



# HeuristicLab

A Paradigm-Independent and Extensible  
Environment for Heuristic Optimization

# Programming HeuristicLab

## Basics

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**HEAL**

Heuristic and Evolutionary  
Algorithms Laboratory



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**HEUREKA!**

# Introduction

- HeuristicLab (HL) is quite a big project
- As of 3.3.11:
  - 5 VS solutions containing 187 projects
  - Lines of code: 665.559 + 887.820 (EXT) = 1.553.379 LOC
  - 368 unit tests
  - Quite a lot of feature branches in the SVN repository
- There are certain patterns/concepts that are used throughout all that code

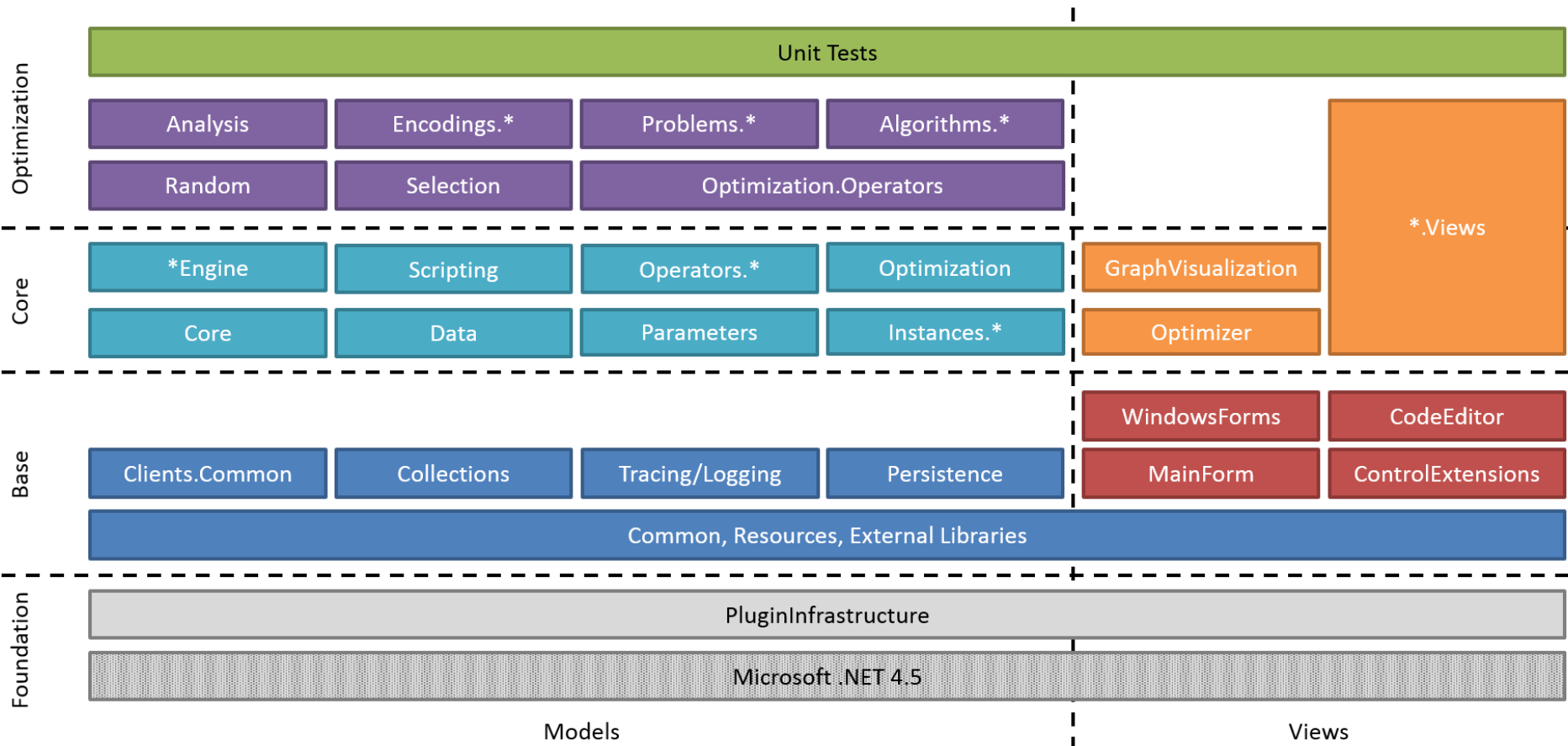
# Extension Points

- HL can be extended in multiple ways
  - Plugins
  - User-Defined algorithm
  - User-Defined problem
  - Programmable operators
  - C# Script
  - Programmable Problem

# Overview

- Plugins
- HL Object Model
- Deep Cloning
- Persistence
- Items
- HL Data Types
- HL Collections
- Content and Views
- ViewHost

# Where are we?



# Plugins

- Every plugin needs to contain a class that inherits `PluginBase`
- If an assembly contains such a class, it is a plugin and loaded by HeuristicLab

