Interaction-based Programming in Classages

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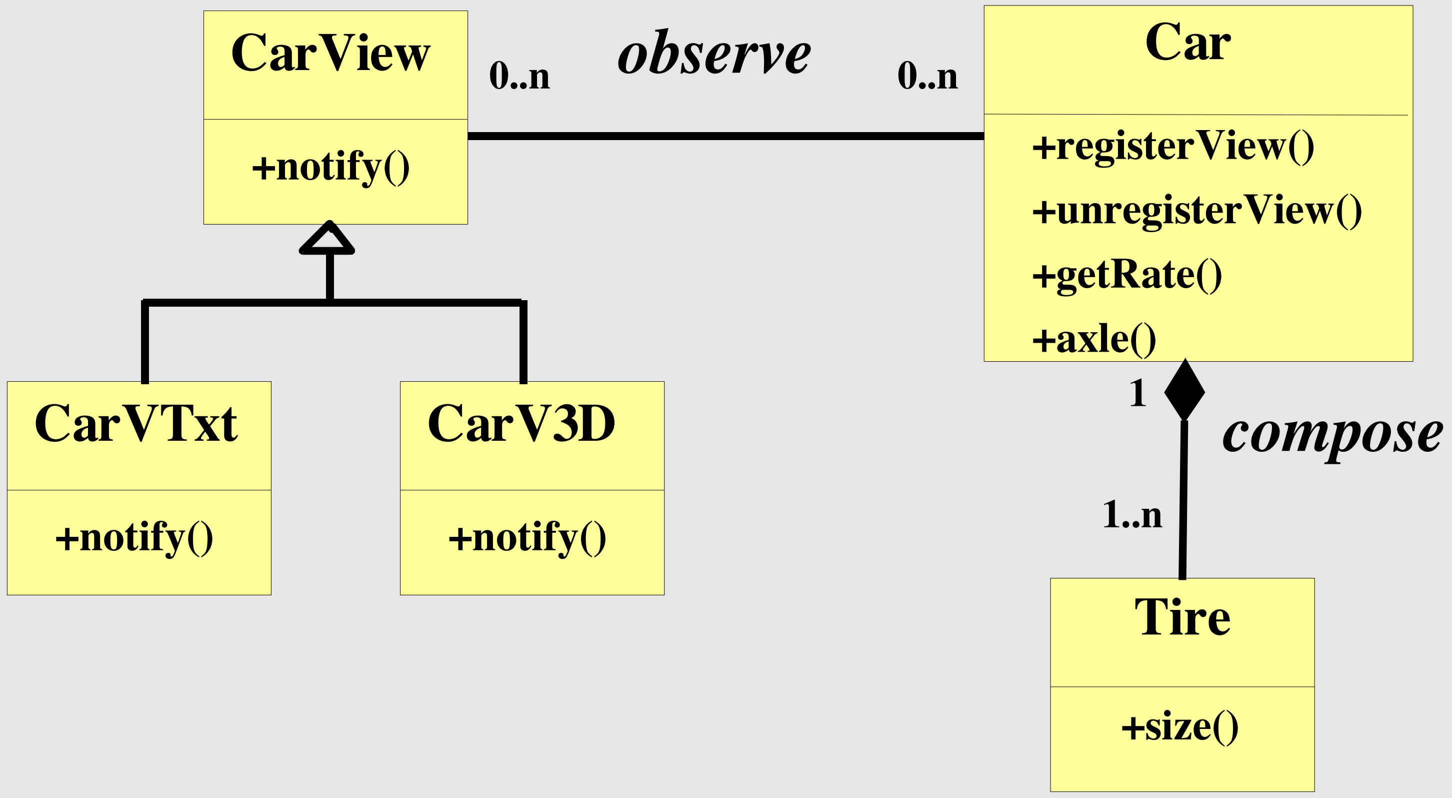
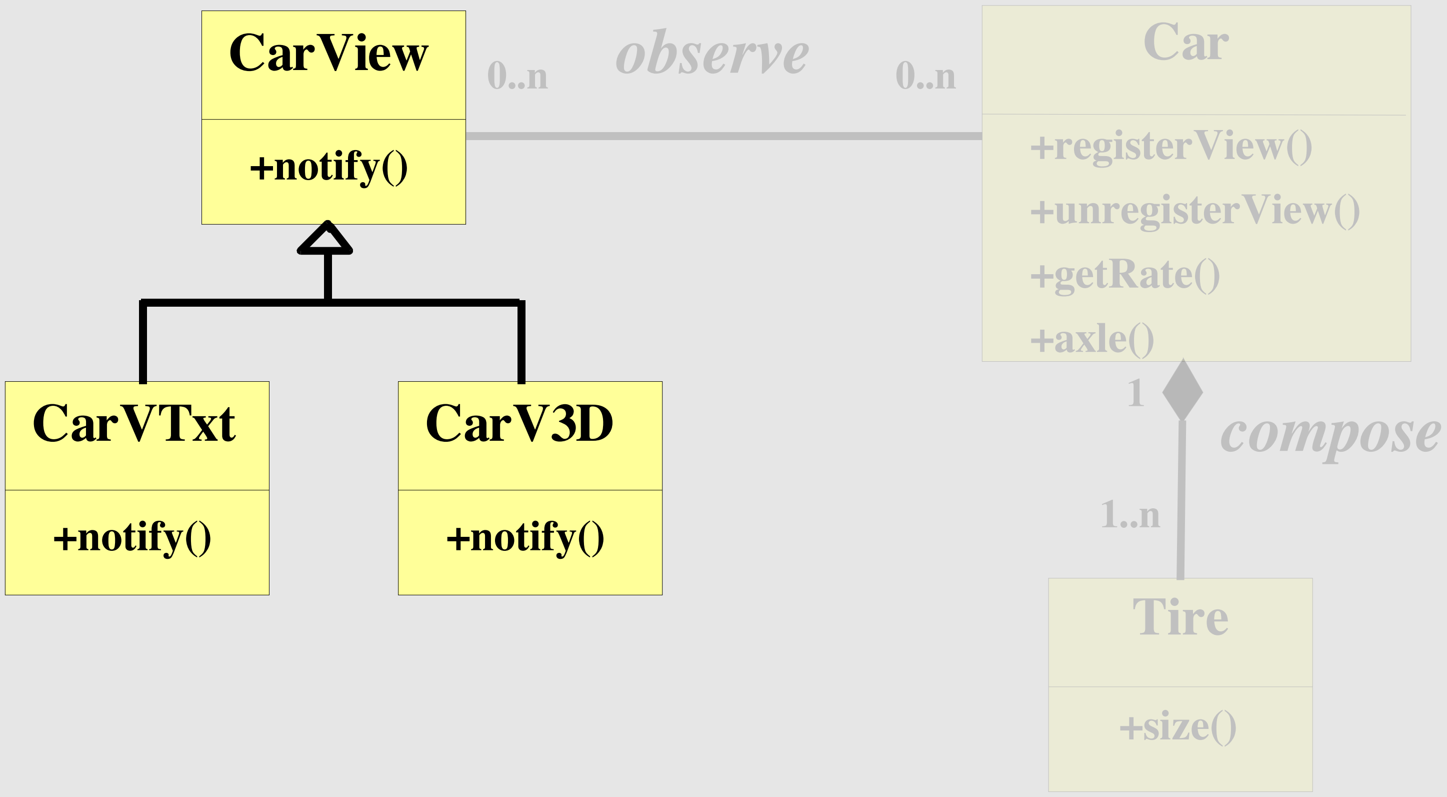
Interactions Illustrated by UML



Interactions Illustrated by UML



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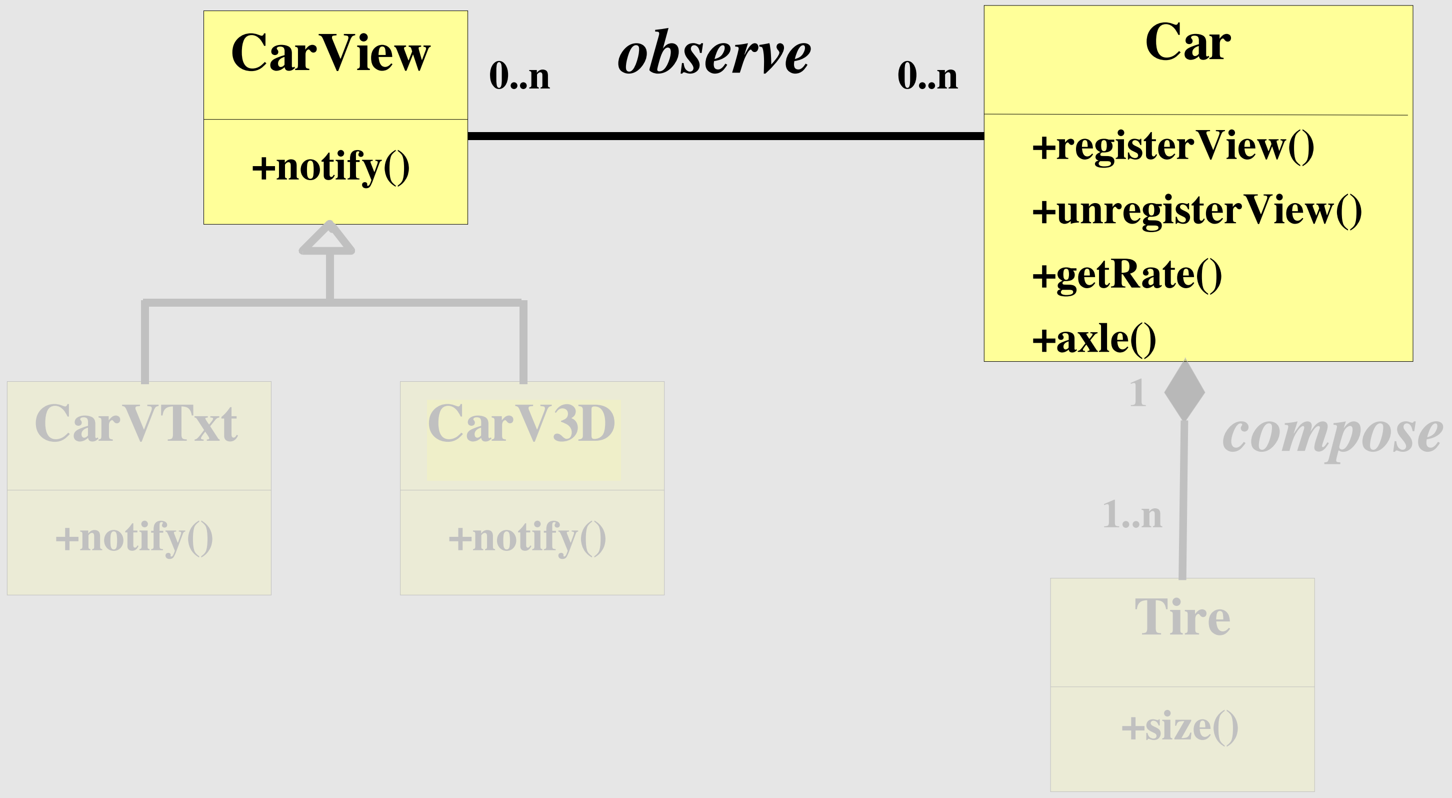

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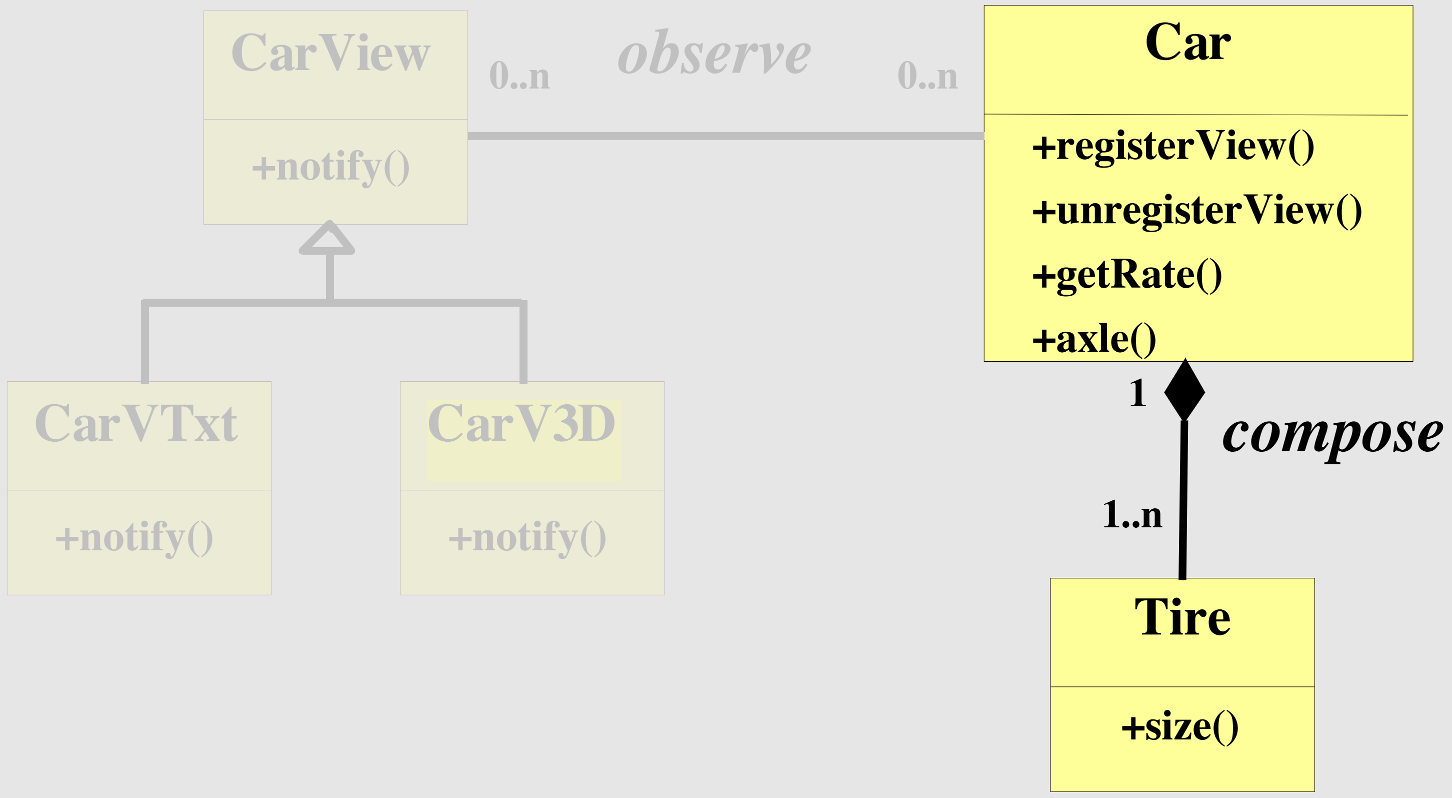
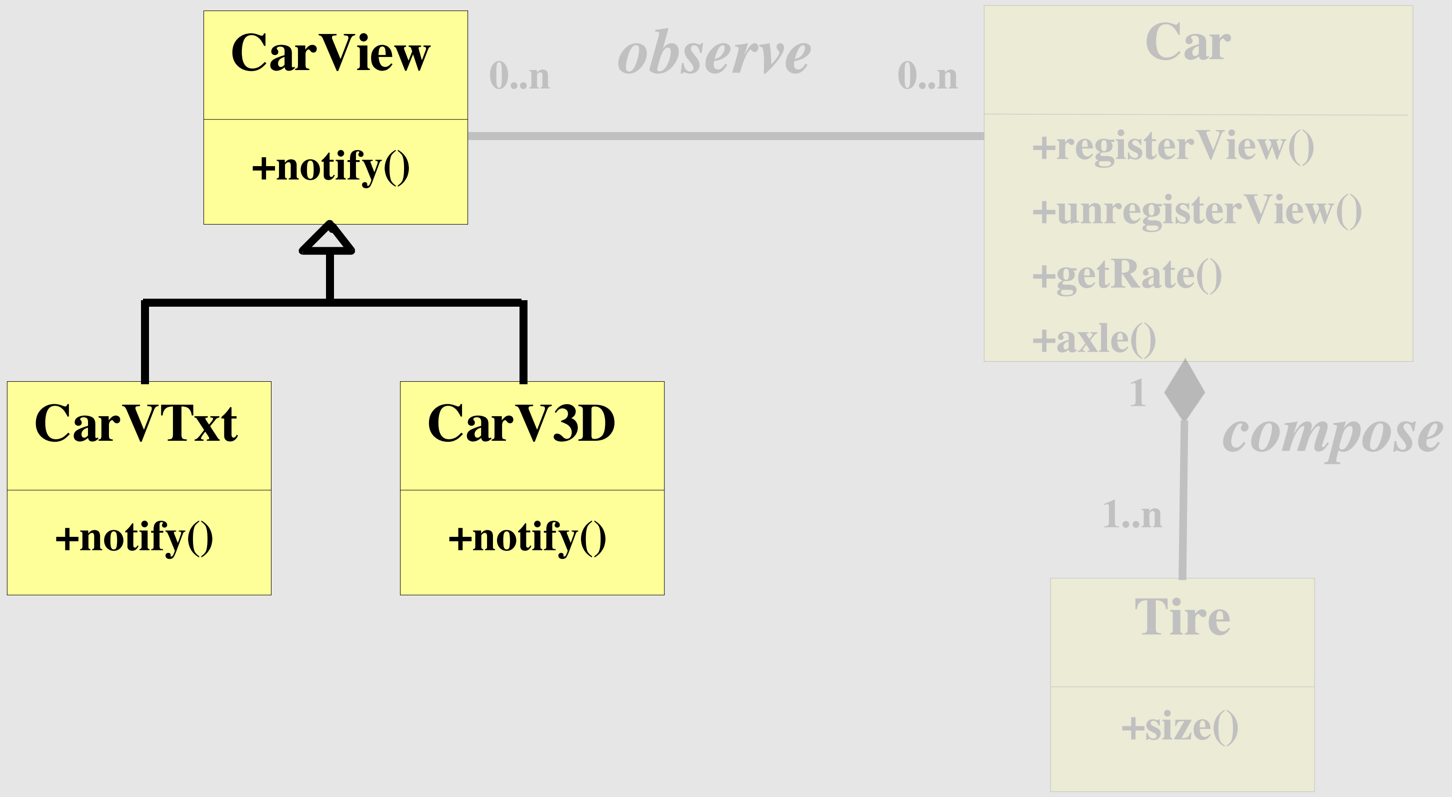
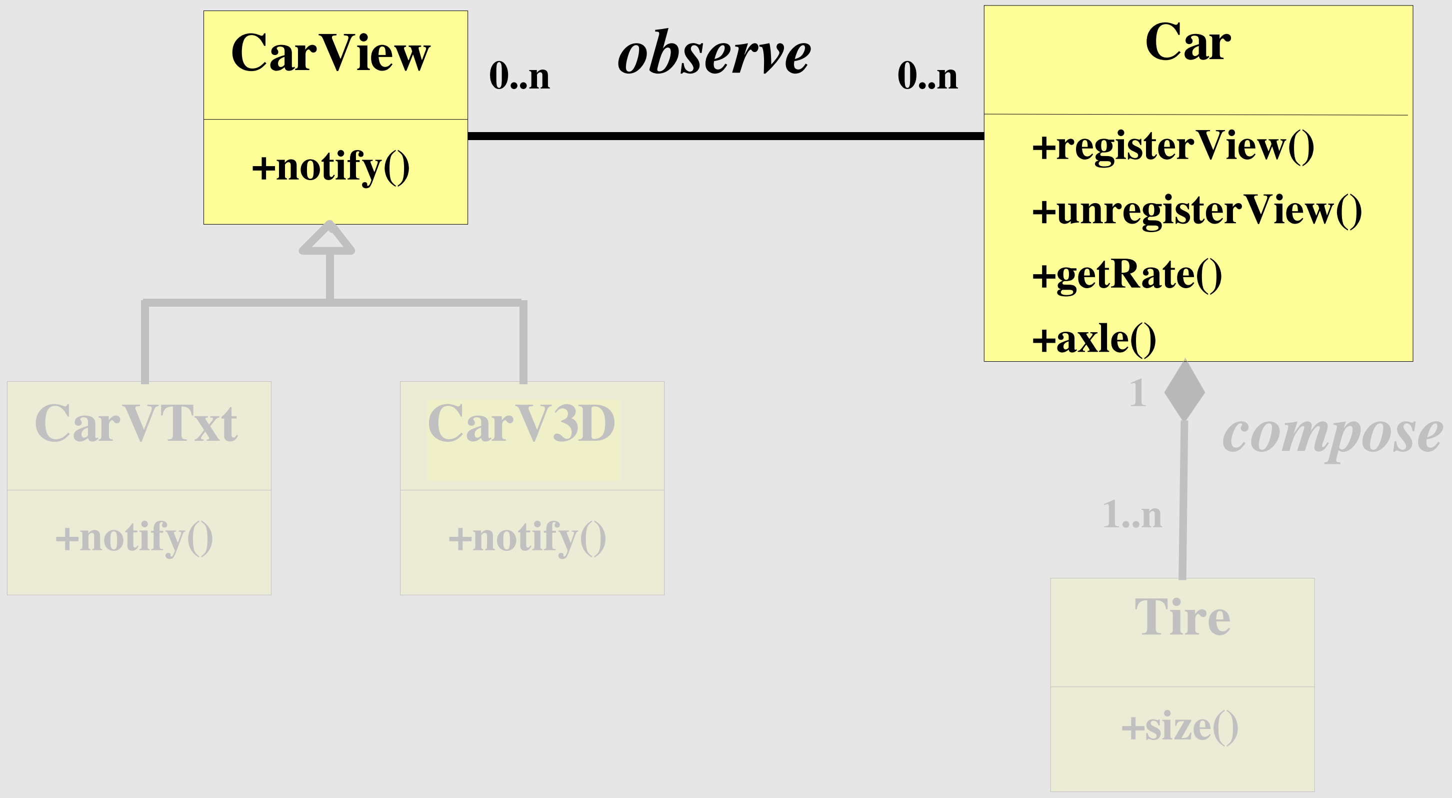


