



Programming Language

[The introduction paper]



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## Preface

This paper describe a subset of M2000 Language, with the core structures and objects. An Interpreter for M2000 exist, as a programming environment with many capabilities like window managing and console managing together. Programming paradigm such as event driven and functional can be apply. Version of interpreter **9.9 Rev. 48**

The idea of M2000 is to be a loved language for pupils to experiment, to make some programs for fun and study. Also there are two vocabularies, one with identifiers in Greek letters, and one with identifiers in Latin letters. We can say: we have Greek and English words, but are identifiers with a meaning for the interpreter according a syntax.

The language first written in 1999 as a simple interpreter like a BASIC clone, but with curly brackets as block of code and a user dictionary like in FORTH of module names and functions, utilizing stacks of values to pass and get data during calls and everywhere in code. The upgrade of language was parallel to the upgrade of interpreter and environment.

## M2000 Environment

The M2000 Environment has the M2000 Interpreter, a free software as GNU GPL3 licensed. The first idea was for a build of an Environment with a console in a full screen display with text scrolling, using a split screen, with a part of screen which non scrolling at the top, and mixing graphics like the way this did in a BBC model B 8bit computer. Additional was two more capabilities, for databases and for multimedia (images, sounds, movies). A help system driven by a database exist and is internal for all identifiers. Use Help All to see all Identifiers. The Help mdb for 17 revision of 9.9 version change to a dat file (we can use the mdb also see Switches).

Many versions prepared, with compatibility to previous, including layers of display, sprites, threads, tune programming with threads, speaking and finally support for COM objects, events, and private windows manager, windows and controls.

The environment written first in VB5 (Windows 98) and later in VB6 (Windows Xp and finally in Windows 7). First was the ANSI version, and later the Unicode. Also the first version exclude the tab character (converted to spaces), but the later use it combining with spaces. From double type as the starting only numeric type added through time many more based on Variant type (a type hidden to user). Right to left text can be used almost everywhere except some points where can't fit without more programming effort. The M2000 editor can handle RTL text. The RTL in the programming editor are prepared per colored chunk, so the LTR M2000 code stay as LTR.

## How to study this paper

For better study use this paper as an entry point, and check the modules offered in the installation in the info.gsb.

If you plan to use M2000 interpreter for Old Style Programming, you have to read:

- The Language until but not included Lambda Object
- Old style programming with M2000 (all)

Or you have to see all the chapters and run each program to M2000 environment. Don't copy them from pdf, open pdf in LibreOffice (has the odt type in pdf)

You find a lot of M2000 programs (300+) in [Rossetacode.org](http://Rossetacode.org)

## ***Install Environment***

You have to install M2000 environment. Visual Basic 6 run time is part of all Windows Os, so the installation can be done from Xp to Windows 10. You found the setup file from M2000 blog, here:

[georgekarras.blogspot.gr](http://georgekarras.blogspot.gr)

After installation and the opening of M2000 console (running M2000.exe) we can give these statements:

Dir AppDir\$ : Load Info <press enter>

When you see the introduction message press the F1 to save info to user directory. So after the **End** statement in console which exit the M2000 environment, you can open it next time just using **Load info** and press enter. Also you can open the user directory using **Win Dir\$** from console, and place gsb files there.

## ***The Help System***

The help system no more depends on Access 2007 runtime.

## ***About Author***

George Philip Karras born in Athens in 1966. Educated in Technological Educational Institute at the city of Kavala, Greece, where he get a BSc on petroleum engineering in 1989. Author starting the programming journey from 1981, on an 8bit micro, a Texas TI 99/4A from a friend. He loves his first own micro, Acorn Electron, which gave him the opportunity to explore structural programming on BBC Basic and on assembly language for 6502 processor. Later he went to 16bit with Atari STE, and GFA BASIC. Finally he landing to a PC with Pentium 32bit CPU, and the Visual Basic. Then he found that Visual Basic is a fantastic RAD environment but not for pupils as he had in mind what pupils needs. His proposal is the M2000 language, a Basic like with a taste of Forth, with a minimal design environment, hidden from start more of complicated programming paradigms such as OOP, but not excluded them.

*This pdf document can be opened in LibreOffice as editable document.*

# The Language

The language use internal Identifiers and user defined as modules names, and functions. Except identifiers used for flow control all internal identifiers can be replaced by user defined. Names are non case sensitive except for labels. To execute code we can use M2000 console as immediate mode for executing statements except loops, and we can make modules and functions at global level and use them as new identifiers. So there is no RUN statement.

Also we can execute a text file with the gsb as type, by loading from a running M2000 environment. We can execute a gsb file by clicking in an Explorer folder if we set the Open With to use the M2000.exe (the environment of M2000). We can use M2000 as a glue language, to run other programs, to prepare data files, to make graphics from data files.

## Literals

A literal is a notation for representing a fixed value in source code. We use literals when we initialize a variable, as arguments when we call named code (a module, a function, a subroutine), and as part of expressions.

Literals used in CSV files, a kind of text files which we can place literals and then we can read from it like we read from console. CSV means comma separated values. In M2000 we can choose two specific properties for CSV the character for decimal point and the character for comma.

For the source code the decimal point always is the dot. The Print statement print numbers using the current decimal point based on Locale number. The Input statement input numbers handling the dot key on keyboard as the current decimal point.

### *Numeric and Alphanumeric literals*

Literals are two kinds: The numeric and the alphanumeric or strings. Numeric by default are double type, so 1 is double type 1 (no need to put a dot zero after one). There are some symbols for interpret a number to another type. So 100& is the 32bit value of 100 (signed integer), 100% is the 16bit value of 100, 100~ is the single floating point value of 100, and there are two more: The 100@ for decimal type and 100# for currency type. For strings we use a pair of " (character code 34), and the curly brackets { }. We can place new line characters - codes 13 and 10 inside curly brackets.

The following example use Print and Report statements. Report used for rendering text. On screen Report stop printing lines at ¾ of scrolling height and wait a spacebar keypress or left mouse button to click, to show the next page.

**Print** "this is a string", {and this is a string too}

**Print** 123456789012345678901234567@ ' this is a decimal literal

```
Report {This is a multiline string  
    this is another line  
}
```

## **Hex Literals**

A Hexadecimal value need two characters: 0X or 0x, and at the end may use the & or %, depending of type of hexadecimal.

Print 0xFFFFFFFF= 4294967295 ' this is unsigned integer 32 bit

Print 0xFFFFFFFF&=-1 ' 32bit signed integer

Print 0xFFFF%=-1 ' 16bit signed integer

The unsigned integer is Currency type, but can be stored as 32 bit in a Buffer object. The 4294967295 value above is a double type. The = used for equality. There is == for comparison with rounding to 13 decimal. A comparison return always a boolean type.

## **Constant Values True and False**

A True constant is a double type of -1 and a False constant is a double value of 0. All comparisons return Boolean type. A Boolean True is equal to -1 in any numeric type. A Boolean False is equal to 0 in any numeric type. Logical expressions using AND, OR, XOR, NOT return Boolean and may work with -1 and 0 instead of Boolean True and Boolean False. The non zero value is a True value also.

There are specific functions for Binary operations, like Binary.Not(), Binary.Neg(), Binary.And(), Binary.Or(), Binary.Xor(), Binary.Shift(), Binary.Rotate(), Binary.Add() which use Currency type for 32 bit unsigned numbers.

## **Html Color Literals**

For colors we can use html format so #FF0000 is the Red color, which is the same as Color(255,0,0), which is the same as 12 (from palette 0 to 15, the Windows Default Colors). The Color(255,0,0) and the #FF0000 are negative values. We can use 0X800000XX where XX is from 00 to FF for the Windows System Colors. We read the pen color using the Pen read only variable.

Pen #FF0000

Pen Color(255,0,0)

Pen HSL(0,100,50) ' Hue: 0 deg, Saturation: 100%, Lightness: 50% (red)

Pen 12 ' red

## Variables

Variable used for assigning values from literals or from expressions. A variable name must have a letter and any letter or number and the symbol dot and underscore. Some times we use dot before the name. We learn about it later. We use & before the name to indicate the pass by reference.

### *Variable Type*

A variable hold the type of first assignment or declaration of type (there are some exceptions). An expression may change the type if we mix types and the top of all types is the double (not for accuracy but for how big number we can put). There is a read only value the INFINITY which we can get the -INFINITY and +INFINITY as double values. If a variable can't cast a numeric type then we get Overflow error. So the overflow happen to assignment not to the expression.

Numeric variables in M2000 can be defined simple by the first assignment.

```
a=0xFFFFFFFF ' actual type is Currency
```

```
Print a, type$(a)="Currency"
```

```
b=0xFFFFFFFF& ' actual type is Long
```

```
Print b, type$(b)="Long"
```

```
c=0xFFFF% ' actual type is Integer
```

```
Print c, type$(c)="Integer"
```

```
d=100
```

```
Print d, type$(d)="Double"
```

```
dd=100~
```

```
Print dd, type$(dd)="Single"
```

```
a=123456789012345.6789# ' was a currency type from first line
```

```
Print a, type$(a)="Currency"
```

```
f=123456789012345678901234567@
```

```
Print f, type$(f)="Decimal"
```

String Variables (max length more than 1 billion characters) need a \$ as the last character:

```
a$="some characters"

$={First line
    Second line
    left margin adjust from closed bracket
}
```

## ***Boolean Type***

There is no specific character to make a value as Boolean. Also the True and False are Double type. But we can define by type name Boolean or using the 1=1 for Boolean True, and 1=0 for Boolean False. All comparisons return boolean type, except the spaceship operator <=>.

```
a=1=1

print type$(a)="Boolean"
```

## ***Statements to define Variables***

Here we will see statements for defining variables with or without literal value. When no literal value given, with these statements a zero for numeric and an empty string for string given by default.

A variable get space for value dynamic (not before the source executed). When the code which define the variable exit the execution state then the variable erased both as name and as value.

Variables names have a scope which can be used, to read the value or assign a new value or alter the value using operators like ++ or – and others. M2000 have a shadowing mechanism. A global variable can be in any scope until either the code which define it exit, or a local variable with the same name defined, or a global variable with the same name defined in the chain of calling of named codes (a named code is a module, a function and a subroutine).

## ***Global***

The Global statement make new variable always. If x and z exist as global then we get shadowing of old x and z. Look that we assign a value in a global using <=. If we use = then we define a local variable with same name and at this scope we shadowing the global variable.

```
Global x, z=10
```



```
Print x=0, z=10
```

```
x<=200
```

```
Print x=200, z=10
```

The same statement can define global arrays too:

```
Global A(10)=10
```

```
Print A()
```

We will see about arrays later

### ***Local***

Statement Local used in Subroutines. Also we can use Local to make local arrays in subroutines.

```
Local x, z=10
```

```
Print x=0, z=10
```

```
x=200
```

```
Print x=200, z=10
```

### ***Def***

The DEF statement used for two things. To define functions in one line (always local) and to define once local variables for current scope. If we use Def to define a local variable which exist then we get an error.

```
Def x, z=10
```

```
Print x=0, z=10
```

```
x=200
```

```
Print x=200, z=10
```

### ***Defining variable using type name***

We can define the Boolean type too.

```
Global x as Integer, z as Decimal=10, m as Boolean=True
```

```
Print x=0, z=10, m
```

```
x<=200 ' look the <= operator
```

```
Print Type$(x)="Integer", Type$(z)="Decimal", Type$(m)="Boolean"
```

For Local statement:

```
Local x as Integer, z as Decimal=10, m as Boolean=True
```

```
Print x=0, z=10, m
```

```
x=200
```

```
Print Type$(x)="Integer", Type$(z)="Decimal", Type$(m)="Boolean"
```

For Def statement multi types:

```
Def x as Integer, z as Decimal=10, m as Boolean=True
```

```
Print x=0, z=10, m
```

```
x=200
```

```
Print Type$(x)="Integer", Type$(z)="Decimal", Type$(m)="Boolean"
```

For Def statement multiple variables with the same type:

```
Def A,B,C ' double by default
```

```
Def Integer A1, B1, C1
```

```
List
```

Using List we see the values of variables (the numbers have the type using the literal symbol). Here the last three give 0% (zero for integer 16bit)

### ***Passing values to Variables***

A variable can get value from user, using the INPUT statement. This statement also make a new local variable if the name is new.

```
Input "A,B=", A, B
```

```
Print A, type$(A)
```

```
Print B, type$(B)
```

A and B are Double type

```
Input "A,B=", A%, B%
```

```
Print A%, type$(A%)
```

```
Print B%, type$(B%)
```

A% and B% are double type but hold no fraction part, only the integer part. We can't pass 1.34 because dot key not used for this kind of variables in Input statement. There is a variation of Input which input values from text files CSV, so we can use "as long" or other types to define the variable type from file, as we see later.

We can use Input with predefined variables at any numeric kind except Boolean

```
Def A as Currency
```

```
Input "Money=", A
```

```
Print A
```

```
Print type$(A)
```

For Boolean use the Menu statement which open a drop down menu and pick True or False:

```
Print "Check: "; ' the semi colon hold cursor so menu open after Check: in
same line
```

```
Menu "True","False"
```

```
A=Menu=1
```

```
Print A
```

```
Print type$(A)
```

## ***Stack of Values***

The stack of values is an idea from FORTH, all calls to modules pass the stack of values, and we can Read values or Push values to it, among other operations. Before reading values from stack we can examine it, display it, match a signature on a number of items on top of stack and a lot of other operations.

Another way to pass a value to a variable is by using the stack of values. You have to think two things: in scope there are identifiers like the local variables and the stack. The stack is a dynamic structure which we can put values, so we say that the stack is a stack of values. The stack has no name. Is a container for values (Any kind) with no name, as opposite to

variables which have names. So to use stack we use statements and read only specific variables for stack.

We can use Push to push values to top of stack, and Data to place values to bottom of stack. We can use Read to read values to variables, always from top of stack. Check the Data statement (FIFO, first in first out)

Flush ' empty the stack

Data 100, 200#, 300@ ' to the bottom a Double, a Currency and a Decimal.

Stack ' display the stack

Read A, B, C

List ' display the values of variables

Now we use the Push statement (LIFO, Last In first out):

Clear ' erase variables

Flush ' empty the stack

Push 100, 200#, 300@ ' to the top

Stack ' display the stack

Read A, B, C

List ' display the values of variables

There are a lot of operations (statements and functions) for using the Stack. Also we can defined named stacks, a kind of object. We will see later about it. When we call a function we get a new stack, so always say the Current stack. Except for stacks we can create, those created by calling system, can't handle by pointer. We can change them getting the pointer with an empty one.

Flush

Push 1, 2, 3

Print Stack.Size=3

A=[] ' A is a pointer to stack object, but current stack change object

Print Len(A)=3, Stack.Size=0

Stack A {Print Stack.Size=3} : Print Stack.Size=0 'temporary attach A.

## Constants

Some times we want some values to be constants. So we want a name like a variable to get a final value. Statement List show the variables (all non hidden variables, and those that aren't in scope in context). Let say that this code is in a module B (for what is a module we will see in the following page).

```
const X=10
const X1=X*3
list
```

we get B,X=[10], B,X1=[30] where B.X is the absolute or global name for X. The value in square brackets indicate in the **list** report that the value is constant.

## Enumerations

Some times we want a list of constants which are in an order, or at least in a set, which we can compare them. Say that the code is in module C (C a name for a module)

```
Enum Pets {Dog=100, Cat}

a=Dog

Print a=100 ' true

a++

Print a=Cat ' true

b=-a

Print Type$(a)="Pets", Eval$(b)="Cat" ' true true

List
```

We get from List: C.PETS\*[Pets], C.DOG\*[Pets], C.CAT\*[Pets], C.A\*[Pets]. C.B\*[Pets] the \*[ ] indicates that the name inside is an Object and the variable is a pointer to that object. M2000 Interpreter handle these objects as constants. The **a** variable can get a number which is part of the numbers in the Pets (100 or 101) or negative numbers -100 and -101. The object B has -101 value but is a Cat (like A which is 101). The type is case sensitive, as we use it in the text. So if we use Enum pEts then all the pointers above give \*[pEts] and we have to use "pEts" to check the type of enum. We can use **Enumeration** instead **Enum**. We can make Global Enumerations.

## Expressions

An expression in a program source is a piece of code which return a value. So we can say that a literal is an expression without operator. Operators are the symbols which works on values to produce results, like the plus + operator where 10+10 has the result of 20.

For M2000 there are two types of expressions: The **numeric expressions** and the **string expression**. In numeric expressions there are also those known as logical expressions. Logical expressions also have two level, the compare level and the gate operator level. The compare level use operators like =, == (for number rounding comparisons), >=, <=, <>, ~ (a like operator for strings) plus IS for comparing pointer of objects (and IS TYPE for groups) and all return a Boolean type. The gate operator level works on Boolean types (or cast to Boolean for numeric values), use gates as AND, OR, XOR and the NOT.

There are a special operator, the **spaceship**, <=>, which compare two numbers or two strings and return one of three results -1,0,1 to indicate the first is less from second, or equal to second, or greater from second. So this is a compare which not return Boolean (a binary value) but a three state value.

Numeric expressions use operators like +, -, \*, /, \*\* and ^ for power, and DIV and MOD for integer division (used also for non integer values) and modulo operation, plus DIV# and MOD# for euclidean division and modulo. We can define operators for groups. A special WITH operator used for groups, for merging groups.

This expression -2^2 is equal 4 and 0-2^2 is equal -4. The difference in first case is the minus operator is the unary one, so first expression is (-2)^2 and the second 0-(2^2). So the next expression 0+-2^2 is equal 4 because we have 0+(-2)^2, the minus operator is unary. The next 0+---2^3 is equal to -8 because we have 0+((---2^3) which is 0+(-2)^3 which is -8.

In numeric expressions we can use Parenthesis. All expressions may have or not literals, and may have variables and other identifiers (constants, enumerations, arrays, functions, objects). String expressions use only operator +, so "A"+"B" return "AB". See an example where we have string expression in comparison and comparisons in numeric expressions.

```
A$="122" : Print ("123">A$)*-3=6+3*(LEN(A$)=4-1) OR FALSE
```

We get True. Comparisons in numeric expressions need parenthesis. The boolean type cast to double, 0 or -1. LEN(A\$) return 3, and 3=4-1 return True, so we get 6+3\*-1, or 6-3, or 3. "123">A\$ is true (as string comparison not numeric), So we get -1\*-3, or 3, so we get 3=3 OR FALSE, or TRUE OR FALSE, so the result is TRUE.

There are many numeric and string built in functions. The name with a \$ at the end is a string function.

We can make Groups with programmable operators to perform group expressions and return Groups.

All expressions may return objects. An object return a value of zero plus the object, except enumerations which are objects return both, and constants which are objects which return values. If we add two objects which there isn't a programmable operator for the first one we get the last object as the return object plus the zero value. If a variable is new or has a numeric value then the object has priority and the variable get the object. If the variable has an object and we place another object which isn't compatible then we get error. There are more rules but not for now. A constant return its value and the operator works on that value. When we assign a value to a constant we get error because constants created with a value not assigned with a value.

Some object constructed applying a list of variables without using parenthesis. If those objects are passed to a list of parameters we have to put them in parenthesis (except the last one, optionally).

```
A=((Stack:=1,2,4,8,16), List:="A":=50,"B":=200, "Name":="Goofy")
```

```
Print A#Eval(0,2)=4, A#Eval(1,1)=200, A#Eval$(1,2)="Goofy"
```

```
Def ByKey(a as list, k$)=a(k$)
```

```
Def ByKey$(a as list, k$)=a$(k$)
```

```
Def ExportKey$(a as list, where)=Eval$(a, where)
```

```
Print ByKey$(A#Val(1),"Name")="Goofy", ByKey(A#Val(1),"A")=50
```

```
Print ExportKey$(A#Val(1), 2)="Name"
```

## Modules and Blocks

### ***Blocks {}***

**Blocks** of curly brackets { } used for mainly two reasons, plus too more: Firstly, a block has an internal logic to handle GOTO statements, for jumping out of block, and EXIT to exit from block. Secondly there is a set of identifiers for making the block as a loop block, and as alone a block can change to a looping block using in the block statements like LOOP and RESTART.

This language use curly brackets as a block of code and as a string, depends the context. Some language's structures exist with block and without block like the For statement:

```
For I=1 to 100
```

```
Next I
```

and the faster:

```
For i=1 to 100 {  
  
}
```

The non block version first find the Next statement (without checking the variable after Next - which is optional) and make a block. So we didn't see a block but the block exist. We will find some other structures with no block inside. Also there some structures which use blocks only and we have to show the block using brackets.

```
Try ok {Print 1/0} : If Not ok Then ? "You get an error:";Error$
```

The ? As statement is the Print statement. A block here has no multi line arrange. We use semicolon to separate with the next statement in the line.

## **Modules**

A **Module** is a named part of a block code, which we can call it. A module construct has a name and a block of code. Optionally we can add a parameter list. A module define a scope for user identifiers. We can't perform a Goto from this block to any other line outside a module's code. The Goto works internal with a return and a request to insert again to the specific label or number. But if nothing found then nothing executed in the block, and those Goto are the same as Exit.

From a module we can use any identifier that is already defined ion that module or as global in the chain of calling modules. An exception exist for names that are exist forward in the code, inside the module, the labels for jumps and the subroutines an simple functions (like subs they exist at the end of the main code of a mdoule). Calling a module means that we pass the current stack of values. Stack of values is a collection of items which we can read from top and we can put items to top using PUSH, or to bottom using DATA. Using PUSH and READ we use stack of values as LIFO. Using in an empty stack of values DATA and READ statements we use it as FIFO. Calling a module with parameters we place the parameters in reverse order at top of stack so we read the left most parameter at the top of stack. Lets see an example (supposed this written In another module:

```
Module One {  
  
    Read X, Y  
  
    Print X, Y  
  
}  
  
One 10, 20  
  
Call One 10, 20
```



First we make the definition of Module One, as local to the module which we place the code above. Next we call the module by name only with two parameters, 10 and 20. The value of 10 is in top of stack of values. So when the interpreter execute the code inside the One, read 10 and 20 to X and Y and then print them to console. The second call use a Call statement. There is a non observant difference from these two calls. Internal there is a difference. They are two different things. Inside Module One if we call One using the name only we get an error because One isn't local to One. Using the Call One we can use recursion for modules.

Using the call by name only (without CALL statement) we can use named parameters:

```
One %Y=500, %X=20
```

If we miss the X value above we get an error, because X can't initialized and X isn't optional. When we have to Read a variable, which isn't initialized we have to provide a value. The value also set the type of variable, if is numeric. The string variable has the \$ character at the end of identifier name, so A\$ is a string variable, and only string value can be hold. We can pass a new name without raise an error. We can check if the name exist in the target module using the Valid() function which return true if the expression inside valid() has no error (also the expression executed). So we can use variable names as signals to module.

```
Module YouSay {
    If valid(Yes) Then Print "Yes", Yes
    If valid(No) Then Print "No", No
}

YouSay %Yes=100

YouSay %No=100

YouSay
```

Because we pass the current stack, we can first push parameters to stack and next we call the ONE

```
Push 500, 20
```

```
One
```

Now we get 20 and 500. In M2000 the caller has to prepare the stack and the callee module has to clear the stack properly. The interpreter never check at the calling of a module for a signature of a parameter list. This means that we can send different set of parameters, and we can check by code the envelope of stack of values, as a string with a

letter for each item on stack marking the type. Also we can push data back, using the stack of values.

Lets make a different example, with two modules which change a value.

```
Module T1 { Read X : Push X**2}
```

```
Module T2 {Read X: Push X+10}
```

```
Push 10
```

```
T1
```

```
T2
```

```
Print Number
```

We push 10 and then we call T1 which get 10 and push  $10^{**}2$  or 100. Then we get 100 and push  $100+10$  or 110. Then we print the top of stack of values using Number which pop a number or return an error if no number found on top of stack of values.

As a syntactic sugar we can make T1 module without placing the Read statement (interpreter place it at the construction of the module)

```
Module T1 (X) {Push X**2}
```

or without space between name and parameter list:

```
Module T1(X) {Push X**2}
```

But the last one isn't a preferable one, because when we mark a module name and search using F2 (up) or F3 (down) the code, the search utility not stop in a T1( name. Another named block is the Function block and for that block the second form is the right one, because we use the function in expression always with parenthesis.

## ***Changing Code For a Module at Runtime***

All local modules (and normal functions) can change code by applying a newer definition. Exception exist for those modules which are fixed for a reason. The reason maybe:

- The module passed in a module call (without Call)
- The module is a member of group and has a tag as Final
- A Function is a member of group and has a tag as Final

There are subs and simple functions coded at the end of a module or function code, which are used by searching the definitions in the code (and not executing definitions as Modules and normal Functions. The names for those searched from the end one time and

memorized the starting point for the next call. These simple structures have no block { }, they use Sub Name() End Sub and Function Name() End Function. We will see that later.

## ***Modules In Modules***

We can put modules in modules but we can't call an inner module from any other module except from the parent module and exactly from the point where the definition of inner module executed before the point of call. Exception exist for Global module. We can make a global module, and we can call it from anywhere, until the module where we make the global one exit the execution. So in a local module we can make a global module and this one **shadow** any global with the same name. Interpreter always do this for same names: Local Shadows Global. Newer Global Shadows Global. And we can change a definition if we redefine a local module with a new local module with same name.

Also we can use IF statement to choose a definition for a module:

```

Module Two {
    If Number=1 then
        Module T1 {
            Push Number**2
        }
    Else
        Module T1 {
            Push Number**3
        }
    End If
    T1
}

Two 1, 10 : Print Number

Two 2, 10 : Print Number

```

The first call return 100 and the second 1000.

## ***Passing a module in a module***

There is a **decoration** mechanism, which pass modules in a module at run time. If the target module (where we pass a module) has a definition for same name module then this definition can't save the code and drop it. The module pass to the target module only for the call. We have to use the normal call (without Call). Because Call used for recursion for modules, we can't use the decoration mechanism for recursive call.

As we see from the example a module not only get parameters but also can return data in the same stack of values where the import done. The (x) in Cnvt2Fahrenheit is a Read x statement, and read from the stack (mentioned before). The Push statement return a value to stack.

In the module temperature, in the example, we have two dummy modules, which do nothing. So if we use them we push a number and the number just stay in stack until we get it (or in another case we drop it using Drop, or Flush which clear all items in stack).

```
Module Cnvt2Fahrenheit (x){  
    Push Round(x*1.8+32, 2)  
}  
  
Module Cnvt2Kelvin (x){  
    Push Round(x+273.15, 2)  
}  
  
Module Temperatures (title$){  
    Module cnvtFrom {  
    }  
  
    Module convert {  
    }  
  
    Print Title$  
  
    for i=-20 to 35 step 5  
        convert i  
        cnvtFrom i  
        \\ numbers pushed to stack of values
```

```

        Print Number, Number

    Next i
}

Temperatures "From Celsius to Celsius"

Temperatures "From Celsius to Fahrenheit" ; convert as Cnvt2Fahrenheit

Temperatures "From Celsius to Kelvin" ; convert as Cnvt2Kelvin

Temperatures "From Fahrenheit to Kelvin" ; convert as Cnvt2Kelvin, cnvtFrom
as Cnvt2Fahrenheit

Temperatures "From Kelvin to Fahrenheit" ; convert as Cnvt2Fahrenheit,
cnvtFrom as Cnvt2Kelvin

```

We can pass any module in a module, ny decoration, without the need to use a local module with a target name like the convert as above. But we have know the name using then Module() function which return true if a module name exist (can be called).

## Group of Variables

We can make a **Group** of values, using the Group statement, and we pass this group to a new module One. Group A is a named Group, a static in some languages, but here in M2000 is just a local group. The named group disposed at the end of run of current module (which we make the group).

```

Group A {
    X=10, Y=500
}

Print A.X, A.Y

Module One (Z) {
    Print Z.X, Z.Y
}

One A

```

The parameter list (Z) with the Z replaced with a READ Z inside the module One.

Groups is not used only as a data structure, but can contain code, operators, return a value other than a copy of itself. A group is the user object for object orientated programming in M2000.

We can use Modules inside a group. So lets make a module which add 10 to X value of group. The block of Group isn't the same kind as a block of code. See that we can use comma between identifiers. Also we can put some expressions using external variables which they used only at the construction.

```
Group A {  
    X=10, Y=500  
  
    Module AddTen {  
        .X+=10  
    }  
  
    Module ResetX {  
        .X<=10  
    }  
}
```

Identifier **.X** is the same as **This.X** and when we place a new value we have to use **<=** because a simple **=** make a local value. The values X and Y are group values, not local values. So now we learn that except local and global variables there are the group variables. A group maybe is global so the group variables are global too. So a group variable is local where the group exist and is in scope in group modules by using the dot or **THIS** plus dot. Inside a **For obj1, ob2... {}** structure the one dot used for obj1, two dots for the second object and so non (max ten objects).

## ***Passing Groups by Value***

A module is a second class citizen, because we can't change the name. A group is more complicated. A group is an object, having data in variables and code in modules. When we make a named group we have something bound to a module, like a local variable. Groups can be copied to stack of values and can be read to a new name. Lets see that:

```
Module Three (Z) {
```

```

    Print Z.X

    Z.AddTen

    Print Z.X

    Z.ResetX

    Print Z.X

}

```

Three A ' this is s remark at end of line: A is a group -see definition above

### ***Defining a Group from another Group***

Also we can do a simple assignment B=A and B get everything A has. B has to be a group or a new value. If B is anything else we get an error. B isn't a pointer of A. B is another named group. We use the definition for A from previous example.

```

B=A

Print B,X

B.AddTen

```

These two groups erased when the parent (a module, or a function) ends execution, at any exit statement, or when execution find the end of parent block (a normal exit). Inside the parent block we can call other modules (local to parent or global) but this only pause the execution (in a call the module transfer the execution to another module, and when that module exits continue to next statement).

We see before a way to pass a module code to decorate specific module in a module. A group may have the same use, but expanded with the use of variables, as group members, to hold state, or to currying information. We see before that we can pass a copy of a group passing it by value. So the modules inside group can be used from the module. All Group objects have one major type, the Group, we can pass any group, but we have to maintain the interface, the actual type of group. The actual type is the interface, the public properties and methods of object. We can use the Type: special statement for group definitions to insert a user type or types for an object. So we can filter the user type of group at the input list, or checking it in an IF statement using the IS TYPE operator (has space between words, is a variation of IS operator).

The next example use two user types for a Group. User Type is a contract between the definition of a group and the consumer, the program. When we say we need a group of type MyType1 for module Four's, we get the object, and all other types which implements. So we say that MyType2 is a contract where a Group has a ShowValues module. We can check the type using the IS TYPE operator.

```
Group Beta {  
    Type: MyType1, MyType2  
  
    Private:  
        X=10, Y=500  
  
    Public:  
        Module AddTen {  
            .X+=10 : .Y+=10  
        }  
        Module ResetX {  
            .X<=10  
        }  
        Module ShowValues {  
            Print .X, .Y  
        }  
}  
  
Module Four (Z as MyType1) {  
    Z.AddTen    ' Z is a copy of Beta  
    If Z is type Mytype2 Then Z.ShowValues  
    Z.ResetX  
    If Z is type Mytype2 Then Z.ShowValues  
    Z.AddTen  
}  
  
Four Beta  
Beta.ShowValues
```



So a type is like an interface, you have to keep the contract for each group of the same type. We can add members in a group but we can't delete them. An interface can't lose members.

### ***Passing group's member variables by reference using &***

We can pass values by reference using & to both parts, the caller and the callee:

```
X=10
```

```
Module AddTen (&Z) {
```

```
    Z+=10
```

```
}
```

```
AddTen &X
```

```
Print X=20
```

We can do the same for a member variable and an inner group which has a value as a number:

```
Group Zeta {
```

```
    X=300, Z=200
```

```
    Group Delta {
```

```
        Private:
```

```
            internalValue=100
```

```
        Public:
```

```
            Operator "+=" (v) {
```

```
                Link parent X, Z to X, Z1
```

```
                X+=v
```

```
                Z1+=v
```

```
                .internalValue+=v
```

```
            }
```

```

        Value {
            =.internalValue
        }
    }

}

Module AddTen (&Z) {

    Z+=10

}

AddTen &Zeta.X

Print Zeta.X=310

AddTen &Zeta.Delta

Print Zeta.Delta=110, Zeta.X=320, Zeta.Z=210

```

As we see in the above example Z in AddTen module one time was a **variable** and the second time was a **group acting as variable**. We have to define the proper operator for the group and this doing with Operator definition. Also there is a link to a variable of the parent group. This link prepared when we need it. Without the use of **Link parent** variant of Link statement the parent scope stay out from the inner group. We can link members (either public or private) of the types variables and arrays, other inner groups, functions (but not modules), to a specific name for each.

M2000 always pass by value, but by using weak references, which is actual a string, we let the Read statement to resolve the reference to a hard link when pop it from stack if we have the & symbol before the name which we want to be the reference. We can use Print &Zeta.X from above example to print the string which return the &Zeta.X, or we can use Print Weak\$(Zeta.X) to do the same.

### ***Groups interaction using by reference pass***

Here is a simple example of an entire group passing by reference. No User Type used here. If Z.DoSomething missing from Z we get an error. Here the actual groups A and Z are different, but we look like they are same; Like Z is a reference of A. But this isn't true for M2000. The reason for this isn't obvious. We need to separate Z from A to allow Z to expand without the expansion affect the reference A. Expansion comes with Merging or adding a new definition Group Z { } inside DoSomething.

```

Group A {
    X=10

    Module AddTen {
        .X+=10
    }
}

Module DoSomething (&Z) {
    Z.AddTen
}

DoSomething &A

Print A.X=20

```

**Explain of the reference mechanism:** The &Z is a string containing the weak reference of Z. When the interpreter found that the variable we send by reference is a group doing something else from just make a reference as for an ordinary variable. To understand what interpreter do we have to look a bit on the implementation of a group by interpreter, All variables and methods of A are not inside A. To call or use them outside from A we haven't to communicate with A. For each method a reference exist and used by interpreter as THIS. So for the example in group A the A.X is a plain variable. The real object has a list of names and references so interpreter, after resolving the reference, get the list and make new names, using the scope defined from name Z and DoSomething module, as references to the members of group A, and make a new group Z with with a copy of the original list. So A and Z are different actual objects but at the starting point of Z, they match on everything, properties and methods.

Lets see how we change the Z group inside DoSomething. Here DoSomething is a member of A, so when we call Changelt passing &A as &Z we get Z as A using reference from A.X to Z.X, and a copy of A.DoSomething to Z.DoSomething. The A.DoSomething has a reference to A and the Z.DoSomething has a reference to Z.

```

Group A {
    X=10

    Module DoSomething (m) {

```

```
        Print m+.X
    }
}

Module Changelit (&Z) {
    Group Z {
        Y=100

        Module DoSomething (m) {
            Print m+.X**2+.Y
        }
    }

    Z.DoSomething 2
}

Changelit &Alfa

Alfa.DoSomething 2
```

**Replace a Method:** In module Changelit we place to Group Z another definition of module DoSomething. This can be done because the Alfa.DoSomething isn't final. The *Module Final DoSomething {}* in Alfa prevents any change on code, without raising an error on a try to change it. Here we haven't the Final clause (if we wish we can use it for the new definition), so we get for the Z a new variable Y and a new code for DoSomething. The Alfa group has own list so the Y variable added to Z only. Also the Code of DoSomething change the Z.DoSomething not the Alfa.DoSomething, because Z.DoSomething isn't a reference of Alfa.DoSomething, is a copy.

**Group Interaction:** After explaining the passing by reference for a group we can see how two groups interact using passing by reference. We have two groups AA and BB. The AA has the SendMessage method (is a module), which get a reference of another group. No user type used here but we can use if we wish. When we call AA.SendMessage the BB passed by reference as Z and we call Z.callBack passing .X or This.X by reference, so BB change the value of private X in AA, through a method of AA.

```
Group AA {
```

Private:

X=10

Public:

Module SendMessage (&Z) {

Z.callBack &.X

}

Value {

=.X

}

}

Group BB {

acc=0

Module callBack (&Z) {

.acc++

Z+=10^.acc

}

}

AA.SendMessage &BB

Print AA, BB.acc

We get 20 and 1. We just perform this **AA.SendMessage &BB** and we get new state for AA and for BB.

## ***A float Group***

Another kind of group is the volatile one, or float group. The volatile one has no name, but has a position in one container or is a return value from a function. In the next example we use the two groups AA and BB and we make a copy of each in two positions in an array

A(), so this array is the container for objects. Internal each item of an array is a Variant type of the OLE system of Windows, which can hold many data types, including objects, numbers and strings. If we didn't offer an initial value for each item of array we get an array of Empty value. We can check the type using **Type\$()**.

In the following example we will see the **For obj {} block**. First we make the definitions for groups AA and BB. We will see how we avoid to use named groups if we didn't need them to stay in the code, like static objects in other languages. We use a Class definition to make constructors (functions) which return float groups. So for the example we use Class definition for AA and Group for BB. A Class definition also insert the a user type of the same name, so Class AA insert type AA. If the class inherits from another class, or classes then also the types from these classes added to the list of types. We call AA() as a function which construct the AA type group from the class definition AA.

Next we make an array of 10 items (Empty type), and we place to A(3) the return value of AA(), the group factory. The class statement produce a function named AA(). If a class is a member of a group then the function is member of the group. If a class defined in a module or a function then it is global until the module or function end execution. There is a rule for globals/locals: Local identifier shadows any global, and a newer global shadows any global unless a local shadows it.

