Hierarchical Layer-based Class Extensions in Squeak/Smalltalk

Matthias Springer Hidehiko Masuhara Robert Hirschfeld

Dept. of Mathematical and Computing Sciences, Tokyo Institute of Technology
Hasso Plattner Institute, University of Potsdam

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Overview

Introduction

- **Class Addition:** Add new method to class
- **Class Refinement:** Change (overwrite) existing method of class
- Use Cases
  - Convenience methods (e.g., `2.hours + 30.minutes`)
  - Bug fixing (*monkey patching*)
  - Multi-dimensional separation of concerns
    ($\rightarrow$ modular understandability)
  - Adding new operations to existing classes
    (c.f. *expression problem*, alternative to Visitor design pattern)
- Popular in Ruby and Smalltalk

Matriona Module System

- Module system for Squeak/Smalltalk
- Supports class nesting and class parameterization

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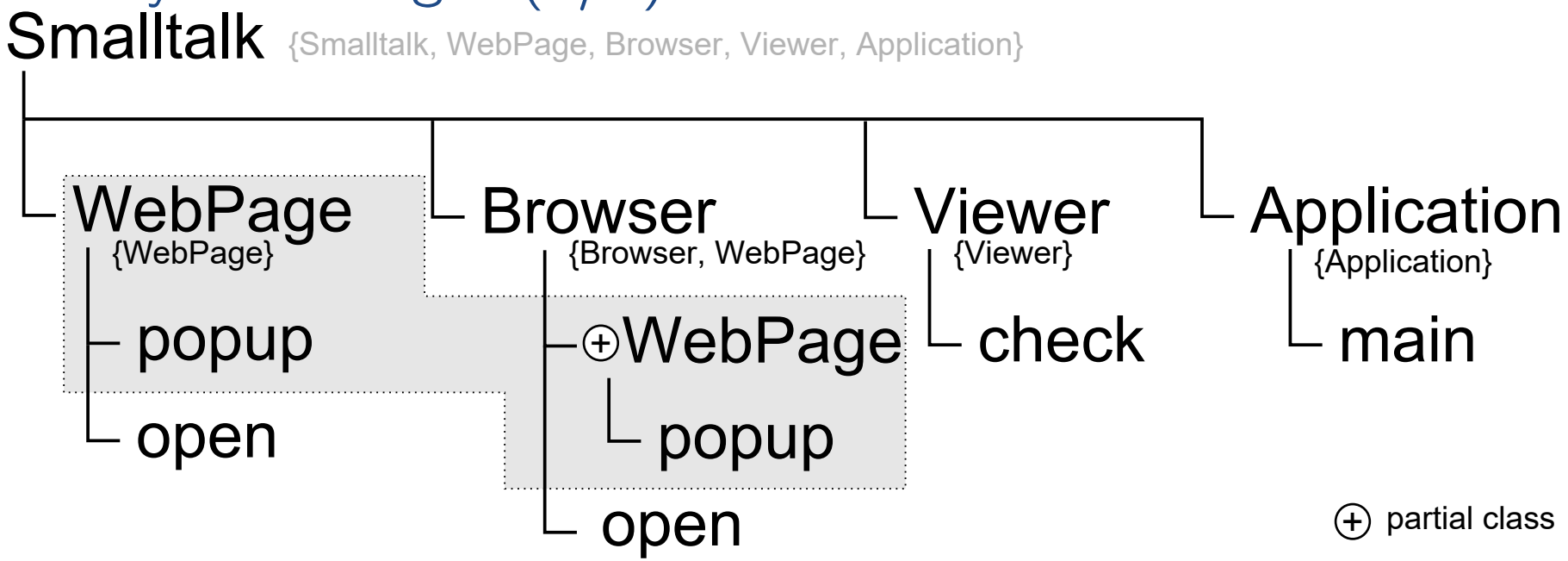
Overview

High-level Idea

Class extensions are . . .

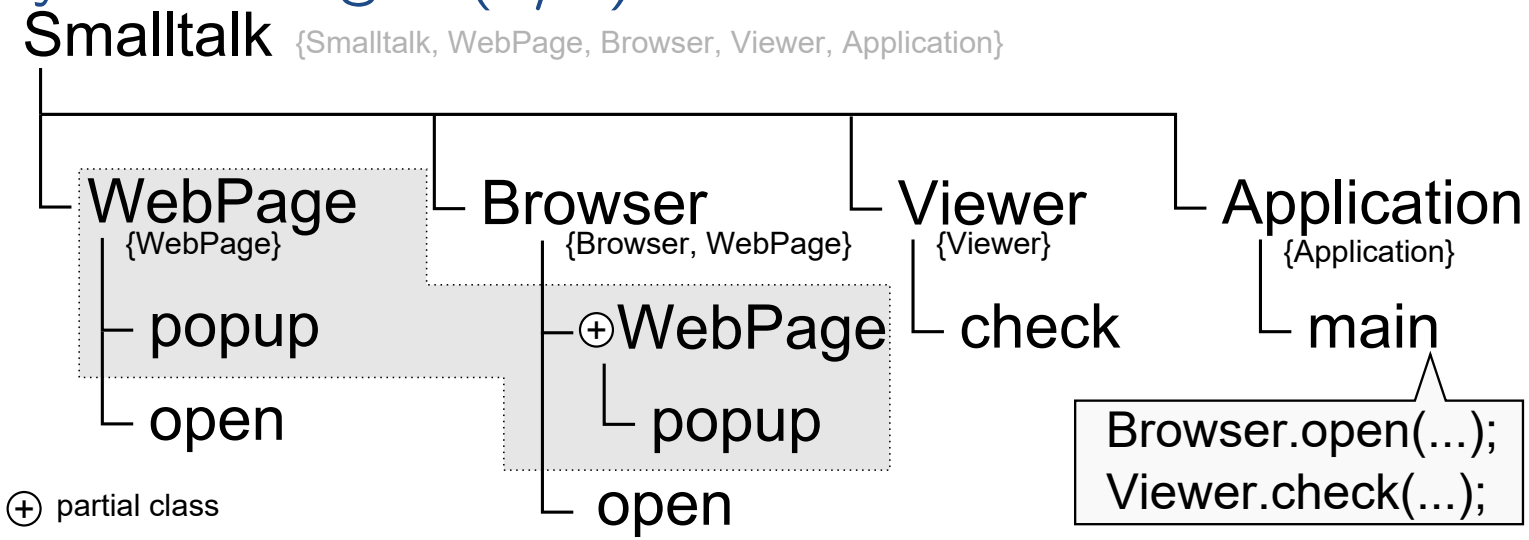
- class members (like methods and nested classes)
- subject to *local rebinding*: avoid breaking unrelated (*black box*) code
- active in a certain scope (*locality of changes*)
  - Explicit activation: class extension specifies in which parts of the program it should be active
  - Import activation: other class *requests* a class extension (mixins)
  - Hierarchical activation: class extension is active in all nested classes
- layered: multiple class extensions can be active at the same time
- (de)activated similar to layers in context-oriented programming (**layer activation stack**)

Locality of Changes (1/3)



- Every class extension belogs to a *partial class*
- Class is activated if one of its methods is executing (e.g., `Browser.open` → `Browser`)
- *Scope* of class `Browser`: determines how long `Browser`'s class extensions will remain active (*deactivation* only)
- **Intuition:** *scope*(C) is the set of classes which are known to be compatible with C's extensions

Locality of Changes (2/3)



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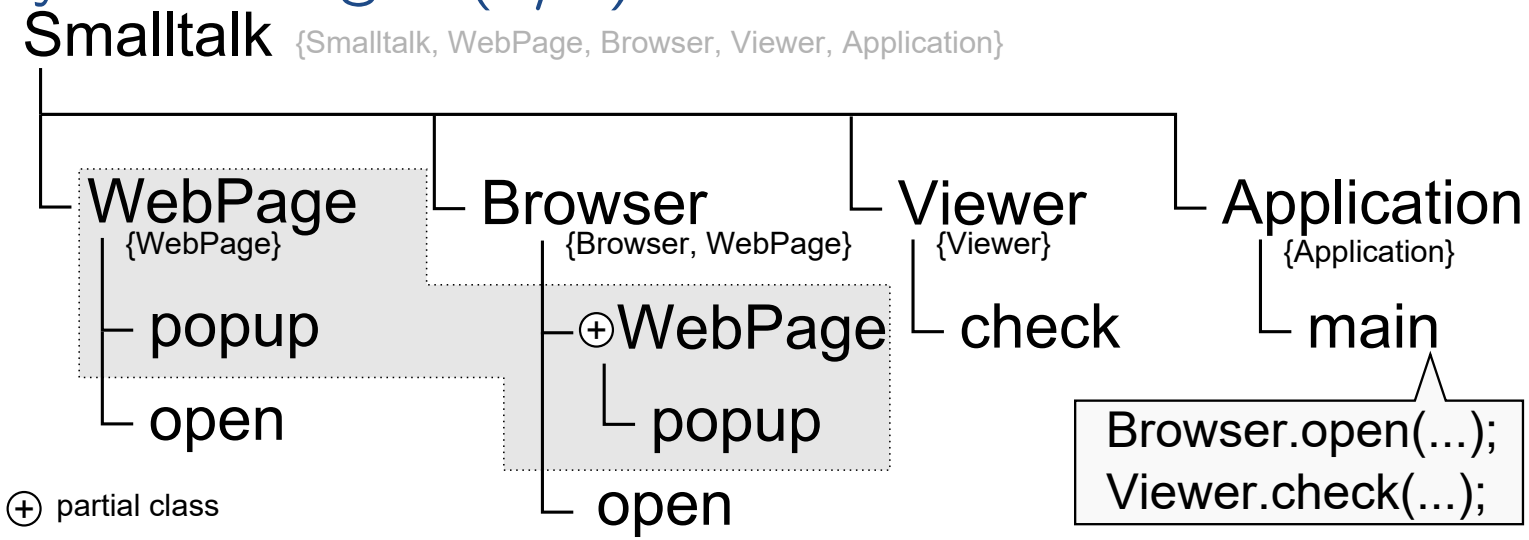

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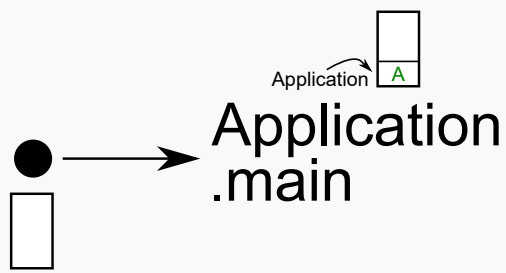

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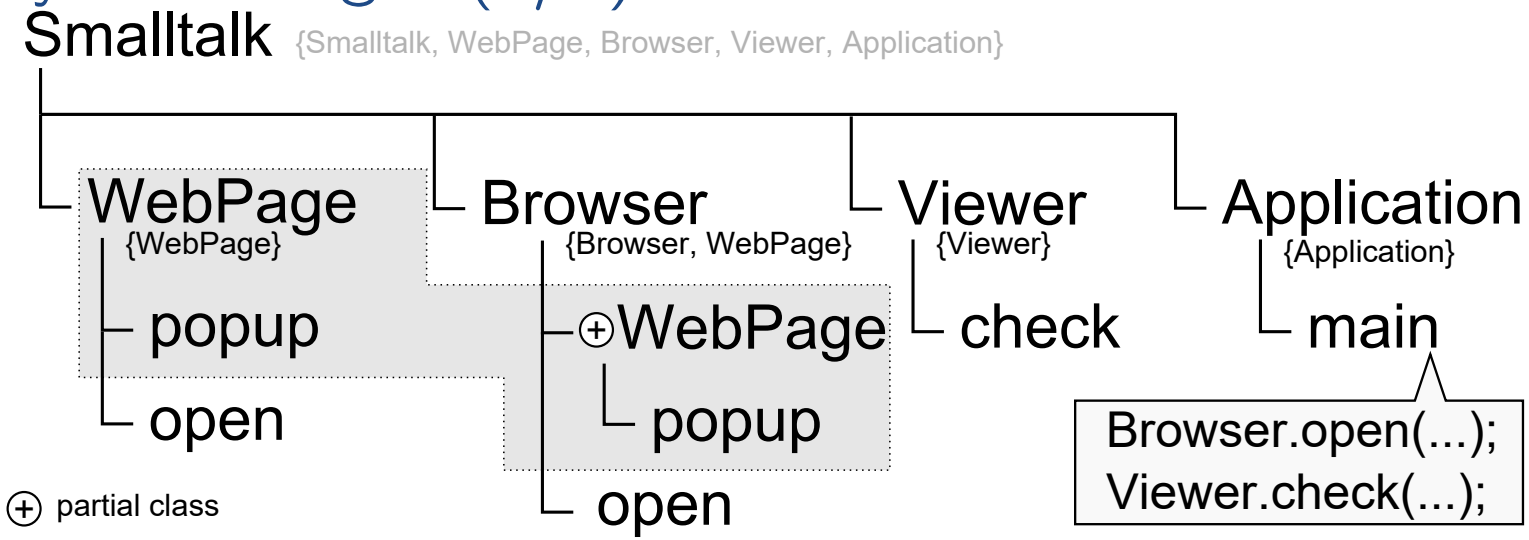

