

Office Automation with Dyalog

Combining Excel, Word and other Tools with Dyalog Applications

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Terminology and TLAs

We will explore how APL can interact with and use some of these technologies:

OLE - Object Linking and Embedding & OLE Automation	<p>sharing the properties and methods of applications by combining and exposing objects within a standard framework (eg. document)</p> <p>(<i>Wikipedia:</i>) the formal interprocess communication mechanism based on COM. It provides an infrastructure whereby applications can access and manipulate (i.e. set properties of, or call methods on) shared automation objects that are exported by other applications. It supersedes DDE. The OLE Automation controller is the "client" and the application exporting the automation objects is the "server".</p>
COM - Component Object Model DCOM - Distributed COM	<p>(<i>MS 2000 Automation Help:</i>) an industry-standard technology that applications use to expose their objects, methods, and properties to development tools, macro languages, and other applications. (DCOM = COM extended for network apps.)</p> <p>(<i>Wikipedia:</i>) ...often used in the software development world as an umbrella term that encompasses the OLE, OLE Automation, ActiveX, COM+ and DCOM technologies.</p>
OLE Server	<p>a usually invisible application which supports the main interface (client)</p> <p>(<i>MFC:</i>) an Automation server is an application (a type of COM server) that exposes its functionality through COM interfaces to other applications, called Automation clients. The exposure enables Automation clients to automate certain functions by directly accessing objects and using the services they provide.</p> <p>(<i>Dyalog Help:</i>) The OLEServer object allows you to export an APL namespace so that its functions and variables become directly accessible to an OLE Automation client application such as Microsoft Visual Basic or Microsoft Excel.</p>
OLE Client	the application interface or application which controls or calls upon the OLE Server.
ActiveX Control (or OLE Control)	<p>a usually visible object which user interacts with; may be embedded in another application.</p> <p>(<i>Wikipedia:</i>) a Microsoft term that is used to denote reusable software components that are based on Microsoft Component Object Model (COM). ActiveX controls provide encapsulated reusable functionality to programs and they are typically but not always visual in nature.</p> <p>(<i>Microsoft:</i>) an ActiveX control is implemented as an in-process server (typically a small object) that can be used in any OLE container.</p>
Object Oriented	<p>numerous meanings, but generally: a modular approach, using reusable units (called object, class, control, etc.) with common design, including properties, methods, and events; (nouns, verbs, things that happen?)</p> <p>(<i>APL+Win:</i>) an instance of any class is an object.</p> <p>consider an everyday example: book</p>
ADO - ActiveX Data Objects	MS specification for interfacing to databases, using ActiveX/COM structure and methodology
DAO - Data Access Objects	older MS specification for database access, similar to ADO; see: C:\Program Files\Common Files\Microsoft Shared\DAO\DAO35.hlp
ODBC - Open Data Base Connectivity	older MS specification for interfacing to databases via SQL queries

Dyalog APL - Terminology

OLEClient	- object that enables your APL application to interact with non-APL objects (eg. Excel) - note how the Dyalog OLEClient object is an OLE Server application
OLEServer	- created by converting an APL Namespace to an object (APL workspace or .dll), which is then referred to by any non-APL application (eg. Excel) - requires dyalog.dll to run - a Dyalog OLEServer object may be called by an OLE Client application
OCXClass	used to access non-APL-derived ActiveX controls (OCX being one of several names associated with this class of objects)
ActiveXControl	stand-alone object created by APL, but accessed from non-APL applications; requires dyalog.dll to run - based on a Dyalog Namespace object
ActiveXContainer	"read-only"; used to represent the application that is hosting an ActiveXControl object, and provides access to its ambient properties (eg. Font, colour) (see: OLEQueryInterface Method, etc.)
GUI Memory	use '.' (root object), and <code>⊞wc</code> , <code>⊞wn</code> , <code>⊞ws</code> , <code>⊞wg</code> to identify and explore
GUID or CLSID	Globally Unique Identifier or CLaSS Identifier - Windows handle

Let's take a glimpse of some of these things,

```

      '.' ⊞wg 'PropList'           Ⓐ root level properties

      ρC← '.' ⊞wg 'OLEControls'    Ⓐ Windows registry OLE Controls
      ↑C

      ρS← '.' ⊞wg 'OLEServers'    Ⓐ Windows registry OLE Server objects
      ↑30↑S

      (∨/ 'xcel' ⊆⌈↑S) /↑S       Ⓐ Excel objects?