This example introduce pointers to float objects. The k and p variables get pointers of float groups.

```
Class AA {  
    X=10  
  
    Module SendMessage (&Z) {  
        Z.callBack &.X  
    }  
}  
  
Group BB {  
    acc=0  
  
    Module callBack (&Z) {  
        .acc++  
  
        Z+=10^.acc  
    }  
}
```

```

}

Dim A(10)

A(3)=AA()

A(4)=BB

For A(4), A(3) {

    ..SendMessage &This

    Print ..X, .acc

}

For A(3) {

    For A(4) {

        Print .X, ..acc

    }

}

p->A(3) ' this is an advanced part

For A(3) {

    Temp=A(4)

    Print .X, Temp.acc, p=>x

    .SendMessage &temp

    Print A(4).acc=1 ' old value

    A(4)=Temp

    Print .X, Temp.acc, p=>x

}

Print p=>x=120, A(3).x=120

k->A(4)

```

```
For A(4), A(3) {  
    Print ..X, This.acc, p=>x  
    ..SendMessage &This ' this is the A(4), SendMessagef on A(3)  
    Print A(4).acc=3  
    Print ..X, This.acc, p=>x  
}  
  
Print p=>x=1120, A(3).x=1120, A(4).acc=3, k=>acc
```

So now we see that For Object structure (here objects from array items) get the float groups and opened giving them names (hidden from us) and bound member names combined with hidden names to global list of variables and to global list of modules and functions, for temporary use (these bindings erased at the exit of For Object structure). We address each member by using dots. One dot for first and two dots for second. The This statement used for the first one. We can use folded For also, and the dots follows the number of objects counting the objects from these For statements

**Use of Pointers:** The last part of the example make p as pointer to A(3), later make k as pointer to A(4). When we make the pointer p, the float group in A(3) became a pointer to. A pointer is a Group which point to another Group. Access properties from a A(3) for pointer and not pointers using dot. If pointer is in a variable as p we have to use fat arrow =>.

**Exit from For Object Structure:** When a For Object structure exit, the opened groups closed again rewriting the values inside private lists. The third For {} shows us that we can use a Temp name to get the A(4) and then we can pass it back to A(4), making a float group from Temp. At exit of For object statement any new definition erased. So Temp erased (and the hidden opened groups).

**Using For This Structure for Temporary Definitions:** We can use a For This {} block in a module which isn't a member of a group. All new definitions inside this block erased after the exit of block.

### **Pointer to Group - Null Group**

Using A->0& or A=Pointer() we get the Null Group.

```
A->0&
```

```
Print Type$(A)="Group", A Is Type Null, A is (Pointer()), A is A
```

We get four True.



Now we want to call a module passing a pointer to group of type Something, and another module passing a reference to that pointer. A class define a global function. Calling Alfa we pass a copy of pointer. Calling Beta we pass the reference of m in p. So changing pointer of p is the same as changing the pointer of m.

```

Class Something {
    x=100
}

Module Alfa (p as *Something) {
    Print p=>x
    p=>x+=1000
}

Module Beta (&p as *Something) {
    Print p=>x
    p->Something()
}

m->Something()

Alfa m

Print m=>x=1100

Beta &m

Print m=>x=100

```

Now see what we can do if we use groups without pointers. First we make a second class the FatSomething to inherit from Something.

```

Class Something {
    x=100
}

Class FatSomething as Something {

```

```
    y=2000
}

Module Alfa (p as Something) {
    Print p.x
    p.x+=1000
}

Module Beta (&p as Something) {
    Print p.x
    p=FatSomething()
    Print p.y=2000 ' true
}

m=Something()

Alfa m

Print m.x=100 ' not 1100

m.x+=1000 ' so now we change m.x to 1100

Beta &m

Print m.x=100

Print valid(m.y)=False ' m has no m.y
```

See how we change the fat arrow => with dot. In module Alfa we pass a copy of m as p, so any change is private to Alfa. In module Beta we pass the m by reference as p. We can merge p with a fatSomething, so p is a fatSomething but not m. Because p.x is reference to m.x, we get new value in m.x the 100. As last statement we check if m.y exist.

**Whats wrong with pointers:** Using pointers by reference we can change in Beta the object to any object and that refers to the pointer outside the Beta module. That isn't bad unless it is a mistake, so we get some errors somewhere else, when a type or an actual interface not exist, and we get "module not exist" or "variable not exist".

We can restrict the merging to group operation using a Set member:

```

Class Something {
    x=100

    Set {
        \\ restrict copy only to this
        read this
    }
}

Class FatSomething as Something{
    y=2000
}

Module Alfa (p as *Something) {
    Print p=>x
    p=>x+=1000
}

Module Beta (&p as *Something) {
    Print p=>x
    \\ P->FatSomething() change pointer so m.y defined.
    p=>=FatSomething() ' merge FatSomething() m.y not defined
    \\ same as
    for p {
        this=FatSomething()
        Print valid(.y)=false
    }
}

```

```
}  
  
m->Something()  
  
Alfa m  
  
Print m=>x=1100  
  
Beta &m  
  
Print m=>x=100, Valid(m=>y)=False
```

## More about Variables

In M2000 language, can exist on same scope **A**, **A%** and **A\$** as three different names (identifiers). The two A and A% are numeric variables, and A\$ is a string variable. The A% is a variable with automatic integer rounding at half unit, so if A% is 1 then A%/=2 make temporary  $\frac{1}{2}$  as 0.5 which turn to 1. The type of A% can be any numeric type.

### *Operator and Assignment together*

Statements like A+=10 add 10 to A. Also A\$+="ok" add "ok" to end of A\$. For numeric variables +=, -=, \*= and /= change the value, also the ++ and – change value by one.

So A++ is a statement which adds one to A. There are two more, the ~ and -!.

The A~ change to opposite Boolean numeric value or Boolean value if A is Boolean. So if A has value 5 (non zero) means true, so A~ turn A to zero. If A has value zero then A~ turn A to -1 (the true value as numeric).

The -! used to change sign. So if A=5 then A-! as statement turn A to -5.

These operators can't be used in expressions. So the ~ operator and assignment is different from ~ operator for string comparisons (the like operator).

We can use |div |mod |div# and |mod# (euclidean) so A|div 10 is the same as A = A div 10

### *Tuple of values*

A variable may content a value or a pointer to an object. Let say that AA is a new name. This make the AA as a pointer to an array of three items

```
AA=(1,2,3)
```

This make AA as a pointer to an empty array. These type of arrays are like Tuple, but may change values and size.

```
AA=(,)
```

In the next example the AA has a tuple of two tuples. A BB=AA make BB to point to same object as AA. We can find the type of a variable using the Type\$() function.

The \$ in Type\$() means that this function return a string. If we make a user function and we want to use it in a string expression we have to place a \$ as the last character before parenthesis.

```
AA=((1,2),(3,4))
```

Tuples have special functions like the #sum(). We will see the tuple or Auto Arrays later.

```
AA=((1,2),(3,4))
```

```
Print AA#val(0)#val(1)=2
```

```
Print (1,2,3,4,5)#sum()=15, AA#val(0)#sum()=3, AA#val(1)#sum()=7
```

We can change a value on a tuple using Return statement. The Return statement do a lot of things, depending of the type of first parameter. Without parameter is a return from a simple Gosub (like in Basic).

```
A=("George", 0)
```

```
Return A, 1:=100 ' change value
```

```
Print A#val$(0), A#val(1) ' the second type is numeric      George 100
```

```
Return A, 1:=A#val(1)+1
```

```
Print A ' this is the same as Print A#val$(0), A#val(1)      George 101
```

Another way to change values as the example before (A is a pointer to tuple)

```
A=("George", 0)
```

```
A+=100
```

```
Print A ' George 100
```

```
A++ ' add one to all numeric values in tuple.
```

```
Print A ' George 101
```

Using a reference to Array (so A and A() and A\$() is the same tuple). Any array may behave like a tuple, and each tuple may behave like array, but aren't the same.

```
A=("George", 0)

Link A, A to A(), A$()

A(1)+=100

Print A           ' George 100

A(1)++

Print A           ' George 101

A$(0)+=" Karras"

Print A           ' Karras 101
```

### ***Assign Multiple Variables***

We can assign multiple values like this  
(A, B\$) = (1000, "Hello")

The mechanism is simple the previous statement are equal to this one:  
Stack New { Data ! (1000, "Hello") : Read A, B\$ }

We can use New to shadow variables like this **(New A, B\$)=(1000, "Hello)** the New clause, using in read. Also we can use types **(A as decimal, B\$)=(1000, "Hello)**

## **User Functions**

A function is like a module but may return a value or more than values in an array. We can call functions in expression or like modules using Call statement. A module get the stack of value from the caller, and the same is true for functions which call as module using Call statement. Functions in expressions have own stack of values. Because of this we can pass any number of arguments, and if we didn't use them in the function the stack dropped with any value left on it.

```
Function DoubleValue(x) {

    =x*2

}

Print DoubleValue(100)=200

Print DoubleValue(DoubleValue(50))=200

Def DV(x)=x*2   ' this is the same as DoubleValue()
```

Using Def statement can make one line function definition. In either form Interpreter take the (x) and add a first line in source of function as Read x.

### ***Program: The Fibonacci sequence***

This program shows as the first 10 items of the sequence 0, 1, 1, 2, 3, 5, 8, 13, 21, 34. Each number in a new line on console. The fb() function can call itself (a recursion call). Also we have the 1<sup>st</sup> item as 0 and the 2<sup>nd</sup> item as 1, by default. We use exit to exit soon from function. The = as statement is not an exit. Maybe we want to return a value but after that we want to change a by reference parameter. Here x is a by value parameter. As we see before a number by default is a double type. When a variable get a value get the type also. If later we pass another type to that variable a conversion happen (we get an overflow error if type can't hold the value). The x here in fb() function created each time we call the function, and take the appropriate type also. In some cases the calculated value can change to a bigger numeric type so that new type can be the type of those x and the return value may also change.

In M2000 we didn't say anything for the return value of a function, except if the function used in a numeric expression or in a string expression. We know this looking the name, so here without \$ at the name we know that fb() used in a numeric expression.

Because a fb() can be an array too, we didn't use a local array with same name as local function, or we have to use \* so a fb(\*) is always a function. We can use fb(\*100) to pass 100 as parameter, the \* character dropped by the interpreter.

```
Function fb(x) {
    if x<=1 then =0 : exit
    if x=2 then =1 : exit
    =fb(x-1)+fb(x-2)
}
For i=1 to 10
    Print fb(i)
Next i
```

We can change the fb() function to return a numeric type based on input type:

```
Function fb(x) {
    if x<=1 then =x-x: exit
```

```
        if x=2 then =1% : exit  
        =fb(x-1%)+fb(x-2%)  
    }
```

```
k=fb(10%)  
Print type$(k)="Integer"  
k1=fb(10&)  
Print type$(k1)="Long"  
k2=fb(10~)  
Print type$(k2)="Single"  
k3=fb(10)  
Print type$(k3)="Double"  
k4=fb(10#)  
Print type$(k4)="Currency"  
k5=fb(10@)  
Print type$(k5)="Decimal"
```

If in the above example change the literals 1% and 2% (Integer type 16bit) with 1 and 2 (Double) then only the first three Print return FALSE. This happen because Currency and Decimal are above Double. So the last two upgrade the return value to Currency and Decimal.

We use k, k2 to k5 and not k for all test because a variable get type from first assignment. So if in k=fb(10#) we have a k as type integer then the fb(10#) return Currency type but converted to integer type. Overflows may occur and raise error, when we assign a value to a variable. In an expression we get the arithmetic type which can hold the result (double).

## ***Variadic Functions***

A variadic function get any number of arguments, in current stack (functions have own stack). So we use here Empty which turn to True if current stack is empty, and then we use Number to pop a numeric value (or we get error), also we count the numbers



```

Function Variadic {
    acc=0
    many=0
    While not Empty
        acc+=Number
        many++
    End While
    if many>0 then =acc/many
}

```

Print Variadic(1,2,3,4,5,6,7,8,9,10)=5.5

Or more compact:

```

Function Variadic {
    acc=0
    many=stack.size
    While not Empty
        acc+=Number
    End While
    if many>0 then =acc/many
}

```

Or using tuple. Here first we check if stack is empty. If not then we check the Envelope\$() which return by a letter the type of stack item. So here we want all items as N (numbers). So we make "NNNN...N" at the length of stack.size and we compare it with Envelope\$(). If this is ok the we get all current stack to as stack object (this do the [] symbols) and converted to array using the array() function, and finally export the pointer of the array to acc. Next we get the sum of all items using acc#sum() and then we divide it using the length of acc (In items).

```
Function Variadic {  
    if Empty then exit  
  
    if Envelope$()=string$("N", stack.size) then  
        acc=array([])  
        =acc#sum()/len(acc)  
    end if  
}  
  
Print Variadic(100, 200, 300)=200  
  
m=(100,200,300)  
  
Print Variadic(!m)=200 ' the !m copy the items of tuple to stack of values.
```

### ***Functions May Return Multiple Values***

```
Def Three(X)=x**2, x**3, x**4  
  
A=Three(2)  
  
Print A#val(0)=4, A#val(1)=8, A#val(2)=16  
  
\\ Def Three(X)=x**4, x**3, x**2 ' reverse order by hand  
\\ using a tuple and a tuple function to reverse the order  
Def Three(X)=(x**2, x**3, x**4)#rev() ' reverse order  
\\ See the ! operator for tuple and stacks  
  
Push !Three(2) ' place at top of stack each item in tuple  
  
Read X, Y, Z  
  
Print X=4, Y=8, Z=16
```

```
Def Three(X)=x**2, x**3, x**4 ' not need to reverse it in a call
```

```
Module Disp {
```

```
    Read X, Y, Z
```

```
    Print X, Y, Z ' 4 8 16
```

```
}
```

```
Disp !Three(2)
```

There is a check for the first value if is numeric (or object), If function is numeric major type, and for string ff it is string major type, and if not then we get an error.

A tuple is like a numeric value, because we place the pointer of tuple in a numeric variable (although the variable from that time return the tuple not the numeric pointer which is hidden to programmer). The following examples use Print to print a tuple to columns in console layer. If we place parenthesis for tuple in function alfa\$() we get an error because tuple isn't a string.

```
Function Two(a$, x) {
```

```
    =(a$+a$, x+x)
```

```
}
```

```
Print Two("hello", 1)
```

```
Function alfa$ {
```

```
    ="hello","M2000","Programming","Language"
```

```
}
```

```
Print alfa$()
```

We can make something else for alfa\$() to return a multi type array (tuple is like array but not exactly the same due to interface we use). We define an empty string array, and we feed it with a tuple, so now the tuple may have any type for items, and we return a string array which interpreter accept it without error, because an array with a name with a \$ is a string major type. Arrays with parenthesis works like values. We can assign a new value, by getting a copy of items. So here we get a copy of tuple, not a pointer copy.

```
Function alfa$ {
```

```
    Dim ret$()

    ret$()=(100, "hello","M2000","Programming","Language")

    =ret$()

}

Print alfa$()
```

## ***Functions Passing by Reference***

Functions are different from Modules because they are used in expressions. Also there is another difference: Functions can be passed by reference.

```
Function Alfa$(a$) {

    ="ALFA "+a$

}

Function Beta$(a$) {

    ="BETA "+a$

}

Module Doit (&func$()) {

    Print func$("ok")

}

Doit &Alfa$()

Doit &Beta$()
```

How we can pass a function which use recursion calls? We can use Lambda() and Lambda\$() for numeric or string functions as an alias for the current name.

```
Function fb(x) {

    if x<=1 then =0 : exit

    if x=2 then =1 : exit

}
```

```

    =Lambda(x-1)+Lambda(x-2)
}

Module ShowTen (&f()) {
    For i=1 to 10
        Print f(i)
    Next i
}

ShowTen &fb()

```

A function can be used as module using the Call statement, with a difference. If we return a non zero value then an error raised, with the return value (numeric or string) as the error information. Also the stack of values from caller passed to function the same way as in modules. See in this example we didn't put the = statement to return a value (So we return the default one).

```

Function CallFunc {
    Print "ok", Number
}

Call CallFunc(100)

```

As special call is the Call Local. Using this call we make the function as part of the calling code, so we have the same scope for identifiers. The next example return 100 and 11, because in function DummyName X is the same as the X from the Caller. This type of call used from objects with events.

```

X=10

Function DummyName {
    Print X*X
    X++
}

Call Local DummyName()

```

Print X

As we see functions are not first class citizen, except for passing by reference. There are two object types as functions. The first one is the Lambda object. The second one is the Event object. Also there is a simple form for functions, the simple function form.

### ***Use of simple functions***

Simple functions are lighter versions of normal functions, and always have one definition (we can't change these dynamically). Like subroutines, simple routines are in same scope as the caller's scope. They read the same variables, and we can use Local to create variables and arrays.

So a Local A(1 to 10, 1 to 10) make a local array of 100 items. Same as Local A(10,10).

Read about them in [Old Style programming>Simple Functions](#)

```
Module Alfa {  
    Print @alfa(100) ' 200  
  
    End  
  
    Function alfa(x)  
        =x*2  
  
    End Function  
  
}  
  
Module Beta {  
    Static M=10  
  
    Print @alfa(M), ' 20 18 16 14 12 10 8 6 4  
  
    M--  
  
    If M>1 then Call Beta Else Print  
  
    Clear ' clear static  
  
}  
  
Alfa
```

Beta

Beta

Call Alfa

Call Beta

Call Beta

In the example above we call Alfa two times (one by using Call), and Beta two times. Using Call Beta from Beta we can call recursive the Beta Module. The static variables from recursive call are accessing from all inner calls. Static variables are not part of name space. Beta call @alfa() which is not part of the block of code of Beta, but because exist in the original code where Beta defined, interpreter find it and link it to execute it. This happen without changing: the execution object ( static variables stay there) and the name space (so local variables in Beta are visible to function @alfa(), but for now we don't have any). The name alfa() not exist in list of functions (the normal functions) and the call to @alfa() never use this list, so maybe we have the same name for a normal and a simple function, and maybe the normal is a global one, so a call to @alfa() is always a call to a simple function, not a defined in the list of functions/modules. When we write the code if the name we choose get a color showing a know internal function is an indication that we don't call them through @name() mechanism (which used to call the original internal functions). The following example demonstrate the use of replacing an inner function like Sgn() (return -1 for negative, 0 for zero, 1 for positive number). As we see the change happen for the CheckRegular not for the inner module not for the parent of CheckRegular. The @Sgn() always use the original internal function. So we can't use it for calling a simple function (we have to make it as normal only as in the example)

```
Module CheckRegular {

    Print Sgn(2)=1

    Function Sgn(X) {

        =X*2

    }

    \\ here we call @Sgn() the original function

    Print Sgn(2)=4, @Sgn(2)=1

    Module Inner {

        \\ here Sgn is the original

        Print Sgn(2)=1
```

```
    }  
    Inner  
}  
  
CheckRegular  
  
Print Sgn(2)=1
```

Simple functions can't change code like normal functions using a new definitions (exception exist for some normal functions in Groups which can't change definition if we define them as Final).

Also we can't choose a definition before the use of a function, using an If statement to apply a specific definition. A normal function exist when the definition executed, but a simple function exist always, like subs, as hard coded at the end of the current code, or the original code where the code first exist.

```
    If rnd>.5 then  
        Function alfa(x) {  
            =x**2  
        }  
    Else  
        Function alfa(x) {  
            =x**3  
        }  
    End If  
  
    Print alfa(10)
```

If we place two times a simple function we use the last one in the code. We can place it only for tests, so we can change the last alfa() with another name say alfa1(), and call the code again, but the change can't be done from code. We have to change it by editing the code in an editor. See the End after the Print statement, it is optional.

```
    Print @alfa(2)=8  
  
    End
```



Function alfa(x) ' never used

=x\*\*2

End Function

Function alfa(x)

=x\*\*3

End Function

Another difference is the lack of a name space. Normal functions, like modules have own scope. Subs with parenthesis and simple functions haven't name space, they use the scope of module or function where they called. We have to use Local for making local variables.

Another difference from normal functions is the use of stack of values. When we call a normal function in an expression a new execution object get the code to execute, defining a new stack of values (and a new name space, so all variables are local to function). A simple value use the same execution object from the caller, and the same stack of values. So the simple function is the only way to call in an expression and feed with the current stack without replace him.

Module CheckIt {

Flush ' empty stack

counter=0

Print @alfa(10)=3628800, counter=10

While not Empty

Print Number ' 1 2 3 ... 10

End While

End

Function alfa(x)

=If(x<2->1, x\*@alfa(x-1))

Data x ' add to the end of Checkit stack of values

counter++ ' use the same name space

End Function

}

Checkit

## Lambda Object

The Lambda object is a value type which include two things, a block of code (the function) and a list of closures. A lambda object has two identifiers, one for the object (the variable) and one for the function. Because there are two major kinds of return values, the numeric and strings we can make lambda function as numeric using Lambda, or string function using Lambda\$. Closures are copies of actual variables and can change values. So lambda functions in M2000 can be used to hold state. A simple example where we change the fb() function with a fb lambda object. We use it like a function, passing function by reference. We can also use passing object by reference and passing object by value too.

```
fb = Lambda (x) -> {  
    if x<=1 then =0 : exit  
    if x=2 then =1 : exit  
    =Lambda(x-1)+lambda(x-2)  
}  
  
Module ShowTen (&f()) {  
    For i=1 to 10  
        Print f(i)  
    Next i  
}  
  
ShowTen &fb()
```

Without the use of recursion. The fb lambda return a new lambda. In module ShowTen we call the f() function ten times and each time we get one item from the Fibonacci sequence. We use the function stack of values to push the sum a+b and then to read to b. Another way to make this without using stack of values: **Swap a, b : b+=a**

```

fb = Lambda -> {
    = Lambda a=0, b=1 -> {
        =a
        Push a+b
        a=b
        Read b
    }
}

Module ShowTen (f) {
    For i=1 to 10
        Print f()
    Next i
}

ShowTen fb()

```

Any time we place the f to a variable (Say d) we place not only the code of function but the list of closures as a copy. So a d=f store to d the state of f, and anytime later a f=d restore the state. Closures can be lambda objects too.

### ***Example: Permutation Step***

The next example use a construction of nested lambda functions by using closures and tuple for data structures. The goal of this example is to use a final function to pass a tuple of numbers or strings (or mix of them) and for each call we get the next permutation, until a passing by reference variable change value at the last permutation to indicate the end. The PermutationStep() get a tuple by value (is a pointer so it is like by reference) and return a lambda function which prepare inside. The result lambda function say StepA() get by reference a variable (the indicator for the last permutation), and return a tuple for current permutation.

Inside lambda function we use three functions, the CONS(), CAR() and the CDR(). The first add two or more tuple to one bigger, the second extract the first value from a tuple, the last one return a tuple from a tuple without the first value.

Let see how PermutationStep works. First we make c1 as a lambda which get two things, a f by reference and a as pointer to a tuple (we know that, and interpreter at run time find this). This c1 assign f the true value, so c1 used for the last permutation.

Next we get m as len of tuple a, and then we copy c1 to c. So while m>1 we make a new c1 with two closures, the c2 which hold th last c, and the m which is a pointer to an empty tuple. Also the parameter list is a &f and an a as pointer to a tuple. After making the new c1 we pass the c1 to c and we decrease the m value and loop or exit accordingly the condition in the While.

The last part return a new lambda with three closures, the c (which have a series of lambdas in closure space), the p for counting, the a as pointer to tuple. So only one parameter we have here, the &f (to indicate the last permutation).

When we call the function StepA we pass the &k as &f and let see what happen: The m is empty so m points to a. Next we have the = statement to return a construction of two tuple, the first item of m and the return from c2 (which is the same as StepA except the last one, which is different). So from that point f maybe is true, and this reset f to false and p increment by one. Because we use the **If then** in one line the part after the then skipped if we don't have an Else clause and we have false condition in if. So after the p++ we place a rotation of tuple members and a new if statement to check if p equal len(m) so the f get a true value. So if all internal c2 return f as true, we have the last permutation.

```
Module StepByStep {
  Function PermutationStep (a) {
    c1=lambda (&f, a) ->{
      =car(a)
      f=true
    }
    m=len(a)
    c=c1
    while m>1 {
      c1=lambda c2=c,p, m=(,) (&f, a) ->{
        if len(m)=0 then m=a
        =cons(car(m),c2(&f, cdr(m)))
      }
      c=c1
      m=m-1
    }
    return c
  }
}
```

```

        if f then f=false:p++: m=cons(cdr(m), car(m)) : if p=len(m) then
p=0 : m=(,): f=true

    }

    c=c1

    m--

}

=lambda c, a (&f) -> {

    =c(&f, a)

}

}

k=false

StepA=PermutationStep((1,2,3,4))

while not k {

    Print StepA(&k)

}

k=false

StepA=PermutationStep((100,200,300))

while not k {

    Print StepA(&k)

}

k=false

StepA=PermutationStep(("A", "B", "C", "D"))

while not k {

    Print StepA(&k)

}

```

```
k=false

StepA=PermutationStep(("DOG", "CAT", "BAT"))

while not k {

    Print StepA(&k)

}

}
```

StepByStep

As we see above we don't have a recursion, but we have stored lambda functions as closures objects with state as closures too. This kind of programming cannot be produced with ordinary programming paradigm. We can use recursion in lambda functions. The closures for each recursion call are the same, like they are global, but are local to all chain of calls.

```
k=lambda m=10 (x) -> {

    m--

    if m<=0 or x<0 then =0: exit

    =x+lambda(x-1)

}

n=k

Print k(100)=864

Print n(3)=6, n(5)=14, n(10)=0
```

A lambda function may return a string like this:

```
z$="0123456789ABCDEF"

k=lambda$ z$, n=0 (m) -> {

    if m=0 and n=0 then ="0" : exit

    if m=0 then exit
```

```

n=1
= lambda$(m div 16)+mid$(z$, m mod 16 + 1, 1)
n=0
}

```

Print k\$(0)="0"

Print k\$(65535)="FFFF"

Print k\$(0xF00F)="F00F"

Print k\$(0xFFFFFFFF)="FFFFFFFF"

We can make the lambda like this **k\$=lambda\$ z\$="0123456789ABCDEF", n=0 (m) -> { }**

Or a more sophisticated example:

```

k$=lambda$ (m, b as integer=16) -> {
    if b<2 or b>16 then error "base out of range"
    if m=0 then ="0" : exit
    z$="0123456789ABCDEF"
    =lambda$ z$, b (m) ->{
        =if$(m=0->"", lambda$(m div b)+mid$(z$, m mod b + 1, 1))
    }(m)
}

```

```

k=lambda (m$, b as integer=16) -> {
    if b<2 or b>16 then error "base out of range"
    m$=trim$(m$)
    if m$="0" then =0 : exit
    z$="0123456789ABCDEF"
    =lambda z$, b (m$) ->{

```

```

        =if(Len(m$)=0->0, lambda(mid$(m$,2))+(instr(z$, left$(m$,1))-
1)*b**(len(m$)-1))

    }(m$)

}

Print k$(0)="0", k("0")=0

Print k$(65535)="FFFF", k("FFFF", 16)=65535

Print k$(0xF00F)="F00F", k("F00F", 16)=0xF00F

Print k$(0xFFFFFFFF)="FFFFFFFF", k("FFFFFFFF", 16)=0xFFFFFFFF

Print k$(100, 8)="144", k("144", 8)=100

Print k$(100, 2)="1100100", k("1100100", 2)=100

```

## Event Object

The Event object has two things: A signature and a list of functions. A call to an event is a call to all functions in the event object. Here is the only part of M2000 where the signature of parameter list matters before the call (all other parts need to matter in the callee). When we call the event we pass specific parameters (by value or and by reference) to each function on the list. Functions may added anytime, or can be deleted anytime. Also an event object maybe enabled or not. All functions called like a Call to function (without returning a value), like a call to a module, but the stack of value is new for the call. We can add simple functions (state can change for global variables), or dummy functions (part of a module, as a call back, to store state to module) or functions members of groups, which can store state to group variables.

An event object is a first class object. We can pass it by value or by reference, and we can copy it to another event object (or new name to make it an event object). Event objects as a group member in a Group is a pointer to event object. Because we call multiple functions at once (in one command, but one after the other), we say we make a multicast call. A variant of event object (without use of signature) can be used for monitoring the event messages from user forms (windows) from M2000 windows manager.

Except of these kind of events, groups may have light events, which are a mechanism to call an event service routine from a named group. So light events are not objects. They don't use signature and has no multicast functionality.

```
Flush ' empty stack
```

```
Print Stack.Size
```



```

Event A {
    Read message$, &z
    Function {
        ' this is the default function (optional)
        Print message$
    }
}

x=10

Call Event A, "ok 1", &x

Event A Hold

Call Event A, "ok 2", &x

Event A Release

Call Event A, "ok 3", &x

Function Addme {
    Read m$, &a
    a++
}

Event A new Addme()

Call Event A, "ok 4", &x

Print x=11

Event A drop Addme()

Call Event A, "ok 5", &x

Print x=11

Function callback {

```

```
    Print Stack.Size

    x+=10

}

Event A new lazy$(&callback()), Addme()


Module Inner (m) {

    z=50

    Call Event m, "Inner", &z

    Print z=51

}

\\ now A has a callback

Inner A

Print x=21, Stack.Size
```

So when we call the Inner module we pass the A event as a copy. When we call the event from inner, we call a part of outer module, named callback, which act as part of module and not as a function. So we can change the x variable. Because we can add or drop functions by logic we can change the response of a module. A callback is like the pass by reference, but now we pass code not only variables. We see before a call from a module as a group member passing by reference another group and change state to each group. Now we place the event object which hide the functions inside, and only the parameter signature used to perform the call. Also the call maybe hold or released, so a Call Event maybe not work, but no error raised.

The lazy\$() function make functions callbacks. We can put a simple expression or a multiline code using a reference to a function (we do the last in the example above). Here is an example with a simple expression:

```
x=10

z=5

Push Lazy$(x**2+z)

Read &a()
```

```
Module TestMe (&b()) {
```

```
    Print b()
```

```
}
```

```
TestMe &a()
```

```
Print a()=105
```

```
x=100
```

```
TestMe &a()
```

```
Print a()=10005
```

```
\\ we can do the following but not in the module TestMe
```

```
Print eval("x**2+z")=10005
```

## Light Events in Groups

Here is the use of light events for groups. See that the service routine has an underscore, not a dot between name of group and name of event. Events from COM objects also has the same type of service routines. Events using event object have name dot and event name.

In the following example we can use Events or Event and then we have to put a list of names as strings. That names are the light events. The B\_alfa is the call back, or the event service routine. The Inner2 pass the group as a copy, the callback also copied. Just change B\_alfa to B\_alfa1. The code has no problem, the call event "alfa" may not have a service routine.

```
Group WithEvents B {
```

```
    Event "alfa"
```

```
    Module doit {
```

```
        call event "alfa", 100
```

```
    }
```

```
}
```

```
K=10

Function B_alfa {
    Print number, K
    K++
}

Module Inner (&C) {
    C.doit
}

B.doit

Inner &B

Module Inner2 (C) {
    C.doit
}

Inner2 B
```

The last example use an event to check the messages from a form. The statement Stack display the current stack (is the stack from event). The method Show with parameter 1 is the modal show for a form (has the loop inside waiting to close it). Because the focus is in the modal form, we have to refresh the console window, when we change it, using Stack.

### **Declare Form1 Form Event B**

```
Function Dummy {
    Stack ' just display stack
    Refresh
}

Event B new &Dummy()

Method Form1, "Show", 1
```

**Declare Form1 Nothing**

## The Document Object

A Document object is an object which used with statements and functions for documents as object and in string expressions as string. For rendering text we have to use Report, or Print #-2, DocVar\$ which use console like a file to output text, with interpretation of special characters, and render as non proportional font (for any font). The Print #-2 used for Text Art too, and not performing justification or column adjustment.

A document object has each paragraph as separate string in a double linked list. For speeding operations when displaying in an editor, each paragraph may split in different strings depends on wrapping. This object used in internal editor and in EditBox control.

The Len() functions get an expression but Doc.Len() get a Document object, so we get the length without any copy of the string.

The Report statement can render document and string variables for all lines, or part of lines, and also can do a dummy render only for counting the lines needed for rendering for the current layer using current font attributes and justification mode (4 modes, Left, Center, Right and Full, using 0,1,2 and 3 as codes). By default 0 (word wrap and left justify) used if no number provided as first parameter. The left margin obtained from the cursor position in row. The max width or a line by default is the width of the layer but we can put another number after the string to render and if is lower than 1000 then the number is the characters width or from 1000 then the number is in twips. Report has more optional arguments, for the first render line from where we render the text, the number of render lines to display and a document to assign these lines (and int this case not to display).

Report statement in displayed layers (not in printer layes) hold the diplaying after ¾ of performing scrolling lines, and wait for space bar or mouse button to continue. In case of waiting threads and events can be executed.

We can sort lines (providing the character position on each paragraph from where we start comparisons). We can save to file, merge to file, load from file and append from file. We can load in any of UTF-16LE, UTF-16BE, UTF-8, and ANSI using Linux or Windows new line character. Also there is an auto encoding recognition, so when we save back a file the saving happen to the same encoding. BOM mark also used for recognition of encoding if exist, but there is an algorithm to find the encoding without using it.

We can count words, and unique words, very fast also we can get the words as result. The same counting happen when we press F9 in editor an in EditBox control.

```
a$={HELLO
```

```
DUDE
```

```
} ' a$ is a string
```

```
Dim B$(10)
```

```
Document A$, B$(2)
```

```
\\ now a$ upgrade to Document, also B$(2) upgrade to Document
```

```
a$="TEST1"
```

```
b$="TEST2"
```

```
Report A$
```

```
Report B$
```

```
Print Doc.Len(A$),Doc.Len(B$)
```

```
\\ we can't erase using A$="" (it is append to document, not assignment)
```

```
Clear A$, B$(2)
```

```
Print Type$(A$), Type$(B$(2))
```

Document statements:

APPEND.DOC, EDIT.DOC, FIND, INSERT, LOAD.DOC, MERGE.DOC, OVERWRITE, SAVE.DOC, SORT, WORDS

Document functions

DOC.LEN(), DOC.PAR(), DOC.UNIQUE.WORDS(), DOC.WORDS(),

Document read only variables

## Data Containers (objects)

There are three objects, as data containers. Each one may contain data or and other containers. We handle these by pointer, a variable name which hold a hidden pointer:

1. Auto Array (a tuple)
2. Inventory
3. Stack

### ***Array Object***

See about Arrays in the [Using Arrays](#). Read this which have information about the array as object.

Arrays in M2000 are objects. There are two interfaces and one underline object, the mArray:

1. Name with Parenthesis like A() or A%() or A\$(). (Array as a Value)
2. Name as pointer to Array like A. (Pointer of Array)

```
Dim A(4)=1
```

```
A=(1,2,3,4)
```

```
Print A ' 1 2 3 4
```

```
Print A() ' 1 1 1 1
```

```
Print Len(A())=4
```

```
Print type$(A)="mArray", Len(A)=4
```

```
Push A(), A ' so now top of stack has a copy of A pointer
```

```
Stack ' show *[mArray], *[mArray] we see two pointers.
```

```
Read A(), A
```

```
\\ get a copy of pointer and drop pointer
```

```
Print A ' 1 1 1 1
```

```
\\ get a copy of array items in A() from pointer, and drop pointer
```

```
Print A() ' 1 2 3 4
```

Passing by value an array A() is passing a pointer, and then if we read to A we get a copy of pointer, else if we read to B() we get a copy of items to B() at the time we read the B().

Lets see the following example. We make a new name A() as an empty array. We make a copy of auto array (or tuple) as (1,2,3,4,5), here with numbers but we can put anything, including pointers to containers. We push A() to stack, and then we copy new items (6,7,8,9) changing the Len(A()) form 5 to 4. The pointer of A() not changed. So we read B() (we can use an new name in READ) and we get a copy of A() as 6 7 8 9.

```
Dim A()
```

```
A()=(1,2,3,4,5)
```

```
Push A()
```

```
A()=(6,7,8,9)
```

```
Read B()
```

```
Print B() ' 6 7 8 9
```

```
B(0)++
```

```
Print A() ' 6 7 8 9 because B() has different pointer, it is a different array
```

Lets see the following example. Variable A is a pointer to the literal (1,2,3,4,5) (a copy of the literal in the memory). Variable B is a copy of A/ We push A to stack, as a copy of pointer A. Now we place a new pointer to A with a copy of literal (6, 7, 8, 9). So now We read B() as a new name and because A is a pointer B() get the pointer only, so no items copied. So B() has the same pointer as B. We prove that by adding one to each item of B using B++.

```
A=(1,2,3,4,5)
```

```
B=A
```

```
Push A
```

```
A=(6,7,8,9)
```

```
Read B()
```

```
Print B() ' 1 2 3 4 5
```

```
B++
```

```
Print B ' 2 3 4 5 6
```

```
Print B() ' 2 3 4 5 6
```

How this is possible for these two example to Read B(), the first time using new pointer and the second time using the same pointer from mArray on stack?

Stack say for each interface that is mArray but they are different. The pointer is another object (named mHandler) which is a carrier of mArray. So interpreter knows what to do. All container pointers which are of the second interface (a simple variable name, not a name with parenthesis) are of the same mHandler object, but all reports from Stack and List for variables always return the underline object. So a container pointer is actually a mHandler. An array A() is actually mArray object, so when we put it to stack we put the mArray not the handler. So when interpreter read this from stack know what is the target (A or A()) and what is the reading object (mHandler which have a mArray, or the mArray).

Names mArray and mHandler are actual names of objects in the source code of M2000 interpreter.



Arrays of first interface allow shallow copy, so a A[]=B[] means that A[] get a copy of B[]. Because B may have pointers to objects, B get copy of that pointers. But Group objects that are items in arrays without pointer we get a copy of Group.

```
Group A {X=10, Y=30} ' this group is a named
```

```
Dim A(10)=A ' a named group copied to each position using different pointer.
```

```
Print A(0).X, A(0).Y
```

```
Push A()
```

```
A(0).X+=10
```

```
Read B()
```

```
Print B(0).X=20 ' as expected - we see that in previous example
```

```
B(0).X=10
```

```
Print B(0).X=10
```

```
Print A(0).X=20 ' because A() has ten different Groups from B()
```

All objects above in A() and B() have unique pointers. We can use groups with unique pointers as Values.

