Compose

Aspect-Oriented Composition Tools for Composition Filters

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Introduction

About Composition Filters

- **Goal: support and reason about robust, scalable, composition**
  - **most AOP is language-specific**
    - CFs are a language-independent extension
    - But the native type systems do not like us always..
  - **most AOPLs allow breaking encapsulation**
    - CFs do only ‘interface programming’
    - this even allows for extending precompiled objects..
  - **declarative specifications**
    - support conflict detection & verifying consistency
    - including reasoning about semantics

Introduction

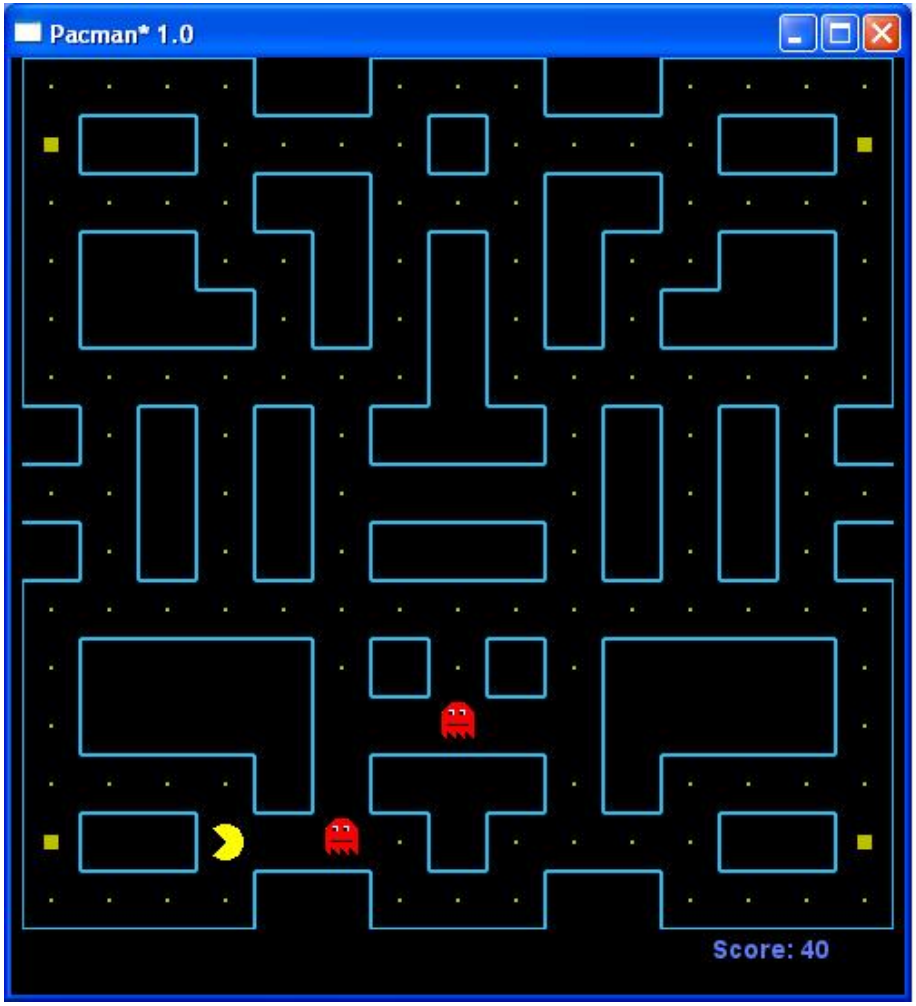
About Compose*

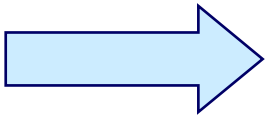
- **A platform for experimentation & proof of concept**
  - but also for third parties
- **(mostly) independent of target platform**
- **Supports multiple target languages/component models**
- **Framework supports any (mixed) approach from interpreter to inlining compiler**

Outline of this presentation

- Introduction
- Example Application: Pacman
- Composition Filters in a Nutshell
- The Compose* tool
- Demonstrating some Features