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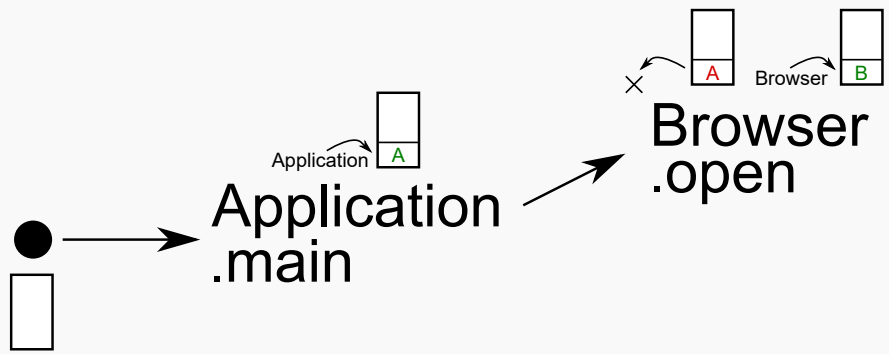

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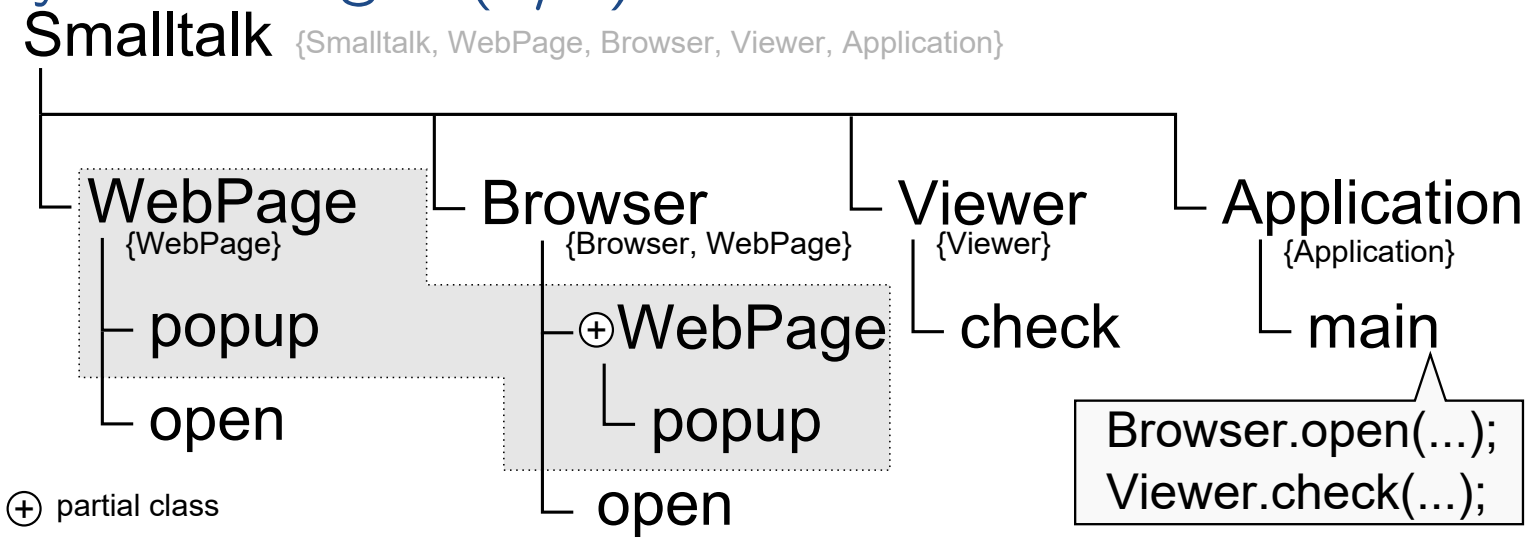

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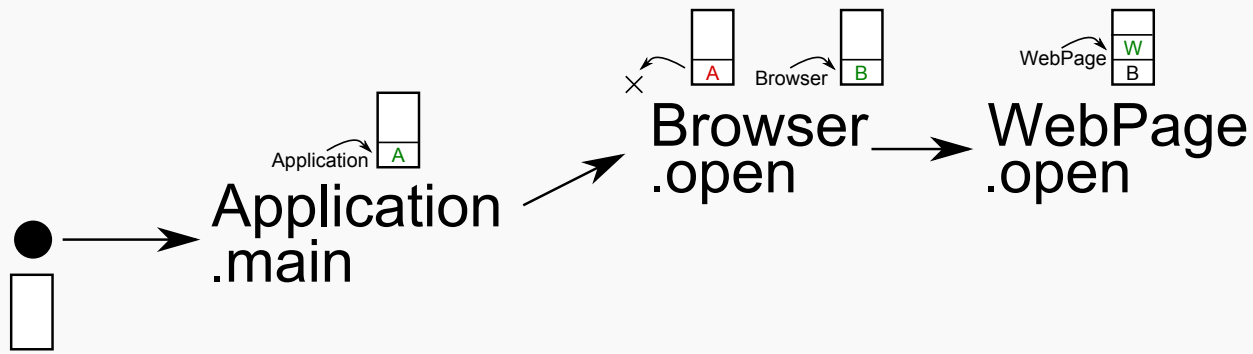

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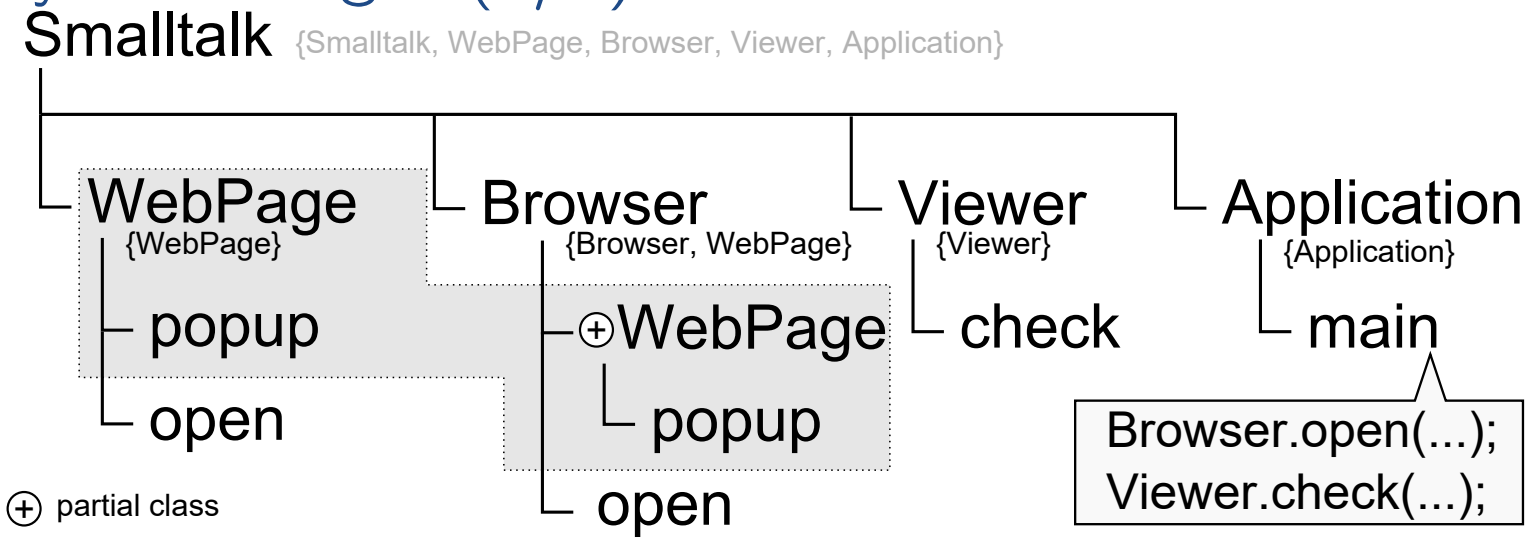

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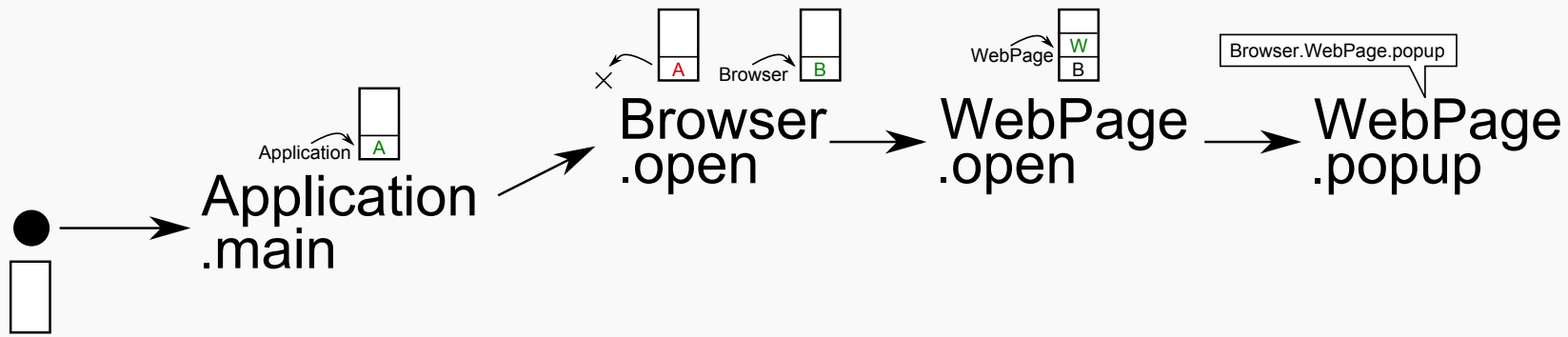

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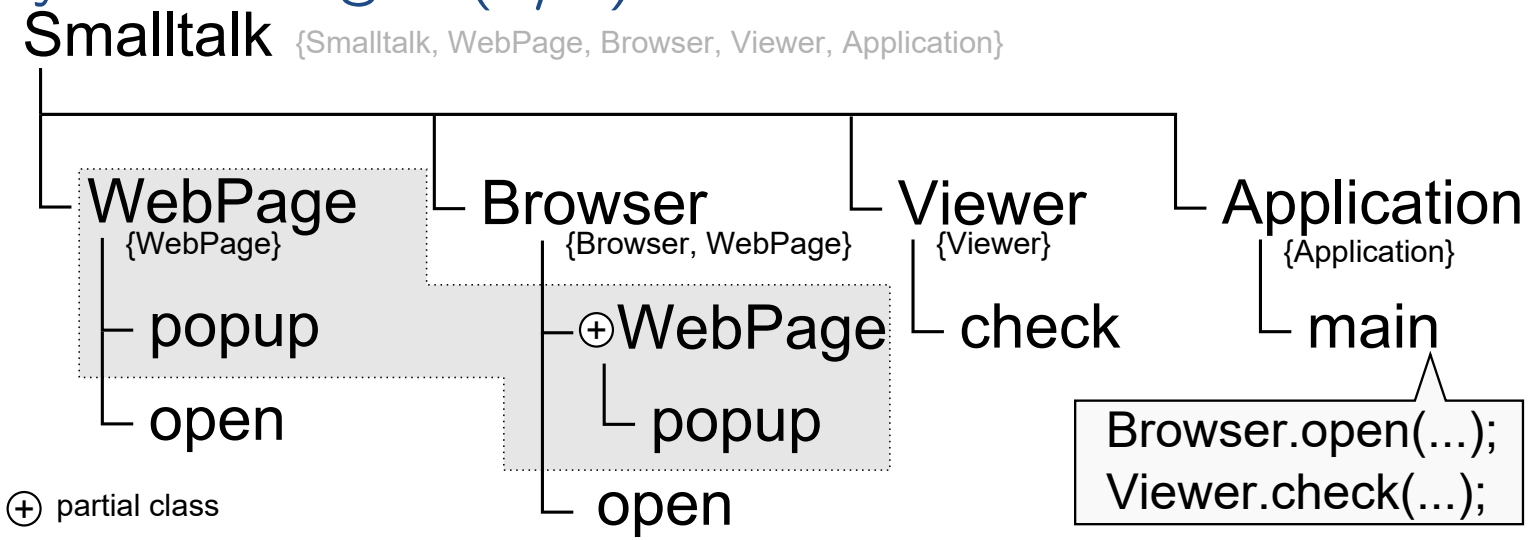

