

GALGAS Book

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Chapter 7

Predefined Types

GALGAS predefines several types. This chapter presents all their features, including their constructors, readers, modifiers, methods, ...

The predefined types are:

- [@binaryset type \(page 25\)](#), binary set objects (implemented with Binary Decision Diagrams);
- [@bool type \(page 40\)](#), boolean objects;
- [@char type \(page 42\)](#), Unicode characters;
- [@double type \(page 48\)](#), floating point numbers;
- [@location type \(page 50\)](#), whose value points out a location in a source file;
- [@sint type \(page 51\)](#), the 32-bit signed integers;
- [@sint64 type \(page 55\)](#), the 64-bit signed integers;
- [@string type \(page 58\)](#), the Unicode string objects;
- [@stringset type \(page 58\)](#), set of @string objects;
- [@uint type \(page 60\)](#), the 32-bit unsigned integers;
- [@uint64 type \(page 65\)](#), the 64-bit unsigned integers.

7.1 The @binaryset Type

The @binaryset type encodes sets, binary relations, boolean mathematical expressions. It is implemented with Binary Decision Diagrams (BDD).

7.1.1 binarySetWithBit Constructor

Returns an @binaryset object whose *inBitIndex* bit is constraint to one.

```
constructor @binaryset binarySetWithBit
  ?@uint inBitIndex
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Example:

```
@binaryset s [binarySetWithBit !2] ;
log s ; # displays <@binaryset: 1XX>
```

7.1.2 binarySetWithEqualComparison Constructor

Returns an @binaryset object that encodes a equality relation between two variables.

```

constructor @binaryset binarySetWithEqualComparison
  ?@uint inLeftFirstIndex
  ?@uint inBitCount
  ?@uint inRightFirstIndex
  -> @binaryset ;

```

Availability: available in GALGAS 1.6.0 and later.

Discussion: the constructor returns an binary set that encodes the $a == b$ relation, where a is encoded from bit index $inLeftFirstIndex$ to bit index $inLeftFirstIndex + inBitCount - 1$, and b is encoded from bit index $inRightFirstIndex$ to $inRightFirstIndex + inBitCount - 1$.

Example:

```

@binaryset s [binarySetWithEqualComparison !0 !2 !3] ;
log s; # displays <@binaryset: 00x00, 01X01, 10X10, 11X11>

```

7.1.3 binarySetWithEqualToConstant Constructor

Returns an @binaryset object that encodes a equality relation between a variable and a constant.

```

constructor @binaryset binarySetWithEqualToConstant
  ?@uint inLeftFirstIndex
  ?@uint inBitCount
  ?@uint64 inConstant
  -> @binaryset ;

```

Availability: available in GALGAS 1.6.0 and later.

Discussion: the constructor returns an binary set that encodes the $a == cst$ relation, where a is encoded from bit index $inBitIndex$ to bit index $inBitIndex + inBitCount - 1$, and cst is defined by the $inConstant$ argument.

Example:

```

@binaryset s [binarySetWithEqualToConstant !0 !6 !23L] ;
log s; # displays <@binaryset: 10111>

```

7.1.4 binarySetWithGreaterOrEqualComparison Constructor

Returns an @binaryset object that encodes a greater or equal relation between two variables.

```

constructor @binaryset binarySetWithGreaterOrEqualComparison
  ?@uint inLeftFirstIndex
  ?@uint inBitCount
  ?@uint inRightFirstIndex
  -> @binaryset ;

```

Availability: available in GALGAS 1.6.0 and later.

Discussion: the constructor returns a binary set that encodes the $a \geq b$ relation, where a is encoded from bit index $inLeftFirstIndex$ to bit index $inLeftFirstIndex + inBitCount - 1$, and b is encoded from bit index $inRightFirstIndex$ to $inRightFirstIndex + inBitCount - 1$.

Example:

```
@binaryset s [binarySetWithGreaterOrEqualComparison !0 !2 !3] ;
log s; # displays <@binaryset: 00XXX, 01X01, 01X1X, 10X1X, 11X11>
```

7.1.5 binarySetWithGreaterOrEqualToConstant Constructor

Returns an @binaryset object that encodes a greater or equal relation between a variable and a constant.

```
constructor @binaryset binarySetWithGreaterOrEqualToConstant
  ?@uint inLeftFirstIndex
  ?@uint inBitCount
  ?@uint64 inConstant
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: the constructor returns a binary set that encodes the $a \geq cst$ relation, where a is encoded from bit index $inBitIndex$ to bit index $inBitIndex + inBitCount - 1$, and cst is defined by the $inConstant$ argument.

7.1.6 binarySetWithLowerOrEqualComparison Constructor

Returns an @binaryset object that encodes a lower or equal relation between two variables.

```
constructor @binaryset binarySetWithLowerOrEqualComparison
  ?@uint inLeftFirstIndex
  ?@uint inBitCount
  ?@uint inRightFirstIndex
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: the constructor returns a binary set that encodes the $a \leq b$ relation, where a is encoded from bit index $inLeftFirstIndex$ to bit index $inLeftFirstIndex + inBitCount - 1$, and b is encoded from bit index $inRightFirstIndex$ to $inRightFirstIndex + inBitCount - 1$.

Example:

```
@binaryset s [binarySetWithLowerOrEqualComparison !0 !2 !3] ;
log s; # displays <@binaryset: 00X00, 01X0X, 10X0X, 10X10, 11XXX>
```

7.1.7 binarySetWithLowerOrEqualToConstant Constructor

Returns an @binaryset object that encodes a lower or equal relation between a variable and a constant.

```

constructor @binaryset binarySetWithLowerOrEqualToConstant
  ?@uint inLeftFirstIndex
  ?@uint inBitCount
  ?@uint64 inConstant
  -> @binaryset ;

```

Availability: available in GALGAS 1.6.0 and later.

Discussion: the constructor returns a binary set that encodes the $a \leq cst$ relation, where a is encoded from bit index $inBitIndex$ to bit index $inBitIndex + inBitCount - 1$, and cst is defined by the $inConstant$ argument.

7.1.8 binarySetWithNotEqualComparison Constructor

Returns an @binaryset object that encodes an inequality relation between two variables.

```

constructor @binaryset binarySetWithNotEqualComparison
  ?@uint inLeftFirstIndex
  ?@uint inBitCount
  ?@uint inRightFirstIndex
  -> @binaryset ;

```

Availability: available in GALGAS 1.6.0 and later.

Discussion: the constructor returns a binary set that encodes the $a \neq b$ relation, where a is encoded from bit index $inLeftFirstIndex$ to bit index $inLeftFirstIndex + inBitCount - 1$, and b is encoded from bit index $inRightFirstIndex$ to $inRightFirstIndex + inBitCount - 1$.

Example:

```

@binaryset s [binarySetWithNotEqualComparison !0 !2 !3] ;
log s; # displays <@binaryset: 00X01, 00X1X, 01X00, 01X1X, 10X0X, 10X11, 11X0X, 11X10>

```

7.1.9 binarySetWithNotEqualToConstant Constructor

Returns an @binaryset object that encodes an inequality relation between a variable and a constant.

```

constructor @binaryset binarySetWithNotEqualToConstant
  ?@uint inLeftFirstIndex
  ?@uint inBitCount
  ?@uint64 inConstant
  -> @binaryset ;

```

Availability: available in GALGAS 1.6.0 and later.

Discussion: the constructor returns a binary set that encodes the $a \neq cst$ relation, where a is encoded from bit index $inBitIndex$ to bit index $inBitIndex + inBitCount - 1$, and cst is defined by the $inConstant$ argument.

7.1.10 binarySetWithPredicateString Constructor

Returns the @binaryset object described by the $inPredicateString$ argument.

```

constructor @binaryset binarySetWithPredicateString
  ?@string inPredicateString
  -> @binaryset ;

```

Availability: available in GALGAS 1.6.0 and later.

Discussion: the *inBitString* argument string encodes a predicate string, such as those returned by [predicateStringValue reader](#) (page 36).

The *inBitString* argument string characters should have one of the five following values:

- '0': a bit set to zero;
- '1': a bit set to one;
- 'X': a don't care bit;
- ' ': a separator (non significant character);
- '|': the boolean *or* operation (in infix notation).

Example. An empty predicate string (or a string containing only spaces) provides an empty binary set:

```

@binaryset s [binarySetWithPredicateString !" "];
@bool b := [s isEmptySet]; # b is true

```

Example. A predicate string containing only 'X' characters (at least one) provides an full binary set:

```

@binaryset s [binarySetWithPredicateString !"X X"]; # Spaces are non significant
@bool b := [s isFullSet]; # b is true

```

Example. You can use the boolean 'l' operator for providing an or'ed values:

```

@binaryset s [binarySetWithPredicateString !"1100"]; # 12 in decimal
log s; # Displays <@binaryset: 1100>

```

Example. A predicate string can encode a binary value (MSB first):

```

@binaryset s [binarySetWithPredicateString !"1100|1101"];
log s; # Displays <@binaryset: 110X>

```

Example. You can use you can use don't care bits and 'l' operator together:

```

@binaryset s [binarySetWithPredicateString !"11X00X0|111XXX"];
log s; # Displays <@binaryset: 1100X0, 111XXX>

```

7.1.11 binarySetWithStrictGreaterComparison Constructor

Returns an @binaryset object that encodes a strict greater than relation between two variables.

