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**Information technology — Coding of audio-visual objects — Part 34: Syntactic description language**

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](https://www.iso.org/directives-and-policies.html)).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](https://www.iso.org/foreword-supplementary-information.html).

This document was prepared by Joint Technical Committee ISO/IEC 1, information technology, Subcommittee SC 29, coding of audio, picture, multimedia and hypermedia information.

A list of all parts in the ISO 14496 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](https://www.iso.org/members.html).

Introduction

This specification describes the mechanism with which bitstream syntax is documented in several standard parts such as in ISO/IEC 14496 or ISO/IEC 23000. This mechanism is based on a Syntactic Description Language (SDL), documented here in the form of syntactic description rules. It leverages concepts defined in the C-like syntax used in ISO/IEC 11172–1:1993 and ISO/IEC 13818–1:2007 into a well-defined framework that lends itself to object-oriented data representations. SDL assumes an object-oriented underlying framework in which bitstream units consist of “classes.” This framework is based on the typing system of the C++ and Java programming languages. SDL extends the typing system by providing facilities for defining bitstream-level quantities, and how they should be parsed.

The elementary constructs are described first, followed by the composite syntactic constructs, and arithmetic and logical expressions. Finally, syntactic control flow and built-in functions are addressed. Syntactic flow control is needed to support context-sensitive data. Several examples are used to clarify the structure.

Initially defined in ISO/IEC 14496-1, this specification is backward-compatible compared to the SDL specified in ISO/IEC 14496-1. That is, a valid SDL definition based on ISO/IEC 14496-1 is also a valid definition based on this specification. However, the inverse is not true. The main additions of this specification are:

* Definition of string types and string literals
* Definition of the float type
* Explicit definition of allowed operators
* Declaration of variable in the first expression of a for statement

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent.

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Information technology — Coding of audio-visual objects — Part 34: Syntactic description language

# Scope

This document specifies a syntactic language for describing the structure of binary data composed of number and characters elements represented in their binary forms.

# Normative references

IETF RFC 4648, The Base16, Base32, and Base64 Data Encodings

IETF RFC 3629, UTF‑8, a transformation format of ISO 10646

IEEE Std 754-2019, IEEE Standard for Floating-Point Arithmetic

# Terms and definitions

For the purposes of this document, the following terms, abbreviations and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

* ISO Online browsing platform: available at <https://www.iso.org/obp>
* IEC Electropedia: available at <https://www.electropedia.org/>

3.1

FLC

Fixed Length Code

constant-length direct representation bit fields

3.2

SDL

Syntactic Description Language

language defined by this specification that allows the description of a bitstream’s syntax

3.3  
non-parsable variable

a variable whose value is undefined until the first assignment statement and whose scope is the current scope defined by enclosing curly brackets ({ and })

3.4  
parsable variable

a variable whose value is initialised at declaration by reading bits from the bitstream and whose scope is the current class. The number of bits to be read from the current position in the stream is indicated by an explicit length attribute or by a stopping condition

# Document conventions

## Rule formatting

The following formatting is used when presenting the informal grammar rules appearing in this document:

* Keywords, punctuators and operators are formatted using a bold monospace font e.g., **keyword**
* Constructs referenced across informal grammar rules are formatted using a bold, italic monospace font e.g., ***construct***
* Tokens used to express the rules (defined in 4.2) are formatted using non-italic, non-bold monospace font e.g., ‘[’ and ‘]’
* Identifiers and values are formatted using an italic variable width font e.g., *identifier*

## Rule tokens

The following tokens are used in the informal grammar rules appearing in this document:

* An optional element is indicated by surrounding it with ‘[’ and ‘]’ e.g., [*optional\_element*]
* Alternative elements are indicated by separating each alternative by ‘|’ e.g., *element\_1* | *element\_2*
* An unspecified sequence of one or more elements is indicated by ‘…’ e.g., *element*;…

## Bitstream examples

This document provides encoded bitstream samples demonstrating the behaviour of various SDL constructs. The bitstream samples should be read left to right top to bottom. Line breaks are irrelevant and are used purely to allow annotation of the bitstream. Annotations appear after a comment marker ‘//’. For example the following indicates the 32-bit value 0xFF11 encoded in a binary bitstream:

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 // first two bytes

// blank lines are irrelevant

0 0 0 0 0 0 0 1 // third byte

0 0 0 0 // another 4 bits

0 0 0 1 // last 4 bits

Examples always have a starting parse position. If parsing has just started, the example's starting parse position will be before the first bit in the bitstream. If parsing has already commenced, the example’s starting parse position will be after the last parsed bit. In both cases the example's starting parse position is before the first bit that is relevant to the example. To emphasize the fact that the example may be part of a larger bitstream definition, examples will always be preceded and succeeded by ‘…’. As an example:

...

0 0 0 0 // first 4 bits

0 0 0 1 // last 4 bits

...

Where skipping an indeterminate number of bits to achieve alignment is part of the example it is indicated as follows:

...

<skip bits> // aligned(8)

0 0 0 0 // first 4 bits

0 0 0 1 // last 4 bits

...

# General syntax aspects

## Case sensitivity

The SDL is case sensitive.

## Identifiers

Variable identifiers can be comprised of a mixture of upper- and lower-case ASCII alphabetic characters, digits and underscore (e.g. ‘\_’). An identifier must include at least one alphabetic character.

For example, the following are all valid identifiers:

EXAMPLE ⎯

myVar

My\_Var

My2ndVar

2D\_Region[2]

\_2d\_region

It is illegal to define a variable identifier which conflicts (ignoring case) with SDL syntax items such as keywords, binary, hexadecimal and string literal prefixes.

For example, the following are all invalid identifiers:

EXAMPLE ⎯

u // conflict with UTF-16 literal string prefix

0b // conflict with binary literal value prefix

0B // case-insensitive conflict with binary literal value prefix

Map // case-insensitive conflict with keyword "map"

1e2 // conflict with floating point literal value

2\_2 // identifier must contain at least one alphabetic character

## Punctuators

The following punctuator tokens are defined in the SDL:

**(** open parenthesis

**)** close parenthesis

**{** open brace

**}** close brace

**[** open bracket

**]** close bracket

**:** colon

**;** semicolon

**,** comma

**"** double quote

[Editor’s note: single quote is extensively used in existing standards, either switch from double to single or support both]

## Keywords

The following keyword tokens are defined in the SDL:

**abstract**

**aligned**

**base64string**

**bit**

**break**

**case**

**class**

**const**

**default**

**do**

**else**

**expandable**

**extends**

**float**

**for**

**if**

**int**

**lengthof**

**map**

**switch**

**unsigned**

**utf8string**

**utf8list**

**utfstring**

**while**

## Operators

Arithmetic and logical operators defined in the SDL are provided below in descending precedence order:

*a***++** postfix increment

*a***--** postfix decrement

**\*** multiplication

**/** division

**%** modulus

**+** addition

**-** subtraction

**<<** bitwise shift left

**>>** bitwise shift right

**<** relational less than

**<=** relational less than or equal

**>** relational greater than

**>=** relational greater than or equal

**==** relational equal

**!=** relational not equal

**&** bitwise AND

**|** bitwise OR

**&&** logical AND

**||** logical OR

**=** assignment

**.** class member access

## Whitespace

One or more space, tab or carriage return characters constitute a whitespace and serve to demarcate tokens in the SDL definition. Whitespace is required wherever parsing of tokens in an SDL definition would be ambiguous. For example, the following are all valid and equivalent:

EXAMPLE ⎯

int ( 10 ) i = -1 .. 3;

int(10)i=-1..3;

int( 10) i= - 1 ..3;

For example, the following is invalid as tokenization of unsigned int is not possible:

EXAMPLE ⎯

unsignedint i; // missing whitespace causing token ambiguity

## Built-in operators

This **lengthof()** operator returns the length, in bits, of the quantity contained in parentheses. The length is the number of bits that was most recently used to parse the quantity at hand. A return value of 0 means that no bits were parsed for this variable i.e., it is a non-parsable variable.