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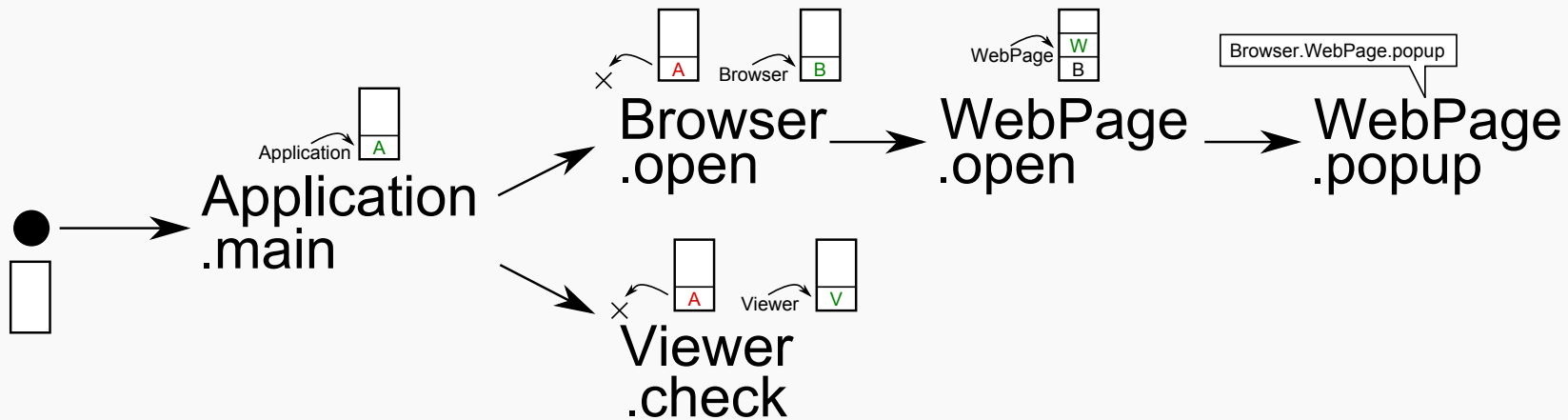

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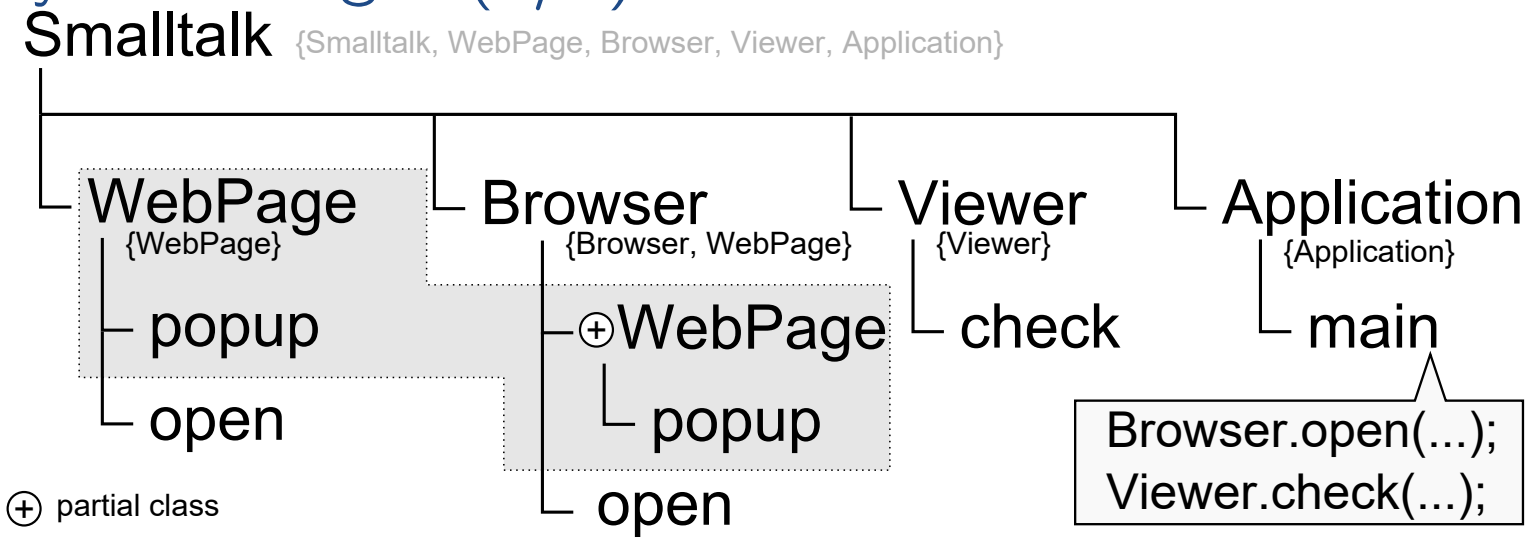

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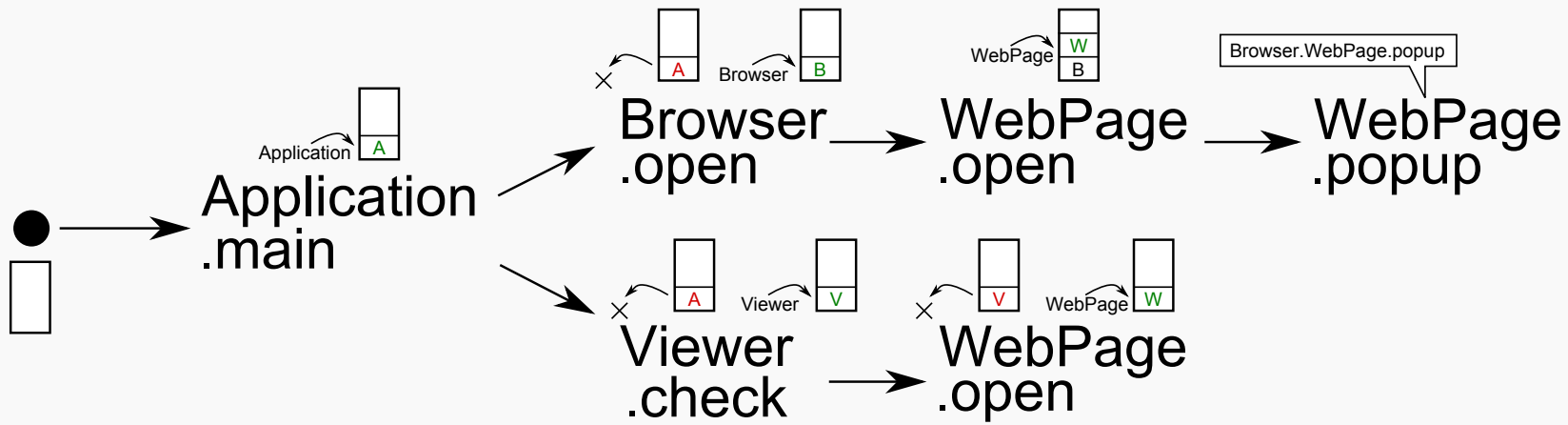

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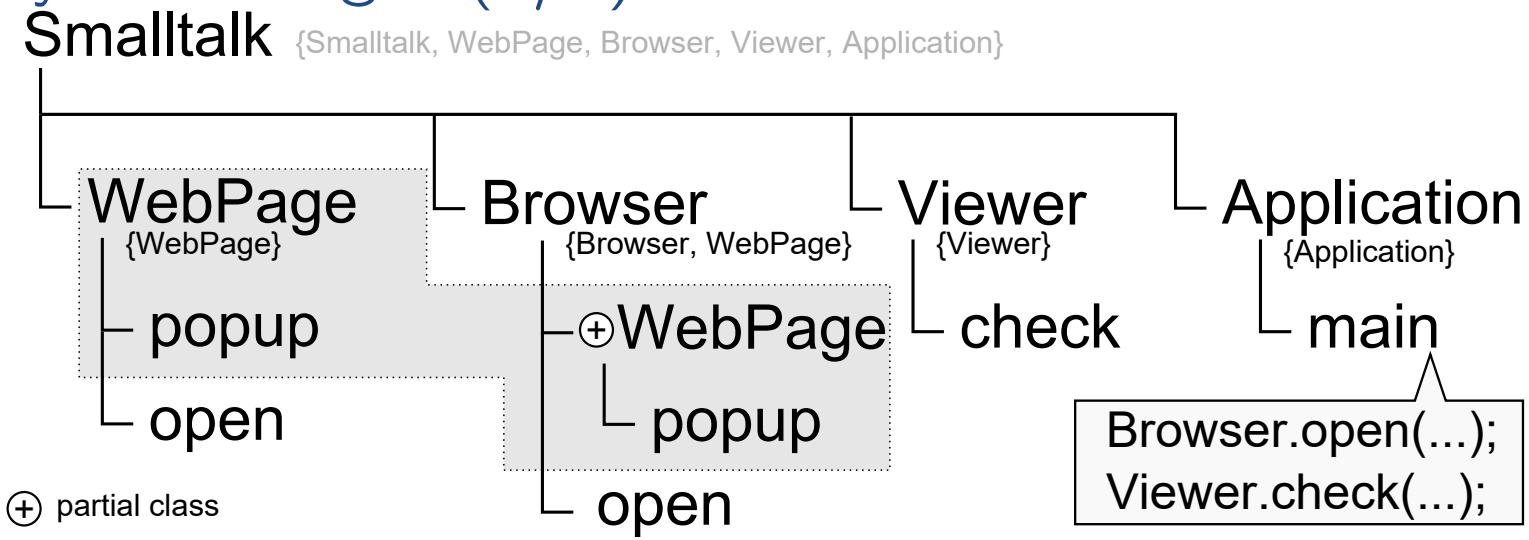

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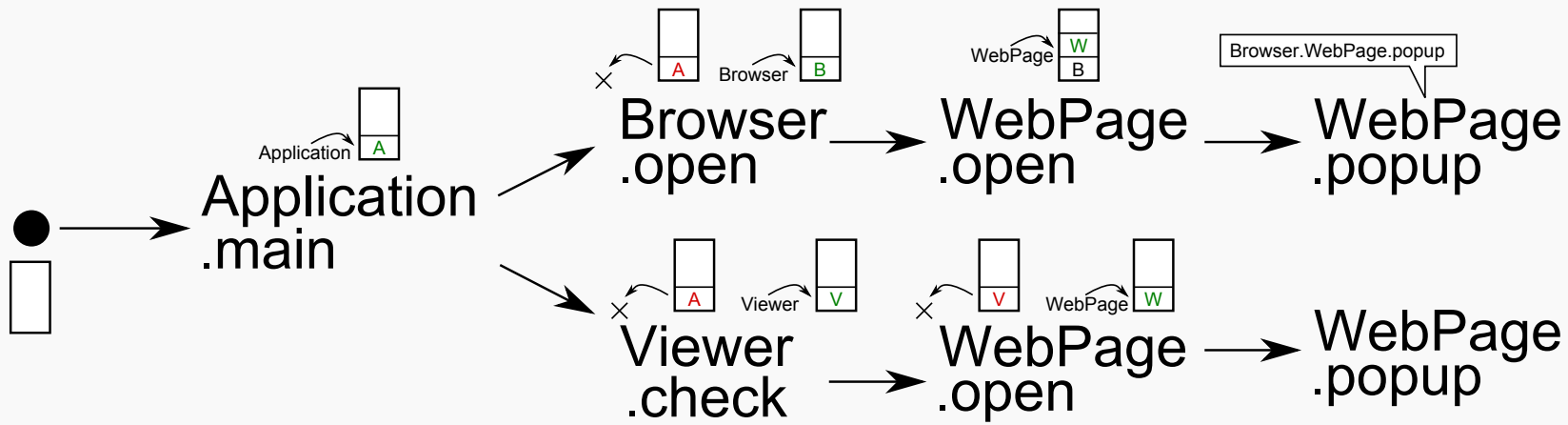