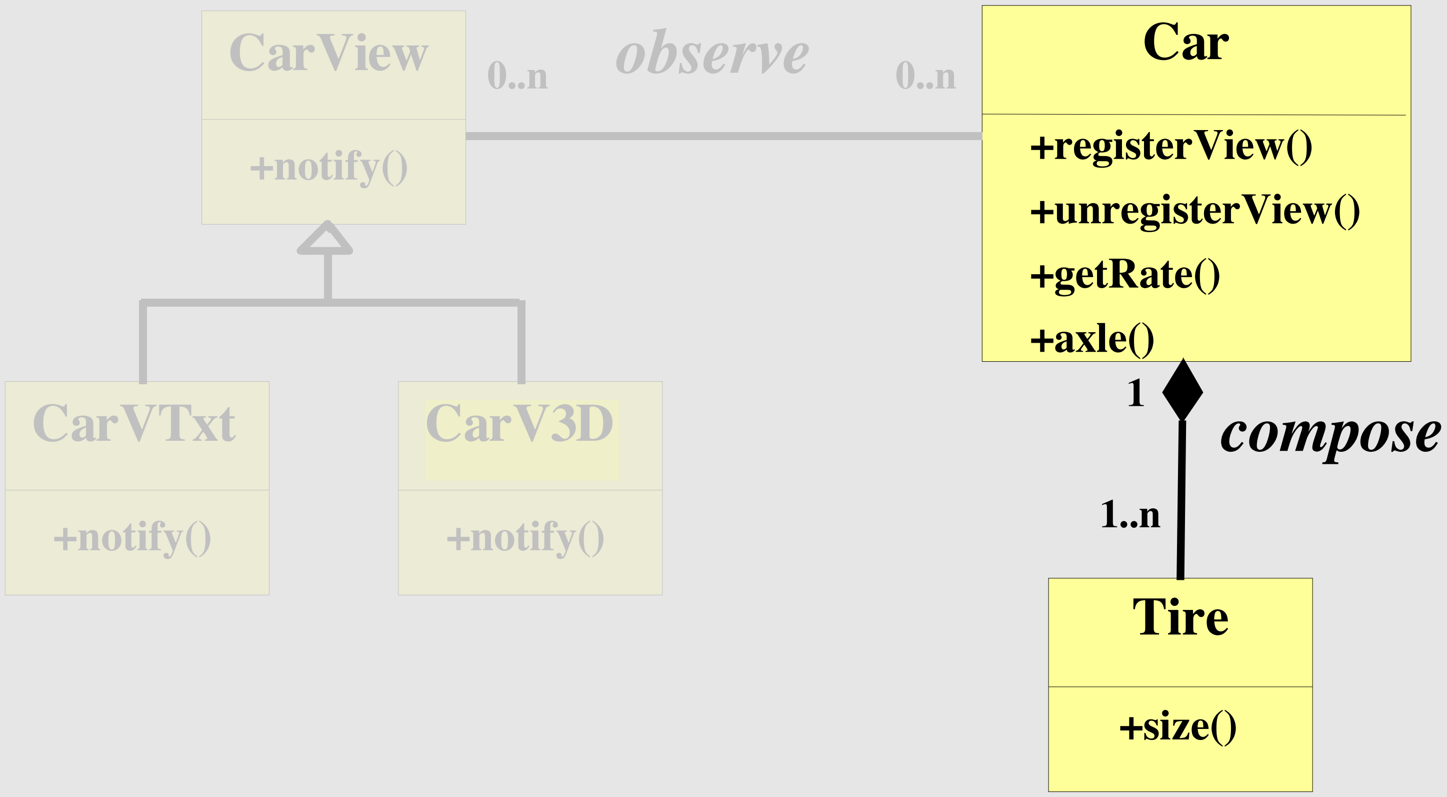
Class Interaction



Object Peer-to-Peer Interaction



Object Whole-Part Interaction



Limitations of Mainstream OOPLs on Object Interactions

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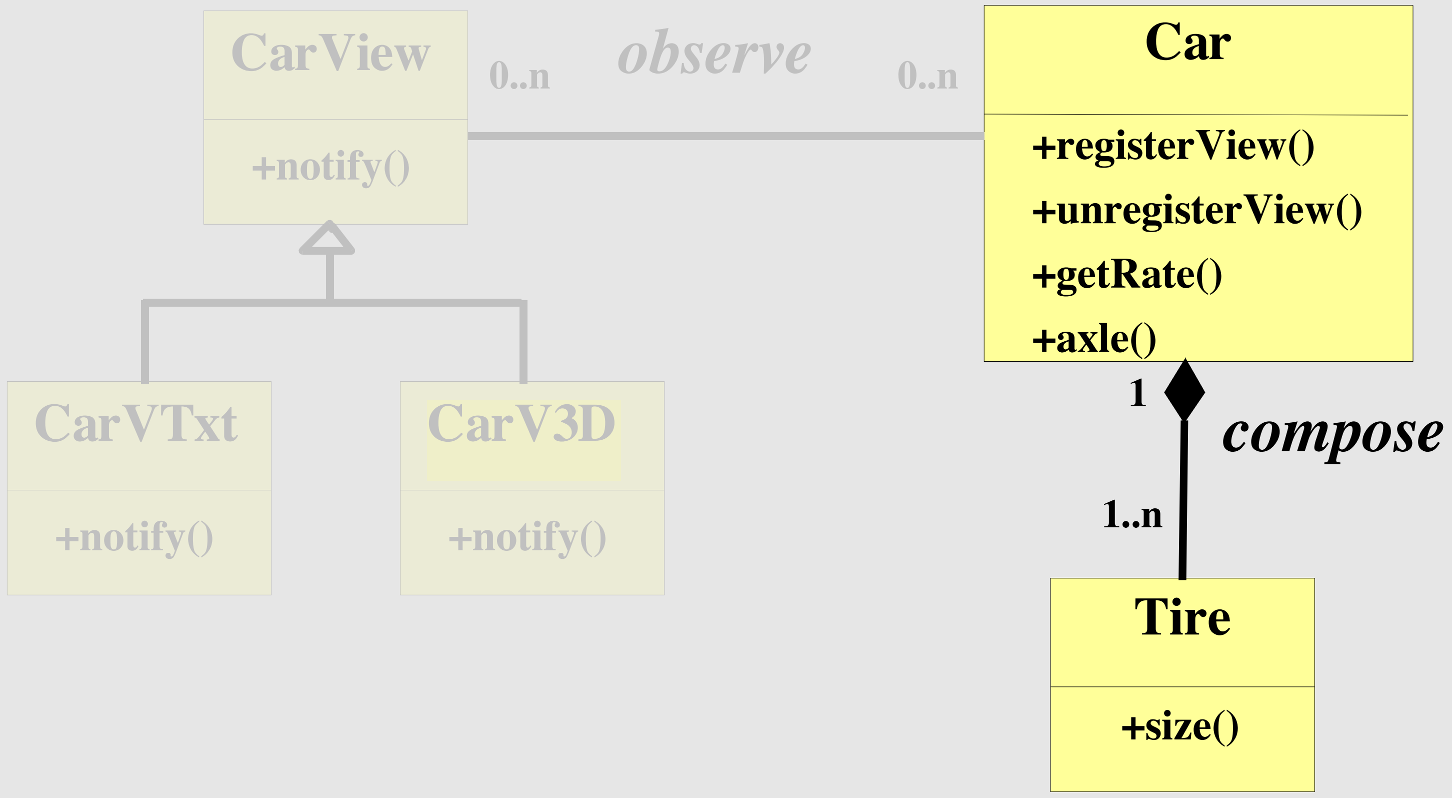
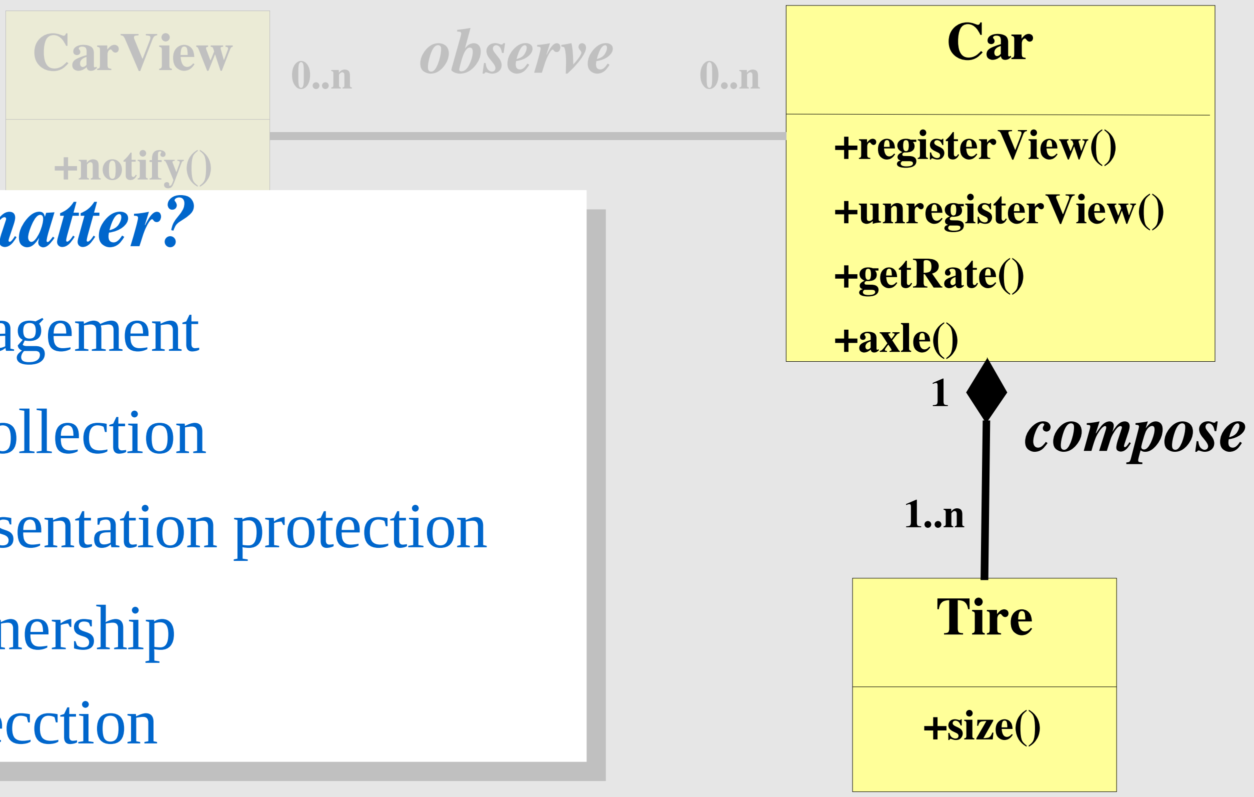
- No explicit support for whole-part interactions.
- Inadequate support for coarse-grained interactions between objects.
- An object has only one encapsulation-enforceable interface for all interactions it might participate in.
- Interaction bi-directional dependencies are not explicit.

Object Whole-Part Interaction



Object Whole-Part Interaction



Why does it matter?

- memory management
  - garbage collection
- internal representation protection
  - object ownership
  - alias protecction

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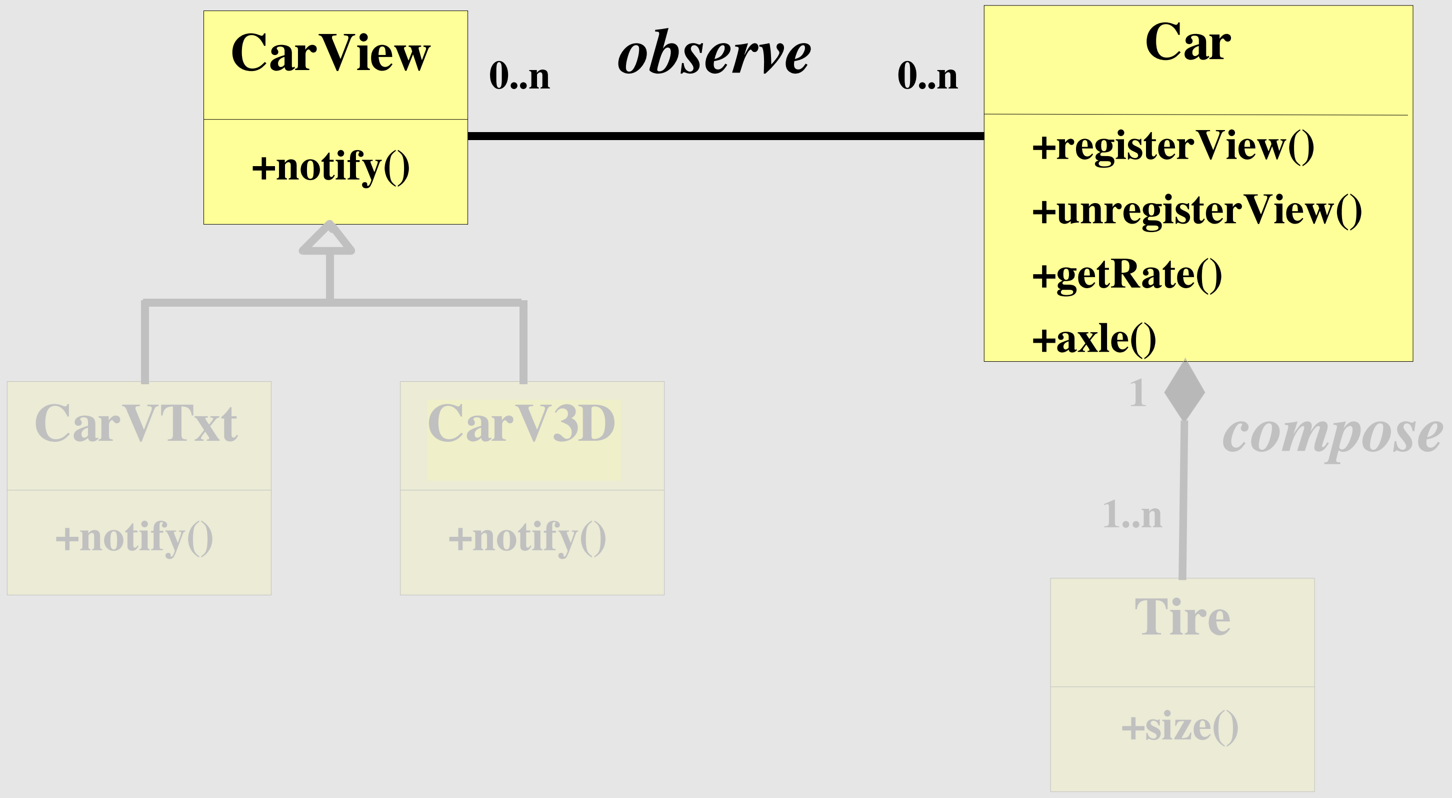
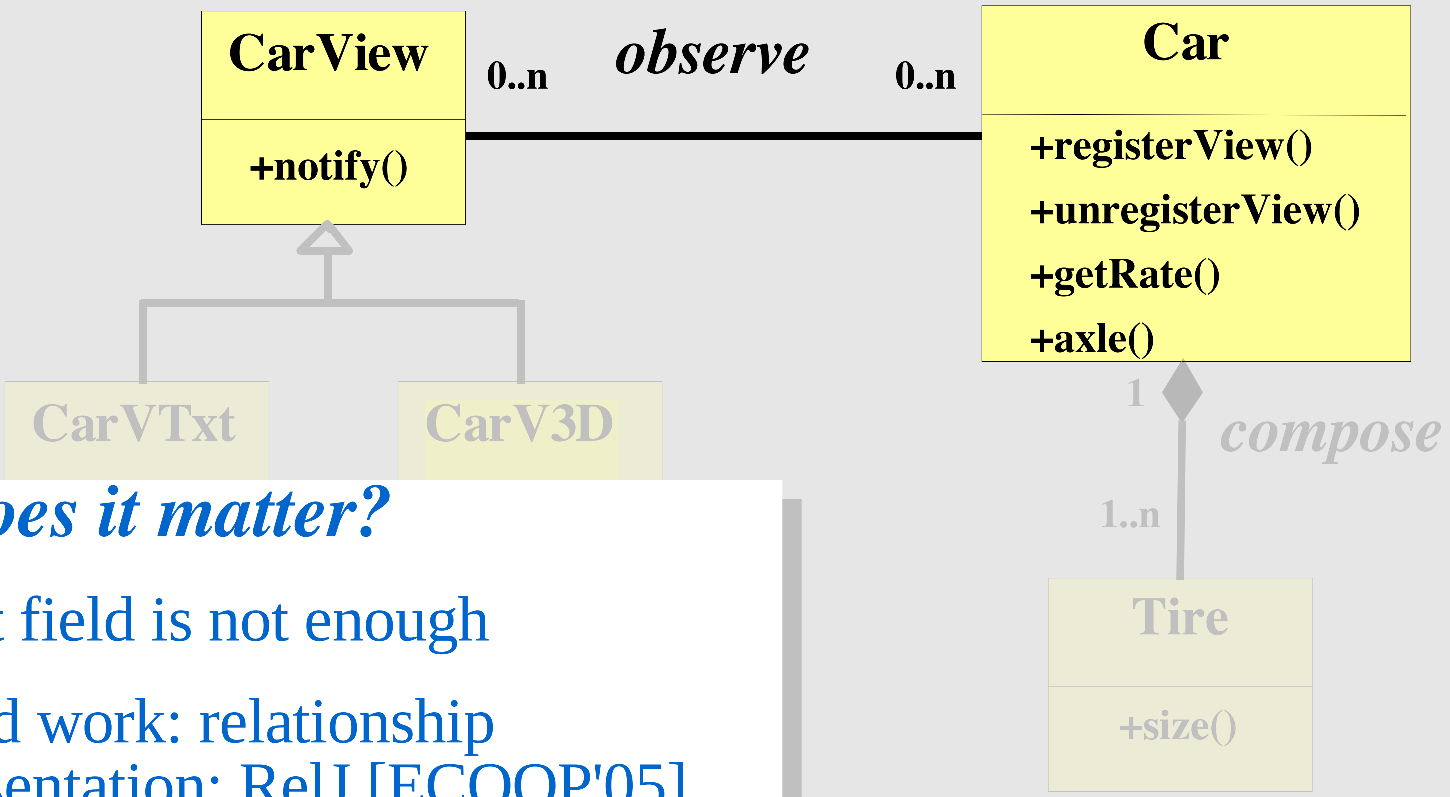
Representing the *observe* Interaction



Representing the *observe* Interaction



Why does it matter?

- object field is not enough
- related work: relationship representation: RelJ [ECOOP'05]

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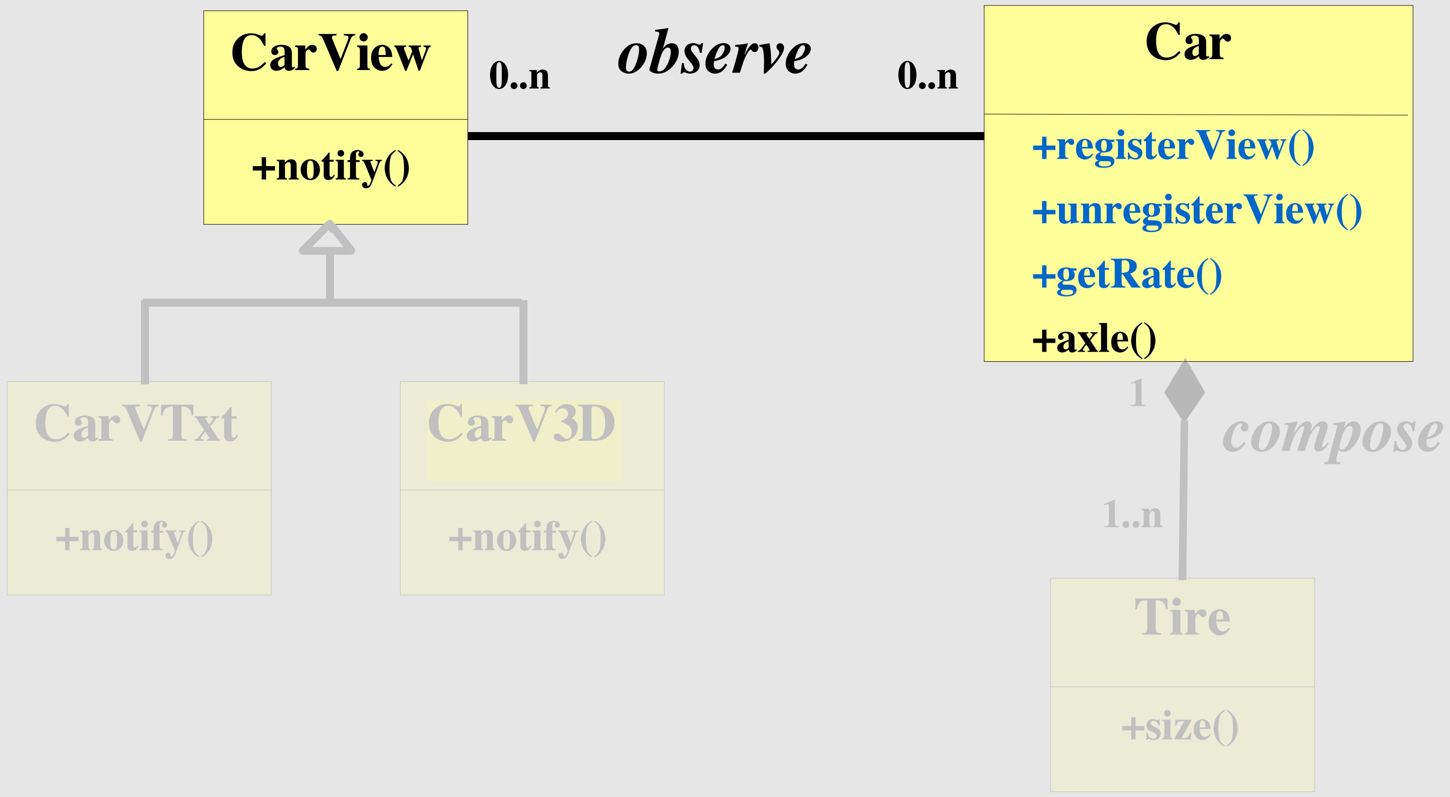
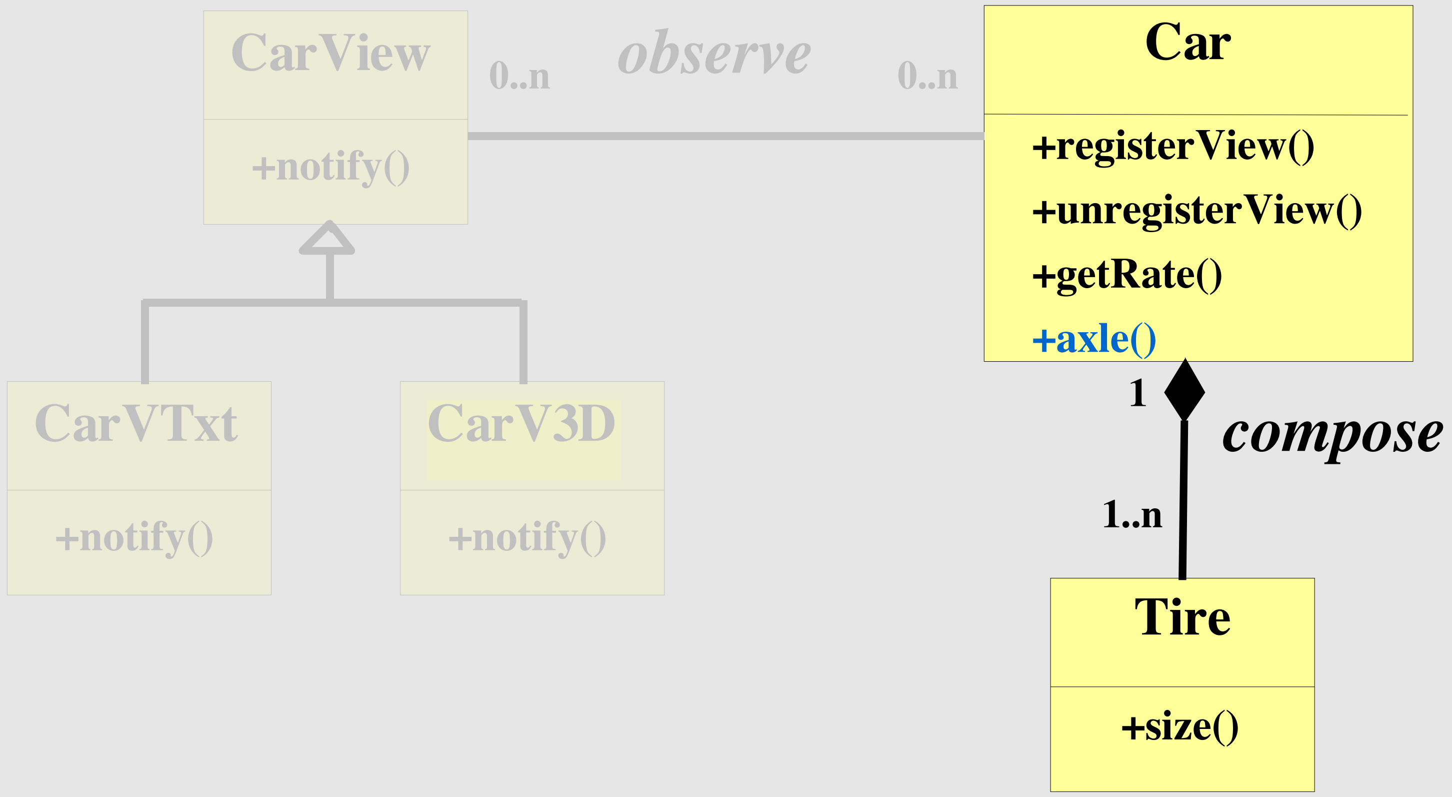
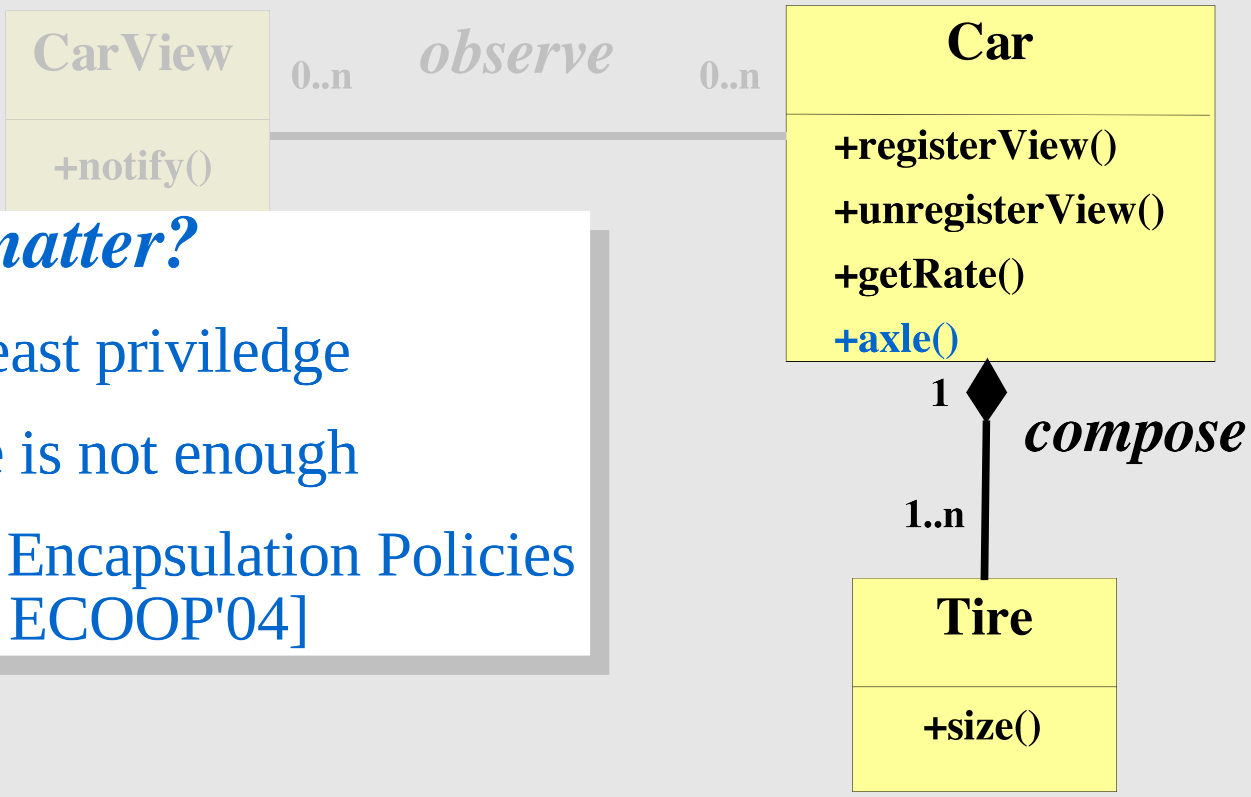
Only One Interface for All Ineractions



Only One Interface for All Interactions



Only One Interface for All Interactions



Why does it matter?

- principle of least priviledge
- Java interface is not enough
- related work: Encapsulation Policies [Scharli et al, ECOOP'04]

Limitations of Mainstream OOPLs on Object Interactions

- No explicit support for whole-part interactions.
- Inadequate support for coarse-grained interactions between objects.
- An object has only one encapsulation-enforceable interface for all interactions it might participate in.
- Interaction bi-directional dependencies are not explicit.
    - Callbacks

Limitations of Mainstream OOPLs on Class Interactions

Limitations of Mainstream OOPLs on Class Interactions

- Interaction bi-directional dependencies are not explicit.
  - Dependencies between superclasses and subclasses are fundamentally bi-directional.
- Interfaces for class interations are tangled with those for object interactions.
- A superclass has only one interface for all subclasses.

Limitations of Mainstream OOPLs on Class Interactions

- Interaction bi-directional dependencies are not explicit.
- Interfaces for class interations are tangled with those for object interactions.
    - related work: Traits
- A superclass has only one interface for all subclasses.