Lets see the same example with pointers to Groups. We put the Group A as a copy in lambda function GetPointer, as a closure, and now we didn't use = to return a value, but arrow to return a pointer of A. Pointers are two types, a pointer to a named group, or a pointer to volatile group. The first pointer is a weak reference so here we want the second one. We have to place A in parenthesis, so -(A) return the volatile A (a copy of A as a volatile group). A volatile group erased when no pointer points to it. A named group erased when the creator exit from call. Here we have a lambda function, and the closure kept as volatile group, and when we call the lambda function then interpreter create A using the volatile group and at the exit copy back the named group as the volatile group. So now each time the GetPointer() called in an expression return a pointer to a new volatile group. So for all items in A() we get ten pointers to different groups.

```
Group A {X=10, Y=30}
```

```
\\ we use (A) to get a pointer to a volatile group
```

```
\\ else we get a pointer as a reference to something which loose the reference
```

```
\\ when GetPointer return from call
```

```
GetPointer=Lambda A -> {  
    ->(A) ' or    =Pointer((A))  
}
```

\\ << execute a function for each item in A()

```
Dim A(10)<<GetPointer()
```

```
Print A(0).X, A(0).Y
```

```
Push A()
```

```
A(0).X+=10
```

```
Read B()
```

```
Print B(0).X=20 ' as expected - we see that in previous example
```

```
B(0).X=10
```

```
M->B(0)
```

```
Print B(0).X=10, M=>X=10
```

```
Print A(0).X=10 ' because A(0) is B(0)
```

```
Print A(0) is B(0) = True, A(0) is M = True
```

```
Print A(1) is B(1) = True
```

```
Print A(1) is A(2) = False
```

When we read B() we get a shallow copy, and this means that we get copy of pointers to groups, not copy of groups. We prove this by altering the B(0).X and see that the same done to A(0).X also the A(0) is B(0) which compare pointers say that is equal, returning true. We see that we can get pointer from B(0) to M which is the same as A(0). Also see that M=>X used to get value from X of M.

Arrays of second interface works with pointers, and if the last pointer erased, say A=B the A points to the same array which point B, and A was a unique pointer to another array, then this array erased.

We can define arrays with parenthesis using:

- DIM
- LOCAL
- GLOBAL

- READ (reading from stack to first interface from either interface on stack)
- Auto Array is a literal definition of an array (1,2,3,4), or jagged arrays ((1,2),(3,4))

We can make references for arrays (each identifier can take one reference when defined)

- READ when we pass a weak reference
- LINK for any mix of interfaces.

We can get a pointer from an array (second interface):

- Assignment A=A() or A=(1,2,3,4) or A=B when B is a pointer of an array
- READ to second interface from stack of values when top of stack is a by value pass of either interface
- Read by reference second interface from a weak reference at top in stack from either interface.

Items in Arrays can be a mixed type. Lets see what happen if we make A() and A\$() as reference of A. Especially when we pass a K() array to A() and next to A. The first make a copy o K() to what A() points, so A and A() and A\$() point to a copy o K(). The second make A to point K() and A() and A\$() as reference of A they point to K(). Reference A() and A\$() can't take new reference.

```
A=("A String", 100)
```

```
Link A,A to A$(), A() ' so now A, A$() and A() are the same
```

```
Print A(1)=100 ' true
```

```
Print A$(0)="A String" ' true
```

```
Print A ' print all using columns
```

```
Print A#val$(0)="A String" ' true
```

```
Print A#val(1)=100 ' true
```

```
Return A, 0:="New name", 1:=500
```

```
Print A$(0), A(1)
```

```
Dim K()
```

```
K=("old name", 100)
```

```
A=K()
```

```
K(1)=1000
```

```
Print A
```

```
Print K() ' A is not K()
```

```
A=K() ' Now A is K()
```

```
K(1)=200
```

```
Print A
```

```
Print A(1)=200
```

Arrays have special functions, plus an iterator object. The iterator object use the Each() to return an iterator from a container as a pointer to a mHandler which hold a hard reference to A(). So we can't return as value an iterator, we have to use in place we make it. To use the iterator we have a special While which find the specific object and handle it accordingly. We can get the counter from m using ^ as m^ (because m is an object, the ^ operator isn't the power operator).

```
counter=lambda x=0 -> {x++ : = x}
```

```
Dim A(10)<<counter()
```

```
Print A() ' 1 2 3 4 5 6 7 8 9 10
```

```
m=each(A())
```

```
While m
```

```
Print Array(m), Array(A(), m^)' print 1 to 10 two values in a row
```

```
End While
```

Because an array may have from zero to ten dimensions, the iterator iterate the array as one dimension. Read the following example. We make A(2,2) which have type Empty as initial value (this treated as zero if we read A() or empty string if we read a reference of A(0 to a A\$()). Next we place to row 0, two values using := assign symbol for arrays, so we can place a string and a number. The same for row 1. We print A() like one dimension in columns using Print (which have a private iterator). So now we make m as iterator of A() and because we didn't place start and end value, the iteration has to be for each item, like the A() has one dimension. The good thing is that we can program inside the While the iterator object, setting the next start value as m^ (the current) plus 2. To print the first item in a row we have to use Array\$(m), see the \$ in this function which return string, and for the second item we have to use the second optional parameter of Array(), so we have to place the number of item as m^+1.

When an array used from a pointer as tuple (also from an iterator) the first item is always at 0 and the last at number of items minus one.

```

Dim a(2,2)

A(0,0):="Alfa",100

A(1,0):="Beta", 300

Print A()

m=each(a())

while m

    Print Array$(m), Array(m, m^+1)

    m=each(m, m^+2) ' add 2 to iterator

end while

```

Special functions for tuples, and arrays (which treated as tuples) are:

#EVAL(), #FILTER(), #FOLD(), #MAP(), #MAX(), #MIN(), #POS(), #REV(), #SLICE(),  
 #SORT(), #SUM(), #VAL(), #EVAL\$(), #FOLD\$(), #MAX\$(), #MIN\$(), #VAL\$()

These functions return a value or an array (a copy) as a pointer, and can be used one after the other.

```

A=("Z","A","B")

Print A#sort() ' A B Z

A=(3,2,1)

Print A#sort() ' 1 2 3

A=(3,2,"Z", 1, "A","B")

Print A#sort() ' 1 2 3 A B Z

Print A#sort()#rev() ' Z B A 3 2 1

```

Also there are three more functions: CAR(), CDR(), CONS().

```

A=(1,2,3)

B=CAR(A)

Print Len(B)=1

Print B ' 1

```

```
C=CDR(A)
```

```
Print Len(C)=2
```

```
Print C ' 2 3
```

```
A=CONS(C,B)
```

```
Print Len(A)=3
```

```
Print A ' 2 3 1
```

```
A=CONS(A,A)
```

```
Print Len(A)=6
```

```
Print A ' 2 3 1 2 3 1
```

We can change dimension of an array without erasing items (if the new total items are same or greater than the old, and we didn't provide a value or a function per item). Also we can copy items from one array to another and from same array with care for overlapping items.

```
A=(1,2,"this is a String",4,5)
```

```
Module Redim (&A(), x) {
```

```
    Dim A(x)
```

```
}
```

```
Redim &A, 100
```

```
Print len(A)=100
```

```
Link A to A()
```

```
Print type$(A(0))="Double", type$(A(5))="Empty"
```

```
For n=0 to 40 step 5
```

```
    Stock A(n) keep 5, A(n+5)
```

```
Next n
```

```
Stock A(0) keep 50, A(50)
```

```
Dim B(5)
```

For n=0 to 95 step 5

    Stock A(n) keep 5, B(0)

    Print B()

Next n

Stock B(0) out a1, a2, a3\$, a4, a5 ' we can place values from an index

Print a1, a2, a3\$, a4, a5

Stock B(0) in a5, a4, StrRev\$(a3\$), a2, a1

\\ same as B(0):= a5, a4, StrRev\$(a3\$), a2, a1

Print B()

Another way to add items to a tuple:

A=(1,2,3)

B=A

A=CONS(A, (4,5,6))

Print B

Print A ' A has a new pointer

\\ Now we use Append to keep the pointer

C=B

Append C, (4,5,6)

Print C

Print B ' C is B, they have the same pointer

## ***Inventory Object***

An inventory object is a container with a key or a key and a value (if not value passed to a key then the key returned as value). A key maybe a number or a string or a mix of these. Internal the inventory works with a hash function. Internal is an array for items which

expands as we place items. So expect for expansion or reducing, to add an item or to delete an item is a  $O(1)$  time complexity. For searching also we have  $O(1)$  time complexity.

The simple type List, has unique keys. We get error if we append a key and the key already exist

```
Inventory Alfa=1,2,3,5,6,17
```

```
Print Alfa ' 1 2 3 5 6 17
```

```
Append Alfa, 4
```

```
Print Alfa ' 1 2 3 5 6 17
```

```
Sort Alfa As number
```

```
Print Alfa ' 1 2 3 4 5 6 17
```

```
Return Alfa, 1:="One", 2:="Two"
```

```
Print Alfa ' One Two 3 4 5 6 17
```

```
If exist(Alfa, 2) Then Print "key 2 exist and has value: ";Eval$(Alfa)
```

```
If exist(Alfa, 5) Then Print "key 5 exist and has value: ";Eval(Alfa)
```

```
Print Alfa(5)=5, Alfa$(2)="Two"
```

```
Print Alfa("5")=5, Alfa$("2")="Two"
```

we can't use `Alfa$(1)="..."` we have to use **Return Alfa, 1:="..."** but we can append

```
Alfa$(1)+="..."
```

```
Print Alfa$(1)="One..."
```

Another way to make a **list** (inventory), using parenthesis for handling then `:=`. Also the inventory identifier exist as read only variable which pop an inventory from the stack (or raise error).

```
Push (list:=1,2,3:="ok",4,5)
```

```
k=inventory
```

```
Print k ' 1 2 ok 4 5
```



From an inventory we can **delete an item**, but the order isn't guarantee.

```
Inventory Beta=1,2,3,4,5
```

```
Delete Beta, 3
```

```
Print Beta ' 1 2 5 4
```

**Inventories also have iterator objects:**

```
Inventory a=1:="one",2:="two",3:="three",4:="four",5:="five"
```

```
m=each(a)
```

```
While m
```

```
    \ index from counter, value as string, key as string, index from item
```

```
    Print m^, eval$(m), eval$(m, m^), eval(m!)
```

```
End While
```

A special version of Inventory is the **Queue inventory**. The Queue take same keys and never break the order, nor when sort.

```
Inventory queue delta=1,2:="two-1",3,1,2:="two-2"
```

```
Print delta ' 1 two-1 3 1 two-2
```

```
sort delta
```

```
Print delta ' 1 1 two-1 two-2 3
```

```
Print Len(delta)
```

```
Drop delta, 1 ' variant of Drop with same effect: Drop delta to len(delta)-1
```

```
Print delta ' 1 1 two-1 two-2
```

```
Print exist(delta,2)=true
```

```
Print exist(delta,2,0)=2
```

```
i=1
```

```
While exist(delta, 2, i)
```

```
\\ value, item no
```

```
print eval$(delta), eval(delta!)
```

```
i++
```

End While

Append delta, 3

\\ we can change the value at specific index accessing delta properties

\\ index is base 0, so first item is 0,

With delta, "index", 2, "value", "New Value"

With delta, "index", 0, "value", 100

Print delta ' 100 1 New Value two-2 3

\\ By default we change the last one of the same keys

Return delta, 2:="last one"

Print delta ' 100 1 New Value Last one 3

Print Len(delta)=5

Inventory delta ' new pointer, if the old one is the last then old data destroyed

Print Len(delta)=0

### **Combining Inventories and arrays:**

Inventory a=1:=(1,2,3),2:=(3,4,5)

Print a(1)(0), a(1)#sum()=6, a(2)#sum()=12

z=a(1) ' we get a pointer form a(1)

return z, 2:=100

Print a(1)#sum()=103

\\ we can place the pointer of a to an item in B()

Dim B(10)

```

B(2)=a
Print B(2)(1)#sum()=103
Print B(2)(2)#val(2)=5
z=a(2)
return z, 2:=1000
Print B(2)(2)#val(2)=1000
Append z, (6,7,8)
Print Len(z)=6
Print B(2)(2)#sum()=1028

```

### **Making a queue in expression:**

```

Print (queue:=1,2,3:="300",400)
q=queue:=1,2,3:="300",400

```

### **Inventory sorting by columns in keys:**

```
inventory queue alfa
```

with alfa, "Stable", false ' so we use quicksort and not insertion sort (default in inventory queue)

\\ 0 means ascending text

\\ 1 means descending text

\\ 2 means ascending numeric

\\ 3 means descending numeric

\\ keys have to place a chr\$(1) to handle it with columns.

```
def d$(a$, n)=a$+chr$(1)+str$(n,"")
```

```
Append alfa, d$("a1",1):=1,"c1",d$("a1",2):=2
```

```
Append alfa , "b1",d$("a1",3):=3,"z1", d$("a1",4):=4,"c2",d$("a1",5):=5,"b5",d$
("a1",100):=100,"z1", "sin","pêche","péché","peach"
```

Print "without sort"

Print alfa

Print "sort first part of key ascending as text (chr\$(1) used to break parts),  
second part ascending as number"

Sort alfa, 0,2

Print alfa

Print "same as previous but use 1036 for clid for text"

Sort ascending alfa, 1036, 0,2

Print alfa

Print "sort key ascending with automatic number recognition"

Sort ascending alfa as number

Print alfa

Print "sort key ascending as text, 1036"

Sort ascending alfa as text , 1036

Print alfa

Print "done"

### **Change an item value by an operator**

```
alfa=list:=1,2,3,4,5
```

\\ without valuse, keys are values also

```
m=each(alfa)
```

\\ we can't use =, we have to use Return alfa, m^:=expression

```
While m {
```

```
    alfa(m^!)*=100 ' change valies
```

```
}
```

Print alfa '100 200 200 400 500

\\ 2 is the key, 1! is the order number (start from 0).

Print alfa(2)=200, alfa(1!)=200

Print alfa(2) div 12 = 16 ' true

alfa(2)|div 12

Print alfa(2)=16 ' true

## ***Stack Object***

So we see until now, data indexing by number for one up to ten dimensions, and list of data in inventories using keys. The third container is the stack object a collection of values, with easy moving. The stack object is identical to stack of values object. The difference is that the current stack never expose a pointer. We can get the current stack only if we place a new one. The identifier [] do that, expose the pointer of current stack and leave a new stack as current stack.

Flush ' empty current stack

Data 1,2, "three", 4

m=[]

Print Empty=true

Print len(m)=4

\\ stack is one based

Push 1, 2, 3

Print Len(m)=4, StackItem(m, 1)=1, Stackitem\$(m, 3)="three", StackType\$(m, 3)="String"

Stack m {

\\ hidden current stack temporary and make m as current stack

Stack

Print envelope\$()="NNSN"

Print StackType\$(3)="String"

```
        While not empty
            If isnum then Print Number else.if islet then Print Letter$ else drop
        End while
    }

    Print "Now old stack restored"

    Stack ' show stack

    Print Stack.Size=3

    Read A, B, C

    Print A=3, B=2, C=1
```

We can make stack objects in expression, also we can make iterator for stack object:

```
alfa(stack:=1,2,"three",3)

Sub alfa(m)

    Print m

    local mm=each(m)

    while mm

        if stacktype$(mm)="String" then

            Print stackitem$(mm)

        else

            Print stackitem(mm)

        end if

    end while

end sub
```

## Binary Data - Buffer Object

The three previous containers can get each other as item. The Buffer container can be an item for the previous containers but can't contain objects.

A Buffer is an object with a memory buffer, and in some cases we can make pointers to strings (BSTR). The memory buffer can be expand or reduced. Any buffer has a number of items, from one and above.

Items for buffer can be simple items or structures of items. An array of numbers in M2000 need at least (without other properties) number of items times 16, because each item is type of Variant (so a Variant can hold any type including objects). A simple item in buffer has the exactly bytes we need to spend for that. So a byte has one byte, an integer has 2 bytes, a long has 4 bytes, a double has 8 bytes. So an array in buffer of 100 double numbers have 100\*8 bytes and not 100\*16 bytes.

### *Simple items*

So lets make 100 bytes of a clear memory buffer. The clear clause erase then memory buffer. We say byte\*100 so we have item as byte and 100 of them. A byte can hold values from 0 to 255 (unsigned value)

```
Buffer clear alfa as byte*100
```

```
Return alfa, 0:=65, 1:=66, 2:=67 ' we place three values from 0 offset
```

```
Print Eval(alfa, 0)=65
```

```
\\ eval$(alfa, 0,3) get 3 bytes from offset 0 and return them as string
```

```
Print chr$(eval$(alfa, 0, 3))="ABC" ' Chr$(string) get a string as ANSI and  
return Utf-16Le
```

```
A$=eval$(alfa, 0,3)
```

```
Print Len(A$)=1.5 \\ len return as words (2 bytes) so 1.5*2= 3 bytes.
```

```
For i=1 to 3
```

```
    \\ a mid$() for ansi strings
```

```
    K$=mid$(A$, i, 1 as byte)
```

```
    Print Len(K$)=0.5, Asc(chr$(K$)) ' True 65 True 66 True 67
```

```
Next i
```

```
\\ using Str$(string) convert a Utf-16LE to ANSI using current Locale number
```

```
Return alfa, 0:=Str$("IKL")
```

```
Print chr$(eval$(alfa, 0, 3))="IKL"
```

```
Print alfa(0) ' return the address of first byte in alfa
```

```
\\ We can place signed bytes, integers, longs using uint()
```

```
Return alfa, 20:=uint(-5)
```

```
\\ but we read them as unsigned, or we can convert them using sint()
```

```
Print eval(alfa, 20)=251
```

```
\\ sint() get 1 for byte, 2 for integer and 4 for long
```

```
Print sint(eval(alfa, 20),1)=-5
```

```
\\ copy pointer to new variable
```

```
a=alfa
```

```
\\ casting, when we use casting at Eval the offset always has byte unit.
```

```
Return a, 30:=0xFFFFFFFF as long
```

```
Print Eval(a, 30 as long)=0xFFFFFFFF ' true
```

```
Print Eval(a, 29 as Integer)=0xFF00 ' so we have little endian
```

```
Buffer beta as long*25 ' Item is Long 4 bytes
```

```
Return beta, 0:=Eval$(alfa,0, 100) ' copy alfa to beta
```

```
Print Eval(beta, 0)=5000009
```

```
Print Eval(beta, 0)=0x4C4B49
```

```
Print Eval(beta, 1 as byte)=0x4B
```

```
Return beta, 0:=0x4C4B48
```

## ***Using Structures***

So how we can but the second byte on first long on beta (at offset 0). We know that reading is easy, because we place the offset as byte at casting. So for returning values we need to use structures with unions.



```

structure aLong {
    {
        a as Long
    }
    {
        a0 as integer
        a1 as integer
    }
    a00 as byte
    {
        a22 as integer
    }
    a01 as byte
    a10 as byte
    a11 as byte
}

Print Len(aLong)=4

Buffer clear Delta as aLong*25

Print len(Delta)=100

offset=1

Return delta, offset!a01:=0XFF, offset+1:=0xFFFFFFFF

Print Eval(delta, offset)=0XFF00

Return delta, offset!a1:=0XFFAA

Print Eval(delta, offset)=0XFFAAFF00, Eval(delta, offset!a1)=0XFFAA

```

```
Print Eval(delta, offset*4+1 as integer)=0XAAFF ' this is casting
```

```
Print Eval(delta, offset!a22)=0XAAFF
```

```
Hex Eval(delta,offset), Eval(delta, offset!a1)
```

## ***BSTR Strings in Buffers***

A BSTR is a windows system string, which a pointer point to an offset in memory and offset-4 is the length of string and from offset we have the string data. String data can be ANSI or Unicode (Utf16-LE) or any data, including zero bytes. For some cases a BSTR string always finish to double zero (two zero bytes), and these bytes aren't report to length. A second property for BSTR is that we can't write to it. So if we change a BSTR string we get a new one in a new pointer. So a pointer points to a "constant" string. All strings in M2000 are BSTR type. The variant type also work with BSTR type of string, so a Variant has 16 bytes, but only 4 bytes needed to point to a BSTR. An empty string has null pointer in variant. So except for null string all other have the BSTR structure (length+data+"00") with offset at first byte of data.

The pointers for BSTR in Buffers are pointers to pointers of BSTR. When a buffer object destroyed, the real pointers of BSTR are in a inventory and from there all strings erased. So at the end all memory return to system.

```
structure alfa {  
    {  
        a as long*4  
    }  
    c as String*4 ' 4*4=16  
    b as long*4 ' 4*4=16  
}
```

```
Print len(alfa)=32, Type$(alfa("c"))="String"
```

```
Buffer Clear Check as alfa*10
```

```
Print Len(Check)=320
```

```
offset=0
```

```
Return Check, offset!c!0:="Hello There"
```

```

Return Check, offest!c!1:=""

Return Check, offest!c!2:=""

Print Eval$(Check, offest!c!0)

Try {

    Print Eval$(Check, offest!c!3)="

}

Print Error$ ' Invalid pointer for BSTR at Buffer

Print Eval(Check, offest!a!1) ' point to a bstr pointer

Print Eval(Check, offest!a!2) ' point to another bstr pointer

```

Offsets with ! Notation may have up to three level, or we have to use functions to calculate the final offsets. A structure is a an read only Inventory. The values are the offsets, and the labels are the keys. These inventories uses a second value for each item to store the type of item. As types we can use other structures.

## ***Binary Files***

Expanding the previous example (add these lines of code), to see how we can use Put and Get for binary files. If we want to read and write a binary file, we open for append, we use Seek to position the file cursor, and the same time we open the file for input and now we get a second file cursor. For this example we use a file for one buffer only. So no need for use of Seek statements. The Put and Get statements read the length of buffer and then use it for the operations. So if we expect to get from file cursor 100 bytes we get error if there are not so many bytes in file. The FileLen() function return the file length in bytes. If a buffer has pointers to BSTR then we make a mistake. We have to use strings inside buffer, ANSI or UTF-16LE, or UTF-8 (look Help String\$() to see the variant which make conversions to some string encodings)

```

Open "Buffer01.bin" for output as #k

    Put #k, delta

Close #k

Print Filelen("Buffer01.bin")=100

Buffer clear Delta as aLong*25

```

```
Hex Eval(delta,offset), Eval(delta, offset!a1)
```

```
Open "Buffer01.bin" for input as #k
```

```
Get #k, delta
```

```
Close #k
```

```
Hex Eval(delta,offset), Eval(delta, offset!a1)
```

## ***Handle of Png File***

We can use Buffer(filename\_string) to get a file as a buffer in memory. If a buffer has an image file then M2000 can handle it using GDI+. Functions like Image.X() and Image.Y() get width and height in twips of the image in buffer. In buffer we have a compressed image, and the PC quickly expand it and drawing. Also if PNG file has information a percentage of opacity on a color or by a mask for each pixel then GDI+ handle it pretty fast. Look [Appendix I](#) for the test.png.

```
Png4=Buffer("test.png")
```

```
x=Image.X(Png4) div 2
```

```
y=Image.Y(Png4) div 2
```

```
hold
```

```
Mouse.icon Hide
```

```
every 25 {
```

```
    release
```

```
    move mouse.x-x, mouse.y-y
```

```
    image Png4
```

```
    refresh
```

```
    if keypress(1) then exit
```

```
}
```

```
Mouse.icon Show
```

There is another variant, where we use a Thread to change N

```

Png4=Buffer("test.png")

hold

N=1

M=1

Thread {

    if keypress(2) then N=if(N=359->0, N+M) : M++ Else M=1

} as K interval 10

Mouse.icon Hide

Main.Task 25 {

    release

    move mouse.x, mouse.y

    sprite Png4,,N

    refresh

    if keypress(1) then exit

}

Mouse.icon Show

```

### ***Machine code execution***

The following example uses two Buffers, one for data and one for code. A buffer for code at execution time is locked for write to it. The first buffer is BinaryData, the second named alfa. We use a PC as program counter and some subs to place code. The PC is the offset for alfa buffer. We use casting for placing 32bit numbers.

Subs run at same scope as module or function where they called. [See about subroutines.](#)

The result can be retrieved from BinnaryData buffer or from accumulator (a non zero return an error) depending of the one before last opcode OpByte(0x31, 0xC0). Last opcode is Ret()

Machine code used in M2000 for experiments. It's very easy to hang the environment with a mistake in the code.

```
\\ we make a buffer to use for DATA
```

```
Buffer BinaryData as Long*10
```

```
Return BinaryData, 1:=500
```

```
Buffer code alfa as byte*1024
```

```
\\ use https://defuse.ca/online-x86-assembler.htm
```

```
\\ to find opcodes
```

```
pc=0
```

```
\\ x86 Machine Code
```

```
OpLong(0xb8, 5100) ' mov eax,0xa    ' 5100 to eax
```

```
OpByteByte(0x83, 0xC0 ,5) ' add  eax,0x5  ' add 5 to eax
```

```
OpByteLong(0x3,0x5, BinaryData(1)) 'add eax, [BinaryData(1)] ' add eax 500  
from second long on BinaryData
```

```
OpLong(0xa3, BinaryData(0)) ' mov [BinaryData(0)], eax
```

```
rem : OpByte(0x31, 0xC0) ' now eax=0 ' without this we get 5605 in M
```

```
Ret() ' return
```

```
\\ end of code
```

```
Try Ok {
```

```
    Execute Code alfa, 0
```

```
}
```

```
M=Uint(Error)
```

```
Hex M
```

```
Print M
```

```
Print Error, ok
```

```
Print Eval(BinaryData, 0) ' 5605
```

```
Sub Ret()
```

```
    Return alfa, pc:=0xC3
```

```
    pc++
```

```
End Sub
```

```
Sub OpByteByte()
```

```
    Return alfa, pc:=number, pc+1:=number, pc+2:=number
```

```
    pc+=3
```

```
End Sub
```

```
Sub OpByte()
```

```
    Return alfa, pc:=number, pc+1:=number
```

```
    pc+=2
```

```
End Sub
```

```
Sub OpLong()
```

```
    Return alfa, pc:=number, pc+1:=number as long
```

```
    pc+=5
```

```
End Sub
```

```
Sub OpByteLong()
```

```
    Return alfa, pc:=number, pc+1:=number, pc+2:=number as Long
```

```
    pc+=6
```

```
End Sub
```





## Old style programming with M2000

The old style programming is like programming with BASIC language, except the use of block of statements in curly brackets which is optional. Parts of old style are the flow control structures.

In M2000 we use the IF structure, the For Loop, the Do or Repeat loop, the While loop, plus a simple block loop. Also we may use Labels named or numeric. We can use GOTO to label, and GOSUB to label using the RETURN like in BASIC. Also we can use subroutines with local variables.

## The Print Statement

We use in the following examples the Print statement. It is like the BASIC statement Print. We print numbers and strings in columns. If a number need more columns or string need more columns the print use more columns. Numbers are justify right, and string justify left to column. If we leave two comma without expression we get a new line. We get new line after the last expression. We can stop the text cursor (not visible), at column using coma.

```
Print 1,,2,,3
```

```
1
```

```
2
```

```
3
```

We can use semicolon to break columns

```
Print 1;2;3
```

```
123
```

```
Print 1,2,3
```

```
1      2      3
```

We will see more about Print later

## Numeric Labels

We can use numbers before statement in a line. We can use colon to split the line in statements. We can use labels with a colon as the last character, alone in a line (or with a remark). A numeric label may have leading zero, from 1 to 5 digits. The next code is like BASIC code:

```
10 FOR I=1 TO 10
```

```
20 PRINT I
```

```
30 NEXT I
```

We can place the numeric labels in any order. But must be the first item in the line.

```
60 FOR I=1 TO 10
```

```
50 PRINT I
```

```
40 NEXT I
```

There is a different approach for FOR NEXT from basic (a special switch, a software switch change the default behavior to that of the BASIC). The For loop always execute once. The direction of counting always describing from the two values. So a FOR i=100 to 1 means counting from 100 to 1. A FOR i=1 to 1 means counting from 1 to 1 (one time). If we use a minus in STEP clause then if we have same start and end point the variable after the For loop get a new value less than the absolute value of STEP. Using the special switch a FOR loop may not happen because the step sign describes the up or down counting. The next example print only one time the value of 1. The Next clause has optional the variable name.

```
for i=1 to 10 step 0
```

```
    print i
```

```
next
```

Also we can use this **for i=1 to 10 step 0 {print i}**

We can use GOTO

```
10 I=1
```

```
20 PRINT I
```

```
30 I++
```

```
40 IF i<10 THEN 20
```

```
090 X=RANDOM(1, 3)
```

```
100 ON X GOTO 130, 140,150
```

```
110 PRINT "OK"
```

```

120 GOTO 390

130 PRINT "ONE": GOTO 110

140 PRINT "TWO": GOTO 110

150 PRINT "THREE": GOTO 110


390 X=RANDOM(1, 3)

400 ON X GOSUB 430, 440,450

410 PRINT "OK"

420 END

430 PRINT "ONE": RETURN

440 PRINT "TWO": RETURN

450 PRINT "THREE": RETURN

```

We can't jump out of a module. A jump from a block of code means that the block terminate at the point of jump.

We see that the GOSUB to a label using a RETURN statement used like the that on the BASIC language. There is one type of subroutines more, we say SUB /END SUB routines. These routines may have local variables and a parameter list. A subroutine like this have the same scope as the module, so the local variables just shadow the same name variables in the module.

The subroutines added to the end of module's or function's code. A subroutine can call itself, and the number of recursion is separate from modules and functions, by using a special stack per module or function. A module or function use a special object called a **basetask** underline (this object belong to M2000 interpreter). A subroutine has no basetask and rely on the module or function where called.

## The If statement

Like in Basic there is the IF THEN ELSE statement. In M2000 there are three variants of IF statement construction:

1. One line IF construction without Block code
2. IF using blocks (in one or multi lines)
3. Multiline IF using END IF as the last statement.

The one line IF handle all statements after IF.

```
If X=20 Then Print "ok": X++
```

When X has a value of 20 we get the ok on the console (or current layer), and then add one to X. But look the next code. We get the "don't care" because the block terminate the IF structure (except we have an ELSE or ELSE.IF clause), So the second example is of 2<sup>nd</sup> type

```
X=2 : If X=20 Then {Print "ok": X++} : Print "don't care"
```

We can write the above as

```
X=2
```

```
If X=20 Then {
```

```
    Print "ok"
```

```
    X++
```

```
}
```

```
Print "don't care"
```

Or using the third type:

```
X=2
```

```
If X=20 Then
```

```
    Print "ok"
```

```
    X++
```

```
End If
```

```
Print "don't care"
```

The third type use identifiers IF condition THEN, IF condition ELSE, ELSE.IF condition THEN, ELSE.IF condition ELSE, ELSE, END IF each without other statements in the line except an optional remark sign ' or \. The logic is simple. If we have a statement after Then or Else or we have an open bracket then this isn't third type. If interpreter find that is the if of third type then expect to find END IF. If not find END IF then an error raised.

```
If condition Then
```

```
Else.If condition1 Then
```

```
Else.If condition1 Else ' reverse logic
```

```
Else.If condition1 Then
```

```
Else
```

```
End if
```

Or

```
If condition Else ' no Else.If after Else in IF statement
```

```
End if
```

So we may have the second type (which is good for jumps from blocks), without using an End IF:

```
If condition Then {
```

```
} Else.If condition1 Then {
```

```
} Else.If condition1 Else { ' reverse logic
```

```
} Else.If condition1 Then {
```

```
} Else {
```

```
}
```

We can use IF THEN ELSE in a line without END IF and with or without blocks

```
X=Random(19,21)
```

```
Print X
```

```
If X<20 Then Print "Lower than 20" Else.if X=20 Then Print "Is 20" : Print "ok" Else Print "Above 20"
```

```
Print "Done"
```

```
X=Random(19,21)
```

```
Print X
```

```
If X<20 Then {Print "Lower than 20"} Else.if X=20 Then {Print "Is 20" : Print "ok" } Else {Print "Above 20"}
```

```
Print "Done"
```

Or this using multi lines (see the first using END IF)

```
X=Random(19,21)

Print X

If X<20 Then

    Print "Lower than 20"

Else.if X=20 Then

    Print "Is 20" : Print "ok"

Else

    Print "Above 20"

End If

Print "Done"

X=Random(19,21)

Print X

If X<20 Then {

    Print "Lower than 20"

} Else.if X=20 Then {

    Print "Is 20" : Print "ok"

} Else {

    Print "Above 20"

}

Print "Done"
```

After the THEN or the ELSE clause a number means a GOTO number. If we want a jump to a non numeric label (a text label) we have to place the GOTO statement. The later is true always if we use the third type of If.

## Example of an Old Sort Algorithm

We have a string with words without termination character. We have offsets for each word (base of 1, so the first word has offset 1). We want to sort the words sorting only the offsets. This is an example of **spaghetti code**, using GOTO in main algorithm.

```
Module OldSort {

    function mxstrcmp(&Cmp$, start1,end1, start2,end2) {

        end1+=1-start1

        end2+=1-start2


        hlp1$=mid$(Cmp$,start1,end1)

        hlp2$=mid$(Cmp$,start2,end2)

        =compare(hlp1$,hlp2$)

    }

    function Getone$(&buffer$, start1, end1) {

        end1+=1-start1

        =mid$(buffer$,start1,end1)

    }

    strSearch$ = "3ne2wo1hree6ive5ix4orth"

    \*strSearch$ = "OneTwoThreeFiveSixForth"

    Flush ' empty stack

    Data 1,4,7,12,16,19,0 ' these are offsets (base 1) in string strSearch$

    i=0 ' we place one more so we use arrays from index 1

    read startKeyWord

    do ' same as Repeat

        dim smarkerskt(i+1), emarkerskt(i+1)

        read nextStart
```

```
        smarkerskt(i)=startKeyWord

        If nextStart = 0 Then

            emarkerskt(i)=len(strSearch$)

            exit ' no Break here (Break stopped only in a Try { } and in
module block )

        Else

            emarkerskt(i)=NextStart-1

            startKeyWord=NextStart

        end If

        i++

always

nKeywordskt=i+1

dim sortptrs(nKeywordskt)

module fillme {

    read &ar()

    k=dimension(ar(),1) : i=0 : do ar(i)=i : i++ : k-- until k=0

}

fillme &sortptrs()

for i=1 to nKeywordskt

    Print getone$( &strSearch$, smarkerskt(sortptrs(i-1)),
emarkerskt(sortptrs(i-1)))

Next

Print "items: ";nKeywordskt

\\ here the old code start
```



```

s1 = nKeywordskt
s2 = s1
s3 = 0 : s4 = 0 : s5 = 0 : s6 = 0
a = 0

```

GP\_SP\_S1:

```

s1 = int(s1 / 2)
If s1 = 0 Then Goto GP_SP_S5
s3 = s2 - s1
s4 = 1

```

GP\_SP\_S2:

```

s5 = s4

```

GP\_SP\_S3:

```

s6 = s5 + s1

a = mxstrcmp(&strSearch$, smarkerskt(sortptrs(s5-1)),
emarkerskt(sortptrs(s5-1)), smarkerskt(sortptrs(s6-1)), emarkerskt(sortptrs(s6-1)))

If a = 0 Then
    If sortptrs(s5-1) < sortptrs(s6-1) Then
        a = -1
    Else
        a = 1
    End If

```

End If

If a <= 0 Then Goto GP\_SP\_S4

Swap sortptrs(s5-1), sortptrs(s6-1)

s5 -= s1

If s5 >= 1 Then Goto GP\_SP\_S3

GP\_SP\_S4:

s4++

If s4 > s3 Then Goto GP\_SP\_S1

Goto GP\_SP\_S2

GP\_SP\_S5:

s1 = 0

\\* here the old code end.

Print "-----"

for i=1 to nKeywords

Print getone\$( &strSearch\$, smarkerskt(sortptrs(i-1)),  
emarkerskt(sortptrs(i-1)))

Next i

Print "done"

}

OldSort

## The Select Case Structure

We can use Select case for numeric or string values. The select case has some limitations:

Between each case we can place a line of statements (using semi colon) or a block of code using { }.with any number of lines inside block. We can't place a case after a case without a line or a block of code.

The **Else Case** or **Else** can be used for the case which not included in the series of cases. Using the select case structure between a IF End If structure we have to use the Else Case, because the Else is the same as the else in that variant of If.

A case get a list of any number of Case expressions.

For numbers the case expression can be a number, a numeric expression including variables, a half comparison like >1000, and a range 10 to 300 where both limits included to the range. If we want the reverse range we place this <10, >399.

The same for strings, we can include a string value, an expression with variables, half comparisons and ranges.

Not all expressions evaluated, but only up to the one which return true.

When a case get a true expression, executed this only. If we place a block and inside the block we place the Break statement then all the cases until the Else Case (not included) executed without evaluation the cases for each one. We can stop this way of execution using a continue (inside a block of code).

```
For i=1 to 10
```

```
    x=random(1,10)*10**random(0,3)
```

```
    Print X
```

```
    Select Case X
```

```
        case 1, 3, 5
```

```
            Print "1 or 3 or 5" : Print "in same line statement"
```

```
        case 10 to 50
```

```
        {
```

```
            Print "10 to 50 use a block of commans"
```

```
            Print "ok..."
```

```
    }  
  
    case <-1000, >1000  
  
        Print "far away"  
  
    else case  
  
        Print "Dropped"  
  
    end select  
  
Next i
```

## The For Loop

The For loop has two forms, one with block and one without using the Next statement. Also There is another For statement using Objects, which isn't a loop structure, but here we see only the loop structure. As in BASIC there are two or three values, where the third is the Step, which control the loop, as a control value. We can exit from loop using EXIT or we can skip to the end of block and advance to next control value using CONTINUE. Also we can jump to some other point and not exactly the next statement after the end of loop. The variable which has the control value, can be change for current iteration, but in the next iteration get the next control value as normal, by copy from an internal true control value. So we can't handle the loop by altering the control value. We can use any numeric type for the loop.

There is a major difference from the For in BASIC. By default the step value used as absolute value, the direction of counting (up or down) always are from first value to second. If the first and second values are equal then we get one run of block and then if a sign exist in step the we get the algebraic result of  $\text{Start\_value} + \text{Step}$ . If step is zero we get one run of block with start value. There is a Switch which change behavior to act as those in BASIC

To change mode of FOR: From console use SWITCH "+FOR" or from code in a block use SET SWITCH "+FOR" to engage the BASIC variation for FOR, use "-FOR" to return to default. Also we can start M2000.exe with swicth +FOR as command line argument). Use Monitor from console to see all the states of switches. Use Help Switches to find information for all switches.

Look at the following example, we can exit from a block which is part of a For structure:

```
FOR i=1 TO 10 {  
  
    IF i=5 THEN 500
```

```

    PRINT I
}

PRINT "NEVER PASS FROM HERE"

500 PRINT "OK"

```

We can use the EXIT FOR with a number, In a FOR/NEXT structure (without a block):

```

FOR i=1 TO 10
    IF i=5 THEN EXIT FOR 500
    PRINT I
NEXT
PRINT "NEVER PASS FROM HERE"

500 PRINT "OK"

```

We can use Continue in a For loop to continue the loop immediate (or exit if can't continue).