```

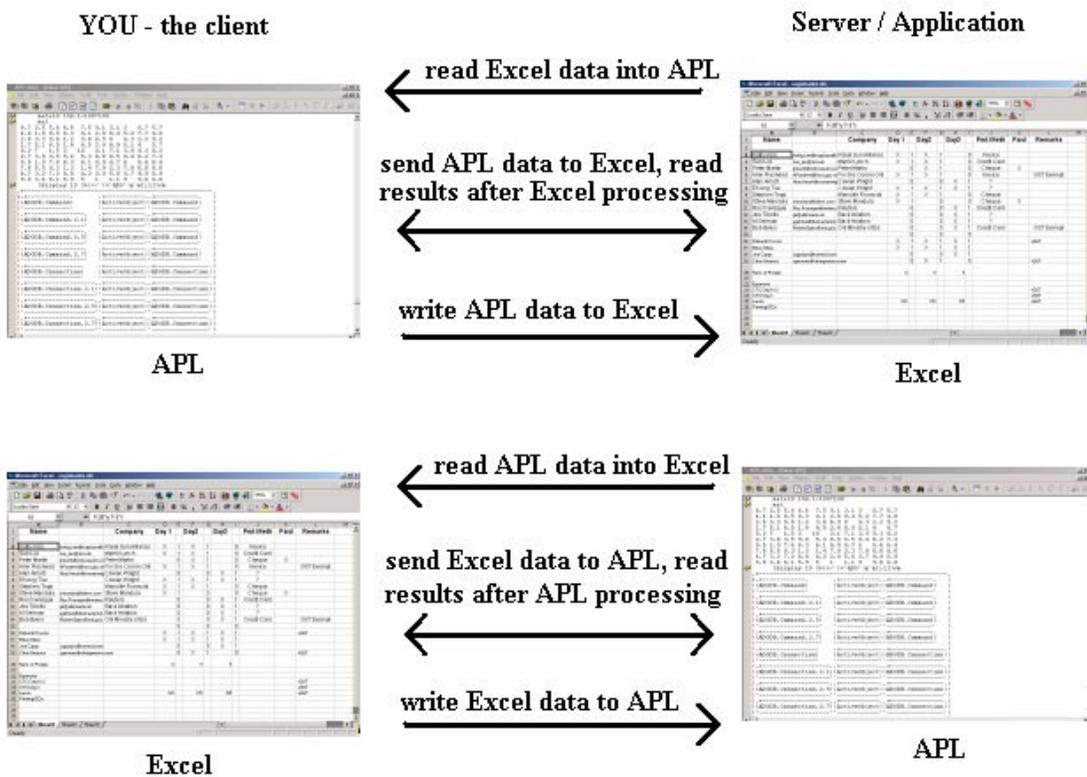
References

- Dyalog session Help > GUI Help
- Dyalog Interface Guide (download .pdf)
- Dyalog Release Notes / Help > Latest Enhancements (especially Version 11)
- Excel Help menu > see: "Table of Contents" > "Visual Basic Reference" > "Excel Object Model"
- Auto2000.chm - Microsoft Office 2000 automation Help file, available at:
<http://support.microsoft.com/default.aspx?scid=http://support.microsoft.com:80/support/kb/articles/q260/4/10.asp&NoWebContent=1>
- MFC - Microsoft Foundation Class Library - online resources,
eg. <http://msdn2.microsoft.com/en-us/library/fe1cf721.aspx>
- APL+Win workspaces and documentation

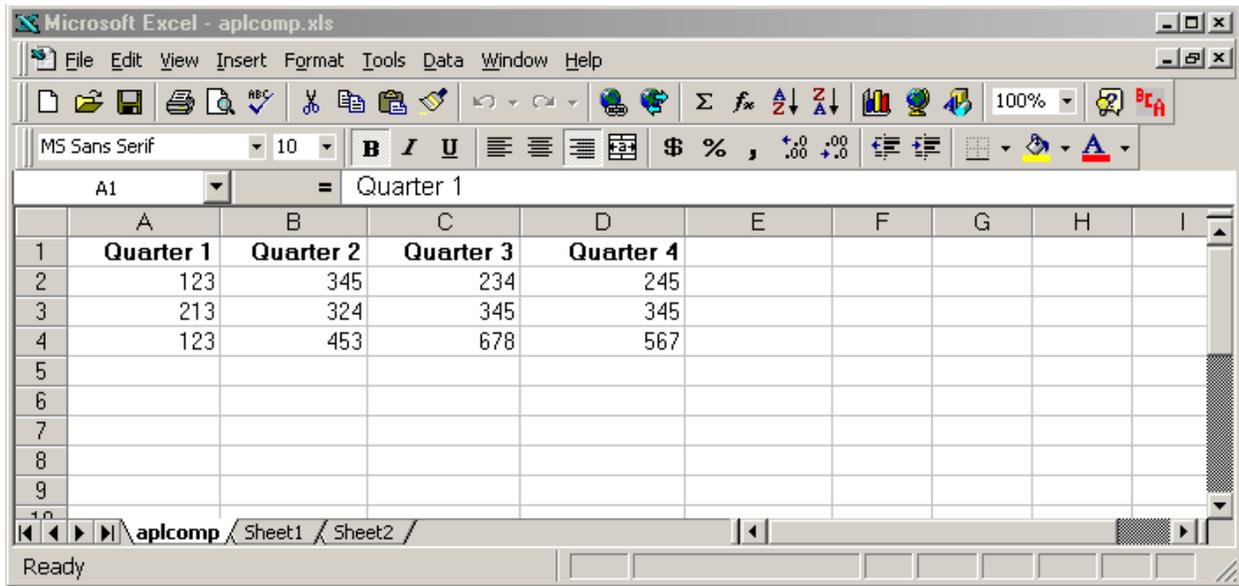
Client? Server? and other Options

Given all of the above, what do you really want to do? It boils down to a few possibilities:

- 1) **APL as Client** - in an APL development session, or an APL-GUI (runtime) application - you **write** data to Excel, and perhaps go on to format and print; do further processing, eg. charts, or you **read** data into your APL environment from Excel.
- 2) **APL as Server** - from within another Office application (eg. Excel) you call upon APL functions to perform calculations, run an existing APL utility, read an APL-driven database etc. and return results. Or, you send data to an APL system and perform final processing there.
- 3) **Other OLE Options** - eg. create ActiveX controls using APL; use non-APL ActiveX objects from within APL; use ADO for database access; etc.



Excel - Components and Overview



Excel's Object-Oriented Structure

In very brief terms, the Excel spreadsheet is a hierarchical collection of objects; objects have properties; most have methods; and when we interact with these objects - events take place. This is the model we must work with to program such applications from any point of view, including APL.

Excel Help provides a good visual display of these objects, and an in-depth resource for understanding how to use these: for starters, try:

"Contents and Index" > "Microsoft Excel Visual Basic Reference" > "Microsoft Excel Object Model"
(it's Microsoft, so your version may differ!)

This diagram displays the hierarchical relationships between objects. Click on any of these to explore the details further down the branches of the tree to expand further levels. Notice the top-level object is called "Application".

