

Generic String Encoding Rules for ASN.1 Types

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Abstract

This document defines a set of Abstract Syntax Notation One (ASN.1) encoding rules, called the Generic String Encoding Rules, that produce a human readable text encoding for values of any given ASN.1 data type.

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2. Introduction

This document defines a set of ASN.1 [8] encoding rules, called the Generic String Encoding Rules or GSER, that produce a human readable UTF8 [6] character string encoding of ASN.1 values of any given arbitrary ASN.1 type.

Note that "ASN.1 value" does not mean a BER [13] encoded value. The ASN.1 value is an abstract concept that is independent of any particular encoding. BER is just one possible encoding of an ASN.1 value.

GSER is based on ASN.1 value notation [8], with changes to accommodate the notation's use as a transfer syntax, and to support

well established ad-hoc string encodings for LDAP [14] directory data types.

Though primarily intended for defining the LDAP-specific encoding of new LDAP attribute syntaxes and assertion syntaxes, these encoding rules could also be used in other domains where human readable renderings of ASN.1 values would be useful.

Referencing the Generic String Encoding Rules (GSER) is sufficient to define a human readable text encoding for values of a specific ASN.1 type, however other specifications may wish to provide a customized ABNF [3] description, independent of the ASN.1, as a convenience for the implementor (equivalent ABNF for the GSER encodings for ASN.1 types commonly occurring in LDAP syntaxes is provided in [15]). Such a specification SHOULD state that if there is a discrepancy between the customized ABNF and the GSER encoding defined by this document, that the GSER encoding takes precedence.

3. Conventions

Throughout this document "type" shall be taken to mean an ASN.1 type, and "value" shall be taken to mean an ASN.1 value.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [1].

4. Generic String Encoding Rules

The GSER encoding of a value of any ASN.1 type is described by the following ABNF [3]:

```
Value = BitStringValue /
        BooleanValue /
        CharacterStringValue /
        ChoiceValue /
        EmbeddedPDVValue /
        EnumeratedValue /
        ExternalValue /
        GeneralizedTimeValue /
        IntegerValue /
        InstanceOfValue /
        NullValue /
        ObjectDescriptorValue /
        ObjectIdentifierValue /
        OctetStringValue /
```

RealValue /
RelativeOIDValue /
SequenceOfValue /
SequenceValue /
SetOfValue /
SetValue /
StringValue /
UTCTimeValue /
VariantEncoding

The ABNF for each of the above rules is given in the following sections.

4.1 Type Referencing Notations

A value of a type with a defined type name is encoded according to the type definition on the right hand side of the type assignment for the type name.

A value of a type denoted by the use of a parameterized type with actual parameters is encoded according to the parameterized type with the DummyReferences [12] substituted with the actual parameters.

A value of a tagged or constrained type is encoded as a value of the type without the tag or constraint, respectively. Tags do not appear in the string encodings defined by this document. See [8] and [11] for the details of ASN.1 constraint notation.

A value of an open type denoted by an ObjectClassFieldType (Clause 14 of [10]) is encoded according to the specific type of the value.

A value of a fixed type denoted by an ObjectClassFieldType is encoded according to that fixed type.

A value of a selection type is encoded according to the type referenced by the selection type.

A value of a type described by TypeFromObject notation (Clause 15 of [10]) is encoded according to the denoted type.

A value of a type described by ValueSetFromObjects notation (Clause 15 of [10]) is encoded according to the governing type.

4.2 Restricted Character String Types

The contents of a string value are encoded as a UTF8 character string

between double quotes, regardless of the ASN.1 string type. Depending on the ASN.1 string type, and an application's internal representation of that string type, a translation to or from the UTF8 character encoding may be required. NumericString, PrintableString, IA5String, VisibleString (ISO646String) are compatible with UTF8 and do not require any translation. BMPString (UCS-2) and UniversalString (UCS-4) have a direct mapping to and from UTF8 [6]. For the remaining string types see [8]. Any embedded double quotes in the resulting UTF8 character string are escaped by repeating the double quote characters.

