Hash table (associative array) COM object

- **take existing C hash table code**
- **put a C++ / COM veneer on it**
  - using Microsoft Visual C++
  - ATL Wizard to create framework and lots of files
  - insert semantics into framework

```
//  insert your code here
```

- **use it in VB applications**
  - add reference to Hashcom object:

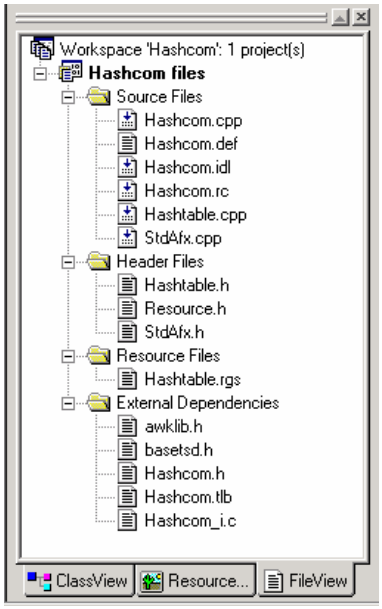
```
Dim h as Object
Set h = New Hashtable
h.put name, val
s = h.get(name)
if h.member(s) then …
```

- **use this in Excel, scripts, etc.**

Existing hash table code

```
typedef struct Array Array;

Array *Anew(int n);
   /* make a new empty array with size n */

int Aput(Array *A, char *s, char *v);
   /* put an element into an array:
   /* A[s] = copy of d */
   /* returns 0 if no room, 1 if installed,
      2 if already there */

char *Aget(Array *A, char *s);
   /* get an element:  return A[s],
      or 0 if not there */

int Amember(Array *A, char *s);
   /* return 1 if A[s] is present, 0 if not */

int Asize(Array *A);
   /* return number of current elements */

int Adelete(Array *A, char *s);
   /* delete item, return new size */
```

Files created by VC++



IDL: Interface definition language

- **COM defines binary format of interface**
- **IDL is a language for defining these interfaces**
- **specifies**
  - type of each argument (int, float *, pointer, etc.)
  - role of each argument in call (in, out, inout, retval)
  - return type of function
  - miscellaneous other stuff

```
interface IHashtable : Idispatch {
  [id(1), helpstring("method put")]
    HRESULT put([in] BSTR name, [in] BSTR val,
      [out,retval] int*stat);
  [id(2), helpstring("method get")]
    HRESULT get([in] BSTR name,
      [out,retval] BSTR *val);
  [id(3), helpstring("method member")]
    HRESULT member([in] BSTR name,
      [out,retval] int *stat);
  ...
 };
```

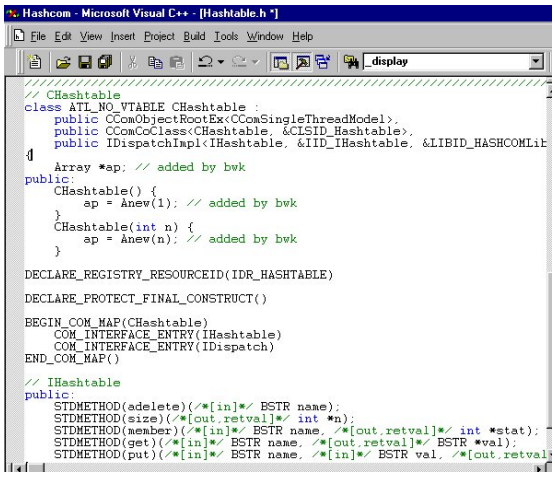
- **IDL compiler converts specification into function templates and code to marshal arguments for function calls**

C++ generated by MIDL

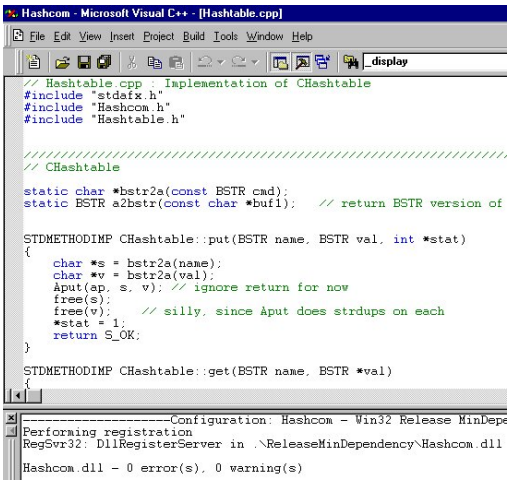
```
MIDL_INTERFACE("24942DFC-6E32-48A0-AF77-
                              C0C009EEC328")
IHashtable : public Idispatch {
public:
 virtual /* [helpstring][id] */
  HRESULT STDMETHODCALLTYPE put(
   /* [in] */ BSTR name,
   /* [in] */ BSTR val,
   /* [retval][out] */ int __RPC_FAR *stat)=0;

 virtual /* [helpstring][id] */
  HRESULT STDMETHODCALLTYPE get(
   /* [in] */ BSTR name,
   /* [retval][out] */ BSTR __RPC_FAR *val)=0;

 virtual /* [helpstring][id] */
  HRESULT STDMETHODCALLTYPE member(
   /* [in] */ BSTR name,
   /* [retval][out] */ int __RPC_FAR *stat)=0;
 ...
```