Key Excel Components and Concepts

Obvious

Menu	Windows standard
Toolbars	one or more; contain tool buttons, combos, etc.; user may modify
Formula Bar	input area
Name Box	apply a name to a cell or range
Workbooks	collection object containing individual Workbooks, ie. opened *.xls files, each one being a Workbook object
Worksheets	(or Sheets) collection object; tabs at bottom-left; add, delete, move
Rows/Columns	A1:Z99 designation; some maximum values; note Rows numeric, Columns alpha; drag/drop heading areas to resize; Ctrl-down-arrow etc.
Cells	contain values or formulas; many properties to consider: datatype, format, font, behaviour, alignment (text left, num right), display precision, etc.

Not so obvious

Collection	special Excel object used to contain other objects, eg. Workbook > Worksheets; Item and Count properties are useful; special syntax needed in APL
Item	Property; collection object unit; demo: select cells, hit Enter key repeatedly
Count	Property; collection object unit count
Range	ambiguous term: a selection of cells (can you say "array" ?), either contiguous or non- (may even span Worksheets); note that a "Range Object" is created by using the Range property of a parent object (eg. Worksheet)
Select/Selection	- Method and Property; drag/drop to select one or more contiguous cells, or whole Rows/Columns/Worksheets; highlight to modify content or format in bulk - useful to programmatically change a block of cells, for eg. - also see: Activate method; CurrentRegion; UsedRange, etc.
PrintOut	and other Methods; eg. print an object; Open, Close, Quit, Select, Activate, etc.
numerous sub-objects	various commonly-used objects and nomenclature such as UsedRange, ThisWorkbook, ActiveSheet, ActiveChart, ActiveCell, etc.
VBA/Macros; GUI elements	GUI objects and code stored as part of the spreadsheet; macro recording facility; built-in edit and debug environment

Now, let's go back to APL. First, we need to spend 5 minutes on:

APL GUI Programming - 101 (very lite)

In all APLs, object programming is accomplished with some handy \square -functions, or more modern Object1.Object2.Property... syntax.

Dyalog	Examples
\square WC = create	'F' \square WC 'Form'
\square WS = set	'F' \square WG 'PropList'
\square WG = get	'F' \square WG 'Size' 'Posn'
\square WN = names	'F' \square WS 'Caption' 'Hello World'
\square DQ = wait	'F' \square WS 'BCol' 255 0 0
\square NQ = invoke	'F.ED1' \square WC 'Edit' ('Posn' 10 10) 'F.B1' \square WC 'Button' 'OK' ('Event' 'Select' ' Δ \square EX' 'F' '') \square WN 'F' \square DQ 'F'
and...	F.Caption←'Goodbye World'

In similar fashion, we can take this methodology, and apply it to the Excel object, or other COM objects.

Exploring the Excel Object from APL

From APL, to use an OLE object as a server, we create an OLEClient object, which is implemented as a "namespace" in Dyalog APL, and we associate a particular server object with it, eg.:

```
□WX ← 1           A or 3, see: "External Object Behaviour" below
```

```
'XL' □wc 'OLEClient' 'Excel.Application'
```

This creates an OLEClient object which will interact with an OLE Server, with the ClassName property as specified from our list of OLEServers, ie. from the Root Object property which examines the Windows Registry.

'XL' becomes a namespace object which we can explore or query and use. Dyalog provides system commands to enable us to explore a namespace's objects:

```
)CS XL           A enter the "XL" namespace
)methods
)events
)props           A list properties
Version
LibraryPath
Columns.Count
```

The above can also be accomplished via □w_ syntax from the root level:

```
)CS           A return to root level
'XL' □wg 'MethodList'
'XL' □wg 'Version'           A Excel version number (may be important)
'XL' □wg 'Visible'           A is the server visible?
'XL' □ws 'vIsIBLe' 1           A make it so; does case matter?
'XL' □ws 'Visible' 0           A make it not
```

Dyalog also allows the use of direct object/property naming via "." syntax, eg.

```
XL.PropList
XL.Version
XL.Visible
XL.Visible←1
XL.visible←0           A suddenly, case matters! (and AutoComplete helps a lot)
XL.Rows.Count
```

Interesting diversion...

```
XL.Speech.Speak 'Are we having fun now? Or what?'
XL.Speech.Speak 'wut, in, hail, yoo, thank, yer, dooon, bo ah?'
```

Also, Dyalog provides the "**Workspace Explorer**" tool to browse such objects.

Want to find out what any of these properties, methods or events **really means**? For starters, try searching for the particular term in the Excel/VBA Help feature.

Some Key Points

- Dyalog implements GUI memory and OLE objects using the namespace concept, hence, use `)OBS` or `⊞NL` to explore these; `)CS` or the `...object.sub-object...` syntax allows us to explore, etc.; `)ERASE` or `⊞EX` erases the object; assignment `←` is used to set properties; `⊞NQ` or `object.sub-object` syntax is used to invoke methods; even the each operator `**` can be put to use for implicit looping, etc.
- upper/lower case-sensitivity varies when addressing properties, methods and events (according to the syntax used?)
- Dyalog AutoComplete - displays object Properties; useful to explore objects to some extent
- Incorrect usage often returns a useful response, eg. Methods are indicated by APL del symbol `▽` when invoked but missing an argument, eg. `XL.Columns.AutoComplete` or in fact an "Exception Error" may appear in a separate "Status" form, eg. try `XL.Workbooks.Open` with an invalid path/filename.
- Visibility - is Excel visible in the task bar? Processes in Task Manager? etc.; set the Visible property
- Is Excel already running?
see: <http://apl2000.com/Discussion+Groups/APL+Win+Interpreter/APL+Interpreter+General/797.aspx.htm>
> [alreadyrunningexceldiscussion.htm](#)
- Launch a "New Instance" of Excel, or not?
see: InstanceMode property (of OLEClient)
- Which 'Excel.Application' server object name to use?
see: "How to run multiple versions of Excel on the same computer"
<http://support.microsoft.com/kb/214388>
- `⊞WX`, enclosed arguments and Item vs. [item] - with Version 11.0+ - External Object Behaviour
see: Language Help > `⊞WX` > External Object Behaviour
- `3 ⊞NQ` invokes a method in an OLE Control. The (shy) result of `⊞NQ` is the result produced by the method.
- Collection Objects - can be confusing, require special syntax, see below

Collection Objects

Consider these definitions from the Excel-Help:

Workbook Object - The Workbook object is a member of the Workbooks collection.