Ordinary loop structures Do Until (or Repeat Until), Do Always (or Repeat Always) and While {} and While/End While: All of these structures have a block of code (some have a hidden one), so Goto works fine

## The Do Until loop

```

X=random(1,3)

Print X

Do
    If X=2 then 300
    X++
Until X>10

Print "ok"

300 Print "Last line"

```

```
X=random(1,3)
Print X
Do {
    If X=2 then 400
    X++
} Until X>10
Print "ok"
400 Print "Last line"
```

## The While loop

```
X=random(1,3)
Print X
While X<=10
    If X=2 then 300
    X++
End While
Print "ok"
300 Print "Last line"
```

```
X=random(1,3)
Print X
While X<=10 {
    If X=2 then 400
```

```

        X++
    }
    Print "ok"
400 Print "Last line"

```

## Jump from nested blocks

Check the following code (we use numeric and text labels), We can make a jump inside a block or we can make a jump in any other block (backward or forward)

```

x= random(1,3)
{
    {
        On x Goto 200, alfa, 400
        Print "---"
        200 Print "ok1"
    }
    alfa: \ only remark after a text label
    Print "ok2"
}
400 Print "ok3"
410 Print x

```

## A block as loop

Any block can be used as a loop block. Each block has a flag, the loop flag. When a statement Loop executed the loop flag raised (as a Boolean value get True). When the block exit normal, check the loop flag and if it is true then restart the block. Each block start always with loop flag to false.

We have the Restart statement which restart the block (and as a new restart we have the loop flag reset to false).

Also we have two different exit statements. The Exit and the Continue. In any loop flag condition the Exit make an exit of block. The Continue statement in a block depends on loop flag, so when this flag is true we get a Restart, and when this flag is false we get an Exit.

Also there is a Break statement, which break all blocks until Module or a special block like those which are part to a statement like For or Do and other.

```
acc=0

\\ like do loop (See Else after IF)

\\ 1 .. 10

{
    acc++
    Print acc
    If acc>10 Else Loop
}

\\ like while (See Else after IF)

\\ 10 .. 1

{
    if acc>0 Else exit
    Print acc
    acc--
    Loop  \\ we can use Restart because is the last one
}

\\ print 0 .. 10
```



```

{
    if acc<10 then loop
    Print acc
    acc++
}
\\ print 10 .. 0
{
    if acc>1 then loop
    acc--
    Print acc
}

```

## Simple Routines

A simple routine used for the use of same code for many times, from different parts of a program. Because the use of modules, we can call a routine if the routine exist in the module where we call it. The executed lines are like to belong to the calling position of the code. Named labels are case sensitive for interpreter.

```

X=0

While X<10
    Gosub 100
    Gosub 110 ' like a second entry
End While

Print X

500 End ' need to stop the passing without normal call

100 Print "This is a routine"

110 If X>5 Then X=100 : Return

```

Old style programming with M2000

```
120 X++
```

```
130 Return
```

Or using named labels (each label in separate line):

```
X=0
```

```
While X<10
```

```
    Gosub first
```

```
    Gosub second ' like a second entry
```

```
End While
```

```
Print X
```

```
End ' need to stop the passing without normal call
```

```
first: ' only remarks after this type of label
```

```
    Print "This is a routine"
```

```
second:
```

```
    If X>5 Then X=100: Return ' we can exit from routine from anywhere
```

```
    X++
```

```
Return
```

## Subroutines

A subroutine open a session for temporary definitions. All new definitions erased at the return from the subroutine. Names for subs aren't case sensitive (for greek names there isn't an automatic removal of any acute over letters, like in other identifiers).

Why subroutines and not modules ?

A module run on an execution object. A subroutine is lighter because use the same execution object as the caller's one. A module use execution stack to return from call, but subroutine use a special stack on the execution object. The stack for subroutines get chunks from memory. The execution stack has standard size. So for recursion a subroutine is better. By design a subroutine is in same scope in the module where we call it. Here we didn't insert END before the SUB definition, because a SUB identifier act as

END if founded at execution. All subroutines added to the end of code in a module or function and always are local to that module or function.

We can place a subroutine in module or in the code where the module defined. When a subroutine called then the code executed like it is in the module we call it. Just see the following code. In alfa() subroutine we use M. If M not exist we get error. Inside Inner module we read M as Inner M, from Outer we read M as Outer M. The X variable inside subroutine alfa() is Local. So this variable shadow the X in Outer when we call it from Outer. When we call alfa() from Inner, there is no X for module Inner.

```

Module Outer {
    X=5000

    M=2000

    Module Inner {
        M=1000

        alfa(100)
    }

    Inner

    alfa(300)

    Print X=5000

    Sub alfa(X)
        Print M, ". Value="; X
    End Sub
}

Outer

```

We can share subroutines from Outer module to Inner and other modules local to Outer.

## Simple Functions

Like subroutines we can make simple functions. Unlike subroutines the calling process include the evaluator which get resources from stack memory quickly, so we are better a

ten percent from normal functions. We call them only in expressions using @ before the name. See some examples in [User Functions>Use of simple functions](#)

A simple function's name has to be different from a subroutine name is same context. Also the name of a simple function has to be different from a name of a standard function from vocabularies (Greek and English) of M2000 identifiers. We can check this easy in M2000 editor because a known function name has different color from user names. To replace temporary a M2000 function use standard function (Function name() {} or Def name()=...)

We can't use Call to call a simple function like a module. We can't pass a simple function by reference. Also a simple function use the stack of value of the caller. We have the same for subs and when we use Call for functions and Modules, but simple functions do that in expressions. So in a @a(1)+@b(2) the first one may leave values in stack of values, and b() take that values and replace them. So simple functions may be a mess if we don't get the things in a right manner. We have to use Local for variables and arrays.

The simple function has to exist in original source, but because at the call we pass the same name space as the current one, we read variables from that one, so M in the following example is from the specific name space (Modules and normal functions make name spaces), If we call @alfa() in Inner module we have M to be defined in the module, before the use of function.

```
Module Outer {  
    X=5000  
  
    M=2000  
  
    Module Inner {  
        M=1000  
  
        Print "Value:";@alfa(100)=2000  
    }  
  
    Inner  
  
    Print "Value:";@alfa(300)=5000  
  
    Print X=5000  
  
    Function alfa(X)  
        =X*10+M  
  
    End Sub
```

```
}
```

```
Outer
```

## Using Arrays

A data structure, in memory, from the first step of programming, is the Array. To make an array we use the DIM identifier. We can copy a value to each item.

### *The DIM statement*

The following example make the three possible types of arrays. The A%() works like the A % variable with rounding to 0.5. The base of an array by default is 0, so for 10 items we get indexes from 0 to 9. We can use up to ten dimensions. Here each array has one dimension. We can **resize** (and redimension) any array, preserving items if we didn't provide a value for all items. By default a Dim A(10) for the first time make each value as Empty type, which is a zero for calculations. So here we make Dim A(10)=0, all values as type Double. After the Dim A(20) we get ten more items, but they are Empty. So the third For Next loop put a 0 to each item from 10 to 19. We prove now that all items are Double from the last For Next loop

```
Dim A(10)=0, A%(10)=1, A$(10)="ok"
```

```
For i=0 to 9
```

```
    Print A(i), A%(i), A$(i)
```

```
Next i
```

```
Dim A(20)
```

```
For i=0 to 19 : Print type$(A(i)) : Next
```

```
For i=10 to 19 : A(i)=0 : Next I
```

```
For i=0 to 19 : Print type$(A(i)) : Next
```

We can make arrays with **specific range for lower and upper limit** for each dimension. We can use negative numbers for indexes too.

```
Dim A(-5 to 5, -5 to 5)=0
```

```
Print Len(A())
```

List

If the module is A (where we put these three lines) we get:

```
121
A.A(11,11)
```

So we have 11X11 items. Function Len() works for strings and any object which have a length of items.

For **Base 1 arrays** we can use the Base 1 clause. Also we can use Print to print an array each value in a column, handling the new line automatic.

```
Dim Base 1, B(10)=2, C(30)=1
```

```
For i=1 to 10: Print B(i), :Next I: Print
```

```
Print B() ' the same as the above line
```

```
Print C()
```

We can make an **empty Array**. We can **copy an array** to another array, we can change value of an item using ++, --, +=, -=, /=, \*=, -! (change sign) and ~ (boolean invert)

```
Dim A(), B(10)=1
```

```
Print Len(A())=0
```

```
A[]=B()
```

```
Print Len(A())=10
```

```
B(0)+=100
```

```
Print B(0)=101, A(0)=1
```

### ***By Value Passing Array***

Passing an array by value as array:

```
Module PassByValue (A()) {
```

```
    i=Dimension(A())
```

```
    if i=0 then Print "Zero Dimension Array": Exit
```

```
    P=1
```

```
    ' center to column using $(2) - try $(6) for center proportional text
```

```

Print $(2),"Dim#", "Lower", "Upper", "total"

Print $(0), ' uaing , ro hold cursor to this line

For j=1 to l
    P*=Dimension(A(),j)

    Print j, Dimension(A(),j,0), Dimension(A(),j,1), Dimension(A(),j)

Next

Print "Len(A()):"; Len(A()), "P: ";P
}

Dim B(2 to 10, 4 to 20)=1

PassByValue B()

Dim B(0), C(), K(10)

PassByValue B()

PassByValue C()

PassByValue K()

```

### ***By Reference Pass (Arrays, Array Items)***

The following example display the pass by reference of an array, pass by value for array item, pass by reference array item. Passing by reference array item is a copy in copy out method. So if at the copy out the array change dimension the copy out process dropped without error.

```

Module PassArrayExample (&A(), &X, Y) {

    A(0)++

    X++

    Y++

    Print Y

}

Dim Base 0, k(10)=100, m(30)=10

```

```
Print k(0)=100, m(3)=10, m(4)=10
```

```
PassArrayExample &k(), &m(3), m(4)
```

```
Print k(0)=101, m(3)=11, m(4)=10
```

## For Subroutines

Here we can't use copy in copy out process for m(3), but we can use another type, the passing of weak reference and use it in a string variable. Here we use the weak\$ (we can use any name). The weak references can be used with a dot. So weak\$.++ is like the m(3)++ but the name is the full name (including a specific part before m()) which produced automatic at run time). To get the value we have to use Eval() so Eval(weak\$) return the value. For string values inside a weak reference we use the Eval\$(), so in one line:

```
A$="ok" : m$=weak$(A$): Print Eval$(m$)="ok" ' true - look the dot in Eval$()
```

```
Dim Base 0, k(10)=100, m(30)=10
```

```
Print k(0)=100, m(3)=10, m(4)=10
```

```
PassArrayExample(&k(), weak$(m(3)), m(4))
```

```
Print k(0)=101, m(3)=11, m(4)=10
```

```
Sub PassArrayExample(&A(), weak$, Y)
```

```
    A(0)++
```

```
    weak$.++
```

```
    Y++
```

```
    Print Y
```

```
End Sub
```

About references. A variable or an array (not an array item) have a specific address, in a list of names for variables and arrays. So if name A has an address 100 and we make B as a reference of A , then the B has the same address 100. A reference can't change reference. We will see about Weak\$() in Advanced Programming later.

## ***Sorting 2D Arrays by multiple columns***

This program is a mix of old and new style. We use a seed for the random generator, so we get each time the same random numbers.



We have two lambda functions. The Rand\$ has a closure labels (a pointer to array, or auto array, or tuple). This return a field of 10 spaces with a name of a capital city. Because we choose to print Cities with proportional letters, and center justification the more spaces trimming from printing routine.

The second lambda has lambda inside and because we provide the (max) parameter (see the end of lambda), we execute it at once. It is a way to make an array which we provide the size of rows. We need the final lambda to retrieve a random number from 1 to max, and remove it from the array. We didn't fill the array to all numbers. Instead we think that each array item has a 0, which indicate "take index as number". When we remove an array item, when this has index less than max, then we copy the number from max, and reduce the max by one and redim the array to exclude one item. During the copy of number from top index to fill the removed number, we check if we have place something. If it is not the case, we have to push the index as number. From old style we use Gosub to numeric labels. These subroutines are just rows of statements with no local. Also we use a Sub End Sub where we want to pass arguments.

We will see a flashing (4 hz) "press any key..." using an Every { } stricture.

```
Form 80,40
```

```
Const max=36
```

```
\\ setup random generator to produse the same sequence
```

```
x=random(!12493587)
```

```
Rand$=Lambda$ labels=("LONDON","PARIS","BERLIN","ATHENS",  
"ROME","SOFIA") ->{
```

```
    = Field$(labels#val$(random(0,5)), 10)
```

```
}
```

```
PickNumber=Lambda (m)-> {
```

```
    dim A(1 to m)
```

```
    =lambda A(), m -> {
```

```
        if m<1 then exit
```

```
        i=random(1, m)
```

```
        =if(A(i)=0->i, A(i))
```

Old style programming with M2000

```
A(i)=if(i<m->if(A(m)=0->m,A(m)),0)

m--

if m=0 then A()=(,) else Dim A(1 to m)

}

}(max)


Flush

Dim A(1 to max, 1 to 3)

Link A() to A$()

Title("1. Populate Array")

R=0

refresh 5000

for i=1 to max

    A(i,1):= PickNumber(), Rand$(), Random(1,6)*100

    Gosub 100

next

Refresh 20

Gosub 240

Title("2. Sort Ascending First Column")

sort A(),1, max, 1,0

R=20

Gosub 200

Title("3. Sort Ascending Second And Third Column, first Ascending")

sort A(),1, max, 2,0,3,0,1,0
```

R=40

Gosub 200

Title("4. Sort Columns Third Descending, Second Ascending, first Ascending")

sort A(),1, max, 3,1,2,0,1,0

R=60

Gosub 200

End

100 Print Part \$(0), @(R),~(11),str\$(A(i,1),"0000 "),@(R+5), ~(0, 7,7), \$(6),A\$(i,2),~(15), @(R+15),\$(0), ~(14), format\$("{0::4}",A(i,3)) : Print

110 Return

200 Refresh 5000

210 For i=1 to max

220     Gosub 100

230 Next : Refresh 50

240 T=True

250 Every 1000/8 {

260     T~

270     Print Over \$(6),~(If(T->7,15)),"PRESS LEFT MOUSE BUTTON"

280     If keypress(1) then Exit

290 }

300 Print Over

310 Return

320 Sub Title(A\$)

330     Cursor 0,0: Double

340     Print Over ~(15),A\$

```
350    Print  
  
360    Normal  
  
370 End Sub
```

## Text Files

A way to store data to disk is through Text files, of Serial or Random access. In M2000 we can use Binary also (which we can see in Advanced Programming later). There is a special object the Document which save/load entire text file and a Log system to write to temporary folder a text file, which will see later.

### ***Serial File Access***

A text file of UTF16LE characters, or Unicode, means a WIDE file, using of 16bit minimum for a character. A text file of ANSI (using current Locale value) using of 8bit characters.

A file can be OPEN for four operations:

1. OUPUT: this operation erase the file if founded, we ge error if we can't write to media. Also we get error if the file is opened exclusive from elsewhere
2. INPUT: we get error if file not exist
3. APPEND: we get error if file not exist. We add to the end of file.
4. RANDOM: For a specific length we can read and write this length of information (the record) to file. A record can be a concatenation of fields of specific length too.

The statement give a number when we open the file.

```
OPEN file_name$ FOR INPUT EXCLUSIVE AS #variable_as_file_handle  
OPEN file_name$ FOR OUTPUT EXCLUSIVE AS #variable_as_file_handle  
OPEN file_name$ FOR APPEND EXCLUSIVE AS #variable_as_file_handle  
OPEN file_name$ FOR RANDOM EXCLUSIVE AS #variable_as_file_handle LEN =  
total_length_for_a_row_in_chars
```

We have to close using CLOSE #variable\_as\_file\_handle

A file may OPEN two or more times we use INPUT and APPEND or RANDOM, without EXCLUSIVE clause.

If we want WIDE (UTF16LE) then

```
OPEN file_name$ FOR WIDE INPUT EXCLUSIVE AS #variable_as_file_handle  
OPEN file_name$ FOR WIDE OUTPUT EXCLUSIVE AS #variable_as_file_handle
```

```

OPEN file_name$ FOR WIDE APPEND EXCLUSIVE AS #variable_as_file_handle
OPEN file_name$ FOR WIDE RANDOM EXCLUSIVE AS #variable_as_file_handle LEN =
total_length_for_a_row_in_chars

```

LEN for wide max is 32766/2, and for ANSI version 32766.

This is an example of standard (ANSI) file, for oupur lines of text and reading lines of text. We need EOF() function for finding End Of File to finish reading

```

Open "TextFileAnsi.txt" for output as #k

    Print "Line one"

    Print "Line two"

Close #k

Open "TextFileAnsi.txt" for Append as #k

    Print "Line Three"

    Print "Line four"

Close #k

Open "TextFileAnsi.txt" for input as #k

    While not EOF(#k)

        Line Input #k, aLine$

        Print aLine$

    End While

Close #k

```

## **CSV Files**

The comma separated values (CSV) type of file, is a text file. The idea is to place lines of text, and for each text a comma to separate values. The original idea use numbers with dot for decimal numbers and quote marks (character 34 in Ansi and Unicode) for placing strings. To write the values M2000 use the Write statement. To read the values M2000 use the Input statement. Both statements have the variant with #fileHandler as first parameter

We can use encoding ANSI or UTF16LE. We can define the characters for value separator and for decimal point. Also we can exclude the quoting marks from string. And we can

convert the strings to JSON encoding strings, to include tabs, newline and other in a format using only plain ANSI characters.

Lets see how we program these properties of Write and Input statements

### **Write With stringsep\$, decimalse\$ [, [JsonFlag], Nouseofchr34]**

stringsep\$	only one char used, if "" then we get the default ","
decimalse\$	only one char used, if "" then we get the default "."
jsonflag	if non zero means encoding string using \n and other characters like
json strings	
	so we can put mulrinlie text withoutbreaking the line
Nouseofchr34	a no zero value means no "" araound a string.

so Write With "", "" reset the writing using Write

### **The same for Input #**

We use Input With as Write With. We can define different set so we can read with one way and write with another.

For ANSI files we have to use LOCALE to set the locale for conversion. A Local 1032 used for greek conversion.

```
Pen 11{Print "Ansi first"}
```

```
Print "Export csv using tab as seperator, and dot for decimal char"
```

```
open "testnochr34.csv" for output as k
```

```
Write With chr$(9), ".", ,1
```

```
Write #k, "Hello There", "And There", 1212.12, "Bye"
```

```
Close #k
```

```
Document docA$
```

```
Load.Doc docA$, "testnochr34.csv" ' automatic get the file type
```

```
Print "The file as a string - tabs are expanded"
```

```
Pen 15 {report DocA$}
```

```
Print "ok..."
```

```
Print "Now we use Input # programming the separator and dot"
```

```

open "testnochr34.csv" for input as k

Input With chr$(9), ".", ,1

Input #k, A$, B$, C, D$

Close #k

Print "Results"

Print A$, B$, C, D$

Pen 11{Print "For UTF16LE wide chars"}

open "testnochr34.csv" for wide output as k

Write With chr$(9), ".", ,1 ' leave an optional value for JSON encoding

Write #k, "Hello There", "surrogate 🐘", 1212.12, "1234 ברוכים הבאים abc"

Close #k

Document docA$

Load.Doc docA$, "testnochr34.csv"

Print "The file as a string - tabs are expanded"

Pen 15 {report DocA$}

open "testnochr34.csv" for wide input as k

Input With chr$(9), ".", ,1

Input #k, A$, B$, C, D$

Close #k

Print "Results"

Print A$, B$, C, D$

```

### ***Random Access Text Files***

A random access file, can be used to save text data as rows of records. We can put and get records with one opening. We can use the Wide version, or the Ansi, and we can use the Exclusive directive so only the running program can handle the file until closing it.

```
Const fieldlen=40, part1=30, part2=10

Def eRecord$

\\ for this example ensure that the test file not exist

Do

    DeleteFile("TextFileAnsi.dat")

Until not exist("TextFileAnsi.dat")

\\ create a data file of records

\\ each record has one big field

\\ Open "TextFileAnsi.dat" for wide random exclusive as #k len=fieldlen

Open "TextFileAnsi.dat" for random as #k len=fieldlen

    Put #k,field$("Kappa George",part1)+field$("1229998800", part2)

    Put #k,field$("Lambda Mary",part1)+field$("1225997861", part2)

    Put #k,field$("Delta Harris",part1)+field$("1225793462", part2)

    Print Records(#k)=3 ' # can be used from revision 17, ver 9.9.

    ListData()

    ChangePhone("1225793999", 3)

    ListData()

Close #k

Print Filelen("TextFileAnsi.dat") ' 240 or 120 depends of WIDE clause exist

\\ no need for End statement. The Sub statement is like End.

Sub DeleteFile(a$)

    Dos "Del "+quote$(dir$+a$); ' send command to a hidden dos box
```



```

Wait 100

End Sub

Sub ChangePhone(NewPhone$, Where)

    Get #k, eRecord$, Where

    Insert part1+1, part2 eRecord$=field$(NewPhone$, part2)

    Put #k, eRecord$, Where

End Sub

Sub ListData()

    if records(#k)=0 then Print "Empty List" : exit sub

    Print "Rec No, Data"

    For i=1 to Records(#k)

        Get #k, eRecord$, i

        Print i, " "+eRecord$

    Next i

End Sub

```

## 2d Drawing

See help file for graphic statements. Also see [Appendix II](#) for name of statemens  
This is an example for Pythagoras tree. An example of recursion of a subroutine.

```

MODULE Pythagoras_tree {

    CLS 5, 0 ' MAGENTA, NO SPLIT SCREEN

    PEN 14 ' YELLOW

    \\ code from zkl/Free Basic

    LET w = scale.x, h = w * 11 div 16

    LET w2 = w div 2, diff = w div 12

```

```
LET TreeOrder = 6
```

```
pythagoras_tree(w2 - diff, h - 10, w2 + diff, h - 10, 0)
```

```
SUB pythagoras_tree(x1, y1, x2, y2, depth)
```

```
IF depth > TreeOrder THEN EXIT SUB
```

```
LOCAL dx = x2 - x1, dy = y1 - y2
```

```
LOCAL x3 = x2 - dy, y3 = y2 - dx
```

```
LOCAL x4 = x1 - dy, y4 = y1 - dx
```

```
LOCAL x5 = x4 + (dx - dy) / 2
```

```
LOCAL y5 = y4 - (dx + dy) / 2
```

```
MOVE x1, y1
```

```
DRAW TO x2, y2
```

```
DRAW TO x3, y3
```

```
DRAW TO x4, y4
```

```
DRAW TO x1, y1
```

```
pythagoras_tree(x4, y4, x5, y5, depth + 1)
```

```
pythagoras_tree(x5, y5, x3, y3, depth + 1)
```

```
END SUB
```

```
}
```

```
Pythagoras_tree
```

## Database

This is an example of creating and using a simple database with one table and one row in this table

```

BASE "ALFA" ' erase Dir$+"alfa.mdb" if found it

EXECUTE "ALFA", {

    CREATE TABLE Employees(ID autoincrement primary key,

    LastName  VARCHAR(40) ,

    FirstName VARCHAR(40) NOT NULL,

    MyMemo TEXT )

    }

APPEND "ALFA","Employees",,"George","йваоаптаЭЭ",{Γεια χαρά από
Ελλάδα

    Hello from Greece

    }

RETRIEVE "ALFA", "Employees", 1,"",""

READ MANY, ID, LASTNAME$, FIRSTNAMES$, MEMO$

PRINT $(4, 6), "BASE:","ALFA"

PRINT "NAME:",LASTNAME$ + " " + FIRSTNAMES$

PRINT "MEMO:",

REPORT MEMO$

CLOSE BASE "ALFA"

PRINT $(0)

```

### DataBase Statements

APPEND, BASE, COMPRESS, DB.PROVIDER, DB.USER, DELETE, EXECUTE, ORDER, RETRIEVE, RETURN, SEARCH, STRUCTURE, TABLE, VIEW

## More for the Print Statement

All M2000 programs executed by an interpreter in the M2000 environment. This environment has a built in layer functionality. A layer is a visual object on screen, which have specific capabilities, such as printing text and drawing lines, circles, curves and fill with color areas. There are two cursors, the text cursor and the graphic cursor. The Print statement use the text cursor. The layer has rows of specific number of characters positions. The number of rows is the **Height**, and the number of characters positions in a row is the **Width**. So characters can be print in Height\*Width places.

The Print statement has same clauses for changing the way of print, and some internal functions. Print always overwrite characters to the given background. When the Print need a new row then the rows scroll up and give a new clear row. The layer has two parts, the upper optional part which has no scroll functionality and the lower part with scroll functionality. The **CLS** statement clear the low part of layer. Also CLS has two optional parameters, the background color and the number of the top row where the second part start, so **CLS 0,0** clear with black the lower part which start from row 0, so there is no room for part one (non scrolling part). A **CLS ,-4** clear the lower part from height-3, with current background color, so we get four lines for scrolling text. Text cursor has 0,0 at top left corner. Also graphic cursor has 0,0 at top left corner. Graphics use unit twip, and **Scale.X** and **Scale.Y** are the number of twips for width and height of console.

There are two read only variables for text cursor, the **Row** and **Pos**, and two more for graphics, **pos.X** and **pos.Y**. We can locate the text cursor using **Cursor** statement, or using Print **@()** so to Print "Hello" at pos 20 and row 10 then:

```
Cursor 20,10
```

```
Print "Hello"
```

or

```
Print @(20,10), "Hello"
```

Both of the two statements above also insert a New Line after the "Hello".

The Print statement use Columns, so we can print numbers in four columns with right justification:

```
Print 1,2,3,4
```

We can break the column rule using the semi colon instead of coma. The following example print X=10 (if we place a coma instead a semi colon we get X= 10)

```
X=10
```

```
Print "X=";X
```

The rules above are the same as in BASIC language. But there are more specific for M2000 environment. The three internal functions ~(), @(), \$():

The ~() used for change color for the column, change background color for column in the row and change color for a box outline the column in the row. The last two parameters are optional.

The @() used for moving the cursor anywhere and also for coloring the display column.

```
@(X,Y, XlowerRightCorner,YlowerRightCorner, BackColor)
@(X,Y, XlowerRightCorner,YlowerRightCorner, BackColor, Outlinecolor) 'make boxes with printing data
@(X,Y, XlowerRightCorner,YlowerRightCorner, BitmapOrFilename$) ' fill with an image...stretching
@(X,Y, XlowerRightCorner,YlowerRightCorner, BitmapOrFilename$, 1) ' lkeep aspect ratio of image
```

So the above used to fill background in an area under the printing. For formatting purposes there is another internal function the \$()

```
$(ColumnsJustifyID)
$(ColumnsJustifyID, ColumnsWidth)
$(StringWay2format$)
$(StringWay2format$ , ColumnsWidth)
$("") reset StringWay2format$
```

Example using the StringWay2format, and setting of 10 character column.

```
Print $("#.000;(#.0000);\z\e\r\o", 10),123.21312,3123.45, -3, 0
```

```
Print $(""), ' comma used to leave cursor to not insert the new line
```

```
Print 123.21312,3123.45, -3, 0
```

The ColumnsJustifyID for numbers and logic expressions:

0 = right, 1 = left, 2 = center, 3 = right - All of these using one character width for all letters  
4 = right, 5 = left, 6 = center, 7,8 = left - All of these using each character width and kerning

The ColumnsJustifyID for strings:

0 = right, 1 = right, 2 = center, 3 = left - All of these using one character width for all letters

4 = right, 5 = right, 6 = center, 7 = left , 8 = left and right both - All of these using each character width and kerning

For 0 and 4 strings can overwrite next column(s) and advance the cursor to the next one

So using 4 and above we use Print with proportional text rendering. Also if the text in a string is RTL (right to left, like Arabian or Jewish letters) then the Print return to proportional to print properly the RTL.

The Print statement count diacritics symbols as expected. So maybe a string has a display length less than actual length. We can find the length of a string using LEN() and the display len using Len.Disp()

```
Print Len.Disp("ãž") ' 2
```

```
Print Len("ãž") ' 4
```

The three clauses, PART, OVER and UNDER. So Print Part, Print Over and Print Under change temporary to proportional \$(4), and neither change the row. Also we can handle the ~() and \$() temporary so after the execution of statement we get the old state.

The Print Over make the width as one column, and clear background except for one line at the base of the row. The Print Under first draw the horizontal line (the same that missing from Print Over) and insert a new line before print. We can move the start position to negative numbers, say @(-10) and change the column length as we print columns. So we can get columns with different lengths (and justification). Because we didn't get a new line in Print Part and Print Over we can use it to view large tables which not fit entire in layer and we can control the displaying part, by moving the start origin and redefine the columns.

HEX is the other PRINT statement, which is like Print but the numbers are returned as HEX values unsigned, so a value under 0 or over 0xFFFFFFFF, we get ???- and ???+

We can use ? Instead of Print. So:

```
? "This is a print statement"
```

A layer may have a **Linespace**, a space between rows, from 0 to some pixels, but we have to feed it as twips. We can convert pixels to twips using twipsX or twipsY, so 10\*twipsX return the twips for 10 pixels.

A **Form 40,20** make the form 40 characters wide (width=40) and 20 rows (Height=20). This statement handle Linespace automatic.

A console form has Back Layer, Layer, 32 layers above. The Layer Is the standard layer. We can move all layers and change the size of each too. The layers above Back layer are masked by the Back Layer, so we may have a layer two times bigger from Back and scroll it inside Back, viewing a part of it. We use **Motion** statement and **Motion.X** and **Motion.Y** to read the current state of the top left corner. For Back layer we use **Motion.W** and variables **Motion.WX** and **Motion.WY**. The following example change the border of the console layer (changing the layer background behind)

```
Back {  
    Cls 11.0  
}
```

For each layer environment use an internal structure to save state. So we can change **Font** and font attribute like **italic** and **bold** (we can use variables to read **Fontname\$**, **italic** and **bold**), We can use **Double** to get double width and height letters and **Normal** to return it to normal characters.

The 32 layers above standard layer can be used with **Layer** statement using the number 1 to 32. The 32 layer is always above layer 1. Layers can be used as sprites with magnify and rotate function plus a transparent color or a bitmap for a mask to define the transparent bits. The following example shows two layers, wait for a keypress, change the priority of layers using the **Player** statement (which is used for sprites), and then swap variables I3 and I4 so now I3 has the real 4 value (always 4 is above 3). Finally we print something and wait for a keypress to hide them.

```
I3=3
```

```
I4=4
```

```
layer I3 {
```

```
    window 12, 6000,12000
```

```
    motion 7000, 2000
```

```
    cls 7, 0
```

```
    pen 0
```

```
    show
```

```
    print "ok.....3"
```

```
}
```

```
layer I4 {
```

```
    window 12, 6000,12000
```

```
    motion 6000,1000
```

```
    cls 15, 0
```

```
    pen 0
```

```
    show
```

```
    print "ok.....4"
```

```
    print
```

```
        print
    }

    \\ WAIT A KEY PRESS ANS STORE IT TO a$

    a$=key$

    player l3 swap l4

    swap l3, l4

    layer l4 {
        Print "This is 4"
    }

    layer l3 {
        Print "This is 3"
    }


    a$=key$


    layer l4 {
        hide
    }

    layer l3 {
        hide
    }
```

Another layer is the Printer layer which can be used to print pages. We can change orientation of a page before use it. Also we can set with Form statement the rows and character per row. We can't use Cls, but we can change page. Instead of scrolling a new empty line we get a new page. We use Printer { } to handle the printer page

Page 1 ' portrait - not form feed to printer



```

Printer {
    Form 64, 66
    Print "To printer"
    Page 1 ' portrait and form feed
    Print "Second Page to printer"
}

```

We can make more (100 more) making user forms, windows. The console form is a form (the size of Back) and maybe can be hide and we can use only forms (windows) and event programming. If we make Form1 then we have the Layer Form1 { } to use it.

See the Report statement (Help Report in M2000 console) which render multi line text, with justification and word wrap.

We can print one or more lines with justification using graphic cursor, with rotation and letter spacing using Legend statement.

## Stop Execution

We can stop execution by keyboard using Escape, Ctrl+C and Break key. For Escape there is a statement Escape Off which disable it and Escape On which enable it. Ctrl+C open a msgbox to ask if you want to terminate the code. The same for Break key. Break key also erase all modules.

### End Statement

The End statement in console terminate the m2000 environment. From code we can give the same using Set End, The Set statement send the rest line to console interpreter (or command line interpreter) which have some differences from the block of code interpreter.

A Test statement stop execution opening a form Control and we can continue, or execute a step, and we can see the code and the stack (third button from left). The Control form has 6 buttons (the three on the left and top are labels which are buttons also). The three at the right and top do three things: Execute a step, Execute at limited speed, stop execution.

We can use Control form to program some variables for inspection as we execute steps, or we can execute statements (use backspace to erase the line to change the mode, in the textbox at the bottom of form).

The control form can be used with GUI programs too. The modal forms can't disable the control form. Events not showing by control form, but threads showing indicating the thread number

### **HALT statement**

We can use Halt to halt execution and go back to console input, and then we can write Continue to continue the execution. Statements are in global scope

### **Stop statement**

We can use Stop statement which opens a message box (default No) and if we click on yes we open in console the input prompt. We have to use exit to return to statements. Statements in Stop state are in local scope

### **Error Statement**

We can produce an error using a string or a number or a string with a number in last chars on string. **Error 0** is the Fatal Error which opens the windows message box and after we press ok the interpreter terminates.

### **Using Context Menu in Task Bar**

We can close the Environment by choosing close in context menu in task bar. Also we can minimize the full screen from that context menu. Also Ctrl+F4 makes the same. It behaves like an End statement. If we change the modules in module list the a message box asks if you want to cancel the exit of environment.

## **Starting a Program**

To start a program you can execute first the environment, m2000.exe and then choose these options: To see what files (type of gsb) exist in user directory execute MODULES statement.

You may want to erase any program: use NEW

You may want to clear any global variable and static variables too, use CLEAR

You may want to flush stack of values, use FLUSH

You may want to reset Environment (stack not flushing) use Start or Start "", ""

Reset can be done using Break button.

### ***Manual execute a module***

Load alfa (for alfa.gsb) or load "alfa beta" for "alfa beta.gsb". Press ctrl+N or Modules ? to see what modules you have and write the name of one and press enter.

### ***Automatic execute a module***

You can save the program with a series of statements at the end. When you load the program that statements also executed.

### ***Start a program by double click on file icon***

You can start a program (which can be started in automatic execution of a module), before you start environment. You have to confirm to OS that gsb opened with M2000.exe. Also in that case you have to use Show statement to show Console form because by default the

console open if we open manual the environment (starting it without passing a file to execute in command line), or when an Input statement need to use console for value input, so the console turn to show mode.

If you have a GUI program, may you don't need to open console, so you don't have to use Show. Also Show statement not only show the form but make it foreground window,

To end a GUI program you may use ctrl+F4, or the square on the top corner (in one corner by default the left but can be change to right).



## Advanced Programming Style

More advanced examples.

### The Pass By Reference &identifier vs Weak\$(identifier)

This is the way to pass by reference using &identifier from calling and from callee:

```
Module Callee { ' or Module Callee (&X) { X++}

    Read &X

    X++

}

M=10

Callee &M

Print M=11
```

About Weak references. A &A return a string which is a weak reference. So this is an example using Weak\$. An identifier can be a reference only once, at definition. A string using it as weak reference can change reference.

```
Module aName {

    A=10

    Print &A=Weak$(A) ' true

    A$=Weak$(A)

    Print Eval(A$)=10

    A$.=30 ' see dot after A$

    Print A=30

    List

}

Call aName ' call using Call
```

aName ' call without using Call - See difference on the output of List

Not all **&identifier** return a weak reference equal to weak\$(). Almost all except of the functions. So a &func1() is not weak\$(func1()). The &func1() has the code of func1() and weak\$(func1()) is the weak function.

A function reference also may include another weak reference, the object where belong. Object have to be a named group. Here we have the Alfa group. The .acc is private so we can't read from outside, the Alfa.acc not exist. Also Alfa not return a group like the standard group because has a value clause. So Alfa return the .acc value. Public function is the final function Alfa.Pow(). Module inner expect a function (or array if the indexes allow to be used in place of function). We can give any function, but here we give from a named group, so we get feedback about the number of use of it.

```

Group Alfa {
    Private:
        acc=0
    Public:
        Function Final Pow(X,Y) {
            =X**Y
            .acc++
        }
        Value {
            =.acc
        }
    }
    Module Inner(&c()) {
        Print c(2,3), c(4,2)
    }
    Inner &Alfa.Pow()
    Print Alfa=2

```

**Weak Reference for module**

A module isn't first citizen, but we can produce a weak reference as string. Check following code:

```
Module CheckIt {
    Module k {
        print number**2
    }
    k 10 ' print 100
    Module inner (a$) {
        a$. 10
        call a$, 10
    }
    inner weak$(k)
}
CheckIt
```

**Weak Reference and Link to new Identifiers**

Check this code for Functions, Arrays, Numeric Variable and String Variable, utilize the weak\$() function. A Def function make one line function (no need for block)

```
Def Pow(X,Y)=X**Y
Pow$=weak$(Pow())
Print Function(Pow$,2,3)=8
```

\\ make a reference from a weak reference

Link weak Pow\$ to P()

Print P(2,3)=8

```
Dim K(1 to 8, 1 to 8)=1
```

```
K(2,2)=100
```

```
Board$=weak$(K())
```

```
Print Array(Board$, 2, 2)=100
```

```
\\ make a reference from a weak reference
```

```
Link weak Board$ to K2()
```

```
Print K2(2,2)=100
```

```
K2(2,2)+=10
```

```
Print K(2,2)=110
```

```
X=10
```

```
X$=weak$(X)
```

```
Print Eval(X$)=10
```

```
\\ make a reference from a weak reference
```

```
Link weak X$ to XX
```

```
XX++
```

```
Print X=11
```

```
Z$="ok"
```

```
ZZ$=weak$(Z$)
```

```
Print Eval$(ZZ$.)="ok"
```



\\ make a reference from a weak reference

Link weak ZZ\$ to ZZZ\$

ZZZ\$+="..."

Print Z\$="ok..."

## Static Variables

Static variables have some rules. We can create simple variables (no arrays) and only tuples, stacks, inventories (as pointers) from objects. We can't create references, except when we call a module or a function (not for simple functions and subroutines).

