Simplifying Test System Development with IVI.NET

Kirk Fertitta
Pacific MindWorks

Motivations for IVI.NET

- **Present an API more suited to .NET developers**
- **Simplify source code**
  - Allow end users to understand instrument behavior by examining driver source
  - Allow end users to fix bugs on their own
  - Allow end users to add features to drivers on their own
- **Richer, more expressive APIs**
  - More flexibility with API data types
  - Clean handling of asynchronous notifications (aka "events")
- **Side-by-side deployment of drivers**
  - Only one version of an IVI-COM or IVI-C driver can be installed at a time
  - IVI.NET allows multiple versions of a driver to be installed

IVI-COM and IVI-C Driver Source

- **IVI-COM and IVI-C drivers are both quite complicated internally**
- **Supporting IVI driver features requires a lot of code**
  - Multi-thread safety
  - Simulation
  - Range-checking
  - State-caching
- **"Basic" COM plumbing is complex and not well understood by many**
- **Multi-model driver support can be complicated**
- **Driver development tools are required, but can only do so much**
  - Nimbus Driver Studio and LabWindows both work hard to factor as much code "out of the way"
  - Tooling around C/C++ is just plain hard
- **Users trying to debug through an IVI-COM driver would find themselves traversing numerous confusing source code files**

IVI.NET Driver Source

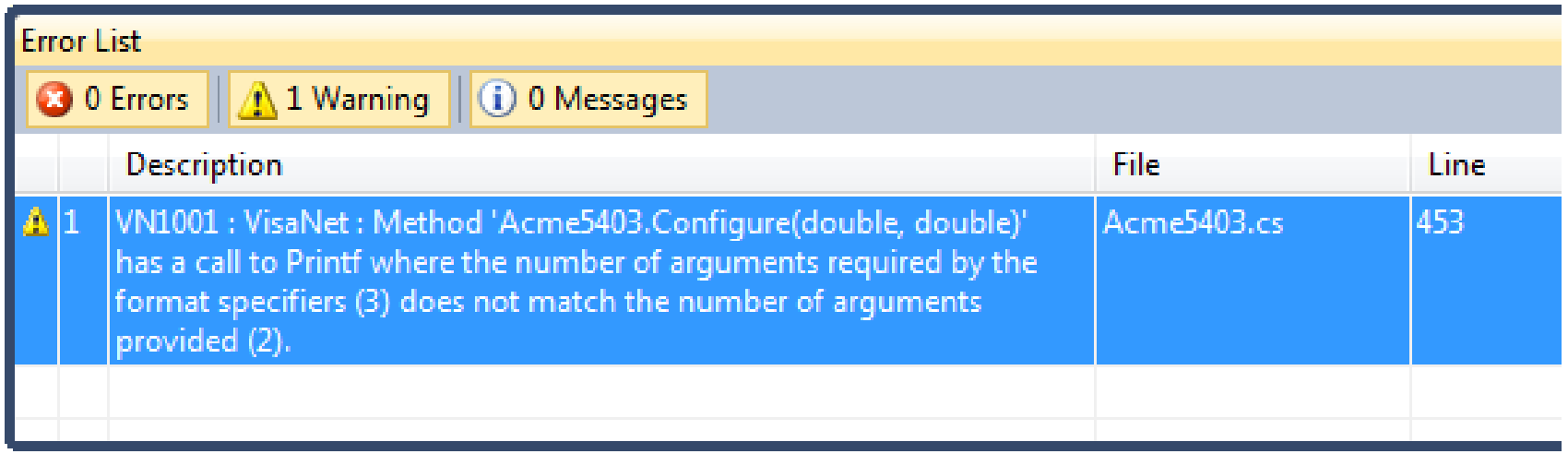
- **Very clean and simple method implementations**
  - Often can be done with a single-line of code
  - No "code-beside" files => simple in-line implementation of each method
- **Plumbing "goo" for many features factored into simple attributes**
  - State caching, range-checking, coercion, locking, parameter validation, and more…
  - This makes it very easy for end users to customize driver behavior without writing any procedural code
- **Simplified I/O by use of standard I/O**
  - All of the advantages of IVI.NET discussed will be available at the I/O level as well
  - VISA.NET API nearing completion by IVI Foundation
  - Pre-release available as part of Nimbus Driver Studio distribution
- ***Any .NET programmer will easily be able to understand and modify an IVI driver***

Advanced Tooling for IVI.NET

- **Many IVI-COM and IVI-C complaints tied to complex source code**
- **Tools have even more difficulty dealing with C/C++ source than humans**
  - Includes files and macros are particularly problematic
  - Few really good C++ refactoring exist in any domain
- **A prime motivator for .NET itself is the improved ability to create tooling**
- **Simpler source possible because .NET code can more easily be roundtripped**
- **Static analysis tools highlight issues at compile time that previously could only be detected at runtime**
- **Browsers can easily interrogate an IVI.NET driver and understand its features**
- **Declarative attributes can be used where procedural code was previously required**
  - Achieved via "extending" the compiler (aka "code-weaving")
- ***Result is that tool-generated code will look just like hand-written code***