```

constructor @binaryset binarySetWithStrictGreaterComparison
  ?@uint inLeftFirstIndex
  ?@uint inBitCount
  ?@uint inRightFirstIndex
  -> @binaryset ;

```

Availability: available in GALGAS 1.6.0 and later.

Discussion: the constructor returns an binary set that encodes the $a > b$ relation, where a is encoded from bit index *inLeftFirstIndex* to bit index *inLeftFirstIndex* + *inBitCount* - 1, and b is encoded

from bit index *inRightFirstIndex* to *inRightFirstIndex* + *inBitCount* - 1.

Example:

```
@binaryset s [binarySetWithStrictGreaterComparison !0 !2 !3] ;
log s; # displays <@binaryset: 00X01, 00X1X, 01X1X, 10X11>
```

7.1.12 binarySetWithStrictGreaterThanConstant Constructor

Returns an @binaryset object that encodes a strict greater than relation between a variable and a constant.

```
constructor @binaryset binarySetWithStrictGreaterThanConstant
  ?@uint inLeftFirstIndex
  ?@uint inBitCount
  ?@uint64 inConstant
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: the constructor returns a binary set that encodes the $a > cst$ relation, where a is encoded from bit index *inBitIndex* to bit index *inBitIndex* + *inBitCount* - 1, and cst is defined by the *inConstant* argument.

7.1.13 binarySetWithStrictLowerComparison Constructor

Returns an @binaryset object that encodes a strict lower than relation between two variables.

```
constructor @binaryset binarySetWithStrictLowerComparison
  ?@uint inLeftFirstIndex
  ?@uint inBitCount
  ?@uint inRightFirstIndex
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: the constructor returns a binary set that encodes the $a < b$ relation, where a is encoded from bit index *inLeftFirstIndex* to bit index *inLeftFirstIndex* + *inBitCount* - 1, and b is encoded from bit index *inRightFirstIndex* to *inRightFirstIndex* + *inBitCount* - 1.

Example:

```
@binaryset s [binarySetWithStrictLowerComparison !0 !2 !3] ;
log s; # displays <@binaryset: 01X00, 10X0X, 11X0X, 11X10>
```

7.1.14 binarySetWithStrictLowerThanConstant Constructor

Returns an @binaryset object that encodes a strict lower than relation between a variable and a constant.

```

constructor @binaryset binarySetWithStrictLowerThanConstant
  ?@uint inLeftFirstIndex
  ?@uint inBitCount
  ?@uint64 inConstant
  -> @binaryset ;

```

Availability: available in GALGAS 1.6.0 and later.

Discussion: the constructor returns a binary set that encodes the $a < cst$ relation, where a is encoded from bit index $inBitIndex$ to bit index $inBitIndex + inBitCount - 1$, and cst is defined by the $inConstant$ argument.

7.1.15 emptyBinarySet Constructor

Returns an empty @binaryset object.

```

constructor @binaryset emptyBinarySet -> @binaryset ;

```

Availability: available in GALGAS 1.6.0 and later.

7.1.16 fullBinarySet Constructor

Returns a full @binaryset object.

```

constructor @binaryset fullBinarySet -> @binaryset ;

```

Availability: available in GALGAS 1.6.0 and later.

7.1.17 accessibleStates Reader

Returns the set of accessible states from an initial state set.

```

reader @binaryset accessibleStates -> @binaryset ;

```

Availability: available in GALGAS 1.6.0 and later.

Discussion: computes the set of accessible states from the $inInitialStateSet$ state set using the accessibility relation encoded by the receiver.

Example:

```

@binaryset graph [binarySetWithPredicateString !"0001 0000"] ; # Edge 0 -> 1
graph := graph | [@binaryset binarySetWithPredicateString !"0010 0001"] ; # Edge 1 ->
2
graph := graph | [@binaryset binarySetWithPredicateString !"0011 0010"] ; # Edge 2 ->
3
graph := graph | [@binaryset binarySetWithPredicateString !"0100 0011"] ; # Edge 3 ->
4
graph := graph | [@binaryset binarySetWithPredicateString !"0101 0100"] ; # Edge 4 ->
5
@binaryset initialState [binarySetWithPredicateString !"0000"] ; # 0 is the initial state
@binaryset accessibleStates := [graph accessibleStates !initialState !4] ;

```

```

message "Accessible:";
@uint64list valueList := [accessibleStates uint64ValueList !4] ;
foreach valueList do
message " " . [mValue string] ;
end foreach ;
message "\n";

```

This program displays: Accessible: 0 1 2 3 4 5.

7.1.18 binarySetByTranslatingFromIndex Reader

Returns a @binaryset value computed by translating the receiver's value by *inTranslation* bits from index *inFirstIndex*.

```

reader @binaryset binarySetByTranslatingFromIndex
?@uint inFirstIndex
?@uint inTranslation
-> @binaryset ;

```

Availability: available in GALGAS 1.6.3 and later.

7.1.19 compressedValueCount Reader

Returns in an @uint64 value the number of different compressed string values encoded by receiver's value.

```

reader @binaryset compressedValueCount -> @uint64 ;

```

Availability: available in GALGAS 1.6.0 and later.

7.1.20 compressedStringValueList Reader

Returns the list of compressed string values corresponding to receiver's value, considering it uses *inBitCount* bits.

```

reader @binaryset compressedStringValueList
?@uint inBitCount
-> @stringlist ;

```

Availability: available in GALGAS 1.6.0 and later.

7.1.21 containsValue Reader

Returns an @bool value indicating whether the receiver's value contains a given value.

```

reader @binaryset containsValue
?@uint inFirstBit
?@uint inBitCount
-> @bool ;

```

Availability: available in GALGAS 1.6.4 and later.

Discussion: returns true if the receiver's contains a value, and false otherwise; this value is computed from the *inBitCount* first bits of *inValue* value, shifted left by *inFirstBit*.

Example:

```
@binaryset s [binarySetWithPredicateString !"0 00XX X111|1 1111 1111" ] ;
log s ; # Displays <@binaryset: 000XXX111, 111111111>
@bool b := [s containsValue !127L !0 !7] ;
log b ; # Displays <@bool:true>
b := [s containsValue !31L !1 !7] ;
log b ; # Displays <@bool:true>
b := [s containsValue !63L !1 !8] ;
log b ; # Displays <@bool:false>
b := [s containsValue !7L !0 !9] ;
log b ; # Displays <@bool:true>
b := [s containsValue !7L !0 !10] ;
log b ; # Displays <@bool:true>
b := [s containsValue !32767L !1 !12] ;
log b ; # Displays <@bool:true>
```

7.1.22 equalTo Reader

Returns the complement of the exclusive or between the receiver's value and the operand's value.

```
reader @binaryset equalTo
  ?@binaryset inOperand
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Note that `[a equalTo !b]` is equivalent to $\sim (a \wedge b)$.

This operation returns an @binaryset value; do not confuse with == operator that returns an @bool value.

7.1.23 existOnBitIndex Reader

Returns the binary computed by applying the *exist* operator on the *inBitIndex* bit of the receiver's value.

```
reader @binaryset existOnBitIndex
  ?@uint inBitIndex
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.3 and later.

7.1.24 existsOnBitRange Reader

Returns the binary computed by applying the *exist* operator on the receiver's value, from *inFirstBitIndex* bit index until the *inFirstBitIndex* + *inBitCount* - 1 bit index.

```
reader @binaryset existsOnBitRange
  ?@uint inFirstBitIndex
  ?@uint inBitCount
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.3 and later.

Example:

```
@binaryset s [binarySetWithPredicateString !"01110010"] ;
log s ; # Displays <@binaryset: 01110010>
@binaryset ss := [s existsOnBitRange !2 !3] ;
log s ; # Displays <@binaryset: 011XXX10>
```

7.1.25 existOnBitIndexAndBeyond Reader

Returns the binary set computed by applying the *exist* operator on all bits from *inFirstBitIndex* bit index of the receiver's value.

```
reader @binaryset existOnBitIndexAndBeyond
  ?@uint inBitIndex
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.3 and later.

7.1.26 forAllOnBitIndex Reader

Returns the binary set computed by applying the *for all* operator on the *inFirstBitIndex* bit index of the receiver's value.

```
reader @binaryset forAllOnBitIndex
  ?@uint inBitIndex
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

7.1.27 forAllOnBitIndexAndBeyond Reader

Returns the binary computed by applying the *for all* operator on all bits from *inFirstBitIndex* bit index of the receiver's value.

```
reader @binaryset forAllOnBitIndexAndBeyond
  ?@uint inBitIndex
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

7.1.28 greaterOrEqualTo Reader

Returns the complement of the exclusive or between the receiver's value and the operand's value.

```
reader @binaryset greaterOrEqualTo
  ?@binaryset inOperand
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Note that `[a greaterOrEqualTo !b]` is equivalent to `(a | ~b)`.

