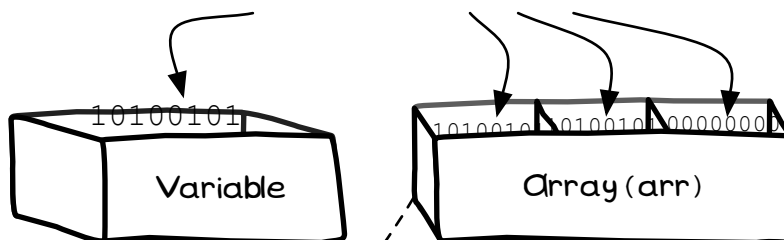


Variables store one or more values



Values exist in many locations in the code

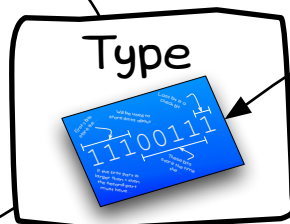
Expressions calculate a value

`my_rect.x + my_rect.width`

In the computer values are binary sequences

10100101

Types give meaning to values

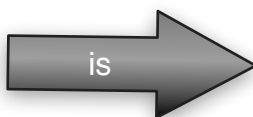


A Type is a blueprint describing how data is stored and interpreted

Type describes the size of the value (number of bits)

10100101

Type defines what the different values mean



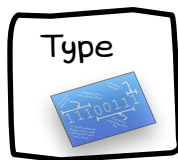
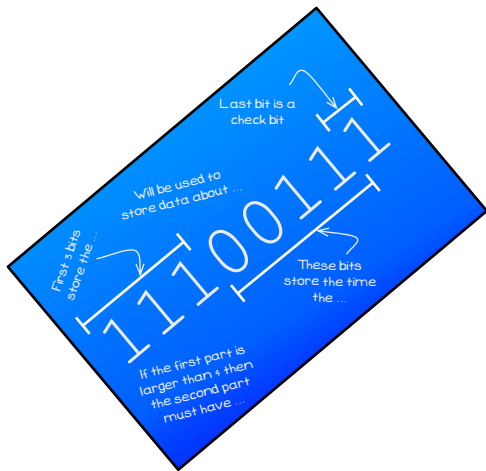
\tilde{N}

- if its a Character

165

- if its an Integer

A Type is a specification



Declares the code the compiler turns into an executable file

May use artefacts from Libraries

Has a name that is an

Program

Identifier

A Program may declare its own Procedures.

Procedure

Instruction 1
Instruction 2
Instruction 3
Instruction 4
Instruction 5

Parameter

Parameter

Constant

10100...

Variable

Variable

Type

Instruction 1
Instruction 2
...

A Program may declare its own Functions.

Function

Function

Function

Function

Function

Function

Function

Function

Function

Function

Function

Function

Function

Function

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Function

Function

Function

Function

A Program may declare its own Types.

The Program has an entry point that indicates where the program's instructions start

Value stores one of
a list of options

Type

Value contains a
number of fields

Enum

Data Kind is:
INT_DATA, or
DBL_DATA, or
TXT_DATA

Record/Struct

Coin Data has fields...
: Count (Integer)
: Value (Integer)
: Description (String)

Union / Variant Record

My Data stores an:
intValue (Integer),
dblValue (Double), or
txtValue (String)

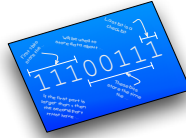
Others...

??????????

Value is one type or
another, from a list
of available options

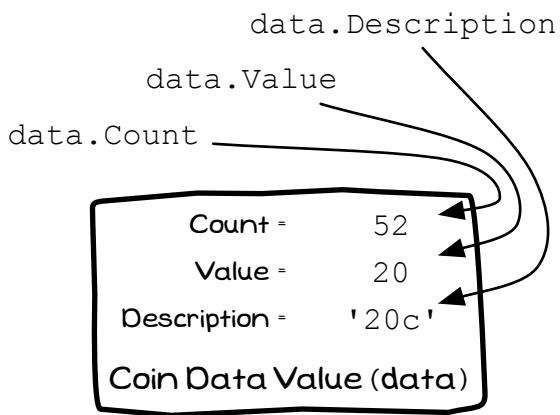
Languages may offer
other kinds of Type
as well

Record/Struct

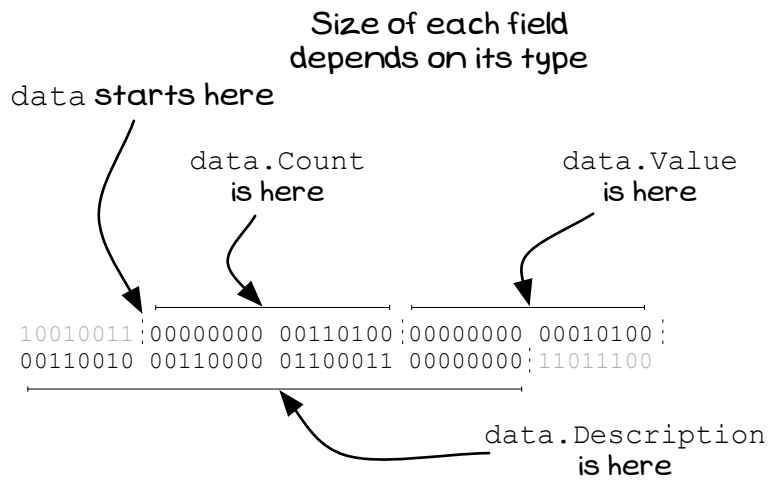


Coin Data has fields...

- : Count (Integer)
- : Value (Integer)
- : Description (String)

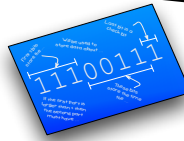


Conceptually



In Memory

Enum



Data Kind is:

INT_DATA, or

DBL_DATA, or

TXT_DATA

Each value is either
INT_DATA, DBL_DATA, or TXT_COINS



Conceptually

Each option is mapped
to a numeric value.