Workbooks Collection Object - A collection of all the Workbook objects that are currently open in the Microsoft Excel application.

Workbooks Property - Returns a Workbooks collection that represents all the open workbooks. Read-only.

Worksheet Object - Represents a worksheet. The Worksheet object is a member of the Worksheets collection. The Worksheets collection contains all the Worksheet objects in a workbook.

Worksheets Collection Object - A collection of all the Worksheet objects in the specified or active workbook. Each Worksheet object represents a worksheet.

See also: ActiveWorkbook; ThisWorkbook; Sheets; ActiveSheet; etc.

In other words, the many objects, levels and similar terms can be confusing. The main points are that collection objects have a special purpose and syntax, and we may refer to the objects they contain by using the **Item** property or equivalent reference via indexing. Compare the following:

First, look for this file or equivalent: 'c:\Program Files\Microsoft Office\Office\Library\common.xls', then:

```
'XL' □wc 'OLEClient' 'Excel.Application'
XL.Workbooks.Count
XL.Workbooks.Open 'c:\...\common.xls'           (NB: v.10)
XL.Workbooks.Open c'c:\...\common.xls'         (NB: v.11, □WX←3)
XL.Workbooks.Count
XL.Workbooks.PropList
(XL.Workbooks) □WG 'PropList'
'XL.Workbooks' □WG 'PropList'
XL.Workbooks.□WG 'PropList'
WBS ← XL.Workbooks
WBS.PropList
(XL.Workbooks.Item 1).PropList   (NB: v.10)
XL.Workbooks[1].PropList        (NB: v.11)
XL.Workbooks[1].Name
WB1 ← XL.Workbooks[1]
WB1.Name
WB1.Sheets.Count
```

Collection objects are typically a part of the hierarchy or path to get to the underlying information in the spreadsheet. The key Collection Objects include: Workbooks, Sheets (Worksheets), Rows, Columns, Range.

NB: Use of ...Item *N* or indexing (via [*N*]) to select a Collection Object Item depends on Dyalog version. (see "External Object (COM and .Net) Behaviour" - Version 11 Release Notes)

APL in Control

First, look for this file or equivalent: 'c:\Program Files\Microsoft Office\Office\Library\common.xls', then find a second .xls file on your system to open, then work through these examples:

```
'XL' □WC 'OLEClient' 'Excel.Application'
XL.Workbooks.Open 'c:\... \common.xls'
(* or: XL.Workbooks.Open c 'c:\... \common.xls')
XL.Workbooks.Open 'c:\... \anysecondspreadsheet.xls'
XL.Workbooks.Count ◇ XL.Workbooks.PropList
XL.Workbooks.Item
XL.Workbooks.Item 1 ◇ XL.Workbooks[1]
(XL.Workbooks.Item 1) □wg 'PropList'
(XL.Workbooks.Item 1).PropList or: XL.Workbooks[1].PropList
WB1←XL.Workbooks.Item 1 ◇ WB2←XL.Workbooks.Item 2
WB1.Name ◇ WB2.Name
DISPLAY (WB1.Sheets.Item⍕WB1.Sheets.Count).Name (and with [n] syntax?)
WB1.Sheets[1].PropList
WB1.Sheets[1].Cells ◇ WB1.Sheets[1].Name
WB1.Sheets[1].Cells.Range
(WB1.Sheets[1].Cells.Range 'A1' 'D5').PropList
(WB1.Sheets[1].Cells.Range 'A1' 'D5').Value2
(** or in V12: WB1.Sheets[1].Range[←'A1:D5'].Value2 )
(WB1.Sheets[1].Range 'A1' 'D5').Value2
M←WB1.Sheets[1].UsedRange.Value2
□NULL≡M
WB1.Sheets[1].UsedRange.Cells.Count
WB1.Sheets[1].UsedRange.Rows.Count
WB1.Sheets[1].UsedRange.Rows[4].Value2
WB1.Sheets[1].UsedRange.Columns[4].Value2
```

To Create a new Workbook (spreadsheet) and Write to it (the basics):

```
WB3←XL.Workbooks.Add 1
(WB3.Sheets[1].Range 'A1' 'E5').Value2←5 5p125
XL.Visible←1
(WB3.Sheets[1].Range 'A1' 'E5').Value2←125
WB3.SaveAs 'APL2Xldemo1.xls'
WB3.Path
WB3.Close 1
```

Datatypes, Formatting, and Related Issues

COM objects such as Excel typically have data represented by more datatypes than those available in APL. Excel datatypes for example include: Boolean, Date/Time, Double, Error, Integer, Long, String, Currency, Variant.

When transferring data back and forth between APL and Excel therefore, we may need to pay attention to the datatype of our data to make sure it is both stored and represented (displayed) correctly.

- APL provides `⍵null` (displayed as `[Null]`) which is used to represent null values which COM methods often return. Other data conversions for data transferred between systems are automatic

- Value vs. Value2? (*from Excel-Help*)

"The only difference between (the Value2) property and the Value property is that the Value2 property doesn't use the Currency and Date data types. You can return values formatted with these data types as floating-point numbers by using the Double data type." (ie. use Value2)

In some cases?? ...Value seems to require a null argument, eg.

```
(WB3.Sheets[1].Range'A1' 'E5').Value 0
```

- IS Functions (*from Excel-Help*) - use these to determine particular characteristics of cells, eg.

```
XL.ISNUMBER XL.Workbooks[1].Sheets[1].UsedRange
```

This returns a 2-cell result with a boolean array in cell-1, indicating cells with numeric values (presumably of any of the numeric datatypes?).