7.1.29 isEmpty Reader

Returns a `@bool` value that indicates whether the receiver's value is the empty set.

```
reader @binaryset isEmpty -> @bool ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: returns true if receiver's value is the empty set, and false otherwise.

7.1.30 isFull Reader

Returns a `@bool` value that indicates whether the receiver's value is the full set.

```
reader @binaryset isFull -> @bool ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: returns true if receiver's value is the full set, and false otherwise.

7.1.31 ITE Reader

Returns the binary set computed by applying the *ite* operator on the receiver's value, the *inThenOperand* argument, and the *inElseOperand* argument.

```
reader @binaryset ITE
  ?@binaryset inThenOperand
  ?@binaryset inElseOperand
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.3 and later.

Discussion: `ite (x, y, z)` is `(x & y) | (~x & z)`.

7.1.32 lowerOrEqualTo Reader

Returns the binary set computed by applying the *lower or equal* operator on the receiver's value and the *inOperand* argument.

```
reader @binaryset lowerOrEqualTo
  ?@binaryset inOperand
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: `[a lowerOrEqualTo !b]` is `((~x) |y)`.

7.1.33 notEqualTo Reader

Returns the binary set computed by applying the *not equal* operator on the receiver's value and the *inOperand* argument.

```
reader @binaryset notEqualTo
  ?@binaryset inOperand
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: $[a \text{ notEqualTo } !b]$ is $(x \wedge y)$.

7.1.34 predicateStringValue Reader

Returns a string representation of the receiver's value.

```
reader @binaryset predicateStringValue -> @string ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: the returned string is compatible with the [binarySetWithPredicateString constructor](#) (page 28).

7.1.35 strictGreaterThan Reader

Returns the binary set computed by applying the *strict greater* operator on the receiver's value and the *inOperand* argument.

```
reader @binaryset strictGreaterThan
  ?@binaryset inOperand
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: $[a \text{ strictGreaterThan } !b]$ is $(x \ \& \ \sim y)$.

7.1.36 strictLowerThan Reader

Returns the binary set computed by applying the *strict lower* operator on the receiver's value and the *inOperand* argument.

```
reader @binaryset strictLowerThan
  ?@binaryset inOperand
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: $[a \text{ strictLowerThan } !b]$ is $(\sim x \ \& \ y)$.

7.1.37 stringValueList Reader

Returns the list of string values corresponding to receiver's value, considering it uses *inBitCount* bits.

```
reader @binaryset stringValueList
  ?@uint inBitCount
  -> @stringlist ;
```

Availability: available in GALGAS 1.6.0 and later.

7.1.38 stringValueListWithNameList Reader

Returns the list of named values corresponding to receiver's value, considering it uses *inBitCount* bits.

```
reader @binaryset stringValueListWithNameList
  ?@uint inBitCount
  ?@stringlist inNameList
  -> @stringlist ;
```

Availability: available in GALGAS 1.9.3 and later.

Discussion: first, the receiver is enumerated, considering it uses *inBitCount* bits. Each enumerated value is used as an index of *inNameList*, and the string value at this index is appended at the end of the returned value.

7.1.39 swap132 Reader

Returns the transposed (x, z, y) relation.

```
reader @binaryset swap132
  ?@uint inBitCount1
  ?@uint inBitCount2
  ?@uint inBitCount3
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: this reader considers that the receiver encodes an (x, y, z) relation, where x is defined by bits index 0 to $inBitCount1 - 1$, y is defined by bits index $inBitCount1$ to $inBitCount1 + inBitCount2 - 1$ and z is defined by bits index $inBitCount1 + inBitCount2$ to $inBitCount1 + inBitCount2 + inBitCount3 - 1$.

7.1.40 swap21 Reader

Returns the transposed (y, x) relation.

```
reader @binaryset swap21
  ?@uint inBitCount1
  ?@uint inBitCount2
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: this reader considers that the receiver encodes an (x, y) relation, where x is defined by bits index 0 to $inBitCount1 - 1$, y is defined by bits index $inBitCount1$ to $inBitCount1 + inBitCount2 - 1$.

7.1.41 swap213 Reader

Returns the transposed (y, x, z) relation.

```
reader @binaryset swap213
  ?@uint inBitCount1
  ?@uint inBitCount2
  ?@uint inBitCount3
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: this reader considers that the receiver encodes an (x, y, z) relation, where x is defined by bits index 0 to $inBitCount1 - 1$, y is defined by bits index $inBitCount1$ to $inBitCount1 + inBitCount2 - 1$ and z is defined by bits index $inBitCount1 + inBitCount2$ to $inBitCount1 + inBitCount2 + inBitCount3 - 1$.

7.1.42 swap231 Reader

Returns the transposed (y, z, x) relation.

```
reader @binaryset swap231
  ?@uint inBitCount1
  ?@uint inBitCount2
  ?@uint inBitCount3
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: this reader considers that the receiver encodes an (x, y, z) relation, where x is defined by bits index 0 to $inBitCount1 - 1$, y is defined by bits index $inBitCount1$ to $inBitCount1 + inBitCount2 - 1$ and z is defined by bits index $inBitCount1 + inBitCount2$ to $inBitCount1 + inBitCount2 + inBitCount3 - 1$.

7.1.43 swap312 Reader

Returns the transposed (z, x, y) relation.

```
reader @binaryset swap312
  ?@uint inBitCount1
  ?@uint inBitCount2
  ?@uint inBitCount3
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: this reader considers that the receiver encodes an (x, y, z) relation, where x is defined by bits index 0 to $inBitCount1 - 1$, y is defined by bits index $inBitCount1$ to $inBitCount1 + inBitCount2$

- 1 and z is defined by bits index $inBitCount1 + inBitCount2$ to $inBitCount1 + inBitCount2 + inBitCount3 - 1$.

7.1.44 swap321 Reader

Returns the transposed (z, y, x) relation.

```
reader @binaryset swap321
  ?@uint inBitCount1
  ?@uint inBitCount2
  ?@uint inBitCount3
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: this reader considers that the receiver encodes an (x, y, z) relation, where x is defined by bits index 0 to $inBitCount1 - 1$, y is defined by bits index $inBitCount1$ to $inBitCount1 + inBitCount2 - 1$ and z is defined by bits index $inBitCount1 + inBitCount2$ to $inBitCount1 + inBitCount2 + inBitCount3 - 1$.

7.1.45 transitiveClosure Reader

Returns the transitive closure of the relation encoded by the receiver.

```
reader @binaryset transitiveClosure
  ?@uint inBitCount
  -> @binaryset ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: this reader considers that the receiver encodes an (x, y) relation, where x is defined by bits index 0 to $inBitCount - 1$, y is defined by bits index $inBitCount$ to $2 * inBitCount - 1$.

7.1.46 uint64ValueList Reader

Returns the list of @uint64 values corresponding to receiver's value, considering it uses $inBitCount$ bits.

```
reader @binaryset uint64ValueList
  ?@uint64 inBitCount
  -> @uint64list ;
```

Availability: available in GALGAS 1.6.0 and later.

7.1.47 valueCount Reader

Returns in an @uint64 object the number of different values encoded by receiver, considering it uses $inBitCount$ bits.

```
reader @binaryset valueCount
?@uint inBitCount
-> @uint64 ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: no overflow test in performed.

7.1.48 Logical Operators

The @binaryset type supports the three logical operators:

&	Logical And, intersection
	Logical Or, union
^	Exclusive or

Theses operators require both arguments to be @binaryset objects and return an @binaryset object.

The @binaryset type supports the logical unary operator:

~	Negation, Complementation
---	---------------------------

This operator returns an @binaryset object.

7.1.49 Comparison Operators

The @binaryset type supports the two comparison operators:

=	Equality
!=	Non Equality

Theses operators require both arguments to be @binaryset objects, and return a @bool object. These operations are very fast and are performed in a constant time (integer equality comparison).

Do not confuse with [equalTo reader \(page 33\)](#) and [notEqualTo reader \(page 36\)](#) that return a @binaryset object.

7.1.50 Shift Operators

The @binaryset type supports the two shift operators:

<<	Left Shift
>>	Right Shift

Example:

```
@binaryset b [binarySetWithPredicateString !"1010"] ;
log b ; # displays: <@binaryset: 1010>
@binaryset bb := b << 3 ;
log bb ; # displays: <@binaryset: 1010XXX>
```

7.2 The @bool Type

An @bool object has a boolean value. The two keywords true and false belong to the @bool type, and denotes the true and false values.

No constructor is defined for the @bool type.

7.2.1 cString Reader

Returns a string representation of the receiver's value.

```
reader @bool cString -> @string ;
```

Availability: available in GALGAS 1.8.7 and later.

Discussion: returns the "true" string if the receiver's value is true, and the "false" string otherwise.

7.2.2 ocString Reader

Returns a string representation of the receiver's value.

```
reader @bool ocString -> @string ;
```

Availability: available in GALGAS 1.8.7 and later.

Discussion: returns the "YES" string if the receiver's value is true, and the "NO" string otherwise.