INT_DATA
is mapped to 0

DBL_DATA
is mapped to 1

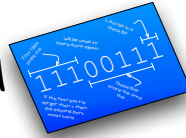
TXT_DATA
is mapped to 2

10010011;00000001;11011100

The first option get 0,
the second 1, the third 2,
and so on...

In Memory

Union / Variant Record

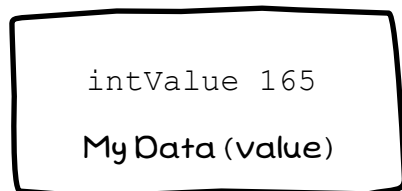


My Data stores an:

```
intValue (Integer),  
dblValue (Double), or  
txtValue (String of 9 chars)
```

Space taken is as large
as the largest type that
could be stored

Each value stores either the
Integer intValue,
the Double dblValue, or
Coin Data coinValue



Conceptually

If this stores
intValue then it only uses
the first four bytes (32 bits)
(others taken, but not used)

All 9 bytes, 72 bits
are used when this
stores txtValue

```
10010011 00000000 00000000 00000000 10100101  
00110010 00110000 01100011 00000000 11011100
```

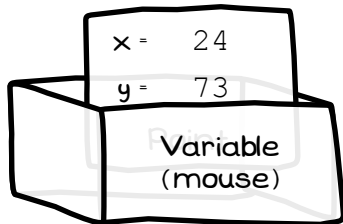
8 bytes (64 bits) are used when
this stores dblValue

In Memory

Is a value.

Values can be read from variables of the different custom types using an Expression

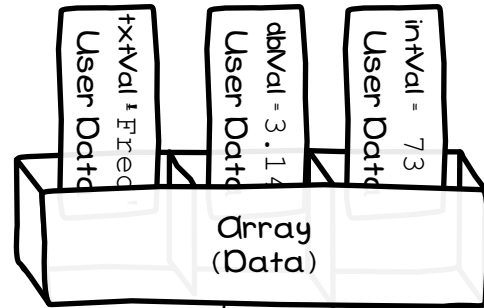
Expression



Read value from the field of a Record Variable

00011000

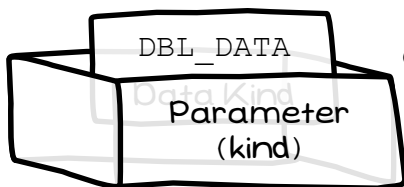
`mouse.x`



Read value from the field of a Union Variable

01001001

`data[2].intVal`

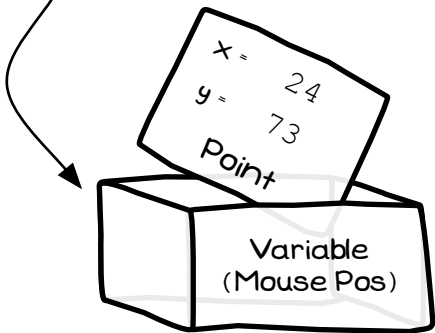


Read value of a Enumeration Variable

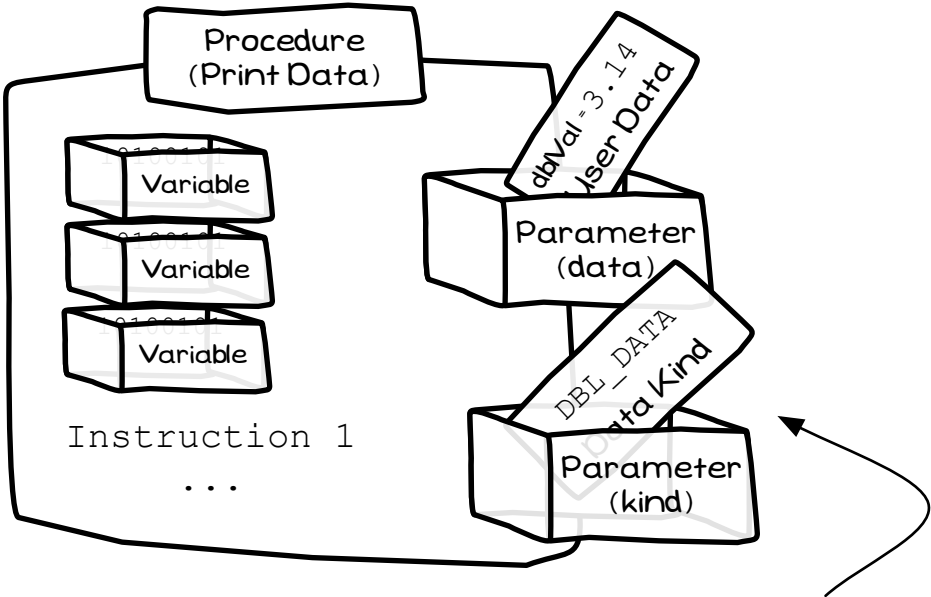
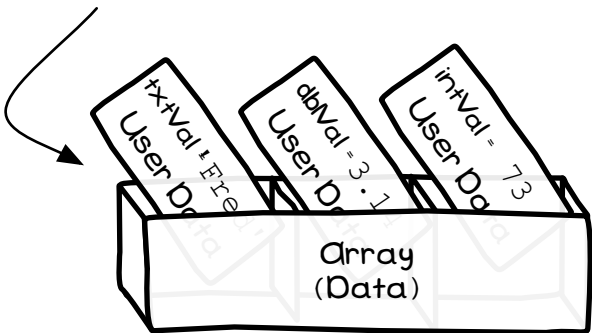
00000001

`kind`

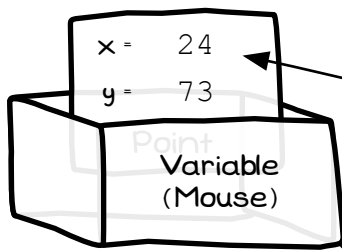
Values can be records like a Point record with X and Y coordinates



Elements of an array can be values of a union, allowing the one array to store integer, double, and text data in different elements



Parameters can accept enumerated values, in this case a value telling the Procedure the kind of data stored in the data parameter (which is a union)