- Information Functions (*from Excel-Help*) - further IS_ functions to return characteristics of cell contents.

Note that not all of the above IS_ functions are available - see XL.MethodList - ie. some Methods are "exposed", others are not (?); and the list seems to grow as these are used (??).

- Formula vs. Value?

Enter some formulae on a spreadsheet, then compare ...Range.Value2 vs. ...Range.Formula

- APL+Win offers root-object-level query & set functionality for data type and value (see the VT_VV workspace).

- Under-filling cells results in "#N/A", eg.

```
(XL.Workbooks[1].Sheets[1].Range'D15' 'F17').Value2←2 2p14
```

Dates

Dates are stored in Excel as a day-count number (days since 1900-01-01) but typically represented (displayed) in other ways, such as '16-Oct-06'. Make sure your date information in Excel is numeric and not a character string that looks like a date. There are several display options, see Format > Cells > Number > Date in the Menu, or In in *Excel-Help*, see: "Available Number Formats" > "Display numbers as dates or times" > "Custom date and time codes".

When calculating day-count values, note that Excel incorrectly counts 1900 as a leap year, hence dates are offset by 1 between APL and Excel (see DateToIDN Method in Dyalog GUI Help > IDN definition).

Some examples: (open a spreadsheet... enter some dates, numerics and text if not already present...)

```
WB1←XL.Workbooks.Item 1
RNG1←WB1.Sheets[1].Range'A1' 'A7'      Ⓐ choose any appropriate range with dates
RNG1.NumberFormat
RNG1.NumberFormat←'yyyy/mm/dd'        Ⓐ and have a look at the Excel result
RNG1.NumberFormat←'###.####'
RNG1.NumberFormat←'$###.00'
```

```
)COPY C:\...\WS\UTIL SM_TS TS_SM DISP
TODAY←SM_TS 3+□TS
WB2←XL.Workbooks.Add 1      Ⓐ create a new Workbook, write some numbers and dates
RNG2←WB2.Sheets[1].Range'B3' 'F7'
RNG2.Value2 ← (TODAY+0,14),5 4ρ 0.001×100?10000
WB2.Sheets[1].Range'B3' 'B7').NumberFormat' ← 'dd-mmm-yy'
```

(...and a bit of formatting, etc.)

```
RNG2.Font.Size ← 14  ⋄ RNG.Font.Italic ← 1
RNG2.Interior.Color ← 256 1 0 0 255
RNG2.Interior.ColorIndex ← 44      Ⓐ some pre-set colours
RNG2.ClearFormats
RNG2.ClearContents
```

Utilities

Rather than invent most of the wheels...

First, find or create an Excel spreadsheet that has more than one worksheet, and some data (numeric or char or a mixture) in a few cells. Then:

```
)LOAD ...\samples\ole\oleauto          (in the Dyalog install folder)
DESCRIBE
```

Reading a spreadsheet

```
ρmat←XLCONTENTS 'C:\...common.xls'
ρ mat          (etc., explore the structure of the result)
```

Examine XLCONTENTS, (or XLCONTENTS1) and note how control structures are used to navigate through Excel's object hierarchy and collection objects.

Writing To a Spreadsheet

```
)ED XLPRINT          (modify it to not PrintOut, Close or Quit, and remove EX from the header)
mat2←10 10ρ0.1×100?1000
1 XLPRINT mat2          (note EX object, EX.Visible, etc.)
```

From here, you can modify & print the Excel sheet, close it, close Excel,)erase EX

or from APL, you could do these actions separately under program control, as in:

```
(EX.Workbook.Item 1).Close 1
EX.Quit ♦ □EX 'EX'
```

Excel Charts?

```
)ED XLCHART          (?? does this work)
```

More on Charts?: see David Crossley's XL functions workspace (not trivial), eg.

```
xl_start'' ♦ xl_plot 10!20
```

A Few More Tips & Tricks

`XL.Workbooks[1].Sheets[1].Activate` **A** "activate" a worksheet

`XL.ActiveSheet.UsedRange.Count`

`XL.ActiveSheet.UsedRange.Address` ''

`XL.ActiveSheet.UsedRange.Select` **A** select a range

Result of Single vs. Multiple Cell Values

`(XL.ActiveSheet.Range'C1').Value2` **A** depends on cell content (empty?)

`(XL.ActiveSheet.Range'C1' 'D1').Value2`

Named Ranges (for template-driven output?)

`(XL.ActiveSheet.Range'E5' 'H9').Name ← 'MyRng1'`

`(XL.ActiveSheet.Range'MyRng1').Value2 ← mat3` **A** populate known ranges

Multi-Area Ranges

`(XL.ActiveSheet.Range'C7:D9,F7:G9').Name←'myrng2'`

`(XL.ActiveSheet.Range'myrng2').Value←(3 2ρ16)(3 2ρ100+16)` **A** ??

`(XL.ActiveSheet.Range'myrng2').Value←(3 2ρ16), (3 2ρ100+16)`

`(XL.ActiveSheet.Range'myrng2').Areas.Count`

`((XL.ActiveSheet.Range'myrng2').Areas[2]).Value2←99` **A** scalar extension!

Conclusion: we can only pass a simple (non-enclosed) argument, so one APL array gets split into sub-arrays according to target-cell geometry in Excel.

A Few Other Nifty Things... *OLE!*

We can launch other OLE applications and/or create documents from APL:

Word

In similar fashion to Excel, we link APL to the OLE Server object for MS-Word, then set or query its various sub-objects, etc.