Limitations of Mainstream OOPLs on Class Interactions

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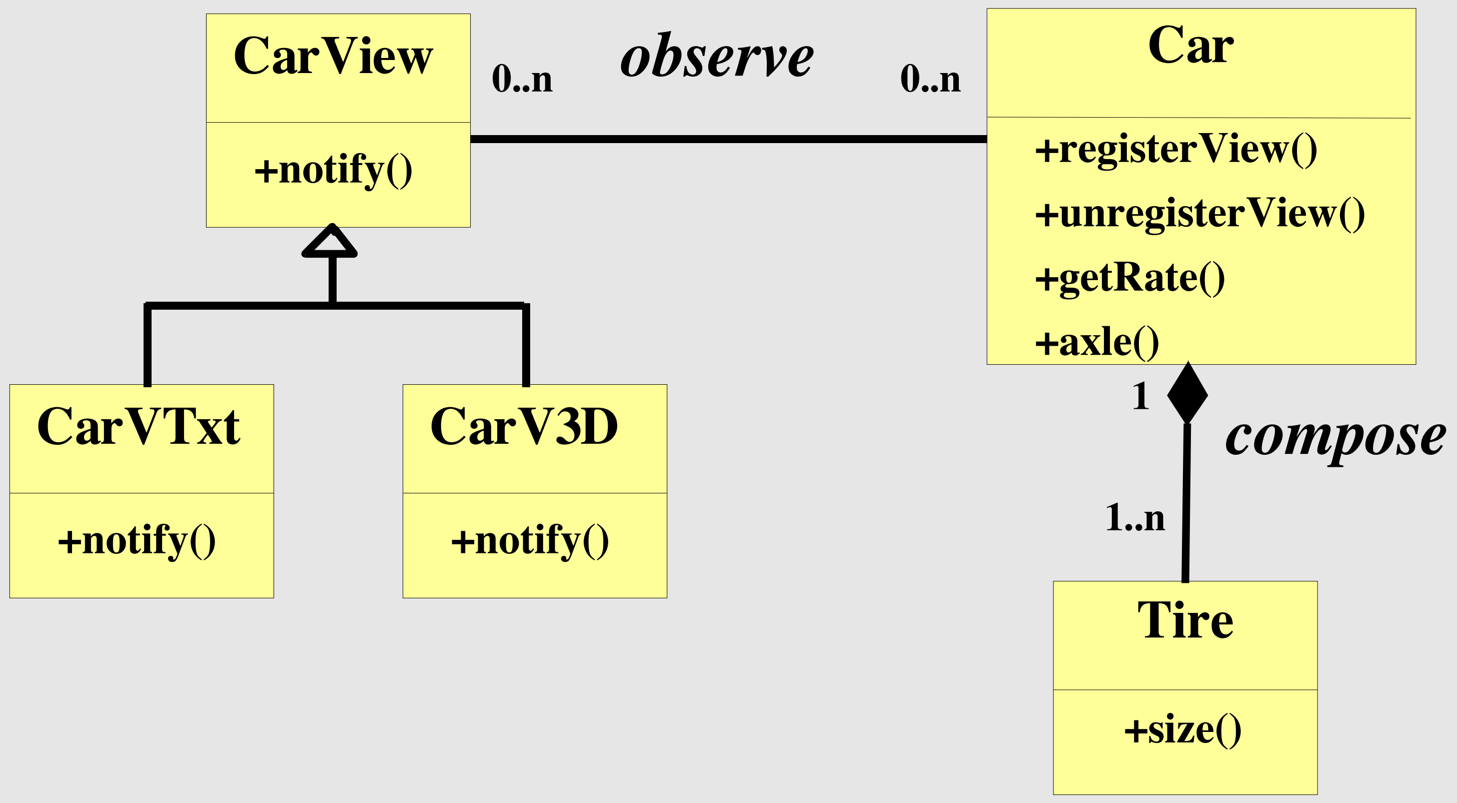
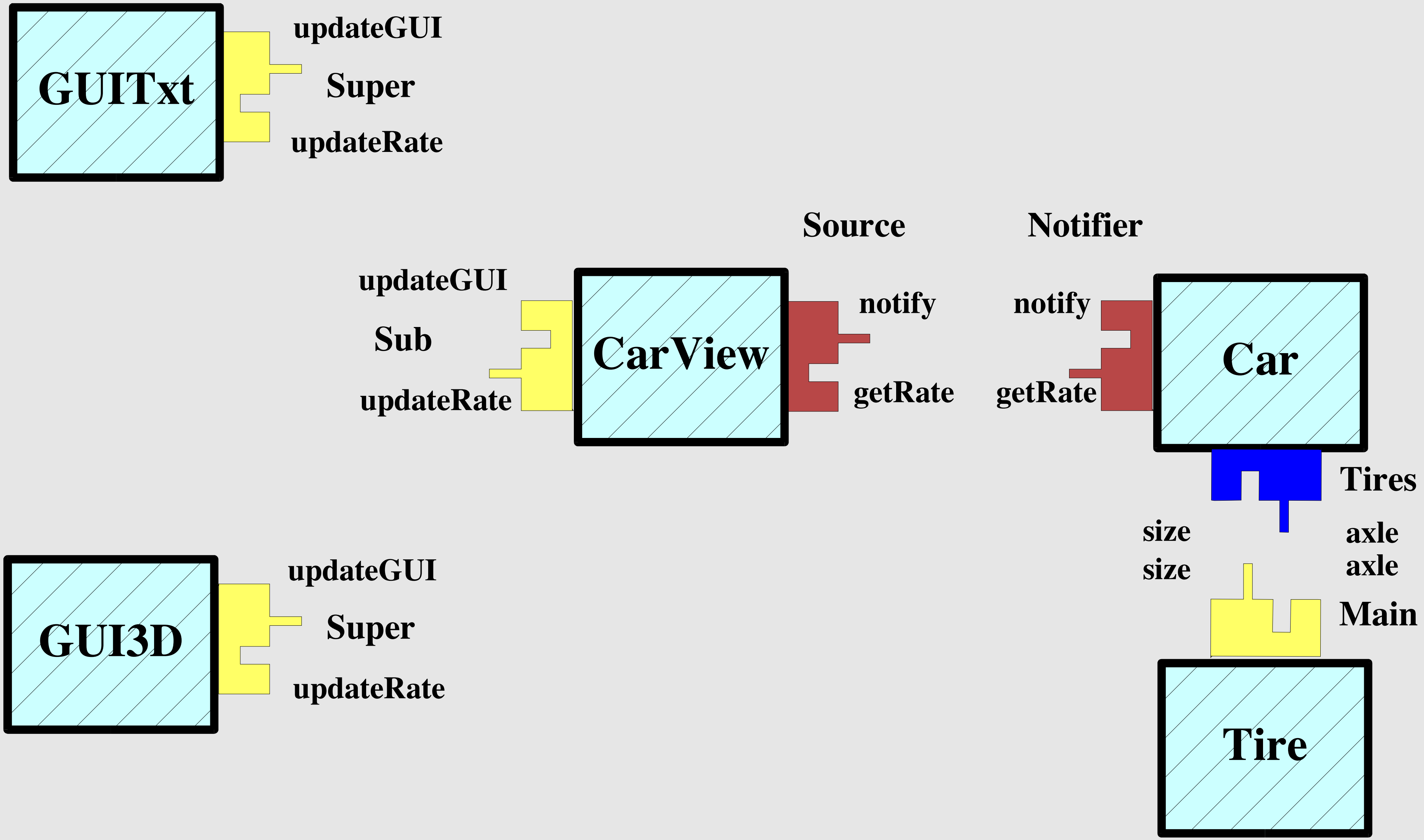
- Interfaces for class interations are tangled with those for object interactions.
- A superclass has only one interface for all subclasses.