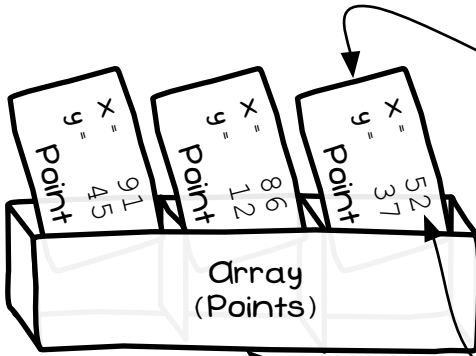


`mouse.x`

Is an Integer, it can be used
anywhere an Integer is required

`mouse`

Is a Point, it can be used
anywhere a Point is required



`points[2]`

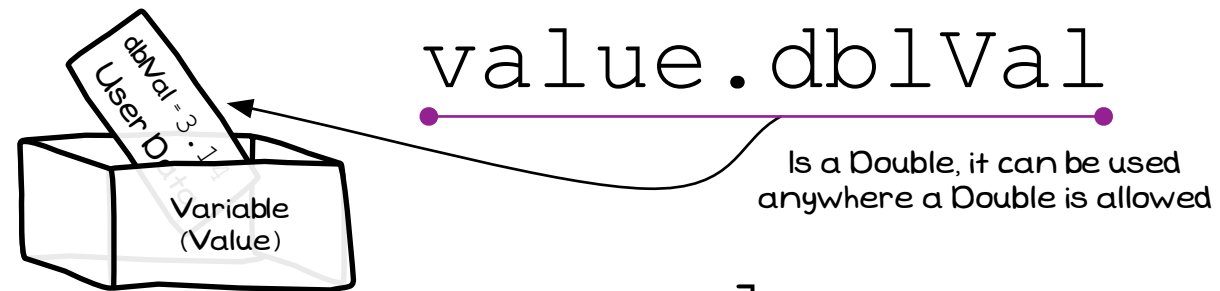
Is a Point, it can be used
anywhere a Point is required

`points[2].x`

Is an Integer, it can be used
anywhere an Integer is required

`points`

Is an Array of 3 Points, it can
be used anywhere an array of
Points is required

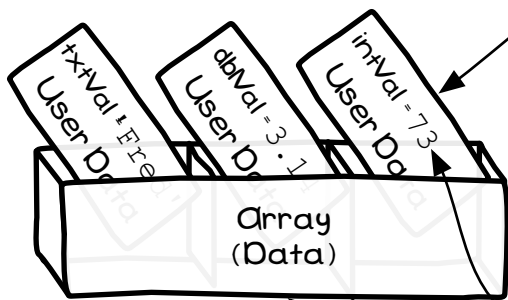


value.dblVal

Is a Double, it can be used
anywhere a Double is allowed

value

Is a UserData value, it can be used
anywhere a UserData value is allowed



data[2]

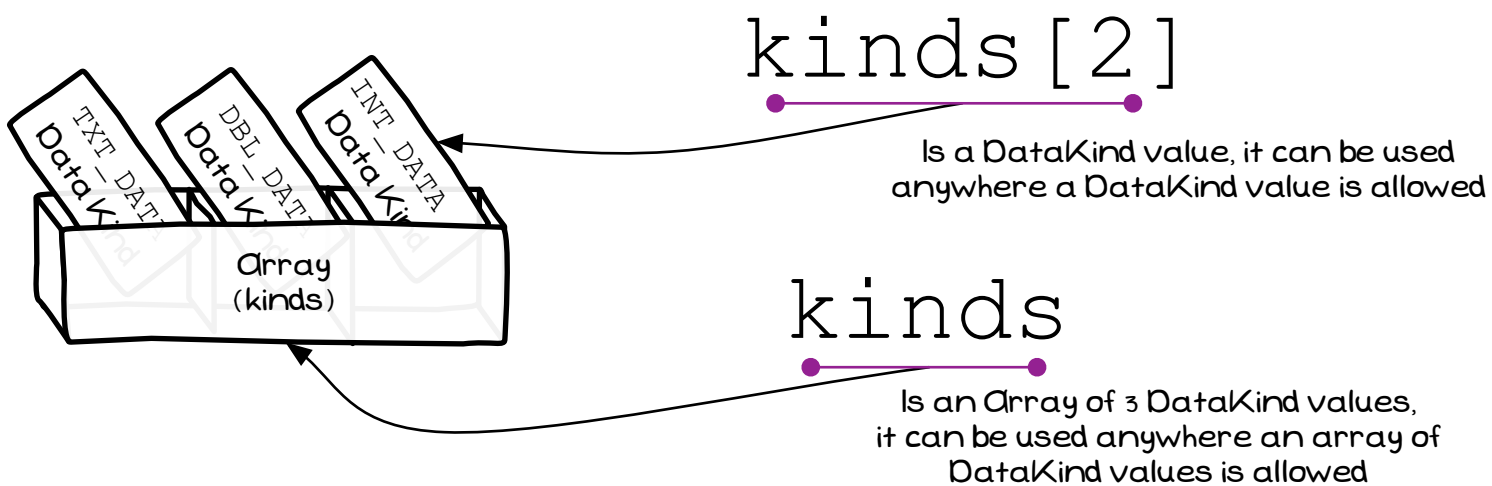
Is a UserData value, it can be used
anywhere a UserData value is allowed

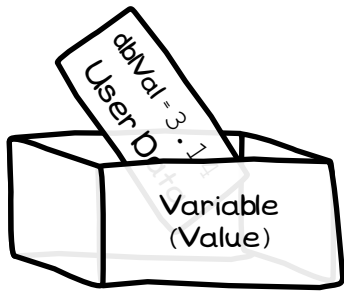
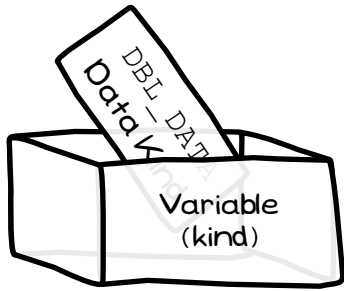
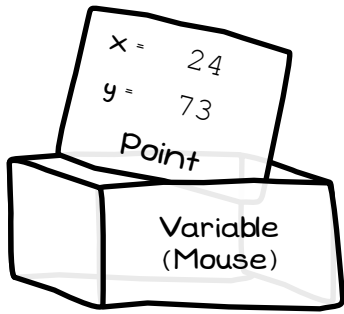
data[2].intVal