[Editor’s note: I believe these statements are true:

* It is an error to invoke lengthof() of an out-of-scope variable.
* Invoking with a non-parsable variable results in zero.
* Invoking on an already parsed elementary type variable results in the width attribute.

I am not sure what the answers to these should be:

* Invoking on an elementary type variable which has not been parsed?
* Invoking on a string variable which has not been parsed?
* Invoking on an already parsed string variable?
* Invoking on a map output which is created from parsing some input bits?
* Invoking on a class not yet parsed?
* Invoking on a parsed class which included flow control?]
* Invoking on a parsed class which included parameter list values?]

Rule O.1: lengthof() Operator

lengthof(variable)

The range operator defines the inclusive range of numbers from the specified *min\_value* up to the specified *max\_value*. The *min\_value* and *max\_value* must be of the same type and the *max\_value* must be greater than or equal to the *min\_value*.

Rule O.2: Range operator

min\_value ..max\_value

The following are all valid and unique range expressions:

EXAMPLE ⎯

-1..3

0b01..0b11

MinID..MaxID

0x01 .. MaxID

-1e5 .. 1e5

A period (i.e., ‘**.**’) can be used to access members of a **class** variable.

Rule O.3: Class member access operator

class\_variable\_identifier.member\_ identifier

The operator may be repeated if the member is itself a class variable e.g.:

EXAMPLE ⎯

level1.level2.level3

## Endianness

All quantities shall be represented in the bitstream with the most significant byte first, and the most significant bit first. Explicit references to endianness should be made in an SDL declaration where this is not the case.

[Editor’s note: this is not related to the syntax of SDL, it should be in a new clause discussing bitstream and in-memory values, value coercion etc.]

## Representation of numbers

The values of signed integer variables shall be represented in the bitstream using the two’s-complement representation. The values of float variables shall be represented in the bitstream using the interchange format for binary floating-point numbers defined in IEEE Std 754-2019 for the corresponding declared bit depth. Floating point variables using bit depths not defined by IEEE Std 754-2019 shall not be used.

[Editor’s note: this is not related to the syntax of SDL, it should be in a new clause discussing bitstream and in-memory values, value coercion etc.]

## Comments

Comments starts by // and ends at the end of the current line. A comment may be preceded by any text between the start of the line and the start of the comment.

Rule S.1: Comments

**//** *This is a comment.*

## Binary values

To designate literal binary values, the 0b prefix shall be used followed by a series of one or more 0 and 1 characters.

Rule S.2: Binary value

0bbinary\_value

A period (‘.’) may be optionally placed after every four digits for readability.

EXAMPLE ⎯

0b00100101

0b0010.0101

As the SDL is case sensitive, usage of a capital ‘**B**’ in the binary literal prefix is invalid. For example the following is invalid:

EXAMPLE ⎯

0B00100101 // not a binary literal as uppercase B has been used

## Hexadecimal values

To designate literal hexadecimal values, the prefix 0x shall be used followed by a series of characters in the range A to F and digits in the range 0 to 9.

Rule S.3: Hexadecimal value

0xhexadecimal\_value

A period (i.e., ‘**.**’) may be optionally placed after every four characters for readability:

EXAMPLE ⎯

0xCAFEBEEF

0xCAFE.BEEF

As the SDL is case sensitive, usage of a capital ‘**X**’ in the hexadecimal literal prefix is invalid. For example the following is invalid:

EXAMPLE ⎯

0XCAFEBEEF // not a hexadecimal literal as uppercase X has been used

NOTE 0x0F is equivalent to 0b0000.1111.

## Integer, decimal and floating-point values

Integer literal values can be defined using digits and an optional sign (i.e. ‘+’, ‘-') character. The following are valid integer literal values:

EXAMPLE ⎯

200

+200

-200

0

The following are invalid integer literal values:

EXAMPLE ⎯

-0 // signed zero is illegal

+0 // signed zero is illegal

002 // leading zeroes are illegal

Decimal literal values can be defined using digits, an optional sign character (i.e. ‘+’, ‘-‘) and an optional decimal separator (i.e. ‘.’). The following are valid decimal values:

EXAMPLE ⎯

58

58.0

58.3

+2.3

-2.3000

The following are invalid decimal literal values:

EXAMPLE ⎯

-0.0 // signed zero is illegal

002.3 // leading zeroes are illegal

Floating-point literal values can be defined using digits, an optional sign character (i.e. ‘+’, ‘-‘), an optional decimal separator (i.e. ‘.’) and an optional exponent indicator (i.e. ‘e’). The following are valid floating-point values:

EXAMPLE ⎯

58

-58.0

123e67

123.456e-67

-0 // negative zero

+0 // positive zero

Although the SDL supports signed zero for floating point literals, the interpretation and behaviour of using these values is not defined.

[Editor’s note: this could potentially be moved/addressed later in a new clause discussing bitstream and in-memory values, value coercion etc.]

The following are invalid floating-point literal values:

EXAMPLE ⎯

123E67 // uppercase E is illegal

00123e67 // leading zeroes are illegal

123e067 // leading zeroes are illegal

## Scoping rules

### Parsable Variables

All parsable variables (defined in 6 and 7) regardless of nested scope blocks and conditional branches have class scope, i.e., they are available as class member variables. The value of parsable variables with declarations that fall outside the flow of parsing shall have a default value of 0 for elementary types and an empty string for string types.

### Non-Parsable Variables

For non-parsable variables (defined in 8), a new scope is introduced by the character '{' and exited by the character '}'.

[Editor’s note: Make a reference to the implicit usage of {} in single line if/else or loop clauses]

A non-parsable variable identifier can only be defined once within a single scope. If an identifier defined in an outer scope is defined again within a nested inner scope, then within the inner scope, references to the identifier will refer to the inner scope variable definition and the outer scope variable definition is not visible.

Non-parsable variables declared in the top-level scope of a class are considered class member variables and are thus available in references to that particular type.

[Editor’s note: There is an outstanding question as to the validity of the last statement above]

# Elementary data types

## Introduction

The SDL defines the following elementary data types as listed below and then described in more detail in the subsequent subclauses:

1. **Constant-length direct representation bit fields or Fixed Length Codes (FLCs)**. These describe the encoded value exactly as it is to be used by the appropriate decoding process. (subclause 6.2)
2. **Variable length direct representation bit fields, or parametric FLCs**. These are FLCs for which the actual length is determined by the context of the bitstream (e.g., the value of another parameter). (subclause 6.3)
3. **Constant-length indirect representation bit fields**. These require an extra lookup using an encoded value FLC into an appropriate table or variable to obtain the desired value or set of values. (subclause 6.4)
4. **Variable-length indirect representation bit fields (e.g., Huffman codes)**. These require an extra lookup using an encoded value parametric FLC into an appropriate table or variable to obtain the desired valu**e** or set of values. (subclause 6.5)
5. **Variable length strings**. These represent a series of characters. (subclause 6.6)

## Constant-length direct representation bit fields

Constant-length direct representation bit fields, or FLCs, shall be represented as:

Rule E.1: Elementary data types

[const] [aligned[(modifier)]] type(length) identifier [**=** value]**;**

### Alignment

The keyword aligned indicates that the data is aligned on a byte boundary.

For example, a 32‑bit value aligned on a byte boundary:

EXAMPLE ⎯

aligned bit(32) foo;

[Editor’s note: An example bitstream for this would be:]

An optional numeric modifier attribute may be used to signify alignment on boundaries other than byte. Allowed values are 8, 16, 32, 64, and 128. Any skipped bits due to alignment shall have the value ‘0’.

For example, a 32‑bit value aligned on a 2‑byte boundary:

EXAMPLE ⎯

aligned(16) bit(32) foo;

[Editor’s note: An example bitstream for this would be:]

### Type

The grammar construct type may be any of the following: int for signed integer, unsigned int for unsigned integer, float for floating point, and bit for raw binary data.

NOTE double is a legacy alias for the keyword float. The use of the keyword double is no longer recommended.

### Length

The length attribute indicates that the length of the element value in bits, as it is stored in the bitstream. When the grammar construct type is float, then the length attribute shall be equal to 16, 32, 64, 128 or 256.