7.2.3 sint Reader

Returns the receiver's value in an [@sint type \(page 51\)](#) (32-bit signed integer) object.

```
reader @bool sint -> @sint ;
```

Availability: available in GALGAS 1.9.4 and later.

Discussion: returns the 1S @sint value if the receiver's value is true, and the 0S @sint value otherwise.

7.2.4 sint64 Reader

Returns the receiver's value in an [@sint64 type \(page 55\)](#) (64-bit signed integer) object.

```
reader @bool sint64 -> @sint64 ;
```

Availability: available in GALGAS 1.9.4 and later.

Discussion: returns the 1LS @sint64 value if the receiver's value is true, and the 0LS @sint64 value otherwise.

7.2.5 uint Reader

Returns the receiver's value in an [@uint type \(page 60\)](#) (32-bit unsigned integer) object.

```
reader @bool uint -> @uint ;
```

Availability: available in GALGAS 1.9.4 and later.

Discussion: returns the 1 @uint value if the receiver's value is true, and the 0 @uint value otherwise.

7.2.6 uint64 Reader

Returns the receiver's value in an @uint64 type (page 65) (64-bit unsigned integer) object.

```
reader @bool uint64 -> @uint64 ;
```

Availability: available in GALGAS 1.9.4 and later.

Discussion: returns the 1L @uint64 value if the receiver's value is true, and the 0S @uint64 value otherwise.

7.2.7 Logical Operators

The @bool type supports the three logical operators:

&	And
	Or
^	Exclusive or

These operators require both arguments to be @bool objects and return an @bool object.

The @uint type supports the logical unary operator:

not	Complementation
-----	-----------------

This operator returns an @bool object.

7.2.8 Comparison Operators

The @bool type supports the six comparison operators:

=	Equality
!=	Non Equality
<	Strict Lower Than
<=	Lower or Equal
>	Strict Greater Than
>=	Greater or Equal

These operators require both arguments to be @bool objects, and return a @bool object.

7.3 The @char Type

An @char object value is an Unicode character. You can initialize an @char object from a character constant:

```
@char myCharacter := 'A';
```

You have several ways for writing a literal character constant. In any case, it should define an assigned Unicode character. A compile-time error is raised if it does not.

A literal character constant is a single character or an escape sequence enclosed by single quotes (").

For an ASCII printable character:

```
@char myCharacter := 'a';
```

If you want to get ASCII source text file, any character that does not correspond to an ASCII printable character should be expressed with an escape sequence.

Otherwise, for any printable Unicode character, you can write it directly, without escape sequence, provided your text file encoding supports this character:

```
@char myCharacter := 'æ';
```

The following escape sequences are defined (they begin with a `\"`).

Character Constant	Meaning
'\f'	A Form Feed Character
'\n'	A New Line Character
'\r'	A Carriage Return Character
'\v'	A Vertical Tabulation Character
'\\'	A back slash Character
'\0'	A Nul Character
'\''	A Single Quote Character

Character Constant	Meaning
'\uABCD'	An Unicode Character

Where *ABCD* is a four digit hexadecimal number that represents an assigned Unicode point code.

For example:

```
@char myCharacter := '\u03A0'; # The 'Σ' character
```

Note: an unassigned point code raises a compile-time error:

```
@char myCharacter := '\uFFFF'; # The \uFFFF point code is not assigned
```

Character Constant	Meaning
'\Uabcdxyzt'	An Unicode Character

Where *abcdxyzt* is a eight digit hexadecimal number that represents an assigned Unicode point code. For example:

```
@char myCharacter := '\U0010170'; # The 'GREEK ACROPHONIC NAXIAN FIVE HUNDRED' character
```

Note: an unassigned point code raises a compile-time error:

```
@char myCharacter := '\U0000FFFF'; # Raises a compile-time error: \U0000FFFF is not assigned.
```

Any point code beyond `\U0010FFFF` is invalid and not assigned.

7.3.1 replacementCharacter **Constructor**

Returns an @char object corresponding to Unicode replacement character (`'\uFFFD`.

```
constructor @char replacementCharacter -> @char ;
```

Availability: available in GALGAS 1.8.3 and later.

7.3.2 unicodeCharacterWithUnsigned Constructor

Returns an @char object from an Unicode code point.

```
constructor @char unicodeCharacterWithUnsigned
  ?@uint inValue
  -> @char ;
```

Availability: available in GALGAS 1.8.3 and later.

Discussion: A run-time error is raised if the *inValue* value does not represent an assigned Unicode value. You can check if an @uint value represents an assigned Unicode value with the [isUnicodeValueAssigned](#) reader (page 62).

7.3.3 isalnum Reader

Returns an @bool value indicating whether the receiver's value represents an ASCII letter or an ASCII digit.

```
reader @char isalnum -> @bool ;
```

Availability: available in GALGAS 1.7.2 and later.

Discussion: returns true if the receiver's value represents an ASCII letter or an ASCII digit (between 'A' and 'Z', or between 'a' and 'z', or between '0' and '9'), and false otherwise.

7.3.4 isalpha Reader

Returns an @bool value indicating whether the receiver's value represents an ASCII letter.

```
reader @char isalpha -> @bool ;
```

Availability: available in GALGAS 1.7.2 and later.

Discussion: returns true if the receiver's value represents an ASCII letter (between 'A' and 'Z', or between 'a' and 'z'), and false otherwise.

7.3.5 iscntrl Reader

Returns an @bool value indicating whether the receiver's value represents an ASCII control character.

```
reader @char iscntrl -> @bool ;
```

Availability: available in GALGAS 1.7.2 and later.

Discussion: returns true if the receiver's value represents an ASCII control character (strictly before the *SPACE* character), and false otherwise.

7.3.6 isdigit Reader

Returns an @bool value indicating whether the receiver's value represents an ASCII digit.

```
reader @char isdigit -> @bool ;
```

Availability: available in GALGAS 1.7.2 and later.

Discussion: returns true if the receiver's value represents an ASCII digit (between '0' and '9'), and false otherwise.

7.3.7 islower Reader

Returns an @bool value indicating whether the receiver's value represents an ASCII lowercase ASCII letter.

```
reader @char islower -> @bool ;
```

Availability: available in GALGAS 1.7.2 and later.

Discussion: returns true if the receiver's value represents an ASCII lowercase letter (between 'a' and 'z'), and false otherwise.

7.3.8 isUnicodeCommand Reader

Returns an @bool value indicating whether the receiver's value represents an Unicode command.

```
reader @char isUnicodeCommand -> @bool ;
```

Availability: available in GALGAS 1.8.3 and later.

Discussion: returns true if the receiver's value represents an Unicode command, and false otherwise.

7.3.9 isUnicodeLetter Reader

Returns an @bool value indicating whether the receiver's value represents an Unicode letter.

```
reader @char isUnicodeLetter -> @bool ;
```

Availability: available in GALGAS 1.8.3 and later.

Discussion: returns true if the receiver's value represents an Unicode letter, and false otherwise.

7.3.10 isUnicodeMark Reader

Returns an @bool value indicating whether the receiver's value represents an Unicode mark character.

```
reader @char isUnicodeMark -> @bool ;
```

Availability: available in GALGAS 1.8.3 and later.

Discussion: returns true if the receiver's value represents an Unicode mark character, and false otherwise.

7.3.11 isUnicodePunctuation Reader

Returns an @bool value indicating whether the receiver's value represents an Unicode punctuation character.

```
reader @char isUnicodePunctuation -> @bool ;
```

Availability: available in GALGAS 1.8.3 and later.

Discussion: returns true if the receiver's value represents an Unicode punctuation character, and false otherwise.

7.3.12 isUnicodeSeparator Reader

Returns an @bool value indicating whether the receiver's value represents an Unicode separator character.

```
reader @char isUnicodeSeparator -> @bool ;
```

Availability: available in GALGAS 1.8.3 and later.

Discussion: returns true if the receiver's value represents an Unicode separator character, and false otherwise.

7.3.13 isUnicodeSymbol Reader

Returns an @bool value indicating whether the receiver's value represents an Unicode symbol character.

```
reader @char isUnicodeSymbol -> @bool ;
```

Availability: available in GALGAS 1.8.3 and later.

Discussion: returns true if the receiver's value represents an Unicode symbol character, and false otherwise.

7.3.14 isupper Reader

Returns an @bool value indicating whether the receiver's value represents an ASCII uppercase ASCII letter.

```
reader @char isupper -> @bool ;
```

Availability: available in GALGAS 1.7.2 and later.

Discussion: returns true if the receiver's value represents an ASCII uppercase letter (between 'A' and 'Z'), and false otherwise.

7.3.15 string Reader

Returns returns a string representation of the receiver's value.

```
reader @char string -> @string ;
```

Availability: available in GALGAS 1.5.5 and later.

Discussion: returns a one character @string object, containing the receiver's value.

7.3.16 uint Reader

Returns an @uint object representing the Unicode code point of the receiver's value.

```
reader @char uint -> @uint64 ;
```

Availability: available in GALGAS 1.7.7 and later.

7.3.17 unicodeName Reader

Returns the unicode name of the receiver's value.

```
reader @char unicodeName -> @string ;
```

Availability: available in GALGAS 1.8.3 and later.