The example application: Pacman





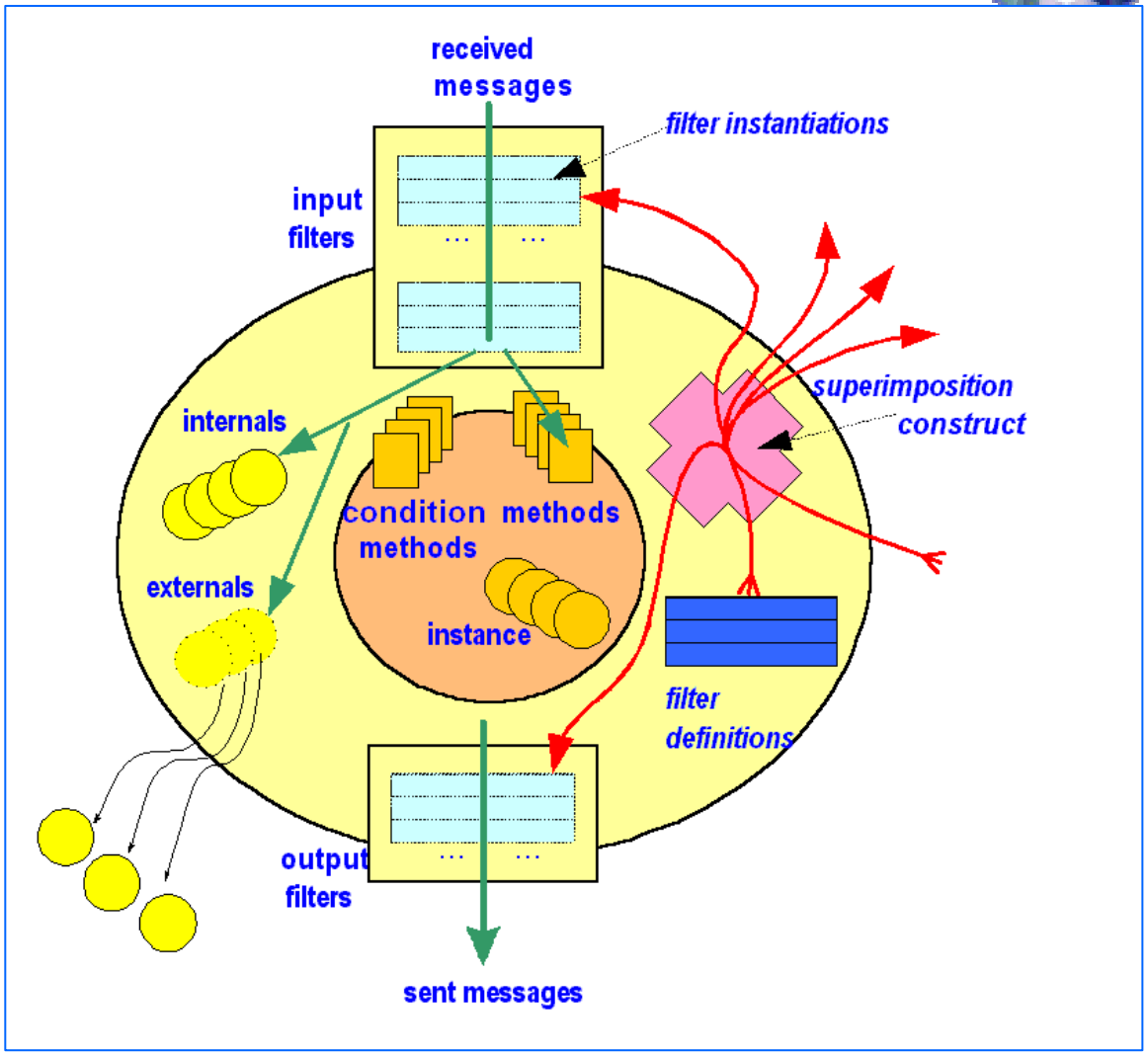
The Core Design

```
Public Class Score
// This is Visual B
    Private score A

    Public Function
        Return scor
    End Function

    Sub increase(By
        score = sco
    End Sub

    Sub setValue(By
        score = poi
    End Sub

End Class
```