NOTE As some of those bit depths may be uncommon for floats, it is recommended to verify that the expected environment implementing a given specification supports the chosen bit depth.

[Editor’s note: What should be a limit for the width of variable types? Is unsigned int(5500000000) parsable\_variable1 valid? Should it be stated to be undefined and dependent on usage/parser implementation?]

For example, a 5‑bit unsigned integer that is parsable would be represented as:

EXAMPLE ⎯

unsigned int(5) parsable\_variable;

[Editor’s note: An example bitstream for this would be:]

### Value

The value attribute shall be present only when the value is constrained to a single value (e.g., start codes) or a range of values (i.e., ‘0x01..0xAF’).

A variable may be used when defining a single value or range of values for the *value* attribute. For example:

EXAMPLE ⎯

unsigned int(8) min = 0..4;

unsigned int(8) max = 4..7;

unsigned int(8) foo = min..max;

The single value or range of values defined must be valid for the declared variable type. For example the following is invalid:

EXAMPLE ⎯

unsigned int(8) foo = 0..5e10; // illegal usage of float value

Value truncation will occur when assigning a value to a parsable variable when the value is larger than the defined width of the variable. For example:

EXAMPLE ⎯

int(3) foo = 15; // the effective value will be 7 due to truncation

[Editor’s note: As a parsable variable value is mutable, once parsed is the value in memory constrained to the length attribute representation?]

[Editor’s note: string coercion to unsigned int needs to be explained as there is existing heavy use of unsigned int(32) "four character code" – potentially discuss string to int coercion and move the above truncation example in a new clause related to bitstream and in-memory values, value coercion etc.]

### Constants

Constants shall be defined using the keyword const.

EXAMPLE ⎯

const int SOME\_VALUE; // the parsed value will be immutable

const bit(2) BIT\_PATTERN=0b01; // the parsed value must be 0b01 and will be immutable

[Editor’s note: An example bitstream for this would be:]

### Look-ahead

In some scenarios, it may be desirable to examine the immediately following bits in the bitstream, without consuming these bits. To support this behavior, a ‘\*’ character shall be placed after the parse *length* parentheses to modify the parse size semantics.

Rule E.2: Look-ahead parsing

[aligned[(modifier)]] type (length)\* identifier [**=** value];

The keyword aligned and its modifier have the same definition as in subclause 6.2.1.

For example, the value of the next 32 bits in the bitstream can be read as an unsigned integer without advancing the current position in the bitstream using the following representation:

EXAMPLE ⎯

aligned unsigned int (32)\* next\_code;

switch(next\_code == 100) {

case 100:

class\_100 foo;

default:

class\_default foo;

}

NOTE The control statement switch is defined in subclause 9.1.

## Variable length direct representation bit fields

The case of variable length direct representation bit fields, or parametric FLCs is covered by Rule E.1, by allowing the length attribute to be a variable included in the bitstream, a non-parsable variable, or an expression involving such variables. In case the length attribute is determined by an expression, the result of this expression shall be a strictly positive integer value.

For example, in the following representation, the size of the variable DC is determined by the 3‑bit unsigned integer value precision:

EXAMPLE ⎯

unsigned int(3) precision;

int(precision) DC;

[Editor’s note: An example bitstream for this would be:]

## Constant-length indirect representation bit fields

Indirect representation indicates that the actual value of the element at hand is indirectly specified by the bitstream using a table or map structure. In other words, the value extracted from the bitstream, which is an FLC, is an index to a map from which the final desired value is extracted. This indirection may be expressed by defining the map itself:

Rule E.3: Maps

map map\_identifier (output\_type) {

index**,** {value[**,** …] }[,

…]

}

The content of the map is defined as a set of pairs of input *index* values and output *values*. The *index* values shall be unique.

NOTE The syntax for maps does not allow to specify the alignment of map index values. Achieving such alignment is the responsibility of the SDL definition author.

The input type of a map (the index specified in the first column) shall always be bit and therefore *index* values always expressed as Binary Values. For the case of constant-length indirect representation bit fields, these Binary Values shall all be the same length. The length in bits of the index is the number of bits read from the bitstream.

The output\_type of a map shall be either a ***type*** or a defined **class** (classes are defined in 7.1).

Output values used to populate the output\_type shall be specified as aggregates surrounded by curly braces.

For example, a map that relates an input binary value to an output populated YUVblocks **class** (classes are defined in subclause 7.1) can be defined using the following representation:

EXAMPLE ⎯

class YUVblocks {// classes are defined later on in this document

int Yblocks;

int Ublocks;

int Vblocks;

}

// a table that relates the chroma format with the number of blocks

// per signal component

map blocks\_per\_component (YUVblocks) {

0b00, {4, 1, 1},

0b01, {4, 2, 2},

0b10, {4, 4, 4}

}

In the above example the class YUVblocks contains only non-parsable member variables (defined in 8) Although the SDL does not prevent declaring map outputs to be classes containing parsable member variables, the behavior in this case is undefined.

As another example, a map that relates an input binary value to an output populated **int** value can be defined using the following representation:

EXAMPLE ⎯

map offsets (int) {

0b00, {1},

0b01, {2},

0b10, {4}

}

As class definitions may include nested hierarchies, the aggregate output values may also include nesting. As an example:

EXAMPLE ⎯

class Foo {

int f1;

f2;

}

class Bar {

int b1;

Foo foo1;

}

map barMap (Bar) {

0b00, {0, { 1, 1} },

0b01, {4, { 2, 2} },

0b10, {4, { 4, 4} }

}

The next rule describes the usage of map definitions to declare variables.

Rule E.4: Mapped data types

output\_type(map\_identifier) *map\_variable\_*identifier**;**

The output\_type of the variable shall be identical to the output\_type defined for the map.

For example, the following makes use of the blocks\_per\_component map defined above which has a YUVBlocks **class** output type:

EXAMPLE ⎯

YUVblocks(blocks\_per\_component) chroma\_format;

if (chroma\_format.Ublocks != 4) {

unsigned int(8) u\_width;

unsigned int(8) u\_height;

}

[Editor’s note: An example bitstream for this would be:]

As another example, the following makes use of the offsets map defined above which has an **int** output type:

EXAMPLE ⎯

int(offsets) index\_offset;

if (index\_offset == 2) {

unsigned int(6) foo;

}

[Editor’s note: An example bitstream for this would be:]

## Variable length indirect representation bit fields

For a variable length element utilizing a Huffman or variable length code table, an identical specification to the fixed length case shall be used.

The only difference is that the indices of the map are now of variable length and shall unambiguously identify each output value in addition of being unique (e.g. leaf values of a binary tree).

EXAMPLE ⎯

class val {

unsigned int foo;

int bar;

}

map sample\_vlc\_map (val) {

0b0000.001, {0, 5},

0b0000.0001, {1, -14}

}

Due to the large number of possible entries in variable length code tables, it may be inefficient to keep using variable length codewords for all possible values. Because of this, they are often partially defined. This necessitates the use of escape codes, that signal the subsequent use of a fixed-length (or even variable length) value representation. To support this, parsable variable ***type*** declarations are allowed for map output values.

In this case, the type of an output *value* within the map definition shall match the type associated with the map’s *output\_type*.

Rule E.5: Maps

map map\_identifier (output\_type) {

index**,** {value | type(length)[**,** …] }[,

…]

}

In the following example, when the codeword 0b0000.0000.1 is encountered in the bitstream, then the value ‘5’ is assigned to the first element of the output *value* (i.e., val.foo). The following 32 bits are then parsed and assigned as the value of the second element of the output *value* (i.e., val.bar).

EXAMPLE ⎯

class val {

unsigned int foo;

int bar;

}

map sample\_map\_with\_esc (val) {

0b0000.001, {0, 5},

0b0000.0001, {1, -14},

0b0000.0000.1, {5, int(32)},

0b0000.0000.0, {0, -20}

}

val(sample\_map\_with\_esc) myVal;

[Editor’s note: An example bitstream for this would be:]

NOTE In case more than one element utilizes a parsable type declaration, the order in which elements are parsed determines the extracted values.