```
[Plugin("HeuristicLab.Core", "3.3.9.10037")]  
[PluginFile("HeuristicLab.Core-3.3.dll", PluginFileType.Assembly)]  
[PluginDependency("HeuristicLab.Collections", "3.3")]  
[PluginDependency("HeuristicLab.Common", "3.3")]  
[PluginDependency("HeuristicLab.Common.Resources", "3.3")]  
[PluginDependency("HeuristicLab.Persistence", "3.3")]  
public class HeuristicLabCorePlugin : PluginBase {  
}
```

# Plugins

- PluginDependency must reflect references
- PluginInfrastructure does not have to be included as it is always needed
- We normally use SubWCRev for version information

```
[Plugin("HeuristicLab.Core", "3.3.9.$WCREV$")]  
[PluginFile("HeuristicLab.Core-3.3.dll", PluginFileType.Assembly)]  
[PluginDependency("HeuristicLab.Collections", "3.3")]  
[PluginDependency("HeuristicLab.Common", "3.3")]  
[PluginDependency("HeuristicLab.Common.Resources", "3.3")]  
[PluginDependency("HeuristicLab.Persistence", "3.3")]  
public class HeuristicLabCorePlugin : PluginBase {  
}
```

## Pre-build Event Command Line

```
set Path= %Path%;$(ProjectDir);$(SolutionDir)  
set ProjectDir=$(ProjectDir)  
set SolutionDir=$(SolutionDir)  
set Outdir=$(Outdir)  
|  
call PreBuildEvent.cmd
```