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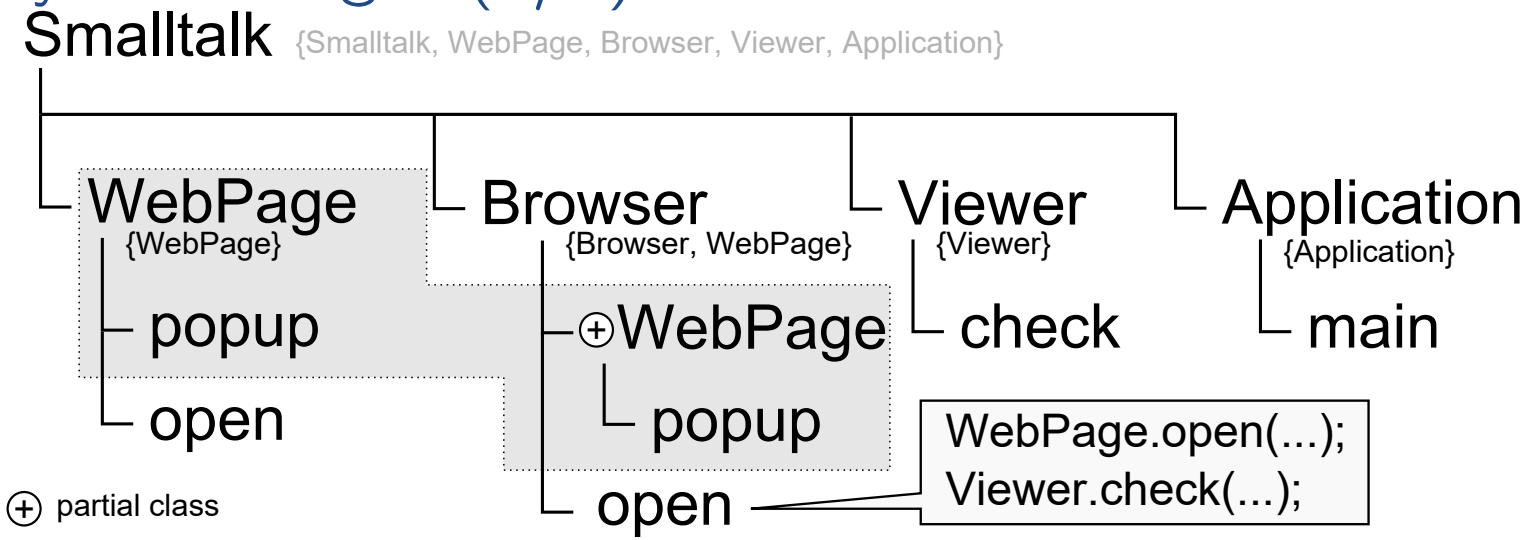

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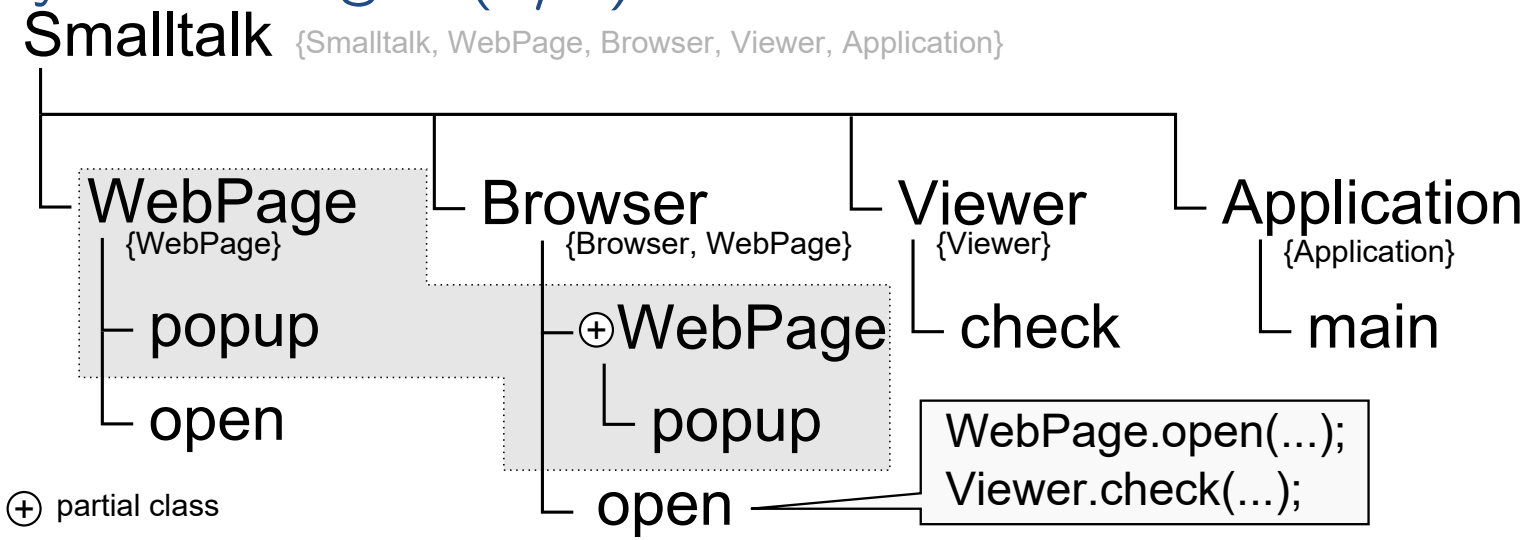

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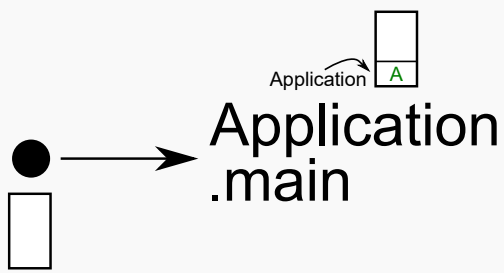

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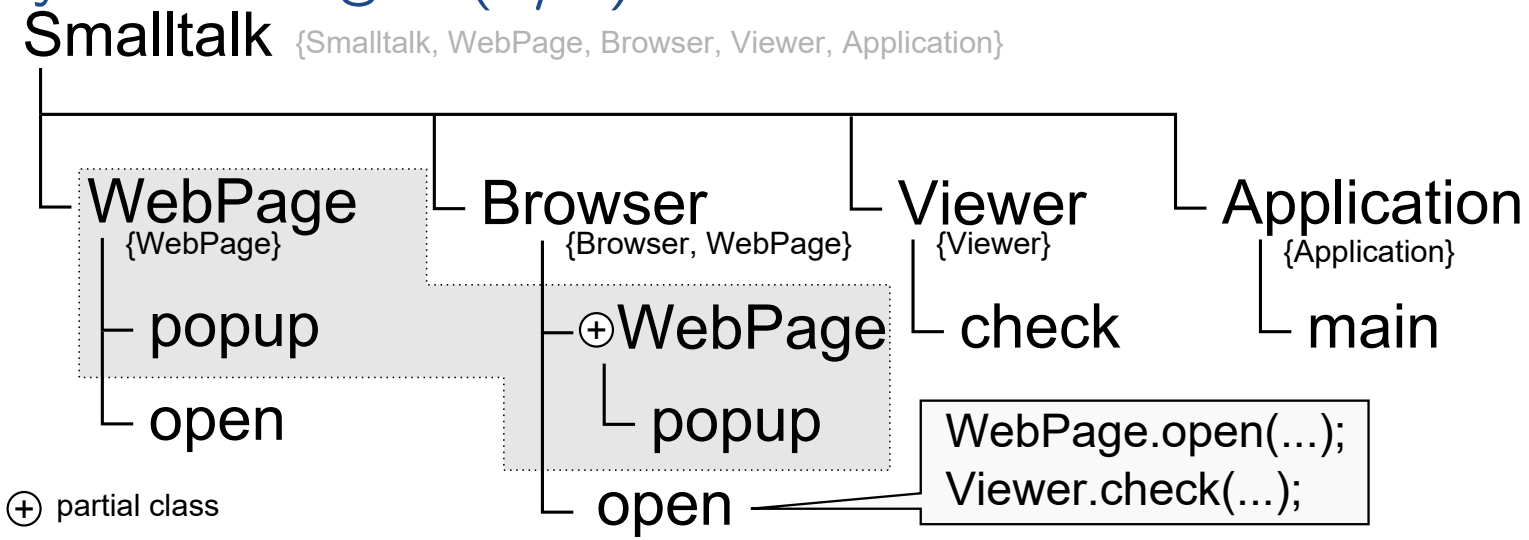

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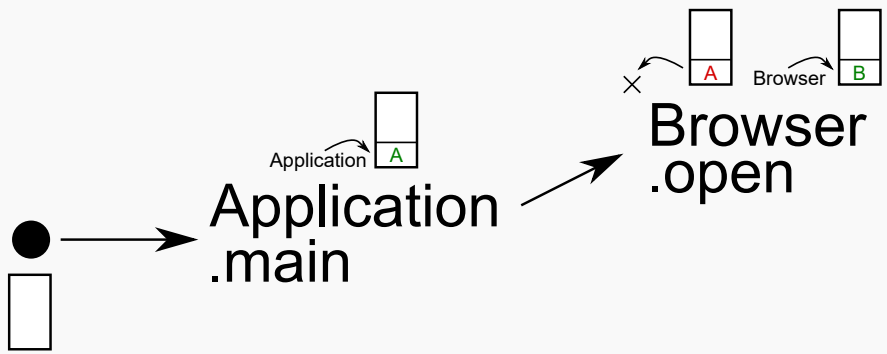

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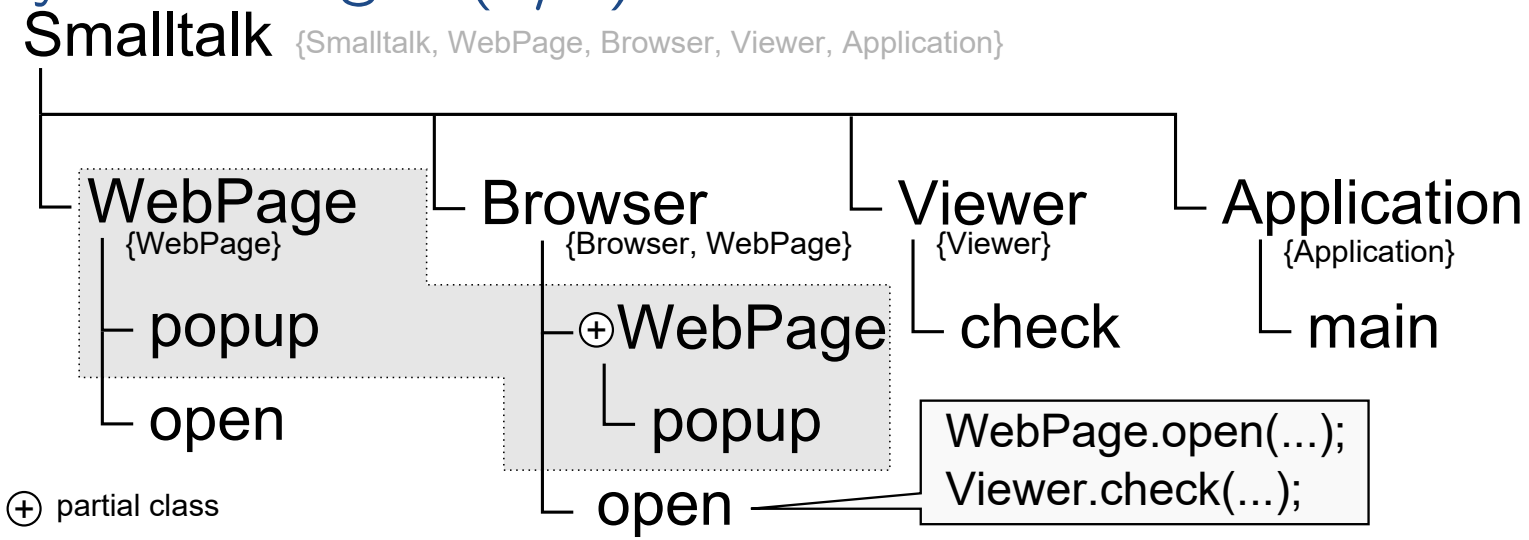

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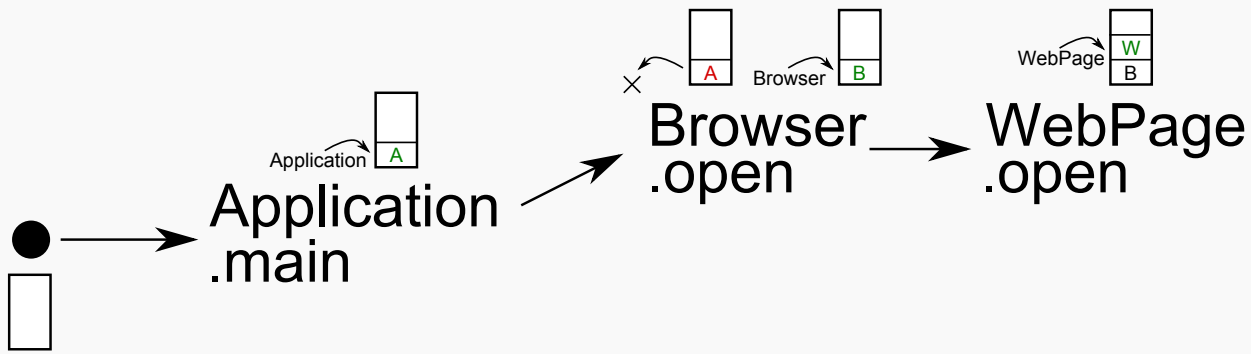