Is an Integer, it can be used
anywhere an Integer is allowed

data

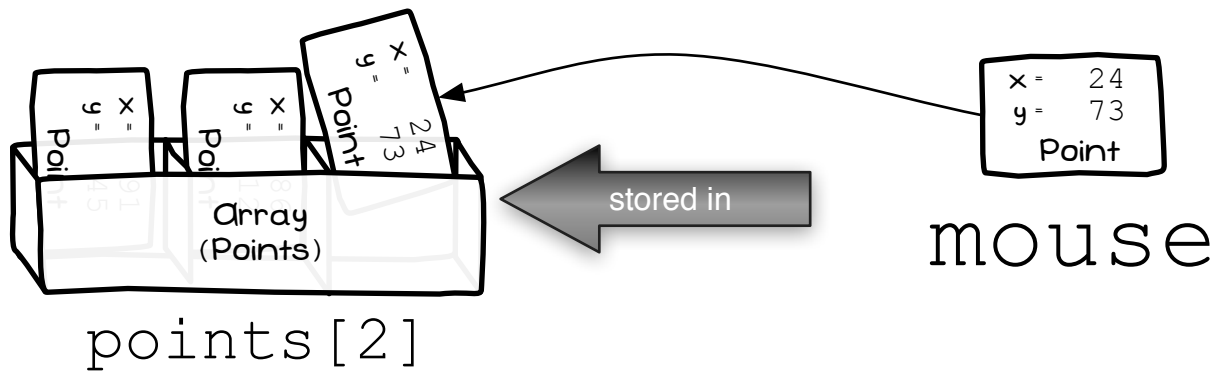
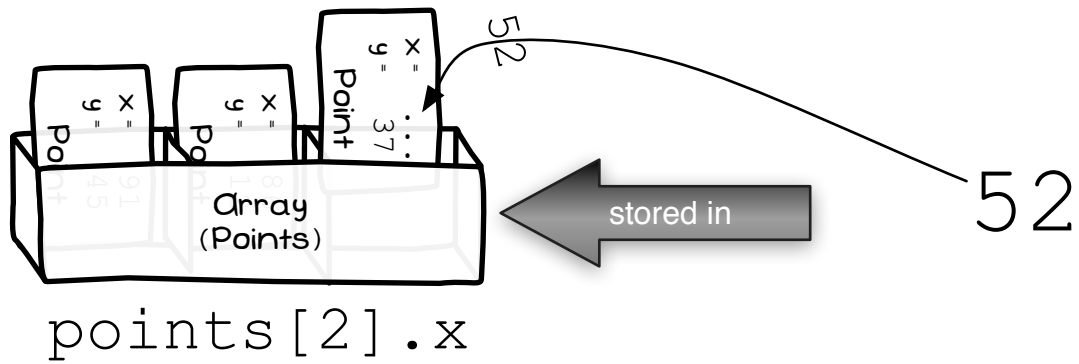
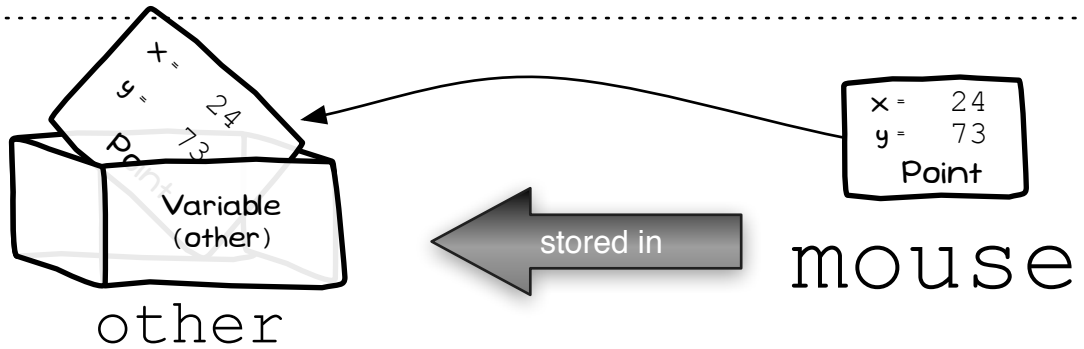
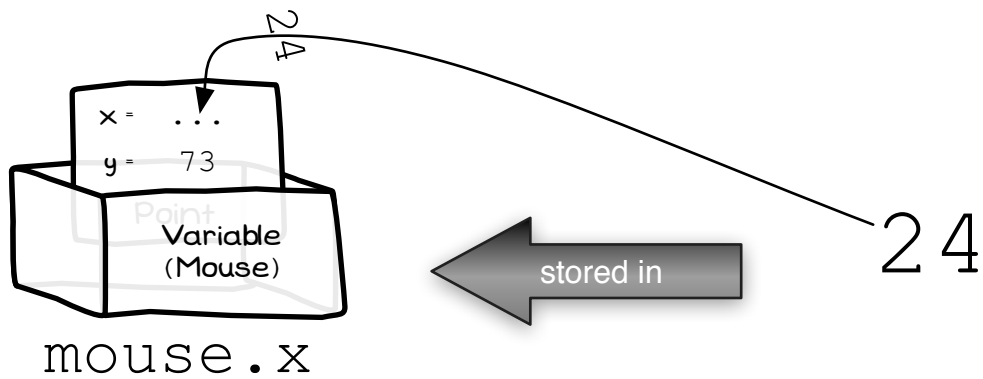
Is an Array of 3 UserData values,
it can be used anywhere an array of
UserData values is allowed