## Variable length strings

A variable length string shall be represented as:

Rule E.6: String data types

[aligned[(modifier)]] string\_type string\_identifier [**=** [**u**|**u8**]**"**string\_value**"**]**;**

[Editor’s note: single quote is extensively used in existing standards, either switch from double to single or support both]

[Editor’s note: should **const** be supported for string types? How can strings be mutated?]

The string\_type may be any of the following: utf8string, utfstring, utf8list, base64string. The format of those string types is defined in Table 1 —. In these definitions, null-terminated means that the last character of a string is Unicode NUL, and hence an empty string is represented by a single Unicode NUL. Some fields using these types may restrict the characters permitted. In addition, space-separated means that a SPACE character whose Unicode is U+0020 is used as string separator. In a **utf8list** string, there shall not be any leading or trailing space character nor two consecutive space characters.

The keyword aligned and its modifier have the same definition as in subclause 6.2.1.

1. String data type definitions

|  |  |
| --- | --- |
| string\_type | **Format** |
| utf8string | UTF-8 string as defined in RFC 3629, null-terminated. |
| utfstring | null-terminated string encoded using either UTF-8 or UTF-16.  If UTF-16 is used, the sequence of bytes shall start with a byte order mark (BOM) and the null termination shall be 2 bytes set to 0. |
| utf8list | null-terminated list of space-separated UTF-8 strings |
| base64string | null-terminated compliant base64 encoded data as defined in clause 4 of RFC 4648 |

EXAMPLE ⎯

aligned(8) utf8string message;

base64string encoded\_data;

## String literals

The *string*\_*value* attribute shall represent a string literal as a sequence of characters enclosed in double quotation marks (**"** and **"**) with an allowed encoding prefix. The encoding prefix is one of the following: u8 for UTF-8 string literal or ufor UTF-16 string literal.

When a string literal is present, the encoding prefix of the string literal shall be compatible with the ***string\_type*** of the variable:

* a string literal prefix u8 with utf8string, utfstring and utf8list variables.
* a string literal prefix u with utfstring.

There shall not be any encoding prefix with base64string variables.

EXAMPLE ⎯

utfstring code = u8"this is a code";

utfstring label = u"this is a UTF-16 label";

utf8list interesting\_list = u8"apple orange cherry";

utf8string mot = u8"cœur";

# Composite data types

## Classes

Classes are the mechanism with which definitions of composite types is performed. Their definition is as follows.

Rule C.1: Classes

[aligned[(modifier)]] class class\_identifier {

[element**;** …]

}

The keyword aligned and its modifier have the same definition as in subclause 6.2.1.

The different *element* declarations within the curly braces (“{“ and “}”) are the definitions of the contained elementary data types (as defined in clause 6), composite data types (as defined in clause 7) or syntactic flow control elements (as defined in clause 9). Furthermore, a particular member element declared in a class may be accessed using the class member access operator (“**.**”).

NOTE Classes may also be encapsulated within other classes. In this case, the element in Rule C.1 is a class itself.

The order of declaration of the *elements* is the same order in which the elements appear in the bitstream.

The next rule describes the use of such a class.

Rule C.2: Class data types

class\_identifier *class\_variable\_*identifier**;**

## Base and derived classes

The optional keyword extends followed by the base\_class attribute specifies that the class is a derived class and that it derives from another class of type base\_class called the base class. The base class is either a class (as defined in subclause 7.1), a derived class (as defined in this subclause) or an abstract class (as defined in subclause 7.3). Derivation implies that all information present in the base class can also be accessed in the derived class, and that, in the bitstream, all such information *precedes* any additional bitstream syntax declarations specified in the derived class.

Rule C.3: Derived classes

[aligned[(modifier)]] class class\_identifier [extends base\_class] [**:** bit(length) [class\_id\_identifier **=**] *class\_*id | id\_range | *extended\_id\_range* ] {

[element**;** …]

}

The keyword aligned and its modifier have the same definition as in subclause 6.2.1.

The meaning of the keyword bit and its related attributes is defined in subclause 7.5.

[Editor’s note: Can a non-aligned class derive from an aligned sub-class?]

[Editor’s note: Can an aligned class derive from a non-aligned sub-class?]

[Editor’s note: Can an aligned class derive from an aligned sub-class with a different alignment width?]

NOTE Classes may also be encapsulated within other classes. In this case, the element in Rule C.3 is a class itself.

The order of declaration of the *element* is the same order in which the elements appear in the bitstream.

In the following example, bar.b immediately precedes bar.c in the bitstream:

EXAMPLE ⎯

class foo {

int(3) a;

}

class bar extends foo {

int(5) b;

int(10) c;

}

bar myBar;

[Editor’s note: An example bitstream for this would be:]

## Abstract classes

The optional keyword abstract specifies that the class is an abstract class. Only non-abstract classes, possibly derived from a base class, shall be present in the bitstream.

As an abstract class cannot appear in the bitstream, the keyword aligned and its modifier cannot be used in the declaration of an abstract class.

Rule C.4: Abstract classes

abstract class class\_identifier [extends base\_class] [**:** bit(length) [class\_id\_identifier**=**] *class\_*id | id\_range | *extended\_id\_range* ] {

[element**;** …]

}

The meaning of the keyword bit and its related attributes defined in subclause 7.5.

[Editor’s note: Can an abstract class derive from an abstract class?]

[Editor’s note: Can an abstract class derive from a non-abstract class?]

EXAMPLE ⎯

abstract class Shape {

}

class Circle extends Shape {

unsigned int(16) radius;

}

class Rectangle extends Shape {

unsigned int(16) width;

unsigned int(16) height;

}

// only Circle and Rectangle classes can be present

class Example {

Circle c;

Rectangle r;

}

Example myExample;

[Editor’s note: An example bitstream for this would be:]

## Expandable classes

When the expandable keyword is used in the class declaration, it indicates that the class may contain implicit arrays or undefined trailing data, called the “expansion”.

Rule C.5: Expandable classes

[aligned[(modifier)]] expandable[(max\_class\_size)] class class\_identifier [extends base\_class] [: bit(length) [class\_id\_identifier**=**] class\_id | id\_range | *extended\_id\_range* ] {

[element**;** …]

}

The keyword aligned and its modifier have the same definition as in subclause 6.2.1.

The meaning of the keyword bit and its related attributes defined in subclause 7.5.

Expandable classes may be used for classes that are required to support future compatible extensions or that may include private data. For example, a legacy device can decode an expandable class up to the last parsable variable appearing in the version of the class definition that the device is aware of and can skip the unknown class data following the last known variable.

To this end, an expandable class explicitly encodes its own size in bytes in the bitstream. The size precedes any parsable variables of the class and its variable-length encoding is defined below using the SDL convention:

int sizeOfInstance = 0;

bit(1) nextByte;

bit(7) sizeByte;

sizeOfInstance = sizeByte;

while(nextByte) {

bit(1) nextByte;

bit(7) sizeByte;

sizeOfInstance = sizeOfInstance << 7 | sizeByte;

}

NOTE By definition, the encoding of sizeOfInstance is always an integer number of bytes in size.

The size information is implicitly accessible within the class as the member variable sizeOfInstance whenever a class is made expandable.

As the sizeOfInstance value encodes the class size in bytes, an expandable class should be defined in a way to ensure that its size is always an integer number of bytes. If this is not the case, padding bits will exist in the bitstream at the end of the last encoded parsable member variable. These padding bits will be included when determining the sizeOfInstance value.

As the **expandable** keyword implies an encoded sizeOfInstance value, it cannot appear with the **abstract** keyword which implies a non-encoded class..

If the class definition uses the **bit** keyword indicating the presence of an encoded class\_id, the encoding of this value shall precede the size encoding. If the class is aligned, the alignment occurs in the bitstream before the encoded *class\_id* and size information. The size information shall not include the number of bytes needed for the size encoding, the bits skipped to achieve alignment nor the *class\_id* encoding.

Anywhere in the syntax where a set of expandable classes with class\_id values is expected, it is permissible to intersperse expandable classes with unknown class\_id values. These classes shall be skipped, using the size information.