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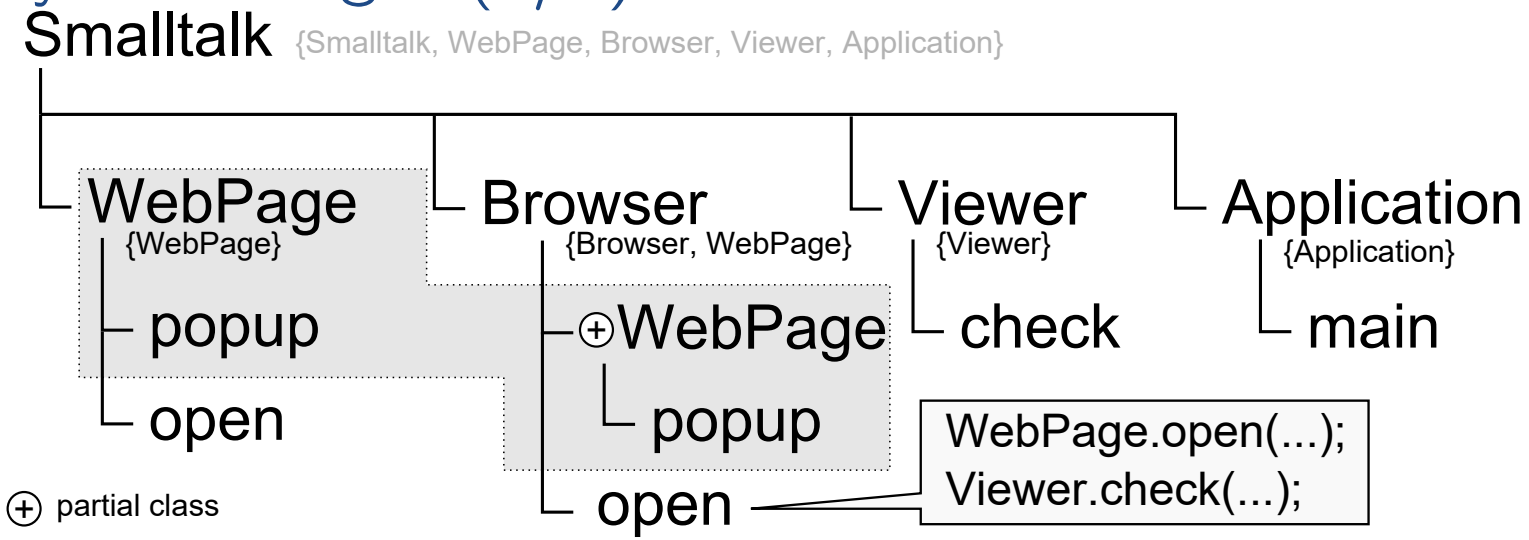

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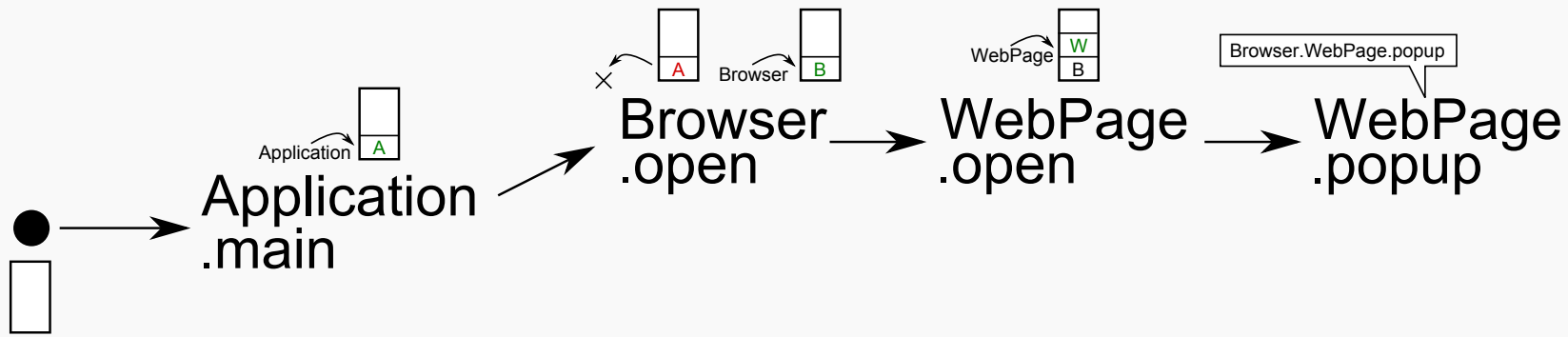

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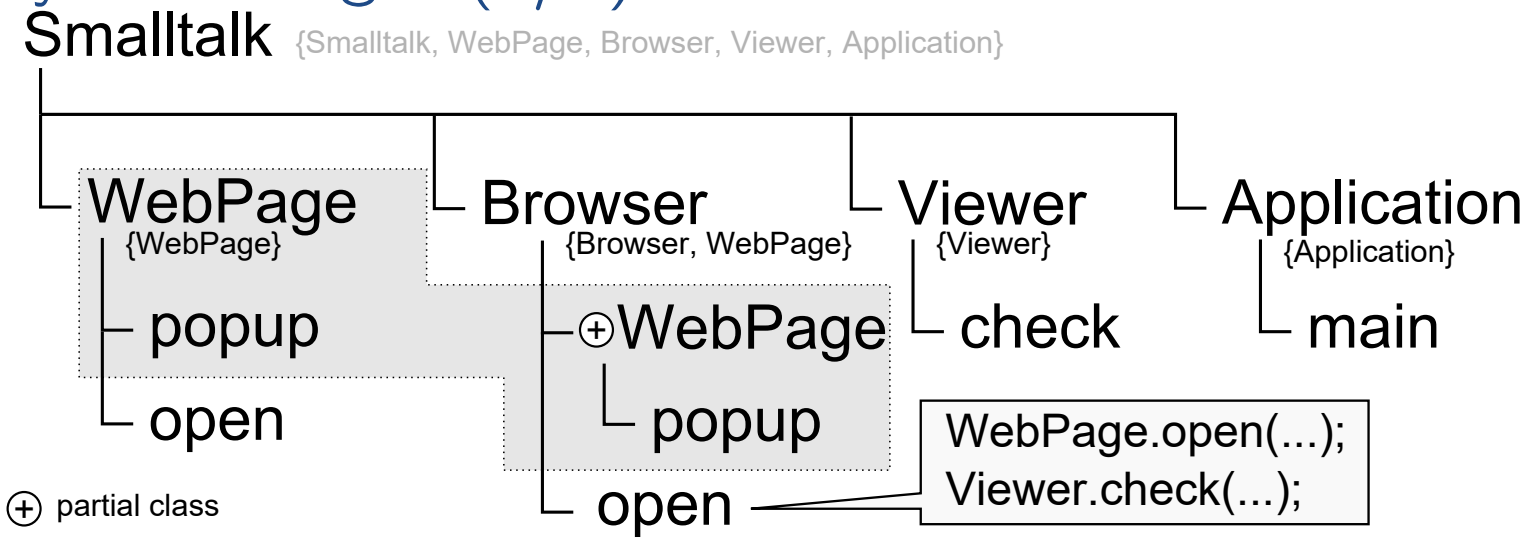

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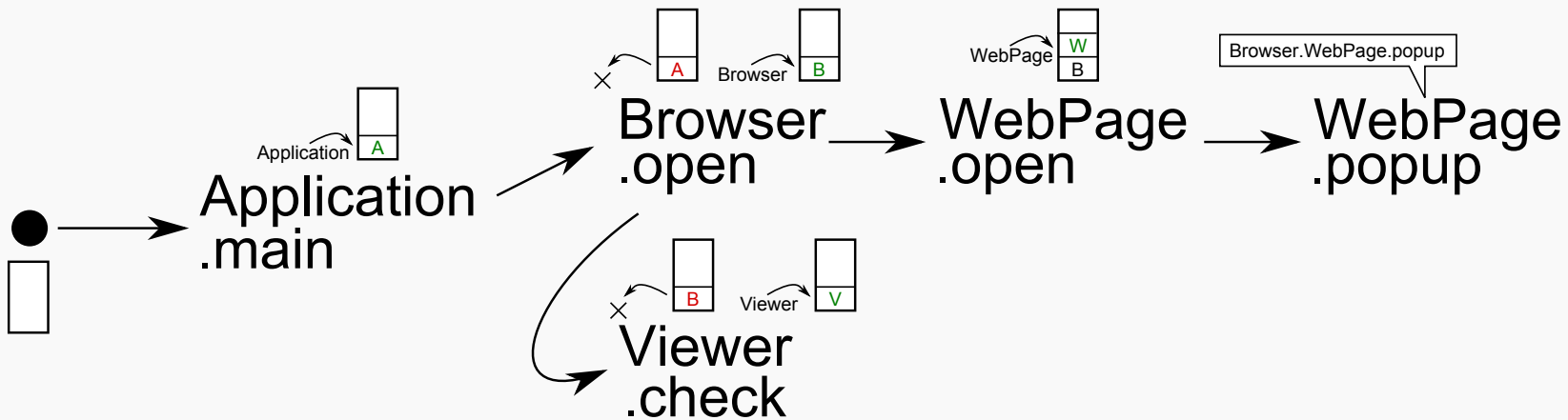

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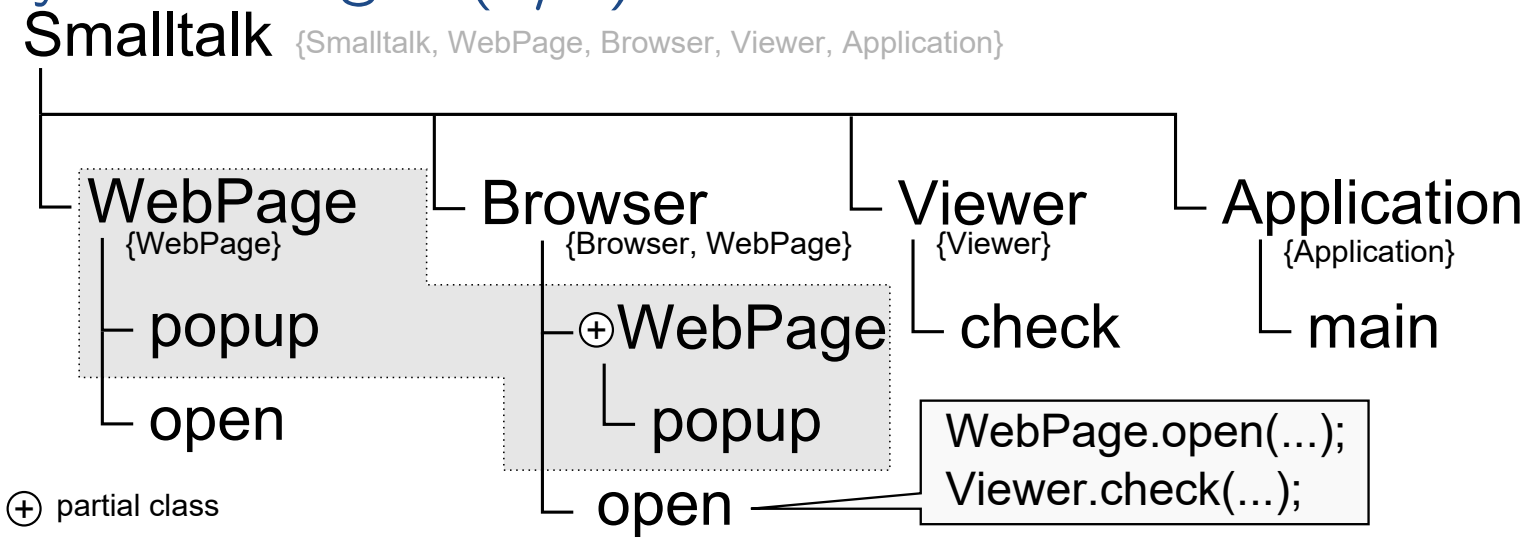

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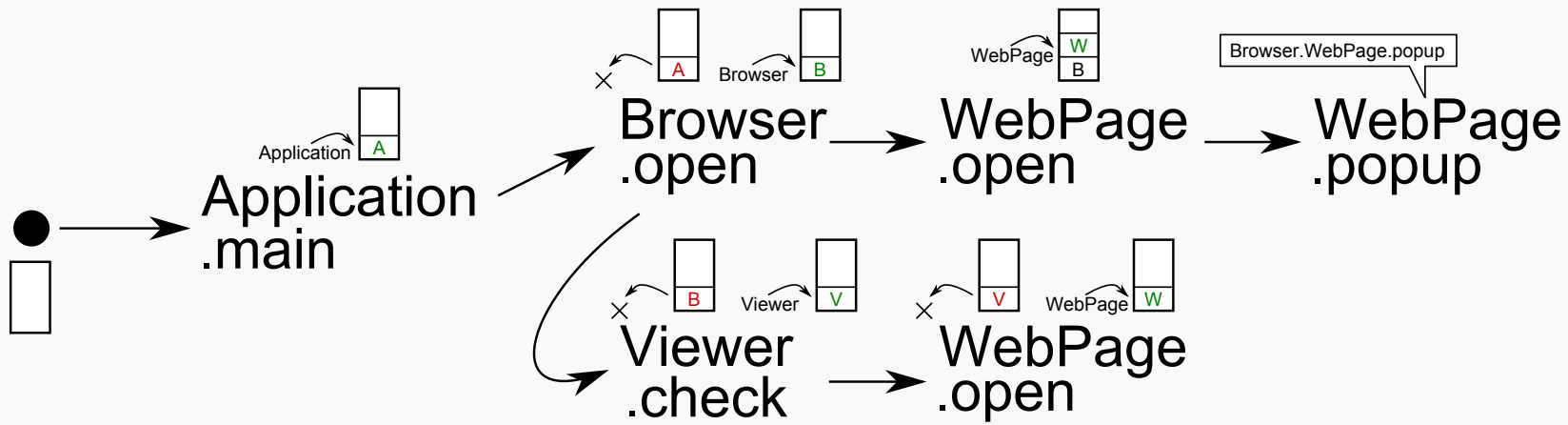