How static variables stored, in a language with dynamic allocation for modules and functions at the execution? The variables stored in the caller execution object. So this happen up to the root as we go back returning from call. If we have a global module and this has static variables then from different modules we call this module with different set of static variables.

\\ count from 10 to 15 rthen 10 to 15 and so on

\\ static variables can be passed by reference...

\\ only in modules and functions, but not in subs

\\ Using a copy in - copy out mechanism

Module CheckStatic {

static a=9

Module inner (&b) {

b++

}

Inner &a

Print a

if a>=15 then clear ' clear variables including static variables

}

For i=1 to 20

    CheckStatic

Next I

## Threads

A thread is a block of code with a handler (a number in a variable), with no name. We can use any of two plans, using Thread.Plan:

- Thread.Plan concurrent
- Thread.Plan sequential (default)

In concurrent mode all commands in thread level are processed one step in time. If we have to process a block then all block processed without interruption. In this mode maybe two threads starts concurrent but not end at same time. Interval for threads aren't expanded (see next)

In sequential mode no thread allow any other thread to break it. This law sometimes break, especially if we call a command that wait for an input. Threads then run in the background. In this mode if a thread slow down then time interval recalculated. So we can place a command to fix this inside thread, for 100 millisecond, we must use THIS inside thread because the thread is out of thread pool when running, so giving a thread number interpreter miss the thread, but using THIS we make interpreter to communicate with process itself and alter internal variables – and these variables are checked from task manager, before putting again in threading pool, (thread this interval 100).

Any thread can Hold, Restart, Erased or we can set Interval. We can access these functions from thread using THIS, or out of thread using the number that we get in a variable when we construct the thread, and we say this a Handler.

Threads have own value's stack. Threads in same module share variables, arrays and modules and functions that are defined in that module. Threads are block of code that runs in time intervals. If a module ends then all threads in that module stopped and deleted (we can press Esc and we stopped them also). New variable in a thread is a new variable in module.

We can use Main.Task time { } as a main thread. We have to start one thread before, and this thread if exit erase threads, or if all treads other threads end then exit too.

m=100

thread {

    m--

    if m<1 then thread this erase

```

} as countdown interval 100

Main.Task 25 {

    Print m, "inside main task"

    if keypress(1) then exit

}

Threads ' just report

Print "ok"

```

We can use EVERY time { } but Every isn't thread so we loose right time slice for every thread. (Every is a block with a Wait command inside)

We can use Wait time to give time to run a thread.

There is the AFTER time { } an automatic thread to execute once after some milliseconds

### ***Threads Example Dining Philosophers***

There are 5 philosophers: Aristotle, Kant, Spinoza, Marx, Russell in a round table and there are 5 forks. Each philosopher may think or eat pasta. To eat has to get two forks. May eat any quantity of pasta, and then return to thinking placing the forks to table.

The problem is that if the five philosophers get one fork then they can't find a second fork, so the energy drop and they die. If each philosophers get the right fork then this happen and we say that we have a deadlock. But what happen if they change randomly the order of picking, so some time the pick the right first and other time pick the left first

The best strategy is to monitoring and counting the times when the forks are all out of table and then we have to decide how we place back a fork and from whom philosopher. If we choose to steady any philosopher pick the right fork first then we will see starving philosophers and maybe the death of one or more.

So we have 6 threads, 5 for philosophers and 1 as Main.Task where we display information in a period of 4hz (4 times per second), and checking the number of forks in table.

```

Module Dining_philosophers (whichplan) {

    Form 80, 32

    Const MayChangePick=Random(True, False)

```

```
Dim energy(1 to 5)=50

Document Doc$

Const nl$={
}

Print $(,12), ' set column width to 12

Pen 14

Pen 15      {

    Doc$="Dining Philosophers"+nl$

    \\ we can change thread plan only if no threads defined

    if whichplan=1 then

        Doc$="Sequential threads - to execute exclusive one threads
code"+nl$

        thread.plan sequential

        \\ need time_to_think>time_to_eat, but time_to_appear maybe the
same for all

        time_to_think=150 ' one or more intervals

        time_to_eat=100 ' one interval to eat only

        time_to_appear=(150,150,150,150,150)

        Return time_to_appear, random(0,3):=300

    else

        Doc$="Concurrent threads - to execute a statement or a block of
code"+nl$

        thread.plan concurrent

        time_to_think=100 ' one or more intervals

        time_to_eat=50 ' one interval to eat only

        time_to_appear=(100,100,100,100,100)
```

```

        Return time_to_appear, random(1,4):=200

    end if

    Print #-2,Doc$

    Print @(0,2),"Press left mouse button to exit"

    Print Part $(1), time_to_appear

    Print under

}

Pen 13 {Print "Aristotle", "Kant", "Spinoza", "Marx", "Russell"}

enum philosopher {

    Aristotle, Kant, Spinoza, Marx, Russell

}

global enum forks {NoFork, Fork}

RoundTable =(Fork, Fork, Fork, Fork, Fork)

Getleft=lambda RoundTable (ph as philosopher) -> {

    where=(ph+4) mod 5

    = RoundTable#val(where)

    Return RoundTable, where:=NoFork

}

GetRight=lambda RoundTable (ph as philosopher) -> {

    where=ph mod 5

    =RoundTable#val(where)

    Return RoundTable, where:=NoFork

}

PlaceForks=lambda RoundTable (ph as philosopher) -> {

```

```
    Return RoundTable, (ph+4) mod 5:=Fork,ph mod 5:=Fork
}

PlaceAnyFork=lambda RoundTable (ph as philosopher, &ForkL, &ForkR) -> {

    If ForkL=Fork then Return RoundTable, (ph+4) mod 5:=Fork :
    ForkL=NoFork

    If ForkR=Fork then Return RoundTable, ph mod 5:=Fork :
    ForkR=NoFork

}

ShowTable=lambda RoundTable -> {

    m=each(RoundTable)

    while m

        print if$(array(m)=NoFork->"No Fork", "Fork"),

    end while

    Print

}

noforks=lambda RoundTable -> {

    k=0

    m=each(RoundTable)

    while m

        if array(m)=NoFork then k++

    end while

    =k=5

}

def critical as long, basetick
```

```

Document page$

m=each(philosopher)

while m {

    \\ we make 5 threads

    \\ a thread has module scope (except for own static variables, and stack
of values)

    thread {

        if energy(f)<1 then {

            call PlaceAnyFork(f, ForkL, ForkR)

            energy(f)=0

            Page$=format$("{0::-12} - ",tick-basetick)+eval$(f)+" -
Die"+nl$

            thread this erase

        } else {

            Page$=format$("{0::-12} - ",tick-basetick)+eval$(f)

            Page$=if$(ForkL=NoFork or ForkR=NoFork->"
thinking", " eating"+str$(eatcount))

            Page$=if$(R->"- R", " - L")+nl$

        }

        if not think then

            { \\ a block always run blocking all other threads

                energy(f)++

                eatcount--

                if eatcount>0 then exit

                Call PlaceForks(f) : ForkL=NoFork:ForkR=NoFork

                eatcount=random(4,8)

```

```

        if MayChangePick then R=random(-1,0)

        think=true :thread this interval
time_to_think*random(1,5)

    }

    else.if energy(f)>70 or critical>5 then

        {

            call PlaceAnyFork(f, &ForkL, &ForkR)

            if energy(f)>70 then energy(f)=60

        }

    else.if R then

        if ForkR=NoFork then ForkR=GetRight(f)

        if ForkR=Fork and ForkL=NoFork then
ForkL=GetLeft(f)

            if ForkL=Fork then think=false:thread this interval
time_to_eat else energy(f)--

        else

            if ForkL=NoFork then ForkL=GetLeft(f)

            if ForkL=Fork and ForkR=NoFork then
ForkR=GetRight(f)

            if ForkR=Fork then think=false:thread this interval
time_to_eat else energy(f)--

        end if

    } as a interval time_to_appear#val(m^)

    \\ a is a variable which hold the number of thread (as returned from task
manager)

    \\ so we can get 5 times a new number.

```



```

\\ for each thread we make some static variables (only for each thread)

\\ this statement execute a line of code in thread a
thread a execute {

    \\ this executed on thread execution object

    static f=eval(m), think=true, ForkL=NoFork

    static ForkR=NoFork, eatcount=random(2,5)

    static R=-1

    if MayChangePick then R=Random(-1,0)

}

}

cls ,5 ' set split screen from fifth row

\\ Main.Task is a thread also. Normaly exit if no other threads running in
background

\\ also serve a the wait loop for task manager (we can use Every 200 {} but isn't
a thread, is a kind of a wait statement)

\\ tick return the counter from task manager which used to triger threads

basetick=tick

\\ 4hz display results

MaxCritical=0

Main.Task 1000/4 {

    { \\ a block always run blocking all other threads

        cls

        Print Part $(1),$( "####;\D\\E;\D\\E"),energy()

        Print Under

        Print "Table:"

```

```

        Call ShowTable()

        if noforks() then critical++ else critical=0

        MaxCritical=if(MaxCritical<critical->critical,MaxCritical)

        Print "noforks on table counter:";critical, "Max:";MaxCritical

        Print #-2,Page$

        Doc$=Page$

        Clear Page$

    }

    if critical>40 or keypress(1) then exit

}

threads erase

Clipboard Doc$

}

Dining_philosophers Random(1,2)

```

## Using Lambda functions

### *Dijkstra's\_Algorithm*

This algorithm show how we find the optimal path from on node to another in a Graph. Out Graph has nodes with one direction to some other nodes, and for each small path between two connected nodes we have a cost. The scope of this program is to show the Dijkstra's algorithm, and how we can put the Graph in a structures of tuples who have tuples also.

We use Infinite constant (a double value) and for Graph we place.

We use a tuple with a list of all nodes. For each node we have a tuple with the node name as string and then the paths, as tuples of two values, the node name to where we direct and the cost of it. If a node has no direction to any other node then we have to place Term a tuple with null string and null cost ("", 0). We look for **edge#val\$(0)<>""** but we can use the advanced **not edge is term** which is the same here and return false if pointer in edge is different from pointer in term. The later need the term to be in scope, but the first comparison is more versatile because it is value oriented. So a tuple of (("",0),("",0)) has two tuples with same values but different pointers, and (term, term) has two tuples with

same pointer. As we see the Edges is a jagged array, has one level for nodes, and a second level for paths to nodes. Also note that using letters for nodes is like we use weak references. The path is hard structure by tuples, but the nodes have no physical pointers to nodes. Think about a structure where each node has a table of two things per row, the pointer to another node and the cost value. In that case we have many pointers to nodes, so a pointer for c has to included in all other nodes which points (as path) to c. And because a node may have from zero to many paths to nodes, we have to use a table of nodes and a private linked list of three values the pointer of destination node, a cost and a pointer to another node or null (no other node destination for the given starting node). To break this structure, we have to pass two times, one per node to erase each path from linked list and final to erase the table of nodes. So we didn't do such a thing, and we do just erasing of Edges, with a cascade "message" to destroy object. Each embedded object send the same message from first to last object in the array, so at the return we get an empty Edges from objects. Only the term object survive because a second pointer exist in term variable. Because the objects have a counter of pointer references, when the term erased as value/object from Edges the counter from 2 turned to 1 and when term erased the counter turned to 0 and the object destroyed. So here we didn't do any special erasing of linked lists, (which are hard connected), because of the nature of tuple structure and the use of weak references, the names of nodes as strings.

```
Module Dijkstra`s_algorithm {

  const max_number=infinity

  GetArr=lambda (n, val)->{

    dim d(n)=val

    =d()

  }

  term=("",0)

  Edges=(("a", ("b",7),("c",9),("f",14)),("b",("c",10),("d",15)),("c",("d",11),("f",2)),
  ("d",("e",6)),("e",("f", 9)),("f",term))

  Document Doc$="Graph:"+{

  }

  ShowGraph()

  Doc$="Paths"+{

  }

  Print "Paths"
```

```

For from_here=0 to 5

    pa=GetArr(len(Edges), -1)

    d=GetArr(len(Edges), max_number)

    Inventory S=1,2,3,4,5,6

    return d, from_here:=0

RemoveMin=Lambda S, d, max_number-> {

    ss=each(S)

    min=max_number

    p=0

    while ss

        val=d#val(eval(S,ss^)-1)

        if min>val then let min=val : p=ss^

    end while

    =s(p!) ' use p as index not key

    Delete S, eval(s,p)

}

Show_Distance_and_Path$=lambda$ d, pa, from_here, max_number (n) -
> {

    ret1$=chr$(from_here+asc("a"))+" to "+chr$(n+asc("a"))

    if d#val(n) =max_number then =ret1$+ " No Path" :exit

    let ret$="", mm=n, m=n

    repeat

        n=m

        ret$+=chr$(asc("a")+n)

        m=pa#val(n)

```

```

until from_here=n

=ret1$+format$("{0::-4} {1}",d#val(mm),strrev$(ret$))
}

while len(s)>0

    u=RemoveMin()

    rem Print u, chr$(u-1+asc("a"))

    Relaxed()

end while

For i=0 to len(d)-1

    line$=Show_Distance_and_Path$(i)

    Print line$

    doc$=line$+{

        }

    next

next

Clipboard Doc$

End

Sub Relaxed()

    local vertex=Edges#val(u-1), i

    local e=Len(vertex)-1, edge=(,), val

    for i=1 to e

        edge=vertex#val(i)

        if edge#val$(0)<>"" then

            val=Asc(edge#val$(0))-Asc("a")

```

```

        if d#val(val)>edge#val(1)+d#val(u-1) then
            Return d, val:=edge#val(1)+d#val(u-1)
            Return Pa, val:=u-1
        end if
    end if
next
end sub

Sub ShowGraph()
    Print "Graph"
    local i
    for i=1 to len(Edges)
        show_edges(i)
    next
end sub

Sub show_edges(n)
    n--
    local vertex=Edges#val(n), line$
    local e=each(vertex 2 to end), v2=(,)
    While e
        v2=array(e)
        line$=vertex#val$(0) ' break the line for this paper
        line$+=if$(v2#val$(0)<>""->"->" +v2#val$(0)+format$(" {0::-2}",v2#val(1)), "")
        Print line$
        Doc$=line$+{

```

```

    }
end while

end sub

}

Dijkstra`s_algorithm

```

**Export this:**

Graph:

```

a->b 7
a->c 9
a->f 14
b->c 10
b->d 15
c->d 11
c->f 2
d->e 6
e->f 9
f

```

Paths

```

a to a 0 a
a to b 7 ab
a to c 9 ac
a to d 20 acd
a to e 26 acde
a to f 11 acf
b to a No Path
b to b 0 b
b to c 10 bc
b to d 15 bd
b to e 21 bde
b to f 12 bcf
c to a No Path
c to b No Path
c to c 0 c
c to d 11 cd
c to e 17 cde
c to f 2 cf
d to a No Path
d to b No Path
d to c No Path
d to d 0 d
d to e 6 de
d to f 15 def

```

```
e to a No Path
e to b No Path
e to c No Path
e to d No Path
e to e 0 e
e to f 9 ef
f to a No Path
f to b No Path
f to c No Path
f to d No Path
f to e No Path
f to f 0 f
```

### ***Example RIPEMD-160***

In the following example we use an algorithm for RIPEMD-160 (slow for an interpreter, but works). We use many Binary functions. The `binary.add()` add two 32 bit numbers and drop the overflow bit (if happen to produced). We place lambda functions in array items.

We make one lambda function which have closures other lambda functions. We use a buffer (see statement: **buffer clear message as byte\*64**)

There are three REM code lines (which we break them so we get Print to get information, but we can delete the new line and leave them to REM to hide these lines)

```
\\ https://en.wikipedia.org/wiki/RIPEMD
```

```
\\ The original RIPEMD function was designed in the framework of the EU project RIPE
(RACE Integrity Primitives Evaluation) in 1992
```

```
\\ RIPEMD-160 is 160bit cryptographic hash function.
```

```
Module Checkit {
```

```
    Function Prepare_RiPeMd_160 {
```

```
        Dim Base 0, K(5), K1(5)
```

```
        K(0)=0x00000000, 0x5A827999, 0x6ED9EBA1, 0x8F1BBCDC, 0xA953FD4E
```

```
        K1(0)=0x50A28BE6,0x5C4DD124, 0x6D703EF3, 0x7A6D76E9, 0x00000000
```

```
        Dim Base 0,r(80), r1(80), s(80), s1(80)
```

```
        r(0)=0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
```

```
        r(16)=7, 4, 13, 1, 10, 6, 15, 3, 12, 0, 9, 5, 2, 14, 11, 8
```

```
        r(32)= 3, 10, 14, 4, 9, 15, 8, 1, 2, 7, 0, 6, 13, 11, 5, 12
```



$r(48)=1, 9, 11, 10, 0, 8, 12, 4, 13, 3, 7, 15, 14, 5, 6, 2$

$r(64)=4, 0, 5, 9, 7, 12, 2, 10, 14, 1, 3, 8, 11, 6, 15, 13$

$k=r() : k*=4$  ' k is a pointer to array. We have to multiply to make them

offsets

$r1(0)=5, 14, 7, 0, 9, 2, 11, 4, 13, 6, 15, 8, 1, 10, 3, 12$

$r1(16)=6, 11, 3, 7, 0, 13, 5, 10, 14, 15, 8, 12, 4, 9, 1, 2$

$r1(32)=15, 5, 1, 3, 7, 14, 6, 9, 11, 8, 12, 2, 10, 0, 4, 13$

$r1(48)=8, 6, 4, 1, 3, 11, 15, 0, 5, 12, 2, 13, 9, 7, 10, 14$

$r1(64)=12, 15, 10, 4, 1, 5, 8, 7, 6, 2, 13, 14, 0, 3, 9, 11$

$k=r1() : k*=4$

$s(0)=11, 14, 15, 12, 5, 8, 7, 9, 11, 13, 14, 15, 6, 7, 9, 8$

$s(16)=7, 6, 8, 13, 11, 9, 7, 15, 7, 12, 15, 9, 11, 7, 13, 12$

$s(32)=11, 13, 6, 7, 14, 9, 13, 15, 14, 8, 13, 6, 5, 12, 7, 5$

$s(48)=11, 12, 14, 15, 14, 15, 9, 8, 9, 14, 5, 6, 8, 6, 5, 12$

$s(64)=9, 15, 5, 11, 6, 8, 13, 12, 5, 12, 13, 14, 11, 8, 5, 6$

$s1(0)=8, 9, 9, 11, 13, 15, 15, 5, 7, 7, 8, 11, 14, 14, 12, 6$

$s1(16)=9, 13, 15, 7, 12, 8, 9, 11, 7, 7, 12, 7, 6, 15, 13, 11$

$s1(32)=9, 7, 15, 11, 8, 6, 6, 14, 12, 13, 5, 14, 13, 13, 7, 5$

$s1(48)=15, 5, 8, 11, 14, 14, 6, 14, 6, 9, 12, 9, 12, 5, 15, 8$

$s1(64)=8, 5, 12, 9, 12, 5, 14, 6, 8, 13, 6, 5, 15, 13, 11, 11$

Dim Base 0, T(5), TT(5)

$T(0)=\lambda \rightarrow \text{binary.xor}(\text{binary.xor}(\text{number}, \text{number}), \text{number})$

$T(1)=\lambda (B, C, D) \rightarrow \text{binary.or}(\text{binary.and}(B, C), \text{binary.and}(\text{binary.not}(B),$

D))

$T(2)=\lambda \rightarrow \text{binary.xor}(\text{binary.or}(\text{number}, \text{binary.not}(\text{number})), \text{number})$

```
T(3)=lambda (B,C,D)->binary.or(binary.and(B,D), binary.and(C,binary.not(D)))
```

```
T(4)=lambda ->binary.xor(number, binary.or(number, binary.not(number)))
```

```
\\ no need for variables we read form stack with number
```

```
TT(0)=lambda ->binary.xor(number, binary.or(number, binary.not(number)))
```

```
TT(1)=lambda (BB,CC,DD)->binary.or(binary.and(BB,DD),  
binary.and(CC,binary.not(DD)))
```

```
TT(2)=lambda ->binary.xor(binary.or(number, binary.not(number)), number)
```

```
TT(3)=lambda (BB,CC,DD)->binary.or(binary.and(BB,CC),  
binary.and(binary.not(BB),DD))
```

```
TT(4)=lambda ->binary.xor(binary.xor(number,number),number)
```

```
\\ return of this function is a lambda function
```

```
\\ all arrays are closures to this lambda
```

```
=lambda K(),K1(),TT(), T(),r(),r1(), s(), s1() (&message$, ansi as  
boolean=true, ansiid=1033)-> {
```

```
    set fast!
```

```
    def h0 = 0x67452301, h1 = 0xEFCDAB89, h2 = 0x98BADCFE
```

```
    def h3 = 0x10325476, h4 = 0xC3D2E1F0
```

```
    def i, j, l, padding, l1, blocks, acc, f64 as boolean=true, oldid
```

```
    if ansi then oldid=locale : locale ansiid
```

```
    \\ we use a buffer of 64 bytes
```

```
    buffer clear message as byte*64
```

```
    l=len(message$)*if(ansi->1,2 )
```

```
    if binary.and(l,63)>55 then padding=64
```

```
    padding+= 64 - (l Mod 64)
```

```
    l1=padding+l+1
```

```
    f64=binary.and(l,63)<>0
```

```

blocks=l1 div 64

rem

Print "blocks:";blocks
\\ now prepare the buffer
PrepareBuffer()
def decimal A, B, C, D, E, AA, BB, CC, DD, EE, T, TT
do
A = h0 : B = h1 : C = h2 : D = h3 : E = h4
AA = h0 : BB = h1 : CC = h2 : DD = h3 : EE = h4
for J=0 to 79 {
JJ=J DIV 16
PUSH binary.add(Binary.Rotate(binary.add(A,T(JJ)
(B,C,D),eval(message ,r(j) as long),k(jj)), s(j)), e)
A = E : E = D : D = Binary.Rotate(C, 10) : C = B : READ B
PUSH binary.add(Binary.Rotate(binary.add(AA,TT(JJ)
(BB,CC,DD),eval(message, r1(j) as long),k1(jj)),s1(j)),EE)
AA = EE : EE = DD : DD = Binary.Rotate(CC, 10) : CC = BB :
READ BB
}
push binary.add(h1, C, DD)
h1 = binary.add(h2, D, EE)
h2 = binary.add(h3, E, AA)
h3 = binary.add(h4, A, BB)
h4 = binary.add(h0, B, CC)
Read h0
blocks--

rem

print over $(0,8), blocks : Refresh
if blocks=0 then exit
PrepareBuffer()

```

```

always
rem
    print
    buffer ans as byte*20
    \\ we put ulong (long ar ulong in buffers)
    Return ans, 0:=h0 as long, 4:=h1 as long,8:=h2 as long, 12:=h3 as
long, 16:=h4 as long
    =ans
    if ansi then locale oldid
    set fast
    Sub PrepareBuffer()

        if l-acc>=64 then
            LoadPart(64)
        else.if blocks=1 then
            return message, 0:=string$(chr$(0),32)
            if l-acc=0 and f64 then
                Return message, 56:=l*8 as long,
60 :=binary.shift(l,-29) as long
            else
                Return message, l-acc:=0x80, 56:=l*8 as long,
60 :=binary.shift(l,-29) as long
                if l>acc then LoadPart(l-acc)
            end if
        else
            Return message, l-acc:=0x80
            LoadPart(l-acc)
        end if
    End Sub
    sub LoadPart(many)

```

```

    \\ str$() convert to ansi, one byte per character
    \\ using 1033 as Ansi language
    if ansi then
        Return message, 0:=str$(mid$(message$,1+acc, many))
    else
        Return message, 0:=mid$(message$, 1+acc, many)
    end if
    acc+=many
end sub
}
}
Module TestHash (RIPEMD){
    Flush
    \\ push data to stack of values, as fifo (each entry append to end of stack)
    Data "b3be159860842cebaa7174c8fff0aa9e50a5199f","Rosetta Code"
    Data "9c1185a5c5e9fc54612808977ee8f548b2258d31",""
    Data "0bdc9d2d256b3ee9daae347be6f4dc835a467ffe","a"
    Data "8eb208f7e05d987a9b044a8e98c6b087f15a0bfc","abc"
    Data "5d0689ef49d2fae572b881b123a85ffa21595f36", "message digest"
    Data
    "f71c27109c692c1b56bbdceb5b9d2865b3708dbc","abcdefghijklmnopqrstuvwxyz"
    Data "b0e20b6e3116640286ed3a87a5713079b21f5189"
    Data
    "ABCDEFGHJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789"
    Data "9b752e45573d4b39f4dbd3323cab82bf63326bfb", String$
    ("1234567890",8)
rem    Data "52783243c1697bdbe16d37f97f68f08325dc1528", String$("a",1000000)

    While not empty
        Read check$, text$

```

```

        Print "RIPEMD160 for ";quote$(Left$(if$(len(text$)>30->left$(
(text$,27)+"...", text$),30))
        \\ pass text$ by reference
        Display(RIPEMD(&text$))
    End While

    sub Display(ans)
        local answer$
        for i=0 to len(ans)-1
            answer$+=hex$(eval(ans,i),1)
        next i
        Print lcase$(answer$)
        Print lcase$(answer$)=check$
    end sub
}
TestHash Prepare_RiPeMd_160()
}

```

Checkit

## Object Oriented Programming

An OOP program use objects. M2000 isn't a pure object language. We can use objects inside any structure, a module, or function. Here we concern about user object. A user object is an object defined by the user (the programmer). A new object created by using another object as a clone, by merging other objects or by using a Class definition. The name of user object category is Group. So we make groups to group state and methods, to add events, to add operators, to control how the object return something from it or how take something when assign a value to it.

Groups in M2000 are value types, and we can make references to them for immediate use, or we can make pointers if we like to point them. Some languages use classes to define objects and some other uses prototypes. M2000 use both. By default a group is a value, and can clone immediate to a new group although for some members which are trait as pointers we get the copy of pointer. Assign a group to already defined group by default we merge the group. Merging replace values and methods when same name exist from source to target group. Also merging add type if we define a type to source group.

Types in groups are new (introduced at latest few revisions in M2000, version 9.9). Each group is type of Group. So if A is a group, then `Type$(A)` return "Group". Before using the new type system a member of group like a variable acted as the type. The new type system can be used to check in a parameter list if a group is a specific type of object.

Also by the new system Classes get a `AS` clause, so Class Alfa as Beta { } do a simple thing, add the definition (and type) of Beta before the definition of Alfa. We can use as many `AS` clause we want. We get a merging of types in definition, before actual object defined. We can use clause `Final` before variables or `After the Module or Function` clause in a definition to not allow the same identifier to change and already in use as `Final`. So we can have multiple inheritance in a flat definition, and this for many cases is good, but for others we have to change to composition style, to include an object inside another object.

Two new operators added for expressions for groups:

**Operator `Is Type`:** This operator is for checking the type of Group. So `Print A is type Something` check the group A if has the type Something in the list of types (not in the inner groups of A). As you see the type name used in this operator is a literal. We can use `Eval()` function to make something like `Eval("A is type "+typename$)`.

**Operator `With`:** This operator merge two groups and return the merging group. If A, B, C are groups and D is a new name then `D=A with B with C` make the D as A as B and as C. If D is already a group then the same hold and also D may have more members (from the old state). This type of merging seems like inheritance at objects (not at classes definitions). We can use classes like `Class1(1,3) with Class2("aName")` to return an object of types Class1 and Class2, using each constructor, or we can use any function which return a Group or pointer to a Group.

At this point we have to clarify the difference of an identifier which we call a Group from an identifier which call a pointer to a Group. The first group lives until the identifier erased, is like a static object in some other languages. The second group lives until nothing point to it. The first group is bound to module or function, as ready to use. The second group is closed, and bound immediately in the current scope, or perhaps is as already bound to a previous scope in the chain of call, and seamless we get access like it was in the current scope, without disturb the previous scope. We can make pointers to point to a group as the first one, and these pointers hold only a weak reference to it. Also we can make a pointer to a copy of the first one. This pointer is a true pointer. So a pointer may point to a named (bound) group, or a float (unnamed,closed) group, or to a second one which temporary bound to system from previous access and still is in that state. A pointer to a group is another group which act as a pointer.

**The Null object.** After introducing types an idea to have a type of Null comes. So the function `Pointer()` or the assignmen `->0&` return a group of type Null. Merging Null object with any other we pass the other as result (null type not added to list of types). The Null object is a group of type Null and when the Environment start created so we can make with `Pointer()` as many pointers we wish using the same object. So if `A=Pointer()` and `B=Pointer()` then `Print A is B` return true. The operator `IS` checking the real pointers of two objects (not only for Groups, but all types of objects in M2000).

## Using Groups

We can compose groups from other groups. A class is a function which produce a group. We can merge definitions also: Groups may have nested groups. We can put Groups in arrays, inventories, stacks, and as closures in lambda functions.

```
M=lambda (Z) -> {
    Group alfa {
        X=Z
    }
    =lambda alfa ->{
        =alfa.x
        alfa.x++
    }
}
```

```
}(100)
```

```
Print M()=100, M()=101
```

```
MM=M    ' save state to MM
```

```
Print M()=102, M()=103
```

```
Print MM()=102, MM()=103
```

The alfa group is a named group, and has a unique pointer which we can't use. The group act as a value. So now we change the rules. We use a pointer to a copy of alfa Group. Now we can't save the state to MM, because we just copy the pointer. So pointers to groups used to share state. See `Pointer((alfa))` if we place `Pointer(alfa)` we pass a reference to alfa not a true pointer. Because alfa has a life only in the current function, the reference became invalid just when the function exit from execution.

```
M=lambda (Z) -> {
    Group alfa {
        X=Z
    }
}
```



```

=lambda a=Pointer((alfa)) ->{
    =a=>x
    a=>x++
}

```

```

}(100)

```

```

Print M()=100, M()=101

```

```

MM=M

```

```

Print M()=102, M()=103

```

```

Print MM()=104, MM()=105

```

To share state between groups we can use a member as a pointer to group. Another way is to use a Superclass. A Superclass is an instance of a group with no public members, but includes a hidden group and we can use it to make new groups or to access the unique state of it. A group may have one pointer to a SuperClass. A SuperClass can't have a SuperClass. Any nested group may have different Superclass. When we merge a group to another group we also replace Superclass if the group in right expression has own Superclass.

```

Superclass Alfa {

```

```

    Unique:

```

```

        counter=0

```

```

    Public:

```

```

        state=10

```

```

    Module doit (x) {

```

```

        .state<=x

```

```

        For SuperClass, this {

```

```

            .counter++

```

```

        \\ notice the double dot before state

```

```

        Print .counter, ..state

```

```

        }
    }
}

A=Alfa

B=Alfa

A.doit 100    ' 1  100

B.doit 300    ' 2  300

A.doit 100    ' 3  100

A.doit 100    ' 4  100

B.doit 300    ' 5  300

Class Other {

    state2=100

    Function ShowCounter {

        for superclass {

            =.counter

        }

    }

}

C=Other() with Alfa

C.doit 500    '6  500

Print C.ShowCounter()=6

```

In the example above we use the With operator (for groups only). We can use C=Alfa and C=Other() or the better C=Other() with Alfa (we can use anything which have a Group as return value. Here we use a class Other() and a superclass Alfa

Merging has some benefits, but how we get lesser members from a group? In the following example we make a basic and a likebasic class. The difference is that in basic we restrict the merging only to those members we have in the class. We use the Set function and we get from stack of values a group which only the members with same name assigned to current object. Also we make another class normal as basic. Now we combine definitions prior of making instance of class. So normal is a basic too. We can use many AS Class clause but here only for other classes (Without parenthesis).

```
Class Likebasic {
```

```
    x=10, y=29
```

```
Class:
```

```
    Module basic (.x, .y) {}
```

```
}
```

```
Class basic {
```

```
    x=10, y=29
```

```
    set {
```

```
        read this
```

```
    }
```

```
Class:
```

```
    Module basic (.x, .y) {}
```

```
}
```

```
Class normal as basic {
```

```
    Z=300
```

```
    Module Apply (&Basic) {
```

```
        Basic=This
```

```
    }
```

```
Class:
```

```
    Module normal (.x, .y) {}
```

```
}  
  
B=basic(2, 3)  
  
Print B.x=2, B.y=3  
  
N=normal(500, 1000)  
  
Print N.x=500, N.y=1000  
  
N.Apply &B  
  
Print B.x=500, B.y=1000  
  
B=basic(2, 3)  
  
B=N  
  
Print B.x=500, B.y=1000  
  
Print Valid(B.Z)=False  
  
Z=LikeBasic(4,5)  
  
Z=N  
  
Print Z.x=500, Z.y=1000  
  
\\ Now Z.Z exist  
  
Print Valid(Z.Z)=True
```

See the example Inheritance as the last part of this unit.

## ***Design Patterns in OOP***

Links for examples for each pattern.

### ***Creational Patterns***

[SingletonPattern](#)  
[FactoryMethod Pattern](#)  
[FactoryPattern](#)  
[AbstractFactory Pattern](#)  
[BuilderPattern](#)  
[PrototypePattern](#)  
[PoolPattern](#)

**Behavioral Patterns**

[MementoPattern](#)  
[MediatorPattern](#)  
[ObserverPattern](#)  
[NullObject Pattern](#)  
[VisitorPattern](#)  
[InterpreterPattern](#)  
[IteratorPattern](#)  
[StrategyPattern](#)  
[CommandPattern](#)  
[StatePattern](#)  
[TemplateMethod Pattern](#)  
[Chainof Responsibility Pattern](#)

**StructuralPatterns**

[AdapterPattern](#)  
[BridgePattern](#)  
[CompositePattern](#)  
[DecoratorPattern](#)  
[FlyweightPattern](#)  
[FacadePattern](#)  
[ProxyPattern](#)

**Simple OOP Example**

In the following example we use a group which return a string value. We have to place the name using \$. Group alfa\$ make two names, alfa anda alfa\$. The first name used to access properties/methods of group.

We can make Private and Public parts. A group normally return a copy of it (a volatile group) unless we have a value function. We can still get the copy of it if we use Group\$(alfa\$) or Group\$(alfa).

```

Group alfa$ {
    Private:
        s$

    Public:
        many

    Value {
        =.s$
    }

    Set (.s$) {
        .many++
    }
}

```

```
    }  
}
```

Print alfa\$, alfa.many=1

z\$=Group\$(alfa\$)

Print z\$, z.many=1

```
Module Beta (&k$) {  
    Print k$, k.many  
    k$="ok2"  
}
```

Beta &alfa\$

Print alfa\$, alfa.many

### ***Classic Book Example***

The class: part removed when the group change to volatile one. Because class is a function the Class Book make a local Book Group where module Book exist, and then return the Book Group as volatile group (nameless), with on;u the four final variables.

```
Class Book {  
    \\ these are public but can get value one time  
    Final title$, des$, price, pback  
    \\ we use a class part, which means a part that exist only at contruction time
```

Class:

```
    Module Book (a$, b$, c as decimal, d as boolean) {  
    \\ we use fresh variables to catch a missing value  
        .title$<=a$  
        .des$<=b$
```

```

        .price<=c
        .pback<=d
    }
}

Class BookDB {
Private:
    countme=0
    dim p()
Public:
    module final AddBook {
        newdim =.countme+1
        dim .p(newdim)
        read .p(.countme)
        .countme++
    }
    module final ProcessPaperbackBooks (&ProcessBookDelegate) {
        if .countme<1 then break
        for i=0 to .countme-1 {
            if .p(i).pback then call ProcessBookDelegate.processBook(.p(i))
        }
    }
}

group PrintTitle {
    function final processBook(AnyBook) { Report format$(" {0}", AnyBook.title$)}
}

group PriceTotaler {

```

```
items, total
```

```
function final processBook(AnyBook) {.items++ : .total+=AnyBook.price }
```

\\ look the <= operator, if we use = then we define local variables. Items and total are like global but for group only

```
module final zero { .total<=0 : .items<=0 }
```

```
function final AveragePrice { if .items>0 then =.total/.items }
```

```
}
```

```
bookDB=bookDB()
```

```
report "First Book DB"
```

```
bookDB.AddBook Book("The C Programming Language", "Brian W. Kernighan and Dennis M. Ritchie", 19.95, true)
```

```
bookDB.AddBook Book("The Unicode Standard 2.0", "The Unicode Consortium", 39.95, true)
```

```
bookDB.AddBook Book("The MS-DOS Encyclopedia", "Ray Duncan", 129.95, false)
```

```
bookDB.AddBook Book("Dogbert's Clues for the Clueless", "Scott Adams", 12.00, true)
```

```
bookDB.ProcessPaperbackBooks &PriceTaller
```

```
report "Average Paperback Book Price: $" + str$(PriceTaller.AveragePrice(), "#.##")
```

```
bookDB.ProcessPaperbackBooks &PrintTitle
```

```
report "Second Book DB" \\report prints text proportionally with justification
```

```
PriceTaller.zero
```

```
SecondbookDB=bookDB()
```

```
SecondbookDB.AddBook Book("Any Big Big and Big Tilt", "Any Author", 3.45, true)
```

```
SecondbookDB.ProcessPaperbackBooks &PriceTaller
```

```
report "Average Paperback Book Price: $" + str$(PriceTaller.AveragePrice(), "#.##")
```

```
SecondbookDB.ProcessPaperbackBooks &PrintTitle
```



**Example Event Listener**

This is an example which we make all the code we need for events, without using event objects or light events in groups. This example used for the making of events in M2000 (was written before interpreter get events). Also this written before the introduction of pointers to groups. So we use weak references of "buttons" and by reference call for call back.

```
Module OOP {

    Set Fast

    cls 1, 0

    pen 14

    report 2, "Event Listener"

    report "Use keys 1, 2 and mouse left, and for exit mouse right"

    cls, 2

    class mousetlistener {

        name$="MousePress", yourkey, auto

        dim ref$()

        module mousetlistener {

            read .yourkey

            .name$<=format$("{0}({1})", .name$, .yourkey)

        }

        module register {

            .auto++

            dim .ref$(.auto)

            read .ref$(.auto-1) \\ weak reference

        }

        function CheckEvent {
```

```

        =Mouse=.yourkey
    }
}

class keylistener {
    name$="KeyPress", yourkey, auto
    dim ref$()

    module keylistener {
        read .yourkey

        .name$<=format$("{0}({1})", .name$, .yourkey)
    }

    module register {
        .auto++

        dim .ref$ (.auto)

        read .ref$ (.auto-1) \\ weak reference
    }

    function CheckEvent {
        =keypress(.yourkey)
    }
}

class EventHandler {
    auto, autoevents, EnableEvents

    Dim Events()

    class widget {
        \\ in classes we can define variables without value
    }
}

```

```

ref$ \\ weak reference

id, caption$, Enabled=True

module linkme {
    read .ref$
}

module widget { \\ this is used as construction function, but is a
    read .id
    read .caption$
}

function Callback {
    read some$
    push .ref$ : read &ref \\ this is the link
    =ref.query(.id, some$, &this)
}

function button { \\ this is the button construction
    .auto++
    read txt$
    makeme =.widget(.auto,txt$)
    makeme.linkme &this
    =makeme \\ we make a group a floating group to export
}

function EventList {
    handle=.autoevents \\ we execute some commands..