The Classages Solution

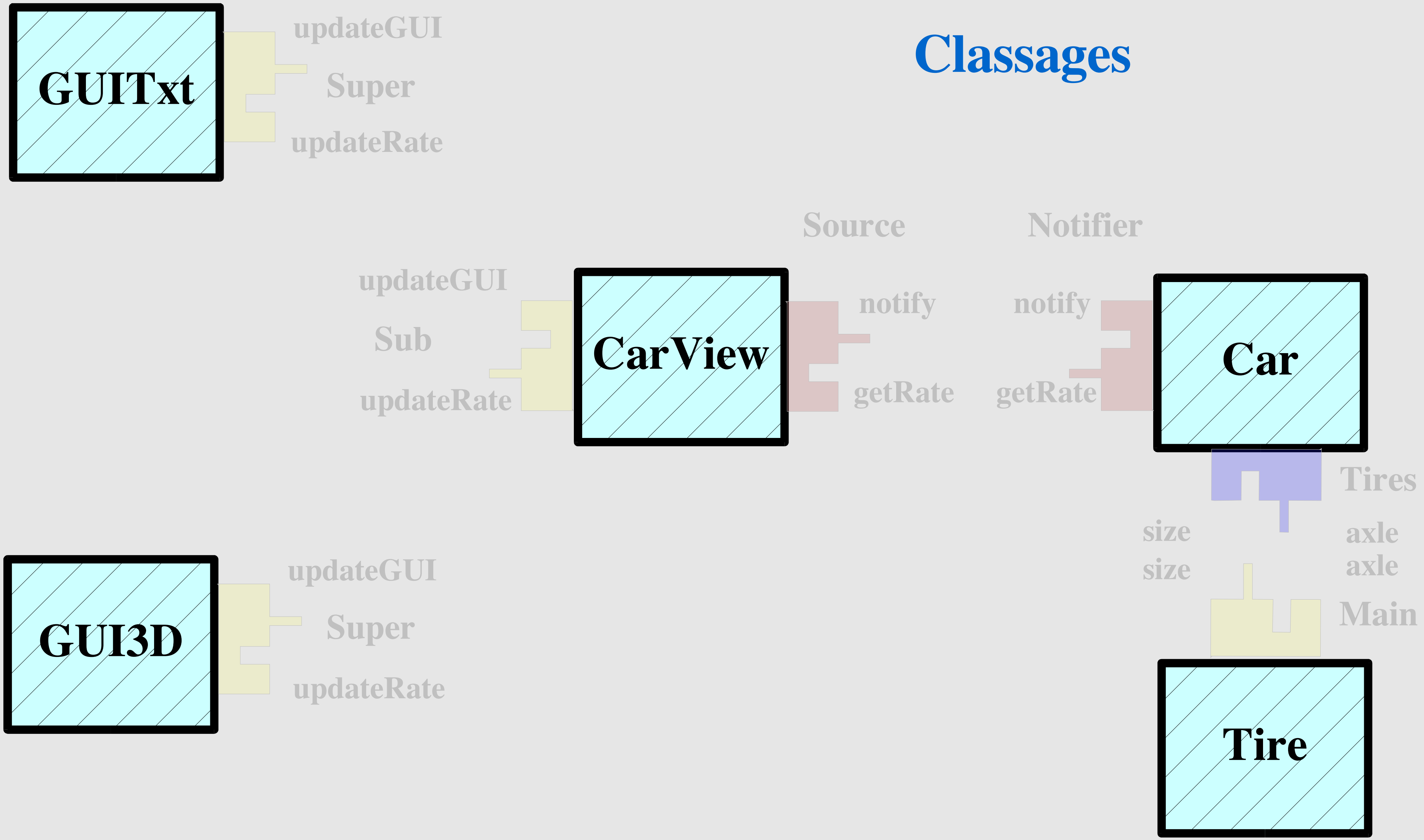
The Simple Example Revisited



The Same Example in Classages

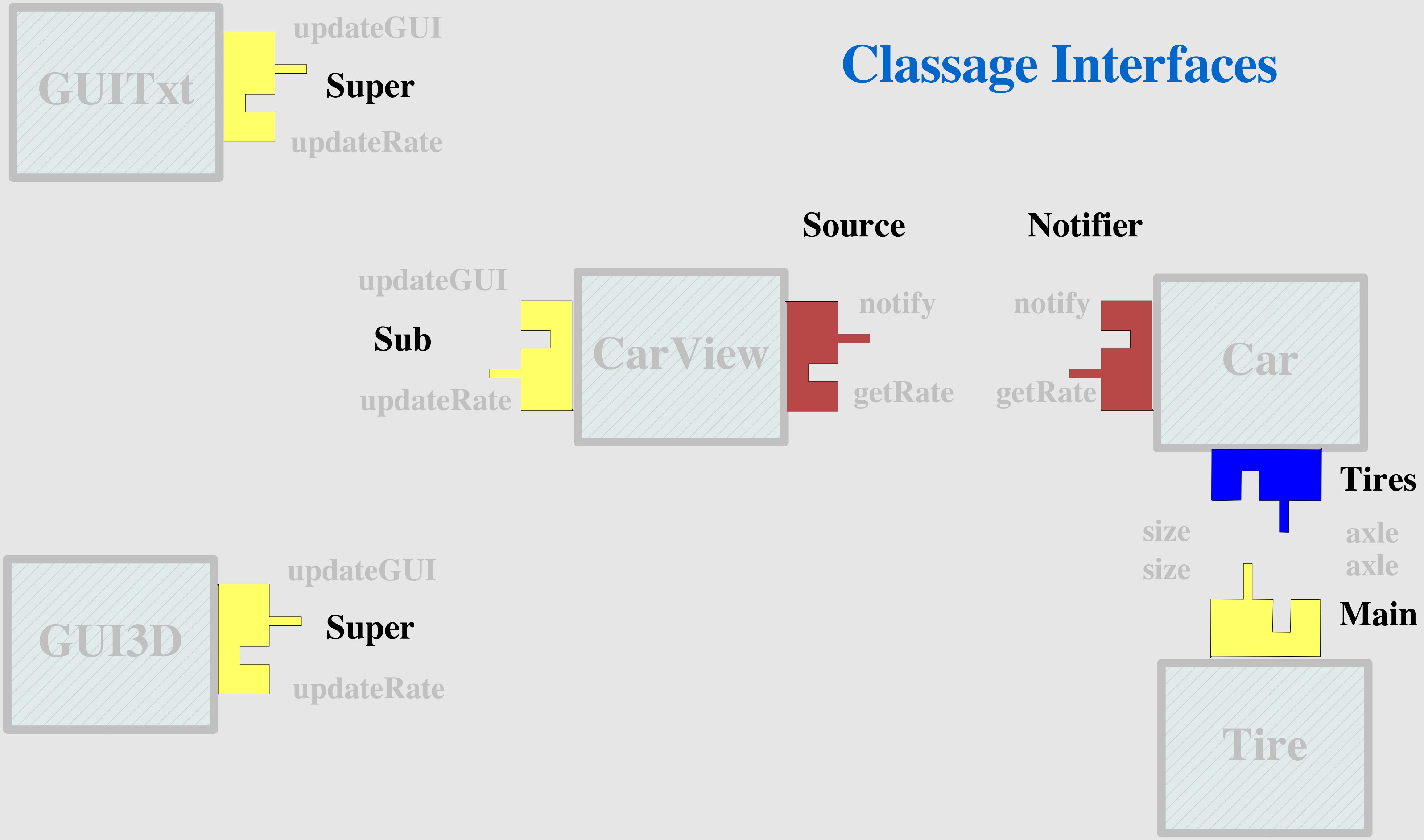


Classage Basics: Classages

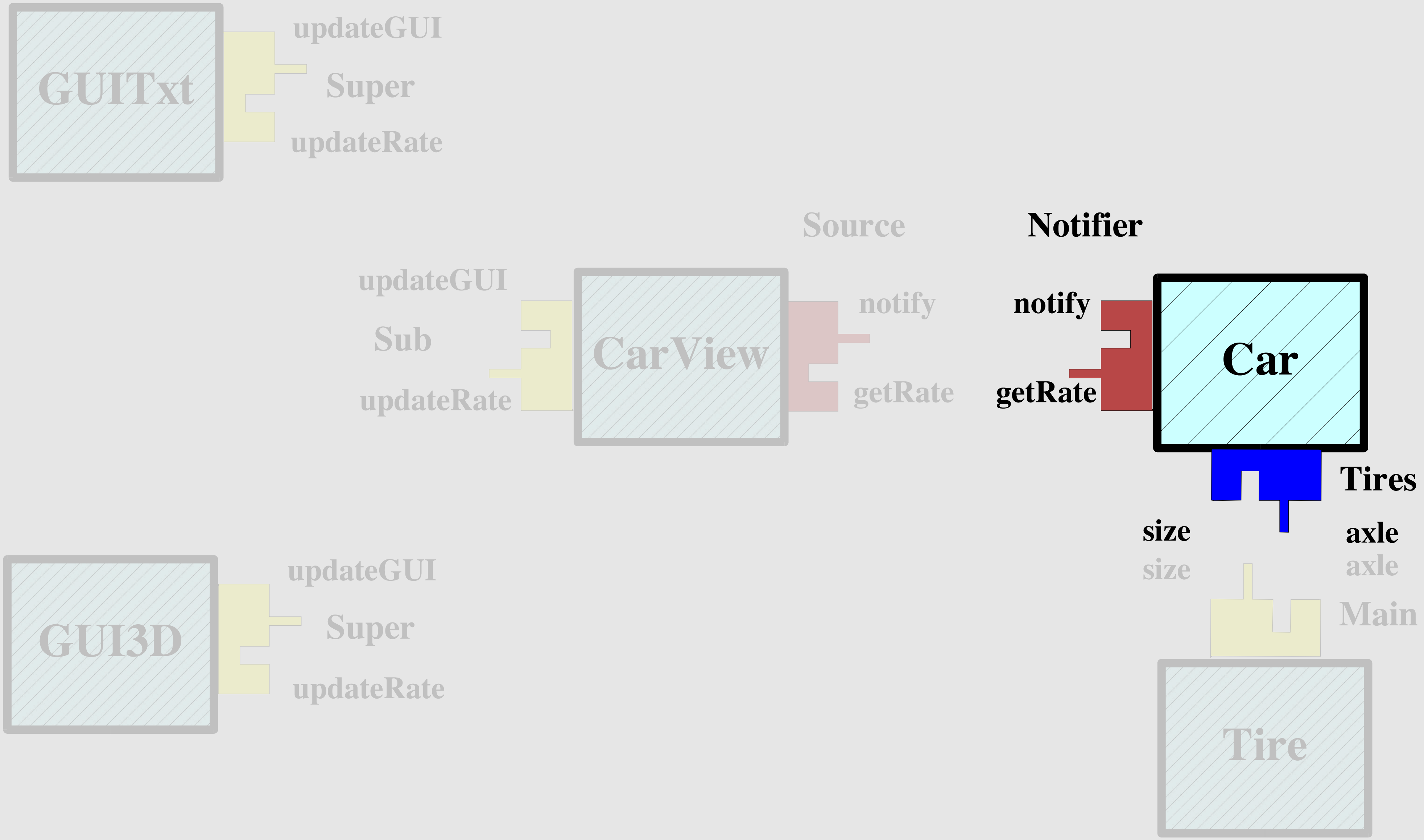


Classage Basics

Classage Interfaces

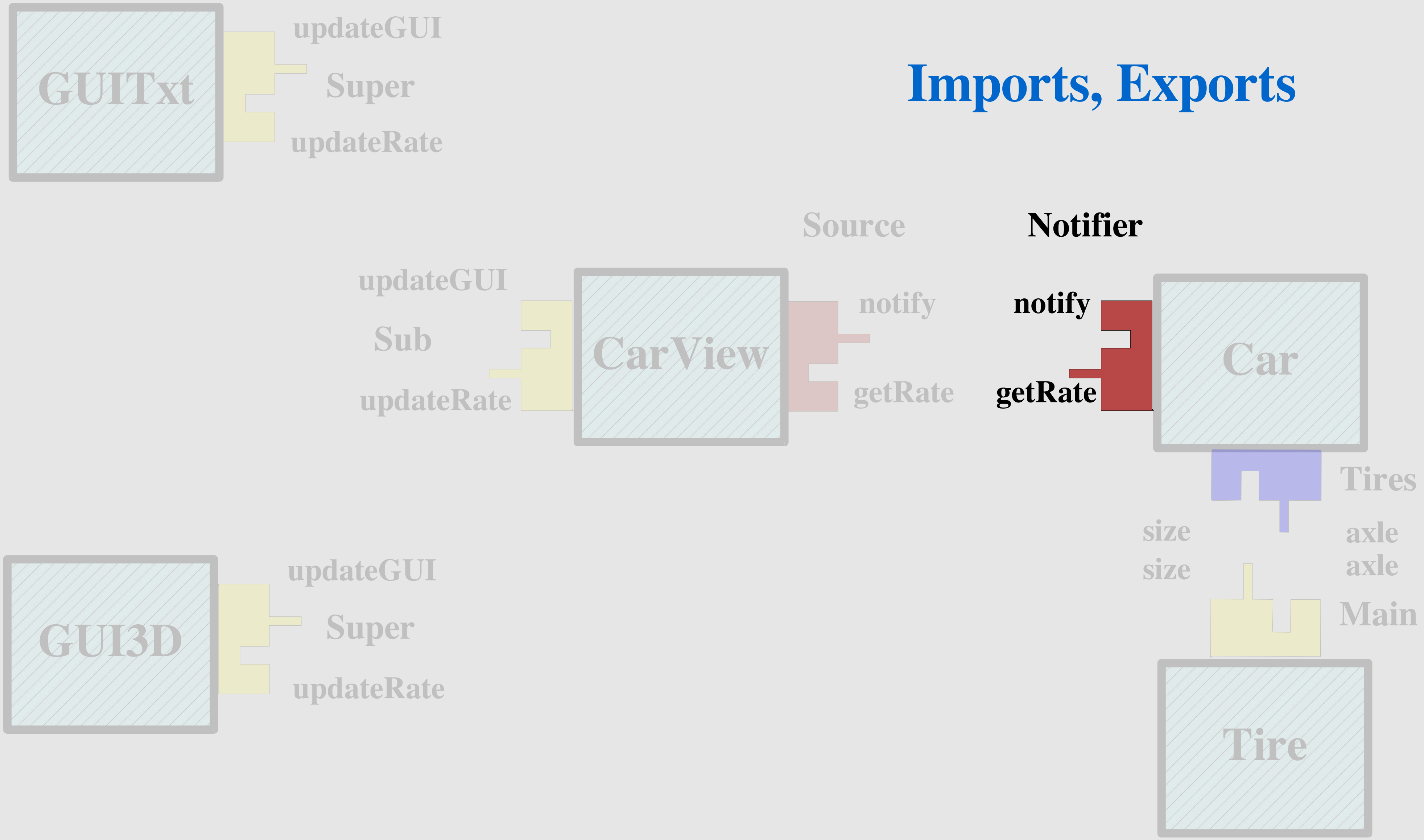


Classage Basics

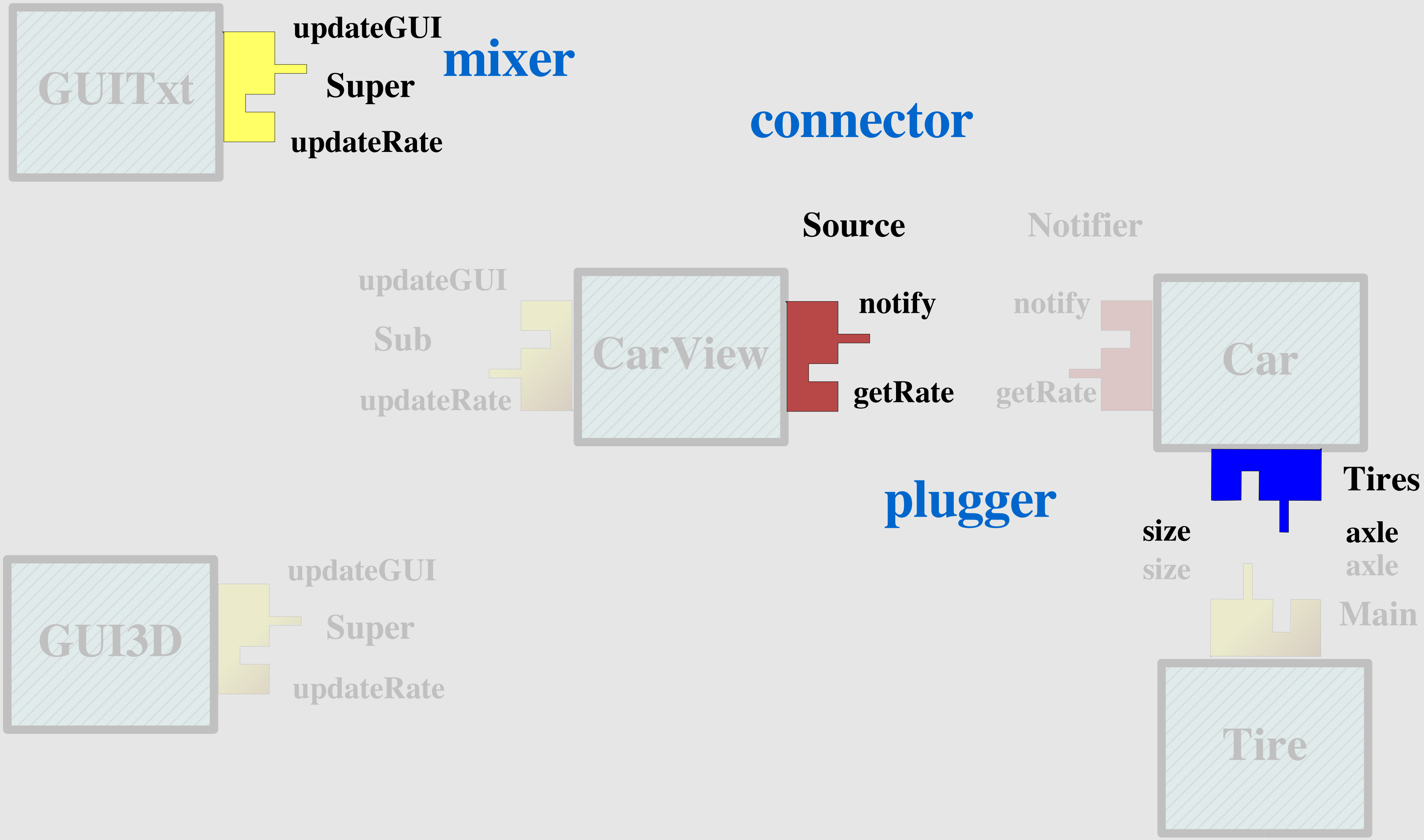


Classage Basics

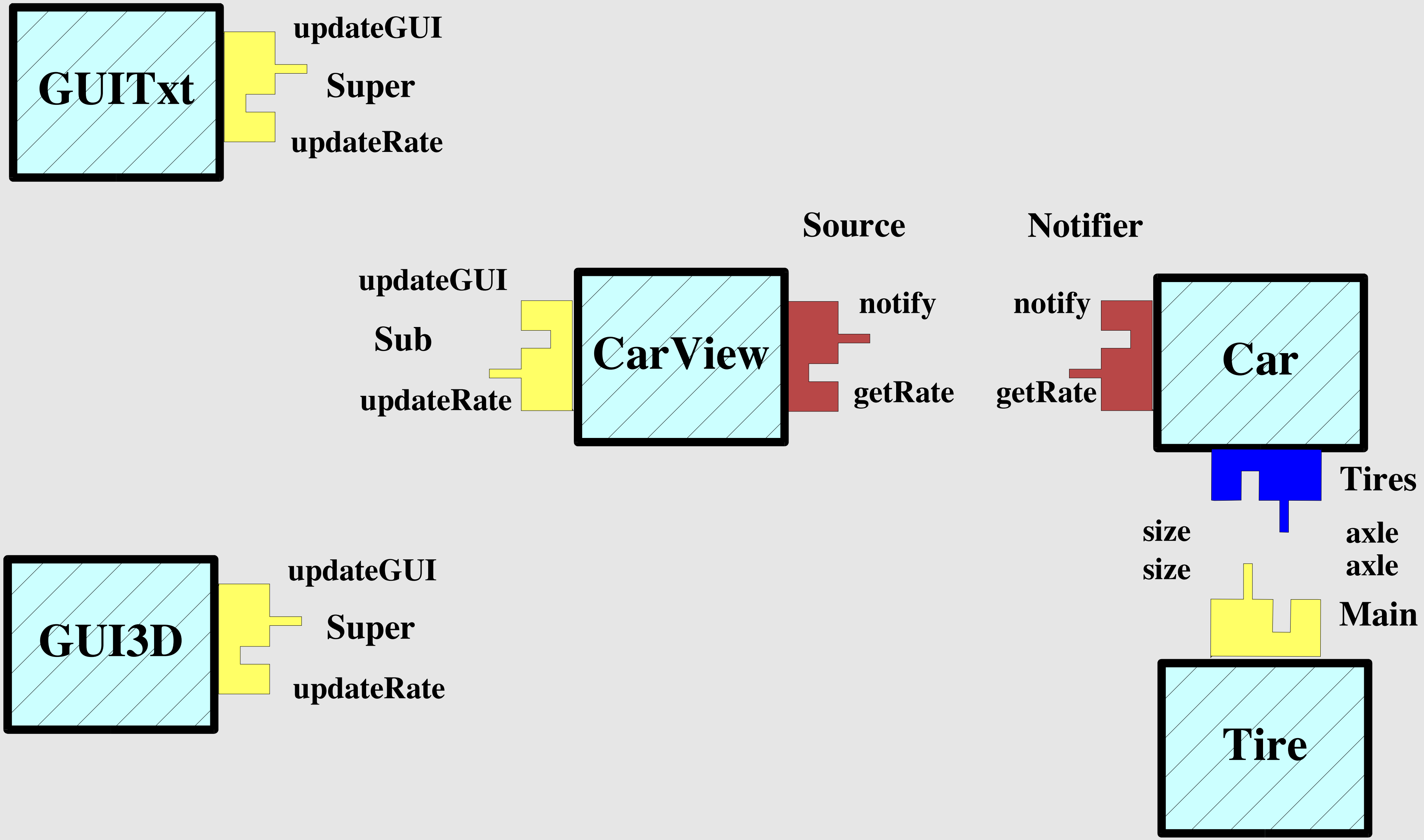
Imports, Exports



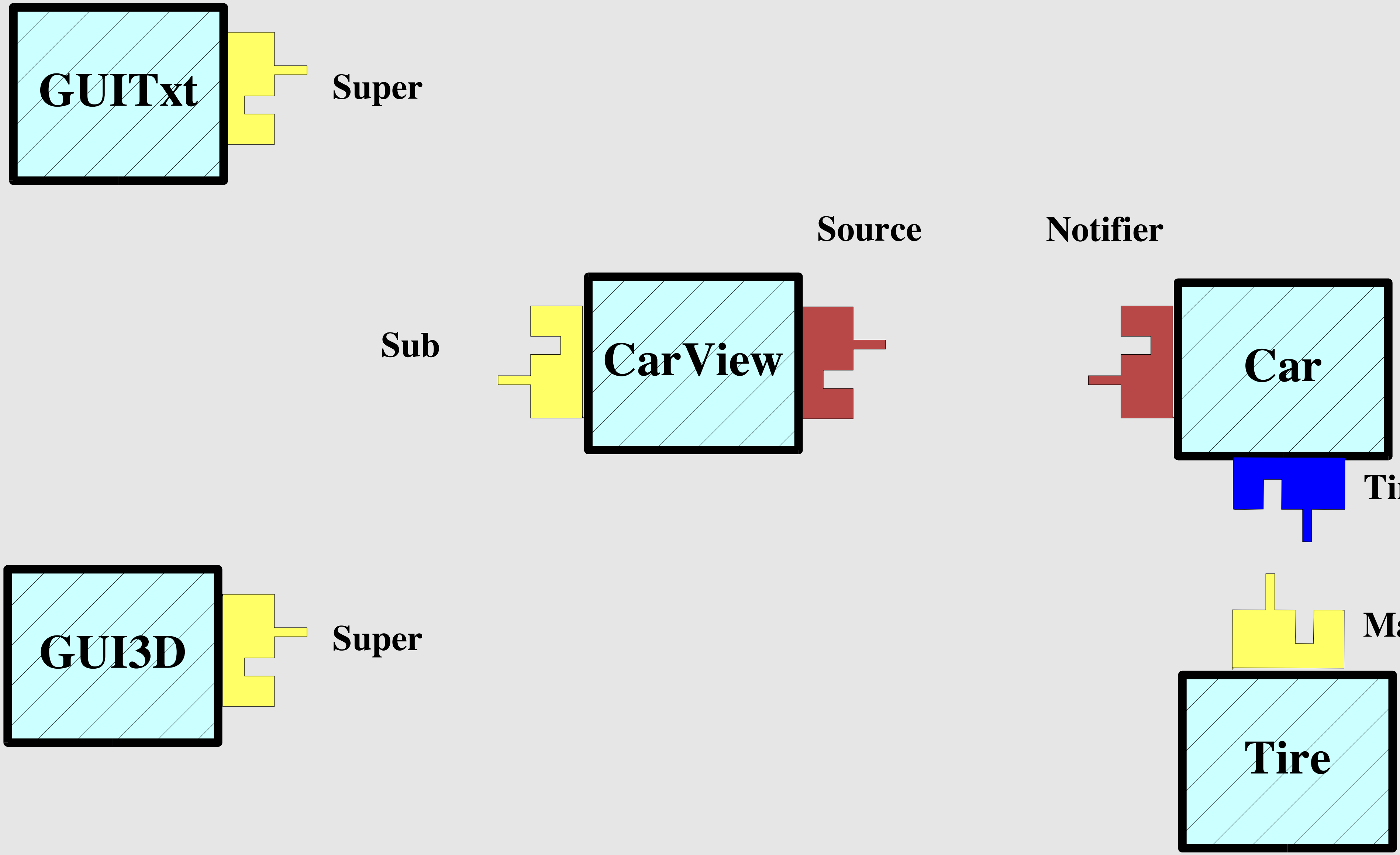
Classage Basics



A Demo

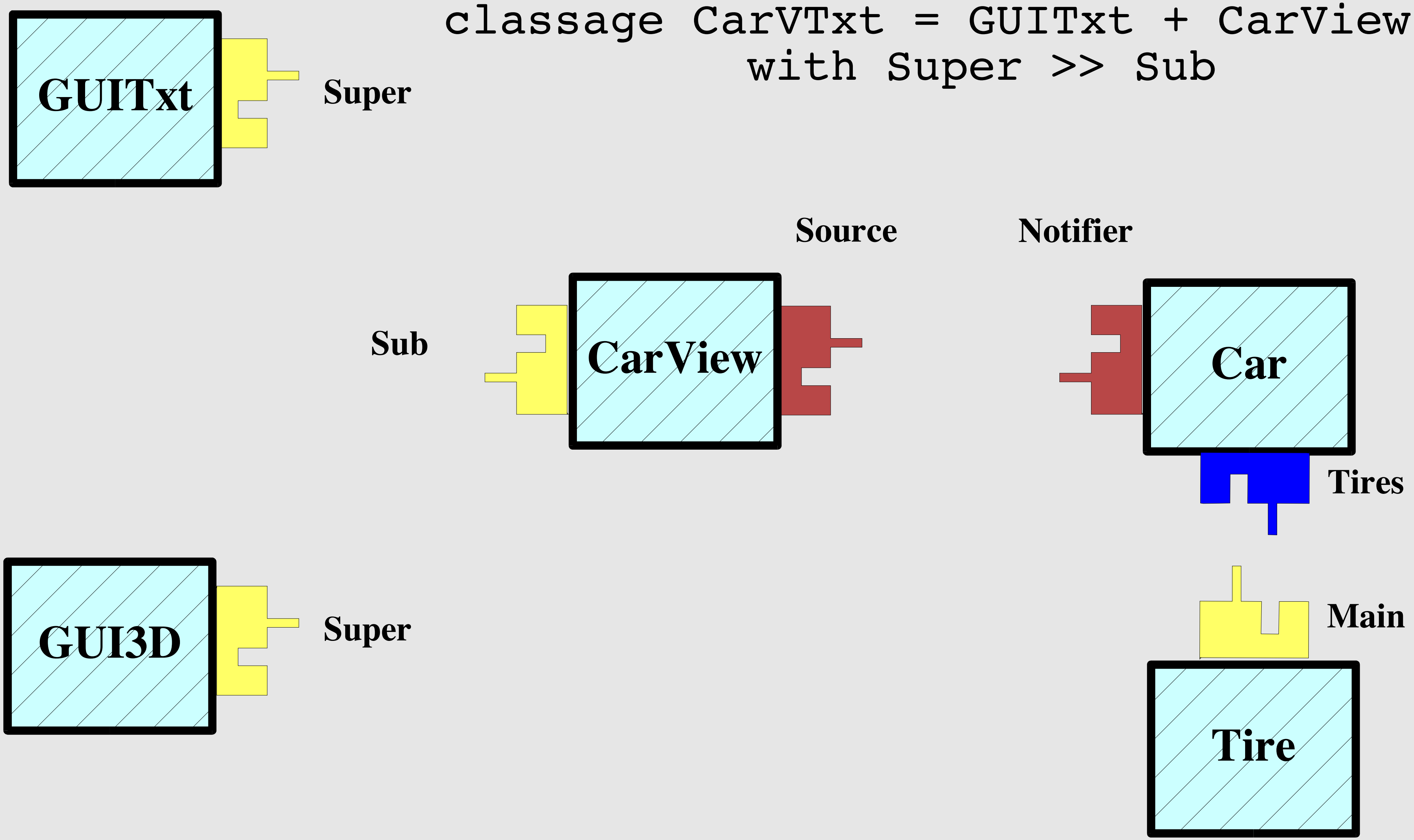

GUITxt
updateGUI
Super
updateRate
Source
Notifier
updateGUI
Sub
updateRate
CarView
notify
getRate
notify
getRate
Car
Tires
size
size
axle
axle
Main
Tire
GUI3D
updateGUI
Super
updateRate

A Demo

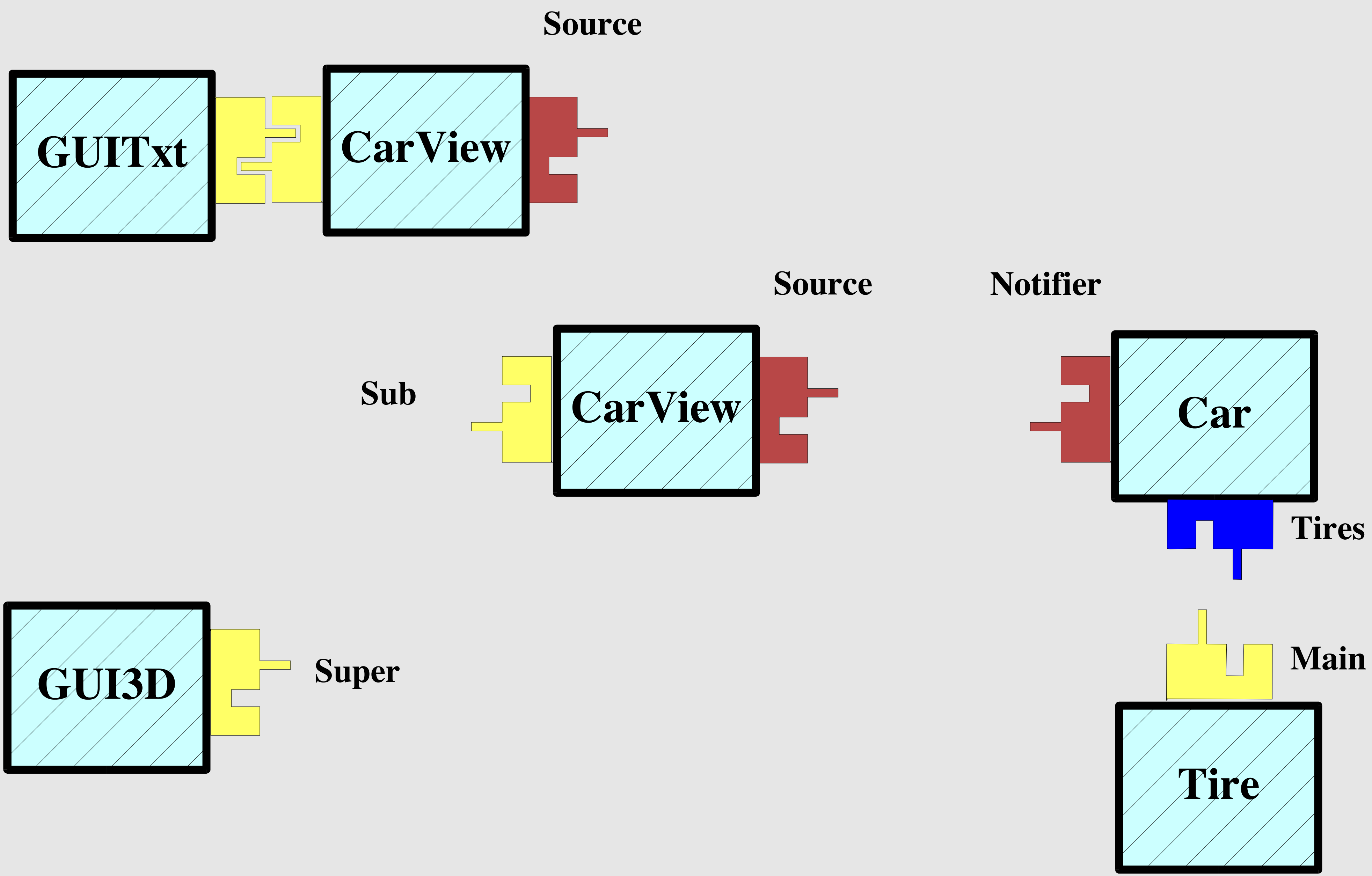

GUITxt
Super
Source
Notifier
Sub
CarView
Car
Tires
Main
GUI3D
Super
Tire

At Compile Time...

```
classage CarVTxt = GUITxt + CarView
          with Super >> Sub
```



Mixing: the Class Interaction



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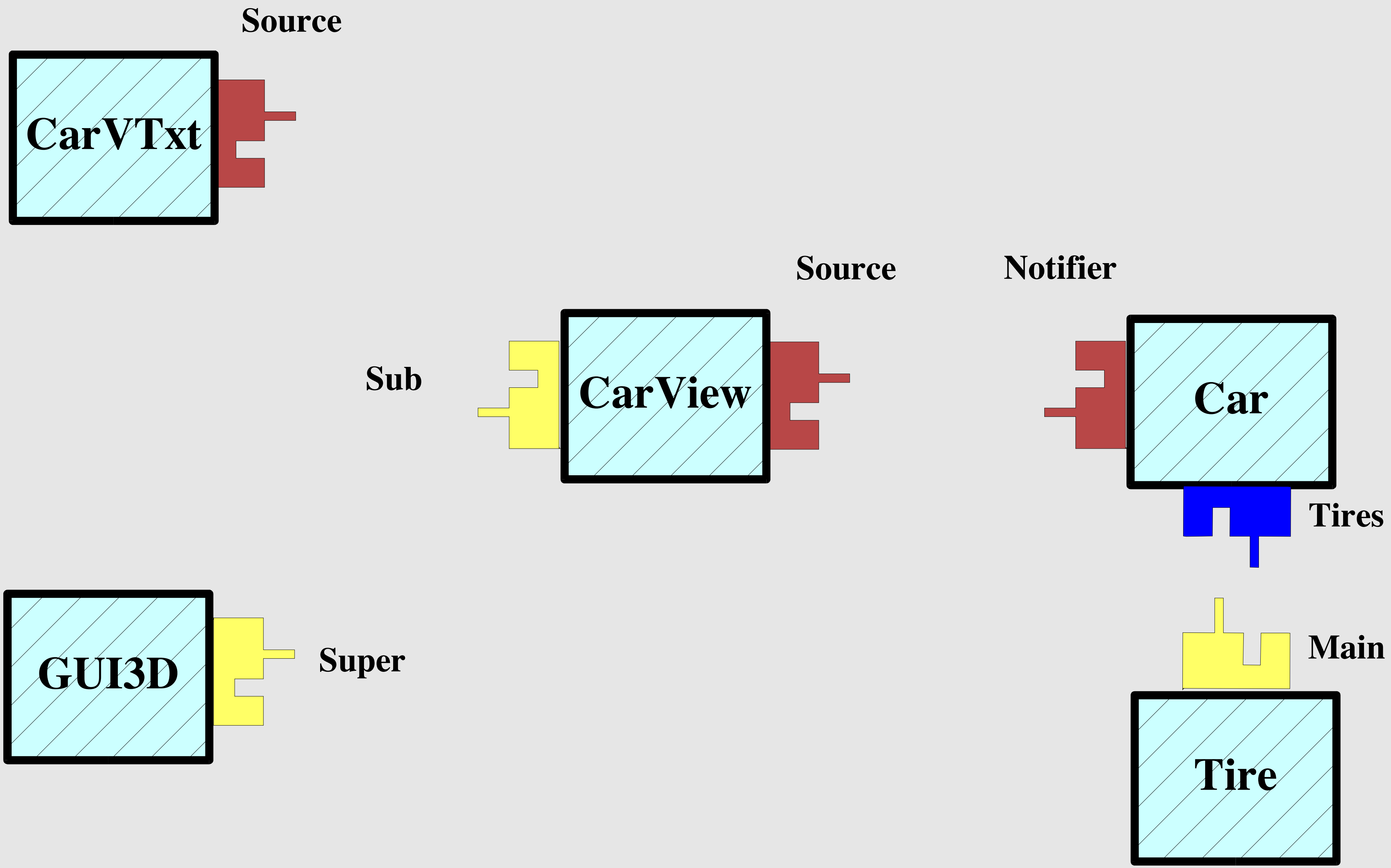
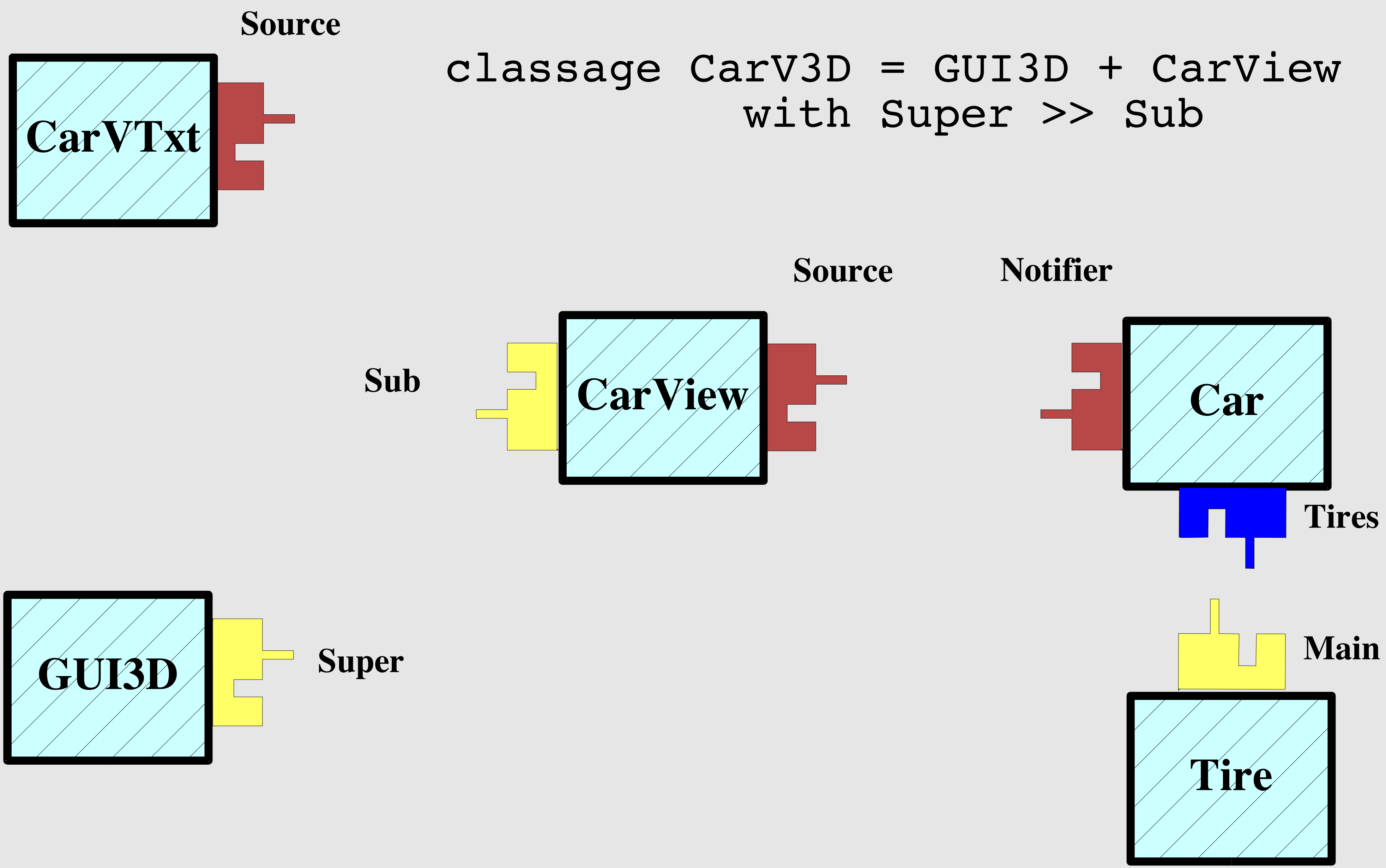


Mixing: the Class Interaction

```
classage CarV3D = GUI3D + CarView
          with Super >> Sub
```



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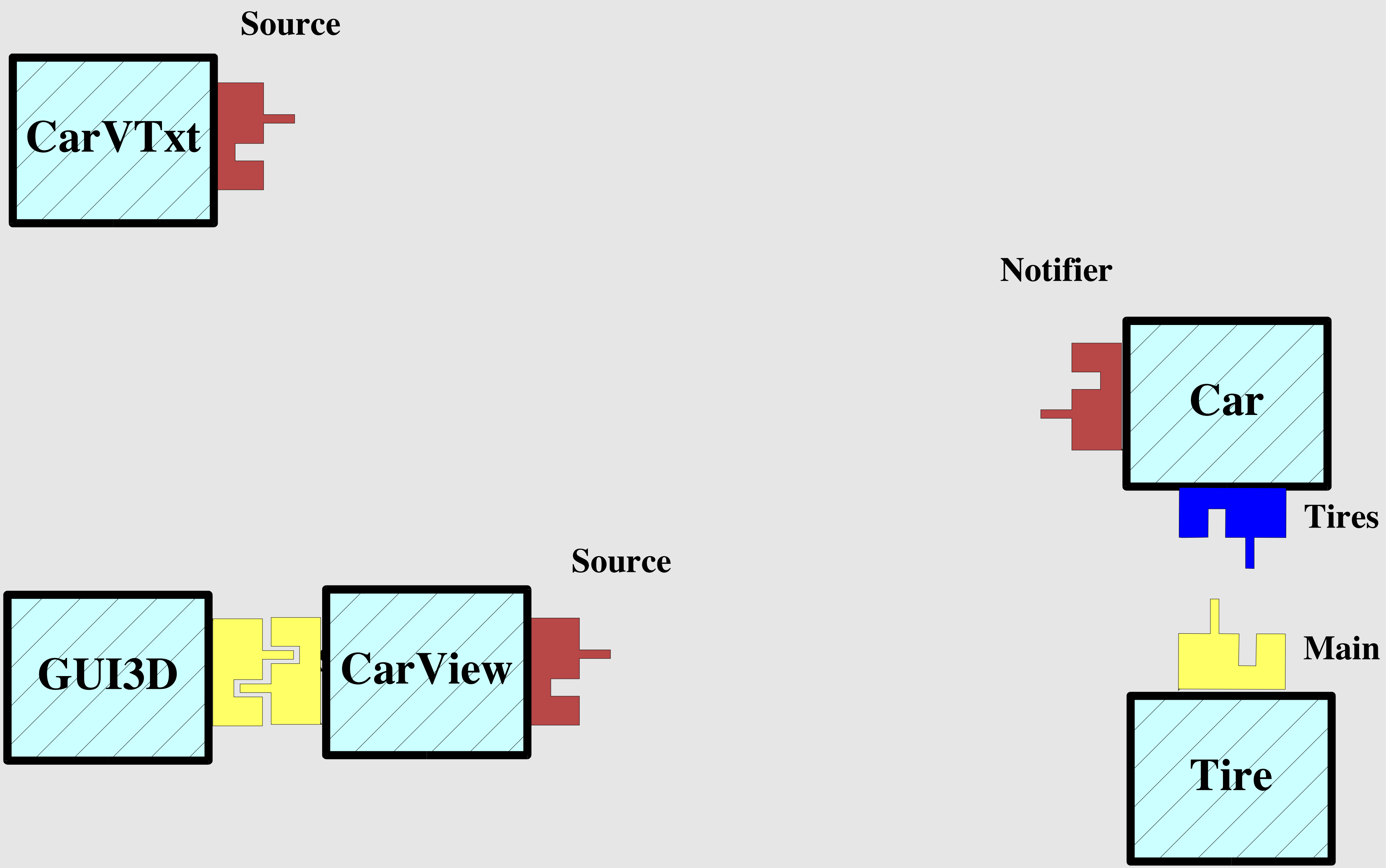