If the expandable keyword has a maxClassSize attribute, then this indicates the maximum permissible size of this class in bytes, i.e. a maximum permissible value for sizeOfInstance. This information can help a parser to determine the appropriate type of integer to choose for holding the value of the variable sizeOfInstance.

Expandable class shall not derive from another expandable class.

[Editor’s note: Can a non-expandable class derive from an expandable class?]

[Editor’s note: Can an expandable class derive from a non-expandable class?]

The following example defines an expandable class with a maximum size of 120 bytes:

EXAMPLE ⎯

aligned expandable(120) class Example {

// note that as the class is expandable “sizeOfInstance” is accessible within this

// class as a constant value and lengthof(sizeOfInstance) will return a multiple of 8

int(3) a;

// 5 padding bits will follow in the bitstream to ensure the class

// size is an integer number of bytes

}

Example myExample;

[Editor’s note: An example bitstream for this would be:]

Note that as this is an expandable class, the sizeOfInstance is not declared in the class definition, but the value is encoded in the bitstream and is implicitly accessible via myExample.sizeOfInstance.

## Polymorphism in class declaration

### General

If the bit keyword is used, a derived class may appear at any point in the bitstream where its base class is used in the syntax, hence allowing to express polymorphism in the SDL syntax description. The class\_id value is the key demultiplexing entity which is present in the bitstream before any class member variable of the class. This allows differentiation between base and derived classes when parsing. The length of the class\_id is given by the length attribute following the bit keyword. The optional attribute *class*\_id\_identifier allows to access the class\_id from within the class. If the class is aligned, the alignment occurs in the bitstream before the encoded *class\_id*.

When the bit keyword is used, all derived class class\_id attributes shall specify the same length attribute value as the base class.

[Editor’s note: It is proposed to state that derived classes shall also always declare the same *class\_id\_identifier*.]

The actual class to be parsed is determined as follows:

* The base class declaration shall assign a constant value to class\_id.
* Each derived class declaration shall assign a constant value to class\_id.

NOTE Derived classes may use the same class\_id value as the base class. In that case, classes can only be discriminated through contextual information such as the value of a member variable from the base class.

EXAMPLE ⎯

class Foo : bit(2) id = 0 {

// note that as "id" is declared it is accessible within this class

// as a constant value and lengthof(id) will return 2

int(5) a;

}

class Foo1 extends Foo : bit(2) id = 1 {

int(5) b; // this b is preceded by the 5 bits of a

}

class Foo2 extends Foo : bit(2) id = 2 {

int(5) c; // this c is preceded by the 5 bits of a

}

class Example {

Foo f; // may be Foo, Foo1 or Foo2

}

Example myExample;

[Editor’s note: An example bitstream for this would be:]

As an alternative to a single class\_id value, it is also possible to define:

* an id\_range attribute which is a range of numerical values specified as start\_id **..** end\_id, inclusive of both bounds
* an *extended\_id\_range* attribute which is a combination of id\_range and class\_id specified as a comma-separated list of class\_id values and range\_id ranges e.g myId=0x01,0x02,0x10..Ox1F.

In such cases:

* The base class declaration shall declare a range of valid values via an id\_range or *extended\_id\_range.*
* Each derived class declaration shall assign a constant value or a range of valid values via an class\_id value or an id\_range or *extended\_id\_range*. This value or range of values shall correspond to legal values defined for the base class.

EXAMPLE ⎯

class Foo : bit(5) id = 1,10..20 {

int(5) a;

}

class Foo1 extends Foo : bit(2) id = 10 {

int(5) b; // this b is preceded by the 5 bits of a

}

### Polymorphism for abstract classes

Since abstract classes are not present in a bitstream, this means that the derived classes of an abstract class may use the entire range of *class\_id* values available. For the abstract base class, the class\_id shall be specified as 0 or alternatively an id\_range or *extended\_id\_range* shall be specified.

EXAMPLE ⎯

abstract class Foo : bit(1) id=0 { // the value 0 is not really used

}

// derived classes are free to use the entire range of ids, in this case 0..1

class Foo0 extends Foo : bit(1) id=0 {

int(5) a;

}

class Foo1 extends Foo : bit(1) id=1 {

int(10) b;

}

class Example {

Foo f; // can only be Foo0 or Foo1, not Foo

}

## Parameter types

A parameter type defines a class with parameters. This addresses cases where the data structure of the class depends on referencing values of one or more other parsed items. Parameter types provide placeholders for such references, in the same way as the arguments in a C function declaration. The syntax of a class definition with parameters is as follows.

Rule C.6: Class parameter types

[aligned[(modifier)]] [abstract] [expandable[(max\_class\_size)]] class class\_identifier [(parameter\_list)] [extends base\_class] [**:** bit(length) [class\_id\_identifier**=**] class\_id | id\_range | *extended\_id\_range*] {

[element**;** …]

}

[Editor’s note: base\_class attribute should be extended to allow parameter list values e.g. class

FileTypeBox extends Box('ftyp')]

The keyword aligned and its modifier have the same definition as in subclause 6.2.1.

The *parameter\_list* is a list of type or **class** identifiers and variable identifier pairs separated by commas. Usage of a ***string\_type*** in a *parameter\_list* is not supported. The value of any parsable variable or non-parsable variable (defined in 8) accessible within the current scope, can be passed as a parameter.

[Editor’s note: Use of string\_type in a parameter list is not necessarily required to support existing constructs such as class FileTypeBox extends Box('ftyp')as long as value coercion is discussed]

A class that uses parameter types is dependent on the values in its parameter list. When populating the member values of such a class, the parameters must be already be populated with values.

EXAMPLE ⎯

class A {

unsigned int(4) format;

}

class B (A a, int i) { // B uses parameter types

unsigned int(i) bar;

if( a.format == SOME\_FORMAT ) {

int(10) b;

}

}

class C {

int(2) i;

A a;

B foo(a, i); // parameters with populated values are required

}

C myExample;

[Editor’s note: An example bitstream for this would be:]

[Editor’s note: Also provide example definition which uses parameter list values in the base class of the extended class definition e.g. class FileTypeBox extends Box('ftyp')]

## Arrays

### General

Arrays are defined using square brackets. The array declaration is applicable to both elementary types and classes.

Rule A.1: Arrays

[aligned[(modifier)]] *typespec* array\_identifier [length]**;**

*typespec* is a parsable type specification (e.g., an elementary typewith a *length* attribute, e.g. **‘**int(2)**’**) or a **class** identifier. The attribute length specifies the capacity of the array. The length value can depend on other bitstream values or expressions that involve such values.

In the following example ‘a’ is an array of 5 elements, each of which is represented using 4 bits in the bitstream and interpreted as an unsigned integer:

EXAMPLE ⎯

unsigned int(4) a[5];

[Editor’s note: An example bitstream for this would be:]

In the following example the length of ‘c’ depends on the actual value of ‘b’:

EXAMPLE ⎯

int(10) b;

int(2) c[b];

[Editor’s note: An example bitstream for this would be:]

Individual values of an array are accessed using square brackets. For example:

EXAMPLE ⎯

int(4) a[5];

int b = a[0]; // b is set to the value of the first entry in a

NOTE In the example above b is a non-parsable variable as defined in 8

### Alignment

The keyword aligned indicates that the start of the array data is aligned on a byte boundary.

For example, an array where the first item is aligned on a byte boundary and the individual items are packed with no skipped bits for alignment:

EXAMPLE ⎯

aligned bit(5) foo[7];

[Editor’s note: An example bitstream for this would be:]

An optional numeric modifier attribute may be used to signify alignment on boundaries other than byte. Allowed values are 8, 16, 32, 64, and 128. Any skipped bits due to alignment shall have the value ‘0’.

## Multi-dimensional arrays

Multi-dimensional arrays are supported as well. The parsing order from the bitstream corresponds to scanning the array by incrementing first the right-most index of the array, then the second, and so on.

Rule A.2: Multi-dimensional arrays

[aligned[(modifier)]] typespec array\_identifier [length][length]…**;**

In the following example, a is an array of 5 elements, each of which is represented as an array of 6 elements using 4 bits in the bitstream and interpreted as an unsigned integer:

EXAMPLE ⎯

unsigned int(4) a[5][6];

## Partial arrays

In several situations, it is desirable to load the values of an array one by one, to check for a terminating or other condition. For this purpose, an extended array declaration is allowed in which individual elements of the array may be accessed for population i.e. allowing the definition of dynamically sized sparse arrays.