```

```

        .autoevents++

        dim .Events(.autoevents)

        read .Events(handle)  \\ .. and then we can read function
parameter
        =handle
    }

    module register {

        read handler, ref$

        .Events(handler).register ref$

    }

    function observe {

        if not .EnableEvents then =true : exit

        print "observe for events"

        for i=0 to .autoevents-1 {

            for .Events(i) {

                if .checkevent() then {

                    for j=0 to .auto-1 {

                        for this {

                            \\ we use a for this {} to make temporary variable

                            \\ because we can't relink a link. so we make a fresh here

                            \\ the link statement to this:  push .ref$(j) : read &Link

                                link weak .ref$(j) to &link

                                call link.callback(.name$)

                        }

                    }

                }

            }

        }

    }

```

```

        }
    }
}

function query {
    read id, what$, &nicesmallgroup
    print under "Inside EventHandler";
    print under
    print part "I get a query from a widget object ";id
    print
    print part "Say: ";what$
    print
    for nicesmallgroup {
        Print part "I get the caption: ";.caption$
        print
        =0
    }
}

}

EventHandler=EventHandler() \ create handler
B1=EventHandler.button("Button1") \ create subjects
B2=EventHandler.button("Button2")
B3=EventHandler.button("Button3")

```

```
for EventHandler {  
    PressKeyOne=.Eventlist(keylistener(49))  
    .Register PressKeyOne, &B1 \register event to subject  
    .Register PressKeyOne, &B2  
    .Register .Eventlist(keylistener(50)) , &B1  
    .Register .Eventlist(Mouselistener(1)) , &B3  
    .EnableEvents=True  
}  
every 150 {  
    if EventHandler.observe() then exit  
    if mouse=2 then exit  
}  
}  
OOP
```

### ***Example Rational Numbers***

This is an example of a class Rational which make objects (groups) as rational numbers with operators. **(this program included in Info.gsb)**

```
Module RationalNumbers {  
    Class Rational {  
        numerator as decimal, denominator as decimal  
        gcd=lambda->0  
        lcm=lambda->0  
        operator "+" {  
            Read I
```

```
denom=.lcm(l.denominator, .denominator)
```

```
.numerator<=denom/l.denominator*l.numerator+denom/.denominator*.numerat  
or
```

```
if .numerator==0 then denom=1
```

```
.denominator<=denom
```

```
}
```

```
Operator Unary {
```

```
.numerator-!
```

```
}
```

```
Operator "-" {
```

```
Read l
```

```
Call Operator "+", -l
```

```
}
```

```
Operator high "*" {
```

```
Read l
```

```
g1=.gcd(l.numerator,.denominator)
```

```
g2=.gcd(.numerator, l.denominator)
```

```
Push l.numerator/g1*.numerator/g2
```

```
Push l.denominator/g2*.denominator/g1
```

```
Read .denominator, .numerator
```

```
}
```

```
Function Inverse {
```

```
if .numerator==0 then Error "Division by zero"
```

```
    ret=This

    sign=Sgn(ret.numerator) : if sign<0 then ret.numerator-!

    swap ret.numerator, ret.denominator

    if sign<0 then ret.numerator-!

    =ret
}

Operator high"/" {

    Read I

    call operator "*", I.inverse()

}

Function Power {

    Read pow as long

    ret=This

    ret.numerator<=.numerator^pow

    ret.denominator<=.denominator^pow

    =ret

}

Operator "=" {

    Read I

    Def boolean T=True, F=False

    if Abs(Sgn(I.numerator))+Abs(Sgn(.numerator))=0 then Push T: exit

    if Sgn(I.numerator) <>Sgn(.numerator) then Push F : exit

    pcomp=I/this

    PUSH pcomp.numerator=1 and pcomp.denominator=1
```



```

}

Operator ">" {
    Read I

    Def boolean F

    if Abs(Sgn(I.numerator))+Abs(Sgn(.numerator))=0 then Push F: exit

    if Sgn(I.numerator)=0 then {
        PUSH .numerator>0
    } Else {
        pcomp=this/I
        PUSH pcomp.real>1
    }
}

Operator ">=" {
    Read I

    if Sgn(I.numerator)=0 then {
        PUSH .numerator>=0
    } Else {
        pcomp=this/I
        PUSH pcomp.real>=1
    }
}

Operator "<" {
    Read I

    Def boolean F

```

```
    if Abs(Sgn(I.numerator))+Abs(Sgn(.numerator))=0 then Push F: exit
    if Sgn(I.numerator)=0 then {
        PUSH .numerator<0
    } Else {
        pcomp=this/I
        PUSH pcomp.real<1
    }
}
Operator "<=" {
    Read I
    if Sgn(I.numerator)=0 then {
        PUSH .numerator<=0
    } Else {
        pcomp=this/I
        PUSH pcomp.real<=1
    }
}
Operator "<>" {
    Read I
    if Sgn(I.numerator)=0 then {
        PUSH .numerator<>0
    } Else {
        pcomp=this/I
        PUSH pcomp.real<>1
    }
}
```

```

    }
}

Group Real {
    value {
        link parent numerator, denominator to n, d
        =n/d
    }
}

Group ToString$ {
    value {
        link parent numerator, denominator to n, d
        =Str$(n)+"/"+Str$(d,"")
    }
}

class:

Module Rational (.numerator, .denominator) {
    if .denominator=0 then Error "Zero denominator"
    sgn=Sgn(.numerator)*Sgn(.denominator)
    .denominator<=abs(.denominator)
    .numerator<=abs(.numerator)*sgn
    gcd1=lambda (a as decimal, b as decimal) -> {
        if a<b then swap a,b
        g=a mod b
        while g {

```

```

        a=b:b=g: g=a mod b

    }

    =abs(b)

}

gcdval=gcd1(abs(.numerator), .denominator)

if gcdval<.denominator and gcdval<>0 then

    .denominator/=gcdval

    .numerator/=gcdval

end if

.gcd<=gcd1

.lcm<=lambda gcd=gcd1 (a as decimal, b as decimal) -> {

    =a/gcd(a,b)*b

}

}

}

Print rational(-3,3)<>rational(-3,3) ' false

M=Rational(10, 150)

N=Rational(2, 4)

Print "M.real+N.real=";M.real+N.real

Print "Z=M+N"

Z=M+N

Print 10/150@+2/4@

Print "Z.real="; Z.real

Print ("";M.numerator;"/"; M.denominator;) + ("";N.numerator;"/";
N.denominator;) = ("";Z.numerator;"/";Z.denominator;)"

```

Print M.toString\$+ " "+N.toString\$+"="+Z.toString\$

Print -10/150@+2/4@

Z=-M+N

Print "-" +M.toString\$+ " "+N.toString\$+"="+Z.toString\$

Print Z.numerator, Z.denominator, Z.numerator/Z.denominator

Print -10/150@+2/4@

Print Z.real

Z=M-N

Print Z.numerator, Z.denominator

Print 10/150@-2/4@

Print Z.real

Z=M\*N

Print Z.numerator, Z.denominator

Print (10/150@)\*(2/4@)

Print Z.real

Z=M/N

Print Z.numerator, Z.denominator

Print (10/150@)/(2/4@)

Print z.toString\$

Print Z.real

Print "Z power 2 = ";

Z=Z.Power(2)

Print Z.real

```
Print z.toString$;" = ";eval(z.toString$)
```

```
Print Z=Z
```

```
Print Z=N ' false
```

```
Print Z=-Z ' false
```

```
ZZ=-Z
```

```
Print ZZ=ZZ
```

```
Print -Z=-Z
```

```
Print Z.numerator, Z.denominator
```

```
Print Z.real, Z.toString$
```

```
\\ Array of rational numbers
```

```
Dim K(100)=rational(1,1)
```

```
M=K(4)+K(3)
```

```
Print M.real
```

```
Print K(4).toString$
```

```
pk->(Z)
```

```
Print pk=>toString$+" +"
```

```
zzz=k(4)+pk
```

```
Print zzz.toString$+ " =" +K(4).toString$+" "+pk=>toString$
```

```
zzz=Rational(10,1)+Rational(3,1)*Rational(2,1)
```

```
Print zzz.toString$, zzz.real=16
```

```
zzz=Rational(10,1)*Rational(3,1)+Rational(2,1)
```

```
Print zzz.toString$, zzz.real=32
```

```
}
```

```
RationalNumbers
```

### ***Example Linked List***

Another example using pointers to groups. We make a doubled linked list of objects, of type group. This program Linked\_List1 is in info.gsb (a better version of Linked\_List which also part of the same file - the modules file type of M2000). Now we have all the logic for a double linked list in one class, with private members. This class create the null object, has a node() function to create nodes. We can use own node class if we want to using different members for data but include the two pointers for the linked list.

```
\\ Second Version
```

```
\\ This example use pointers to groups.
```

```
\\ One class which make Node and Null class inside
```

```
\\ Head and Tail are private
```

```
Module Checkit {
```

```
    Form 80, 50
```

```
    Class LList {
```

```
        Private:
```

```
            Group Head, Tail
```

```
            Class Null {}
```

```
        Public:
```

```
            Property Null {Value}
```

```
            Group GetHead {
```

```
                Value {
```

```
                    link parent Head to Head
```

```
        ->Head
    }
}

Group GetTail {
    Value {
        link parent Tail to Tail
        ->Tail
    }
}

Function Node {
    Group Ret {
        group pred, succ
        dat=0
        Remove {
            Print "destroyed", .dat
        }
    }
    Ret.pred->.[Null]
    Ret.succ->.[Null]
    if match("N") Then Read Ret.dat
    ->(Ret)
}

Module PushTail(k as pointer) {
    if .Tail is .[Null] then {
```



```

        .Head<=k

        .Tail<=k
    } else {
        n=.Tail

        .Tail<=k

        k=>pred=n=>pred

        n=>pred=k

        k=>succ=n
    }
}

Function RemoveTail {
    n=.Tail

    if n is .Head then {
        .Head->.[Null]

        .Tail->.[Null]
    } Else {
        .Tail<=n=>succ

        .Tail=>pred=n=>pred

        n=>pred->.[Null]
    }

    for n, This {
        .succ->.[Null]

        .pred->.[Null]
    }
}

```

```

        =n
    }

Module PushHead(k as pointer) {
    if .head is .[Null] then {
        .Head<=k
        .Tail<=k
    } else {
        n=.head
        .head<=k
        k=>succ=n=>succ
        n=>succ=k
        k=>pred=n
    }
}

Function RemoveHead {
    n=.Head
    if n is .Tail then {
        .Head->.[Null]
        .Tail->.[Null]
    } Else {
        .Head<=n=>pred
        .Head=>succ=n=>succ
        n=>succ->.[Null]
    }
}

```

```

for n, This {
    .succ->..[Null]
    .pred->..[Null]
}
=n
}

Module RemoveNode(k as pointer) {
    pred=k=>pred
    succ=k=>succ
    if pred is succ then {
        if .head is k else Error "Can't remove this node"
        k=.RemoveHead()
        clear k
    } else {
        pred=>succ=succ
        succ=>pred=pred
    }
}

Module InsertAfter(k as pointer, n as pointer) {
    pred=k=>pred
    n=>pred=pred
    n=>succ=k
    pred=>succ=n
    k=>pred=n
}

```

```
    }

    Module DeleteAll {
        While not .IsEmpty(){
            For This {
                A=.RemoveTail()
                clear A
            }
        }
    }

    Remove {
        .DeleteAll
    }

    Function IsEmpty {
        = .Head is .[Null] or .tail is .[Null]
    }
class:

    Module LList {
        .[Null]->.Null()
        .Head->.[Null]
        .Tail->.[Null]
    }
}

L=LList()
```

```

Null=L.Null

m->L.Node(100)

L.PushTail m

If not L.GetHead is Null then Print L.GetHead=>dat=100

for i=101 to 103 {
    m->L.Node(i)
    L.PushTail m
    Print "ok....", i
}

for i=104 to 106 {
    m->L.Node(i)
    L.PushHead m
    Print "ok....", i
}

Print "Use Head to display from last to first"

m=L.GetHead

do {
    Print m=>dat
    m=m=>pred
} Until m is Null

Print "ok, now find 3rd and remove it"

m1=L.GetHead

i=1

```

```
Index=3

While i<Index {

    if m1 is Null then exit

    m1=m1=>pred

    i++

}

If i<>Index then {

    Print "List has less than "; Index;" Items"

} Else {

    Print "First add one new node"

    newNode->L.Node(1000)

    L.InsertAfter m1, newNode

    L.RemoveNode m1

    clear m1 ' last time m1 used here

    newNode=NULL

    Print "ok....."

}

Print "Use Tail to display from first to last"

m=L.GetTail

do {

    Print m=>dat

    m=m=>succ

} Until m is Null
```

```

If rnd<.5 Then
useother=True
While not L.IsEmpty(){
    For This {
        \\ we have to use a temporary variable name, here A
        A=If(useother->L.RemoveTail(),L.RemoveHead())
        ? A=>dat
        useother~
        \\ now we can try to perform removing
        clear A
    }
}
Else
L.deleteAll
End if
Print "list is empty: "; If$(L.IsEmpty()->"Yes","No")
mm=0
for i=50 to 80 {
    m->L.Node(i)
    L.PushTail m
    mm++
}
m->Null
Print "Added ";mm; " nodes"

```

```
        Push Pointer((L))
    }

    Checkit

    Stack

    Print "Press a key for phase 2"

    Print "now Linked_list is a pointer to a group object"

    Push key$ : Drop

    Read Linked_List

    Null=Linked_List=>Null

    m=Linked_List=>GetHead

    While not m is Null

        Print m=>dat

        m=m=>pred

    End While

    List

    \\ we have to use Clear. Clear act only if the pointer is the last one.

    \\ Then Linlkd_List Remove do a Clear for each node. If we didn't use any
    extenal pointer for these we get all destroyed.

    Clear Linked_list, Null, m

    Print " now all variables aren't pointers. They have an empty group"

    List
```

### ***Example of OOP Inheritance***

```
    \\ because deconstructor (Remove {}) is final
```



\\ and we want to apply a different deconstructor

\\ for all derived objects from GameObject

\\ intentionally we didn't apply the deconstructor in Class

\\ But see later how we can import this

```
class GameObject {
    \\ by default functions are virtual
    state=0
    Group PointerToGameObject->0&
    function update() {
        =2
    }
    function draw() {
        =3
    }
    function collide() {
        =4
    }
}
```

Class:

```
Module GameObject (.state) {
    \\ this is the user constructor
    Print "You just create GameObject"
}
}
```

\\ Visible, Solid, Movable compose GameObject

\\ Without using the constructor

\\ but their GameObject would be a different instance of class GameObject

```
class Visible as GameObject {  
    \\ using final the function stay as is  
    function final Draw() {  
        =100  
    }  
}
```

```
class Solid as GameObject {  
    function final collide() {  
        =1000  
    }  
}
```

```
class Movable as GameObject {  
    function final update() {  
        =10000  
    }  
}
```

\\ here we compose Player, Cloud, Building, Trap from other objects

```
class Player as Solid as Movable as Visible {  
    Remove {  
        Print "Player removed"  
    }  
}
```

class:

```

    Module Player (.PointerToGameObject) {}
}

```

```

Class Cloud as Movable as Visible {
    Remove {
        Print "Cloud removed"
    }
}

```

class:

```

    Module Cloud (.PointerToGameObject) {}
}

```

```

Class Building as Solid as Visible {
    Remove {
        Print "Building removed"
    }
}

```

class:

```

    Module Building (.PointerToGameObject) {}
}

```

```

Class Trap as Solid {
    Remove {
        Print "Trap removed"
    }
}

```

class:

```

    Module Trap (.PointerToGameObject) {}
}

```

```

Class TraitRemove {

```

```
        Remove {  
            Print "GameObject Removed"  
        }  
    }  
  
    \\ Game is a pointer to Group  
    \\ Because we want to include Remove function  
    \\ we can do that merging two objects  
    \\ so Game is a GameObject but has a TraitRemove  
    Game->(GameObject(1234) with TraitRemove())  
    Print Game=>Update()=2, Game=>draw()=3, Game=>collide()=4  
    \\ P, C, B, T are static objects here  
    P=Player(Game)  
    Print P.Update()=10000, P.draw()=100, P.collide()=1000  
    C=Cloud(Game)  
    Print C.Update()=10000, C.draw()=100, C.collide()=4  
    B=Building(Game)  
    Print B.Update()=2, B.draw()=100, B.collide()=1000  
    T=Trap(Game)  
    Print T.Update()=2, T.draw()=3, T.collide()=1000  
    \\ All objects has the same pointer to Game  
    Print P.PointerToGameObject=>state=1234  
    Print C.PointerToGameObject=>state=1234  
    Print B.PointerToGameObject=>state=1234  
    Print T.PointerToGameObject=>state=1234
```

\\ When state of Game change, these objects can find it

Game=>state+=20000

Print P.PointerToGameObject=>state=21234

Print C.PointerToGameObject=>state=21234

Print B.PointerToGameObject=>state=21234

Print T.PointerToGameObject=>state=21234

\\ we use Parenthesis to get a pointer to a copy of P

\\ so we make a pointer to a new object with same state

\\ without parenthesis we get a pointer to static group

PP->(P)

PC=Pointer((C)) ' this is the same as ->(C)

PB=Pointer((B))

PT=Pointer((T))

Print PP=>Update()=10000, PP=>draw()=100, PP=>collide()=1000

Print PC=>Update()=10000, PC=>draw()=100, PC=>collide()=4

Print PB=>Update()=2, PB=>draw()=100, PB=>collide()=1000

Print PT=>Update()=2, PT=>draw()=3, PT=>collide()=1000

Print PP=>PointerToGameObject=>state=21234

Print PC=>PointerToGameObject=>state=21234

Print PB=>PointerToGameObject=>state=21234

Print PT=>PointerToGameObject=>state=21234

\\ Remove function called for 5 pointers at the end of this module

\\ We can manule execute Remove for static groups if we want

\\ We have 4 static objects (in M2000 we say named groups)

Report "Removing using Clear Named Groups"

Clear P, C, B, T

Report "Automatic Removing Groups erasing Pointers when this module exit .  
The last one is the GameObject"

### Example Shape

\\ to bypass a function we can use this

\\ function alfa {=.beta(![])}

\\ [] is the current stack and when we read it, we get a pointer and leave an empty stack as current stack

\\ so anything we pass to alfa() passed to .beta(), the dot is This, so to This.Beta()

\\ here we use toString\$() to call super.toString\$() without parameteres

\\ For modules is very easy because a module get the current stack

\\ so if we have a member Module alfa {.beta} calling alfa 10,20 is like calling .beta 10, 20 (and all other values the current stack have)

\\ Constructors are modules but called from functions so they get the function's stack (a new one)

\\ Also a constructor skip the erasing phase (the function which call the module do this)

\\ We need this because we can expand the This object.

Report {

there is no super like java super in M2000 when we use inheritance through classes

see Superclass (example SUP) which is something different

```
}
```

```
class Shape {
```

```
private:
```

```
    super.X, super.Y
```

```
    Function super.toString$(a=10) {
```

```
        ="Shape(" + str$(.super.X,"") + ", " + str$(.super.Y,"") + ")"
```

```
    }
```

```
public:
```

```
    Module final setPosition (px, py) {
```

```
        .super.X <= px
```

```
        .super.Y <= py
```

```
    }
```

```
    Function toString$() {
```

```
        =.super.toString$()
```

```
    }
```

```
}
```

```
class MoveShape {
```

```
    Module MoveRelative(xr, yr) {
```

```
        .super.X+=xr
```

```
        .super.Y+=yr
```

```

    }

}

class Circle as MoveShape as Shape {

private:

    radius

public:

    Module setRadius (r) {

        .radius <= r

    }

    Function toString$() {

        = .super.toString$() + ": Circle(" + str$(.radius,"") + ")"

    }

}

```

```

class Rectangle as MoveShape as Shape {

private:

    height, width

public:

    Module MoveLeftSide (p as *Rectangle) {

        \\ for same type objects private members are like public

        for This, p {

            .super.X<=..super.X+..width

            .super.Y<=..super.Y

        }

    }

}

```



```

    }

    module setDimensions (h,w) {

        .height <= h

        .width <= w

    }

    Function toString$() {

        = .super.toString$() + ": Rectangle(" + str$(.height,"") + " x " + str$(.width,"")
+ ")"

    }

}

c = Circle()
r = Rectangle()


r.setPosition 1, 2
r.setDimensions 50, 50
c.setPosition 3, 4
c.setRadius 10

Print r.toString$()
Print c.toString$()

r.MoveRelative 100,100
c.MoveRelative -50,-50

Print r.toString$()
Print c.toString$()


Report {

```

wokring with pointers like in c++

pointers in M2000 are objects, so null pointer (pc->0&) isn't a zero, but an empty Group (object)

```
}
```

```
pc->circle()
```

```
pr->rectangle()
```

```
pr=>setPosition 1, 2
```

```
pr=>setDimensions 50, 50
```

```
pc=>setPosition 3, 4
```

```
pc=>setRadius 10
```

```
Print pr=>toString$()
```

```
Print pc=>toString$()
```

\\ we can open up to ten objects (from one to ten dots, normaly one to three)

\\ if we use nestef for object {} also we have up to ten objects in total

\\ every for object {} is an area for temporary definitions, after exit from brackets

\\ any new definition erased.

```
For pr, pc {
```

```
    .MoveRelative 100,100
```

```
    ..MoveRelative -50,-50
```

```
    Print .toString$()
```

```
    Print ..toString$()
```

```
}
```

```
pr2->rectangle()
```

```
pr2=>SetDimensions 30, 30
```

```
pr2=>MoveLeftSide pr
```

Print pr2=>toString\$()

### ***Example Traversal***

Report {

Tree traversal

```

      1
    /  \
   /    \
  /      \
 2        3
 / \      /
4  5  6
/      / \
7      8  9

```

}

Pen 15 {Report "Using types in class Node"}

Print

Module OOP {

Class Node {

private:

\\ Pointer() of Pointer(0) is the Null type pointer

x, LeftNode=Pointer(), RightNode=Pointer()

Public:

```
Module preorder (visitor){  
    T->This  
    printtree(T)  
    sub printtree(T)  
        If T is type Null Then Exit sub  
        call visitor(T=>x)  
        printtree(T=>LeftNode)  
        printtree(T=>RightNode)  
    end sub  
}
```

```
Module inorder (visitor){  
    T->This  
    printtree(T)  
    sub printtree(T)  
        If T is type Null Then Exit sub  
        printtree(T=>LeftNode)  
        call visitor(T=>x)  
        printtree(T=>RightNode)  
    end sub  
}
```

```
Module postorder (visitor) {  
    T->This  
    printtree(T)  
    sub printtree(T)
```

```

    If T is type Null Then Exit sub

    printtree(T=>LeftNode)

    printtree(T=>RightNode)

    call visitor(T=>x)

end sub

}

Module level_order (visitor){

    M=stack:= Pointer(This)

    \\ using M as FIFO

    Stack M {

        if empty then exit

        Read T

        if T is type Node Then

            call visitor(T=>x)

            Data T=>LeftNode, T=>RightNode

        end if

        Loop

    }

}

remove {

    print format$("node {0} destroyed", .x)

}

```

Class:

```
Module Node {
```

```

        Read .x, .LeftNode, .RightNode

    }

}

\\ Function NodeTree return a pointer to a new Node

Function NodeTree {

    \\ ![] pass current stack to Node()

    ->Node(![])

}

\\ Tree is type Node

Tree=NodeTree(1, NodeTree(2,NodeTree(4, NodeTree(7)), NodeTree(5)),
NodeTree(3, NodeTree(6, NodeTree(8), NodeTree(9))))

printnum=lambda (title$) -> {

    Print

    Print title$;

    =lambda (x)-> {

        Print x;" ";

    }

}

Tree=>preorder printnum("preorder: ")

Tree=>inorder printnum("inorder: ")

Tree=>postorder printnum("postorder: ")

Tree=>level_order printnum("level-order: ")

Print

```

Print

}

OOP

Pen 15 {Report "Using types and inheritance: a class Tree as a class Node, which returns a pointer to Tree object"}

Print

Module OOP {

Class Node {

private:

    \\ Pointer() of Pointer(0) is the Null type pointer

    x, LeftNode=Pointer(), RightNode=Pointer()

Public:

Module preorder (visitor){

    T->This

    printtree(T)

    sub printtree(T)

        If T is type Null Then Exit sub

        call visitor(T=>x)

        printtree(T=>LeftNode)

        printtree(T=>RightNode)

    end sub

}

Module inorder (visitor){

```
T->This
printtree(T)
sub printtree(T)
    If T is type Null Then Exit sub
    printtree(T=>LeftNode)
    call visitor(T=>x)
    printtree(T=>RightNode)
end sub
}

Module postorder (visitor) {
    T->This
    printtree(T)
    sub printtree(T)
        If T is type Null Then Exit sub
        printtree(T=>LeftNode)
        printtree(T=>RightNode)
        call visitor(T=>x)
    end sub
}

Module level_order (visitor){
    M=stack:= Pointer(This)
    \\ using M as FIFO
    Stack M {
        if empty then exit
```



```

    Read T

    if T is type Null Else

        call visitor(T=>x)

        Data T=>LeftNode, T=>RightNode

    end if

    Loop

}

}

remove {

    print format$("node {0} destroyed", .x)

}

}

```

```

Class Tree as Node {

    value (xval) {

        .LeftNode<=Pointer()

        .RightNode<=Pointer()

        Read ? .LeftNode, .RightNode

        .x<=xval

        ->(This)

    }

}

```

\\ now NodeTree is a static group with value which generate other trees.

\\ Tree is type Tree

```
NodeTree=Tree()
```

```
Tree=NodeTree(1, NodeTree(2,NodeTree(4, NodeTree(7)), NodeTree(5)),  
NodeTree(3, NodeTree(6, NodeTree(8), NodeTree(9))))
```

```
printnum=lambda (title$) -> {
```

```
    Print
```

```
    Print title$;
```

```
    =lambda (x)-> {
```

```
        Print x;" ";
```

```
    }
```

```
}
```

```
Tree=>preorder printnum("preorder:  ")
```

```
Tree=>inorder printnum("inorder:  ")
```

```
Tree=>postorder printnum("postorder:  ")
```

```
Tree=>level_order printnum("level-order: ")
```

```
Print
```

```
Print
```

```
}
```

OOP

Pen 15 {Report "Using types and inner class Node in a class Tree which returns a pointer to Node object"}

Print

Module OOP {

Class Tree {

Private:

Class Node {

private:

\\ Pointer() of Pointer(0) is the Null type pointer

x, LeftNode=Pointer(), RightNode=Pointer()

Public:

Module preorder (visitor){

T->This

printtree(T)

sub printtree(T)

If T is type Null Then Exit sub

call visitor(T=>x)

printtree(T=>LeftNode)

printtree(T=>RightNode)

end sub

}

Module inorder (visitor){

T->This

printtree(T)

sub printtree(T)

If T is type Null Then Exit sub

printtree(T=>LeftNode)

```
        call visitor(T=>x)

        printtree(T=>RightNode)

    end sub
}

Module postorder (visitor) {

    T->This

    printtree(T)

    sub printtree(T)

        If T is type Null Then Exit sub

        printtree(T=>LeftNode)

        printtree(T=>RightNode)

        call visitor(T=>x)

    end sub

}

Module level_order (visitor){

    M:=stack:= Pointer(This)

    \\ using M as FIFO

    Stack M {

        if empty then exit

        Read T

        if T is type Node Then

            call visitor(T=>x)

            Data T=>LeftNode, T=>RightNode

        end if

    }

}
```

```

        Loop
    }
}

remove {
    print format$("node {0} destroyed", .x)
}

Class:

    Module Node {
        Read .x, .LeftNode, .RightNode
    }
}

public:

    value (xval as double) {
        Rem {
            LeftNode=Pointer()
            RightNode=Pointer()
            Read ? LeftNode, RightNode
            ->.Node(xval,LeftNode, RightNode)
        }
        ->.Node(xval,![])
    }

}

```

\\ now NodeTree is a static group with a private Node class

```
\\ return a pointer to a Node object

\\ Tree is type Node

NodeTree=Tree()

Tree=NodeTree(1, NodeTree(2,NodeTree(4, NodeTree(7)), NodeTree(5)),
NodeTree(3, NodeTree(6, NodeTree(8), NodeTree(9))))

printnum=lambda (title$) -> {

  Print

  Print title$;

  =lambda (x)-> {

    Print x;" ";

  }

}

Tree=>preorder printnum("preorder: ")

Tree=>inorder printnum("inorder: ")

Tree=>postorder printnum("postorder: ")

Tree=>level_order printnum("level-order: ")

Print

Print

}

OOP
```

## Logging to File in Temporary Directory

Some time we want to export some values as the program run for review them later. We can do this by using the log files. We can also use the Test to run e module, so we can

execute the module by a step by step manner. Using logging is a different approach, for finding errors, depending on values.

We can use text files for logging purposes. Logging is the procedure to save to file values or labels or both to indicate the state of program in various stages.

We can use three types of character encoding, the ANSI, the UTF-16LE, and the UTF-8. For simplicity we can pass labels in a string which are interpreted as variables. We can string pass expressions too. See the example bellow. For Utf-8 encoding we can read file using Document object.

```

Const programname$="MyProgram"

Text UTF-16 logging.txt {##STR$(TODAY+NOW,"YYYYMMDDHHNNSS")##
}

For var1=1 to 10

    Text UTF-16 logging.txt + {This is a line for LOG ##var1## for
##programname$##

    }

Next var1

\\ win temporary$+"logging.txt" ' we can open the file in notepad

\\ or we can open using OPEN (not for UTF-8)

Open temporary$+"logging.txt" for wide input as #k

    Try {Seek #k, 3} ' SKIP BOM

    While not EOF(#k)

        Line Input #k, aLine$

        Print aLine$

    End While

Close #k

\\ delete the log file

```

Text logging.txt

## BreakPoint

We can place statements to get breakpoints, and we can display a test form to see the executed code as executed.

```
Test "start", test("ok"), A
```

```
For A=1 to 100 {
```

```
    Wait 1
```

```
    Print A
```

```
    if A=41 then test "ok" : test test("ok2")
```

```
    if A=81 then test "ok2": test \\ wait for keypress
```

```
}
```

```
Test !
```



# Final Examples

## GAME 2048

This example has the color from the internal editor of M2000 Environment (convert to html when we place it to clipboard).

We use lambda functions to feed the Process() subroutine. We use an Inventory object to put the Empty Tiles and to pick one from there. Main loop loops while EmptyTiles has some empty tiles, so we can play.

The game has an array 4X4 in the display, but inside we have only one dimension array the Board(). We have four lambda objects, four functions which get a two dimension indexes, and return the actual one dimension for the board. Each function translate the 2D to 1D depends on the Direction as the name of it says, by using the appropriate formula.

An interest part of the code is the Gravity subroutine, which use a complex loop with three Continue statements. The important part of the sub is the assignment board(boardtile(k,i))=boardtile(j,i). Gravity finds the k for all tiles in the board always in the current direction which we choose as response of the each new tile.

Gravity plays two times. The first time to place all items without empty places. Next we make any doubling of tile so 2 2 2 2 change to 0 4 0 4. And then a Gravity again to get 0 0 4 4 where 0 is the empty tile. For each column, we check for empty tiles and we add to the EmptyTiles, appending the index of the empty tile. For each process we make a new EmptyTiles inventory, an empty, so for each column process we place only the tiles with 0, the empty tiles. When we fill all the board with tiles>0 the EmptyTiles will be empty so the game stopped.

```
Module Game2048 {
  \\ 10% 4 and 90% 2
  Def GetTileNumber()=If(Random(1,10)=1->4, 2)
  \\ tile
  Def Tile$(x)=If$(x=0->"[  ]", format$("[{0::-4}]", x))
  \\ empty board
  BoardTileRight =lambda (x, y)->x+y*4
  BoardTileLeft=lambda (x, y)->3-x+y*4
  BoardTileUp=lambda (x, y)->x*4+y
  BoardTileDown=lambda (x, y)->(3-x)*4+y
  Dim Board(0 to 15)
  Inventory EmptyTiles
  \\ Score is a statement but we can use it as a variable too.
  Score=0
  \\ Win is also a statement but we can use it as a variable too.
  Win=False
```

```

ExitNow=False
BoardDirection=BoardtileRight
Process(BoardDirection)
\\ Split Rem lines to insert start condition to check valid moves
Rem : board(0)=2
Rem : board(1)=2, 2, 2 ' place to (1), (2), (3)
While len(EmptyTiles) {
    NewTile()
    DrawBoard()
    Action=False
    do {
        a$=key$
        if len(a$)=2 then {
            Action=true
            Select case Asc(mid$(a$,2))
            Case 72
                BoardDirection=BoardTileUp
            Case 75
                BoardDirection=BoardTileRight
            Case 77
                BoardDirection=BoardTileLeft
            Case 80
                BoardDirection=BoardTileDown
            Case 79 ' End key
                ExitNow=True
            Else
                Action=false
            end select
        }
    } until Action
    If ExitNow then exit
    Process(BoardDirection)
}
If Win then {
    Print "You Win"
} Else {
    Print "You Loose"
}
Refresh 30
End
Sub Process(Boardtile)
Inventory EmptyTiles ' clear inventory
local where, i, j, k
For i=0 to 3
    Gravity()
    k=boardtile(0,i)
    For j=1 to 3
        where=boardtile(j,i)

```

```

        if Board(where)<>0 then {
            if board(k)=board(where) then {
                board(k)*=2 : score+=board(where): board(where)=0
                if board(k)=2048 Then Win=True : ExitNow=true
            }
        }
        k=where
    Next j
    Gravity()
    For j=0 to 3
        where=boardtile(j,i)
        if board(where)=0 then Append EmptyTiles, where
    Next j
Next i
End Sub
Sub NewTile()
    local m=EmptyTiles(Random(0, len(EmptyTiles)-1)!)
    Board(m)=GetTileNumber()
    Delete EmptyTiles, m
End Sub
Sub DrawBoard()
    Refresh 2000
    Cls
    Cursor 0, 10
    Local Doc$, line$
    Document Doc$
    Doc$=Format$("Game 2048 Score {0}", score)
    \\ Using Report 2 we use rendering as text, with center justify
    Report 2, Doc$
    Doc$={
    }
    Local i, j
    For i=0 to 3
        line$=""
        For j=0 to 3
            line$+=Tile$(Board(BoardTileRight(j, i)))
        Next j
        Print Over $(2), Line$
        Print
        Doc$=Line$+{
        }
    Next i
    Report 2, "Next:Use Arrows | Exit: Press End"
    Refresh
    ClipBoard Doc$
End Sub
Sub Gravity()
    k=-1

```

```

    for j=0 to 3 {
        where=boardtile(j,i)
        if k=-1 then if board(where)=0 then k=j : continue
        if board(where)=0 then continue
        if k=-1 then continue
        board(boardtile(k,i))=board(where)
        board(where)=0
        k++
    }
End Sub
}
Game2048

```

## Keyboard 005 - Piano

Playing music using keyboard. Press space bar for more volume. With a good keyboard you can play 6 note at once. You can find this program in info.gsb

```

Refresh 5000
Thread.Plan Sequential
Play 0 \ clear music threads

```

```

dim note1$(10,3), note2$(10,3)
FillArray()

```

```

Refresh 5000
Move 0,0
Pen 14
Gradient 5,5
Cursor 0,0
Double
Report 2, "Keyboard 005
Normal
Report 2,{Menu

```

1-Exit 3-Xylophone 4-Piano 5-Saxophone 8-Show Keys/Notes 9-Rythm Yes 0-Rythm No

Space bar - set higher the volume for each note  
 -- George Karras --

```

}
Global kb$=" ", dur=300, org=5, f=0, vol$="V90", voi(18), use(17) ' 0 ..17,
n=1
For i=1 to 16 { use(i)=True }
use(10)= false \ For drum machine
\ compute virtual clavier position
mm=2*(scale.x div 14)

```

```

mm2= mm div 2
kk=scale.y/5
kk1=scale.y/4
gram=scale.y/20
DisplayNoRefresh(mm, kk, mm2, kk1)
refresh 5000
Scroll Split Height/2+1
Cursor 0, Height/2+1
Module ClKey {
    Read a$, press, sel
    If press Then {
        If Instr(kb$,a$+"-")>0 Then Exit
        Next()
        voi(sel)=f
        Print a$, f
        Score f, dur, a$+vol$ : kb$<=kb$+a$+"-": Play f, org
    } else {
        kb$<=Replace$(a$+"-", "", kb$)
        If voi(sel)>0 Then {
            Play voi(sel), 0
            use(voi(sel))~
            voi(sel)=0
        }
    }
}
Sub Next()
Local i
For i=1 to 16 {
    If use(i) Then Exit
}
If i<17 Then { f<=i : use(i)~ } else f<=1: use(1)=True : Print "!!!!!!!"
End Sub
}
\\ 10 for drum machine
Thread { Score 10,400,"CV90CC ab Cd eCC" : Play 10,1 } as L Interval 60
Thread {
    ClKey "A#2", KeyPress(asc("A")), 1
    ClKey "B2", KeyPress(asc("Z")), 2
    ClKey "C3", KeyPress(asc("X")), 3
    ClKey "C#3", KeyPress(asc("D")), 4
    ClKey "D3", KeyPress(asc("C")), 5
    ClKey "D#3", KeyPress(asc("F")), 6
    ClKey "E3", KeyPress(asc("V")), 7
}