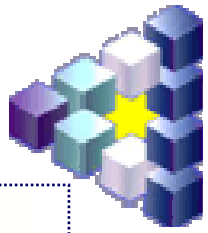
```
package pacman;

public abstract class Glyph
// This is Java (J#)
{
    private int speed = 0;
    private int direction = 3;
    protected int x = 0;
    protected int y = 0;
    protected int dx = 0;
    protected int dy = 0;
    protected int vy = 0;
    protected int vx = 1;
    protected World world;

public Glyph(World world)
    {
        this.world = world;
        this.reset();
    }

 ...
```

Composition Filters in a Nutshell

- **filters**
  - ❖input~ & output~
- **internals & externals**
- **conditions**
- **superimposition**
  - ❖selectors
  - ❖filtermodules
  - ❖binding



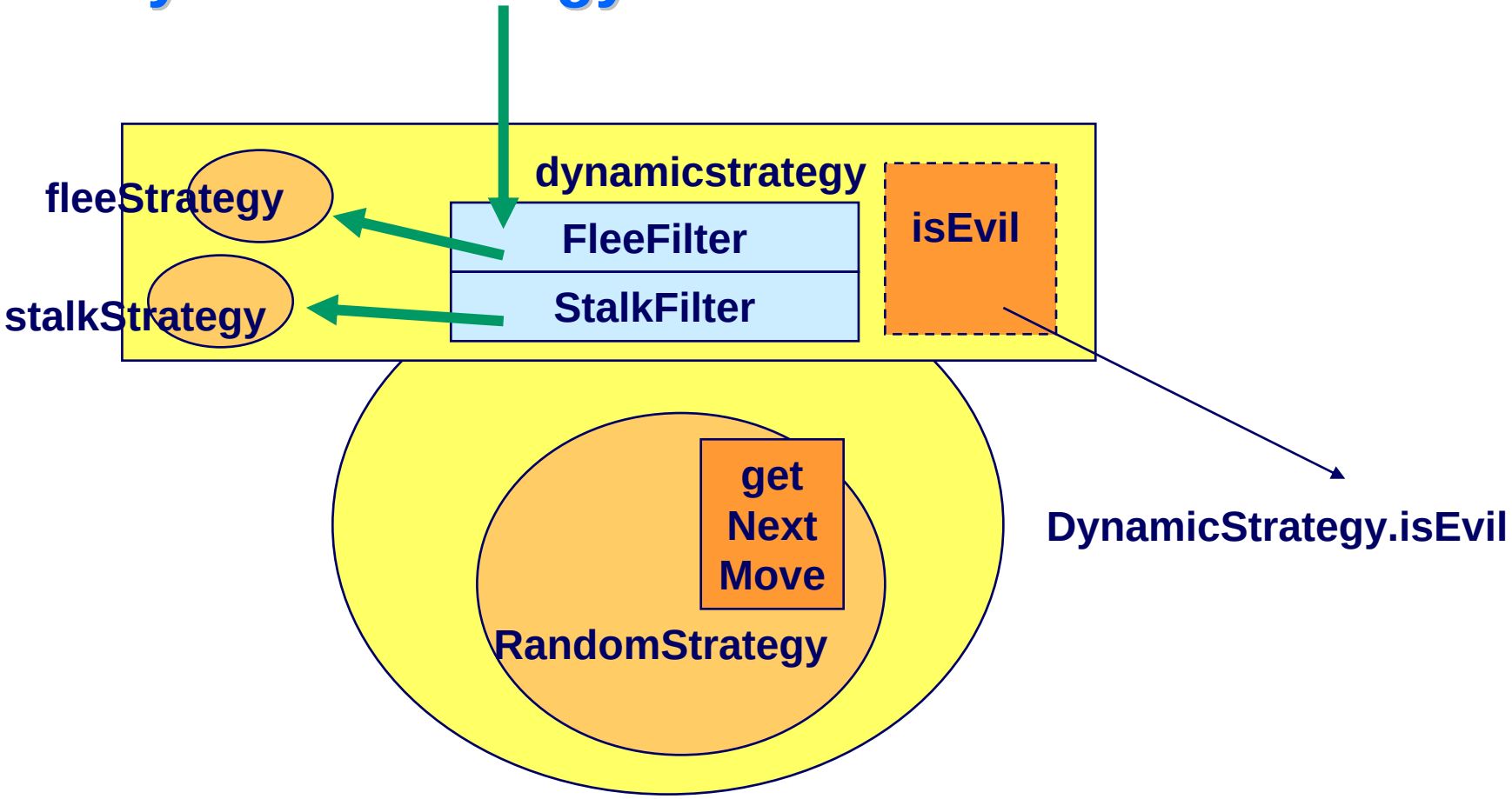
Example Concern DynamicStrategy



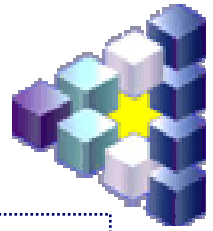
```
filtermodule dynamicstrategy {
      internals
            flee_strategy : FleeStrategy;
            stalk_strategy:StalkStrategy;
   conditions
         isEvil
   inputfilters
         flee_filter : Dispatch = { isEvil =>
              <*.getNextMove>flee_strategy.getNextMove };
         stalk_filter : Dispatch = { True =>
              <*.getNextMove>stalk_strategy.getNextMove };
      }
```

```
superimposition{
  selectors   strategy = { *=RandomStrategy };
  conditions  strategy <- isEvil;
  filtermodules  strategy <- dynamicstrategy;
}
```