A value of the NumericString, PrintableString, TeletexString (T61String), VideotexString, IA5String, GraphicString, VisibleString (ISO646String), GeneralString, BMPString, UniversalString or UTF8String type is encoded according to the <StringValue> rule.

```
StringValue      = dquote *SafeUTF8Character dquote
dquote           = %x22 ; " (double quote)
SafeUTF8Character = %x00-21 / %x23-7F /      ; ASCII minus dquote
                  dquote dquote /         ; escaped double quote
                  %xC0-DF %x80-BF /      ; 2 byte UTF8 character
                  %xE0-EF 2(%x80-BF) /  ; 3 byte UTF8 character
                  %xF0-F7 3(%x80-BF) /  ; 4 byte UTF8 character
                  %xF8-FB 4(%x80-BF) /  ; 5 byte UTF8 character
                  %xFC-FD 5(%x80-BF)    ; 6 byte UTF8 character
```

A value of the GeneralizedTime type, UTCTime type or ObjectDescriptor type is encoded as a string value. GeneralizedTime and UTCTime use the VisibleString character set so the conversion to UTF8 is trivial. ObjectDescriptor uses the GraphicString type.

```
GeneralizedTimeValue = StringValue
UTCTimeValue         = StringValue
ObjectDescriptorValue = StringValue
```

4.3 ChoiceOfStrings Types

It is not uncommon for ASN.1 specifications to define types that are a CHOICE between two or more alternative ASN.1 string types, where the particular alternative chosen carries no semantic significance (DirectoryString [7] being a prime example). Such types are defined to avoid having to use a complicated character encoding for all values when most values could use a simpler string type, or to deal with evolving requirements that compel the use of a broader character set while still maintaining backward compatibility.

GSER encodes values of all the ASN.1 string types as UTF8 character strings so the alternative chosen in a purely syntactic CHOICE of string types makes no material difference to the final encoding of the string value.

While there are certain ASN.1 constructs that betray the semantic significance of the alternatives within a CHOICE type, the absence of those constructs does not necessarily mean a CHOICE type is purely syntactic. Therefore, it is necessary for specifications to declare the purely syntactic CHOICE types so that they may be more compactly encoded (see Section 4.12). These declared CHOICE types are referred to as ChoiceOfStrings types.

To be eligible to be declared a ChoiceOfStrings type an ASN.1 type MUST satisfy the following conditions.

- a) The type is a CHOICE type.
- b) The component type of each alternative is one of the following ASN.1 restricted string types: NumericString, PrintableString, TeletexString (T61String), VideotexString, IA5String, GraphicString, VisibleString (ISO646String), GeneralString, BMPString, UniversalString or UTF8String.
- c) All the alternatives are of different restricted string types, i.e. no two alternatives have the same ASN.1 restricted string type.
- d) Either none of the alternatives has a constraint, or all of the alternatives have exactly the same constraint.

Tagging on the alternative types is ignored.

Consider the ASN.1 parameterized type definition of DirectoryString.

```
DirectoryString { INTEGER : maxSize } ::= CHOICE {
    teletexString      TeletexString (SIZE (1..maxSize)),
    printableString    PrintableString (SIZE (1..maxSize)),
    bmpString          BMPString (SIZE (1..maxSize)),
    universalString    UniversalString (SIZE (1..maxSize)),
    utf8String         UTF8String (SIZE (1..maxSize)) }
```

Any use of the DirectoryString parameterized type with an actual parameter defines a ASN.1 type that satisfies the above conditions. Recognising that the alternative within a DirectoryString carries no semantic significance, this document declares (each and every use of) DirectoryString{} to be a ChoiceOfStrings type.

Other specifications MAY declare other types satisfying the above conditions to be ChoiceOfStrings types. The declaration SHOULD be made at the point where the ASN.1 type is defined, otherwise it SHOULD be made at the point where it is introduced as, or in, an LDAP attribute or assertion syntax.