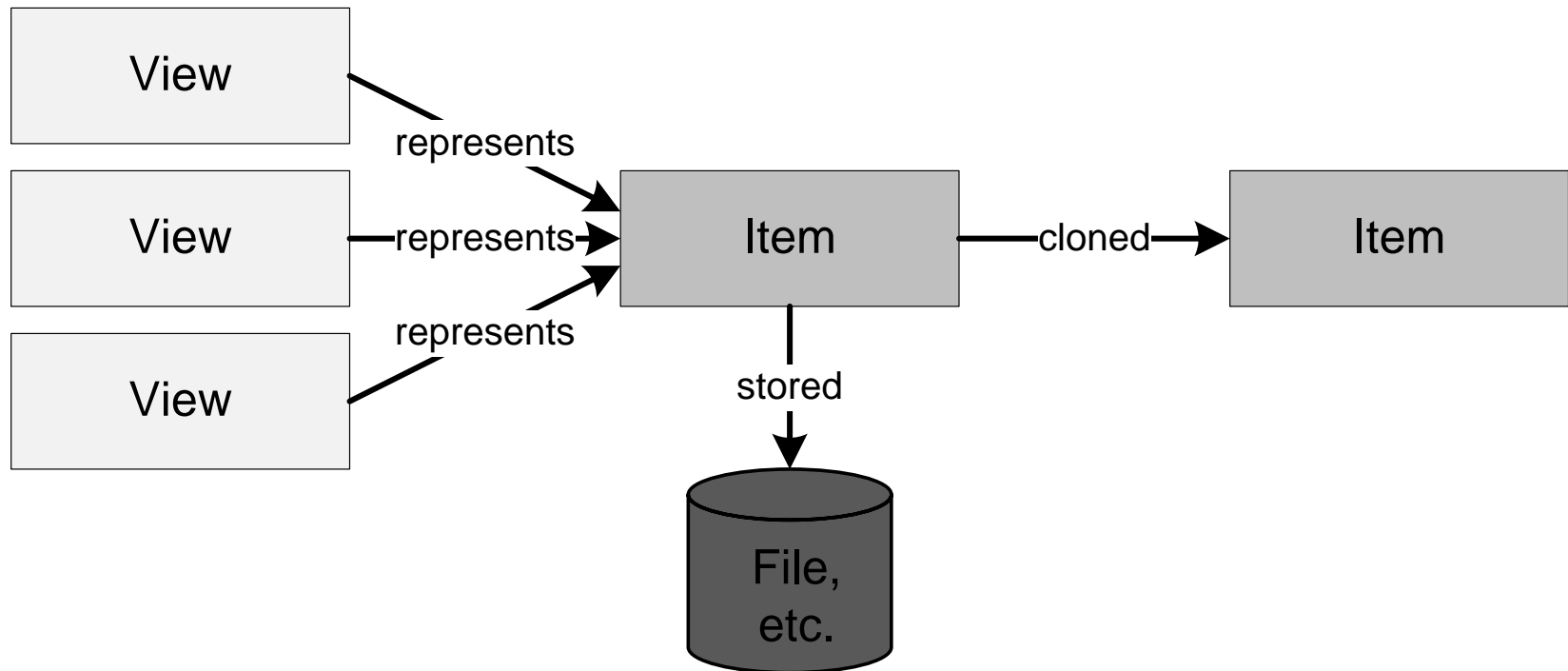
# Some additional remarks



- Plugins are signed with the HeuristicLab key
- Every plugin builds to sources\bin (output path of project should be “..\..\bin\” for all configurations adhering to standard HL folder structure)
- Default namespace and assembly name should/must match plugin description
- There should be x86, x64, Any CPU Debug and Release configurations
- “Copy Local” should be false for all Project/File references



# HL Object Model



# Deep Cloning

- Objects in HeuristicLab that store data and may be displayed in views/collection views should be deep cloneable
- UI allows “copying” of these objects
- Inherit from either IDeepCloneable or Item
- Implement interface and cloning constructor
- Actual cloning happens in the cloning constructor

# Deep Cloning

Item implements  
IDeepCloneable

```
public class Log : Item, ILog, IStorableContent {  
    protected Log(Log original, Cloner cloner)  
        : base(original, cloner) {  
        this.messages = new List<string>(original.messages);  
        this.maxMessageCount = original.maxMessageCount;  
    }  
  
    public override IDeepCloneable Clone(Cloner cloner) {  
        return new Log(this, cloner);  
    }  
}
```

Call cloning constructor  
which implements the  
cloning

# Persistence

- HL provides its own serialization mechanism
- A class that should be serializable has to be marked with the `[StorableClass]` attribute
- Properties that should be serialized have to be marked with the `[Storable]` attribute
- `StorableConstructor` has to be implemented
- Optional: Define Hooks with attribute `[StorableHook]` to react on loading/saving events
- Implement `IStorableContent` to signal that this is a root object

# Persistence

```
[StorableClass]
```

```
public class Log : Item, ILog, IStorableContent
```

Properties that should be stored in a file have to be marked with [Storable]

```
[Storable]
```

```
protected IList<string> messages;  
public virtual IEnumerable<string> Messages {  
    get { return messages; }  
}
```

```
[Storable]
```

```
protected long maxMessageCount;  
public virtual long MaxMessageCount {  
    get { return maxMessageCount; }  
}
```

