number identifiers are specified for the integer type. In this case, if the number matches one of the declared identifiers, the identifier text is used.

If BER/DER/CER data is being decoded without a schema and the universal tag for this type is parsed, an <INTEGER> tag is added.

`i INTEGER ::= 35`	
Schemaless	`<INTEGER>35</INTEGER>`
With schema	`<i>35</i>`

ENUMERATED. An ASN.1 enumerated value is transformed into the enumerated identifier text value. If BER/DER/CER data is being decoded without a schema and the universal tag for this type is parsed, an <ENUMERATED> tag is added.

colors ENUMERATED {r, g, b} ::= g	
Schemaless	`<ENUMERATED>1</ENUMERATED>`
XML Mode	`<colors>g</colors>`
XER Mode	`<colors><g/></colors>`

BIT STRING. An ASN.1 bit string value is transformed into one of three forms:

1. Binary Text (0's and 1's)
2. Hexadecimal text
3. Named bit identifiers

Binary text is the default output format. This is used if the bit string type contains no named bit identifiers and if specification of hexadecimal output was not specified on the `asn2txt` command-line.

Hexadecimal text is displayed when the `-bitsfmt hex` command-line option is used. Any unused bits in the last octet are set to zero. Note that the other bits are displayed in most-significant bit order as they appear in the string in the last byte (i.e., they are not right shifted). For example, if the last byte contains a bit string value of 1010xxxx (where x denotes an unused bit), the string is displayed as A0 in the XML output, not 0A.

Named bit identifiers are used in the case of a bit string declared with identifiers. In this case, the XML content is a space-separated list of identifier values corresponding to the bits that are set. It is assumed that bits in the string all have corresponding identifier values.

If BER/DER/CER data is being decoded without a schema and the universal tag for this type is parsed, a <BIT_STRING> tag is added.

bs BIT STRING {z(0), a(1), b(2), c(3)} ::= '100100'B	
Schemaless	`<BIT_STRING>100100</BIT_STRING>`
With Schema	`<bs>100100</bs>`

OCTET STRING. An ASN.1 octet string value is transformed into one of two forms:

1. Hexadecimal text
2. ASCII character text

Hexadecimal text is the default display type. ASCII text will be used for the content when the `ascii` command-line option is used and the field contains are printable ASCII characters. A special case of OCTET STRING handling is for declared binary-coded decimal (BCD) data types. This is discussed in a later section.

If BER/DER/CER data is being decoded without a schema and the universal tag for this type is parsed, a <OCTET_STRING> tag is added.

os OCTET STRING ::= '3031'H	
Schemaless	<OCTET_STRING>3031</OCTET_STRING>
With schema	<os>3031</os>
With -ascii	<os>01</os>

NULL. An ASN.1 null value is displayed as an empty XML element. If BER/DER/CER data is being decoded without a schema and the universal tag for this type is parsed, a <NULL> tag is added.

n NULL ::= NULL	
Schemaless	<NULL/>
XML Mode	<n/>
XER Mode	<n><NULL/></n>

OBJECT IDENTIFIER and RELATIVE OID. An ASN.1 object identifier value is mapped into space-separated list of identifiers in numeric and/or named-number format. The identifiers are enclosed in curly braces ({ }). Numeric identifiers are simply numbers. The named-number format is a textual identifier followed by the corresponding numeric identifier in parentheses. It is used in cases where the identifier can be determined from the schema or is a well known identifier as specified in the ASN.1 standard.

If BER/DER/CER data is being decoded without a schema and the universal tag for this type is parsed, an <OBJECT_IDENTIFIER> tag is added.

oid OBJECT IDENTFIER ::= { 1 2 840 113549 1 1 2 }	
Schemaless	<OBJECTIDENTIFIER>{1 2 840 113549 1 1 2} </OBJECTIDENTIFIER>
With schema	<oid>{ 1 2 840 113549 1 1 2 }</oid>

The mapping for RELATIVE OID is the same as that for OBJECT IDENTIFIER.

Character String. An ASN.1 value of any of the known character string types is transformed into the character string text in whatever the default encoding for that type is. For example, an IA5String would contain an ASCII text value whereas a BMPString would contain a Unicode value.