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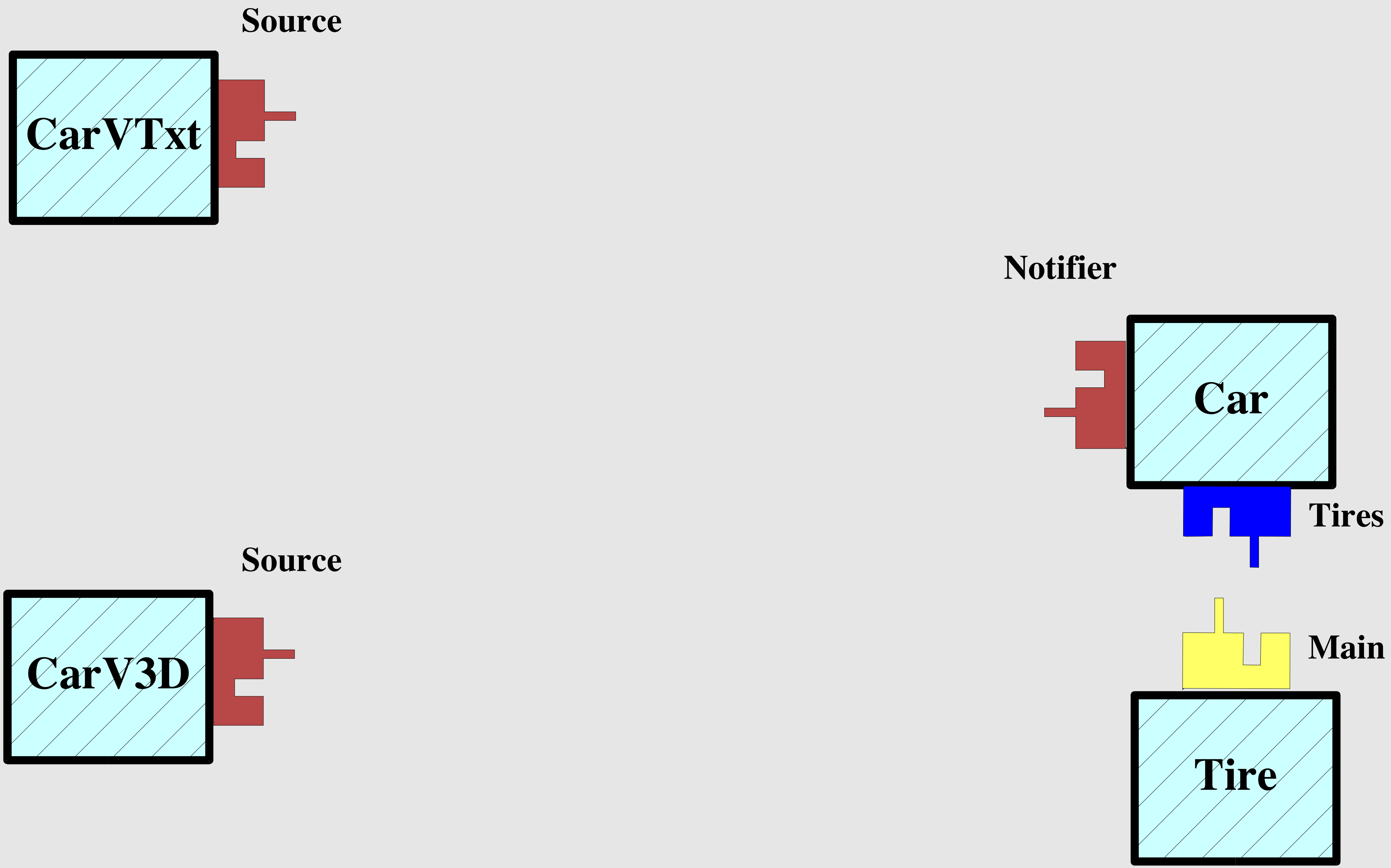
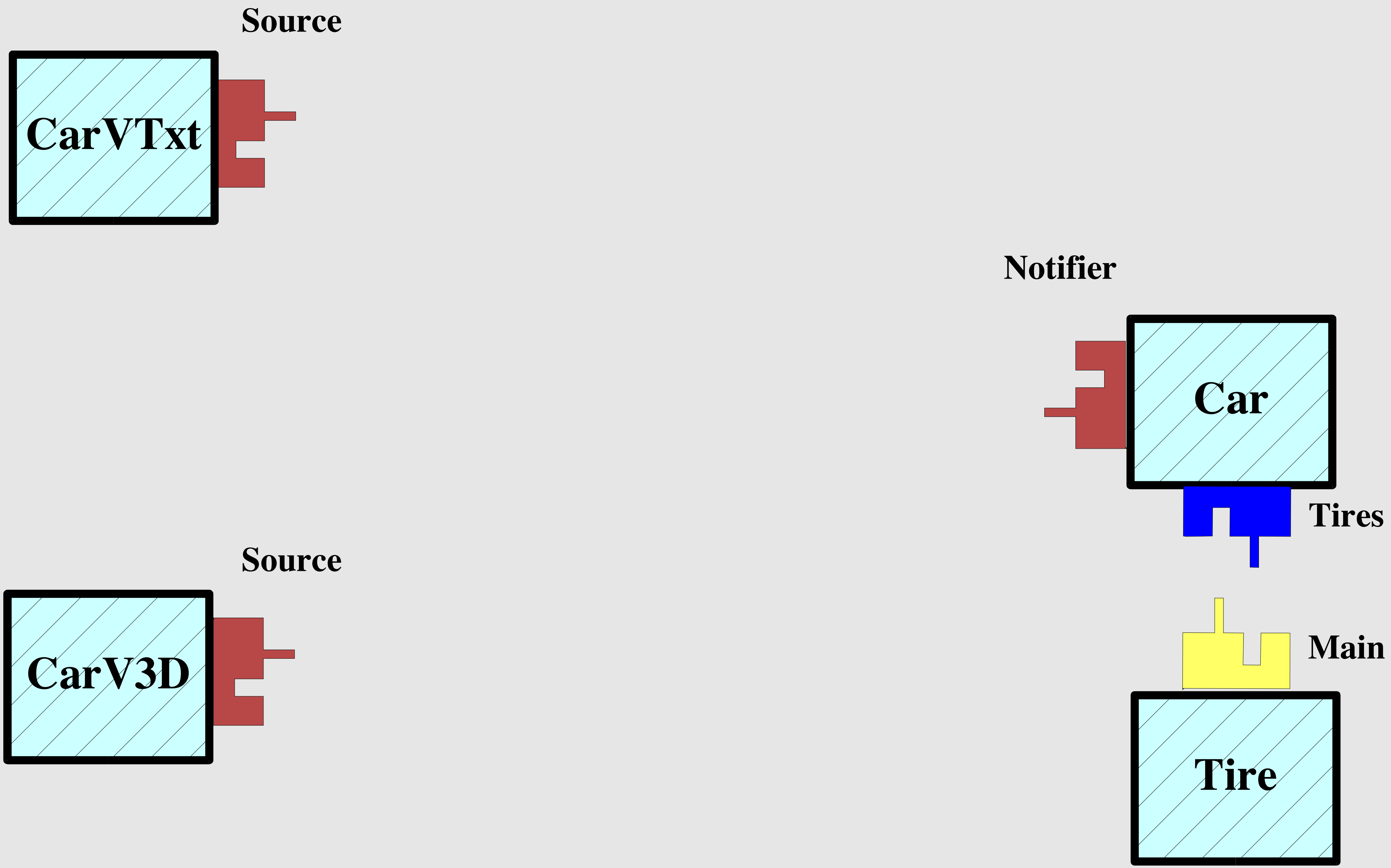
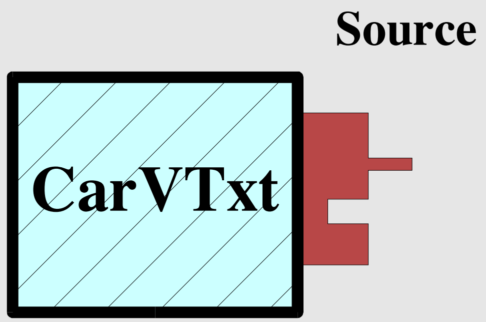


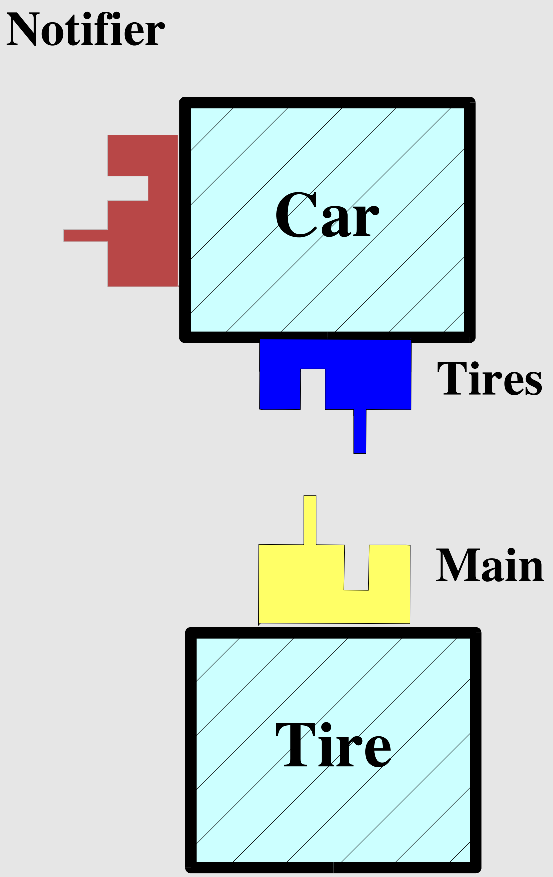
Now the program is running...

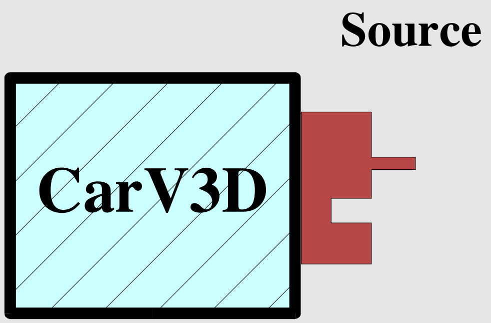


Objectage Instantiation

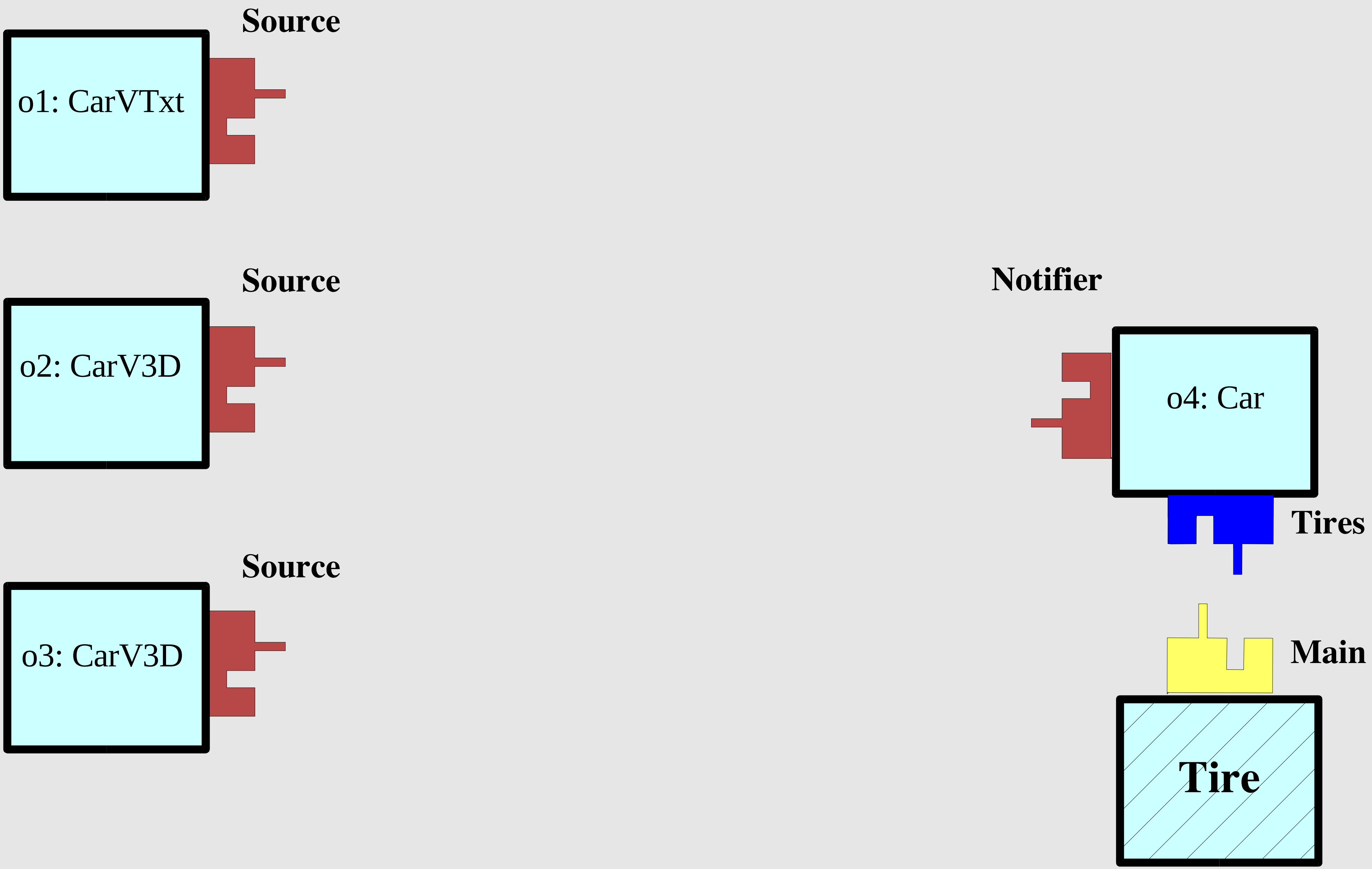
```
o1 = create CarVTxt();
o2 = create CarV3D();
o3 = create CarV3D();
o4 = create Car();
```



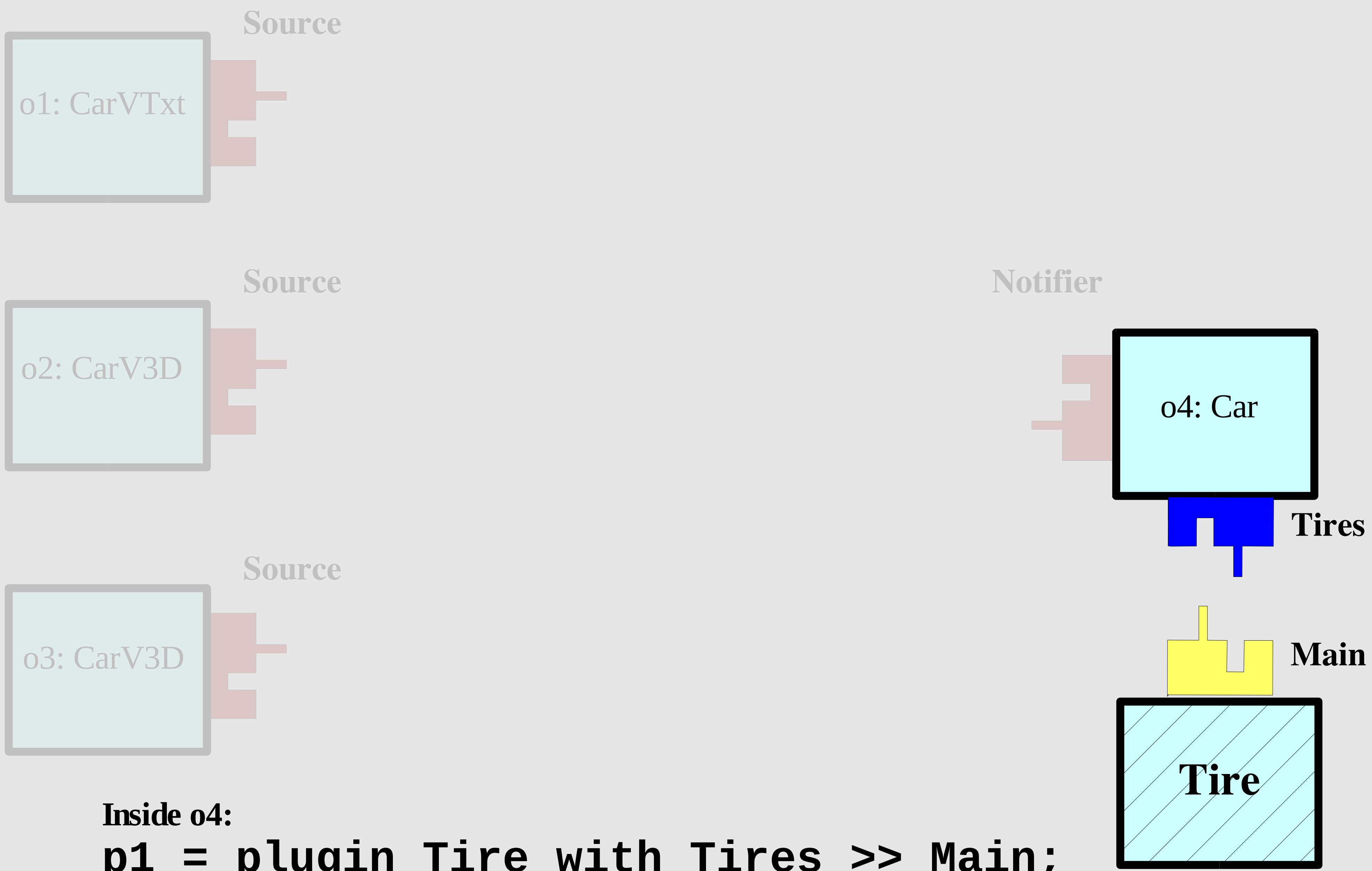




Objectage Instantiation



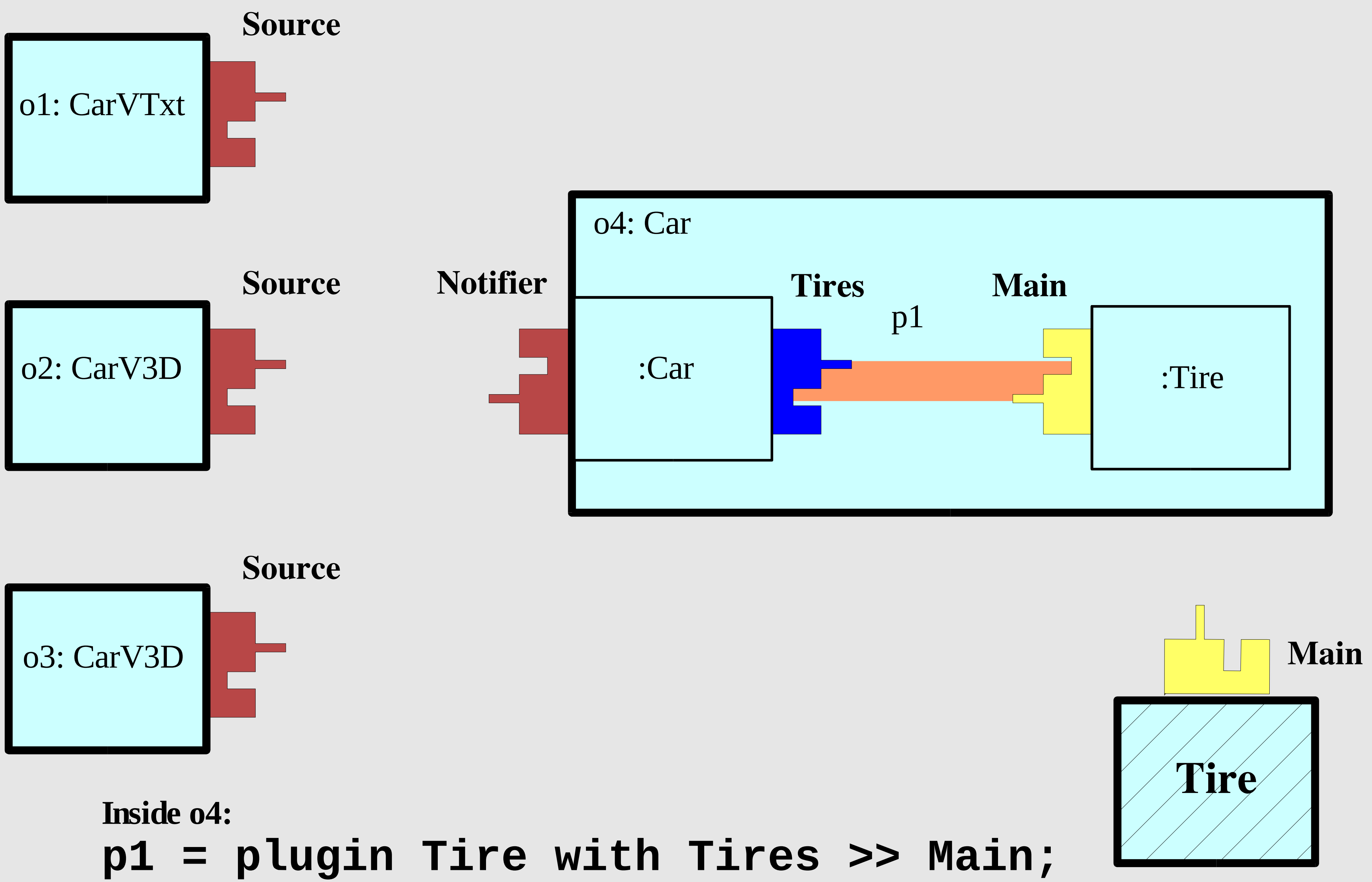
Plugging: Whole-Part Interaction



Inside o4:

```
p1 = plugin Tire with Tires >> Main;
```

Plugging: Whole-Part Interaction



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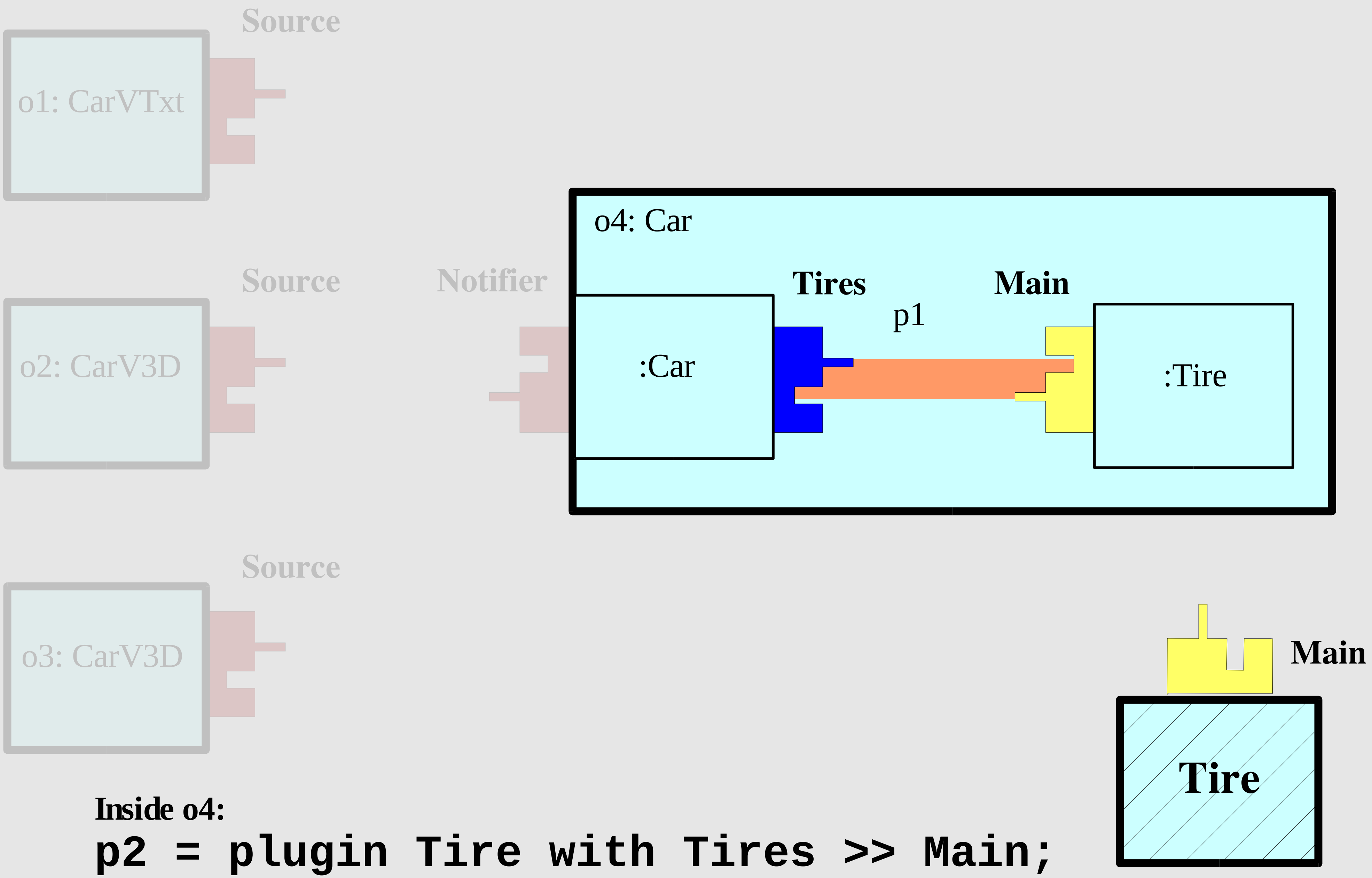
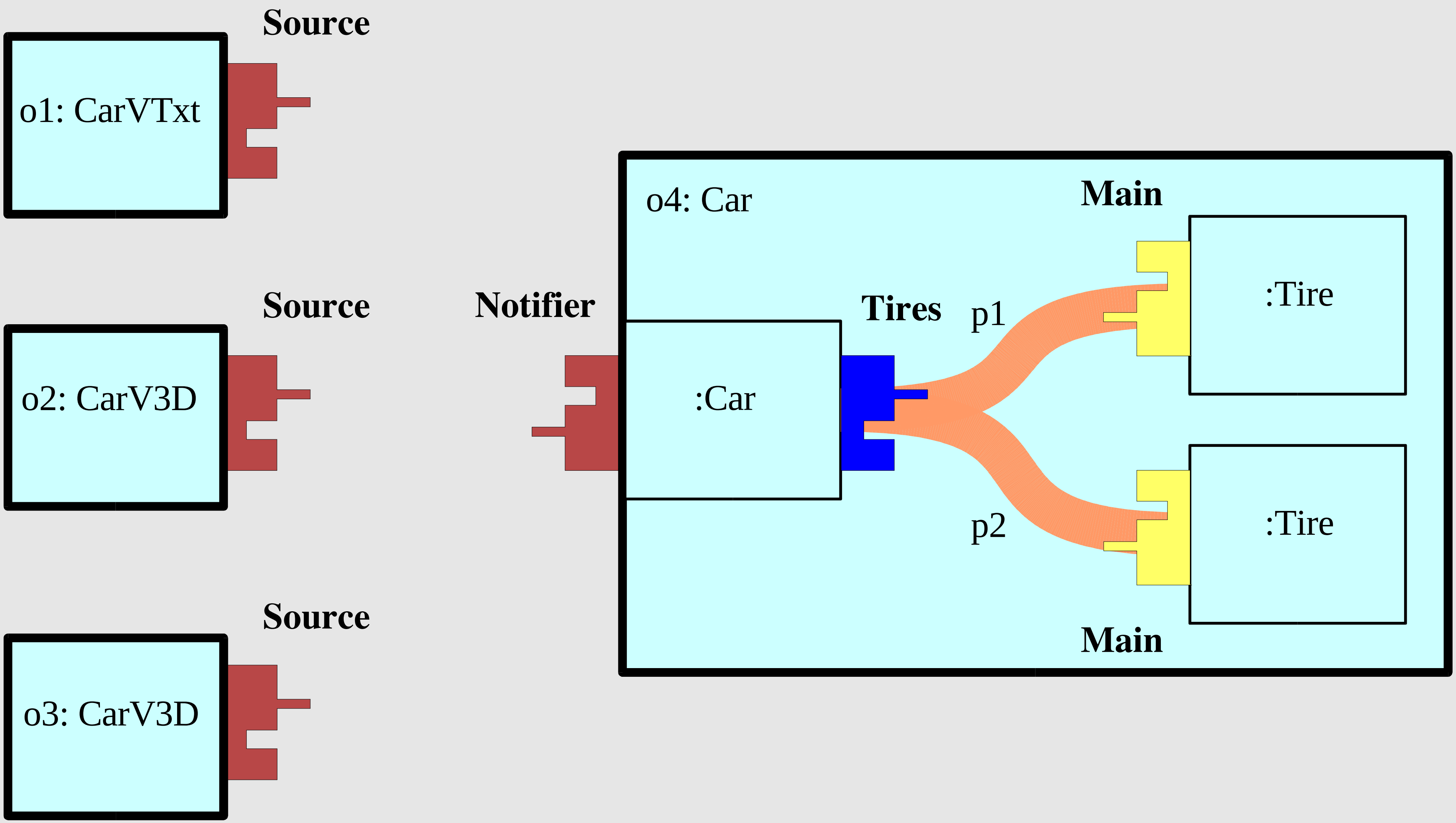