Mandatory storable constructor. Used by the persistence when deserializing.

```
[StorableConstructor]
```

```
protected Log(bool deserializing) : base(deserializing) { }
```

# Items

- Items have
  - A name
  - A description
  - An icon
  - ToStringChanged and ItemImageChanged events
- All Items are DeepCloneables and Storable
- Most Items are marked as IContent to allow displaying in views
- Use [Item] attribute to set name and description

# Items

```
[Item("Log", "A log for logging string messages.")]
```

```
[StorableClass]
```

```
public class Log : Item, ILog, IStorableContent {
```

```
    public string Filename { get; set; }
```

```
    public static new Image StaticItemImage {
```

```
        get { return HeuristicLab.Common.Resources.VSImageLibrary.File; }
```

```
    }
```

# HL Data Types

- Located in HeuristicLab.Data (and corresponding views in Data.Views)
- Wrap standard .NET data types and provide functionality necessary for UIs:
  - ValueChanged Event
  - Parsing of strings
  - Validation
- DataTypes include
  - IntValue, DoubleValue, PercentValue, StringValue,...
  - Ranges, Arrays, Matrices



# Collections



- Located in HeuristicLab.Collections/Core (and Core.Views for the corresponding views)
- Same as with data types, provide UI friendly wrappers for .NET collections (e.g. additional events)
- There are Lists, Arrays, Sets, Dictionaries and read-only collections
- Most are designed for Items

# Content and Views



- HL provides views for all data types, collections and much more (including input validation and updates)
- Views display (and manipulate) Content
- Use [Content] attribute to define the type of Content a view can display
- Inherit UserControl from AsynchronousContentView or ItemView
- Content is set by HeuristicLab or manually
- React on events (e.g. OnContentChanged, (De)RegisterContentEvents, ...)

# Content and Views

```
[View("Log View")]
[Content(typeof(Log), true)]
[Content(typeof(ILog), false)]
public partial class LogView : ItemView {
    public new ILog Content {
        get { return (ILog)base.Content; }
        set { base.Content = value; }
    }
    protected override void DeregisterContentEvents() {
        Content.Cleared -= new EventHandler(Content_Cleared);
        Content.MessageAdded -= new EventHandler<EventArgs<string>>(Content_MessageAdded);
        base.DeregisterContentEvents();
    }
    protected override void RegisterContentEvents() {
        base.RegisterContentEvents();
        Content.Cleared += new EventHandler(Content_Cleared);
        Content.MessageAdded += new EventHandler<EventArgs<string>>(Content_MessageAdded);
    }
    protected override void OnContentChanged() {
        base.OnContentChanged();
        logTextBox.Clear();
        if (Content == null) {
            logTextBox.Enabled = false;
        } else {
            logTextBox.Enabled = true;
            if (Content.Messages.FirstOrDefault() != null)
                logTextBox.Text = string.Join(Environment.NewLine, Content.Messages.ToArray());
        }
    }
}
```

Defines what Content can be displayed with this view

# Displaying Content



- Manually:
  - `Log log = new Log();`
  - `LogView logview = new LogView();`
  - `logview.Content = log;`
- In an own tab using discovery:
  - `MainFormManager.MainForm.ShowContent(log);`
- Using a ViewHost

# ViewHost

- ViewHost is a special ContentView that changes it's appearance based on the type of Content
- [Content] attribute marks a view for a certain content type
- ViewHost looks up the view based on the Content type and uses it to display the Content
- Useful for views that can contain different Content types or collection views

# Useful Links



<http://dev.heuristiclab.com/trac/hl/core/wiki/UsersHowtos>

<http://dev.heuristiclab.com/trac/hl/core/wiki/Publications>

[heuristiclab@googlegroups.com](mailto:heuristiclab@googlegroups.com)

<http://www.youtube.com/heuristiclab>