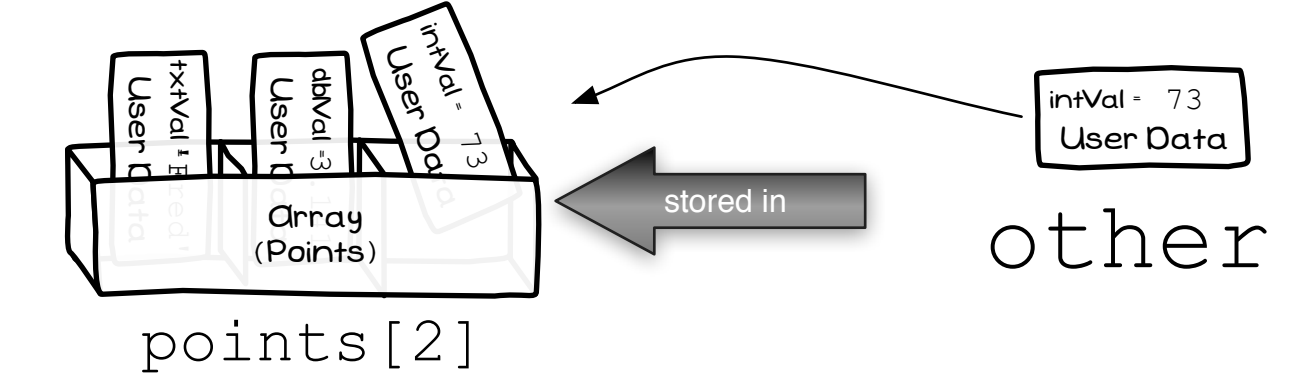
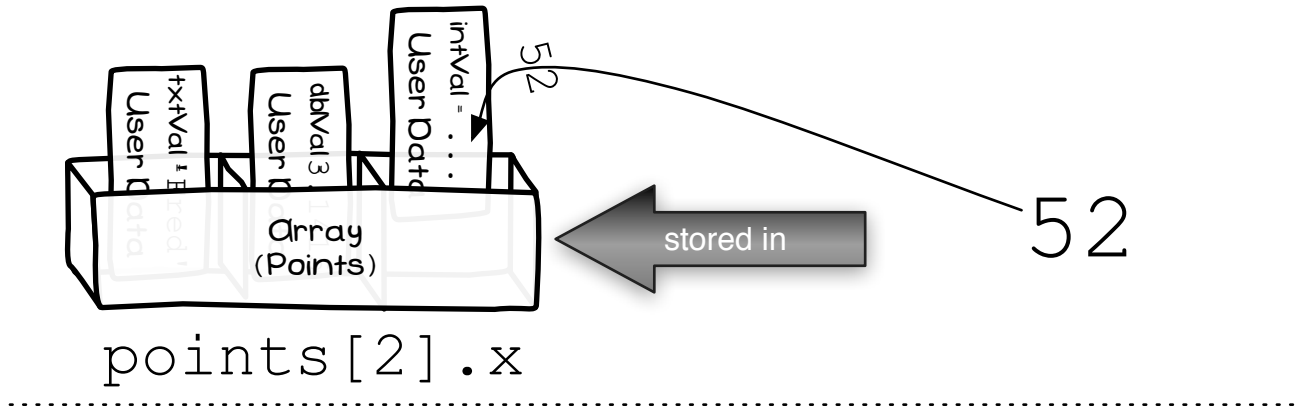
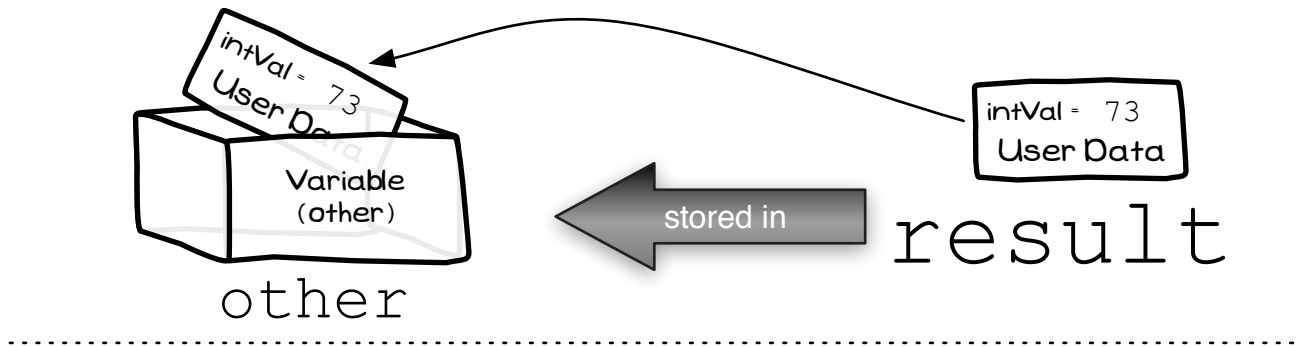
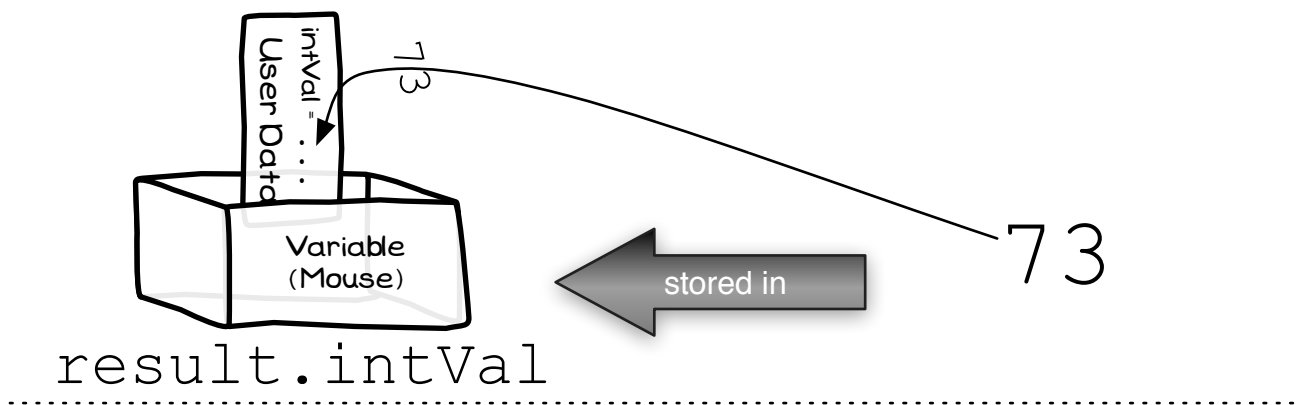