Inside o4:

```
p2 = plugin Tire with Tires >> Main;
```

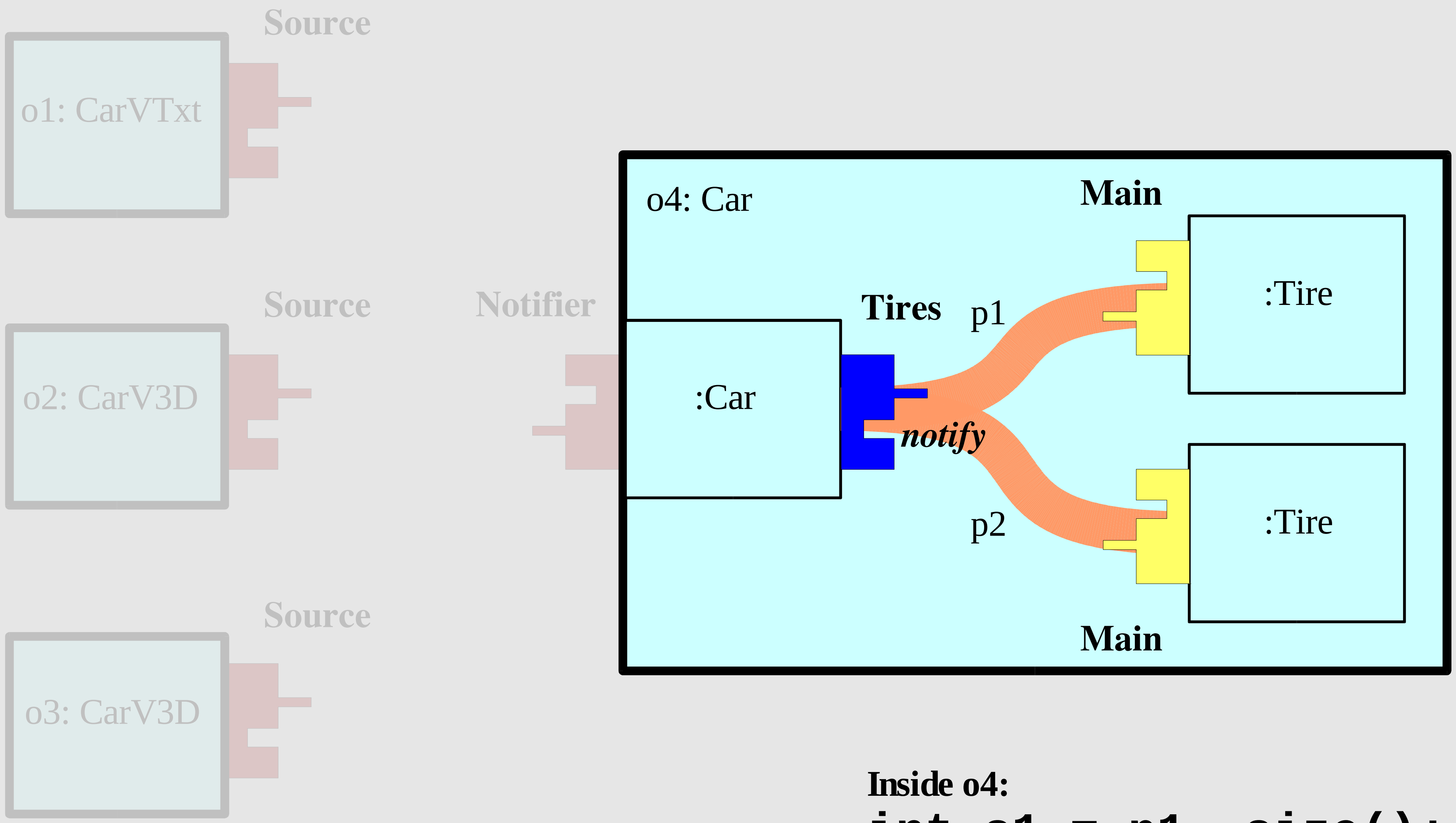
Plugging: Whole-Part Interaction



Inside o4:

```
p2 = plugin Tire with Tires >> Main;
```

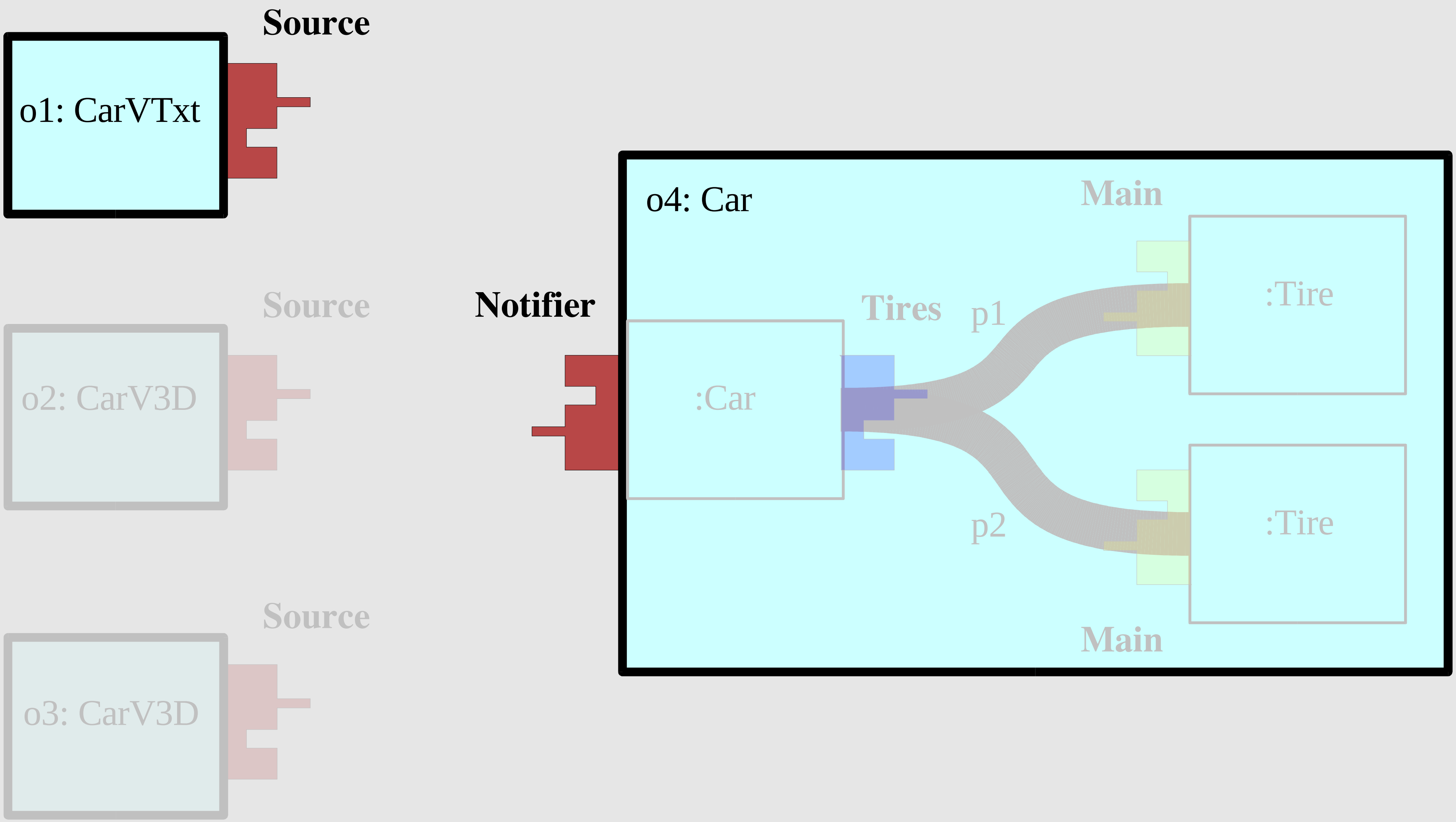
Plugging Handles



Inside o4:

```
int s1 = p1..size();
int s2 = p2..size();
```

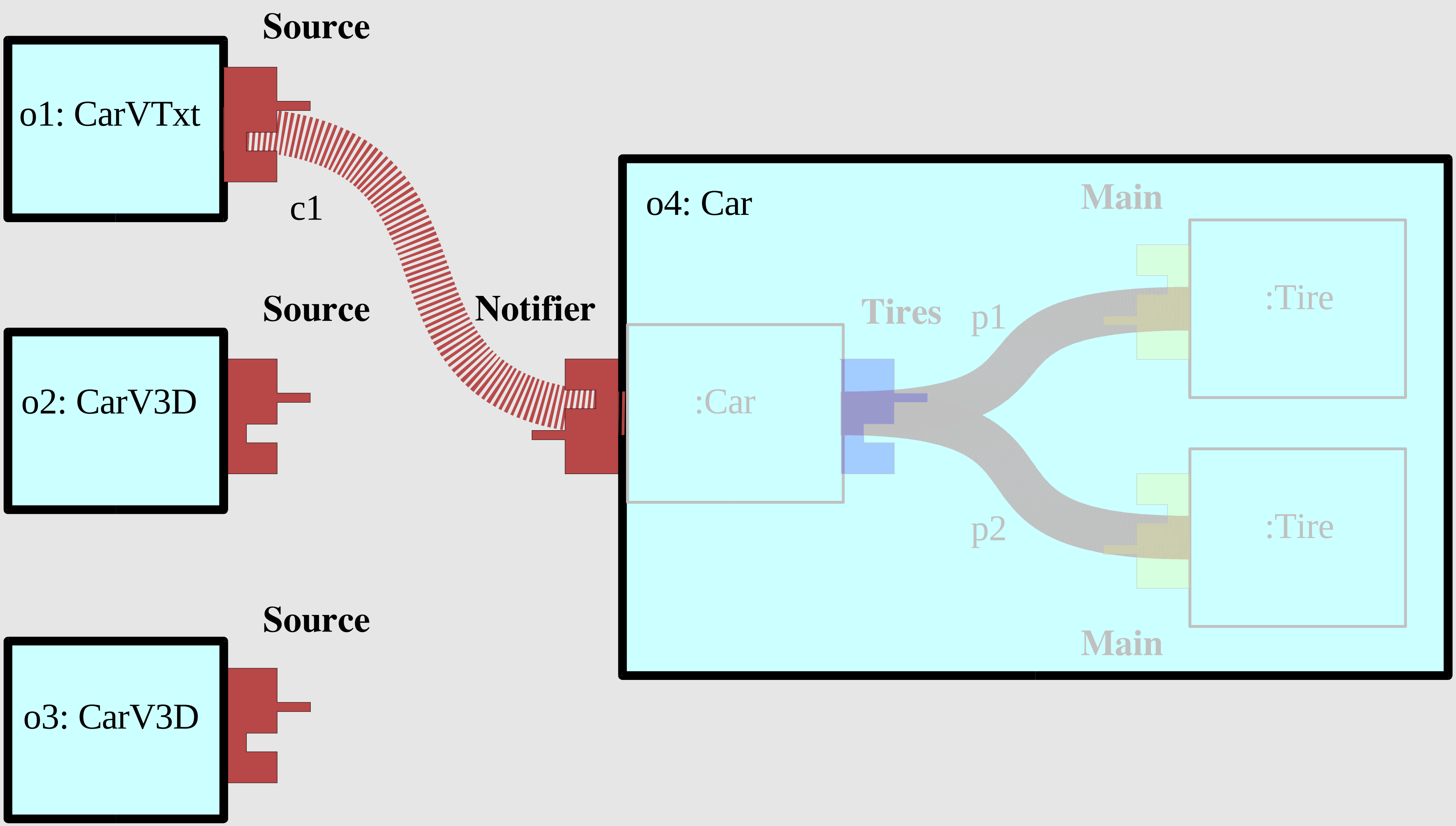
Connection: Peer-to-Peer Interaction



Inside o1:

```
c1 = connect o4 with Source >> Notifier;
```

Connection Established



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```
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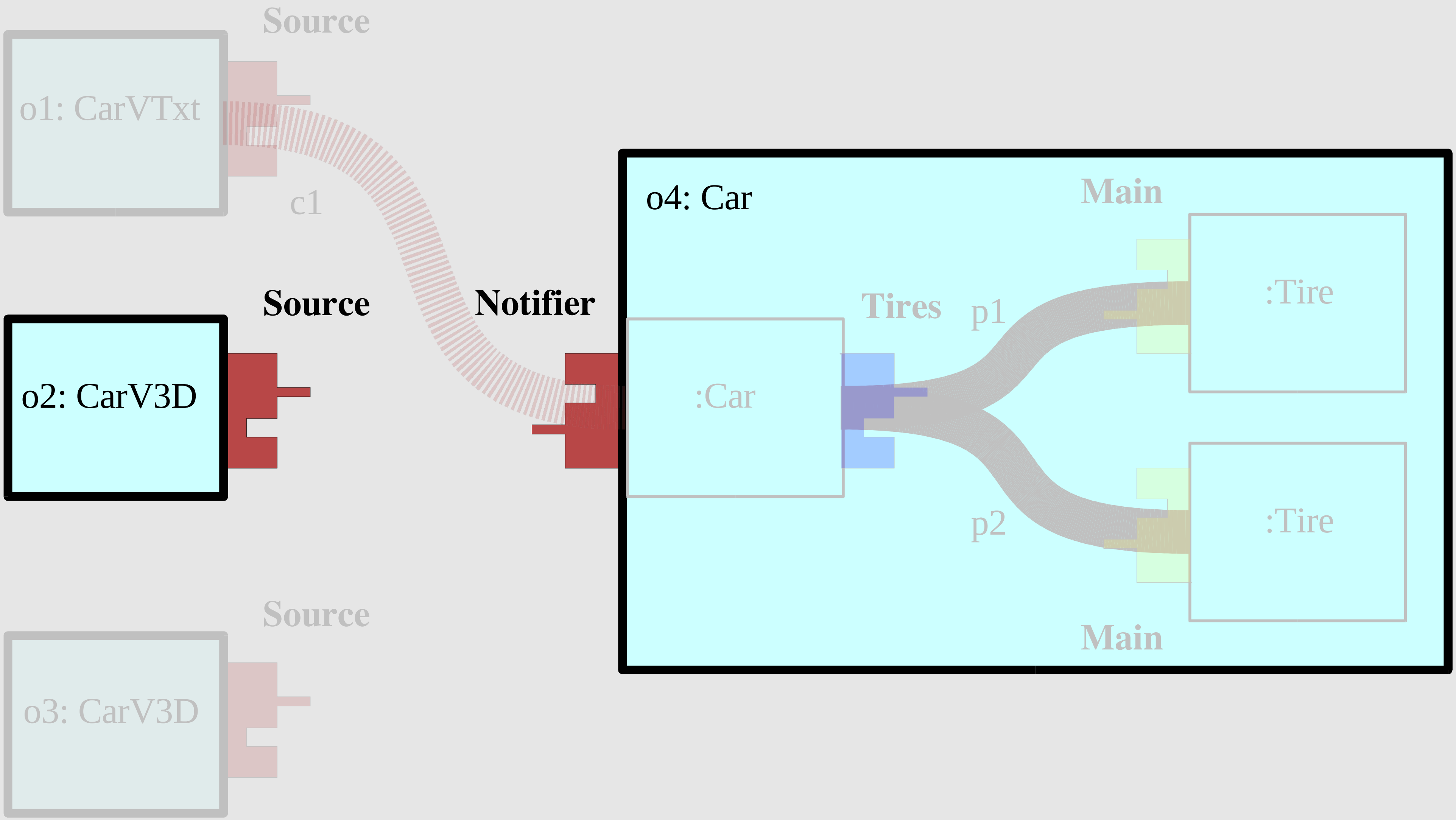
```

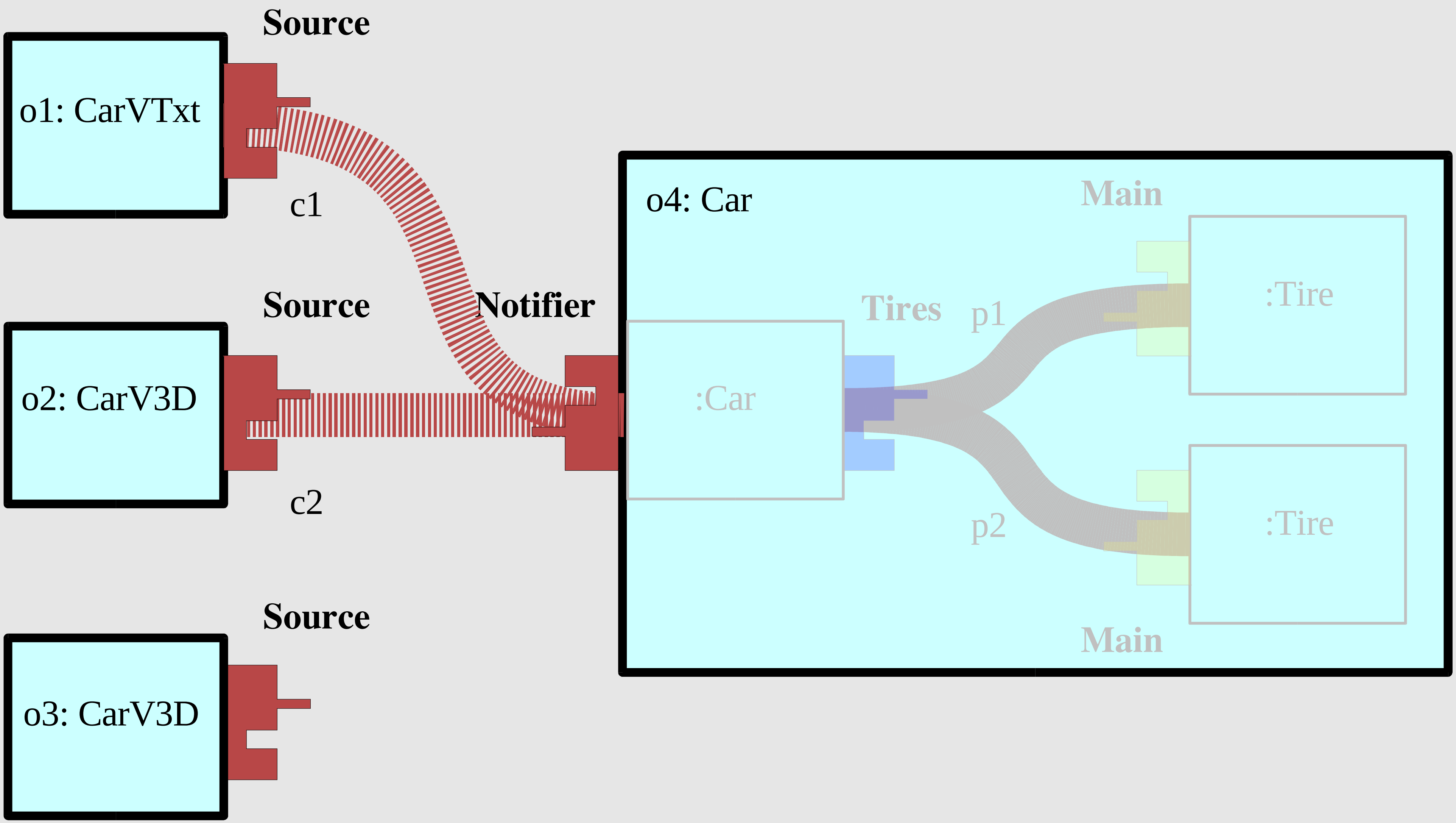
More Connections



Inside o2:

```
c2 = connect o4 with Source >> Notifier;
```

More Connections



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```
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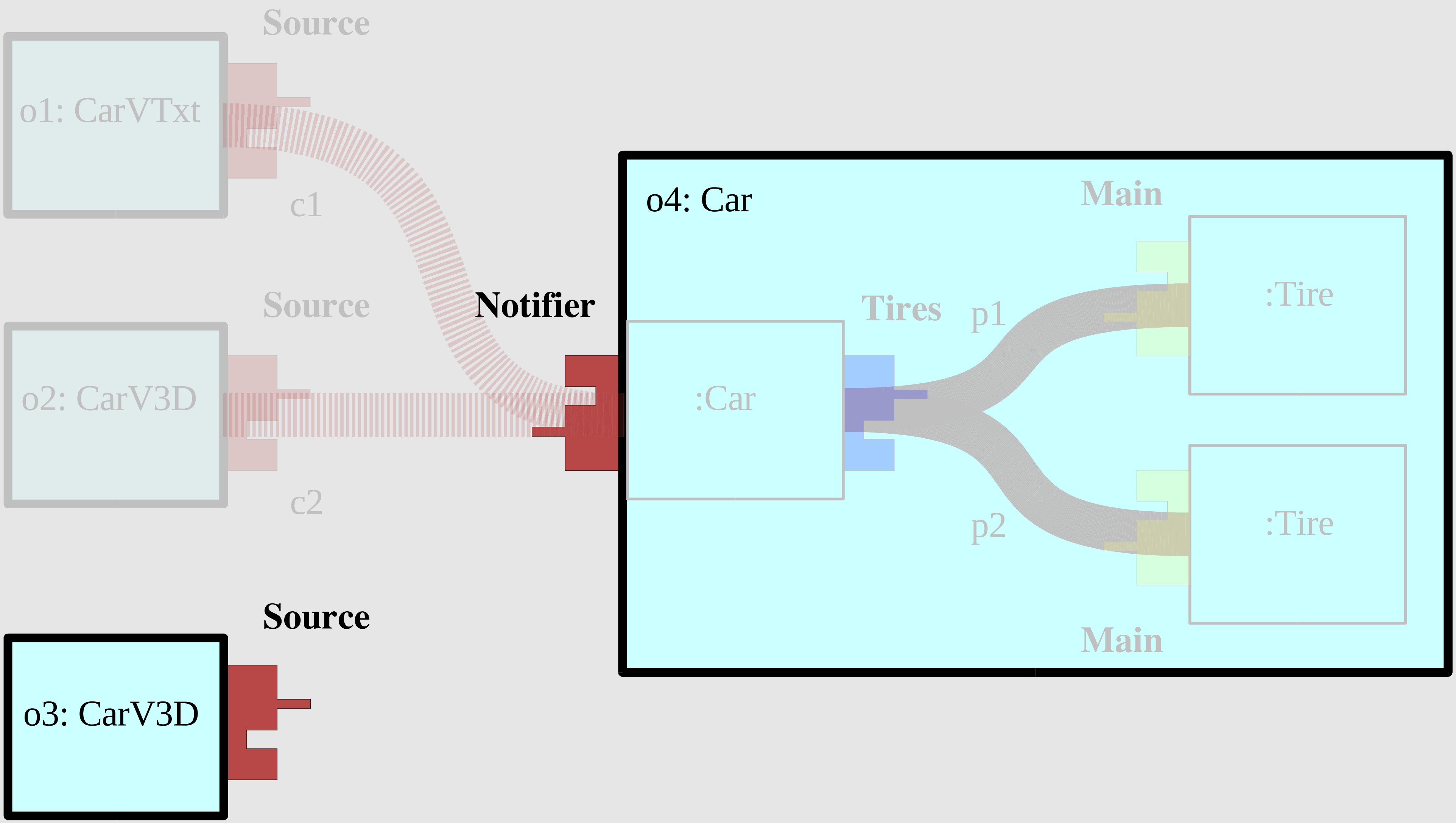
```