4.4 Identifiers

An <identifier> conforms to the definition of an identifier in ASN.1 notation (Clause 11.3 of [8]). It begins with a lowercase letter and is followed by zero or more letters, digits, and hyphens. A hyphen is not permitted to be the last character and a hyphen is not permitted to be followed by another hyphen. The case of letters in an identifier is always significant.

```
identifier      = lowercase *alphanumeric *(hyphen 1*alphanumeric)
alphanumeric    = uppercase / lowercase / decimal-digit
uppercase       = %x41-5A ; "A" to "Z"
lowercase       = %x61-7A ; "a" to "z"
decimal-digit   = %x30-39 ; "0" to "9"
hyphen          = "-"
```

4.5 BIT STRING

A value of the BIT STRING type is encoded according to the <BitStringValue> rule. If the definition of the BIT STRING type includes a named bit list, the <bit-list> form of <BitStringValue> MAY be used. If the number of bits in a BIT STRING value is a multiple of four the <hstring> form of <BitStringValue> MAY be used. The <bstring> form of <BitStringValue> is used otherwise.

```
BitStringValue = bstring / hstring / bit-list
```

The <bit-list> rule encodes the one bits in the bit string value as a comma separated list of identifiers. Each <identifier> MUST be one of those in the named bit list. An <identifier> MUST NOT appear more than once in the same <bit-list>. The <bstring> rule encodes each bit as the character "0" or "1" in order from the first bit to the last bit. The <hstring> rule encodes each group of four bits as a hexadecimal number where the first bit is the most significant. An odd number of hexadecimal digits is permitted.

```
bit-list        = "{" [ sp identifier
                    *( "," sp identifier ) ] sp "}"
hstring         = squote *hexadecimal-digit squote %x48 ; '...'
```

```
hexadecimal-digit = %x30-39 / ; "0" to "9"
                  %x41-46   ; "A" to "F"

bstring           = squote *binary-digit squote %x42 ; '...'B
binary-digit      = "0" / "1"

sp                = *%x20 ; zero, one or more space characters
squote           = %x27 ; ' (single quote)
```

4.6 BOOLEAN

A value of the BOOLEAN type is encoded according to the <BooleanValue> rule.

```
BooleanValue = %x54.52.55.45 / ; "TRUE"
              %x46.41.4C.53.45 ; "FALSE"
```

4.7 ENUMERATED

A value of the ENUMERATED type is encoded according to the <EnumeratedValue> rule. The <identifier> MUST be one of those in the list of enumerations in the definition of the ENUMERATED type.

```
EnumeratedValue = identifier
```

4.8 INTEGER

A value of the INTEGER type is encoded according to the <IntegerValue> rule. If the definition of the INTEGER type includes a named number list, the <identifier> form of <IntegerValue> MAY be used, in which case the <identifier> MUST be one of those in the named number list.

```
IntegerValue = "0" /
              positive-number /
              ("-" positive-number) /
              identifier

positive-number = non-zero-digit *decimal-digit
non-zero-digit = %x31-39 ; "1" to "9"
```

4.9 NULL

A value of the NULL type is encoded according to the <NullValue>

rule.

```
NullValue = %x4E.55.4C.4C ; "NULL"
```

4.10 OBJECT IDENTIFIER and RELATIVE-OID

A value of the OBJECT IDENTIFIER type is encoded according to the <ObjectIdentifierValue> rule. The <ObjectIdentifierValue> rule allows either a dotted decimal representation of the OBJECT IDENTIFIER value or an object descriptor name, i.e. <descr>. The <descr> rule is described in [4]. An object descriptor name is potentially ambiguous and should be used with care.

```
ObjectIdentifierValue = numeric-oid / descr
numeric-oid           = oid-component 1*( "." oid-component )
oid-component         = "0" / positive-number
```

A value of the RELATIVE-OID [9] type is encoded according to the <RelativeOIDValue> rule.

```
RelativeOIDValue = oid-component *( "." oid-component )
```

4.11 OCTET STRING

A value of the OCTET STRING type is encoded according to the <OctetStringValue> rule. The octets are encoded in order from the first octet to the last octet. Each octet is encoded as a pair of hexadecimal digits where the first digit corresponds to the four most significant bits of the octet. If the hexadecimal string does not have an even number of digits the four least significant bits in the last octet are assumed to be zero.

```
OctetStringValue = hstring
```