Rule A.3: Partial arrays

[aligned[(modifier)]] typespec array\_identifier[[index]]**;**

Here index is the index of the element of the array that is defined. Index values start at the value ‘0’. Several such partial definitions may be given, but they shall all agree on the typespec specification. This notation is also valid for multidimensional arrays.

In the following example, the entries of the one-dimensional array wordLength are populated in a sparse manner within the for loop. On the subsequent line, these values are then accessed to define and populate the two-dimensional array words (again in a sparse manner for one of the dimensions):

EXAMPLE ⎯

int i;

unsigned int(8) wordCount;

for (i = 0; i < wordCount; i++) {

// sparse array population

unsigned int(8) wordLength[[i]];

// first dimension sparse array population

// second dimension fully populated with a size defined by wordLength[i]

bit(8) words[[i]][wordLength[i]];

}

The following example indicates the element a(5, 3) of the array (the element in the 6th row and the 4th column):

EXAMPLE ⎯

int(4) a[[3]][[5]];

[Editor’s note: An example bitstream for this would be:]

The following example indicates the entire 6th column (index ‘5’) of the array, with a length of 3 elements of 4-bit integer values:

EXAMPLE ⎯

int(4) a[3][[5]];

[Editor’s note: An example bitstream for this would be:]

The following example indicates the entire 4th row (index ‘3’) of the array, with a length of 5 elements of 4-bit integer values:

EXAMPLE ⎯

int(4) a[[3]][5];

[Editor’s note: An example bitstream for this would be:]

NOTE a[5] specifies an array of five elements, whereas a[[5]] specifies the 6th element of an array which can contain at least six elements.

## Implicit arrays

An array with an implicit length is an implicit array. It is indicated by an array declaration without a length specification. To limit the possible minimum and maximum implicit length of the array, an optional range specification may be used as the specification of the length.

Rule A.4: Implicit arrays

[aligned[(modifier)]] typespec array\_identifier [[range]];

When a series of polymorphic classes is present in the bitstream, it may be represented as an array of the same type as that of the base class.

For example, assume that a set of polymorphic classes is defined, derived from the base class Foo (which may or may not be abstract):

EXAMPLE ⎯

class Foo : bit(16) id = 0 {

int(5) a;

}

Then an array of polymorphic classes with an explicit length of 100 can be defined as follows:

EXAMPLE ⎯

Foo explicit\_length\_array[100];

For an array of such classes, it is possible to implicitly determine the length by examining the validity of the class\_id of the class. Classes are inserted in the array as long as the class\_id can be properly resolved to one of the class\_id values defined in the base (if not abstract) or its derived classes.

NOTE When an implicit array is followed by further parsable data, there is a possibility that the following encoded bits match the value of a class class\_id. In this case, the SDL definition author should take care of preventing this possible ambiguity in the bitstream by a mechanism such as emulation prevention bytes or reserved value markers.

In the following example, the number of elements is implicitly obtained via class\_id resolution:

EXAMPLE ⎯

Foo f[]; // length implicitly obtained via class\_idresolution

In the following example, ‘f’ may have at least 1 and at most 255 elements:

EXAMPLE ⎯

Foo f[1..255]; // at least 1, at most 255 elements

# Non-parsable variables

## General

To accommodate complex syntactic constructs, in which context information cannot be directly obtained from the bitstream but only as a result of a computation, non-parsable variables are allowed.

Non-parsable variables may be used in expressions and conditions in the same way as parsable variables. In the following example, the number of non-zero elements of an array is computed.

EXAMPLE ⎯

int(4) myArray[100];

int i; // this is a temporary, non-parsable variable

int n = 0; // this is a temporary, non-parsable variable

for (i = 0; i < 100; i++) {

if (myArray[i] != 0) {

n++;

}

}

// read as many coefficients as there are non-zero elements in array

int(3) coefficients[n];

The memory storage size of non-parsable variables is not defined by the SDL. Care should be taken when creating SDL definitions to avoid unspecified behaviour. As an example:

EXAMPLE ⎯

bit b = 0;

b++; // b is now equal to 1

b++; // undefined as to whether this causes an error or b wraps to 0 or increments to 2

[Editor’s note: this could potentially be moved to a new clause discussing bitstream and in-memory values, value coercion etc.]

## Elementary data types

Non-parsable elementary data type variable declarations are distinguished from parsable variable declarations due to the absence of a *length* attribute.

Rule NP.1: Elementary data types

[const] type identifier [**=** value]**;**

The keyword const has the same definition as in subclause 6.2.5 and ***type*** is as previously defined in 6.2.2.

variable

foo

### Value

The value attribute shall be present only when the variable should be initialised with a value. A variable may be used when defining a value.

For example:

EXAMPLE ⎯

unsigned int initial = 0;

unsigned int foo = initial;

NOTE Unlike a parsable variable, a range of values cannot be specified when declaring a non-parsable variable.

## Arrays

Arrays are defined using square brackets. The array declaration for non-parsable variables is only applicable to elementary types.

Rule NP.2: Arrays

*type* array\_identifier [length]**;**

The attribute length has the same definition as in subclause 7.7 and ***type*** is as previously defined in 6.2.2.

In the following example ‘a’ is an array of 5 elements, each of which is an unsigned integer:

EXAMPLE ⎯

unsigned int a[5];

In the following example the length of ‘c’ depends on the value of the parsable variable ‘b’:

EXAMPLE ⎯

int(10) b;

int c[b];

Individual values of an array are accessed using square brackets. For example:

EXAMPLE ⎯

int a[5];

int b = a[0]; // b is set to the value of the first entry in a

## Multi-dimensional arrays

Non-parsable multi-dimensional arrays are supported as well.

Rule NP.3: Multi-dimensional arrays

typespec array\_identifier [length][length]…**;**

In the following example, a is an array of 5 elements, each of which is represented as an array of unsigned integer values:

EXAMPLE ⎯

unsigned int a[5][6];

## Scope

Non-parsable variables are strictly of local scope to the scope block (introduced by the character '{' and exited by the character '}' they are defined in.

[Editor’s note: Make reference to implicit {} in single line if/else or loop clauses]

However, non-parsable variables declared in the top-level scope of a class are considered class member variables and are thus may be accessed using the class member access operator e.g. ‘**.**’.

[Editor’s note: There is an outstanding question as to the validity of the statement above]

# Syntactic flow control

Syntactic flow control provides constructs that allow conditional parsing, depending on context, as well as repetitive parsing.

## Conditionals

The if-then-else construct is used for testing conditions.

A condition equal to zero corresponds to false, and non-zero condition corresponds to true.

[Editor’s note: this could potentially be moved to a new clause discussing bitstream and in-memory values, value coercion etc.]

Rule FC.1: Flow control using if-then-else

if (condition)

…

[ else if (condition)

…

]

[else

…

]

If a conditional clause contains a single statement, then usage of braces ‘{’ and ‘}’ is optional (they are implicit), but if multiple statements are present then braces are required. For example:

EXAMPLE ⎯

if (condition)

int(8) a;

else {

int(8) b;

int(8) c;

}

In the following example, the presence of the parsable variable ‘bar’ is determined by the ‘bar\_flag’:

EXAMPLE ⎯

class conditional\_class {

unsigned int(3) foo;

bit(1) bar\_flag;

if (bar\_flag) {

unsigned int(8) bar;

}

unsigned int(32) more\_foo;

}

conditional\_class myExample;

[Editor’s note: An example bitstream for this would be:]

NOTE The use of bar\_flag necessitates its declaration before the conditional is encountered.

A parsable variable may be defined more than once across conditional branches if the declared ***type*** is identical (the *length* attribute may differ). In the following example, two different representations for the parsable variable ‘bar’ are defined, depending on the value of ‘bar\_flag’.