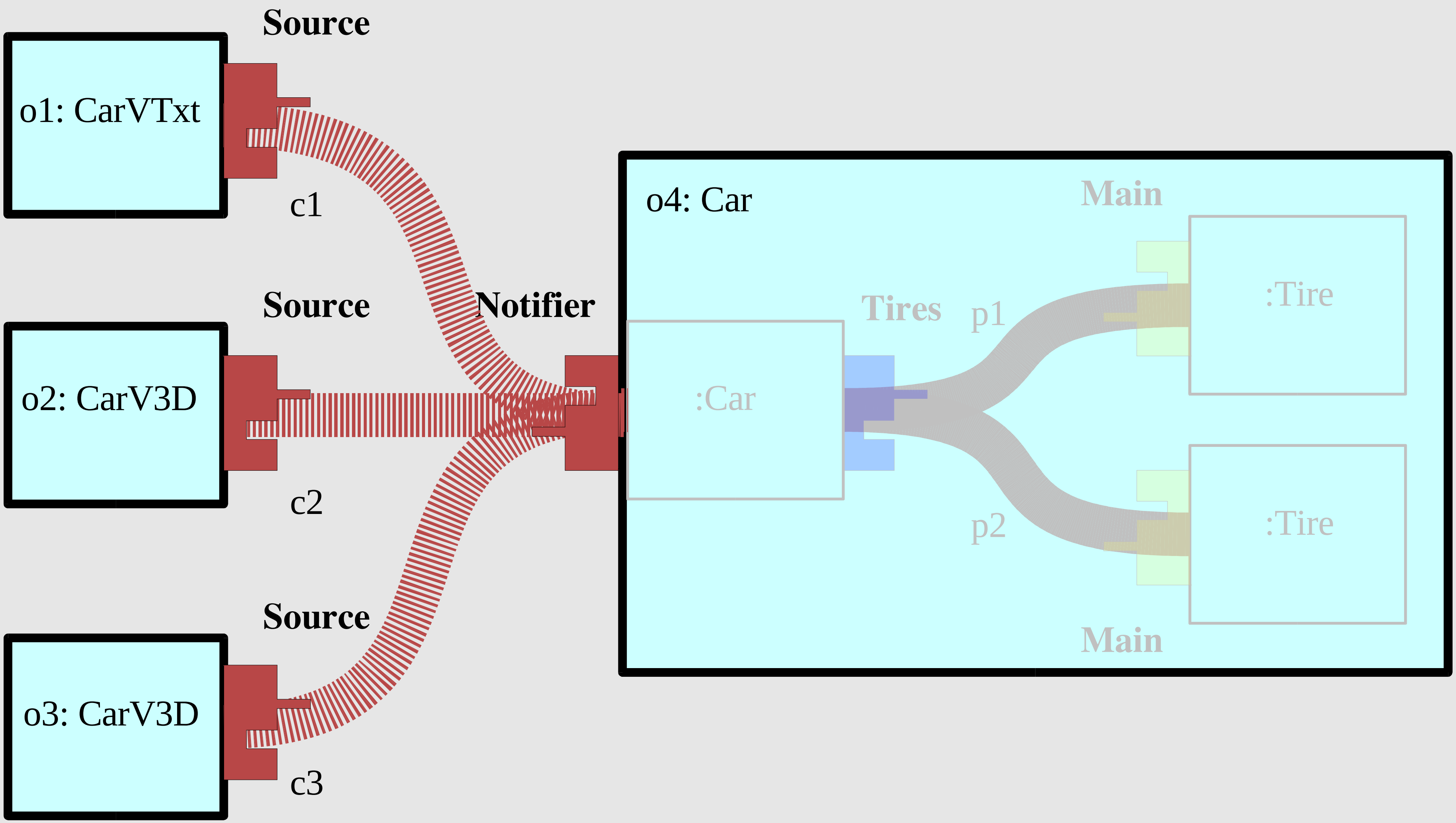
More Connections



Inside o3:

```
c3 = connect o4 with Source >> Notifier;
```

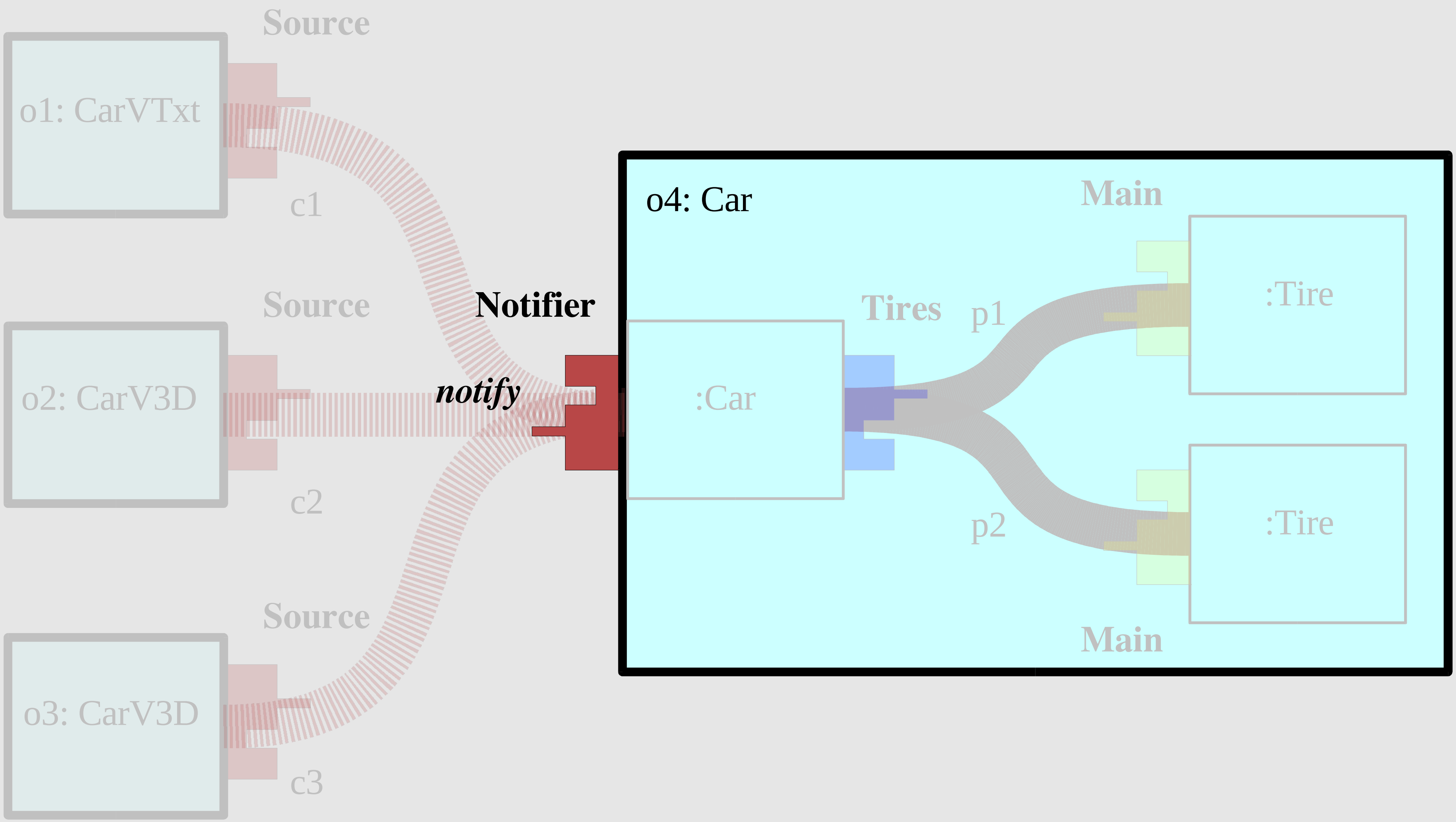
More Connections



Inside o3:

```
c3 = connect o4 with Source >> Notifier;
```

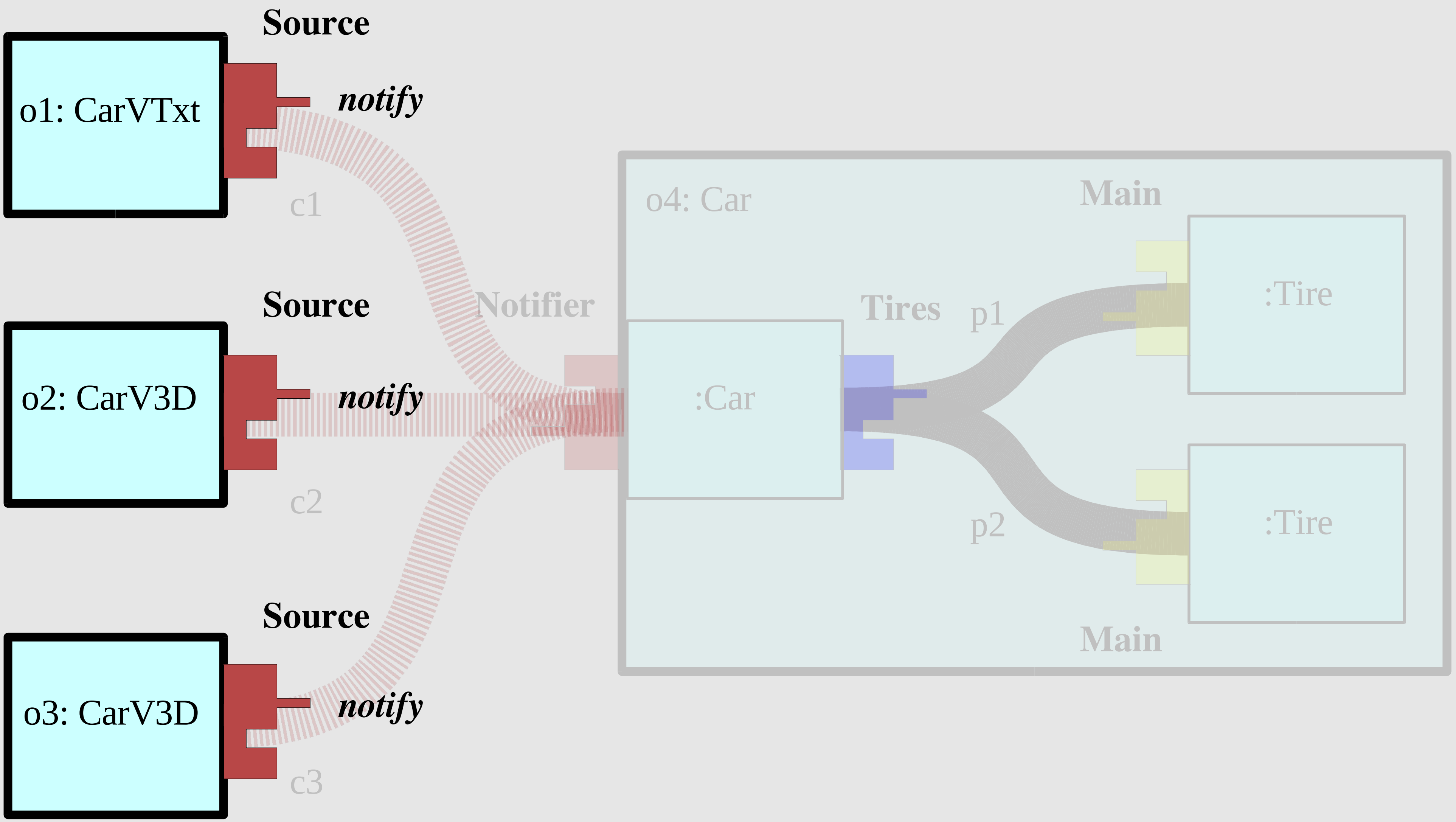
For All Connections



Inside o4:

```
forall(c: Notifier) {c->notify(); }
```

For All Connections



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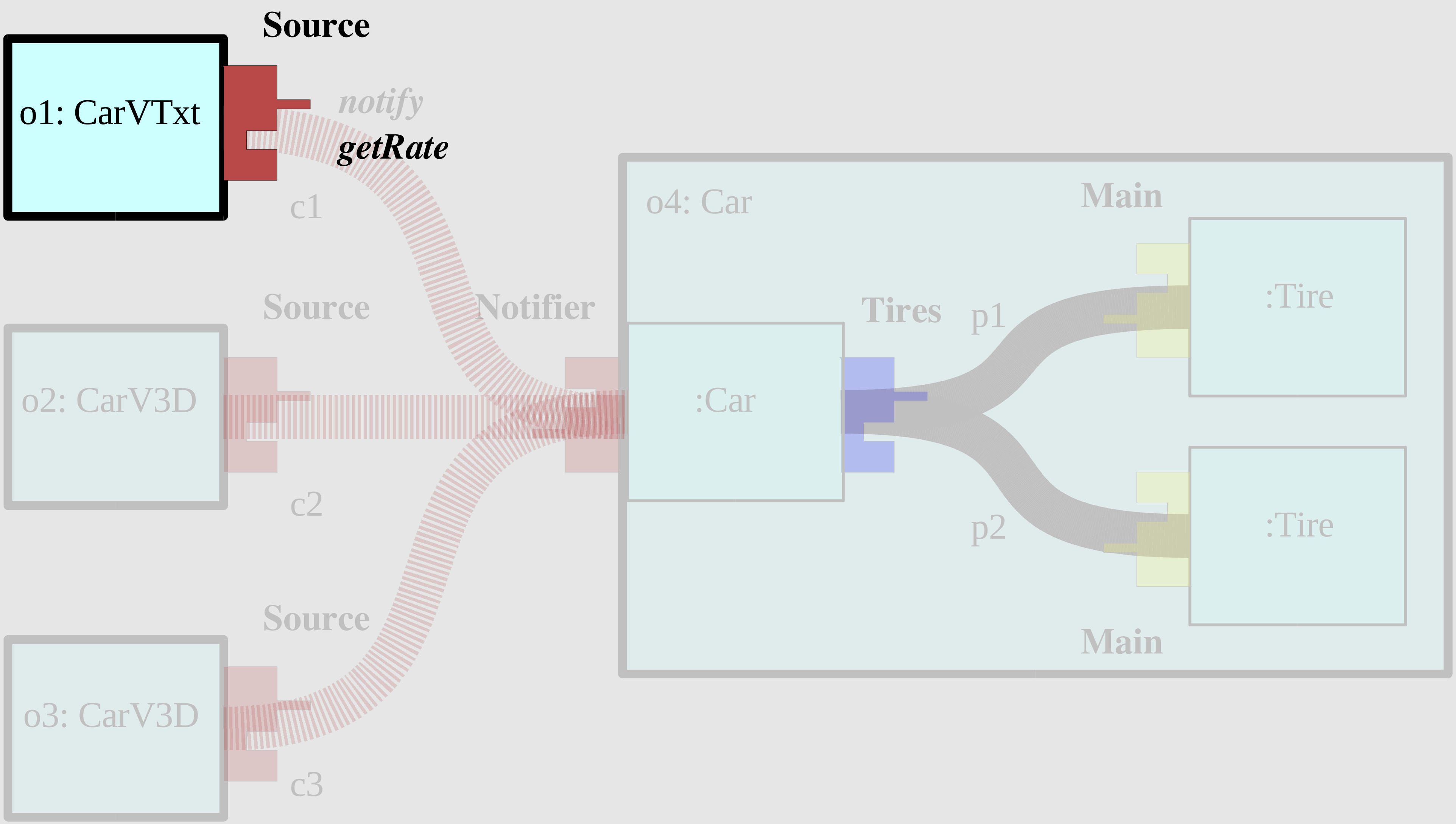
```

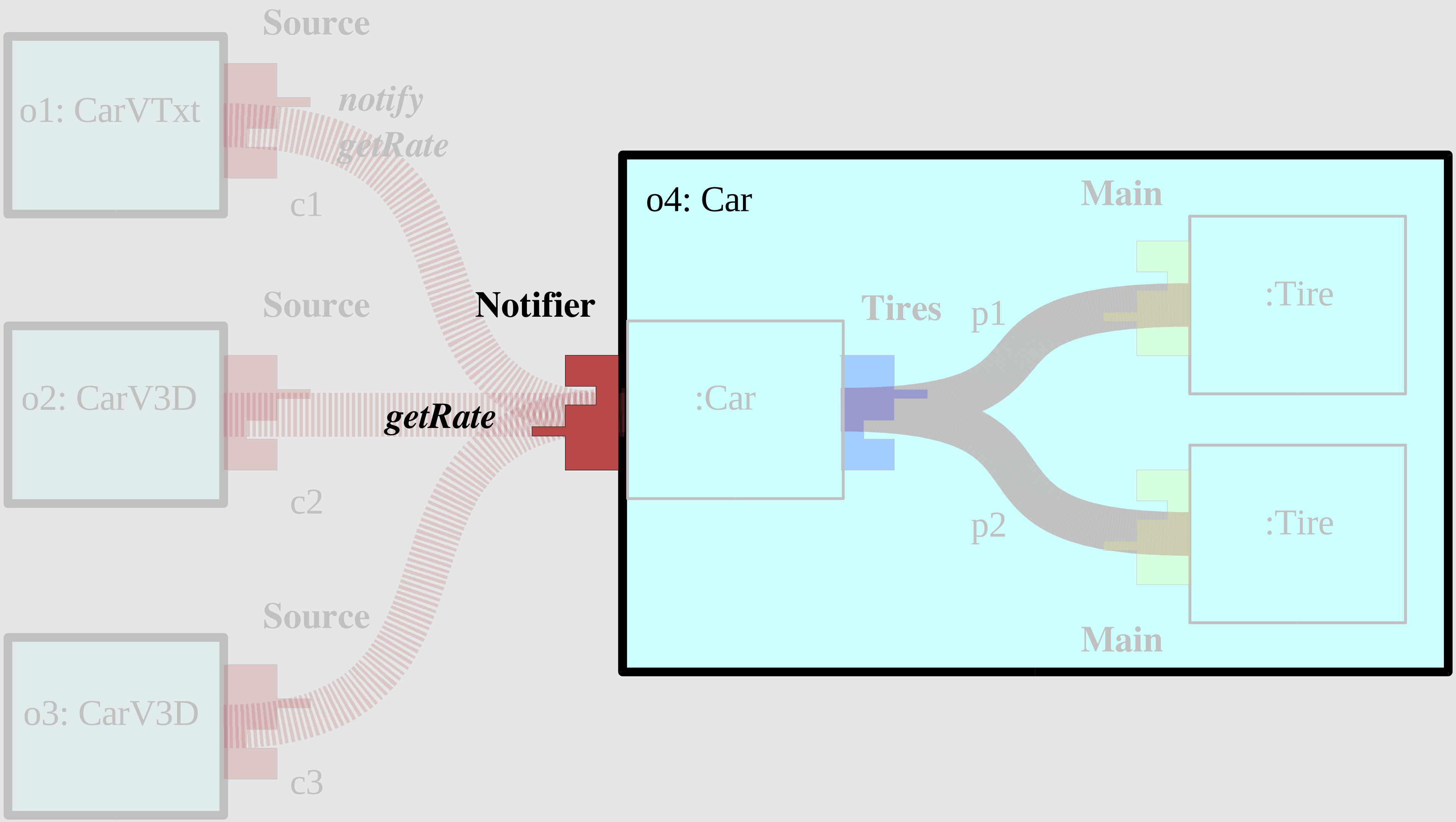
Callbacks



Inside *notify* of o1:

```
int r = getRate();
```

Callbacks



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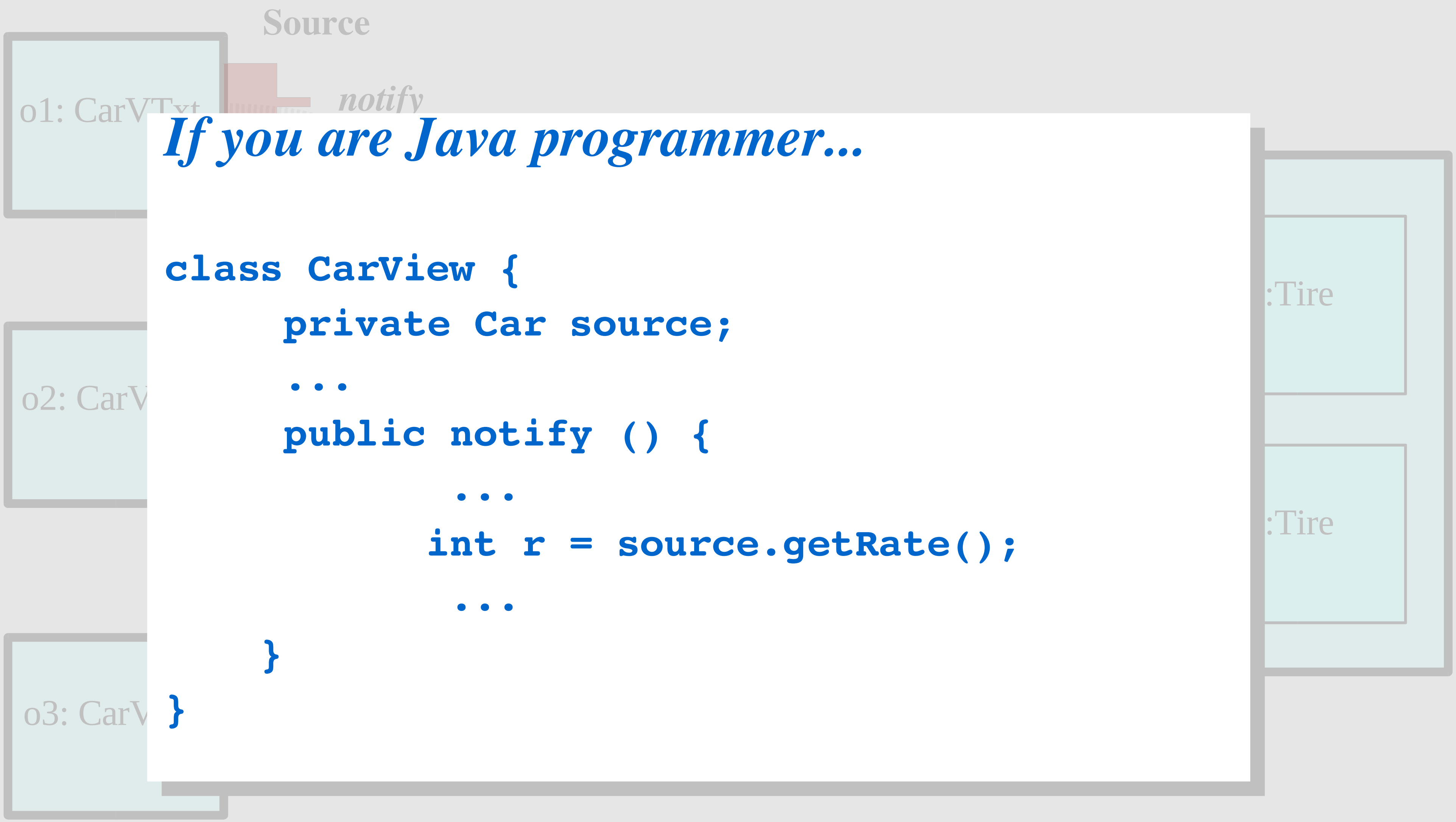


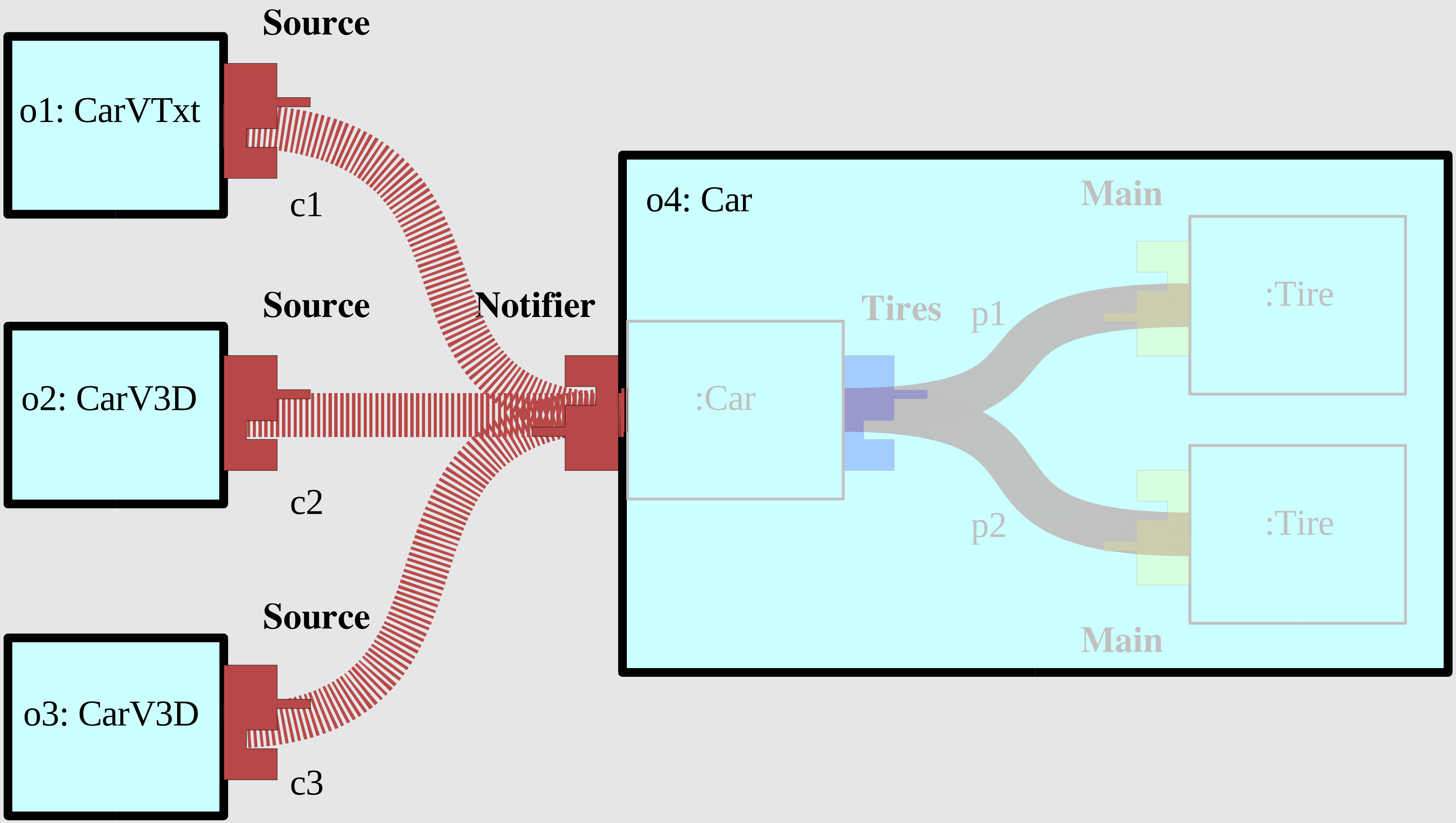
If you are Java programmer...