- study the VB code in some of the following: (ie. Google "Word OLE Automation")
 - <http://vbcity.com/forums/topic.asp?tid=34572>
 - http://groups.google.ca/group/comp.lang.basic.visual.misc/browse_thread/thread/5f469ecaf624045b/a63af721977b6c7f?lnk=st&q=%27Running+Word+Using+Automation%27+InsertDateTime+MM-DD-YY+HH%3AMM%3ASS&rnum=5&hl=en#a63af721977b6c7f
 - <http://support.microsoft.com/?kbid=250501>
- emulate this code in APL and create an APL driver function to send arbitrary text to a Word document

PowerPoint

- find the PowerPoint OLEServer object
- create an OLEClient object which uses the PowerPoint server
- explore the server object properties & methods
- create an APL driver function which will open and run a PowerPoint .pps file

OCX Demo

OCX Controls behave similarly to the OLE Server objects above, except they may need to be associated with a Form or other container to be useful. These objects are designed to take on some of the properties of their environment (container).

See: "Loading an ActiveX Control", in the Dyalog Windows Interface Guide (Chapter 11).

- use the 'Microsoft Forms 2.0 TextBox' OLE Control object by building an APL driver function to contain and present this object

PDF

Similar to the OCX control above, Adobe Acrobat provides an ActiveX control which can be used to display a PDF document.

- find the Adobe Acrobat ActiveX component needed to display PDF documents
- create an APL driver function which will display a given PDF document

What Else Is New?

1. `⎕WX` changes - see Session Help "Latest Enhancements": "Expose Windows Object Properties" and "External Object Behaviour"
2. `⎕NL` and COM Objects - see: Session Help "Latest Enhancements", `⎕NL`, `⎕NC` and "name-class" definitions
Extensions for more detailed object information.
3. APL Classes based on `OLEClient` - see:

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Writing Classes based on `OLEClient`

You may define APL Classes (See Language Reference) based upon the `OLEClient` object. For example:

```
:Class Excel: 'OLEClient'
  ▽ ctor wkbk
    :Access Public
    :Implements Constructor :Base ,=('ClassName' 'Excel.A
pplication')
    Workbooks.Open ←wkbk
  ▽
:EndClass a Excel
```

```
XL←[NEW Excel 'f:\help11.0\days.xls'
XL.Workbooks[1].Sheets[1].UsedRange.Value2
```

From	To	Days	Hours
38790	38791	0	3.25
38792	38792	[Null]	2.25
38793	38793	[Null]	2.5
38799	38799	[Null]	5
38800	38800	[Null]	3
[Null]	[Null]	[Null]	16

Excel in Control

Here, we focus on designing the user interface in Excel/VBA. APL may be "plugged into" this application as a black box, hidden from view normally. APL functions are passed arguments, and return results as with any other Excel/VBA function. Excel is the client, APL the server (often called "calculation server or engine").

In General

Calling APL functions from within your Excel application involves the following steps:

- create appropriate APL code in a workspace, with some special considerations; test and debug
- create/register the required .dll using this code
- create the Excel spreadsheet, including VBA code which links into APL code
- test and debug

In Dyalog APL, we use a Namespace object to contain the code which Excel will call upon, and Dyalog provides a special facility to turn that code into a .dll file.

DATE	SP500	XR	MCI	RAG10	RAG3	RAG30
1/1/90	342.9375	0.8428	1.214854	8.16	8.13	8.21
2/1/90	329.57	0.8386	1.263772	8.48	8.39	8.51
3/1/90	337.48	0.8549	1.544117	8.57	8.63	8.56
4/1/90	338.7575	0.8584	1.603492	8.77	8.78	8.74
5/1/90	347.6775	0.8535	1.379276	8.79	8.69	8.76
6/1/90	360.494	0.8593	1.279276	8.5	8.4	8.48

Dyalog APL provides a built-in facility in the session manager for creating the required .dll object which will deliver APL capability to your Excel application. This is documented in the Dyalog APL "Interface Guide" (Chapter 12: "OLE Automation Server").

Worth reading in that chapter:

- Rules for Exported Functions
- Out-of-Process and In-Process OLE Servers

Key steps include:

- Create an APL workspace containing a namespace, into which all the relevant code and other objects are placed
- make the namespace an OLEServer object, eg. `Loan.⌈WC 'OLEServer'`
-) **SAVE** the workspace (use a new name if starting with one of the demos)
- Choose File-Export from the menu, and select "In Process Server (*.dll)" or "Out of Process COM Server" (typically "In Process" - see Dyalog's Interface Guide)

Dyalog APL will automatically package up the namespace contents, "export" those items, and register the supplied Namespace as a .dll object (and produce a small log/report). This .dll is the object we then refer to in our Excel/VBA code, using the CreateObject function.

On the VBA/Excel Side

- Create your spreadsheet - typically this will be designed with input areas for data parameters to be passed to APL, and one or more "controls" (buttons, input boxes, etc.)
- Enter "Design Mode", using the toolbar brought into view by: View > Toolbars > Control Toolbox
- Right-click on controls to choose "View Code" or "Properties"; or enter the VBA Macro editor to modify these

Let's look at the supplied example: ...\\samples\ole\loan.xls

```
Private Sub CBGet_Click()           (or use the "Assign Macro" feature)
    Dim APLWS As Object
    Set APLWS = CreateObject("dyalog.NAMESPACENAME")
    ...
```

```
Sub Calc()
    Dim APLLoan As Object
    Dim Payments As Variant
    Set APLLoan = CreateObject("dyalog.Loan")
    LoanAmt = Cells(1, 3).Value
    LenMax = Cells(2, 3).Value
    LenMin = Cells(3, 3).Value
    IntrMax = Cells(4, 3).Value
    IntrMin = Cells(5, 3).Value
    APLLoan.PeriodType = 1
    Payments = APLLoan.CalcPayments(LoanAmt, LenMax, LenMin, IntrMax, IntrMin)
    For r = 0 To UBound(Payments, 1)
        For c = 0 To UBound(Payments, 2)
            Cells(r + 1, c + 5).Value = Payments(r, c)
        Next c
    Next r
End Sub
```

```
Sub CalcPayments()                 (alternate coding to above)
    ...
```