Picture After Superimposition of DynamicStrategy

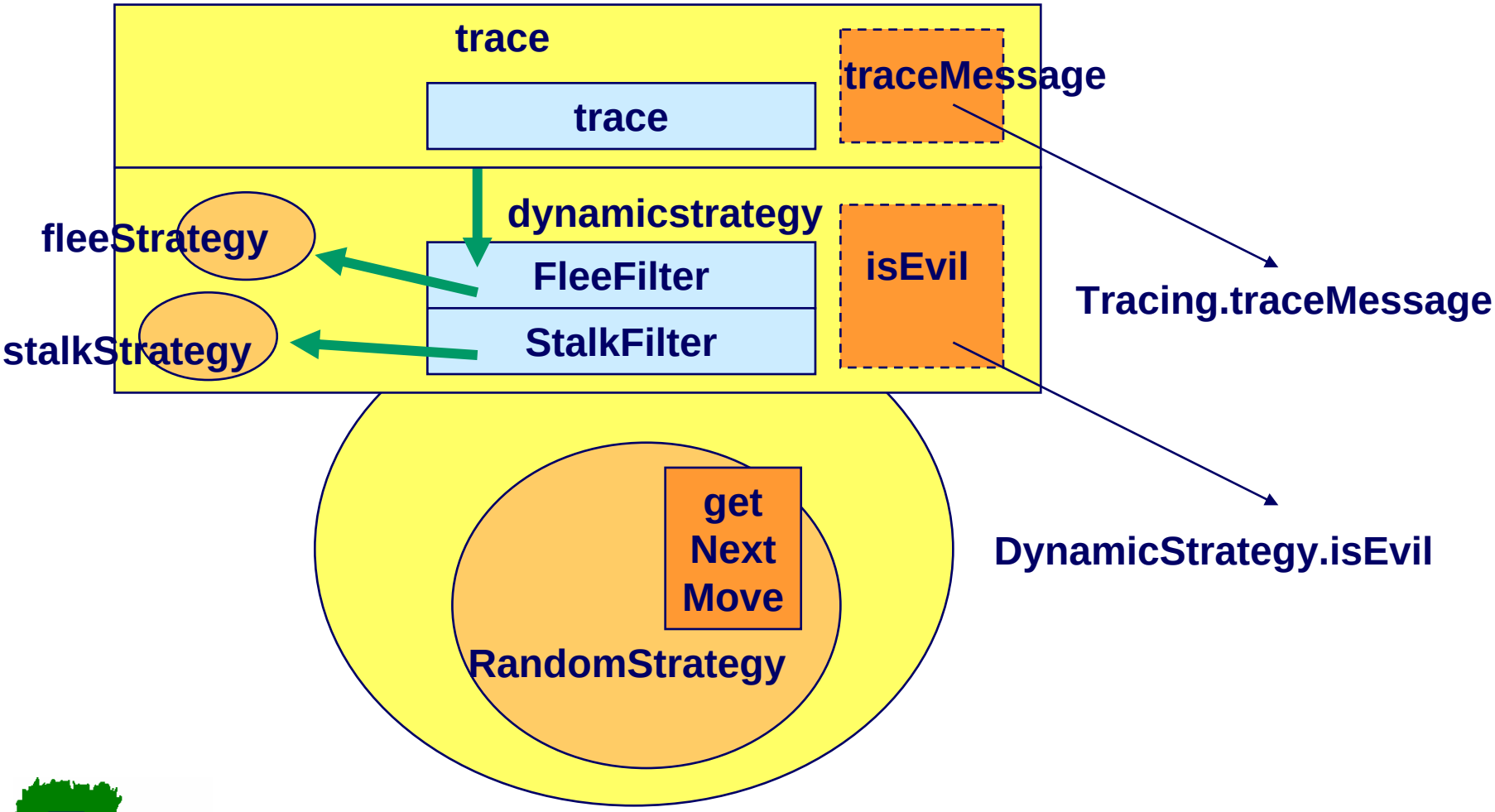


Example Concern Tracing



```
concern Tracing{
  filtermodule trace{
    inputfilters
      trace: Meta = { <*.*>inner.traceMessage };
  };
  superimposition {
    selectors
      tracedItems = {*=pacman_Ghost,
                     *=pacman_RandomStrategy };
    filtermodules
      tracedItems <- trace;
    methods
      tracedItems <- inner.traceMessage; //
  };
…
```