EXAMPLE ⎯

class conditional\_class {

unsigned int(3) foo;

bit(1) bar\_flag;

if (bar\_flag) {

unsigned int(8) bar;

int dummy1 = 1; // inner-scope, non-parsable variable

} else {

unsigned int(16) bar;

int(8) optional\_foo;

int dummy2 = 2; // inner-scope, non-parsable variable

}

unsigned int(32) more\_foo;

int dummy3 = 3; // top-level scope, non-parsable variable

}

conditional\_class myExample;

[Editor’s note: An example bitstream for this would be:]

Using the above class definition, the following example clarifies this further:

EXAMPLE ⎯

conditional\_class CC;

// CC.foo, CC.bar\_flag, CC.bar, CC.optional\_foo and CC.more\_foo are accessible

// CC.dummy1 and CC.dummy2 are not accessible

// CC.dummy3 is accessible

// if CC.bar\_flag == 1 then:

// CC.bar is an 8-bit unsigned integer with a value parsed from the bitstream

// CC.optional\_foo is an 8-bit integer with a default value of 0

// if CC.bar\_flag == 0 then:

// CC.bar is a 16-bit unsigned integer with a value parsed from the bitstream

// CC.optional\_foo is an 8-bit integer with a value parsed from the bitstream

NOTE Usage of the keyword **break** to exit a clause within an if-then-else construct is not supported.

To facilitate cascades of if-then-else constructs, the **switch** statement is also allowed.

Rule FC.2: Flow control using switch

switch (condition) {

[case label:  
 [… ]  
 [break;]]

[default:

[…]]

}

EXAMPLE ⎯

unsigned int(32) type;

switch(type) {

case 0:

Foo f;

break;

case 1:

Bar b;

break;

default:

Moo m;

}

If the **break** keyword is not encountered, then the flow will continue onto the next labelled clause. The **case** and the **default** clauses may be optionally placed in braces ‘{’ and ‘}’ and this has no effect on the conditional flow. For example:

EXAMPLE ⎯

unsigned int(32) type;

switch(type) {

case 0:

// flow through to case 1

case 1: {

Foo f1;

} // brace scope has no effect

Foo f2;

// flow through to case 2

case 2: {

Bar b1;

Bar b2;

break;

} // brace scope has no effect

// no flow through to default

default:

Moo m;

}

## Loops

Context-sensitive constructs are also provided for iterative parsing. These constructs imply the repetitive use of the same syntax to parse the bitstream, until some condition is met.

In the **for**-loop syntax, expression1, expression2 and expression3 each constitute a single statement. If defined, expression1 can be either a non-parsable variable declaration with an assigned value or a value assignment and is executed prior to starting the repetitions. Then if expression2 is not defined, or it is defined and it evaluates to a non-zero numeric value or a logic value of true, the declarations within the scope of the **for**-loop are processed, followed by the execution of expression3 if it is defined. The process repeats until expression2 evaluates to a numeric value of zero or a logic value of false.

Rule FC.3: Flow control using for

for ([expression1]; [expression2]; [expression3])

…

If a single statement is defined within the **for**-loop, then usage of braces ‘{’ and ‘}’ is optional (they are implicit), but if multiple statements are present then braces are required. For example:

EXAMPLE ⎯

int i;

int n = 0;

for (i = 0; i < 10; i++) {

n++;

n--;

}

// n == 0 here

for (i = 0; i < 10; i++)

n++;

n--; // this is outside of the for loop

// n == 9 here

The following example shows a non-parsable variable declared within the scope of the for-loop construct:

EXAMPLE ⎯

int n = 0;

for (int i = 0; i < 10; i++) {

n++;

// i is accessible here

}

// i is not accessible here

NOTE Usage of the keyword **break** to exit a for-loop construct is not supported.

In the **do-while**-loop syntax, the block of statements is executed until condition evaluates to a numeric value of zero or a logical value of false.

NOTE The block will be executed at least once.

Rule FC.4: Flow control using do

do {

…

} while (condition);

Braces ‘{’ and ‘}’ are always required.

EXAMPLE ⎯

int i = 10;

do {

i--;

} while (i > 0);

NOTE Usage of the keyword **break** to exit a do-while-loop construct is not supported.

In the **while**-loop syntax, the loop is executed zero or more times, as long as condition evaluates to a non-zero numeric value or a logic value of true.

Rule FC.5: Flow control using while

while (condition)

…

If a single statement is defined within the **while**-loop, then usage of braces ‘{’ and ‘}’ is optional (they are implicit), but if multiple statements are present then braces are required. For example:

EXAMPLE ⎯

int i = 10;

while (i > 0) {

i++;

i = i - 2;

}

// i < 0 here

i = 10

while (i > 0)

i++;

i = i - 2; // this is outside of the while loop and is never reached

NOTE Usage of the keyword **break** to exit a while-loop construct is not supported.

1. (informative)  
     
   SDL user guide
   1. Getting started

In this section, we are going to cover some basic concepts to describe a binary structure using SDL. In order to avoid confusion with standards written using the SDL syntax, we will take the example of the MPEG-2 transport packet and construct a possible SDL declaration to describe it.

According to ISO/IEC 13818-1, the binary structure of a transport packet is:

Table 2-2 – Transport packet of this Recommendation | International Standard

| Syntax | No. of bits | Mnemonic |
| --- | --- | --- |
| transport\_packet(){ |  |  |
| **sync\_byte** | **8** | **bslbf** |
| **transport\_error\_indicator** | **1** | **bslbf** |
| **payload\_unit\_start\_indicator** | **1** | **bslbf** |
| **transport\_priority** | **1** | **bslbf** |
| **PID** | **13** | **uimsbf** |
| **transport\_scrambling\_control** | **2** | **bslbf** |
| **adaptation\_field\_control** | **2** | **bslbf** |
| **continuity\_counter** | **4** | **uimsbf** |
| if(adaptation\_field\_control = = '10' || adaptation\_field\_control = = '11'){ |  |  |
| adaptation\_field() |  |  |
| } |  |  |
| if(adaptation\_field\_control = = '01' || adaptation\_field\_control = = '11') { |  |  |
| for (i = 0; i < N; i++){ |  |  |
| **data\_byte** | **8** | **bslbf** |
| } |  |  |
| } |  |  |
| } |  |  |

As shown above, a transport packet is declared as a logical structure which can be encoded in a bitstream. A convenient way to reuse the same logical structure in SDL is to declare a **class**.

The minimum declaration for a class is an identifier and an empty body.

class transport\_packet {

// to be defined

}

The body of the class corresponds to the representation of the sequence of bits to be described. Based on the Table 2-2, we can see that the first byte of a transport packet is the sync\_byte. Let’s then declare this first byte in our new class.

class transport\_packet {

unsigned int(8) sync\_byte;

}

We chose to declare our first variable as unsigned integer and call it sync\_byte. Since its length is one byte, we pass the number 8 in parenthesis as the length attribute of this variable. But we can go a step further. Since the ISO/IEC 13818-1 standard requires the sync\_byte to be equal to '0100 0111' (0x47), we can also declare that this variable must be equal to this value.

class transport\_packet {

unsigned int(8) sync\_byte = 0x47;

}

The sync\_byte is followed by three 1-bit flag elements in the transport packet which are transport\_error\_indicator, payload\_unit\_start\_indicator, and transport\_priority. SDL allows to have syntax elements of any raw binary data using the keyword **bit** which we will use. Alternatively, we could also use unsigned int(1).

class transport\_packet {

unsigned int(8) sync\_byte = 0x47;  
 bit(1) transport\_error\_indicator;

bit(1) payload\_unit\_start\_indicator;

bit(1) transport\_priority;

}

Following the flags is the packet identifier (PID) which is a 13-bit field. Since we may want to manipulate this variable as a number (PID has well-defined hexadecimal values), we can declare it as an unsigned integer.

class transport\_packet {

unsigned int(8) sync\_byte = 0x47;  
 bit(1) transport\_error\_indicator;

bit(1) payload\_unit\_start\_indicator;

bit(1) transport\_priority;

unsigned int(13) PID;

}

After the PID comes two 2-bit control syntax elements whose values are defined as bit strings, e.g. '00' = Not scrambled, '01' = User-defined, etc. For simplicity, we will thus also define those variables as bit variables so that we can directly reuse the defined values in our declaration.

class transport\_packet {

unsigned int(8) sync\_byte = 0x47;  
 bit(1) transport\_error\_indicator;

bit(1) payload\_unit\_start\_indicator;

bit(1) transport\_priority;

unsigned int(13) PID;  
 bit(2) transport\_scrambling\_control;

bit(2) adaptation\_field\_control;

}

At this point, we have declared the non-variable part of the transport packet. As shown in Table 2-2, the reminder of the packet depends on the value of the adaptation\_field\_control element.