Discussion: for an decimal string representation of the receiver's value, see the [hexString reader \(page 62\)](#); for a decimal string representation of the receiver's value, see the [string reader \(page 63\)](#).

Example:

```
['Æ'.unicodeName] returns "LATIN CAPITAL LETTER AE "
```

7.3.18 unicodeToLower Reader

Returns the lowercase character corresponding to the receiver's value.

```
reader @char unicodeToLower -> @char ;
```

Availability: available in GALGAS 1.8.3 and later.

Discussion: if the receiver's value is an Unicode uppercase character, this reader returns the corresponding lowercase character. Otherwise, it returns the receiver's value.

Example:

```
['Æ'.unicodeToLower] returns 'æ'  
['æ'.unicodeToLower] returns 'æ'
```

7.3.19 unicodeToUpper Reader

Returns the uppercase character corresponding to the receiver's value.

```
reader @char unicodeToUpper -> @char ;
```

Availability: available in GALGAS 1.8.3 and later.

Discussion: if the receiver's value is an Unicode lowercase character, this reader returns the corresponding uppercase character. Otherwise, it returns the receiver's value.

Example:

```
['Æ'unicodeToUpper] returns 'Æ'
['æ'unicodeToUpper] returns 'Æ'
```

7.3.20 Comparison Operators

The @char type supports the six comparison operators:

=	Equality
!=	Non Equality
<	Strict Lower Than
<=	Lower or Equal
>	Strict Greater Than
>=	Greater or Equal

These operators require both arguments to be @char objects, and return a @bool object. Comparison is done by comparing of the Unicode code point's value.

7.4 The @double Type

The @double object values correspond to the C type double values. You can initialize an @double object from a float constant:

```
@double myDouble := 123.456 ;
```

Note that a @double constant is characterized by the occurrence of the decimal point (.)

7.4.1 sint Reader

Returns the receiver's value in an [@sint type \(page 51\)](#) (32-bit signed integer) object.

```
reader @double sint -> @sint ;
```

Availability: available in GALGAS 1.9.9 and later.

Discussion: if receiver's value is outside @sint bounds, a runtime error is raised.

7.4.2 sint64 Reader

Returns the receiver's value in an [@sint64 type \(page 55\)](#) (64-bit signed integer) object.

```
reader @double sint64 -> @sint64 ;
```

Availability: available in GALGAS 1.9.9 and later.

Discussion: if receiver's value is outside @sint64 bounds, a runtime error is raised.

7.4.3 string Reader

Returns a decimal string representation of the receiver's value.

```
reader @double string -> @string ;
```

Availability: available in GALGAS 1.7.7 and later.

Discussion: this reader never fails.

7.4.4 uint Reader

Returns the receiver's value in an @uint type (page 60) (32-bit unsigned integer) object.

```
reader @double uint -> @uint ;
```

Availability: available in GALGAS 1.9.9 and later.

Discussion: if receiver's value is outside @uint bounds, a runtime error is raised.

7.4.5 uint64 Reader

Returns the receiver's value in an @uint64 type (page 65) (64-bit unsigned integer) object.

```
reader @double uint64 -> @uint64 ;
```

Availability: available in GALGAS 1.9.9 and later.

Discussion: if receiver's value is outside @uint64 bounds, a runtime error is raised.

7.4.6 Arithmetic Operators

The @double type supports the five arithmetic diadic operators:

+	Addition
-	Substraction
*	Multiplication
/	Division
%	Modulo

Theses operators require both arguments to be @double objects.

A run-time error is raised if the operation leads to an overflow.

The @double type supports the following arithmetic unary operators:

+	No operation
-	Negate

This operator returns the receiver's value (an @double object).

7.4.7 Comparison Operators

The @double type supports the six comparison operators:

=	Equality
!=	Non Equality
<	Strict Lower Than
<=	Lower or Equal
>	Strict Greater Than
>=	Greater or Equal

These operators require both arguments to be @double objects, and return a @bool object.

7.5 The @location Type

An @location object value is a location in a source file. Objects of this type are useful for pointing out an error or a warning location.

7.5.1 The here Keyword

The here keyword indicates the current parsing location is the current source file. Assigning an @location object from the here keyword is a way for initializing an @location object:

```
@location currentLocation := here ;
```

7.5.2 nowhere Constructor

Returns an @location that does not points out any location.

```
constructor @location nowhere -> @location ;
```

Availability: available in GALGAS 2.1.2 and later.

Discussion: The returned object responds true to the [isNowhere reader \(page 50\)](#).

7.5.3 column Reader

Returns an @uint value containing the column of the receiver's value.

```
reader @location column -> @uint ;
```

Availability: available in GALGAS 1.8.2 and later.

Discussion: this reader raises a run-time error if the receiver's value responds true to the [isNowhere reader \(page 50\)](#).

7.5.4 isNowhere Reader

Returns an @bool value indicating whether the receiver's value points out a source location or does not.

```
reader @location isNowhere -> @bool ;
```

Availability: available in GALGAS 2.1.2 and later.

Discussion: this reader returns `true` if the receiver's value does not point out an actual location in a text source (i.e. it has been constructed using the `nowhere` constructor), and `false` if the receiver's value points out an actual location in a text source (i.e. it has been constructed using the `here` keyword).

7.5.5 line Reader

Returns an `@uint` value containing the line of the receiver's value.

```
reader @location line -> @uint ;
```

Availability: available in GALGAS 1.8.2 and later.

Discussion: this reader raises a run-time error if the receiver's value responds true to the [isNowhere reader \(page 50\)](#).

7.5.6 locationIndex Reader

Returns an `@uint` value containing the the offset from the the beginning of the source of the location defined by receiver's value.

```
reader @location locationIndex -> @uint ;
```

Availability: available in GALGAS 1.8.2 and later.

Discussion: this reader raises a run-time error if the receiver's value responds true to the [isNowhere reader \(page 50\)](#).

7.5.7 locationString Reader

returns an `@string` object that contains a string representation of the location defined by receiver's value.

```
reader @location locationString -> @string ;
```

Availability: available in GALGAS 1.8.2 and later.

Discussion: this reader raises a run-time error if the receiver's value responds true to the [isNowhere reader \(page 50\)](#).

7.6 The @sint Type

An `@sint` object value is a 32-bit signed integer value. You can initialize an `@sint` object from an 32-bit signed integer constant:

```
@sint mySignedInteger := 123_456S ;
```

Note that a 32-bit signed integer constant is characterized by the 'S' suffix.

7.6.1 min Constructor

Returns an @sint object that the minimum value of the 32-bit signed range.

```
constructor @sint min -> @sint ;
```

Availability: available in GALGAS 1.3.0 and later.

Discussion: the returned value is -2^{31} .

7.6.2 max Constructor

Returns an @sint object that the maximum value of the 32-bit signed range.

```
constructor @sint max -> @sint ;
```

Availability: available in GALGAS 1.3.0 and later.

Discussion: the returned value is $2^{31} - 1$.

7.6.3 double Reader

Returns the receiver's value converted in a @double object.

```
reader @sint double -> @double ;
```

Availability: available in GALGAS 1.9.8 and later.

Discussion: as a 32-bit integer value can always be converted in a @double value, this reader never fails.

7.6.4 sint64 Reader

Returns the receiver's value in an @sint64 type (page 55) (64-bit signed integer) object.

```
reader @sint sint64 -> @sint64 ;
```

Availability: available in GALGAS 1.6.12 and later.

Discussion: as a 32-bit signed value can always be converted in a 64-bit signed value, this reader never fails.

This reader is the only way to convert an @sint type (page 51) object into an @sint64 type (page 55) object.

7.6.5 string Reader

Returns a decimal string representation of the receiver's value.

```
reader @sint string -> @string ;
```

Availability: available in GALGAS 1.6.12 and later.

Discussion: for an hexadecimal string representation of the receiver's value, see [hexString reader \(page 62\)](#) and [xString reader \(page 64\)](#).

7.6.6 uint Reader

Returns the receiver's value in an [@uint type \(page 60\)](#) (32-bit unsigned integer) object.

```
reader @sint uint -> @uint ;
```

Availability: available in GALGAS 1.3.0 and later.

Discussion: an error is raised is receiver's value is negative.

This reader is the only way to convert an [@sint type \(page 51\)](#) object into an [@uint type \(page 60\)](#) object.

7.6.7 uint64 Reader

Returns the receiver's value in an [@uint64 type \(page 65\)](#) (64-bit unsigned integer) object.

```
reader @sint uint64 -> @uint64 ;
```

Availability: available in GALGAS 1.3.0 and later.

Discussion: an error is raised is receiver's value is negative.

This reader is the only way to convert an [@sint type \(page 51\)](#) object into an [@uint64 type \(page 65\)](#) object.

7.6.8 Incrementation and decrementation

The [@sint type \(page 51\)](#) supports incrementation and decrementation instructions.

```
@sint n := ... ; n ++ ; # Incrementation
@sint p := ... ; p - ; # Decrementation
```

The incrementation instruction raises an error if receiver's value is equal to $2^{31} - 1$.

The decrementation instruction raises an error if receiver's value is equal to -2^{31} .