Picture after superimposition of Tracing



Implementation of Composition Filters

- **Composition Filters**
  - **Compose* is a modular language extension**
  - **Current target: extend .NET**
- **Implementation**
  - **implementation is crucial**
    - for our own verification
    - for the trust of the community
    - for the learning process internal/external
  - **many past implementations**
    - throw-away prototypes; wasted effort

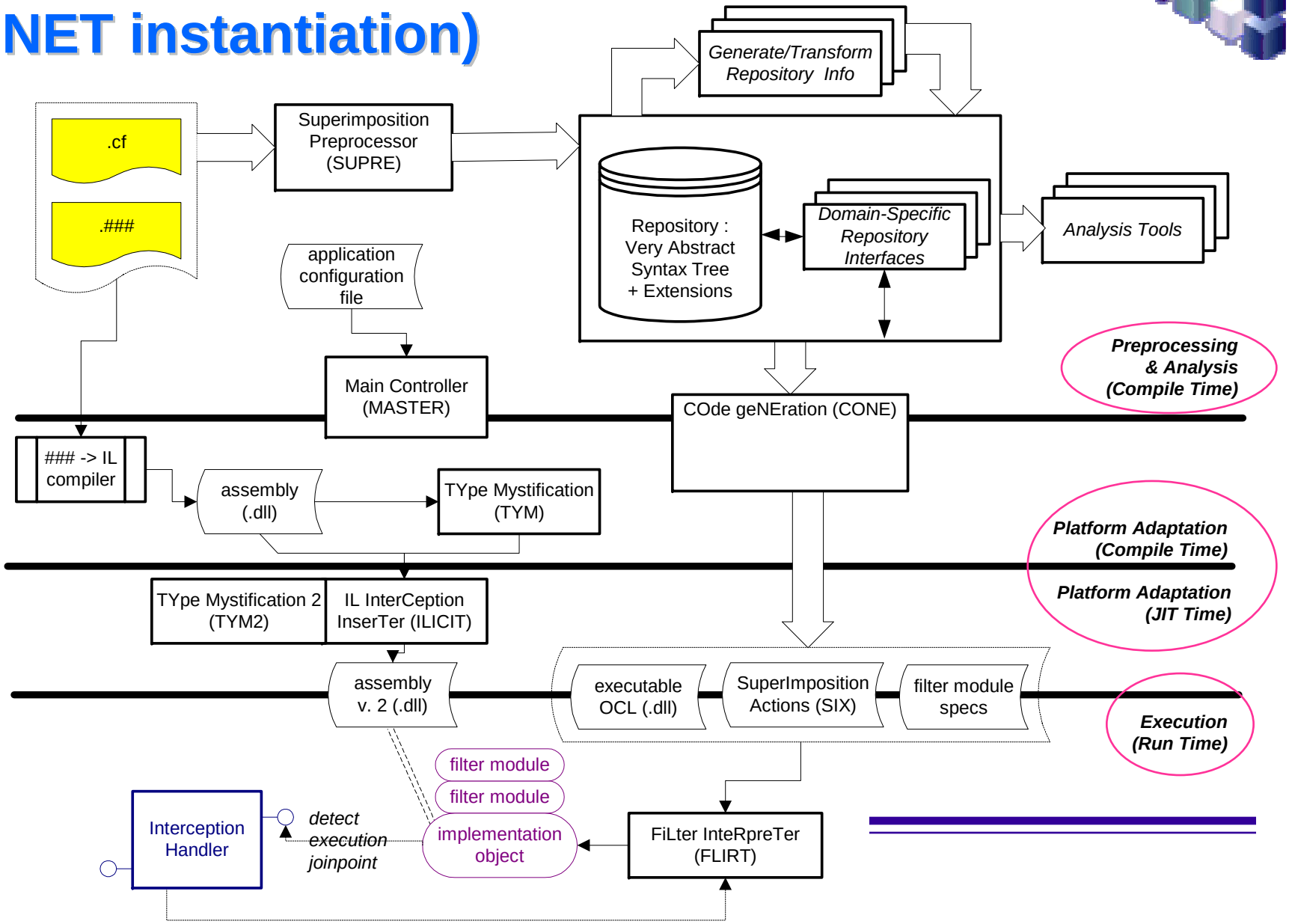
Current project:

Compose*

- A platform for experimentation & proof of concept
  - but also experimentation for third parties
- (mostly) platform independent
- target language/component model independent (multiple)
- targeting any approach from interpreter to inlining compiler
- currently 6 MSc students active, 1 finished
- Current state: pre-alpha (…)

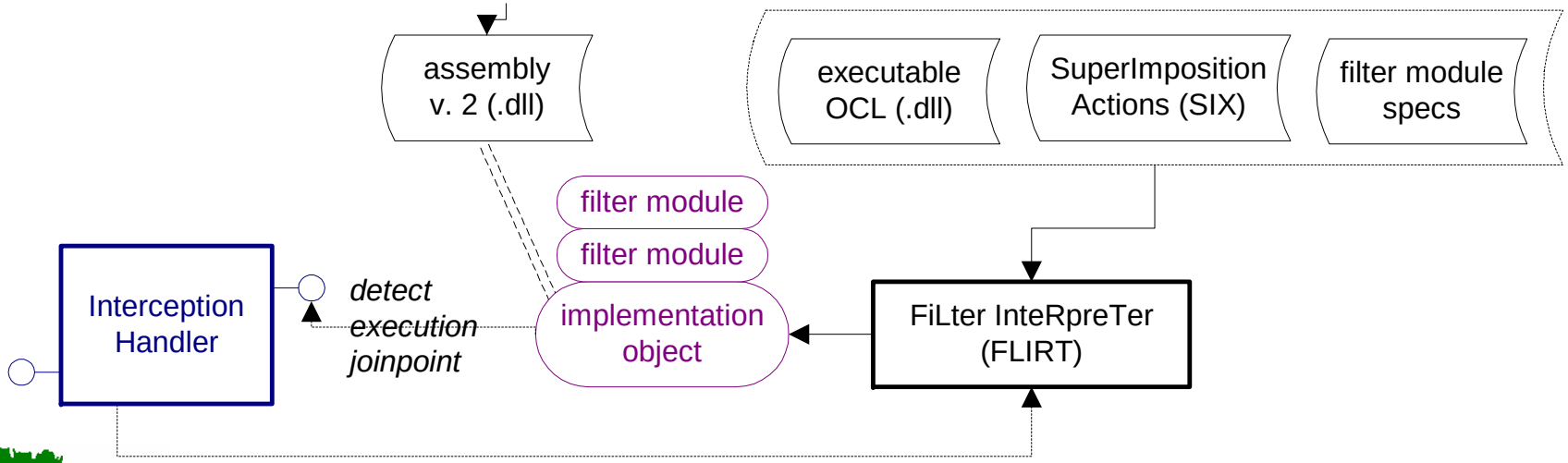
About the Architecture

(.NET instantiation)