The Tricks

For Dyalog APL, the following rules and caveats apply *at creation time*, when creating the .dll through the above process:

- all functions must be niladic or monadic; no dyadic functions, nor dynamic functions, derived functions or operators; this could lead to numerous code changes obviously for some existing systems
- any global variables cannot be enclosed arrays
- results (returned to Excel) may be simple or enclosed
- reporting exceptions, errors, etc. back to Excel can be a chore, depending on desired level of detail

from the *Interface Guide*:

Rule 1: Exported APL functions must be niladic or monadic *defined* functions; dyadic functions, dynamic functions, derived functions and operators are not allowed. However, ambivalent functions may be called (monadically) by OLE.

Rule 2: Character arrays whose rank is greater than 1 are passed as 1-byte integer arrays. This means that 1-byte integer matrices and higher-order arrays will always be converted to character arrays.

Rule 3: An exported APL function may not be called with an empty numeric vector (zilde) as its single argument. Zilde is used by an APL client to call a non-niladic OLE method with no arguments.

Rule 4: If an exported APL function is called with more than one parameter, its argument will be a nested vector. If it is called with a single parameter that is a character vector or an array whose rank is greater than 1, the argument supplied to the APL function will be a simple array. Effectively, a 1-element nested array received from an OLE Client is disclosed.

Valence

Make dyadic functions monadic, by combining the arguments into one:

```
R← CAT1 arg                vs.   R← arg1 CAT1 arg2
[1] A concatenate 2 arrays on the 1st axis
[2] ...
```

Then, change the syntactic use of each function which has changed, eg.

```
C← CAT1 (A B)
```

Globals

Create "make" functions instead of globals, and invoke these in a "QUADLX" function which is called by VBA before calling any other code, or invoke them as needed at the beginning of other processes or functions, eg.

```
MAKEΔFrequencies
Frequencies←6 2ρCUT'/D/DAILY/W/WEEKLY/M/MONTHLY/Q/QUARTERLY/S/SEMI/Y/YEARLY'
Frequencies←261 52 12 4 2 1,Frequencies
```

Error, Exceptions

Error handling can be as (un)sophisticated as you wish, but consider these suggestions:

- do as much input-checking "up front", ie. in Excel, before sending bad info to APL
- modify your APL code to always return a result, being an error message or valid result; ie. let Excel deal with the result according to content
- return an error code with all results from APL (0 = OK; 1 = not OK, etc.)

A Few Other Issues

1. A hierarchy of Namespaces in your server application?

Implementing an Object Hierarchy

Despite the close correspondence between the object model and Dyalog APL namespace technology, there is one significant difference. OLE does not support object hierarchies in the sense that one object *contains* or *owns* another.

Instead you must implement object hierarchies using *properties* that refer to other objects and/or *methods* that return objects as results.

It is not possible to pass Dyalog APL namespace hierarchies through OLE because OLE does not support them. If you want to write an OLE Automation Server in APL that implements an object hierarchy, you must follow the OLE conventions for doing so.

2. Running your server application on a network?

Configuring an *out-of-process* OLEServer for DCOM

Introduction

When you register an *out-of-process* OLEServer using *File/Export* or *OLERegister*, Dyalog APL automatically updates the Windows registry so that your OLEServer is immediately accessible to an OLE client application running on *the same* computer.

If you wish to make the same object accessible to client applications running on *different* computers (using distributed COM, or DCOM) you have to install additional registry entries on the server and on each of the clients.

3. Calling your server asynchronously, see the OLEASYNC workspace, and:

Calling an OLE Function Asynchronously

Introduction

Functions exported by an OLEServer are executed (by the underlying OLE technology) in a *synchronous* manner. This means that the OLE client must wait for the function to complete before it can continue processing.

In certain cases the client may not be interested in a result from a function and it may be desirable for client not to have to wait. For example, if a function updates files or performs a printing task, it would be nice for the client application to continue while the server performs this task in background, or indeed (using DCOM) on another computer.

4. Writing ActiveX Controls in Dyalog APL - see Interface Guide, Chapter 13

What is an ActiveX Control ?

An ActiveX Control is a dynamic link library that represents a particular type of COM object. When an ActiveX Control is loaded by a host application, it runs *in-process*, i.e. it is part of the host application's address space. Furthermore, an ActiveX Control typically has a *window* associated with it, which normally appears on the screen and has a user interface.

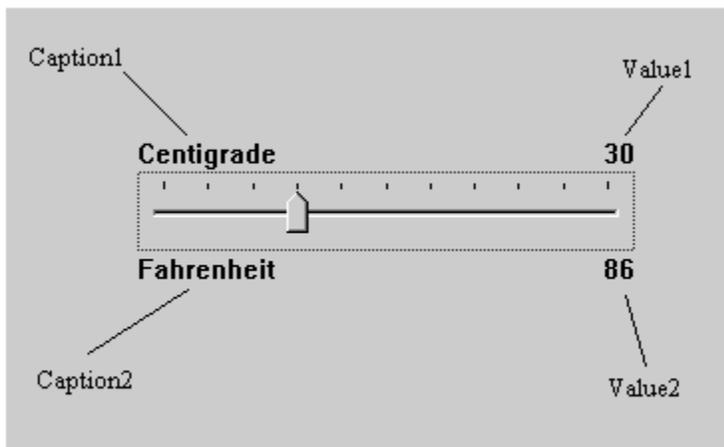
An ActiveX Control is usually stored in file with the extension `.OCX`. The functionality provided by the control can be supplied entirely by functions in that file alone, or can be provided by other dynamic link libraries that it loads and calls, i.e. an ActiveX Control can be stand-alone or can rely on one or more other dynamic link libraries.