If BER/DER/CER data is being decoded without a schema and the universal tag for this type is parsed, a tag is added which is the name of the character string type as defined in the ASN.1 standard in angle brackets. For example, the default tag for a UTF8String type would be <UTF8String>.

str UTF8String ::= “testing”	
Schemaless	`<UTF8String>TRUE</UTF8String>`
With schema	`<str>testing</str>`

Binary-coded Decimal String. Binary-Coded Decimal (BCD) strings and Telephony Binary-Coded Decimal (TBCD) strings are not part of the ASN.1 standard, but their use is prevalent in many telephony-related ASN.1 specifications. Conversion of these types into standard numeric text strings is supported.

In general, BCD strings pack two numeric digits into a single byte value by using a four-bit nibble to hold each digit. By convention, the digits are reversed in TBCD strings, but there are no official standards for this encoding.

The `-bcdhandling` command-line option can be used to force a certain type of conversion if an encoding does not follow the usual conventions. The default handling is to reverse digits in strings determined to be TBCD strings and not reverse digits in BCD strings. The `bcd` option is used to for no reversal of digits in all of these types of strings. The `tbcd` option instructs ASN2TXT to reverse the digits for all BCD strings.

If no processing is desired, `-bcdhandling none` can be used to instruct ASN2TXT not to process these strings.

REAL. An ASN.1 real value is transformed into numeric text in exponential number format. If BER/DER/CER data is being decoded without a schema and the universal tag for this type is parsed, a <REAL> tag is added.

r REAL ::= 2.99

Schemaless	<REAL>2.99</REAL>
With schema	<r>2.99</r>

SEQUENCE and SET. An ASN.1 sequence value is transformed into an XML value containing an element wrapper with each of the XML element encoded values inside.

name ::= SEQUENCE { **first UTF8String,** **middle UTF8String OPTIONAL,** **last UTF8String** **}**	**name Name ::= {** **first “Joe”,** **last “Jones”** **}**
Schemaless	<SEQUENCE> <CONTEXT_0> <UTF8String>Joe</UTF8String> </CONTEXT_0> <CONTEXT_2> <UTF8String>Jones</UTF8String> </CONTEXT_2> </SEQUENCE>
With schema	<name> <first>Joe</first> <last>Jones</last> </name>
With -emptyOptionals	<name> <first>Joe</first> <middle/> <last>Jones</last> </name>

When a SET is used instead, the outer SEQUENCE tag is replaced with SET. The mappings are otherwise identical.

SEQUENCE OF / SET OF. The representation of a repeating value in XML varies depending on the type of the element value.

If the value being translated is a sequence of an atomic primitive type, the XML content is a space-separated list of values. The definition of "atomic primitive type" is any primitive type whose value may not contain embedded whitespace. This includes BOOLEAN, INTEGER, ENUMERATED, REAL, BIT STRING, and OCTET STRING values.

If the value being translated is a constructed type or if it may contain whitespace, the value is wrapped in a tag which is either the name of the encapsulating type (defined or built-in) or the SEQUENCE OF element name if this form of the type was used.

If BER/DER/CER data is being decoded without a schema and the universal tag for this type is parsed, a <SEQUENCE> or <SET> tag is added. That is because the tag value (hex 30 or 31) is the same for SEQUENCE OF or SET OF as it is for SEQUENCE or SET.

soi SEQUENCE OF INTEGER ::= {1, 2, 3}	
Schemaless	<SEQUENCE> <INTEGER>1</INTEGER> <INTEGER>2</INTEGER> <INTEGER>3</INTEGER> </SEQUENCE>
With schema	<soi> <INTEGER>1</INTEGER> <INTEGER>2</INTEGER> <INTEGER>3</INTEGER> </soi>

sos SEQUENCE OF UTF8String ::= { “test 1”, “test 2” }	
Schemaless	<SEQUENCE> <UTF8STRING>test 1</UTF8STRING> <UTF8STRING>test 2</UTF8STRING> </SEQUENCE>
With schema	<sos> <UTF8String>test 1</UTF8String> <UTF8String>test 2</UTF8String> </sos>

Name ::= SEQUENCE { first UTF8String, middle UTF8String OPTIONAL, last UTF8String }	**son SEQUENCE OF Name ::= { { first 'Joe', last 'Jones' }, { first 'John', middle 'P', last 'Smith' } }**
Schemaless	<SEQUENCE>

	<SEQUENCE> <UTF8STRING>Joe</UTF8STRING> <UTF8STRING>Jones</UTF8STRING> </SEQUENCE> <SEQUENCE> <UTF8STRING>John</UTF8STRING> <UTF8STRING>P</UTF8STRING> <UTF8STRING>Smith</UTF8STRING> </SEQUENCE>
With schema. This example shows the results with `-emptyOptionals` selected. If it were not, the first `<middle/>` element would be omitted.	<son> <Name> <first>Joe</first> <middle/> <last>Jones</last> </Name> <Name> <first>John</first> <middle>P</middle> <last>Smith</last> </Name> </son>

CHOICE. The mapping of an ASN.1 CHOICE value is the alternative element tag followed by the value translated to XML format.