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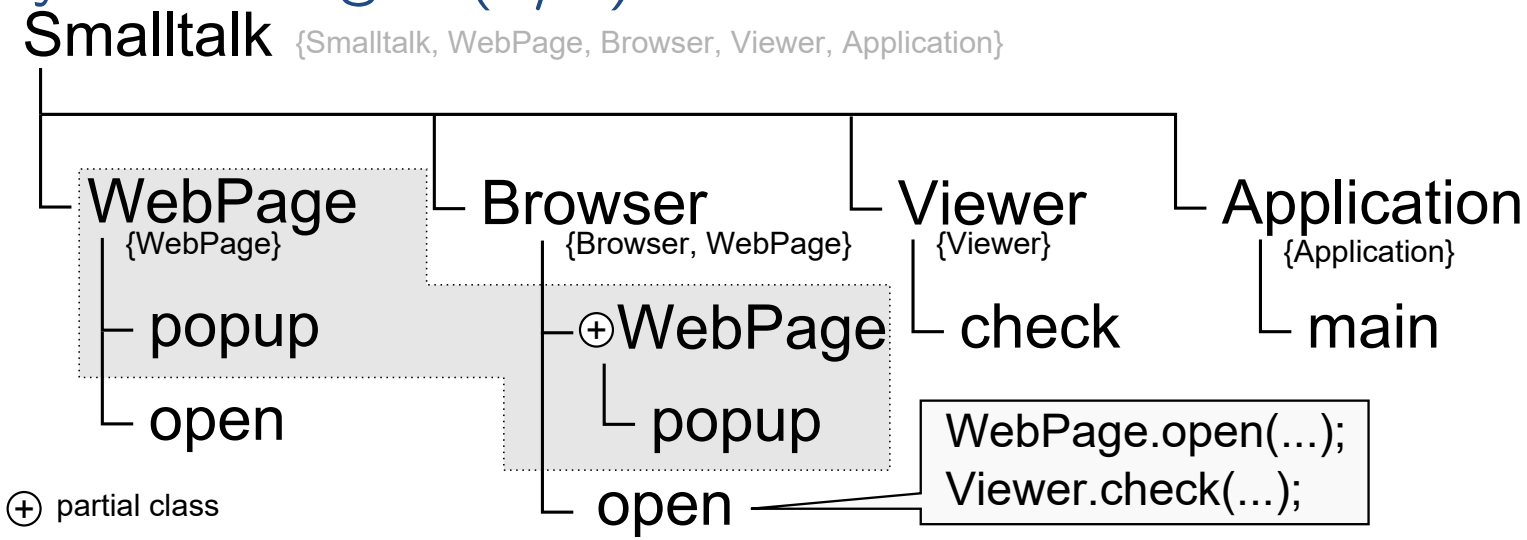

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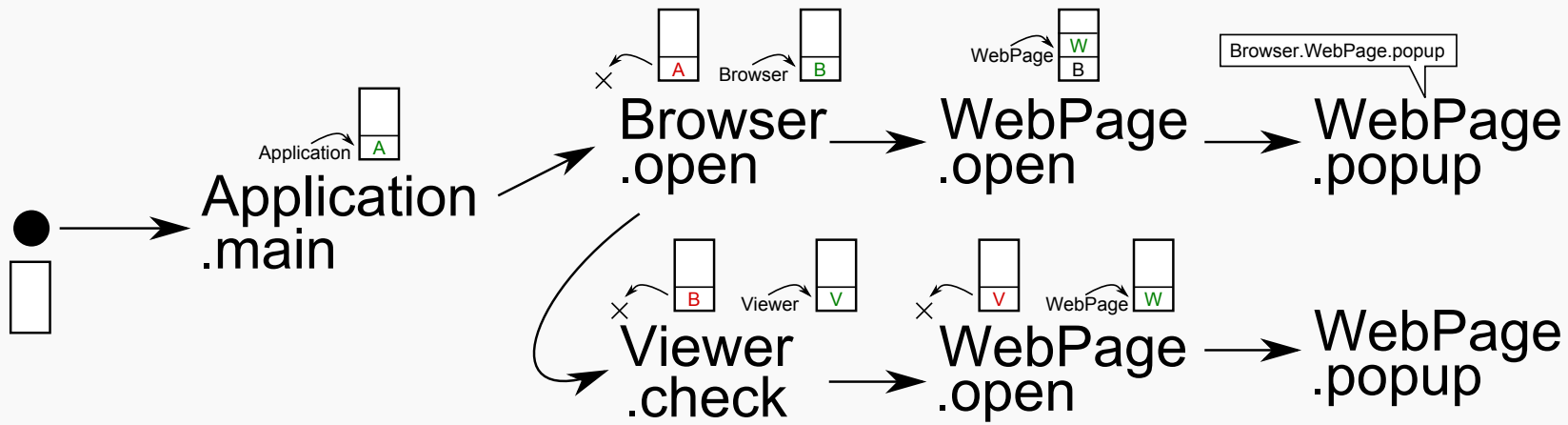

Scope of a Class

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Definition

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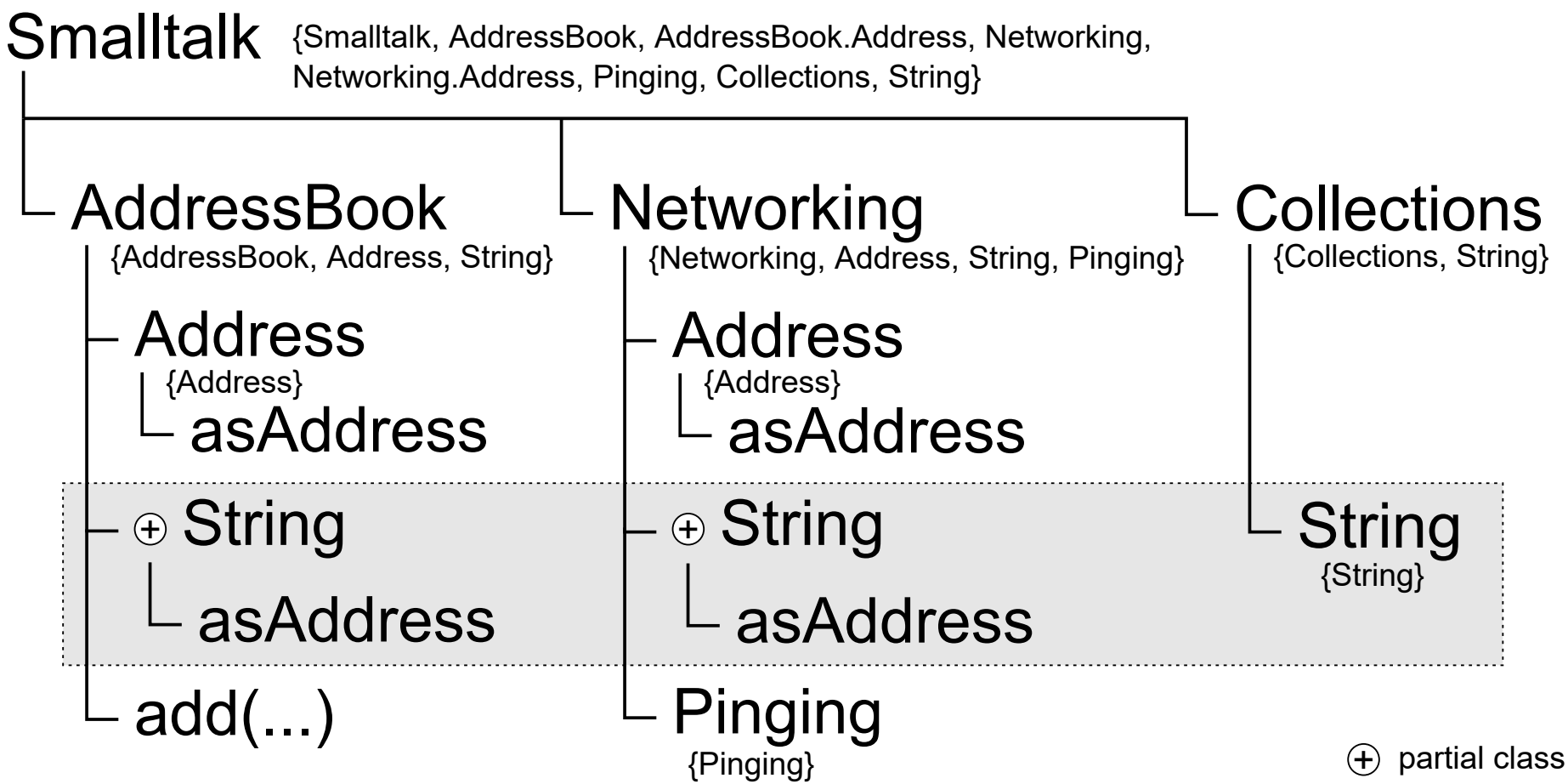
Hierarchical Scoping



Hierarchical Scoping

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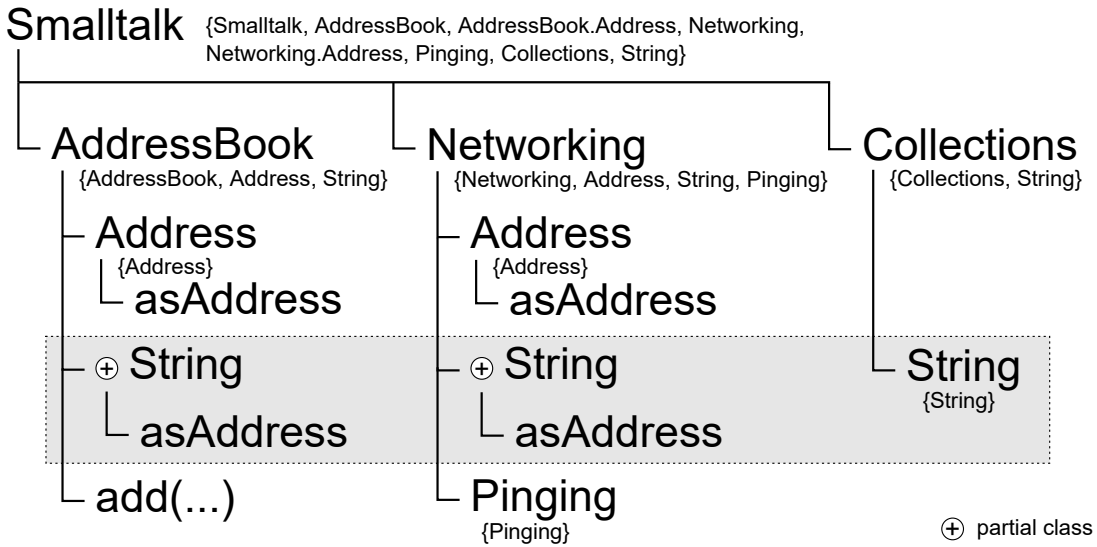
- **Deactivation:** For all nested classes N in C: $scope(N) \subseteq scope(C)$



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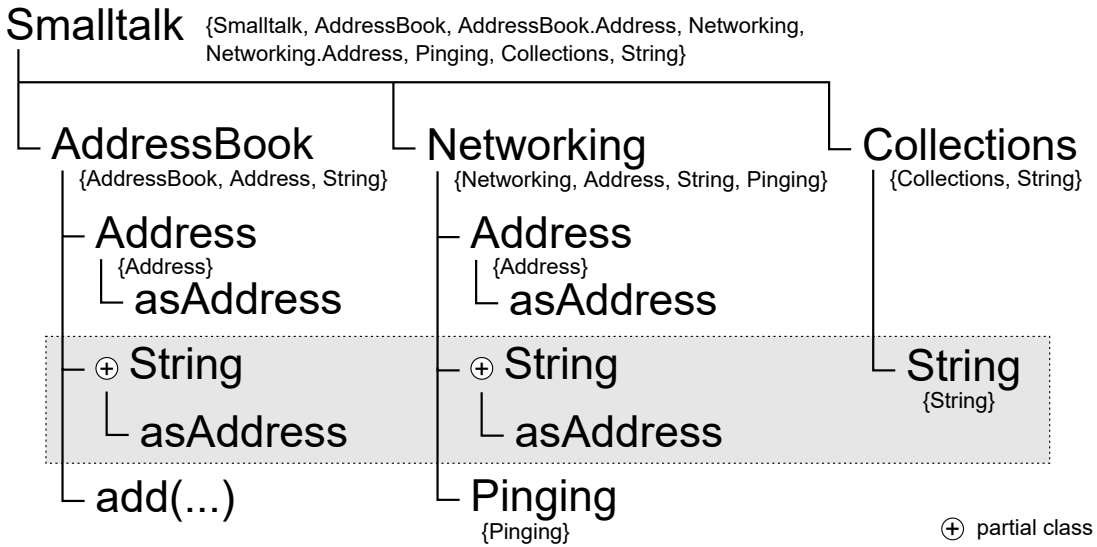