Note that incrementation and decrementation are not available within an expression.

7.6.9 Arithmetic Operators

The @sint type supports the five arithmetic diadic operators:

+	Addition
-	Substraction
*	Multiplication
/	Division
%	Modulo

These operators require both arguments to be @sint objects.

A run-time error is raised if the operation leads to a 32-bit signed overflow.

The @sint type supports the following arithmetic unary operators:

+	No operation
-	Negate

This operator returns the receiver's value (an @sint object). A run-time error is raised if "-" operator is invoked on an object whose value is -2^{31} .

7.6.10 Shift Operators

The @sint type supports right and left shift operators:

<<	Left shift
>>	Right shift

These operators require the right argument to be @sint object, and the left argument to be @uint object.

Note the right shift inserts a zero bit in the most significant bit location if the receiver's value is negative, and a one bit otherwise (it is a arithmetic right shift).

The actual amount of the shift is the value of the right-hand operand masked by 31, i.e. the shift distance is always between 0 and 31.

7.6.11 Logical Operators

The @sint type supports the three bit-wise logical operators:

&	Bit-wise and
	Bit-wise or
^	Bit-wise exclusive or

These operators require both arguments to be @sint objects.

The @sint type supports the bit-wise logical unary operator:

~	Bit-wise complementation
---	--------------------------

This operator returns an @sint object.

7.6.12 Comparison Operators

The @sint type supports the six comparison operators:

=	Equality
!=	Non Equality
<	Strict Lower Than
<=	Lower or Equal
>	Strict Greater Than
>=	Greater or Equal

These operators require both arguments to be @sint objects, and return a @bool object.

7.7 The @sint64 Type

An @sint64 object value is a 64-bit signed integer value. You can initialize an @sint64 object from an 64-bit signed integer constant:

```
@sint64 mySignedInteger := 123_456LS ;
```

Note that a 64-bit signed integer constant is characterized by the 'LS' suffix.

7.7.1 min Constructor

Returns an @sint64 object that the minimum value of the 64-bit signed range.

```
constructor @sint64 min -> @sint64 ;
```

Availability: available in GALGAS 1.3.0 and later.

Discussion: the returned value is -2^{63} .

7.7.2 max Constructor

Returns an @sint64 object that the maximum value of the 64-bit signed range.

```
constructor @sint64 max -> @sint64 ;
```

Availability: available in GALGAS 1.3.0 and later.

Discussion: the returned value is $2^{63} - 1$.

7.7.3 double Reader

Returns the receiver's value converted in a @double object.

```
reader @sint64 double -> @double ;
```

Availability: available in GALGAS 1.9.8 and later.

Discussion: as a 64-bit integer value can always be converted in a @double value, this reader never fails.

7.7.4 sint Reader

Returns the receiver's value in an @sint type (page 51) (32-bit signed integer) object.

```
reader @sint64 sint -> @sint ;
```

Availability: available in GALGAS 1.3.0 and later.

Discussion: an error is raised is receiver's value is lower than -2^{31} or greater than $2^{31} - 1$.

This reader is the only way to convert an @sint64 type (page 55) object into an @sint type (page 51) object.

7.7.5 string Reader

Returns a decimal string representation of the receiver's value.

```
reader @sint64 string -> @string ;
```

Availability: available in GALGAS 1.6.12 and later.

Discussion: this reader never fails.

7.7.6 uint Reader

Returns the receiver's value in an [@uint type \(page 60\)](#) (32-bit unsigned integer) object.

```
reader @sint64 uint -> @uint ;
```

Availability: available in GALGAS 1.3.0 and later.

Discussion: an error is raised if receiver's value is negative or greater than $2^{32} - 1$.

This reader is the only way to convert an [@sint64 type \(page 55\)](#) object into an [@uint type \(page 60\)](#) object.

7.7.7 uint64 Reader

Returns the receiver's value in an [@uint64 type \(page 65\)](#) (64-bit unsigned integer) object.

```
reader @sint64 uint64 -> @uint64 ;
```

Availability: available in GALGAS 1.3.0 and later.

Discussion: this reader raises a run-time error if the receiver's value is negative.

This reader is the only way to convert an [@sint64 type \(page 55\)](#) object into an [@uint64 type \(page 65\)](#) object.

7.7.8 Incrementation and decrementation

The [@sint64 type \(page 55\)](#) supports incrementation and decrementation instructions.

```
@sint64 n := ... ; n ++ ; # Incrementation
@sint64 p := ... ; p - ; # Decrementation
```

The incrementation instruction raises an error if receiver's value is equal to $2^{63} - 1$.

The decrementation instruction raises an error if receiver's value is equal to -2^{63} .

Note that incrementation and decrementation are not available within an expression.

7.7.9 Arithmetic Operators

The [@sint64 type](#) supports the five arithmetic diadic operators:

+	Addition
-	Substraction
*	Multiplication
/	Division
%	Modulo

Theses operators require both arguments to be @sint64 objects.

A run-time error is raised if the operation leads to a 64-bit signed overflow.

The @sint type supports the following arithmetic unary operators:

+	No operation
-	Negate

This operator returns the receiver's value (an @sint object). A run-time error is raised if "-" operator is invoked on an object whose value is -2^{63} .

7.7.10 Shift Operators

The @sint64 type supports right and left shift operators:

<<	Left shift
>>	Right shift

Theses operators require the right argument to be @sint64 object, and the left argument to be @uint object.

Note the right shift inserts a zero bit in the most significant bit location if the receiver's value is negative, and a one bit otherwise (it is a arithmetic right shift).

The actual amount of the shift is the value of the right-hand operand masked by 63, i.e. the shift distance is always between 0 and 63.

7.7.11 Logical Operators

The @sint64 type supports the three bit-wise logical operators:

&	Bit-wise and
	Bit-wise or
^	Bit-wise exclusive or

Theses operators require both arguments to be @sint64 objects.

The @sint64 type supports the bit-wise logical unary operator:

~	Bit-wise complementation
---	--------------------------

This operator returns an @sint64 object.

7.7.12 Comparison Operators

The @sint64 type supports the six comparison operators:

=	Equality
!=	Non Equality
<	Strict Lower Than
<=	Lower or Equal
>	Strict Greater Than
>=	Greater or Equal

These operators require both arguments to be @sint64 objects, and return a @bool object.

7.8 The @string Type

A @string object value is an Unicode character string value. The @string type defines several constructors, readers constant methods and modifiers, described below.

Literal String Constants. Characters strings are written enclosed within quotation marks (") characters, as in many languages. For example: "a string". Note that a literal string constant is an actual @string object, so a reader can be used on it. For example: ["ae" uppercaseString] returns the "AE" string.

7.8.1 rightSubString Reader

Creates and returns the string built with the *inLength* last characters of the receiver. If the receiver contains less than *inLength* characters, the receiver's value is returned.

```
reader @string rightSubString
    ?@uint inLength
    -> @string ;
```

Availability: available in GALGAS 1.7.7 and later.

Example:

```
@string s := "abcdef";
@string s2 := [s rightSubString!3]; # The value of s2 is "def"
```

7.9 The @stringset Type

An @stringset object value is a set of @string values.

7.9.1 emptySet Constructor

Creates and returns an empty @stringset object.

```
constructor @stringset emptySet -> @stringset ;
```

Availability: available in GALGAS 1.3.0 and later.

7.9.2 setWithString Constructor

Creates and returns an @stringset object that contains the value of the *inString* argument object.

```
constructor @stringset setWithString
    ?@string inString
    -> @stringset ;
```

Availability: available in GALGAS 1.3.0 and later.

7.9.3 count Reader

Returns the number of strings in the set.

```
reader @stringset count -> @uint ;
```

Availability: available in GALGAS 1.3.0 and later.

7.9.4 hasKey Reader

Returns a boolean value that indicates whether the value of *inString* argument is present in the set.

```
reader @stringset hasKey
  ?@string inString
  -> @bool ;
```

Availability: available in GALGAS 1.3.0 and later.

Discussion: returns true if the value of *inString* argument is present in the set, false otherwise.

7.9.5 removeKey Modifier

Removes the value of *inString* argument from the receiver's value.

```
modifier @stringset removeKey
  ?@string inString
```

Availability: available in GALGAS 1.3.0 and later.

Discussion: if the receiver's value does not contain the value of *inString* argument, this modifier leaves the receiver's value unchanged.

7.9.6 the += Operator

The += operator adds a string value to the receiver. If the receiver's value already contains the added value, this operator has no effect.

Example:

```
@string aString := ... ;
@stringset aStringSet := ... ;
aStringSet += !aString ;
```

7.9.7 the & Operator

The & operator returns the intersection of its operand values.

Example:

```
@stringset s1 := ... ;
@stringset s2 := ... ;
@stringset s := s1 & s2 ; # s is the intersection of s1 and s2
```

7.9.8 the | Operator

The | operator returns the union of its operand values.

Example:

```
@stringset s1 := ... ;
@stringset s2 := ... ;
@stringset s := s1 |s2 ; # s is the union of s1 and s2
```

7.9.9 the – Operator

The – operator returns the difference of its operand values.