C CHOICE ::= { **a INTEGER,** **b OCTET STRING,** **c UTF8String** **}**	**c C ::= { a : 42 }**
Schemaless	<INTEGER>42</INTEGER>
With schema	<C> <a>42 </C>

Open Type. The mapping of an ASN.1 open type value depends on whether the actual type used to represent the value can be determined. ASN2TXT attempts to determine the actual type using the following methods (in this order):

1. Table constraints
2. Tag lookup in all defined schema types (BER/DER/CER only)

3. Universal tag lookup (BER/DER/CER only)

If the type can be determined, an XML element tag containing the type name is first added followed by the translated content of the value.

If the type cannot be determined, the open type content is translated into hexadecimal text from of the encoded value. This will also be done if the `-noopentype` command-line switch is used.

As an example, consider the AlgorithmIdentifier type used in the AuthenticationFramework and other related security specifications:

```
AlgorithmIdentifier ::= SEQUENCE {
   algorithm ALGORITHM.&id({SupportedAlgorithms}),
   parameters ALGORITHM.&Type({SupportedAlgorithms}{@algorithm})
    OPTIONAL
}
```

In this case, the parameters element references an open type that is tied to a type value based on the value of the algorithm key. Without getting into the details of the use of the accompanying information object sets, it is known that for an algorithm value of object identifier `{ 1 2 840 113549 1 1 2 }`, the type of the parameters field is NULL (i.e. there are no associated parameters). The XML translation in this case will be the following:

```
<algorithm>{ 1 2 840 113549 1 1 2 }</algorithm>
<parameters>
   <NULL/>
</parameters>
```

ASN.1 to CSV Type Mappings

Converting ASN.1 types to CSV output is not always very straightforward. It is akin to normalizing a database, except that there is only one table. For complex types, it is necessary to duplicate information across several rows.

There exists no standard for converting ASN.1 data to CSV. BER, CER, and DER data are encoded in a hierarchical format that lends itself to translation to other hierarchical formats such as XML. CSV, on the other hand, is flat data format: there are no structured types or children, and all data in a CSV file are displayed on single lines. This complicates the translation of ASN.1 to CSV, since structured data types like SEQUENCEs can be nested to an arbitrary depth or repeated an arbitrary number of times.

While these limitations make conversion a difficult problem, CSV offers some advantages over XML. CSV files are usually considerably smaller than XML, since no markup is necessary to distinguish elements. Many databases import CSV data directly into tables, so no intermediate transformations are required. CSV files can be easier to manipulate procedurally; no external XML parsers are required to read the files, and many scripting languages have built-in facilities for working with comma-delimited data.

We may divide conversion into roughly two steps: collecting the column headers and then outputting the column data. Header information comes from parsing the input specification, while the column data are found in the actual encoded content. This documentation is primarily concerned with how the column headers are collected.

Mapping Top-Level Types

PDU data types are stored in their own CSV files, usually in the form of `ModuleName_ProductionName.csv`. There are three main top-level data types of interest:

1. SEQUENCE / SEQUENCE OF
2. SET / SET OF
3. CHOICE

The list types (SEQUENCE and SET OF) are the same as the unit types. The content is repeated when needed on multiple rows of the CSV file.

Simple types may be used as top-level data types, but in practice this is rare. Translation in this case proceeds as described in the following sections.

As an example, the following SEQUENCE would be dumped to `MyModule_Type1.csv`:

```
MyModule DEFINITIONS ::= BEGIN

Type1 ::= SEQUENCE {
   ...
}

END
```

If the input file type had two such SEQUENCEs, the resulting files would be `MyModule_Type1.csv` and `MyModule_Type2.csv`.