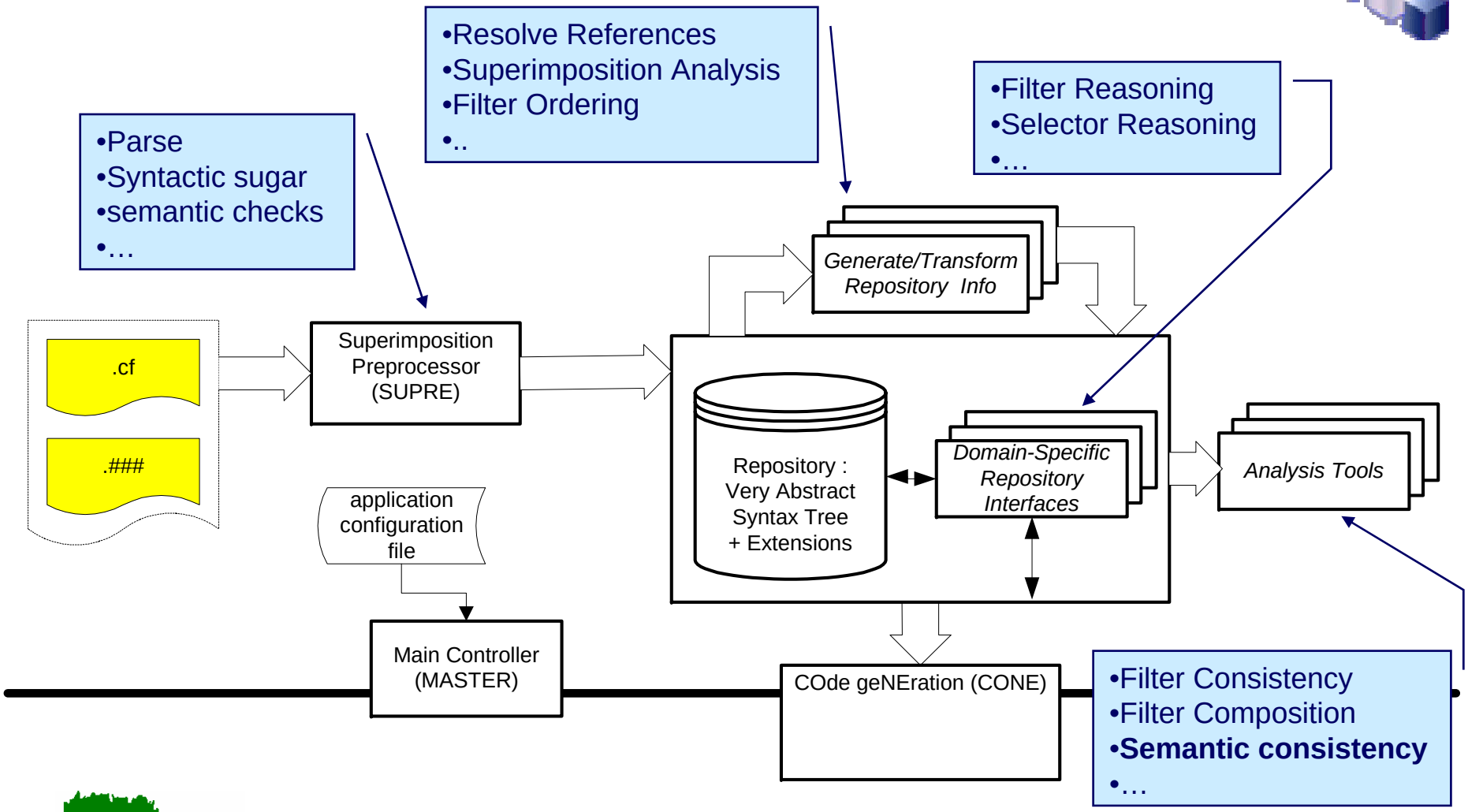


Execution Model

- **Currently: interpreter**
  - of the filtering & superimposition only!
  - focus on functionality
  - experiment with dynamic composition

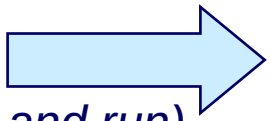


Preprocessing & Analysis



Some Important Characteristics of Compose*

- Language/Model & Platform are variable
  - e.g. .NET (any .NET language), Java (JVM), C, ..
  - The filter specifications remain unaffected!
- Various execution engines possible:
  - only for filters & superimposition
  - interpreter … code transformation … inlining compiler
- Set of Analysis Tools
  - e.g. superimposition analysis, semantic conflict analysis
- Architecture is a repository-centered toolkit
  - adding e.g. new analysis tools is flexible



(make and run)

TRESE

Multi-language Support

How does it work?