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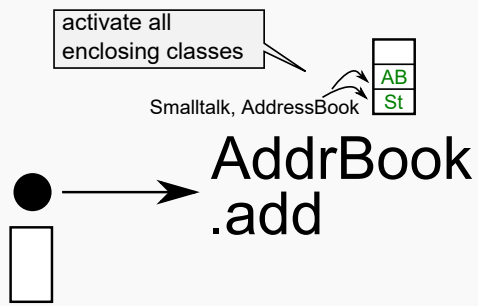

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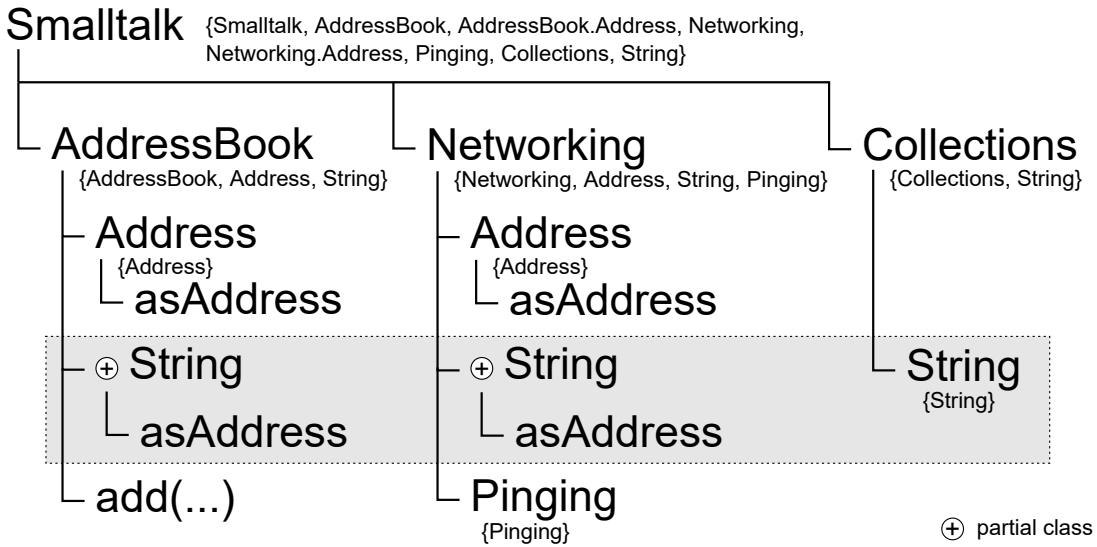

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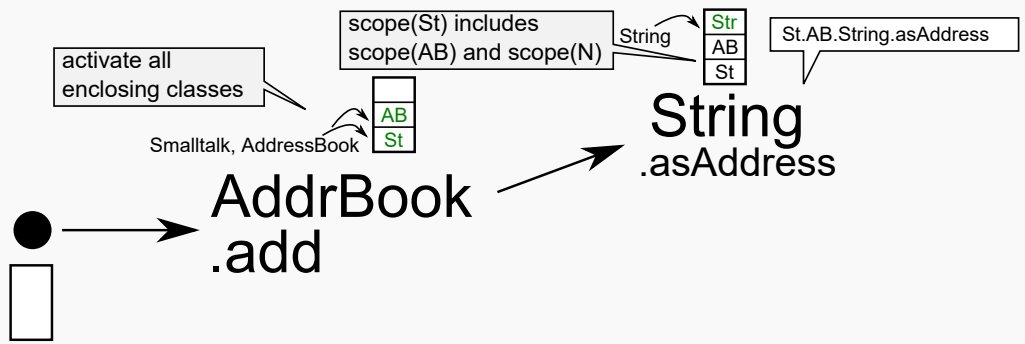

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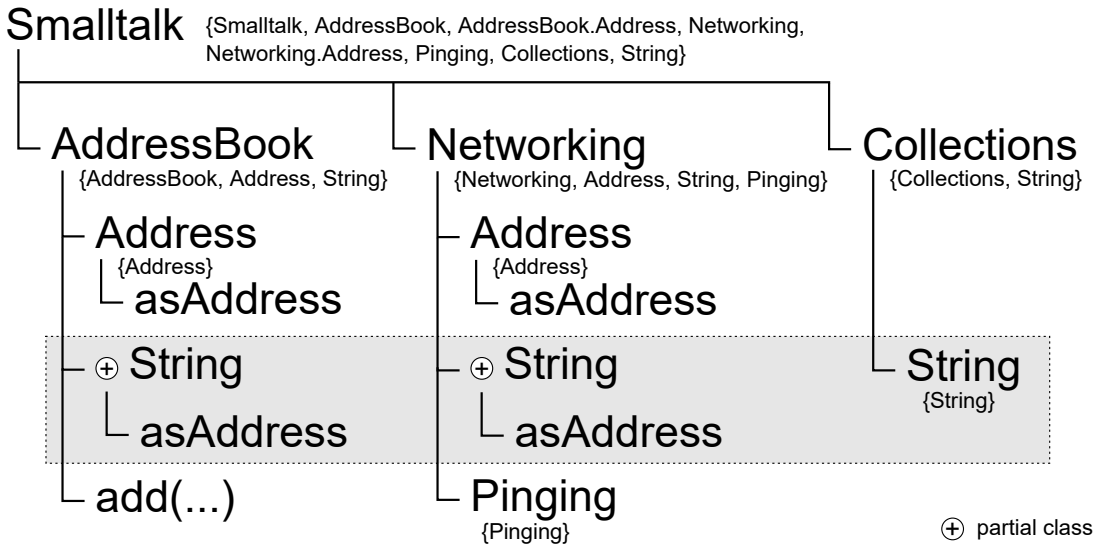

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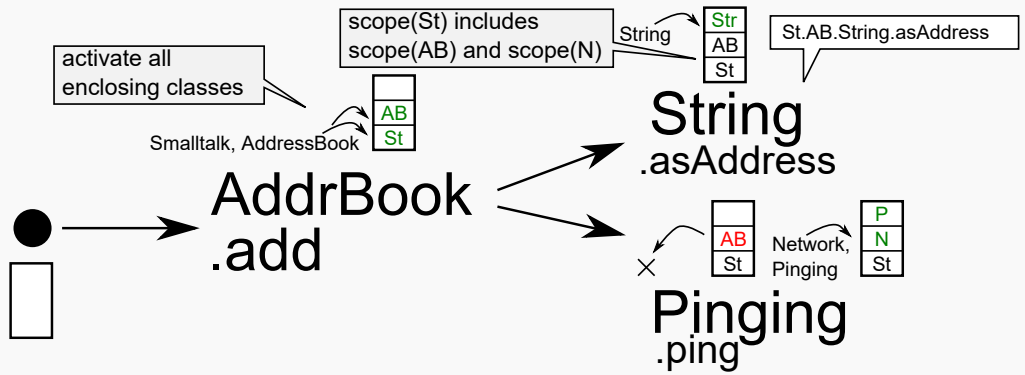

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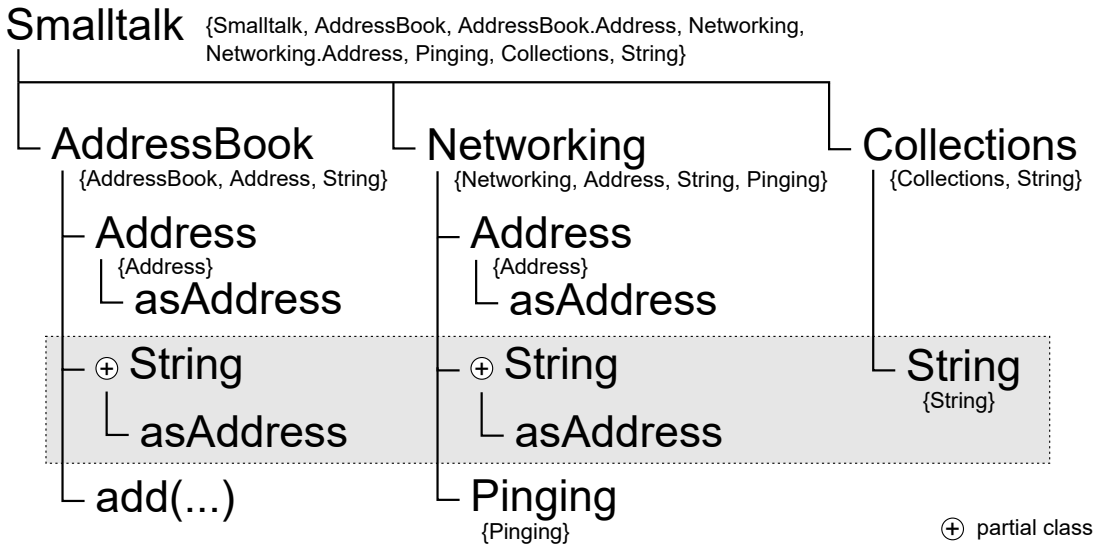

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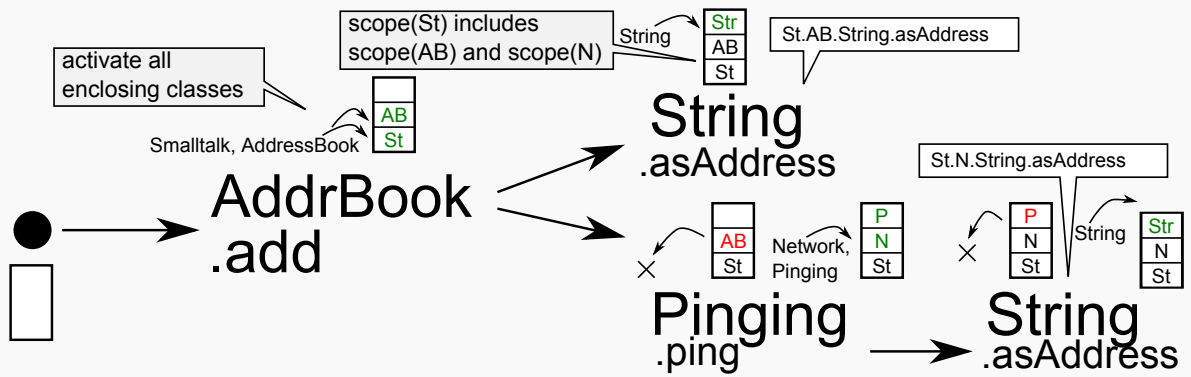