4.12 CHOICE

A value of a CHOICE type is encoded according to the <ChoiceValue> rule. The <ChoiceOfStringsValue> encoding MAY be used if the corresponding CHOICE type has been declared a ChoiceOfStrings type. This document declares DirectoryString to be a ChoiceOfStrings type (see Section 4.3). The <IdentifiedChoiceValue> form of <ChoiceValue> is used otherwise.

```
ChoiceValue           = IdentifiedChoiceValue /
                       ChoiceOfStringsValue
```

```
IdentifiedChoiceValue = identifier ":" Value
ChoiceOfStringsValue  = StringValue
```

For implementations that recognise the internal structure of the DirectoryString CHOICE type (e.g. X.500 directories [16]), if the character string between the quotes in a <StringValue> contains only characters that are permitted in a PrintableString the DirectoryString is assumed to use the printableString alternative, otherwise it is assumed to use the uTF8String alternative. The <IdentifiedChoiceValue> rule MAY be used for a value of type DirectoryString to indicate a different alternative to the one that would otherwise be assumed from the string contents. No matter what alternative is chosen, the <Value> will still be a UTF8 encoded character string, however it is a syntax error if the characters in the UTF8 string cannot be represented in the string type of the chosen alternative.

Implementations that don't care about the internal structure of a DirectoryString value MUST be able to parse the <IdentifiedChoiceValue> form for a DirectoryString value, though the particular identifier found will be of no interest.

4.13 SEQUENCE and SET

A value of a SEQUENCE type is encoded according to the <SequenceValue> rule. The <ComponentList> rule encodes a comma separated list of the particular component values present in the SEQUENCE value, where each component value is preceded by the corresponding identifier from the SEQUENCE type definition. The components are encoded in the order of their definition in the SEQUENCE type.

```
SequenceValue = ComponentList
```

```
ComponentList = "{" [ sp NamedValue *( "," sp NamedValue) ] sp "}"
NamedValue    = identifier msp Value
msp           = 1*%x20 ; one or more space characters
```

A value of a SET type is encoded according to the <SetValue> rule. The components are encoded in the order of their definition in the SET type (i.e. just like a SEQUENCE value). This is a deliberate departure from ASN.1 value notation where the components of a SET can be written in any order.

```
SetValue = ComponentList
```

SEQUENCE and SET type definitions are sometimes extended by the inclusion of additional component types, so an implementation SHOULD

be capable of skipping over any <NamedValue> encoding with an identifier that is not recognised, on the assumption that the sender is using a more recent definition of the SEQUENCE or SET type.

4.14 SEQUENCE OF and SET OF

A value of a SEQUENCE OF type is encoded according to the <SequenceOfValue> rule, as a comma separated list of the instances in the value. Each instance is encoded according to the component type of the SEQUENCE OF type.

```
SequenceOfValue = "{" [ sp Value *( "," sp Value) ] sp "}"
```

A value of a SET OF type is encoded according to the <SetOfValue> rule, as a list of the instances in the value. Each instance is encoded according to the component type of the SET OF type.

```
SetOfValue      = "{" [ sp Value *( "," sp Value) ] sp "}"
```

4.15 CHARACTER STRING

A value of the unrestricted CHARACTER STRING type is encoded according to the corresponding SEQUENCE type defined in Clause 39.5 of [8] (see [15] for equivalent ABNF).

```
CharacterStringValue = SequenceValue
```

4.16 EMBEDDED PDV

A value of the EMBEDDED PDV type is encoded according to the corresponding SEQUENCE type defined in Clause 32.5 of [8] (see [15] for equivalent ABNF).

```
EmbeddedPDVValue = SequenceValue
```

4.17 EXTERNAL

A value of the EXTERNAL type is encoded according to the corresponding SEQUENCE type defined in Clause 8.18.1 of [13] (see [15] for equivalent ABNF).

```
ExternalValue = SequenceValue
```

4.18 INSTANCE OF

A value of the INSTANCE OF type is encoded according to the corresponding SEQUENCE type defined in Annex C of [10].