- **The filter specifications are language independent**
  - so reuse base and aspect code in any language.
- **Notations are based on UML and OCL**
- **.NET has a language-agnostic component model; the implementation is ‘for free’**
- **But: the native compilers have to compile against enhanced interfaces due to introductions!**

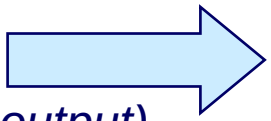
Demonstration of some Features:

Filter Reasoning ('FIRE')

- The Filter Language is declarative
  - limited expressiveness, e.g. not Turing-complete
  - domain specific semantics are encapsulated in the filter type

```
flee_filter : Dispatch = { isEvil =>
        <*.getNextMove>flee_strategy.getNextMove };
```

  - hence we can 'predict' when a filter (or a composition of filters) will do what



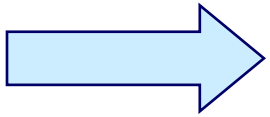
(FIRE output)

Demonstration of some Features:

Filter Composition ('FILTH')

- **As filtermodules are superimposed upon the same join point, there are several ways to compose them, such as ordering.**
- **this is not in the language (yet), but as a separate specification:**
  - define individual ordering constraints between superimposed filtermodules
- **if not restrained, all possible orderings are allowed**

(FILTH output before and after constraint)

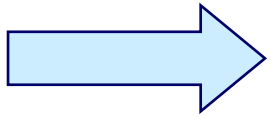


Demonstration of some Features:

Semantic Reasoning ('SECRET')

- **Since:**
  - Filters are declarative
  - Filter types encapsulate (domain-specific) behaviour
- **By annotating the filter types with a (common) behavioral model/abstraction**
- **And analyzing superimposition and possible orderings**
- **We can detect *possible* semantic conflicts**

(SECRET output)



Conclusion

- Filters aim at robust, predictable composition
  - they are declarative, language independent and highly composable
- Compose* is a tool/framework for composition filters
  - architecture supports multiple targets, repository-based set of analysis tools
- We demonstrated a few simple examples and *current* output of the tools

Conclusion

Future

- beta-release this summer
- open source (composestar.sf.net)
- things to do before release:
  - stabilize & missing features (e.g. filter types)
  - improve semantic detection by integrating FIRE (filter reasoning) and SECRET (semantic reasoning)
  - full integration with .NET
- Subsequent releases:
  - full OCL support for conditions & selectors (PCDs)
  - more advanced aspect composition at shared join points,
    - specifications integrated with language.
  - support abstract specifications of semantics in ACTs & user-defined filter types
  - experiment with dynamic weaving

Credits

The Development Team

Lost Puppies After this slide

Motivation

- **The OO model has known deficiencies,**
  1. **need for additional mechanisms, e.g. AOP techniques**
     - solving it by extending CIL is not feasible because languages do not support new concepts
     - solving this at the language level requires extending all prog. languages
     - → use selection of email example to illustrate -an AOP- problem?
     - → solution is a language neutral modular extension to CIL
  2. ***new challenges caused by language-heterogeneous composition (?)***
     - because languages have different abstractions
     - semantic consistency checks really hard (n^2 language combinations)
  3. **more advanced consistency checking needed, e.g. for accidental composition conflicts**

Characteristics of CF approach

- most AOP is language-specific
  - CFs are a language-independent extension
  - But the native type systems do not like us always..
- most AOPLs allow breaking encapsulation
  - CFs do only ‘interface programming’
  - this even allows for extending precompiled objects..
    - but CFs are not meant for ‘patching’
- declarative specifications
  - support conflict detection & verifying consistency