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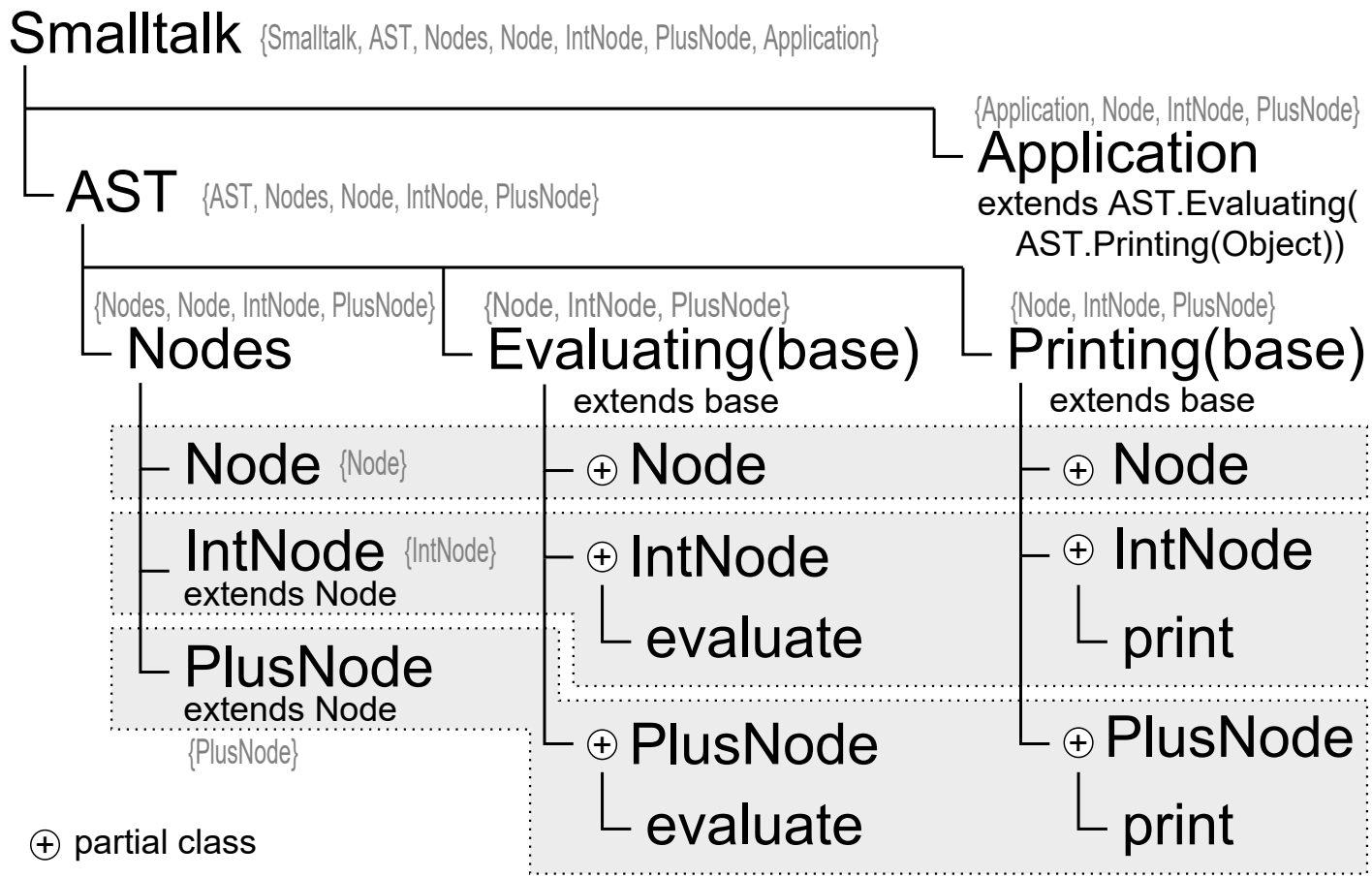
Importing Class Extensions



- Scope of a class includes scope of superclass
- Activate a class `C` if a method is executing in its context (polymorphic receiver class's superclass hierarchy includes `C`)

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$$\cup\, scope(superclass(L)) \qquad \text{(importing class extensions)}$$

Overview

Scope of a Class

When calling or returning to a method on an object of class C, activate all enclosing classes of C and C.

Class L remains active as long as a method within $scope(L)$ is executing.

Definition

$$
\begin{aligned}
scope(L) = \{L\} & \qquad \text{(reflexivity)} \\
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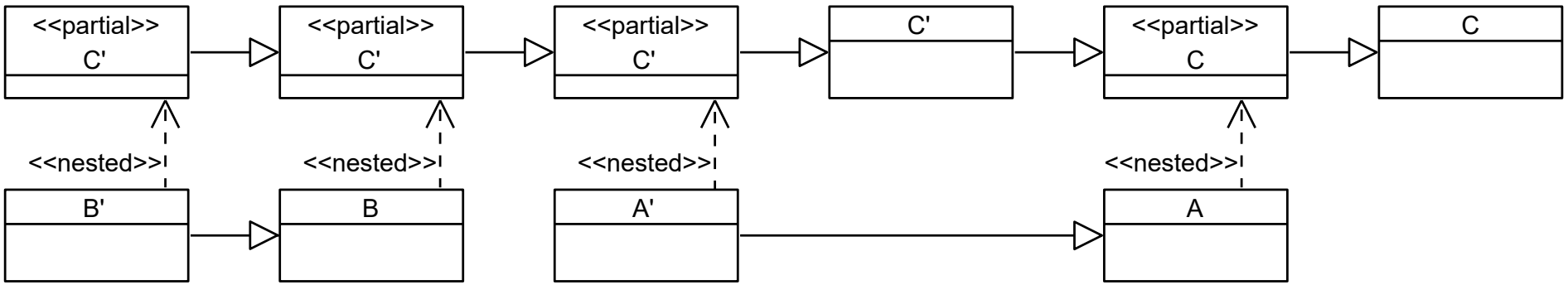
\end{aligned}
$$

Effective Superclass Hierarchy



- Insert active partial classes in superclass hierarchy
- Activation order determines order of partial classes
- No `proceed` statement, use `super` instead

Overview

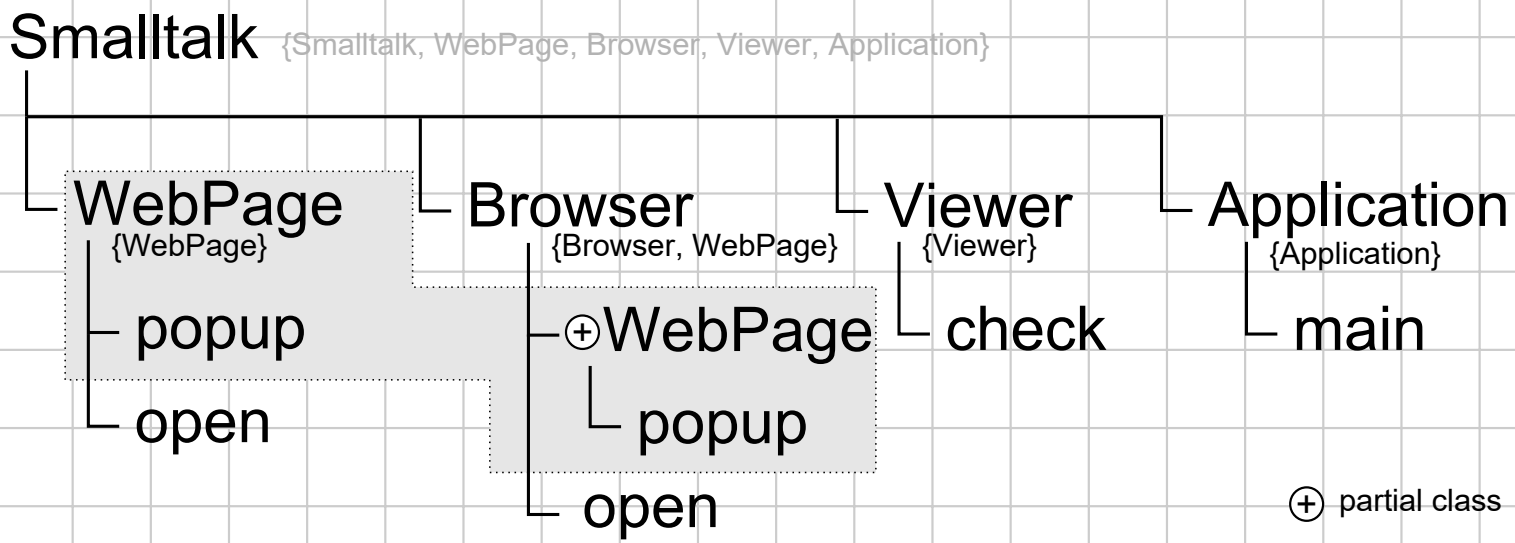
Conclusion

- **High-level idea:** Make sure that class extensions are not destructive by confining their scope to *compatible* classes
- **Scoping dimensions:** explicit scoping, class nesting hierarchy (*hierarchical scoping*), superclass hierarchy (*import scoping*)
- Future Work
  - Implementation details and performance optimizations
  - Blocks/anonymous functions
  - Formal semantics of the mechanism

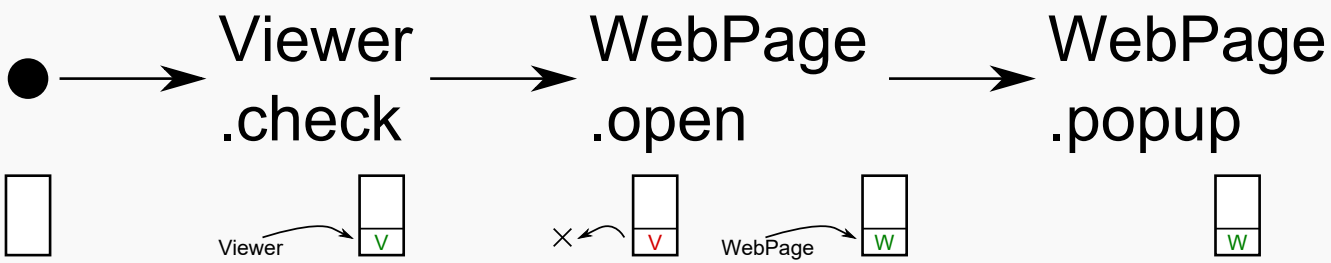
Appendix

Appendix

Locality of Changes (4/3)

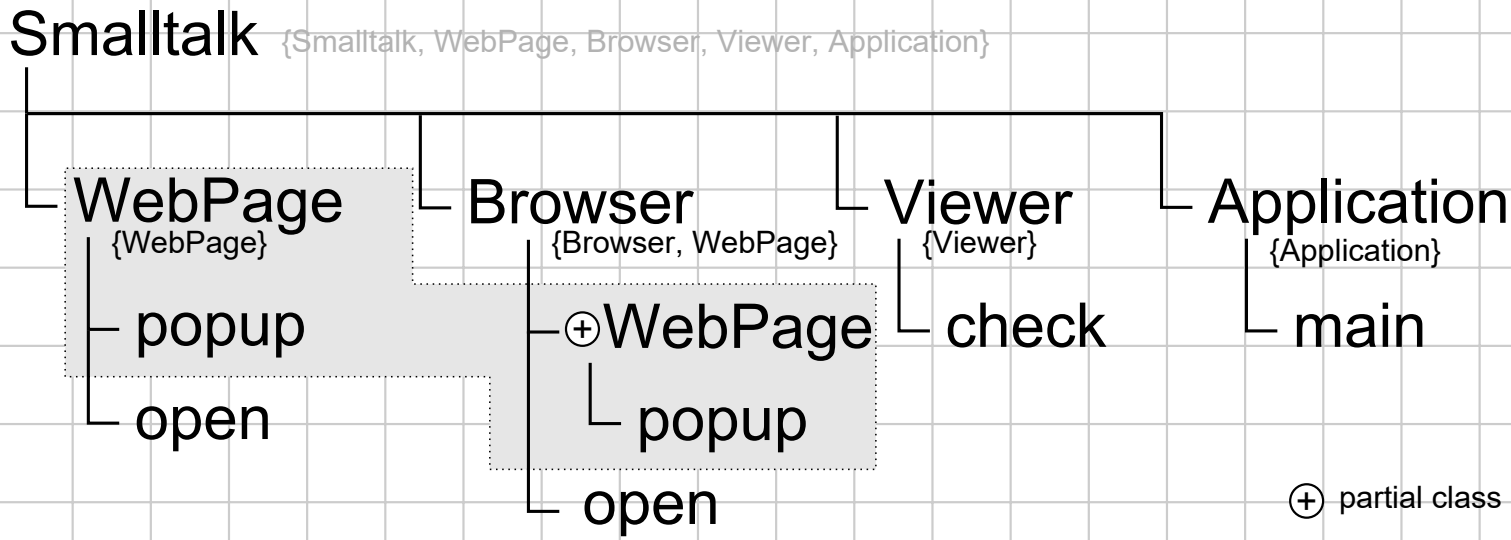


Example: Standalone usage of `Viewer`



`WebPage.Browser` is never activated

Locality of Changes (5/3)



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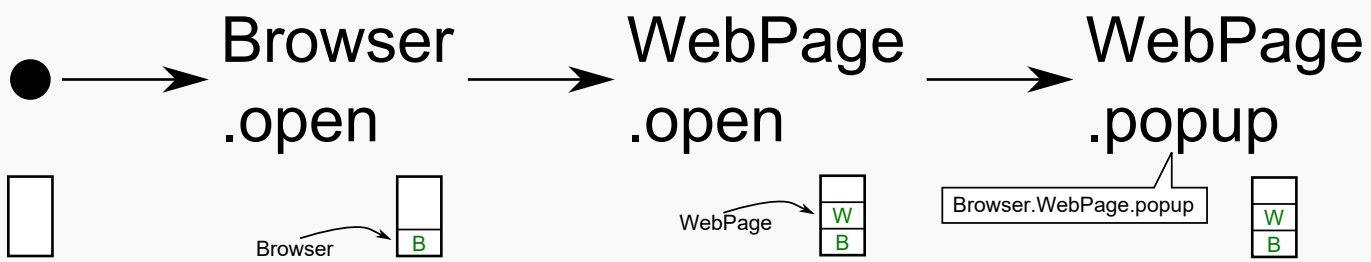

`Browser.WebPage.popup` is called