InstanceOfValue = SequenceValue

4.19 REAL

A value of the REAL type MUST be encoded as "0" if it is zero, otherwise it is encoded as either the special value <PLUS-INFINITY>, the special value <MINUS-INFINITY>, an optionally signed <realnumber> (based on the extended value notation for REAL from [17]) or as a value of the corresponding SEQUENCE type for REAL defined in Clause 20.5 of [8] (see [15] for equivalent ABNF).

```

RealValue = "0"           ; zero REAL value
           / PLUS-INFINITY ; positive infinity
           / MINUS-INFINITY ; negative infinity
           / realnumber    ; positive base 10 REAL value
           / "-" realnumber ; negative base 10 REAL value
           / SequenceValue ; non-zero REAL value, base 2 or 10
realnumber = mantissa exponent
mantissa   = (positive-number [ "." *decimal-digit ])
           / ( "0." *("0") positive-number )
exponent   = "E" ( "0" / ([ "-" ] positive-number))

PLUS-INFINITY = %x50.4C.55.53.2D.49.4E.46.49.4E.49.54.59
               ; "PLUS-INFINITY"
MINUS-INFINITY = %x4D.49.4E.55.53.2D.49.4E.46.49.4E.49.54.59
                ; "MINUS-INFINITY"

```

4.20 Variant Encodings

The values of some named complex ASN.1 types have special string encodings. These special encodings are always used instead of the encoding that would otherwise apply based on the ASN.1 type definition.

```

VariantEncoding = RDNSequenceValue /
                  RelativeDistinguishedNameValue /
                  ORAddressValue

```

A value of the RDNSequence type, i.e. a distinguished name, is encoded according to the <RDNSequenceValue> rule, as a quoted LDAPDN character string. The character string is first derived according to

the <distinguishedName> rule in Section 3 of [5], and then it is encoded as if it were a UTF8String value, i.e. between double quotes with any embedded double quotes escaped by being repeated.

RDNSequenceValue = StringValue

A RelativeDistinguishedName value that is not part of an RDNSequence value is encoded according to the <RelativeDistinguishedNameValue> rule as a quoted character string. The character string is first derived according to the <name-component> rule in Section 3 of [5], and then it is encoded as if it were a UTF8String value.

RelativeDistinguishedNameValue = StringValue

A value of the ORAddress type is encoded according to the <ORAddressValue> rule as a quoted character string. The character string is first derived according to the textual representation of MTS.ORAddress from [2], and then it is encoded as if it were an IA5String value.

ORAddressValue = StringValue

5. GSER Transfer Syntax

The following OBJECT IDENTIFIER has been assigned to identify the Generic String Encoding Rules:

```
{ 1 2 36 79672281 0 0 }
```

This OBJECT IDENTIFIER would be used, for example, to describe the transfer syntax for a GSER encoded data-value in an EMBEDDED PDV value.

6. Security Considerations

The Generic String Encoding Rules do not define a canonical encoding. That is, a transformation from a GSER encoding into some other encoding (e.g. BER) and back into GSER will not necessarily reproduce exactly the original GSER octet encoding. Therefore GSER SHOULD NOT be used where a canonical encoding is needed.

Furthermore, GSER does not necessarily enable the exact octet encoding of values of the TeletexString, VideotexString, GraphicString or GeneralString types to be reconstructed, so a transformation from DER to GSER and back to DER may not reproduce the original DER encoding. Therefore GSER SHOULD NOT be used where

reversibility to DER is needed, e.g. for the verification of digital signatures. Instead, DER or a DER-reversible encoding should be used.

When interpreting security-sensitive fields, and in particular fields used to grant or deny access, implementations MUST ensure that any comparisons are done on the underlying abstract value, regardless of the particular encoding used.

7. Normative References

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- [4] Wahl, M., Coulbeck, A., Howes, T. and S. Kille, "Lightweight Directory Access Protocol (v3): Attribute Syntax Definitions", RFC 2252, December 1997.
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- [16] ITU-T Recommendation X.500 (1993) | ISO/IEC 9594-1:1994,
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Directory: Overview of concepts, models and services
- [17] ITU-T Recommendation X.680 - Corrigendum 3 (02/2001)

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