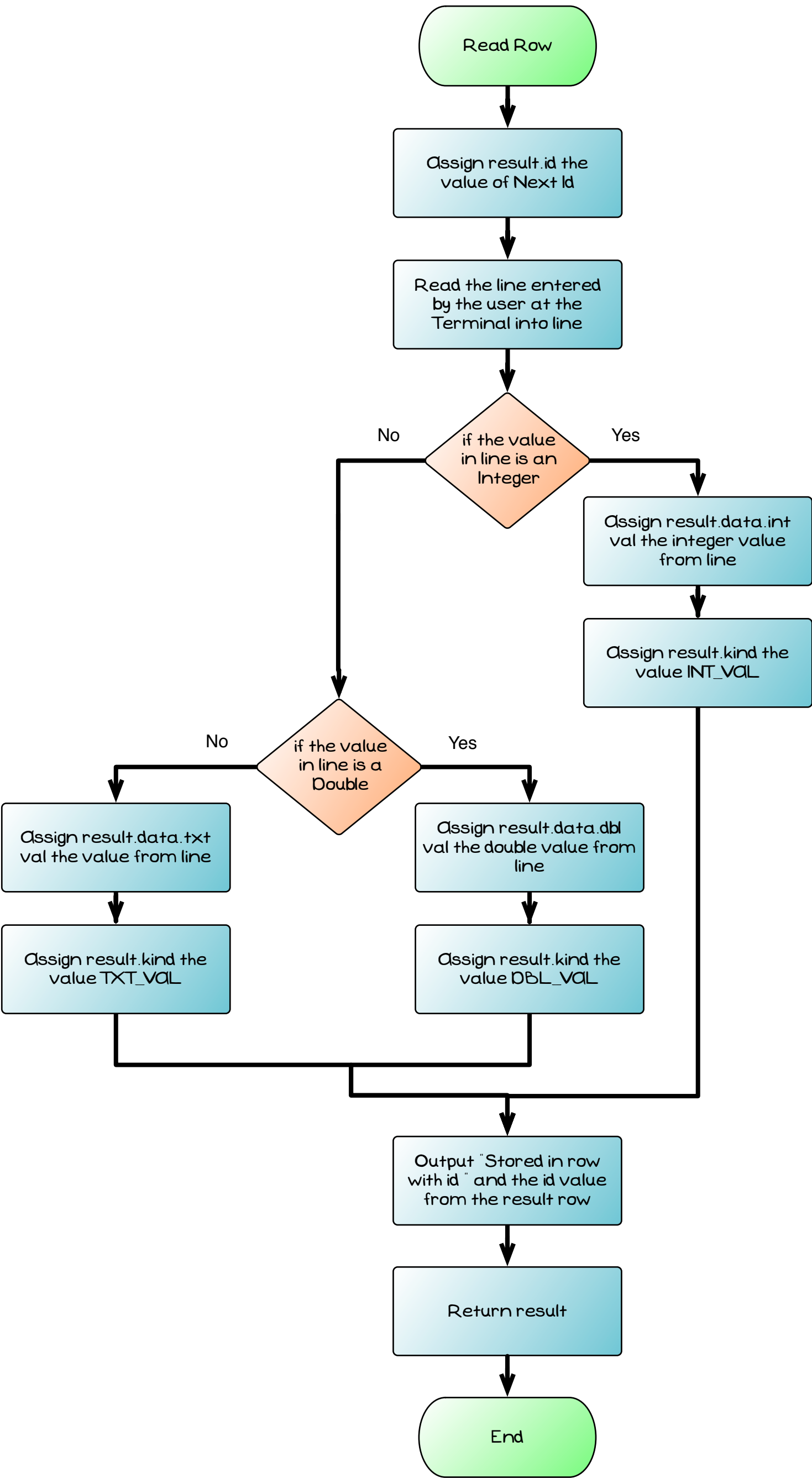


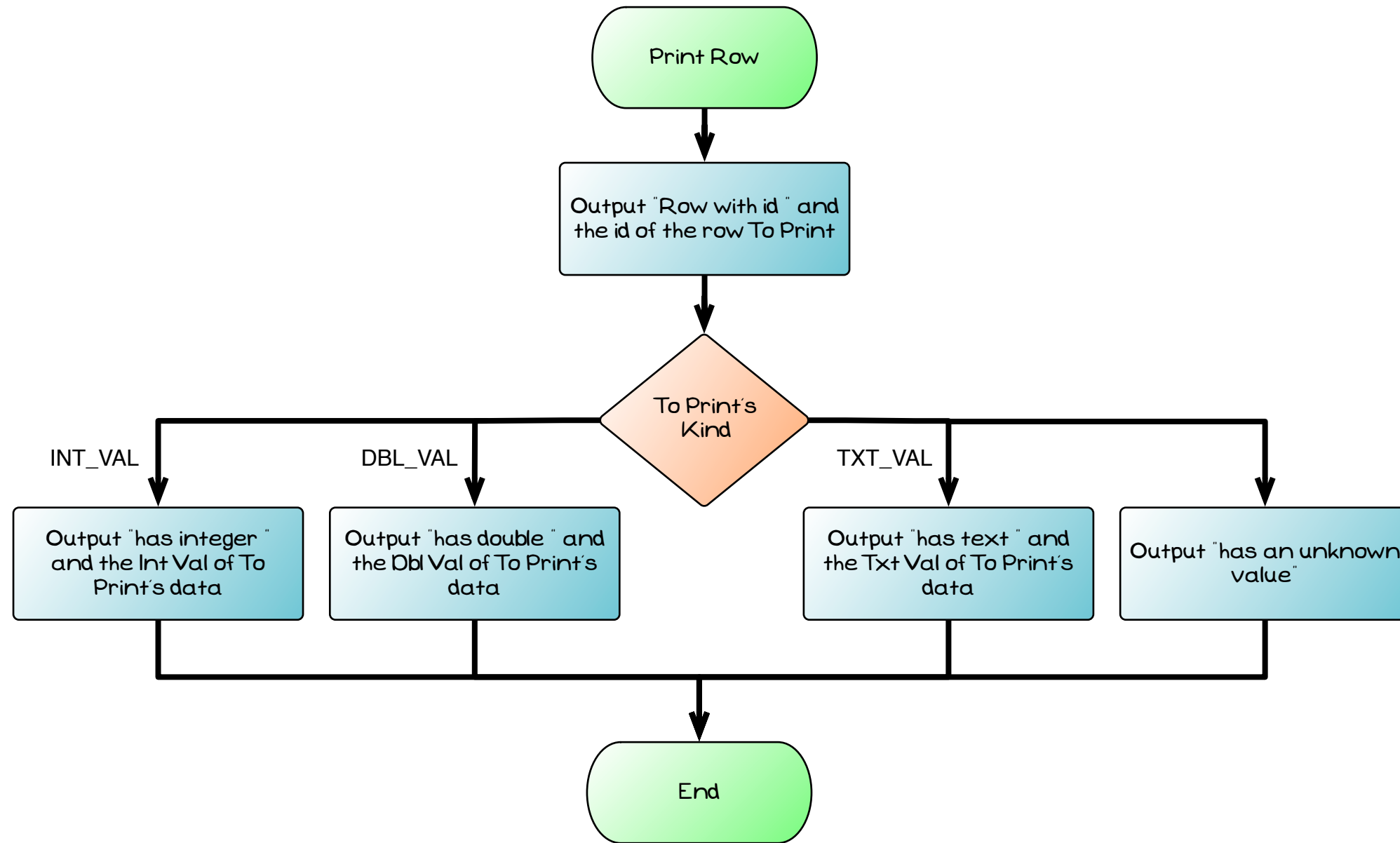
Expression