When a CHOICE is used as the top-level data type, the typename for the CHOICE is ignored and the files are generated using the typenames in the CHOICE. For example, the following specification would generate the same output as the one with two top-level SEQUENCEs named `Type1` and `Type2`:

```
MyModule DEFINITIONS AUTOMATIC TAGS ::= BEGIN

Type1 ::= SEQUENCE {
   ...
}

Type2 ::= SEQUENCE {
   ...
}

PDU ::= CHOICE {
   t1 Type1,
   t2 Type2
}
```

When a SEQUENCE or SET OF type is used as the top level, the underlying unit type is referenced instead. For example, the following ASN.1 specification would create the file `MyModule_Type1.csv`:

```
MyModule DEFINITIONS ::= BEGIN

Type1 ::= SEQUENCE {
   ...
}

PDU ::= SEQUENCE OF Type1

END
```

In this case, the PDU type carries no extra information for outputting the data; the contents of `Type1` are outputted on separate lines.

One of the implications of this kind of translation is that the message structure cannot be reconstructed from the output data files. A top-level data type of a CHOICE, SEQUENCE, or SEQUENCE OF may result in exactly the same output files, even though the bytes of the message may differ. Such ambiguity should not cause any problems since a specification is required for decoding the ASN.1 data.

Mapping Simple Types

Simple types in ASN.1 consist of the following:

- BOOLEAN
- INTEGER
- BIT STRING
- OCTET STRING
- NULL
- OBJECT IDENTIFIER
- REAL
- ENUMERATED

- Character strings
- RELATIVE-OID
- UTCTime
- GeneralizedTime
- GraphicString
- VisibleString
- GeneralString

Each simple type is mapped to a corresponding string representation of the input data. This is a relatively straightforward conversion. Of special note, we use the BOOLEAN values "TRUE" (for any hex octet not equal to 0x00) and "FALSE" (for any hex octet equal to 0x00). NULL values are outputted simply as "NULL."

Simple type mappings require no extra logic for output. Their textual representations are generally quite straightforward. Mapping complex types, however, is more difficult.

Mapping Complex Types

Complex types of interest include the following:

- SEQUENCE
- SEQUENCE OF
- SET
- SET OF
- CHOICE

Complex types by their nature are more difficult to transform than simple types. They can be self-referential and nested, which complicates transformation. CSV is a flat file format that cannot properly represent nested types in a fixed number of columns, so care must be taken in transforming the data to ensure that it is properly represented. This process is very similar to a first-order database normalization.

CHOICE

As explained in the previous section, the CHOICE at the top level is effectively ignored: the elements of the CHOICE are used to generate the output of a file instead. In the routine case where the CHOICE is contained in another data type or stands alone, the mapping is slightly different.

Take for example the following CHOICE:

```
C ::= CHOICE {
   i INTEGER,
   b BOOLEAN,
   s UTF8String
}
```

The elements contained in the CHOICE will be used as the column names. The name of the CHOICE itself will be ignored. The resulting column names from this example would look like this:

```
i,b,s
```

Simple SEQUENCEs and SETs

This section describes the transformation of SEQUENCE data types. The SET data type is analogous to the SEQUENCE and so bears no extra discussion. As described in previous sections, the SEQUENCE OF and SET OF types are likewise equivalent.

The only significant difference between SEQUENCE and SET is that elements may be encoded in any order in a SET. ASN2TXT will order SET elements in the order they appear in the specification. The SEQUENCEs considered in this section contain only simple types to simplify the collection of header data. Other cases are considered in the next sections.

Take, for example, the following SEQUENCE specification:

```
S ::= SEQUENCE {
   i INTEGER ,
   s UTF8String,
   b BIT STRING
}
```

Each element of the SEQUENCE will be represented by an item in the output CSV file as follows:

```
i,s,b
```

Mapping Nested Types

When a SEQUENCE or SET contains other complex data types, it is said to be *nested*. Types may be nested to an arbitrary depth in ASN.1, so the resulting output can be extremely verbose in complex specifications. Moreover, these nested types can be repeating. The following sections describe how ASN2TXT handles nested types. A SEQUENCE is exactly the same as a SET to ASN2TXT; the two types are used interchangeably in the following sections.

SEQUENCE in a SEQUENCE

One form of nested data occurs when a SEQUENCE type contains another, as in the following example:

```
A ::= SEQUENCE {
   a INTEGER,
   b SEQUENCE { aa INTEGER, bb BOOLEAN },
   c BIT STRING
}
```

In this case, the following columns would be generated in the output CSV:

```
a,aa,bb,c
```

ASN2TXT removes all references to the SEQUENCE named b. Instead, the inner data (aa and bb) is collapsed into the main data type. It is as though we have instead provided the following specification:

```
A ::= SEQUENCE {
   a  INTEGER,
   aa INTEGER,
   bb BOOLEAN,
   b  BIT STRING
}
```

While the BER encoding of the two specifications is different, they are functionally equivalent to ASN2TXT.