To represent this, we can use the **if**-statement defined by the SDL specification.

class transport\_packet {

unsigned int(8) sync\_byte = 0x47;  
 bit(1) transport\_error\_indicator;

bit(1) payload\_unit\_start\_indicator;

bit(1) transport\_priority;

unsigned int(13) PID;  
 bit(2) transport\_scrambling\_control;

bit(2) adaptation\_field\_control;

if (adaptation\_field\_control == 0b10 || adaptation\_field\_control == 0b11){

// to be defined

}

if (adaptation\_field\_control == 0b01 || adaptation\_field\_control == 0b11) {  
 // to be defined

}

}

As the reader can see, SDL allows us to test the value of a variable using the relation equal ‘**==**’ operator. Here since they are bit variables we use the binary value literal representation with prefix ‘**0b**’. Finally, the logical combination of tests is achieved using the logical OR operator ‘**||**’.

All that remains to declare is the two bodies of the **if**-statement. In the first one, a logical structure adaptation\_field() is present. To represent this, let’s assume that we have previously defined a **class** adaptation\_field so that we declare a variable whose type is this class.

class transport\_packet {

unsigned int(8) sync\_byte = 0x47;  
 bit(1) transport\_error\_indicator;

bit(1) payload\_unit\_start\_indicator;

bit(1) transport\_priority;

unsigned int(13) PID;  
 bit(2) transport\_scrambling\_control;

bit(2) adaptation\_field\_control;

if (adaptation\_field\_control == 0b10 || adaptation\_field\_control == 0b11){  
 adaptation\_field data;

}

if (adaptation\_field\_control == 0b01 || adaptation\_field\_control == 0b11) {  
 // to be defined

}

}

Note that we don’t need to declare how large this data field is as long as the declaration of the class adaptation\_field determines it.

To complete the transport packet, we need to declare the body of the second **if**-statement. The ISO/IEC 13818-1 defines this part of the transport packet as a loop over N-1 elements corresponding to a sequence of N-1 bytes. The SDL author may be tempted to use a **for** loop as well which would give:

class transport\_packet {

unsigned int(8) sync\_byte = 0x47;  
 bit(1) transport\_error\_indicator;

bit(1) payload\_unit\_start\_indicator;

bit(1) transport\_priority;

unsigned int(13) PID;  
 bit(2) transport\_scrambling\_control;

bit(2) adaptation\_field\_control;

if (adaptation\_field\_control == 0b10 || adaptation\_field\_control == 0b11){  
 adaptation\_field data;

}

if (adaptation\_field\_control == 0b01 || adaptation\_field\_control == 0b11) {  
 for (int i = 0; i < N; i++){

bit(8) data\_byte;

}

}

}

However, this declaration may not yield the intended result – declaring the same variable N-1 times will overwrite all previously parsed values and only keep the last one, just as if this SDL was defining executable code. If the SDL parser does not need those values this may be acceptable, however here this data constitutes the payload of the transport packet and we intend to keep this data intact. An elegant way to declare such sequence of bytes is by declaring an array of N-1 element instead of using a **for**-loop as follows:

class transport\_packet {

unsigned int(8) sync\_byte = 0x47;  
 bit(1) transport\_error\_indicator;

bit(1) payload\_unit\_start\_indicator;

bit(1) transport\_priority;

unsigned int(13) PID;  
 bit(2) transport\_scrambling\_control;

bit(2) adaptation\_field\_control;

if (adaptation\_field\_control == 0b10 || adaptation\_field\_control == 0b11){  
 adaptation\_field data;

}

if (adaptation\_field\_control == 0b01 || adaptation\_field\_control == 0b11) {

bit(8) data\_byte[N-1];

}

}

Our transport\_packet class is almost over. There is still an unknown variable we are using which is N. The ISO/IEC 13818-1 standard defines N as “specified by 184 minus the number of bytes in the adaptation\_field()”.

The variable N is thus not written in the bitstream but computed based on the context of the class at this point of the binary structure. For this, SDL defines non-parsable variables which can hold any value for the purpose of declaring SDL elements. Let’s then declare this variable as an unsigned integer and initialise it with the value 184.

class transport\_packet {

unsigned int(8) sync\_byte = 0x47;  
 bit(1) transport\_error\_indicator;

bit(1) payload\_unit\_start\_indicator;

bit(1) transport\_priority;

unsigned int(13) PID;  
 bit(2) transport\_scrambling\_control;

bit(2) adaptation\_field\_control;

unsigned int N = 184;

if (adaptation\_field\_control == 0b10 || adaptation\_field\_control == 0b11){  
 adaptation\_field data;  
 N = N – 1 – data.adaptation\_field\_length;

}

if (adaptation\_field\_control == 0b01 || adaptation\_field\_control == 0b11) {

bit(8) data\_byte[N];

}

}

In the class adaption\_field, we assume the existence of the variable adaptation\_field\_length as defined in the ISO/IEC 13818-1 standard as “an 8-bit field specifying the number of bytes in the adaptation\_field immediately following the adaptation\_field\_length”. Therefore, we can access this variable with the ‘**.**’ operator and calculate the size of the array.

With this last variable, this completes the declaration of the MPEG-2 transport packet as an SDL class.

* 1. Advanced concepts

[Editor’s note: Some advanced concepts in more details.]

* + 1. **Identifiers**

When defining identifiers in an SDL it is recommended to consider that automated tools may use these identifiers directly in a diverse range of programming languages. It is therefore recommended to avoid defining identifiers which start with digits or underscores as these identifiers may be illegal or have specific meaning in some programming languages. It is also recommended to avoid identifiers which may conflict with keywords in programming languages e.g. public.

* + 1. **Scoping and class member access**
    2. **Byte alignment**
    3. **Constants**
    4. **Maps**
    5. **Class inheritance**

When a class is defined using the **bit** keyword this indicates a *class\_id* is encoded in the bitstream before the encoded members of the class. The *class\_id* can be used by a parser to differentiate between base and derived classes.

The range of values that the *class\_id* can take is firstly defined by the *length* attribute defined after the **bit** keyword. For example bit(3) means that the total range of encoded *class\_id* values would be 0 to 7.

However, a base class may also define an *id\_range* or *extended\_id\_range* which acts to limit the potential valid values of a *class\_id*. For example:

class Foo : bit(3) 0,5,6..7 {

}

One area of uncertainty is if the definition using SDL does not define classes for all valid *class\_id* values.

For example:

class Foo : bit(3) 0,5,6..7 {

}

class Foo0 : bit(3) 0 {

}

class Foo5 : bit(3) 5 {

}

In the scenario above there are no class definitions for the *class\_id* values of 6 and 7. The behavior of a parser encountering a *class\_id*\_of 6 is not defined by the SDL and this must be addressed by the standard making use of the SDL.

If there were two further classes defined, such as:

class Foo6 : bit(3) 6 {

}

class Foo7 : bit(3) 7 {

}

a further area of uncertainty is if the parser encounters an illegal *class\_id* such as 2. The parser behaviour is not defined by the SDL and again this must be addressed by the standard making use of the SDL.

* + 1. **Abstract class**
    2. **Expandable class**
    3. **Parameter types**
    4. **Array**
  1. Common patterns

[Editor’s note: Discussion on top level scope/entry point via implicit array and using the following MPEG2 table as an example:]

[Editor’s note: Some example patterns such as Type–length–value (TLV), e.g. ISOBMFF box definition based on 4ccs.]

* 1. Tooling

[Editor’s note: Description of tooling for validating SDL syntax? generating binary parser from SDL?, etc..]