```

```

CIKey "F3", KeyPress(asc("B")), 8
CIKey "F#3", KeyPress(asc("H")), 9
CIKey "G3", KeyPress(asc("N")), 10
CIKey "G#3", KeyPress(asc("J")), 11
CIKey "A3", KeyPress(asc("M")), 12
CIKey "A#3", KeyPress(asc("K")), 13
\\ https://msdn.microsoft.com/en-us/library/windows/desktop/dd375731(v=vs.85).aspx
CIKey "B3", KeyPress(0xBC), 14 \\ VK_OEM_COMMA
CIKey "C4", KeyPress(0xBE), 15 \\ VK_OEM_PERIOD
CIKey "C#4", KeyPress(0xBA), 16 \\ VK_OEM_1
CIKey "D4", KeyPress(0xBF), 17 \\VK_OEM_2
} as al Interval 50
Print "ok"
Threads
Thread L Interval 6000
Main.Task 10 {
    Display(mm, kk, mm2, kk1)
    Refresh 1000
    If KeyPress(asc("1")) Then Exit
    If KeyPress(asc("3")) Then org<=14 : dur<=100
    If KeyPress(asc("4")) Then org<=5 : dur<=300
    If KeyPress(asc("5")) Then org<=65 : dur<=5000
    If KeyPress(asc("8")) Then n=1-n
    If KeyPress(asc("9")) Then Thread L Restart
    If KeyPress(asc("0")) Then Thread L Hold
    If KeyPress(32) Then { vol$ <= "V127" } else vol$ <=if$(dur=300->"V100", "V110")
    Print "-----"
}
Threads Erase
Print "End"
Scroll Split 0

Exit
Sub DisplayNoRefresh(p0,y0, p1, y1)
    Clavie(p0, y0, p1, y1, 0, ¬e1$())
    Clavie(p0-p1/2,y0,p1,y1*2/3, -1, ¬e2$())
End Sub
Sub Display(p0,y0, p1, y1)
    Clavie(p0, y0, p1, y1, 0, ¬e1$())
    Clavie(p0-p1/2,y0,p1,y1*2/3, -1, ¬e2$())
    Refresh 1000
End Sub

```

```

Sub Clavie(p0, y0,p1, y1, p3, &n$())
  Link n$() to n()
  p3-!
  Local k=-1, i
  For i=p0 to 9*p1+p0 step p1
    k++
    If n$(k,0)<>"" Then {
      Move i+p3*p1/6, y0
      If p3 Then {
        Fill p1-p3*p1/3-15,y1-15, 7* (1-(voi(n(k,2))>0))+1, 0,1
      } else {
        Fill p1-15,y1-15,15,7* (1-(voi(n(k,2))=0))+1,1
      }
      Move i+p3*p1/6, y0
      Fill @ p1-p3*p1/3,y1,2,1
      Move i+p3*p1/6, y0+y1-gram
      Pen p3*15 { Fill @ p1-p3*p1/3,gram,5,n$(k,n)}
    }
  Next i
End Sub

Sub FillArray()
  Local n,p, n$, k$, no
  Stack New {
    Data "A#2", "A", 1, 1, 2
    Data "B2", "Z", 2, 1, 1
    Data "C3", "X", 3, 2, 1
    Data "C#3", "D", 4, 3, 2
    Data "D3", "C", 5, 3, 1
    Data "D#3", "F", 6, 4, 2
    Data "E3", "V", 7, 4, 1
    Data "F3", "B", 8, 5, 1
    Data "F#3", "H", 9, 6, 2
    Data "G3", "N", 10, 6, 1
    Data "G#3", "J", 11, 7, 2
    Data "A3", "M", 12, 7, 1
    Data "A#3", "K", 13, 8, 2
    Data "B3", ",", 14, 8, 1
    Data "C4", ".", 15, 9, 1
    Data "C#4", ":", 16, 10, 2
    Data "D4", "/", 17, 10, 1
    While Not Empty {
      Read n$, k$, no, n, p
    }
  }

```

```

    If p=1 Then {
        note1$(n-1,0):= n$, k$, no \\ feed a row
    } else {
        note2$(n-1,0):= n$, k$, no
    }
}
}
End Sub

```

## GUI Example using 3D rotating Graphics

This example use a build in MATH object which have many methods, which use multiple values. We use Buffer for values.

```

Set Fast !
smooth on
Rem :
Thread.plan sequential
\\ we can set Thread.plan before any thread created
Rem : Thread.plan concurrent
\\ concurrent execute one by one statements
\\ except those in { }
\\ also from Revision 52 Part {} as variable works fine with it
local counter1, counter2
Title "", 0 ' 0 to hide console
Set FAST !
\\ by api
Structure VecType {
    x As Double
    y As Double
    z As Double
}
\\ Program
Structure Variables {
    vRot1 As VecType
    vRot2 As VecType
    vRot3 As VecType
    vRot4 As VecType
    vBase As VecType
    vAxis As VecType
}
Buffer Clear Var As Variables
\\ utility function
VecAdr=Lambda Var (a$) -> {
    =Var(0,a$)
}

```



```

}
VecOff=Lambda Var, VecType (a$, b$) -> {
  =Var(0, a$, VecType(b$)!)
}
Class cLine {
  X1, Y1, X2, Y2, color
  Module Render {
    ' read Number from stack
    z=Round(Number,4)
    z1=Round(Number, 4)
    If z>=z1 Then {
      Move .X1, .Y1
      Width 3 {Draw to .X2, .Y2, .color}
      Circle Fill #aa33cc, z/40+200
    } Else {
      Move .X2, .Y2
      Circle Fill #aa33cc, z/40+200
      Width 3 {Draw to .X1, .Y1, .color}
    }
  }
}
Class:
  Module cLine (.color){
    If Match("NNNN") Then Read .X1, .Y1, .X2, .Y2
  }
}

```

\\ find address

```

vBase=VecAdr("vBase")
vBase.x=VecOff("vBase", "x")
vBase.y=VecOff("vBase", "y")
vBase.z=VecOff("vBase", "z")
vRot1=VecAdr("vRot1")
vRot1.x=VecOff("vRot1", "x")
vRot1.y=VecOff("vRot1", "y")
vRot1.z=VecOff("vRot1", "z")
vRot2=VecAdr("vRot2")
vRot2.x=VecOff("vRot2", "x")
vRot2.y=VecOff("vRot2", "y")
vRot2.z=VecOff("vRot2", "z")
vRot3=VecAdr("vRot3")
vRot3.x=VecOff("vRot3", "x")
vRot3.y=VecOff("vRot3", "y")
vRot3.z=VecOff("vRot3", "z")
vRot4=VecAdr("vRot4")
vRot4.x=VecOff("vRot4", "x")

```

```

vRot4.y=VecOff("vRot4","y")
vRot4.z=VecOff("vRot4","z")
vAxis=VecAdr("vAxis")
Refresh 100
Declare Alfa Form
With Alfa, "Title", "Demo1", "UseIcon", True, "UseReverse", True ' icon now is in the left
side
Method Alfa,"MakeStandardInfo", 1 ' 1 for English
Def info$, AskRet
Function Alfa.InfoClick {
    Read New X
    If X=0 then
        after 100 {
            Info$={
                This is an example
                of using MATH object
                (included in M2000 Interpreter)
            }
            AskRet=Ask(info$,"About Demo1","", "")
        }
    end if
}
\\ a string to hold static background
screen$=""
disp=False
Inventory Depth
aLine=Each(Depth)
once=False
Function DepthSort() {
    Inventory Queue Depth ' clear Depth, Then make keys As numbers
    Append Depth, Eval(Var, vRot1.z As double):=1, Eval(Var, vRot2.z As
double):=2, Eval(Var, vRot3.z As double):=3
    Sort Depth As number
}
Thread {
    part {
        Method Math, "RotVectMult", 4, vRot1, vAxis, vRot1, dAngle
        Push Eval(Var, vBase.y As double), Eval(Var, vBase.x As double)
        \\ x is in top, y is after x
        Over 2, 2 \\ copy two times from second, so double two top
        Push Eval(Var, vRot4.x As double)+Number : Over 1, 2 \\ copy 2 times top only
        Read Line1.X1, Line2.X1, Line3.X1
    }
}

```

```

Push Eval(Var, vRot4.y As double)+Number : Over 1, 2
Read Line1.Y1, Line2.Y1, Line3.Y1
Over 2, 4 \\ now original 2 values copied 4 times
Line1.X2 = Eval(Var, vRot1.x As double)+Number
Line1.Y2 = Eval(Var, vRot1.y As double)+Number
Line2.X2 = Eval(Var, vRot2.x As double)+Number
Line2.Y2 = Eval(Var, vRot2.y As double)+Number
Line3.X2 = Eval(Var, vRot3.x As double)+Number
Line3.Y2 = Eval(Var, vRot3.y As double)+Number
call local depthsort()
counter1++
if random(20)>1 then exit
Method Math, "Vector", vAxis, .4 -.8*rnd, 1.6, .2-.3*rnd
Method Math, "UnitVect", vAxis
} As once
} As Compute
dim All(1 to 3)
Layer Alfa {
Window 12, 10000, 8000;
Form 40, 20
Line1=cline(#0000FF, scale.x/2, scale.y/2, scale.x/2, scale.y/2-2220 )
Line2=cline(#FF0000, scale.x/2, scale.y/2, scale.x/2-2340, scale.y/2-60 )
Line3=cline(#00FF00, scale.x/2, scale.y/2, scale.x/2-780, scale.y/2-1200 )
All(1)->Line1
All(2)->line2
All(3)->line3
Declare Math Math
Method Math, "Vector", vBase, scale.x/2-1500, scale.y/2+1500, 1500 ' -1000
Method Math, "Vector", vRot1, Line1.X2, Line1.Y2, -1000
Method Math, "Vector", vRot2, Line2.X2, Line2.Y2, -1200
Method Math, "Vector", vRot3, Line3.X2, Line3.Y2, 1700
Method Math, "Vector", vRot4, Line1.X1, Line1.Y1, 0
Method Math, "VecDiffMult", 4, vRot1, vBase, vRot1
Inventory Depth=Eval(Var, vRot1.z As double):=1, Eval(Var, vRot2.z As double):=2,
Eval(Var, vRot3.z As double):=3
Sort Depth As number
Method Math, "Vector", vAxis, -.8, 1.6, .3
Method Math, "UnitVect", vAxis
Rad2Deg =Lambda pdivby180=pi/180 (RadAngle)->RadAngle / pdivby180
dAngle =5
Pen 0
Cls 7

```

```

Gradient 11, 13
Move 0,0
Cursor 0, Height-1
Cls 7, Height-1
Copy scale.x, scale.y to screen$
Cursor 0,Height
together=False
ok1=true
Thread {
    ok1~
} as mm interval 1000/25
tm=0
Thread {
    static internal=1
    Move 0,0
    Copy 0,0 use screen$
    Part {
        tm=timecount
    } as ok1
    Print @(3,3); format$("{0:2:-5}",tm)
    Cursor 0,height-1

    Part {
        Part {
            aLine=Each(Depth)
            push Eval(Var, vRot4.z As double) : Over 1, 2
            while aline {
                pp=all(eval(aLine))
                pp=>render Val(eval$(Depth, aLine^))
            }
            counter2++
        } As disp
        Print Part $(5,Width/4), counter1, counter2,internal, $(7),Str$(Now ,
"hh:mm:ss" )
        Refresh 5000' execute together
    } As together
    internal++
    Profiler
} As PlayThis
}
\\ we set variables outside threads
State=False

```

```

blinking=False
Thread {
    If state Then disp~
} As blink
Thread blink Hold
ExitNow=False
Function Alfa.Unload {
    ExitNow=True
    threads erase
}
Function Alfa.Click {
    State~
    If State Then {
        Thread compute Hold
        Thread blink interval 1000/4
        Thread blink Restart
        blinking=true
    } Else {
        disp=False
        If blinking Then Thread blink Hold : blinking~
        Thread compute Restart
    }
}
if IsWine then
    Thread PlayThis interval 1000/30
else
    Thread PlayThis interval 1000/120
end if
Thread compute interval 10
Wait 200
Method Alfa, "Show"
\\ Change Task.Main with Every
\\ Task.Main is a Thread
\\ ExitNow needed If we have Every in place of Task.Main
Task.Main 50 {
    \\ If counter1>1000 Then Threads Erase : Exit
    If ExitNow Then Exit
}
Threads Erase
Wait 100 \ some delay here
Method Alfa, "CloseNow"
Declare Alfa Nothing

```

Declare Math Nothing  
Print counter1, counter2  
Title "Demo Complete"  
Set Fast ' return to normal

## **GUI Example C# Editor**

A C# editor. We can run the cs programs from editor. We use the color syntax capability of EditBox. Gui have menu and editor. We can choose bright or dark theme for EditBox.

Clear \\ Clear all variables/objects

Flush \\ Empty the stack

```
first$={using System;
        using System.Drawing;
        using System.Windows.Forms;

        class CSharpPendulum
        {
            Form _form;
            Timer _timer;

            double _angle = Math.PI / 2,
                _angleAccel,
                _angleVelocity = 0,
                _dt = 0.1;

            int _length = 50;

            [STAThread]
            static void Main()
            {
                var p = new CSharpPendulum();
            }

            public CSharpPendulum()
            {
                _form = new Form() { Text = "Pendulum - Γιώργος", Width = 400, Height =
200 };
                _timer = new Timer() { Interval = 30 };

                _timer.Tick += delegate(object sender, EventArgs e)
```

```

    {
        int anchorX = (_form.Width / 2) - 12,
            anchorY = _form.Height / 4,
            ballX = anchorX + (int)(Math.Sin(_angle) * _length),
            ballY = anchorY + (int)(Math.Cos(_angle) * _length);

        _angleAccel = -9.81 / _length * Math.Sin(_angle);
        _angleVelocity += _angleAccel * _dt;
        _angle += _angleVelocity * _dt;

        Bitmap dblBuffer = new Bitmap(_form.Width, _form.Height);
        Graphics g = Graphics.FromImage(dblBuffer);
        Graphics f = Graphics.FromHwnd(_form.Handle);

        g.DrawLine(Pens.Black, new Point(anchorX, anchorY), new Point(ballX,
ballY));

        g.FillEllipse(Brushes.Black, anchorX - 3, anchorY - 4, 7, 7);
        g.FillEllipse(Brushes.DarkGoldenrod, ballX - 7, ballY - 7, 14, 14);

        f.Clear(Color.White);
        f.DrawImage(dblBuffer, new Point(0, 0));
    };

    _timer.Start();
    Application.Run(_form);
}
}
}

title$="C# Editor"
typ$="cs"
W$=""
path$=""
Dir User
lookpath$=dir$
Declare Notepad Form
Declare Pad EditText Form Notepad
Declare Inform1 Button Form Notepad
With Inform1, "Caption" as Informe$
Method Inform1, "Colors", 15, #FFA000
With Inform1, "Locked", True
Declare File1 Combobox Form Notepad
Declare Edit1 Combobox Form Notepad

```

```

Declare Run1 Combobox Form NotePad
Declare Help1 Combobox Form NotePad
With File1,"label","File", "listtext" As list$, "list" As list$() '
With Edit1,"label","Edit", "Mark", Color(255,100,0)
With Run1,"label","Run", "Mark", Color(255,100,0)
With Help1,"label","Help", "Mark", Color(255,100,0)

With NotePad, "Title" As Caption$, "Visible" As Visible, "TitleHeight" As tHeight, "Sizable",
True
With NotePad, "Uselcon", True, "UseReverse", True
With Pad, "Text" As Pad.text$, "ShowAlways", True,"NoColor", True,"SelLength" as
SelLength
With Pad, "ColorSet", 1, "linespace", 30, "NoCenterLineEdit", True ' we can toggle value
of NoCenterLineEdit using shift F9
Method Pad, "UserColorSet", false, , -#ff0000
Def TitleStr$(a$)=Ucase$(Left$(a$,1))+Mid$(a$,2)
Filename$=Dir$+"pendulum.cs"

Caption$=TitleStr$(File.Name$(Filename$)) +" - C# Editor"
Title "",0
Method NotePad,"MakeStandardInfo", 1
Method NotePad,"move", 2000, 4000, 8000, 4000
Layer NotePad {Cls #FFA000}
With File1,"MenuStyle", True, "MenuWidth", 3000
With Edit1,"MenuStyle", True, "MenuWidth", 3000,"menuEnabled" as Enabled()
With Run1,"MenuStyle", True, "MenuWidth", 3000,"menuEnabled" as Comp.Enabled()
With Help1,"MenuStyle", True, "MenuWidth", 3000
With File1, "MenuEnabled" As mEnable()
For This {
    mi$="MenuItem" \\ is a temporary variable only for For This Block
    With File1, "MenuGroup", "This"
    Method File1, mi$, "Open", True
    Method File1, mi$, "Save", True
    Method File1, mi$, "" \\ only a line here
    Method File1, "MenuRadio", "txt files", True, False
    Method File1, "MenuRadio", "cs files", True, True

    Method File1, mi$, ""
    Method File1, mi$, "Close", True
    Method File1, mi$, ""
    Method File1, mi$, "Quit", True

```



```
With Edit1, "MenuGroup", "This"  
Method Edit1, mi$, "Cut", False  
Method Edit1, mi$, "Copy", False  
Method Edit1, mi$, "Paste", True  
Method Edit1, mi$, ""  
Method Edit1, mi$, "Less Indent", True  
Method Edit1, mi$, "More Indent", True
```

```
With Run1, "MenuGroup", "This"  
Method Run1, mi$, "Compile test", true  
Method Run1, mi$, "Run test > out", False  
Method Run1, mi$, "Run test", False  
Method Run1, mi$, "Show Out.Txt", False  
Method Run1, mi$, ""  
Method Run1, mi$, "Compile Final", true  
Method Run1, mi$, "Open Cmd.exe", true
```

```
With Help1, "MenuGroup", "This"  
Method Help1, mi$, "About", True  
Method Help1, mi$, ""  
Method Help1, mi$, "Bright Themel", true  
Method Help1, mi$, "Dark Theme", true
```

```
}
```

```
if exist(Filename$) then  
    Document BackUp$  
    Load.Doc BackUp$, filename$  
else  
    Document BackUp$=first$  
end if  
Pad.text$=BackUp$  
Function Notepad.Unload {  
    Read New &Ok  
    After 30 {Call local File1.DbIClick(8) }  
    Ok=True
```

```
}
```

```
Function Notepad.Resize {  
    Layer Notepad { Cls Color(255, 160, 0) ,0}
```

```

With NotePad, "Width" As NP.Width, "Height" As NP.Height, "TitleHeight" As tHeight
tHeight1=tHeight*2
Method File1,"move", twipsX*2, tHeight, twipsX*80, tHeight
Method Edit1,"move", twipsX*2+twipsX*80, tHeight, twipsX*80, tHeight
Method Run1,"move", twipsX*2+twipsX*160, tHeight, twipsX*80, tHeight
Method Help1,"move", twipsX*2+twipsX*240, tHeight, twipsX*160, tHeight
Method Inform1,"move", twipsX*2+twipsX*320, tHeight, twipsX*240, tHeight
If NP.height>1000 Then {
    Method Pad,"move", twipsX*2, tHeight1, NP.Width-twipsX*5, NP.Height-tHeight1-
twipsx*3
    With Pad, "NoWrap" As NoWrap
    If Not NoWrap Then Method Pad,"Resize"
    }
}
Function Edit1.OpenMenu {
    Local X
    X=SelLength>0
    Enabled(0)=X
    Enabled(1)=X
}

Function Edit1.DblClick {
    Read Local Edit1index
    Select Case Edit1index
    Case 0
        {
            Method Pad,"mn1sub"
            Method Pad,"Resize"
        }
    Case 1
        Method Pad,"mn2sub"
    Case 2
        {
            Method Pad, "mn3sub"
            Method Pad,"GetFocus"
            Method Pad,"Resize"
        }
    Case 4
        {
            Method Pad,"PressKey", 9, 1
        }
    Case 5

```

```

    {
        Method Pad,"PressKey", 9, 0
    }
End Select

```

```

}
Function Pad.Inform {
    Read New L, P
    Inform$=format$("{0}-{1}", L,P)
    Method Pad,"Show"
}

```

```

Function Pad.PopUp {
    Read Local X, Y
    Method Pad,"PopUpMenu", "",X , Y
}

```

```

function cs_choose{
    With Pad, "ColorCollection1", lcase$("|abstract|as|base|bool|break|byte|case|catch|
char|checked|class|const|continue|decimal|default|delegate|do|double|else|enum|event|
explicit|extern|false|finally|fixed|float|for|foreach|goto|if|implicit|in|int|interface|internal|is|
lock|long|namespace|new|null|object|operator|out|override|params|private|protected|public|
readonly|ref|return|sbyte|sealed|short|sizeof|stackalloc|static|string|struct|switch|this|throw|
True|try|typeof|uint|ulong|unchecked|unsafe|ushort|using|using|static|virtual|void|volatile|
while|add|alias|ascending|async|await|by|descending|dynamic|equals|from|get|global|
group|into|join|let|nameof|on|orderby|partial|remove|select|set|value|var|when|where|
yield|"), "NoColor", False, "UseCase", True, "ExtraFront", "_", "LineComment2", "",
"CommentSymbols", "[/]/", "ComSymbolsWidth", 2, "CommentLineLight", false,
"MultiLineComment1", "/*", "MultiLineComment2", "*/"
    With Pad, "WordCharLeft", "+-/*^()[];<>:?", "WordCharRight", ".,+-/*^()
[];<>?:", "OtherSymbols", "@", "UseColon", ":",
    With Pad, "StartSymbols", "+-&|*=></,.1234567890()"+chr$(34), "StringSep2", "",
"EnablePairs", True, "linespace", 30
    With Pad, "SearchWords", True, "nowrap", True, "AllowInsertBrackets", True,
"SpaceIndent", 2, "HighlightParagraph", True
    Method Pad, "ReColor"
    Method Pad, "Show"
}

```

```

Function Dark(){ ' 13619071
    With Pad, "ColorSet", 0, "linespace", 60, "SelectionColor", -#FF0000,
"SelectionTextColor", -color(14), "HighLightColor", -Color(60,60,128)
    Method Pad, "Colors", -color(50,50,50),-color(14),,-color(0)
}

```

```

    Method Pad, "Show"
}
Function Bright(){
    With Pad, "ColorSet", 1, "HighLightColor", -Color(225,255,255)
    Method Pad, "UserColorSet",0,,,,,,,,-#FF0000
    With Pad, "ColorSet", -1
    Method Pad, "ColorsReset"
    Method Pad, "ResetSelColors"
    Method Pad, "Show"
}

Function Run1Status() {
    if file.type$(filename$)="cs" then
        Comp.Enabled(0)=True
        Comp.Enabled(1)=False
        Comp.Enabled(2)=False
        Comp.Enabled(5)=True
    else
        Comp.Enabled(0)=False
        Comp.Enabled(1)=False
        Comp.Enabled(2)=False
        Comp.Enabled(5)=False
    end if
}

Function File1.MenuChecked {
Read New RadiolIndex \\ 3 or 4
If RadiolIndex =3 Then {
    After 30 { Static a$="."+File.type$(Filename$), b$=File.name$(Filename$)
    Filename$=File.path$(Filename$)+Left$(b$,Len(b$)-Len(a$))+".txt"
    Caption$=TitleStr$(File.Name$(Filename$)) +" - M2000 Pad"
    typ$="txt"
    Call local Run1Status()
    With Pad, "ColorCollection1", "", "NoColor", True, "UseCase", False
    Pad.text$=Pad.text$
    Method Pad, "Show"
    }
} Else.If RadiolIndex =4 Then {
    After 30 { local a$="."+File.type$(Filename$), b$=File.name$(Filename$)
    Filename$=File.path$(Filename$)+Left$(b$,Len(b$)-Len(a$))+".cs"
    Caption$=TitleStr$(File.Name$(Filename$)) +" - M2000 Pad"
    typ$="cs"
    Call local cs_choose()
}
}

```

```

    Call local Run1Status()
}

}

Function File1.DblClick {
\\ we use functions As subs here
\\ each function and each module have a name (define a namespace)
\\ but here real module name is the File1.DblClick() host module
\\ this is done because is a Gui Event Service Function
\\ and is Call With Local tag (Call Local)
    Read New File1index
    Local cont, cont2, f$, NL$={
    }
    File1index++
    \\ Because we want some jumps..we use On Goto
    \\ on Goto need here a block
    {
        On File1index Goto Open1, Save1, ExitNow, ExitNow, ExitNow, ExitNow, Save2,
ExitNow, Unload
Exitnow:
        Exit
Open1:
        If Pad.text$<>BackUp$ Then {
            If Ask("Save Changes first?",title$, "Yes","No")=1 Then Goto Save1
        }
        Layer NotePad {
            Open.file filename$,, "Load Text (" + typ$ + ") File", typ$
        }

Method Pad, "GetFocus"
Read f$
If f$<>"" Then {
    Filename$=f$
    If Exist(F$) Then {
        Clear BackUp$
        Call Local Run1Status()
        Load.Doc BackUp$, f$

        Caption$=TitleStr$(File.Name$(Filename$)) + " - C# Editor"
        lookpath$=file.path$(Filename$)
        \\ silent means here without refresh

```

```

        With Pad, "SelStartSilent", 0, "SellengthSilent", 0
        Pad.text$=BackUp$
    } Else Pad.text$="": Clear BackUp$
    Method Pad, "ReColor"
}
Exit
Save1:
    Layer NotePad {
        Save.As Filename$,, "Save Text (" + typ$ + ") File", typ$
    }
    If Not cont2 Then Method Pad, "GetFocus"
    Read f$ ' from save.as we get a value
    If f$="" Then Exit
    If Lcase$(File.type$(f$)) <> typ$ Then f$=f$+"."+typ$
    If Exist(f$) Then If Ask(NL$+"Overwrite"+NL$+f$, title$, "Yes", "No") <> 1 Then Exit
    Try ok {
        Clear BackUp$
        BackUp$=Pad.text$
        Save.Doc BackUp$, f$ ' by default 2 - Utf-8
        filename$=f$
        lookpath$=file.path$(Filename$)
        Caption$=TitleStr$(File.Name$(Filename$)) + " - C# Editor"
    }
    If ok Else Beep
    If Not cont Then Exit
Save2:
    cont=True
    If Pad.text$ <> BackUp$ Then {
        If Ask("Save Changes?", title$, "Yes", "No")=1 Then Goto Save1
    }
    Clear BackUp$
    Pad.text$=""
    If Cont2 Then {
        Method NotePad, "CloseNow"
    } Else {
        FileName$=Dir$+"Untitled."+typ$
        Caption$=TitleStr$(File.Name$(Filename$)) + " - C# Editor"
        Method Pad, "Resize"
    }
    Exit
Unload:
    Cont2=True : Goto Save2

```

```

    }
}
function gecsc_folder {
    dir path$(0x24)+"Microsoft.NET\Framework\"
    dir ? dir$, "Choose Framework"
    path$=dir$
    dir user
}

thread {
    informe$=if$((tick mod 4 +1) ->"|", "/", "-", "\")
    If not Comp.Enabled(3) then {
        if exist(dir$+"test.bat") then {
            Informe$="ready to compile"
            Comp.Enabled(3)=True
            Comp.Enabled(0)=True
            Method Pad,"Show"
        }
    } else if exist(lookpath$+"test.exe") then {
        Comp.Enabled(1)=true
        Comp.Enabled(2)=true
        informe$="Compiled"
        thread this hold
    }
}

} as lookEXE interval 1000
thread lookEXE hold
Function Run1.DblClick {
    Read New Run1index
    select case Run1index
    case 0
    {
        Comp.Enabled(0)=False
        Comp.Enabled(1)=False
        Comp.Enabled(2)=False
        Comp.Enabled(3)=False
        Informe$=""
        Call local gecsc_folder()
        if path$="" then Beep:Comp.Enabled(0)=True :exit
        if not exist(path$+"csc.exe") then beep : Comp.Enabled(0)=true : exit
        try {

```

```

        if exist(dir$+"test.bat") then dos "del "+quote$(dir$+"test.bat");
        if exist(dir$+"test.exe") then dos "del "+quote$(dir$+"test.exe");
    }
    local aa$
    Document aa$=Pad.text$
    dir user
    Save.doc aa$, "test.cs", 2 ' for UTF-8 see help

    if instr(aa$, "System.Windows.Forms")>9 then w$="win" else w$=""
    clear aa$
    aa$={setlocal
        set PATH=)+Path$+{;
        set LIB=%WINDIR%\Microsoft.NET\Framework\;
        csc.exe /target:)+w$+{exe /out:test.exe test.cs
        endlocal
    }
    Save.doc aa$, "test.bat", 3 ' Ansi for bat
    after 300 {
        dir user
        dos "cd "+dir$+" && test.bat > out.txt";
        after 200 {

            Thread lookEXE interval 100
            Thread lookEXE Restart
        }
        'Method Pad,"GetFocus"
    }
    after 500 {Comp.Enabled(0)=true}
}
case 1
{
    thread lookEXE Hold
    After 40 {
        if w$="" then
            dos "cd "+dir$+" && test.exe > out.txt";
            Comp.Enabled(3)=True
        else
            win dir$+"test.exe"
        end if
    }
}
case 2

```



```

{
    thread lookEXE Hold
    After 40 {
        if w$="" then
            dos "cd "+dir$+" && test.exe"
            Comp.Enabled(3)=False
        else
            win dir$+"test.exe"
        end if
    }
}
case 3
{
    try {win "out.txt"
        Thread lookEXE hold
    }
    informe$=""
}
case 5
{
    local aa$
    Document aa$
    try {
        Call local gecsc_folder()
        if path$="" then exit
        if not exist(Filename$) then
            Call local File1.DblClick(1)
        else
            Load.doc aa$, Filename$
            if aa$<>Pad.text$ then Call local File1.DblClick(1)
            if instr(aa$,"System.Windows.Forms")>9 then w$="win" else w$=""
            clear aa$
        end if
        aa$={setlocal
            set PATH=)+Path$+{;
            set LIB=%WINDIR%\Microsoft.NET\Framework\;
            csc.exe /target:)+w$+{exe /out:)+quote$(File.Name.only$(Filename$)
+ ".exe")+ " "+quote$(File.Name$(Filename$))+{
            endllocal
        }
        Save.doc aa$, "final.bat", 3
        After 40 {

```

```

        dos "cd "+shortdir$(dir$)+" && final.bat";
    }
}
}
case 6
dos "cd "+quote$(dir$)+" && cls "
end select
}
Function Help1.DbClick {
rem Read New Help1index \\ we get the number without variable
select case Number
case 0
{
    Local A, info$
    Info$={
        This is an example
        of an editor for c#
        written for M2000 Environment
        use F1 to change wrap
    }
    A=Ask(info$,title$,"","")
    Method Pad, "GetFocus"
}
Case 2
Call Local Bright()
Case 3
Call Local Dark()
End Select

}
Function Notepad.InfoClick {
    Read New X
    If X=0 Then Call Local Help1.DbClick(0) ' 0 for first menu item
}
Call Local Notepad.Resize()
\\ open As modal
Title "", 0
Call local cs_choose()
Call Local Bright()
Method NotePad,"Show" , 1
Declare Pad Nothing
Declare NotePad Nothing

```

## ***Example Chess for Two***

A thousand line program (you can find it in info.gsb as chessgame)

```
\\ George Karras, 2019
\\ Chess Example (a big one)
\\ Example Using sprites
\\ Rev. 4
chessfont$="Arial Unicode MS"
Font chessfont$
if not Fontname$="Arial Unicode MS" then
  chessfont$="DejaVu Sans"
end if
Font "Verdana"
Thread.plan sequential
Set Fast
Hide
window 12, window
if random(1, 3)=1 then
window 12, scale.x*random(6,9)/10,scale.y*random(6,9)/10;
end if
form 48,34
def thismode
thismode=mode
global const NoSound = False
Module NothingToMove {
  Layer {Print $(4)," Nothing to move",$(0);}
}
Module Proper {
  Layer {Print $(4)," Wrong color",$(0);}
}
Module Beep {
  Layer {Print $(4)," Not Possible",$(0);}
  if NoSound Else Beep
}
back {
  \\ we use a switch to alter the return code in Input ! variant, when we press Enter key
  \\ normally "-inp" return in Field read only variable 1 when we press enter or down
arrow
  \\ using "+inp" we can get 13 for enter and 1 for down arrow
  Cls 0,0
  font "Times"
```

```

Pen 15
Mode thismode*5
cursor 0,height div 2
Report 2, "Wait...."
refresh 10000
Mode thismode

```

```

set switches "+inp"
Fkey Clear
Escape off
Cls #FFA000,0
Pen 14
bold 1
mode thismode
Def White$="PNBRQK", Black$="pnbrqk", WhiteDisp$="♙♘♗♖♕♔"
Def BlackDisp$="♟♞♝♜♛♚", empty$="12345678", disp$
disp$=WhiteDisp$+BlackDisp$
Def White_♔_file, White_♔_rank, Black_♚_rank, Black_♚_file
Def boolean White_♔_no_roke, Black_♚_no_roke
Def boolean White_no_left_roke, Black_no_left_roke
Def boolean White_no_right_roke, Black_no_right_roke
Def Halfmove_clock, Fullmove_number, threat, Clip$
Dim emptydisp$(1 to 8), BoardSq(1 to 8, 1 to 8)=(,)
Def en_pasant_rank=0, en_pasant_file=0
for i=1 to 8 :emptydisp$(i)=string$(" ",i):next i
Def board$, status$, oldI, color1, color2, C=14
color1=Color(209, 139, 71)
color2=Color(255, 206,158)

```

```

dim line$()
Def flashtime=300
Dim PastGames$(1 to 200)
Def freeSlot=0, cur=0, ok=true, k$, condition$
Def double ip, jp, ip1, jp1, si, sj, getone as boolean
Def st, fig$, tr, mx, my, lx,ly, key=0, mmx,mmy, mmb
Def movelogic as boolean=false, mvx, mvy
sa=(,) : sb=each(sa)
Double
OldI=Italic
Italic 1
Def upperlimit
Cursor 0,0

```

```

Pen 15 {Report 2, "Chess Game for two"}
Italic OldI
Normal
Move ! ' Move graphic cursor to character cursor - Cursor ! the other way
upperlimit=pos.y*1.6
move 0, upperlimit*6/8
Fill scale.x,scale.y-upperlimit*6/8, 3,5,1
Set Fast !
\\ calc based to height
HalfWidth=(scale.y*.65) div 16
def downlimit=0, White as boolean=True, fw
DrawEmptyBoard((scale.x/2-HalfWidth*8),upperlimit, HalfWidth, 15)
fw=HalfWidth*2-60
\\ hold
\\ set new game
\\ -1 for no FEN
def NoFEN(aGame$)=len(aGame$)<>len(filter$(aGame$,"/"))+7
Inventory OnBoard
Const NewGame$="rnbqkbnr/pppppppp/8/8/8/PPPPPPPP/RNBQKBNR w KQkq - 0
1"
Def ThisGame$
\\ CHECK IF A STRING IS IN STACK (SO THIS MAYBE A FEN NOTATION FOR A
STARTING POSITION)
if match("S") then
  For this {
    \\block for temporary definitions
    Local row$( ), i, nok, m
    Read ThisGame$
    row$=piece$(ThisGame$, chr$(13)+chr$(10))
    \\ we drop lines by redim the array (dim also is a "dim preserve")
    while len(row$())>1
      if row$(len(row$())-1)="" then dim row$(len(row$())-1) else exit
    end while
    if len(row$())>0 then
      m=each(row$())
      while m
        if NoFEN(array$(m)) Then nok=true: exit
      end while
    End if
    if nok then Push ThisGame$ : ThisGame$=NewGame$ : exit
    PastGames$=row$()
    Dim PastGames$(1 to 200)
  }

```

```

        freeSlot=len(row$())
        ThisGame$=PastGames$(freeSlot)
    }
else
    ThisGame$=NewGame$
End if

```

```

SetBoard(ThisGame$)
RedrawBoard(True)
sx=scale.x
sy=scale.y-downlimit
move 0,downlimit
fill sx,sy, 5
Layer {
    font "Verdanal"
    mode thismode, sx,sy
    motion center
    motion, downlimit
    Cls 5,0
    Pen 14
}

```

```

Refresh 60
flush
move$=""
refresh

```

\\ ctrl+F1 help

About ! "How to play", 14000,9000,{Give one or more moves in one input line.

Each move has a letter a number a letter and final a number

so:

e2e4 or e2-e4 or e2..e4

(symbols other than aebcdefgh and 123456789 are white space)

move something from e2 to e4, but this

e2e3e7e5

give two moves (so we can paste a number of moves)

before a move a new FEN string compiled and copied to clipboard.

if nothing exist in e2 then we get a beep sound. If a move break a rule then no move happen and we get a beep. If King have a threat then we have to do a proper move to eliminate threat otherwise we get a beep.

We can press enter without giving a move, so we asked for ending the game or not.

If we press Y then a new input start to get a FEN board notation, so we can use ctrl+V to paste the string and pressing enter we get the new board.

\* Castling work automatic. So if rules are ok wen can give a e1c1 for queen side

castling for white king.

- \* En passant works fine

- \* A pawn at last rank turn to Queen

You can call this module passing a FEN string as parameter.

George Karras

}

Thread {

if control\$<>"MAIN" then continue

mmb=mouse

If mmb=0 then continue

mmy=mouse.y : mmx=mouse.x

if mmy>downlimit then

if mmx<scale.x\*.8 then

if mmb=2 then Field New 99 : Input End

else

if mmb=1 then Input End

end if

else if mmy<downlimit and mmy>upperlimit then

Field New if(mmy>((downlimit+upperlimit)/2)->1,-1)

Input End

end if

} as Handler interval 100

Thread Handler Hold

Thread {

if control\$<>"MAIN" then continue

if getone then

move lx, ly

Refresh 100

sprite sprite\$

mx=mouse.x : my=mouse.y : mmb=mouse

sb=each(BoardSq())

St=(.)