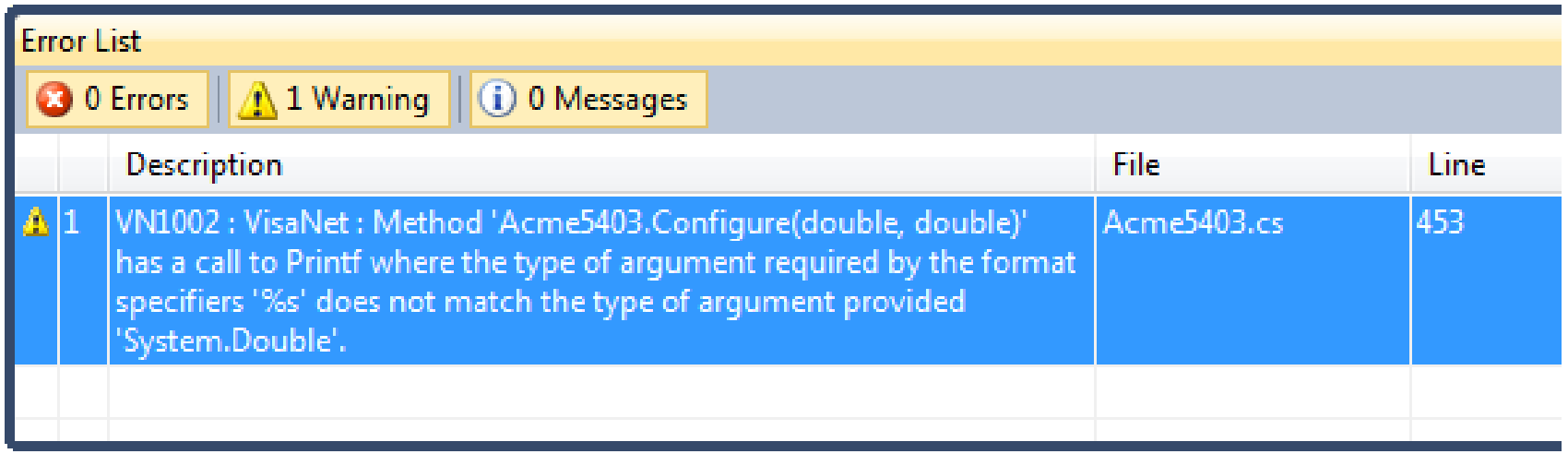
Static Analysis Example 1

```
[DriverMethod]
public void Configure(double bandwidth, double frequency)
{
  // ...
  io.Printf("CONFIG %g,%g,%s", bandwidth, frequency);
}
```



Static Analysis Example 2

```
[DriverMethod]
public void Configure(double bandwidth, double frequency)
{
  // ...
  io.Printf("CONFIG %g,%s", bandwidth, frequency);
}
```



Richer Type System

- **Both IVI-COM and IVI-C drivers suffer from a limited set of data types**
  - Integers, floats, Booleans, strings
  - Arrays of the above, but extra parameters are required in IVI-C
- **IVI-C cannot expose an array of strings**
- **IVI-C cannot expose structs**
  - Can be done in IVI-COM, but it's tedious to implement

```
IviScope_FetchWaveform(ViSession vi,
        ViConstString channel,
        ViInt32 waveformSize,     // # of elements on input
        ViReal64 waveform[],      // actual data buffer
        ViInt32 *actualPoints,    // # of elements on output
        ViReal64 *initialX,
        ViReal64 *xIncrement);
```

Simplifying APIs with .NET TYpes

IVI-C signature

```
IviDigitizer_FetchWaveformReal64(ViSession Vi,
        ViConstString ChannelName,
        ViInt64 WaveformArraySize,
        ViReal64 WaveformArray[],
        ViInt64* ActualPoints,
        ViInt64* FirstValidPoint,
        ViReal64* InitialXOffset,
        ViReal64* InitialXTimeSeconds,
        ViReal64* InitialXTimeFraction,
        ViReal64* XIncrement);
```

IVI.NET signature

```
Channels[].Measurement.FetchWaveform(IWaveform<Double> waveform)
```

How to deal with Events?