CHOICE in a SEQUENCE

When a CHOICE appears in a SEQUENCE, each of the elements in the CHOICE is represented in the output CSV file, even though only one will be selected in any given message.

For example, take the following specification:

```
A ::= SEQUENCE {
   a INTEGER,
   b CHOICE { aa INTEGER, bb BOOLEAN },
   c BIT STRING
}
```

The resulting columns will appear as though the CHOICE were actually a SEQUENCE:

```
a,aa,bb,c
```

SEQUENCE OF in a SEQUENCE

The last data type to consider is the SEQUENCE OF. This is handled very much like a SEQUENCE: the SEQUENCE OF is ignored and its contents are represented for the column headers as in the following example:

```
A ::= SEQUENCE {
   a INTEGER,
   b SEQUENCE OF INTEGER,
   c BIT STRING
}
```

In this case, the columns will be straightforwardly translated:

```
a,b,c
```

It is possible that the repeated data type is not primitive, but rather complex. For example:

```
A ::= SEQUENCE {
   a INTEGER,
   b SEQUENCE OF SEQUENCE {
      aa INTEGER,
      bb BOOLEAN
   },
   c BIT STRING
}
```

In this case, the innermost data are represented in the output CSV files, but the actual SEQUENCE OF will be ignored as before:

```
a,aa,bb,c
```

The exact same columns would be represented if a CHOICE were used instead of a SEQUENCE. ASN2TXT will always do its best to collapse nested data types, drilling down to the innermost data to collect the column headers.

Data Conversion

Having collected column headers for the output CSV, the second and final step is to output the actual data from the decoded BER message. Fortunately this is considerably more straightforward than collapsing the data structures in the specification.

The main case to consider is that in which data types are repeated: when a SEQUENCE OF is nested inside of a SEQUENCE. Some brief comments follow for other nested data types.

SEQUENCE OF in a SEQUENCE

Take for example the simple case previously seen:

```
A ::= SEQUENCE {
   a INTEGER,
   b SEQUENCE OF INTEGER,
   c BIT STRING
}
```

Let us assume for sake of argument that there are two integers in the inner SEQUENCE OF. In this case, the resulting CSV file will have two rows in addition to the header row.

The common data, columns `a` and `c`, will be represented once in the output file (unless `-padFields` is specified), while the repeated element `b` will change. For example:

```
a,b,c
1,97823789324,010010
,18927481,
```

If you have chosen to pad the fields, the output will look like this:

```
a,b,c
1,97823789324,010010
1,18927481,010010
```

While this example is very simple, it is possible to nest data types to an arbitrary depth, and the representation of columns and their data can be quite large. In pathological instances, the CSV output may be larger than the output generated by other tools like ASN2XML.

Other Nested Data Types

The other nested data types, SEQUENCE and CHOICE, are relatively trivial to convert once the columns have been assembled as described in the previous section. A single row may be used to output a message without repeating types.

The CHOICE data type bears some explanation. The following specification is the same used in the previous section:

```
A ::= SEQUENCE {
   a INTEGER,
   b CHOICE { aa INTEGER, bb BOOLEAN },
   c BIT STRING
}
```

Some example output data follows:

```
a,aa,bb,c
1,,FALSE,101010
2,137,,100001
```

The output lines will contain data in either the `aa` or `bb` columns but not both. Only the selected data should be represented in the output line.

OPTIONAL and DEFAULT Elements

Optional primitive elements that are missing in an input message will result in a blank entry in the output CSV file. Take, for example, the following specification:

```
A ::= SEQUENCE {
   a INTEGER,
   b UTF8String OPTIONAL,
   c BIT STRING
}
```

This might result in the following output:

```
a,b,c
1,test string,100100
2,,100101
3,another test,100100
```

In this example, the second message does not contain the optional UTF8String, so it is omitted from the output.

Elements marked DEFAULT are handled differently in the output. If an element is missing in the input specification, the default value is copied into the output CSV file. The following specification is used to demonstrate:

```
A ::= SEQUENCE {
   a INTEGER,
   b UTF8String DEFAULT "test",
   c BIT STRING
}
```

In this case, we might have the following output:

```
a,b,c
1,test string,100100
2,test,100101
3,another test,100100
```

Like the previous example, the input data omitted the default UTF8String. Instead of a blank entry, however, the output CSV data contains `test`.