While sb

sa=array(sb)

if sa#val(3)-twipsX<=mx and sa#val(5)+twipsX>=mx and sa#val(4)-twipsY<=my and  
sa#val(6)+twipsY>=my then St=sa : exit

End While

if len(st)>0 then

si=st#val(10) : sj=st#val(11)

```

if mmb=0 then
    keyboard chr$(ip+96)+chr$(jp+48)+chr$(si+96)+chr$(sj+48)+chr$(13)
    getone=false: refresh 100 : mouse.icon show
else
    lx=mx : ly=my
    move lx, ly
    if st#val$(8)=" " or (si=ip and sj=jp) then
        sprite fig$, tr
    else
        sprite fig$, tr,-10,,80
    end if
    refresh 100
end if
else if mmb=0 then
    RedrawBoard(?)
    getone=false
    mouse.icon show
    Thread Sp restart
end if
if not getone then Thread this hold
} as pSp interval 1000/30
Thread pSp hold
Thread {
    if control$<>"MAIN" then continue
    if mouse=0 and movelogic then movelogic=false
    if mouse.y<upperlimit then mouse.icon 15 else mouse.icon 1

    if not movelogic then if mouse.y<upperlimit and mouse=1 then movelogic=true:
mvx=mousea.x : mvy=mousea.y:continue
    if movelogic then if mouse=1 then motion motion.wx- mvx+mousea.x, motion.wy-
mvy+mousea.y : continue

    mx=mouse.x : my=mouse.y
    if mouse=1 and my>downlimit then input end : Thread this hold
    if mouse=1 and not getone then{
        move mx, my
        if point=0 or point=#FFFFFF else exit
        sb=each(OnBoard)

        St=(,)
        While sb
            sa=eval(sb)

```



```

if sa#val(3)<mx and sa#val(5)>mx and sa#val(4)<my and sa#val(6)>my then St=sa :
exit
End While
if len(st)=0 then exit
move st#val(3)+30, st#val(4)+30
refresh 1000
tr=point
copy fw, fw to fig$
Image fig$ to fig$, 120, 120
fill fw, fw, tr
move mx, my
lx=mx:ly=my
ip=st#val(10):jp=st#val(11)
sprite fig$, tr
mouse.icon hide
getone=true
Thread pSp restart
Thread this hold
}
} as Sp interval 100
mouse.icon show
isok=true
{
{
if white then
CheckThreat(white, White_♔_file, White_♔_rank, &threat)
else
CheckThreat(white, Black_♚_file, Black_♚_rank, &threat)
end if
if isok then
freeSlot++
GetBoard(&Clip$)
if freeSlot>Len(PastGames$()) then Dim PastGame$(1 to 2*Len(PastGames$
)))
PastGames$(freeSlot)=Clip$
end if
\\test
condition$=if$(White->"White move", "Black move") + if$(threat->" (check)", "")+ if$
(Halfmove_clock>50->"(You can draw)", "")+":"
Layer {
Print Part $(4,5), right$(string$(chr$(8199), 3))+str$

```

```
(Fullmove_number,""),3)+".", $(7,12),condition$,  
}
```

White~

if empty then

Layer {

Pen 15 {Input "",move\$;}

}

\\test !

Thread Sp hold

Thread pSp Hold

mouse.icon 1

getone=false

if move\$="" then

Layer {

wait 100

Refresh 60

profiler

Every 1000/60 {

if timecount>flashtime then

profiler

Cls

Pen C {Double : Report 2,"End this Game ?" : Normal}

C=20-C

Cursor width, Height

Move ! \\ copy character cursor to graphic cursor

Legend "Use Y or Left Mouse Click to exit | Right Mouse Click or N to

continue", FontName\$, Mode\*.7, 0,1, 1,twipsX

end if

k\$=""

if keypress(0x1B) then k\$="Y":exit

if keypress(0x4E) then exit

if keypress(0x59) then k\$="Y":exit

if keypress(1) then k\$="Y": exit

if keypress(2) then exit

}

}

while not inkey\$="" {Wait 1} 'drop key any

If k\$="Y" else

\\ if stack has something then RedrawBoard may use it (because read for

optional variable)

\\ we can be sure we set the optional value using ?

White~ :RedrawBoard(?): Layer {Cls}

getone=false

Thread Sp restart

flush ' make empty true (so stack is empty for sure)

loop ' set a flag for restart at end bracket of current block

end if

else

move\$=lcase\$(move\$)

while len(move\$)>0

select case left\$(move\$,1)

case "1" to "8"

data asc(move\$)-48

case "a" to "h"

data asc(move\$)-96

end select

insert 1,1 move\$=""

end while

end if

isok=false

if not empty then

if stack.size mod 4 = 0 then

try ok {

MakeAmove(&isok)

if not isok then flush : White~: exit

if not empty then

white~: refresh : wait 500 : loop

end if

}

Layer {Print}

getone=false

if isok else RedrawBoard(?)

if ok then loop : Thread Sp restart

else

flush : White~ : loop : Thread Sp restart' loop processed at the end of the

block, so only a flag raised here

end if

end if

}

```

Thread Sp Hold
Thread pSp Hold
cur=freeSlot
Clip$=PastGames$(cur)
Layer {
    if cur=0 then cur=1
    if cur>freeSlot then cur=freeSlot
    if Clip$<>PastGames$(cur) then
        Clip$=PastGames$(cur)
        if len(Clip$)=len(filter$(Clip$,"/"))+7 and trim$(Clip$)<>"" then Back
    {SetBoard(Clip$) :RedrawBoard(?)}
    end if
    Refresh 60
    Cls
    Cursor width, Height
    Move !
    Legend "Right Mouse Click or Esc to Quit | Left Mouse Click right of the FEN to
continue play | About Ctrl+F1", FontName$, Mode*.7, 0,1, 1,twipsX
    Cursor 0,0
    Report 2, "Replay the Game,(arrows u/d) or Start a new one setting a new FEN"
    Print Part $(7,7), "Board FEN: "
    Field New 13
    Thread Handler Restart
    Pen 15 {Input ! Clip$, width-7 len=100}
    Thread Handler Hold
    Report Clip$
    refresh 60
    if field=13 then exit
    if field=-1 then cur-- : loop
    if field=99 then Clip$="": exit
    if field=1 then cur++ : loop
}
if len(Clip$)<>len(filter$(Clip$,"/"))+7 or trim$(Clip$)=" then SaveGame():Layer {Cls} :
exit
if Clip$<>PastGames$(cur) then
    SaveGame()
    PastGames$(1)=Clip$:cur=1
end if
freeSlot=cur
SetBoard(Clip$)
RedrawBoard(?)
Layer {Cls}

```

```

        Thread Sp restart
        Loop
    }
    Cls 0,0
}
hide
threads erase
wait 200
about ""
if module(info) then keyboard "info"+chr$(13)
Flush
set switches "-inp"
escape off
Window 12,0
form
form ;
About ! ""
end
Sub SaveGame()
if freeSlot=1 then exit sub
Local Out$
Document Out$ ' upgrade to Document
layer {
    Cls
    if ask("Copy the game to clipboard?", "Finish", "**Yes", "No")=1 then
        Report "Wait..."
        for i=1 to freeSlot
            Out$+=PastGames$(i)
            if i<freeSlot then
                Out$={
            }
            end if
        next
        Clipboard Out$
        Save.Doc Out$, "LastGame.chess"
        Report "Done..."
        wait 300
    end if
}
end sub
Sub SaveGame1()
local Out$, i

```

Document Out\$ ' upgrade to document

```
layer {  
}
```

End Sub

Sub DrawEmptyBoard(leftmargin, topmargin, squarewidth, labelcolor)

Local a=true, z=bold : bold 0

Local l=squarewidth, k=2\*l, k1=k\*.85, N1=6, N=6, M=4, B=k\*8, B1

Local d=0, im=0, jm=0

Repeat

N=N1

N1+=.25

Until K1<size.Y("A",chessfont\$, N1)

topmargin-=l

leftmargin-=l

move leftmargin+l,topmargin+l

B1=(l div 300)\*twipsX

step -B1,-B1

B+=B1\*2

Pen 0 {

Width b1 div 2+1 {

color color1 , 1{Polygon 0, B, 0, 0, B, -B, 0, 0, -B}

}

M=N\*.65

For i=1 to 9

d=leftmargin

move d, topmargin

if i<9 then

step 0, k

Pen labelcolor{Legend str\$(9-i,""), chessfont\$, M,0,2}

step 0, -k

else

N=M

end if

for j=1 to 8

If i<9 then

step l, l

color color1,1 {fill k,k, if(a->color1,color2)}

step -l, -l

BoardSq(j, 9-i)=(N, pos.x, pos.y, pos.x-l+twipsX, pos.y-l+twipsX, pos.x+l-twipsX,  
pos.y+l-twipsX, k-twipsX\*2, " ", a, j,9-i)

a~

else

```

        step k, k
        pen labelcolor {
            Legend mid$("abcdefgh",j,1), chessfont$, N, 0, 2
        }
    end If
    d+=k
    move d, topmargin
next
a~ : topmargin+=k
next
}
bold z
downlimit=topmargin+500
end sub
Sub MakeAMove( &ok, i, j, i1, j1)
Local z=bold, p$, p1$ : bold 0
Local t,t1, N=BoardSq(1,1)#val(0), again as boolean, playroke as boolean
ok=false
Local rule=true, threat as boolean
refresh 10000
Pen 0 {
    again=false
    t=BoardSq(i,j)
    t1=BoardSq(i1, j1)
    p$=t#val$(8)
    p1$=t1#val$(8)
    if p$="" then NothingToMove : exit
    if t is t1 then NothingToMove : exit
    if p1$<>" " then if p1$<"♙" and p$<"♙" then Proper : exit
    if p1$<>" " then if p1$>"♙" and p$>"♙" then Proper : exit
    \\ white change logic here
    if not white and instr(WhiteDisp$, p$)=0 then Proper : exit
    if white and instr(BlackDisp$, p$)=0 then Proper :exit
    select case p$
    case "♙"
    {
        If not White_♙_no_roke then
            CheckThreat(not white, White_♙_file, White_♙_rank, &threat)
            if not threat then
                if i1=3 and j1=1 then
                    if p1$="" and BoardSq(2,1)#val$(8)="" and BoardSq(4,1)#val$(8)="" and not
White_no_left_roke then

```

```

        CheckThreat(not white, 4, 1, &threat)
        if not threat then push 1, 4, 1, 1 : again=true : playroke=true
    end if
else if i1=7 and j1=1 then
    if p1$=" " and BoardSq(6,1)#val$(8)=" " and not White_no_right_roke then
        CheckThreat(not white, 6, 1, &threat)
        if not threat then push 1, 6, 1, 8 : again=true : playroke=true
    end if
end if
end if
end if
if not playroke Then
    if abs(i-i1)>1 then rule=false: exit
    if abs(j-j1)>1 then rule=false: exit
    White_♔_no_roke=true
    White_no_right_roke=True
    White_no_left_roke=true
end if
CheckKing()
if threat then
    rule=false
    if playroke then drop 4
else
    White_♔_rank=j1
    White_♔_file=i1
end if
}
case "♔"
{
    If not Black_♔_no_roke then
        CheckThreat(not white, Black_♔_file, Black_♔_rank, &threat)
        if not threat then
            if i1=3 and j1=8 then
                if p1$=" " and BoardSq(2,8)#val$(8)=" " and BoardSq(4,8)#val$(8)=" " and not
Black_no_left_roke then
                    CheckThreat(not white, 4, 8, &threat)
                    if not threat then push 8, 4, 8, 1 : again=true : playroke=true
                end if
            else if i1=7 and j1=8 then
                if p1$=" " and BoardSq(6,8)#val$(8)=" " and not Black_no_right_roke then
                    CheckThreat(not white, 6, 8, &threat)
                    if not threat then push 8, 6, 8, 8 : again=true : playroke=true
                end if
            end if
        end if
    end if
}

```



```

        end if
    end if
end if
if not playroke Then
    if abs(i-i1)>1 then rule=false: exit
    if abs(j-j1)>1 then rule=false: exit
    Black_♔_no_roke=true
    Black_no_right_roke=true
    Black_no_left_roke=true
end if
CheckKing()
if threat then
    rule=false
    if playroke then drop 4
else
    Black_♔_rank=j1
    Black_♔_file=i1
end if
}
case "♚", "♛"
{
    if i1<>i and j1<>j then
        if abs(i1-i)<>abs(j1-j) then rule=false: exit
        jm=0
        if abs(i1-i)>1 then
            jm=j+sgn(j1-j)
            for im=i+sgn(i1-i) to i1-sgn(i1-i)
                if BoardSq(im,jm)#val$(8)<>" " then jm=-1: exit for
                jm+=sgn(j1-j)
            next
        end if
    else
        jm=0:im=0
        if abs(i1-i)>1 then
            for im=i+sgn(i1-i) to i1-sgn(i1-i)
                if BoardSq(im,j)#val$(8)<>" " then jm=-1: exit for
            next
        else if abs(j1-j)>1 then
            for jm=j+sgn(j1-j) to j1-sgn(j1-j)
                if BoardSq(i,jm)#val$(8)<>" " then im=-1: exit for
            next
        end if
    end if
}

```

```

    end if
    if im=-1 or jm=-1 then rule=false:exit
    end if
    CheckIt()
}
case " ♖ "
{
    If playroke then Black_no_right_roke=true : Black_no_left_roke=true :
Black_♖_no_roke=True : exit
    if i1<>i and j1<>j then rule=false: exit
    jm=0:im=0
    if abs(i1-i)>1 then
        for im=i+sgn(i1-i) to i1-sgn(i1-i)
            if BoardSq(im,j)#val$(8)<>" " then jm=-1: exit for
        next
    else.if abs(j1-j)>1 then
        for jm=j+sgn(j1-j) to j1-sgn(j1-j)
            if BoardSq(i,jm)#val$(8)<>" " then im=-1 :exit for
        next
    end if
    if im=-1 or jm=-1 then rule=false:exit
    CheckIt()
    if not rule then exit
    if i=1 and j=8 then Black_no_left_roke=true
    if i=8 and j=8 then Black_no_right_roke=true
}
case " ♗ "
{
    If playroke then White_no_right_roke=true : White_no_left_roke=true :
White_♗_no_roke=True : exit
    if i1<>i and j1<>j then rule=false: exit
    jm=0:im=0
    if abs(i1-i)>1 then
        for im=i+sgn(i1-i) to i1-sgn(i1-i)
            if BoardSq(im,j)#val$(8)<>" " then jm=-1: exit for
        next
    else.if abs(j1-j)>1 then
        for jm=j+sgn(j1-j) to j1-sgn(j1-j)
            if BoardSq(i,jm)#val$(8)<>" " then im=-1 :exit for
        next
    end if
    if im=-1 or jm=-1 then rule=false:exit

```

```

CheckIt()
if not rule then exit
if i=1 and j=1 then White_no_left_roke=true
if i=8 and j=1 then White_no_right_roke=true
}
case "♙", "♚"
{
if i1=i or j1=j then rule=false: exit
if abs(i1-i)<>abs(j1-j) then rule=false: exit
jm=0
if abs(i1-i)>1 then
jm=j+sgn(j1-j)
for im=i+sgn(i1-i) to i1-sgn(i1-i)
if BoardSq(im,jm)#val$(8)<>" " then jm=-1: exit for
jm+=sgn(j1-j)
next
end if
if jm=-1 then rule=false:exit
CheckIt()
}
case "♖", "♗"
{
if abs(i1-i)=abs(j1-j) then rule=false: exit
if abs(i1-i)=0 or abs(j1-j)=0 then rule=false: exit
if abs(i1-i)+abs(j1-j)<>3 then rule=false: exit
CheckIt()
}
case "♝"
{
if j1<=j then rule=false:exit
if i<>i1 then if i1<i-1 or i1>i+1 then rule=false: exit
if j>2 then if j1>j+1 then rule=false:exit
if j=2 and j1>j+2 then rule=false:exit
if i=i1 and p1$<>" " then rule=false:exit
if i<>i1 and p1$=" "and not (en_passant_file=i1 and en_passant_rank=j1-1) then
rule=false:exit
if i<>i1 and j1>j+1 then rule=false: exit
if en_passant_file=i1 and en_passant_rank=j1-1 then
CheckIt2()
else
CheckIt()
End if

```

```

en_passant_file=0
en_passant_rank=0
if j1=8 then p$="♔" else if j1=j+2 then en_passant_file=i1:en_passant_rank=j1
}
case " ♚ "
{
  if j1>=j then rule=false:exit
  if i<>i1 then if i1<i-1 or i1>i+1 then rule=false: exit
  if j<7 then if j1<j-1 then rule=false:exit
  if j=7 and j1<j-2 then rule=false:exit
  if i=i1 and p1$<>" " then rule=false:exit
  if i<>i1 and p1$=" " and not (en_passant_file=i1 and en_passant_rank=j1+1) then
rule=false:exit
  if i<>i1 and j1<j-1 then rule=false:exit
  if en_passant_file=i1 and en_passant_rank=j1+1 then
    Checkit2()
  else
    Checkit()
  End if
  en_passant_file=0
  en_passant_rank=0
  if j1=1 then p$="♚" else if j1=j-2 then en_passant_file=i1:en_passant_rank=j1
}
end select
If not rule then beep : exit
move t#val(3), t#val(4)
return t, 8:=" "
delete OnBoard, i*9+j
if t#val(9) then fill t#val(7), t#val(7),color1 else fill t#val(7), t#val(7), color2

t=t1
move t#val(3), t#val(4)
fill t#val(7), t#val(7),15
if p1$<>" " then
  Halfmove_clock=0
  Return OnBoard, i1*9+j1:=t
else
  Halfmove_clock++
  Append OnBoard, i1*9+j1:=t
end if
return t, 8:=p$
move t#val(1), t#val(2): Legend p$, chessfont$, N, 0, 2,0

```

```

move t#val(3)+twipsx*2, t#val(4)+twipsy*2
if t#val(9) then floodfill ,,color1 else floodfill , , color2
if again then read i, j, i1, j1 : Restart
if p$<>" ♔ " and p$<>" ♚ " then en_passant_file=0 : en_passant_rank=0
if white then Fullmove_number++
Ok=true
}
bold z
refresh 10000
end Sub

```

```

Sub RedrawBoard(NoRefresh as boolean=False)
Local z=bold, p$ : bold 0
Local t, N=BoardSq(1,1)#val(0)
If NoRefresh Else refresh 10000
Pen 0 {
  For j=1 to 8
    For i=1 to 8
      t=BoardSq(i,j)
      move t#val(3), t#val(4)
      fill t#val(7), t#val(7),15
      p$=t#val$(8)

      if p$=" " else move t#val(1), t#val(2): Legend p$, chessfont$, N, 0, 2,0
      move t#val(3)+twipsx*2, t#val(4)+twipsy*2
      if t#val(9) then floodfill ,,color1 else floodfill , , color2
    Next
  Next
}
bold z
If NoRefresh Else refresh 60
end Sub
Sub GetBoard(&chessboard$)
chessboard$=""
local i, j,a$, spc, line$
for j=8 to 1
line$=""
for i=1 to 8
a$=BoardSq(i,j)#val$(8)
if a$<>" " then
if spc>0 then line$+=str$(spc,""): spc=0

```

```

line$+=mid$("PNBRQKpnbrqk", instr("♙♘♗♖♕♔♓♒♑♐♏♎♍", a$),1)
else
spc++
end if
next
if spc>0 then line$+=str$(spc,""): spc=0
if j>1 then chessboard$+=line$+ "/" else chessboard$+=line$+" "
next
if white then chessboard$+="w " else chessboard$+="b "
if White_♔_no_roke and Black_♚_no_roke then
chessboard$+="-"
else
if White_no_right_roke else chessboard$+="K"
if White_no_left_roke else chessboard$+="Q"
if Black_no_right_roke else chessboard$+="k"
if Black_no_left_roke else chessboard$+="q"
end if
if not en_passant_file=0 then
chessboard$+="- "+chr$(96+en_passant_file)+chr$(48+en_passant_rank)
else
chessboard$+="- "
end if
chessboard$+=str$(Halfmove_clock)
chessboard$+=str$(Fullmove_number)
End Sub
Sub SetBoard(chessboard$)
Rem https://en.wikipedia.org/wiki/Forsyth-Edwards\_Notation
Clear OnBoard
board$=leftpart$(chessboard$, " ")
if len(filter$(board$, "K"))<>len(board$)-1 Then Error "Problem with White King"
if len(filter$(board$, "k"))<>len(board$)-1 Then Error "Problem with Black King"
status$=ltrim$(rightpart$(chessboard$, " "))
white=left$(status$,1)="w"
status$=ltrim$(mid$(status$,2))
if left$(status$,1)="-" then
White_no_right_roke=True
White_no_left_roke=True
White_♔_no_roke =True
Black_no_right_roke=True
Black_no_left_roke=True
Black_♚_no_roke=True

```

```

    status$=ltrim$(mid$(status$,2))
else
    local L=len(status$)
    status$=filter$(status$,"K")
    White_no_right_roke= len(status$)=L
    L=len(status$) : status$=filter$(status$,"Q")
    White_no_left_roke= len(status$)=L
    White_♔_no_roke = White_no_right_roke and White_no_left_roke
    L=len(status$) : status$=filter$(status$,"k")
    Black_no_right_roke= len(status$)=L
    L=len(status$) : status$=filter$(status$,"q")
    Black_no_left_roke= len(status$)=L
    Black_♚_no_roke=Black_no_right_roke and Black_no_left_roke
    status$=ltrim$(status$)

End if
if left$(status$,1)="-" then
    en_passant_file=0
    en_passant_rank=0
    status$=mid$(status$,2)
else
    en_passant_file=Asc(left$(status$,1))-96
    en_passant_rank=Asc(Mid$(status$,2,1))-48
    if en_passant_rank=3 then en_passant_rank=4 else en_passant_rank=5
    status$=mid$(status$,3)
end if
Local m
Halfmove_clock=val(status$, "int", &m)
status$=mid$(status$,m)
Fullmove_number=max.data(val(status$, "int", &m), 1)
nl$={
}
for i=1 to 6
    board$=replace$(mid$(White$,i,1),mid$(WhiteDisp$,i,1), board$)
    board$=replace$(mid$(Black$,i,1),mid$(BlackDisp$,i,1), board$)
next
for j=1 to 8
    board$=replace$(str$(j,""),emptydisp$(j), board$)
next
line$=piece$(board$,"/")
local t
dim line$(1 to 8)

```

```

For j=1 to 8: For i=1 to 8
    t=BoardSq(i,j)
    return t, 8:=mid$(line$(9-j), i, 1)
    if t#val$(8)<>" " then Append OnBoard, i*9+j:=t
    if t#val$(8)="♔" then
        White_♔_rank=j
        White_♔_file=i
        if i<>5 and j<>1 then White_♔_no_roke=True : White_no_left_roke=true :
White_no_right_roke=true
    else if t#val$(8)="♚" then
        Black_♚_rank=j
        Black_♚_file=i
        if i<>5 and j<>8 then Black_♚_no_roke=True: Black_no_left_roke=true :
Black_no_right_roke=true
    end if
next : next
end Sub
Sub CheckIt()
    return t, 8:=""
    return t1, 8:=p$
    if not white then
        CheckThreat(not white, White_♔_file, White_♔_rank, &threat)
    else
        CheckThreat(not white, Black_♚_file, Black_♚_rank, &threat)
    end if
    if threat then rule=false
    return t, 8:=p$
    return t1, 8:=p1$
end Sub
Sub CheckIt2()
    return t, 8:=""
    return t1, 8:=p$
    local t2=BoardSq(en_passant_file, en_passant_rank)
    local p2$=t2#val$(8)
    return t2, 8:=""
    if not white then
        CheckThreat(not white, White_♔_file, White_♔_rank, &threat)
    else
        CheckThreat(not white, Black_♚_file, Black_♚_rank, &threat)
    end if
    if threat then rule=false
    return t, 8:=p$

```



```

return t1, 8:=p1$
if threat then
    return t2, 6:=p2$
else
    move t2#val(3), t2#val(4)
    if t2#val(9) then
        fill t2#val(7), t2#val(7),color1
    else
        fill t2#val(7), t2#val(7), color2
    end if
    Halfmove_clock--1
end if

```

end Sub

```

Sub CheckKing()
    return t, 8:=" "
    return t1, 8:=p$
    CheckThreat(not white, i1, j1,&threat)
    if threat then rule=false
    return t, 8:=p$
    return t1, 8:=p1$

```

end Sub

```

Sub CheckThreat(White as boolean, c, c1, &Yes)

```

```

local i=1, i1=8, j=1, j1=8, k=c, k1=c1

```

```

if white then

```

```

    local oKin$="♔",hor$="♖♗", dia$="♘♙", Kni$="♚"

```

```

else

```

```

    local oKin$="♚",hor$="♜♞", dia$="♟♞", Kni$="♝"

```

```

end if

```

```

' WhiteDisp$="♙♘♗♖♔"

```

```

' BlackDisp$="♙♘♗♖♔"

```

```

Yes=false

```

```

if c1<7 and white then

```

```

    if c>1 then

```

```

        if BoardSq(c-1, c1+1)#val$(8)="♙" then Yes=True :exit sub

```

```

    end if

```

```

    if c<8 then

```

```

        if BoardSq(c+1, c1+1)#val$(8)="♙" then Yes=True :exit sub

```

```

    end if

```

```

else if c1>1 and not white then

```

```

    if c>1 then

```

```

    if BoardSq(c-1, c1-1)#val$(8)="  " then Yes=True :exit sub
end if
if c<8 then
    if BoardSq(c+1, c1-1)#val$(8)="  " then Yes=True :exit sub
end if
end if
for k=max.data(c-1, 1) to min.data(c+1, 8)
for k1=max.data(c1-1, 1) to min.data(c1+1, 8)
if k1=c1 and k=c else if BoardSq(k, k1)#val$(8) =oKin$ then Yes=True : Exit Sub
next
next
for k=c to i
    if Instr(hor$,BoardSq(k,c1)#val$(8))>0 then Yes=True :exit sub
    if k<>c then if Instr(disps$,BoardSq(k,c1)#val$(8))>0 then exit for
next
if c>1 and c1<8 then {
k1=c1+1
for k=c-1 to i \\ look up left
    if Instr(Dia$,BoardSq(k,k1)#val$(8))>0 then Yes=True :exit sub
    if k<>c then if Instr(disps$,BoardSq(k,k1)#val$(8))>0 then exit for
    K1++
    if k1>8 then exit for
next
}
for k=c to i1
    if Instr(hor$,BoardSq(k,c1)#val$(8))>0 then Yes=True :exit sub
    if k<>c then if Instr(disps$,BoardSq(k,c1)#val$(8))>0 then exit for
next
if c<i1 and c1>1 then {
k1=c1-1
for k=c+1 to i1 \\ look down right
    if Instr(Dia$,BoardSq(k,k1)#val$(8))>0 then Yes=True :exit sub
    if Instr(disps$,BoardSq(k,k1)#val$(8))>0 then exit for
    K1--
    if k1<1 then exit for
next
}
for k1=c1 to j
    if Instr(hor$,BoardSq(c,k1)#val$(8))>0 then Yes=True :exit sub
    if k1<>c1 then if Instr(disps$,BoardSq(c,k1)#val$(8))>0 then exit for
next
if c1>j and c>1 then {

```

```

k=c-1
for k1=c1-1 to j \\ look down left
    if Instr(Dia$,BoardSq(k,k1)#val$(8))>0 then Yes=True :exit sub
    if Instr(disps$,BoardSq(k,k1)#val$(8))>0 then exit for
    k--
    if k<1 then exit for
next
}
for k1=c1 to j1
    if Instr(hor$,BoardSq(c,k1)#val$(8))>0 then Yes=True :exit sub
    if k1<>c1 then if Instr(disps$,BoardSq(c,k1)#val$(8))>0 then exit for
next
if c1<j1 and c<8 then {
k=c+1
for k1=c1+1 to j1 \\ look up right
    if Instr(Dia$,BoardSq(k,k1)#val$(8))>0 then Yes=True :exit sub
    if Instr(disps$,BoardSq(k,k1)#val$(8))>0 then exit for
    k++
    if k>8 then exit for
next
}
rem test "here"
for k=max.data(c-2,i) to min.data(c+2, i1)
    for k1=max.data(c1-2,j) to min.data(c1+2, j1)
        if Abs(k-c)+Abs(k1-c1)=3 then if BoardSq(k,k1)#val$(8)=Kni$ then Yes=True :exit sub
    next
next
end Sub

```



# Appendix I

For the examples in [Handle of Png File](#)

\\ test.png

Binary {

```
iVBORw0KGgoAAAANSUHeUgAAAIAAACWCAYAAAA16tGYAAAAABmJLR0QAAAAAAAD5
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```

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} As Png4

\\ you can use it as Png4 or you can export to file

Open "test.png" for output as #k

Put #k, Png4

Close #k

# Appendix II

Help All show the following list. Most of them are identifiers and some of them are information (like Formating or Auto\_Arrays)

## **INTERPRETER**

ABOUT, AND, CLEAR, CLIPBOARD, DIV, DIV#, DOS, EDIT, END, FAST, FKEY, HELP, IS, KEYBOARD, LIST, LOAD, MOD, MOD#, MONITOR, NEW, OPERATORS, OR, PROTOTYPE, RECURSION.LIMIT, REM, REMOVE, SAVE, SCRIPT, SLOW, SORT, START, SWITCHES, TEST, VERSION, WIN, WRITER

## **MODULE COMMANDS**

ERROR, ESCAPE, FUNCTION, HALT, INLINE, LINK, MODULE, MODULES, PIPE, STOP, SUB, THREAD, THREADS, USE

## **FLOW CONTROL**

AFTER, BREAK, CALL, CASE, CONTINUE, DO, ELSE, ELSE.IF, EVERY, EXIT, FOR, GOSUB, GOTO, IF, LOOP, MAIN.TASK, ON, PART, PROFILER, REPEAT, RESTART, SELECT, THEN, THREAD.PLAN, TRY, UNTIL, WAIT, WHILE

## **STACK COMMANDS**

COMMIT, DATA, DROP, FLUSH, OVER, PUSH, READ, REFER, SHIFT, SHIFTBACK, STACK

## **DEFINITIONS**

AUTO\_ARRAYS, BINARY, BUFFER, CLASS, CONST, DECLARE, DEF, DIM, DOCUMENT, ENUM, ENUMERATION, EVENT, GLOBAL, GROUP, INVENTORY, LAMBDA, LET, LOCAL, LONG, METHOD, PROPERTY, SET, STATIC, STOCK, SUPERCLASS, SWAP, WITH

## **DOCUMENTS**

APPEND.DOC, EDIT.DOC, FIND, INSERT, LOAD.DOC, MERGE.DOC, OVERWRITE, SAVE.DOC, SORT(DOCUMENT), WORDS

## **FILE OPERATIONS**

BITMAPS, CLOSE, DRAWINGS, FILES, GET, LINE INPUT, MOVIES, NAME, OPEN, PUT, SEEK, SOUNDS, WRITE

## **CONSOLE COMMANDS**

BACK, BACKGROUND, BOLD, CHARSET, CLS, CURSOR, DESKTOP, DOUBLE, FIELD, FONT, FORM, FRAME, GRADIENT, GREEK, HIDE, HOLD, ICON, ITALIC, LATIN, LAYER, LEGEND, LINESPACE, LOCALE, MARK, MODE, MOTION, MOTION.W, NORMAL, PEN, REFRESH, RELEASE, REPORT, SCROLL, SHOW, WINDOW

## **SCREEN & FILES**

?, HEX, INPUT, PRINT

## **OPERATORS IN PRINT**

\$(), @(), ~()

## **TARGET & MENU**

CHANGE, MENU, SCAN, TARGET, TARGETS

## **DRAWING 2D**

CIRCLE, COLOR, CURVE, DRAW, FILL, FLOODFILL, MOVE, POLYGON, PSET, SMOOTH, STEP, WIDTH

## **BITMAP COMMANDS**

COPY, IMAGE, PLAYER, SPRITE

## **DATABASES**

APPEND, BASE, COMPRESS, DB.PROVIDER, DB.USER, DELETE, EXECUTE, ORDER, RETRIEVE, RETURN, SEARCH, STRUCTURE, TABLE, VIEW

## **SOUNDS AND MOVIES**

BEEP, CHOOSE.ORGAN, MOVIE, MEDIA, MUSIC, PLAY, SCORE, SOUND, SPEECH, TONE, TUNE, VOLUME

## **MOUSE COMMANDS**

JOYPAD, MOUSE.ICON

## **BROWSER COMMANDS**

BROWSER, TEXT, HTML

## **COMMON DIALOGUES**

CHOOSE.COLOR, CHOOSE.FONT, DIR, OPEN.FILE, OPEN.IMAGE, SAVE.AS, SETTINGS, SUBDIR, TITLE

## **ARITHMETIC FUNCTIONS**

#EVAL(), #FILTER(), #FOLD(), #MAP(), #MAX(), #MIN(), #POS(), #REV(), #SLICE(), #SORT(), #SUM(), #VAL(), ABS(), ARRAY(), ASC(), ASK(), ATN(), BACKWARD(), BANK(), BINARY.ADD(), BINARY.AND(), BINARY.NEG(), BINARY.NOT(), BINARY.OR(), BINARY.ROTATE(), BINARY.SHIFT(), BINARY.XOR(), BUFFER(), CAR(), CDATE(), CDR(), CEIL(), CHRCODE(), COLLIDE(), COLOR(), COMPARE(), CONS(), COS(), CTIME(), DATE(), DIMENSION(), DOC.LEN(), DOC.PAR(), DOC.UNIQUE.WORDS(), DOC.WORDS(), DRIVE.SERIAL(), EACH(), EOF(), EVAL(), EXIST(), EXIST.DIR(), FILE.STAMP(), FILELEN(), FLOOR(), FORWARD(), FRAC(), FREQUENCY(), FUNCTION(), GROUP(), GROUP.COUNT(), HIGHWORD(), HILOWWORD(), HSL(), IF(), IMAGE(), IMAGE.X(), IMAGE.X.PIXELS(), IMAGE.Y(), IMAGE.Y.PIXELS(), INKEY(), INSTR(), INT(), JOYPAD(), JOYPAD.ANALOG.X(), JOYPAD.ANALOG.Y(), JOYPAD.DIRECTION(), KEYPRESS(), LEN(), LEN.DISP(), LN(), LOCALE(), LOG(), LOWWORD(), MATCH(), MAX(), MAX.DATA(), MDB(), MIN(), MIN.DATA(), MODULE(), NOT(), NOT\_2, ORDER(), PARAGRAPH(), PARAGRAPH.INDEX(), PARAM(), POINT(), POINTER(), PROPERTY(), RANDOM(), READY(), RECORDS(), RINSTR(), ROUND(),

SEEK(, SGN(, SIN(, SINT(, SIZE.X(, SIZE.Y(, SQRT(, STACK(, STACKITEM(, TAB(, TAN(, TEST(, TIME(, UINT(, USGN(, VAL(, VALID(, WRITABLE(

### **STRING FUNCTIONS**

#EVAL\$(, #FOLD\$(, #MAX\$(, #MIN\$(, #VAL\$(, ADD.LICENSE\$(, ARRAY\$(, ASK\$(, BMP\$(, CHR\$(, CHRCODE\$(, DATE\$(, DRIVE\$(, DRW\$(, ENVELOPE\$(, EVAL\$(, FIELD\$(, FILE\$(, FILE.APP\$(, FILE.NAME\$(, FILE.NAME.ONLY\$(, FILE.PATH\$(, FILE.TITLE\$(, FILE.TYPE\$(, FILTER\$(, FORMAT\$(, FUNCTION\$(, GROUP\$(, HEX\$(, HIDE\$(, IF\$(, INPUT\$(, JPG\$(, LAZY\$(, LCASE\$(, LEFT\$(, LEFTPART\$(, LOCALE\$(, LTRIM\$(, MAX.DATA\$(, MEMBER\$(, MEMBER.TYPE\$(, MENU\$(, MID\$(, MIN.DATA\$(, PARAGRAPH\$(, PARAM\$(, PATH\$(, PIECE\$(, PIPENAMES\$(, PROPERTY\$(, QUOTE\$(, REPLACE\$(, RIGHT\$(, RIGHTPART\$(, RTRIM\$(, SHORTDIR\$(, SHOW\$(, SND\$(, SPEECH\$(, STACK\$(, STACKITEM\$(, STACKTYPE\$(, STR\$(, STRING\$(, STRREV\$(, TIME\$(, TITLE\$(, TRIM\$(, TYPE\$(, UCASE\$(, UNION.DATA\$(, WEAK\$(

### **VARS READ ONLY**

ABOUT\$, APPDIR\$, BROWSER\$, CLIPBOARD\$, CLIPBOARD.IMAGE\$, CODEPAGE, COLORS, COMMAND\$, COMPUTER\$, CONTROL\$, DIR\$, DURATION, EMPTY, ERROR\$, FIELD\_as variable, FONTNAME\$, GRABFRAME\$, GREEK\_variable, HEIGHT, HWND, INKEY\$, INTERNET, INTERNET\$, ISLET, ISNUM, KEY\$, LAN\$, LETTER\$, MEMORY, MENU.VISIBLE, MENU\_as variable, MENUITEMS, MODE\_variable, MODULE\$, MONITOR.STACK, MONITOR.STACK.SIZE, MOTION.WX, MOTION.WY, MOTION.X, MOTION.XW, MOTION.Y, MOTION.YW, MOUSE, MOUSE.KEY, MOUSE.X, MOUSE.Y, MOUSEA.X, MOUSEA.Y, MOVIE.COUNTER, MOVIE.DEVICE\$, MOVIE.ERROR\$, MOVIE.STATUS\$, MOVIE\_as variable, MUSIC.COUNTER, NOW, NUMBER, OS\$, OSBIT, PARAMETERS\$, PEN\_variable, PLATFORM\$, PLAYSORE, POINT, POS, POS.X, POS.Y, PRINTERNAME\$, PROPERTIES\$, REPORTLINES, RND, ROW, SCALE.X, SCALE.Y, SPEECH as variable, SPRITE\$, STACK.SIZE, TAB, TEMPNAME\$, TEMPORARY\$, THIS, THREADS\$, TICK, TIMECOUNT, TODAY, TWIPX, TWIPSY, USER.NAME\$, VOLUME\_as variable, WIDTH\_as variable, X.TWIPS, Y.TWIPS

### **CONSTANTS**

ASCENDING, BINARY\_const, BOOLEAN, BYTE, CURRENCY, DATEFIELD, DESCENDING, DOUBLE\_as constant, FALSE, FALSE \_2, FORMATING\_ANY TYPE, FORMATING\_DATE AND TIME, FORMATING\_NUMBERS, FORMATING\_STRINGS, INFINITY, INTEGER, ISWINE, LONG\_TYPE, MEMO, PI, SINGLE, TEXT\_as constant, TRUE, TRUE \_2, VERSION\_as constant

### **PRINTINGS**

PAGE, PRINTER, PRINTING, PROPERTIES



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