- **IVI-COM and IVI-C drivers almost never expose events**
  - Exposing something as commonly needed as an SRQ is tortuous
  - Requires special knowledge/programming by the driver developer
  - Requires special knowledge/programming by the client programmer
- **.NET supplies a standard mechanism for exposing events**
  - No special programming required by the driver developer or client programmer
  - Trivial code to subscribe/unsubscribe
  - Trivial code for driver developers to customize subscribe/unsubscribe semantics
- **Warnings can now be dealt with properly in IVI drivers by the use of events**

Shared IVI.NET Data Types

- **IVI Foundation felt it would be useful to offer commonly used data types as part of the IVI.NET Shared Components**
  - Increase consistency amongst IVI.NET drivers
  - Facilitate data interchange between drivers
- **Standardized IWaveform and ISpectrum interfaces**
  - Digitizers and scopes and RF spectrum analyzers all read waveforms
  - Function generators and RF signal generators source waveforms
  - Without a common definition of a "waveform", client applications would need to write the tedious code to translate between each class's notion of a waveform
- **Time-based parameters can use PrecisionDateTime and PrecisionTimeSpan**
  - No confusion about ms vs sec, absolute vs relative time, UTC time, etc
  - Precision adequate for IEEE 1588 devices
- **Common trigger source data type**
  - Useful in "stitching" together devices in triggered source-measure operations

Error Handling in IVI.NET

- **IVI-C drivers rely solely on return codes**
  - Errors can easily be ignored by the client application
  - After getting the error code, a second function call is required to get the message
  - Special handling of warning codes required
- **IVI-COM error code handling depends upon the client environment**
  - Return codes in raw C++
  - Special exception classes in C++
  - COMException class in .NET interop scenarios
  - *.NET clients can't see warnings at all from IVI-COM drivers*
- **IVI.NET drivers always use exceptions**
  - User can always see the full context of the error
  - Error content less dependent upon specific driver implementation
  - Natural mechanism

Simplified Usage Syntax

- **Simplified access to very commonly used features**
  - Enums
  - Repeated capabilities (e.g. "channels")

C# client using IVI-COM driver through interop

```
digitizer.Arm.Sources.get_Item("LAN3").Detection =
        IviLxiSyncArmSourceDectionEnum.IviLxiSyncArmSourceDetectionHigh;
```

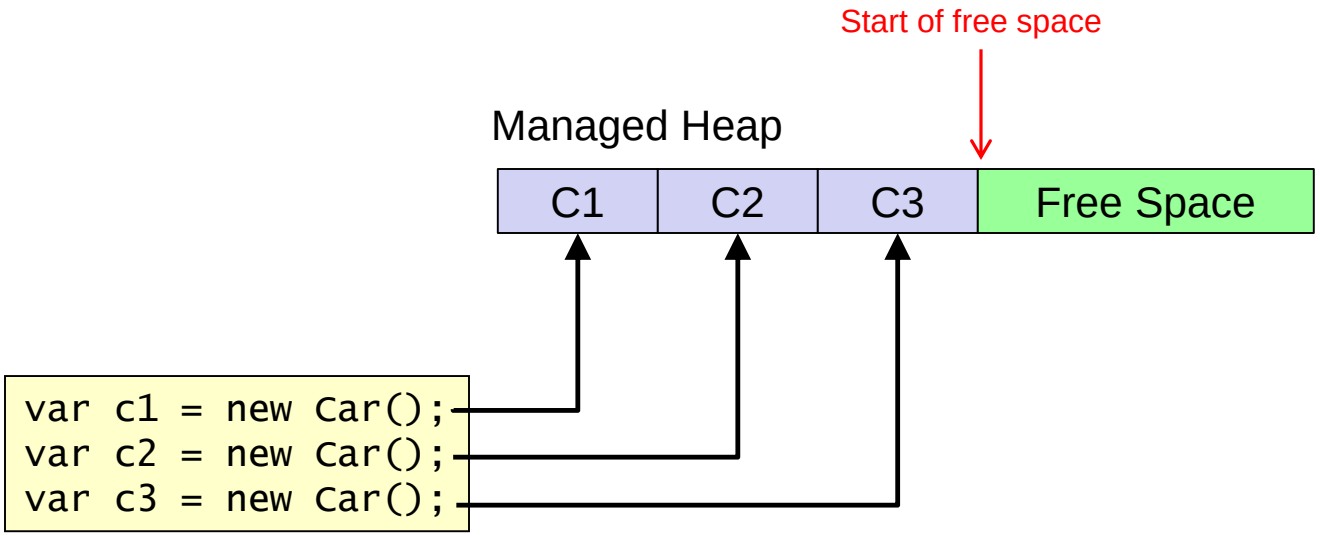
C# client using IVI.NET driver

```
digitizer.Arm.Sources["LAN3“].Detection = ArmSourceDetection.High;
```

Performance of IVI.NET

- **Fewer memory leaks**
- **Reference counting has a cost**
  - Reference count field per-object
  - Increment and decrement called much more frequently than one might think
  - Reference count field must be thread-safe
    - Even more per-object overhead
    - Frequently lock/unlock operations
- **Conventional memory-managed systems (such as C-runtime library) produce highly fragmented memory**
  - Allocation of objects can be expensive
  - Objects spread out in memory => poor locality of reference
- **.NET memory allocation produces very good locality of reference**
  - Object allocation extremely fast
  - Objects allocated close together in time live close together in memory
  - Fewer cache misses and better virtual paging performance

Dynamic Memory Allocation in .NET



[1] *Garbage Collection: Algorithms for Automatic Dynamic Memory Management*, by Richard Jones and Rafael Lins (John Wiley & Sons, 1996)