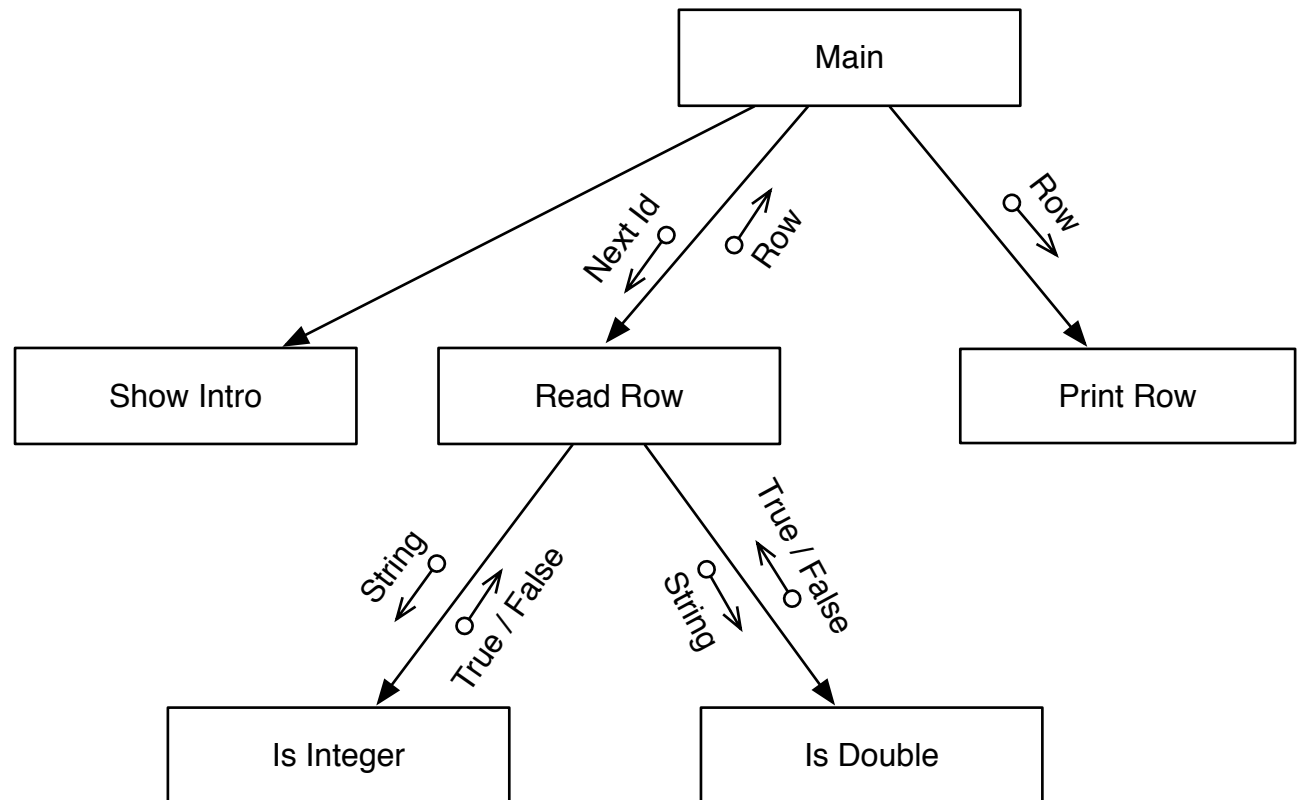
The right hand side of the Assignment is an Expression, the value that is to be stored