What is a Dyalog APL ActiveX Control ?

An ActiveX Control written using Dyalog APL is also a file with a `.OCX` extension. The file combines a small dynamic link library *stub* and a workspace. The functionality of the control is provided by the functions and variables in the workspace combined with a dynamic link library version of Dyalog APL named `DYALOG101.DLL` or `DYALOG101RT.DLL` that is normally installed in the Windows System directory.

Note that an ActiveX Control written in Dyalog APL is a GUI object that has a visible appearance and a user interface.

To write an ActiveX Control in Dyalog APL, you use `AWC` to create an `ActiveXControl` object, as a child of a `Form`. An `ActiveXControl` is a container object, akin to a `Group` or a `SubForm`, that may contain a whole range of other controls such as `Edit`, `Combo`, `Button` and `Grid` objects. You may populate your `ActiveXControl` with other objects at this stage and save them in the workspace. However, you may prefer to create these sub-objects when an instance of the `ActiveXControl` is created. This happens when your control is loaded by a host application.



External Object (COM and .Net) Behaviour

(from: *Dyalog Version 11 Release Notes*)

Version 11.0 improves the behaviour of COM and .Net objects, but for backwards compatibility it is possible to select old or new behaviour using `⎕WX`.

Old behaviour:

- a) Character vectors supplied as arguments to external functions, which are defined as String parameters, are automatically enclosed for you. Similarly, string results are automatically disclosed.
- b) Properties that take parameters, such as the Item Property in a Collection, are treated as methods.
- c) APL provides lists of the Properties, Methods and Events provided by a GUI object by exposing additional properties named PropList, MethodList and EventList.

New behaviour:

- a) Character vectors supplied as arguments to external functions, which are defined as String parameters, must be enclosed. Strings are returned as enclosed character vectors.
- b) Properties that take indices, such as the Item Property in a Collection, are honoured as Numbered or Keyed Properties and may be accessed by indexing.
- c) PropList, MethodList and EventList are not exposed. Instead, the information is provided by `⎕NL`, `⎕3` and `⎕8` (but alphabetically sorted).

The actual behaviour of a COM or .Net object is now determined by its value of `⎕WX`. If `⎕WX` is 0 or 1, the old behaviour will apply. If `⎕WX` is 3, the new behaviour will apply.

The behaviour of COM and .Net objects in existing applications will remain the same (because `⎕WX` will be 0 or 1) but you may obtain the benefits of the new behaviour by setting `⎕WX` to 3 at the appropriate level in your application. Then, everything below that (in the namespace hierarchy) will adopt the new behaviour.

Note that regardless of the value of `⎕WX`, Version 11 will honour the Default Property of an external object thereby permitting the direct use of indexing on the object itself.

For example, if `x1` is an instance of the Excel.Application COM class, the following expression to obtain the contents of the first Sheet in the first Workbook will succeed, whatever the value of `⎕WX`.

```
x1.Workbooks[1].Sheets[1].UsedRange.Value2
```

Note that it is the value of `⎕WX` which the object acquired when it was created, rather than the current value of `⎕WX`, which decide the behaviour.

Like other system variables, `⎕WX` is inherited from the environment when a new namespace, class or instance is created. Classes inherit the value of `⎕WX` when a class is edited or fixed, unless the class script explicitly sets a value for `⎕WX`. In the case of .NET classes, `⎕WX` is inherited when the class or namespace is loaded from a .NET assembly. For built-in (GUI) classes, each new instance inherits `⎕WX` when it is created.

Examples

```

WX←1
'XLW' WC 'oleClient' 'Excel.Application'
XLW.Workbooks.Add 0
XLW.ActiveWorkbook.Sheets.(Item 'Sheet2').Index
2

WX←3
XL←WC 'oleClient' (c'ClassName' 'Excel.Application')
XL.Workbooks.Add 0
XL.ActiveWorkbook.Sheets[c'Sheet2'].Index
2

```

Note that it is the value of `WX` in the object, and not in the calling environment, that decides the behaviour:

```

WX←3
using←' '
System.DateTime.Parse<'2006-09-12'
12/09/2006 00:00:00
WX←1
System.DateTime.Parse'2006-09-12'
LENGTH ERROR
System.DateTime.Parse'2006-09-12'
^
System.DateTime.WX←1
System.DateTime.Parse'2006-09-12'
12/09/2006 00:00:00

```

Note that, if we expunged the `System.DateTime` class instead of setting `WX` to 1, and repeated the expression, a new `DateTime` class would be created but it would inherit `WX` from its parent (`System`), where `WX` still has the value 3. Using .NET classes in an application where `WX` varies within a single APL namespace can therefore lead to unexpected results. It is recommended that applications only use more than one value for `WX` as a temporary measure during a conversion project.

ADO and Dyalog APL

Using DAO (precursor to ADO) Dyalog allows us an easy-to-use facility for exploring SQL-based data sources:

```
)LOAD c:\...\dyalog...\samples\ole\oleauto
TESTDB← 'c:\...\fpnwind.mdb'      A the MS-Access "NORTHWIND" sample DB
SEL←'Select * from Customers where Country = ''Canada'' '
TESTDB SQL SEL
TESTDB LIST_FIELDS SEL
```

With time, one could dive into the SQL function code and create new options for more elaborate selections, update mechanisms, etc.

For databases other than MS-Access and the like, Dyalog offers the ODBC interface tools (Chapter 15 - Interface Guide) which provide a complete and detailed set of utilities for interacting with any of these data sources. This is non-trivial in scope.