- **UUID: universally unique 128-bit identifier**
  24942DFC-6E32-48A0-AF77-C0C009EEC328
  - every COM object has one
  - guaranteed unique across everything
  - used to identify objects regardless of where they are

Interface specification (IDL)



Add semantics to framework



BSTR string data type

- **most scalar data types based on C++ types**
- **strings are special: *COM* uses BSTR**
  - 16-bit Unicode characters
  - 4-byte length field before the first character
  - small, irregular set of functions for manipulating them
- **Visual Basic, etc., all use BSTR**
- **Windows API uses either Unicode (but not BSTR) or ASCII (8-bit, not 16)**

```
char *bstr2a(const BSTR cmd) // convert cmd to ascii
{
  int n, i;
  char *buf;

  n = SysStringLen(cmd);      // length of input

  buf = (char *) malloc(n+3);
  for (i = 0; i < n; i++)     // wide to narrow
       buf[i] = (char) cmd[i];
  buf[i] = 0;
  return buf;
}

BSTR a2bstr(const char *buf1) // cvt buf1 to BSTR
{
  int i, n = strlen(buf1);
  BSTR buf2 = SysAllocStringLen(NULL, n);
  for (i = 0; i < n; i++)     // narrow to wide
       buf2[i] = buf1[i];
  buf2[i] = 0;
  return buf2;
}
```

Calling a COM object

- **conceptually, what happens when a COM object is called from a program...**

- **first time**
  - find its code
    look up in Windows registry
    registered during install or when created or by explicit call
  - do any initialization
    Windows needs to keep track of what DLLs are in use
  - link it into current program (if a DLL)
    fill in calls with pointer to real code: vtbl

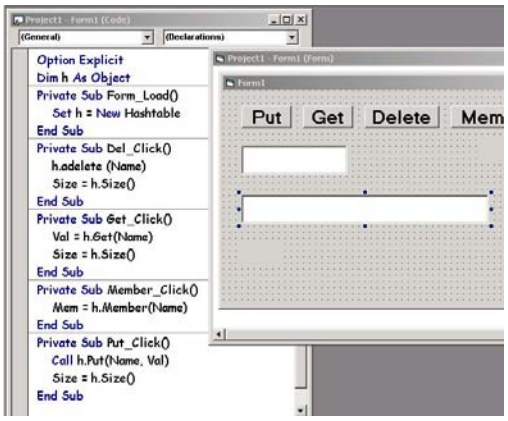
- **each subsequent method call**
  - collect arguments into proper form ("marshalling")
  - call function
  - convert return value and output arguments into proper form

- **when done**
  - do any finalization
  - release resources
    last user tells Windows that DLL is no longer in use

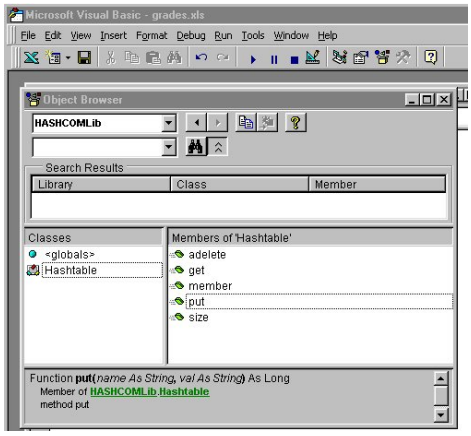
DLL startup code excerpt (machine generated)

```
// DLL Entry Point

extern "C"
BOOL WINAPI DllMain(HINSTANCE hInstance,
       DWORD dwReason, LPVOID /*lpReserved*/)
{
    if (dwReason == DLL_PROCESS_ATTACH)
    {
        _Module.Init(ObjectMap, hInstance,
                  &LIBID_HASHCOMLib);
        DisableThreadLibraryCalls(hInstance);
    }
    else if (dwReason == DLL_PROCESS_DETACH)
        _Module.Term();
    return TRUE;    // ok
}

// Used to determine whether the DLL
                     can be unloaded by OLE
STDAPI DllCanUnloadNow(void)
{
    return (_Module.GetLockCount()==0)
        ? S_OK : S_FALSE;
}
```

Use hashtable in VB



Automatically generated usage info



Use in Excel

```
Dim h As Hashtable
Public Function hashinit() As Integer
    Set h = New Hashtable
End Function
Public Function hashput(n As Range, v As Range) As Integer
    If h Is Nothing Then Set h = New Hashtable
    For i = 1 To n.Count
        h.put n.Cells(i, 1), v.Cells(i, 1)
    Next i
    hashput = n.Count
End Function
Public Function hashget(n As Range) As String
    hashget = h.get(n.Cells(1, 1))
End Function
Public Function hashsize() As String
    hashsize = h.Size()
End Function
Public Function hashmember(n As Range) As Integer
    Dim c As Integer
    c = 0
    For i = 1 To n.Count
        If h.member(n.Cells(i, 1)) = 1 Then c = c + 1
    Next i
    hashmember = c
```