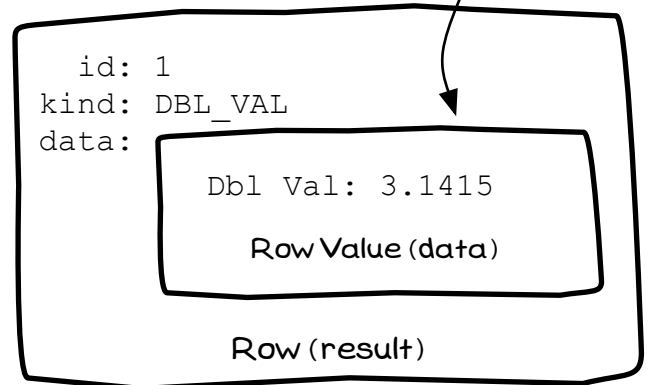
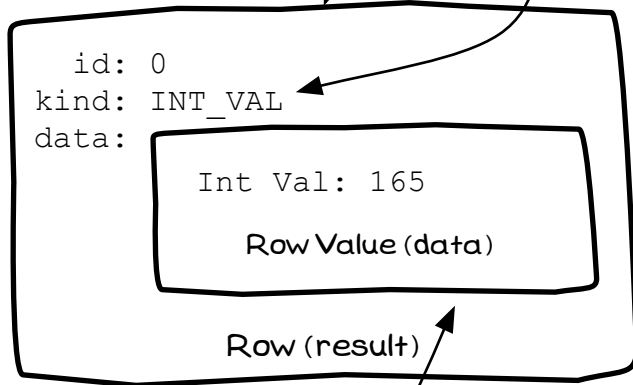




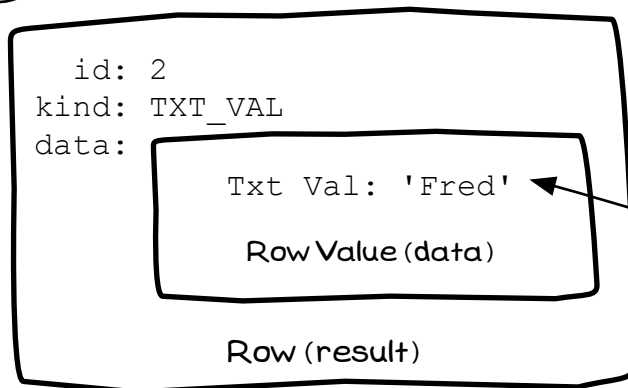
Example Row value, it contains an id, kind, and data value.

Row contains a Data Kind value. In this case storing the value INT_VAL

The data field stores a value from the Row Value union



This Row Value is storing an Integer value 165



This Row Value is storing a text value 'Fred'



result:

id:	2
kind:	TXT_VAL
data.int_val:	
data.dbl_val:	Fred
data.txt_val:	

Main

i: 2

db_data[]:

id:	0
kind:	DBL_VAL
data.int_val:	
data.dbl_val:	3.1415
data.txt_val:	
id:	1
kind:	INT_VAL
data.int_val:	27
data.dbl_val:	
data.txt_val:	
id:	2
kind:	TXT_VAL
data.int_val:	
data.dbl_val:	
data.txt_val:	Fred

Instruction: Step 2

Function: Read Row

Returns: Row - a Row with data read from the user

Parameters:

1: next id (Integer) - the id of the row to be read

Local Variables:

*: line (String - 16 characters) - the text read from the user

Steps:

- 1: Set result's id to next id
- 2: Output 'Enter value: ' to the Terminal
- 3: Read text entered by user into line
- 4: If line is an integer
- 5: set result's data's Int Val to the integer value in line
- 6: set result's kind to INT_VAL
- 7: Else If line is a double
- 8: set result's data's Dbl Val to the double value in line
- 9: set result's kind to DBL_VAL
- 10: Else
- 11: set result's data's Txt Val to the text in line
- 12: set result's kind to TXT_VAL
- 13: Output "Stored in row with id " and result's id
- 14: Return the result

Procedure: Main

Local Variables:

*: db_data (array containing 3 Row values)

*: i (Integer) -

Steps:

- 1: for i loops over each element in db data
- 2: set db_data[i] result of calling Read Row(i)
- 3: ...

Third time through returns this value, which is copied into the array

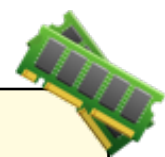
Second time through the loop assigns a value to this element

Each time the value returned is stored in an element of the array



Enter value: 3.1415
Stored in row with id 0
Enter value: 27
Stored in row with id 1
Enter value: Fred
Stored in row with id 2





Print Row

to print:

id:	2
kind:	TXT_VAL
data.int_val:	
data.dbl_val:	Fred
data.txt_val:	

Instruction: Step 8

Main

i: 2

db_data[]:

id:	0
kind:	DBL_VAL
data.int_val:	
data.dbl_val:	3.1415
data.txt_val:	
id:	1
kind:	INT_VAL
data.int_val:	
data.dbl_val:	27
data.txt_val:	
id:	2
kind:	TXT_VAL
data.int_val:	
data.dbl_val:	Fred
data.txt_val:	

Instruction: Step 4

2

The kind indicates to read the txt_val field from the data union

Procedure: Print Row

Parameters:

1: to print (Row) - the row to print

Steps:

- 1: Output 'Row with id ', and to print's id to the Terminal
- 2: select case from to print's kind
- 3: case is INT_VAL
- 4: Output ' has integer ' and int_val of to print's data
- 5: case is DBL_VAL
- 6: Output ' has double ' and dbl_val of to print's data
- 7: case is TXT_VAL
- 8: Output ' has text ' and txt_val of print's data

Procedure: Main

Local Variables:

- *: db_data (array containing 3 Row values)
- *: i (Integer) -

Steps:

- 2: ...
- 3: for i loops over each element in db_data
- 4: call Print Row(db_data[i])

1

The txt_val of the Row's data is output (in quotes)



Enter value: 27
Stored in row with id 1
Enter value: Fred
Stored in row with id 2
Row with id 0 has double 3.1415
Row with id 1 has integer 27
Row with id 2 has text 'Fred'