Example:

```
@stringset s1 := ... ;
@stringset s2 := ... ;
@stringset s := s1 - s2 ; # s is the difference of s1 and s2
```

7.9.10 Enumerating @stringset objects

The foreach instruction can be used for enumerating @stringset values; enumeration is performed in the ascending order, or in the reverse alphabetical order using the '>' qualifier.

```
@stringset s := ... ;
foreach s do
# the key constant has the value of current entry of s stringset
end foreach ;
```

7.9.11 Comparison Operators

The @stringset type supports the six comparison operators:

=	Equality
!=	Non Equality
<	Strict Inclusion
<=	Inclusion or Equality
>	Strict Greater
>=	Greater or Equality

These operators require both arguments to be @stringset objects, and return a @stringset object.

7.10 The @uint Type

An @uint object value is a 32-bit unsigned integer value. You can initialize an @uint object from an unsigned integer constant:

```
@uint myUnsignedInteger := 123_456 ;
Note that a 32-bit unsigned integer constant is characterized by no suffix.
```

7.10.1 errorCount Constructor

Returns an @uint object that contains the number of errors.

```
constructor @uint errorCount -> @uint ;
```

Availability: available in GALGAS 1.4.9 and later.

Discussion: The returned value is the cumulative count of errors from the beginning of execution.

Example:

```
@uint x := [@uint errorCount] ;
```

7.10.2 max Constructor

Returns an @uint object that the maximum value of the 32-bit unsigned range.

```
constructor @uint max -> @uint ;
```

Availability: available in GALGAS 1.3.0 and later.

Discussion: The returned value is $2^{32} - 1$ (4294967295).

7.10.3 valueWithMask Constructor

Returns an @uint object with bits from *inLowerIndex* to *inUpperIndex* equal to 1.

```
constructor @uint valueWithMask
  ?@uint inLowerIndex
  ?@uint inUpperIndex
  -> @uint ;
```

Availability: available in GALGAS 1.6.12 and later.

Discussion: a run-time error is raised if *inLowerIndex* > *inUpperIndex* or if *inUpperIndex* > 31.

Example:

```
@uint x := [@uint valueWithMask !2 !4] ; # x is equal to 28 (11100 in binary)
```

7.10.4 warningCount Constructor

Returns an @uint object that contains the number of warnings.

```
constructor @uint warningCount -> @uint ;
```

Availability: available in GALGAS 1.4.9 and later.

Discussion: The returned value is the cumulative count of warnings from the beginning of execution.

7.10.5 double Reader

Returns the receiver's value converted in a @double object.

```
reader @uint double -> @double ;
```

Availability: available in GALGAS 1.9.8 and later.

Discussion: as a 32-bit integer value can always be converted in a @double value, this reader never fails.

7.10.6 hexString Reader

Returns the an hexadecimal string representation of the receiver value, prefixed by the string "0x".

```
reader @uint hexString -> @string ;
```

Availability: available in GALGAS 1.5.2 and later.

Discussion: for getting an hexadecimal representation string without '0x' prefix, see [xString reader](#) (page 64).

7.10.7 isUnicodeValueAssigned Reader

Returns an @bool value indicating whether the receiver' value represents an assigned Unicode character.

```
reader @uint isUnicodeValueAssigned -> @bool ;
```

Availability: available in GALGAS 1.8.3 and later.

Discussion: it returns true if the receiver value represents an assigned Unicode character, false and otherwise.

Example:

```
[0xFFFF isUnicodeValueAssigned] # is false, as \uFFFF is not assigned.
[0x41 isUnicodeValueAssigned] # is true, as \u0041 is assigned (LATIN CAPITAL LETTER A).
```

7.10.8 lsbIndex Reader

Returns an @uint value of the index of the most significant bit of the receiver value.

```
reader @uint lsbIndex -> @uint ;
```

Availability: available in GALGAS 1.6.12 and later.

Discussion: it raises a run-time error if the receiver value is zero.

Example :

```
@uint value := 192 ; # 192 is 11000000 in binary
@uint x := [value lsbIndex] ; # x is equal to 7
The most significant bit of 192 is the 7th bit.
```

7.10.9 significantBitCount Reader

Returns the number of bits needed to express the receiver value.

```
reader @uint significantBitCount -> @uint ;
```

Availability: available in GALGAS 1.6.12 and later.

Discussion: if the receiver value is zero, it returns 0 ; otherwise, it returns the most significant bit index plus one.

Example :

```
@uint value := 145 ; # 145 is 10010001 in binary
```

```
@uint x := [value significantBitCount] ; # x is equal to 8
```

7.10.10 sint Reader

Returns the receiver's value in an [@sint type \(page 51\)](#) (32-bit signed integer) object.

```
reader @uint sint -> @sint ;
```

Availability: available in GALGAS 1.6.12 and later.

Discussion: an error is raised if receiver's value is greater than $2^{31} - 1$.

This reader is the only way to convert an [@uint type \(page 60\)](#) object into an [@sint type \(page 51\)](#) object.

7.10.11 sint64 Reader

Returns the receiver's value in an [@sint64 type \(page 55\)](#) (64-bit signed integer) object.

```
reader @uint sint64 -> @sint64 ;
```

Availability: available in GALGAS 1.6.12 and later.

Discussion: as a 32-bit unsigned value can always be converted in a 64-bit signed value, this reader never fails.

This reader is the only way to convert an [@uint type \(page 60\)](#) object into an [@sint64 type \(page 55\)](#) object.

7.10.12 string Reader

Returns a decimal string representation of the receiver's value.

```
reader @uint string -> @string ;
```

Availability: available in GALGAS 1.6.12 and later.

Discussion: for an hexadecimal string representation of the receiver's value, see [hexString reader \(page 62\)](#) and [xString reader \(page 64\)](#).

7.10.13 uint64 Reader

Returns the receiver's value in an [@uint64 type \(page 65\)](#) (64-bit unsigned integer) object.

```
reader @uint uint64 -> @uint64 ;
```

Availability: available in GALGAS 1.6.12 and later.

Discussion: as a 32-bit unsigned value can always be converted in a 64-bit unsigned value, this reader never fails.

This reader is the only way to convert an [@uint type \(page 60\)](#) object into an [@uint64 type \(page 65\)](#) object.

7.10.14 xString Reader

Returns an hexadecimal string representation of the receiver's value (without any prefix).

```
reader @uint xString -> @string ;
```

Availability: available in GALGAS 1.9.10 and later.

Discussion: for an decimal string representation of the receiver's value, see the [hexString reader \(page 62\)](#); for a decimal string representation of the receiver's value, see the [string reader \(page 63\)](#).

7.10.15 Incrementation and decrementation

The [@uint type \(page 60\)](#) supports incrementation and decrementation instructions.

```
@uint n := ... ; n ++ ; # Incrementation
@uint p := ... ; p - ; # Decrementation
```

The incrementation instruction raises an error if receiver's value is equal to $2^{32} - 1$.

The decrementation instruction raises an error if receiver's value is equal to 0.

Note that incrementation and decrementation are not available within an expression.

7.10.16 Arithmetic Operators

The [@uint type](#) supports the five arithmetic diadic operators:

+	Addition
-	Substraction
*	Multiplication
/	Division
%	Modulo

Theses operators require both arguments to be [@uint](#) objects.

A run-time error is raised if the operation leads to a 32-bit unsigned overflow.

The [@uint type](#) supports the following arithmetic unary operator:

+	No operation
---	--------------

This operator returns the receiver's value (an [@uint](#) object).

7.10.17 Shift Operators

The @uint type supports right and left shift operators:

<<	Left shift
>>	Right shift

Theses operators require both arguments to be @uint objects.

Note the right shift inserts always a zero bit in the most significant bit location (it is a logical right shift).

The actual amount of the shift is the value of the right-hand operand masked by 31, i.e. the shift distance is always between 0 and 31.

7.10.18 Logical Operators

The @uint type supports the three bit-wise logical operators:

&	Bit-wise and
	Bit-wise or
^	Bit-wise exclusive or

Theses operators require both arguments to be @uint objects.

The @uint type supports the bit-wise logical unary operator:

~	Bit-wise complementation
---	--------------------------

This operator returns an @uint object.

7.10.19 Comparison Operators

The @uint type supports the six comparison operators:

=	Equality
!=	Non Equality
<	Strict Lower Than
<=	Lower or Equal
>	Strict Greater Than
>=	Greater or Equal

Theses operators require both arguments to be @uint objects, and return a @bool object.

7.11 The @uint64 Type

An @uint64 object value is a 64-bit unsigned integer value. You can initialize an @uint64 object from a 64-bit unsigned integer constant:

```
@uint64 myUnsignedInteger := 123_456L ;
```

Note the 'L' suffix is required for a 64-bit unsigned integer constant.

7.11.1 max Constructor

Returns an @uint64 object that the maximum value of the 64-bit unsigned range.

```
constructor @uint64 max -> @uint64 ;
```

Availability: available in GALGAS 1.3.0 and later.

Discussion: The returned value is $2^{64} - 1$.

7.11.2 uint64BaseValueWithCompressedBitString Constructor

Returns an @uint64 object computed from a string containing '0', '1' or 'X' characters, replacing all occurrences of 'X' by '0'.

```
constructor @uint64 uint64BaseValueWithCompressedBitString
  ?@string inBitString
  -> @uint64 ;
```

Availability: available in GALGAS 1.6.4 and later.

Discussion: the *inBitString* argument should contain only '0', '1' or 'X' characters. A run time exception is raised if an other character appears.

This constructor considers the *inBitString* argument value as a binary encoding of an integer value. First, it internally replaces all 'X's by '0's, and then converts the resulting string into an integer value that is the one returned by this constructor.

Note that the first character of the *inBitString* argument value corresponds to the most significant bit of the converted value.

Example:

```
@uint64 v [uint64BaseValueWithCompressedBitString !"01XX10"] ;
log v ; # Displays <@uint64:18> ;
```

7.11.3 uint64MaskWithCompressedBitString Constructor

Returns an @uint64 object computed from a string containing '0', '1' or 'X' characters, replacing all occurrences of '0' by '1' and all occurrences of 'X' by '0'.

```
constructor @uint64 uint64MaskWithCompressedBitString
  ?@string inBitString
  -> @uint64 ;
```

Availability: available in GALGAS 1.6.4 and later.

Discussion: the *inBitString* argument should contain only '0', '1' and 'X' characters. A run time exception is raised if an other character appears.

This constructor considers the *inBitString* argument value as a binary encoding of an integer value. First, it internally replaces all '0's by '1's and all 'X's by '0's, and then converts the resulting string into an integer value that is the one returned by this constructor.

Note that the first '0' or '1' character of the *inBitString* argument value corresponds to the most significant Bit of the converted value.

Example:

```
@uint64 v [uint64MaskWithCompressedBitString !"01XX10"] ;
log v ; # Displays <@uint64:51> ;
```

7.11.4 uint64WithBitString Constructor

Returns an @uint64 object computed from a string containing '0' or '1' characters.

```
constructor @uint64 uint64WithBitString
  ?@string inBitString
  -> @uint64 ;
```

Availability: available in GALGAS 1.6.4 and later.

Discussion: the *inBitString* argument should contain only '0' and '1' characters. A run time exception is raised if an other character appears.

This constructor considers the *inBitString* argument value as a binary encoding of an integer value. It returns an @uint64 object containing the converted value.

Note that the first '1' character of the *inBitString* argument value corresponds to the most significant bit of the converted value.

Example:

```
@uint64 v [uint64WithBitString !"0101"]] ;
log v ; # Displays <@uint64:5> ;
```

7.11.5 double Reader

Returns the receiver's value converted in a @double object.

```
reader @uint64 double -> @double ;
```

Availability: available in GALGAS 1.9.8 and later.

Discussion: as a 64-bit integer value can always be converted in a @double value, this reader never fails.

7.11.6 hexString Reader

Returns the an hexadecimal string representation of the receiver value, prefixed by the string "0x".

```
reader @uint64 hexString -> @string ;
```

Availability: available in GALGAS 1.5.2 and later.

Discussion: for getting an hexadecimal representation string without "0x" prefix, see [xString reader \(page 69\)](#).

7.11.7 sint Reader

Returns the receiver's value in an [@sint type \(page 51\)](#) (32-bit signed integer) object.

```
reader @uint64 sint -> @sint ;
```

Availability: available in GALGAS 1.6.12 and later.

Discussion: an error is raised is receiver's value is greater than $2^{31} - 1$.

This reader is the only way to convert an [@uint64 type \(page 65\)](#) object into an [@sint type \(page 51\)](#) object.

7.11.8 sint64 Reader

Returns the receiver's value in an [@sint64 type \(page 55\)](#) (64-bit signed integer) object.

```
reader @uint64 sint64 -> @sint64 ;
```

Availability: available in GALGAS 1.6.12 and later.

Discussion: an error is raised is receiver's value is greater than $2^{63} - 1$.

This reader is the only way to convert an [@uint64 type \(page 65\)](#) object into an [@sint64 type \(page 55\)](#) object.

7.11.9 string Reader

Returns a decimal string representation of the receiver's value.

```
reader @uint64 string -> @string ;
```

Availability: available in GALGAS 1.6.12 and later.

Discussion: for an hexadecimal string representation of the receiver's value, see [hexString reader \(page 67\)](#) and [xString reader \(page 69\)](#).

7.11.10 uint Reader

Returns the receiver's value in an [@uint type \(page 60\)](#) (32-bit unsigned integer) object.

```
reader @uint64 uint -> @uint ;
```

Availability: available in GALGAS 1.6.12 and later.

Discussion: an error is raised is receiver's value is greater than $2^{32} - 1$.

This reader is the only way to convert an [@uint64 type \(page 65\)](#) object into an [@uint type \(page 60\)](#) object.

7.11.11 uintSlice Reader

Returns an [@uint type \(page 60\)](#) value, extracted from a bit slice of the receiver's value.

```
reader @uint64 uintSlice
  ?@uint inStartBit
  ?@uint inBitCount
  -> @uint ;
```

Availability: available in GALGAS 1.6.0 and later.

Discussion: the receiver's value is right shifted by *inStartBit*, and the resulted value is and'ed with a mask equal to $2^{inBitCount} - 1$.

This reader is the only way to convert an [@uint type \(page 60\)](#) object into an [@uint64 type \(page 65\)](#) object.

Example:

```
@uint64 v := 0x1234_5678_9ABC_DEF0L ;
@uint result := [v uintSlice !4 !5] ; # The result value is 0x8_9ABC
```

7.11.12 xString Reader

Returns an hexadecimal string representation of the receiver's value (without any prefix).

```
reader @uint64 xString -> @string ;
```

Availability: available in GALGAS 1.9.10 and later.

Discussion: for an decimal string representation of the receiver's value, see the [hexString reader \(page 67\)](#); for a decimal string representation of the receiver's value, see the [string reader \(page 68\)](#).

7.11.13 Incrementation and decrementation

The [@uint64 type \(page 65\)](#) supports incrementation and decrementation instructions.

```
@uint64 n := ... ; n ++ ; # Incrementation
@uint64 p := ... ; p - ; # Decrementation
```

The incrementation instruction raises an error if receiver's value is equal to $2^{64} - 1$.

The decrementation instruction raises an error if receiver's value is equal to 0.

Note that incrementation and decrementation are not available within an expression.

7.11.14 Arithmetic Operators

The [@uint64 type](#) supports the five arithmetic diadic operators:

+	Addition
-	Substraction
*	Multiplication
/	Division
%	Modulo

Theses operators require both arguments to be [@uint64](#) objects.

A run-time error is raised if the operation leads to a 64-bit unsigned overflow.

The [@uint64 type](#) supports the following arithmetic unary operator:

+	No operation
---	--------------

This operator returns the receiver's value (an [@uint64](#) object).

7.11.15 Shift Operators

The @uint type supports right and left shift operators:

<<	Left shift
>>	Right shift

Theses operators require the left argument to be @uint64 object, and the right argument to be @uint object.

Note the right shift inserts always a zero bit in the most significant bit location (it is a logical right shift).

The actual amount of the shift is the value of the right-hand operand masked by 63, i.e. the shift distance is always between 0 and 63.

7.11.16 Logical Operators

The @uint64 type supports the three bit-wise logical diadic operators:

&	Bit-wise and
	Bit-wise or
^	Bit-wise exclusive or

Theses operators require both arguments to be @uint64 objects.

The @uint64 type supports the bit-wise logical unary operator:

~	Bit-wise complementation
---	--------------------------

This operator returns an @uint64 object.

7.11.17 Comparison Operators

The @uint64 type supports the six comparison operators:

=	Equality
!=	Non Equality
<	Strict Lower Than
<=	Lower or Equal
>	Strict Greater Than
>=	Greater or Equal

Theses operators require both arguments to be @uint64 objects, and return a @bool object.

Chapter 8

User Types

8.1 List type

8.2 Sorted list type

8.3 Struct type

8.4 Class type

8.5 Map type

8.6 Map proxy type

8.7 Graph type

Chapter 9

Semantic Instructions

9.1 Append Instruction

9.2 Assignment Instruction

9.3 Cast Instruction

9.4 Drop Instruction

```
drop variable , ... ;
```

9.5 Error Instruction

9.6 Extern Action Call Instruction

9.7 Foreach Instruction

9.8 Grammar Instruction

9.9 If Instruction

9.10 Local Variable Declaration Instruction

```
@type variable ;
```

```
@type variable := expression ;
```

```
@type variable [constructor arguments] ;
```

9.11 Local Constant Declaration Instruction

9.12 Log Instruction

9.13 Loop Instruction

9.14 Method Call Instruction

9.15 Modifier Call Instruction

9.16 Switch Instruction

9.17 Send Instruction

9.18 Warning Instruction

Chapter 10

Syntax and Grammar Components

10.1 GALGAS and Context-Free Grammars

10.2 Writing a Syntax Component

10.3 Syntax Instructions

10.3.1 Terminal Symbol Instruction

10.3.2 Non Terminal Symbol Instruction

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