```
class CarView {
     private Car source;
     ...
     public notify () {
            ...
            int r = source.getRate();
            ...
     }
}
```

Inside *notify* of o1:

```
int r = getRate();
```

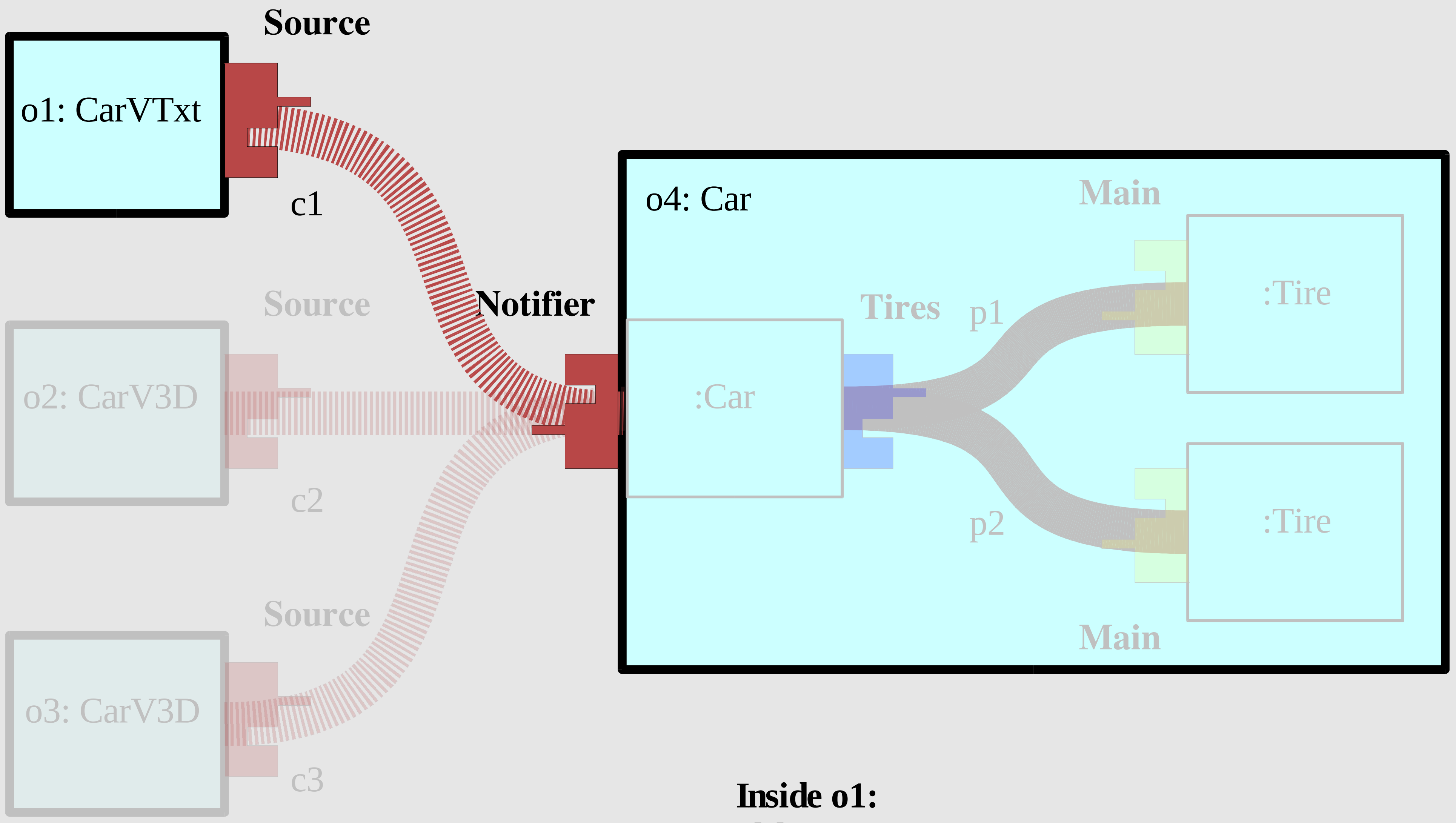
Stateful Connections



Inside *notify* of Source:

```
::counter = ::counter + 1;
```

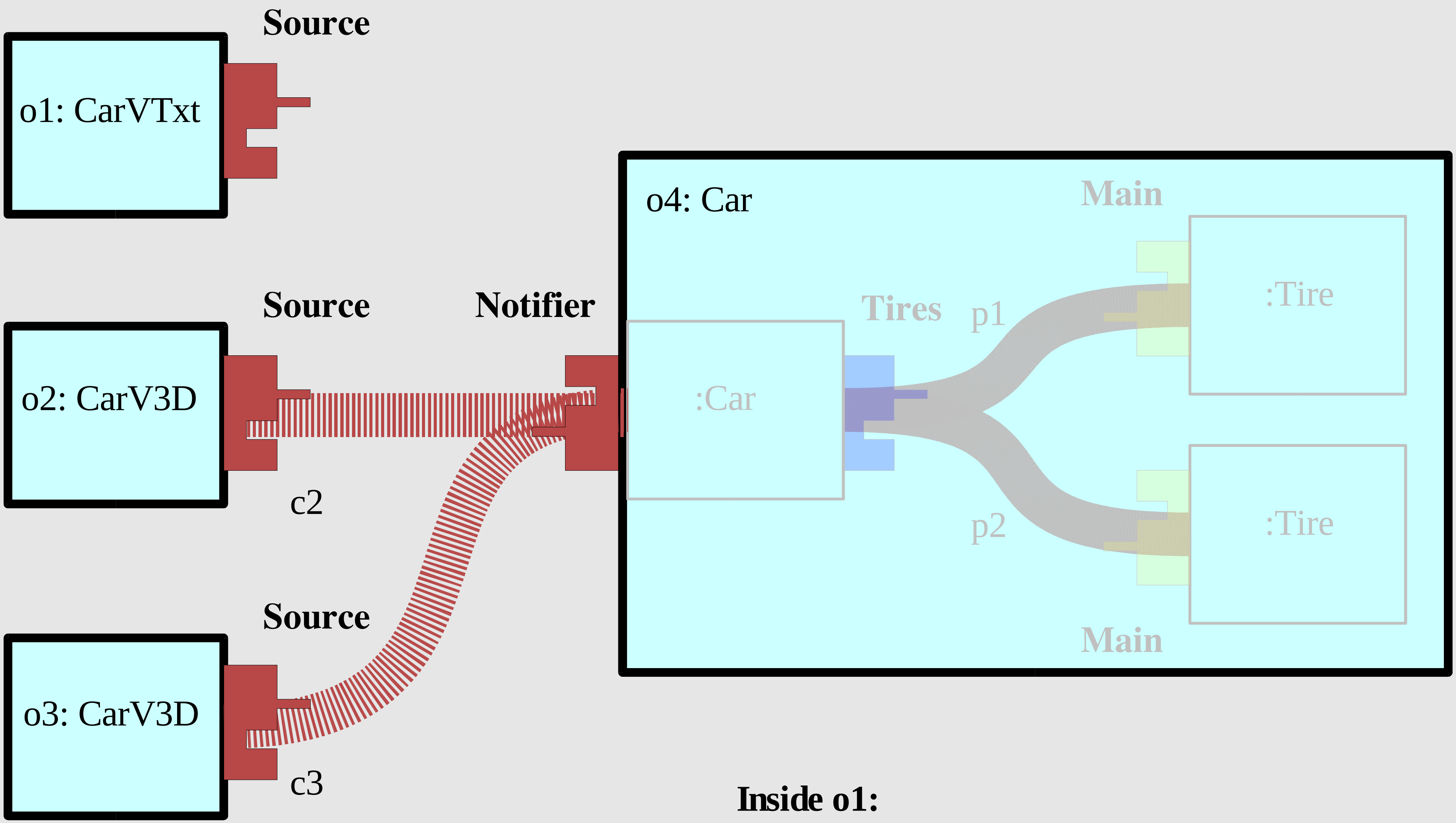
Disconnect



Inside o1:

```
disconnect c1;
```

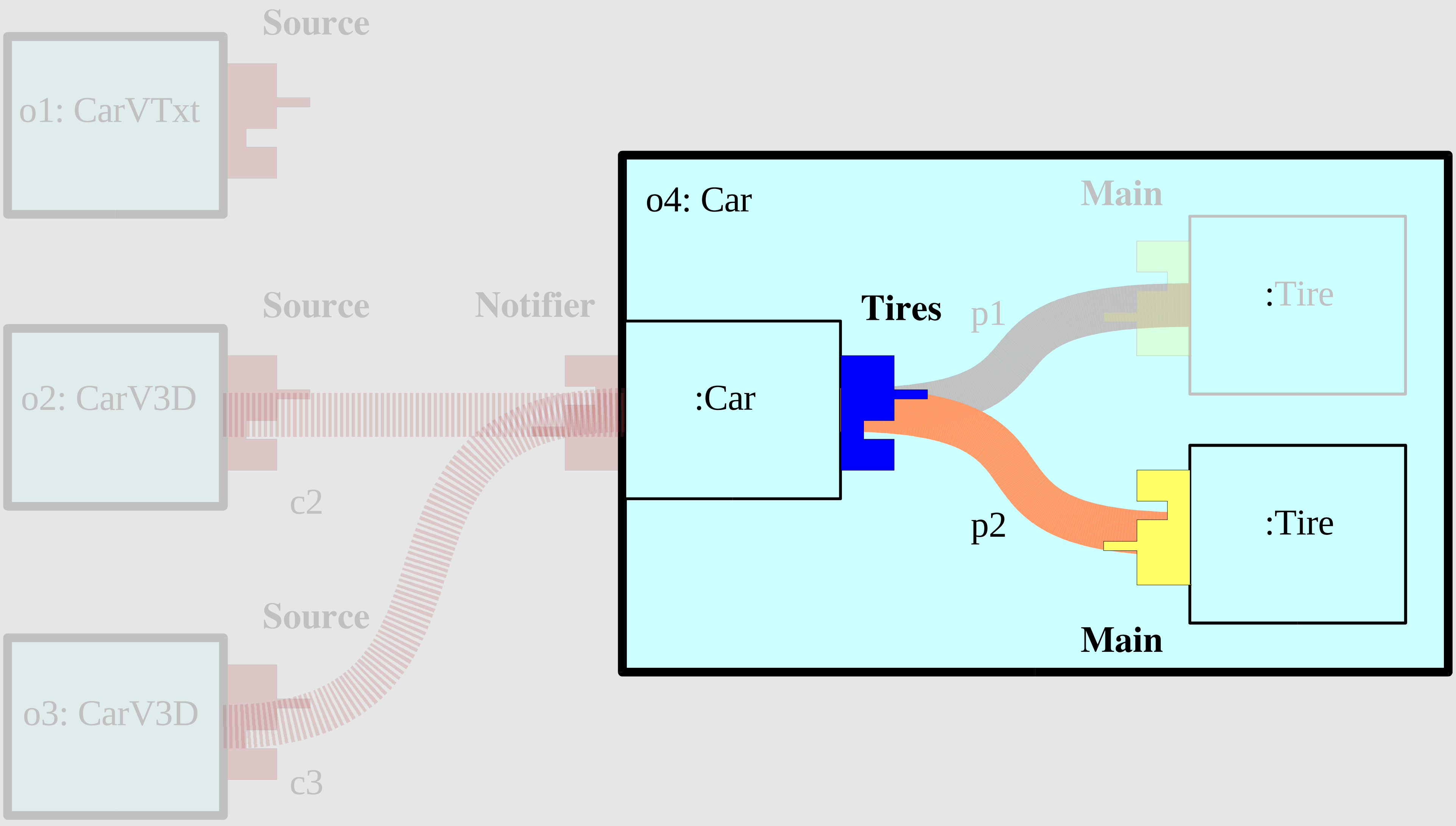
Disconnect



Inside o1:

```
disconnect c1;
```

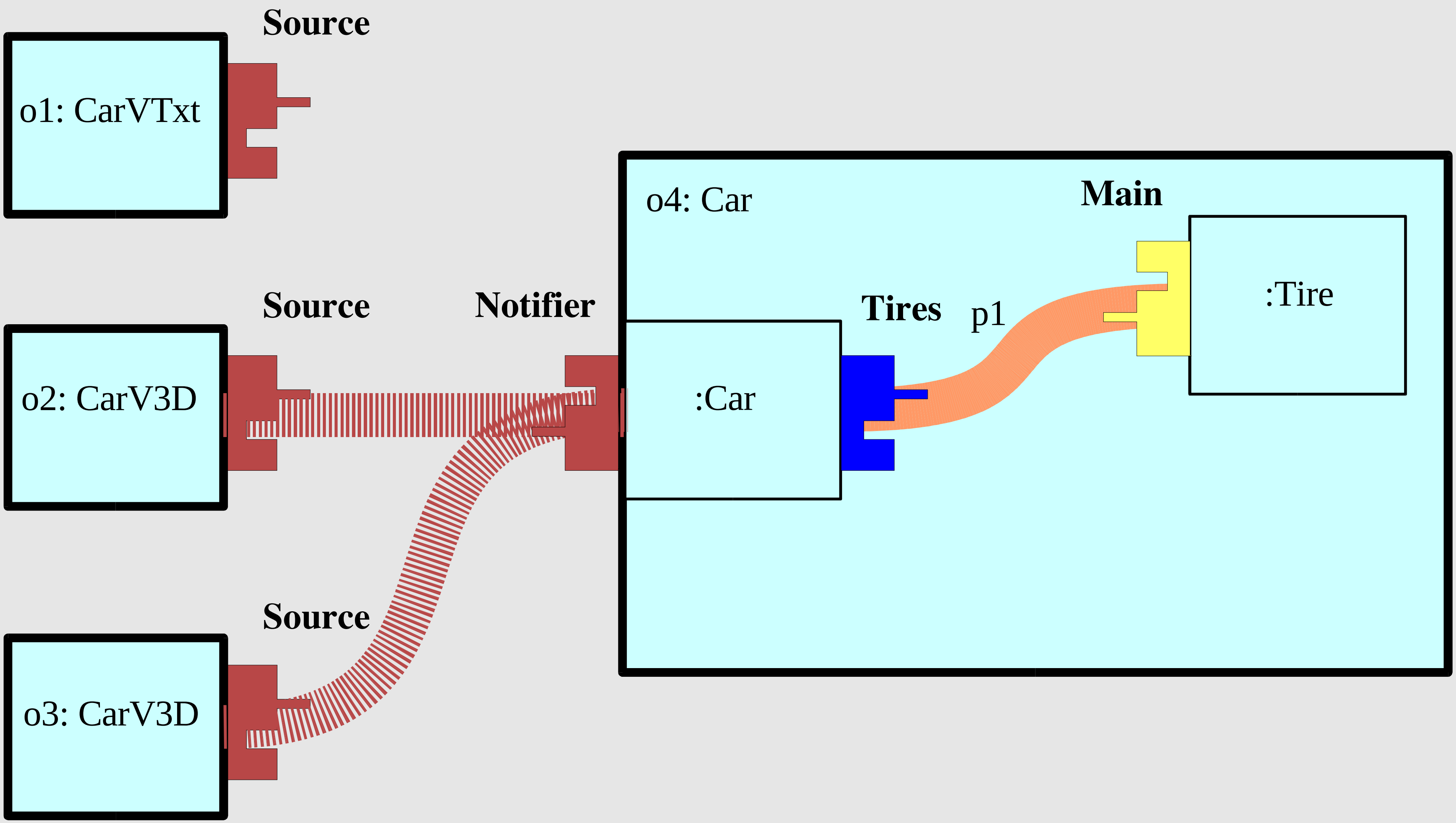
Unplug



Inside o4:

```
unplug p2;
```

Unplug



Inside o4:

```
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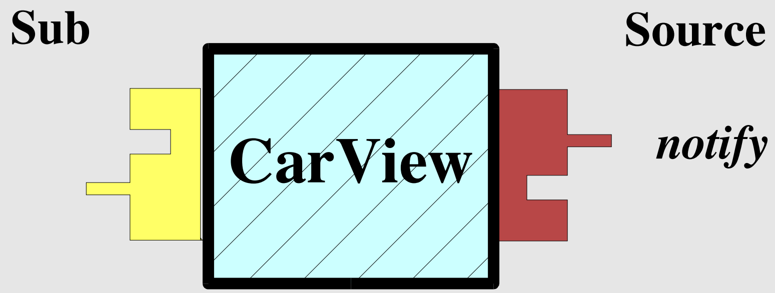
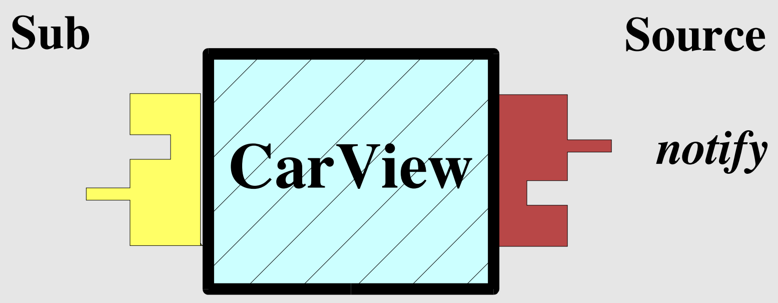
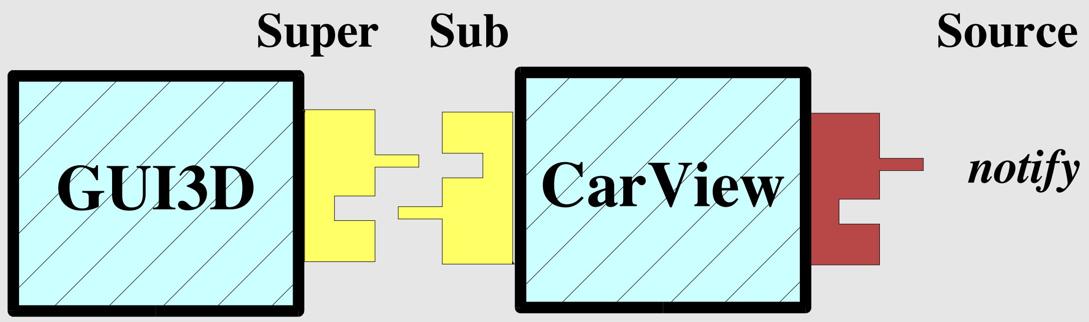
```

Dynamic Dispatch

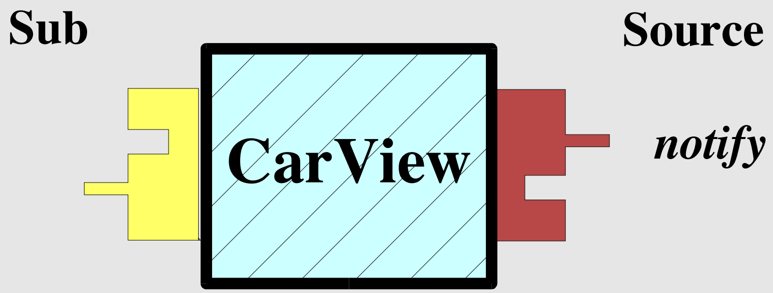


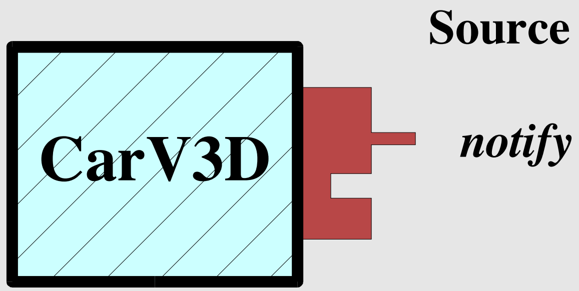
Dynamic Dispatch





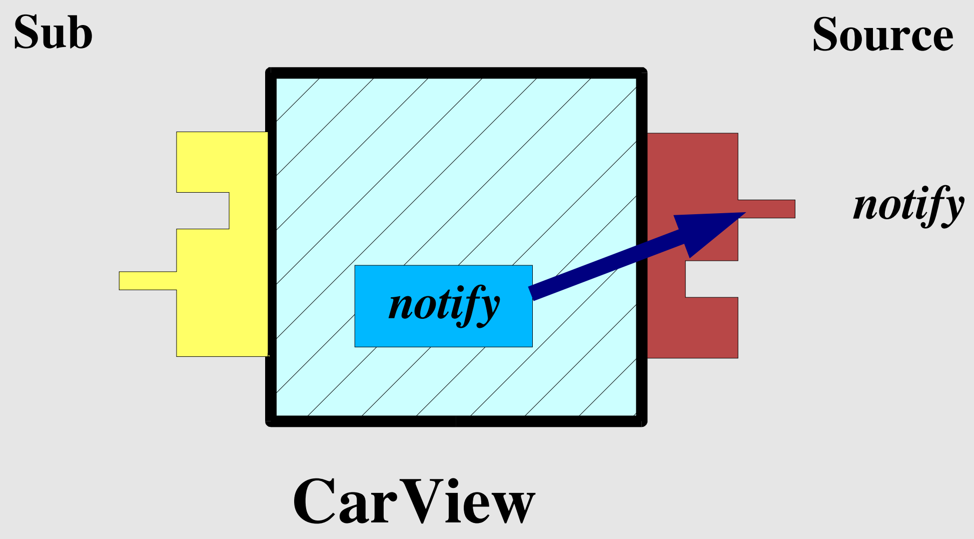
Dynamic Dispatch



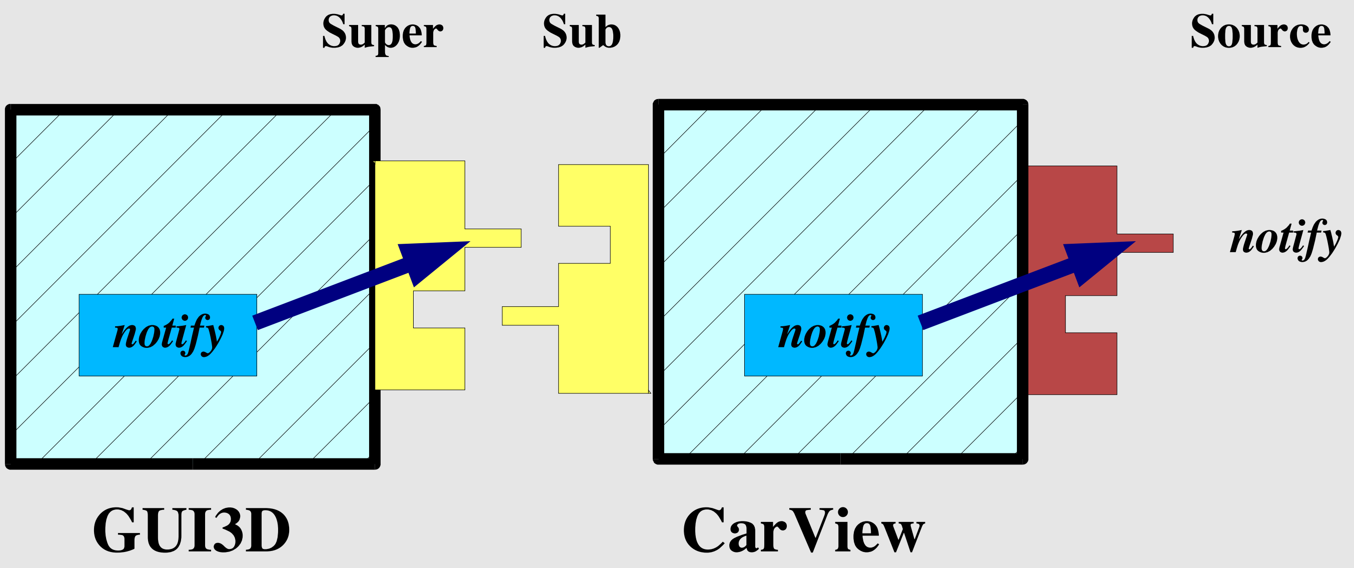


objectage type **CarV3D** **<:** objectage type **CarView**

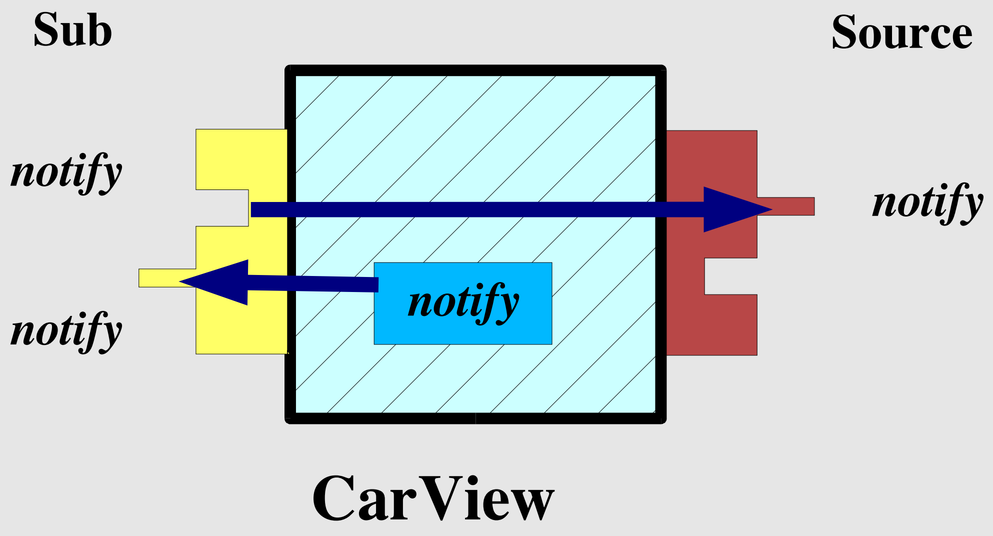
Static Dispatch



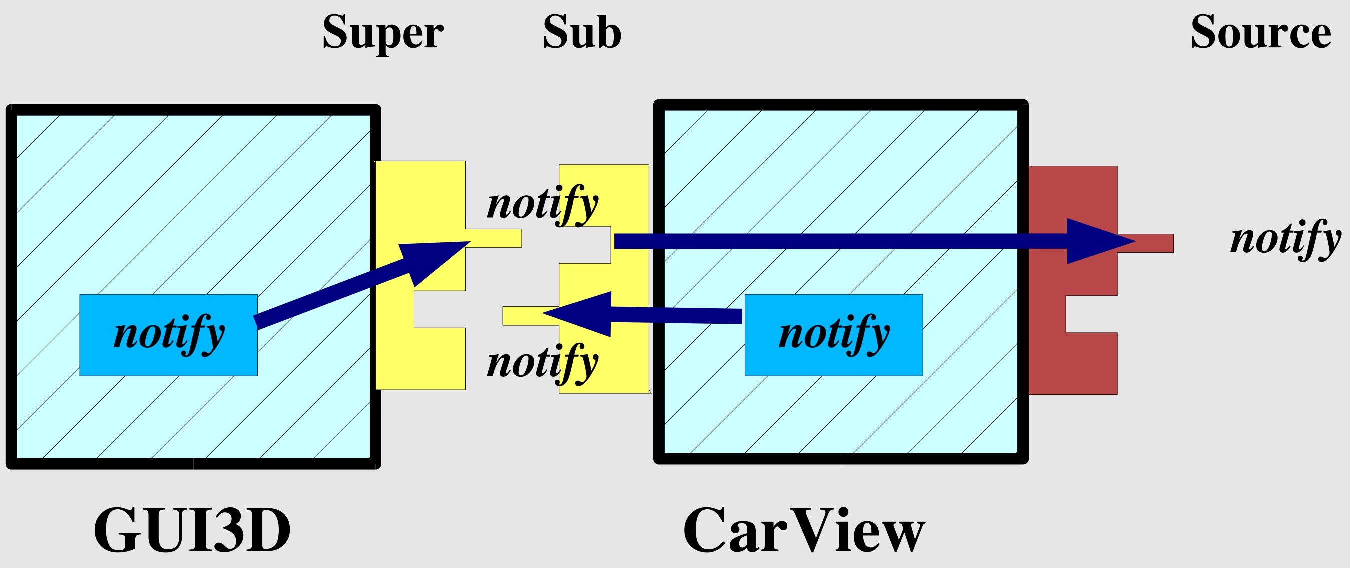
Static Dispatch



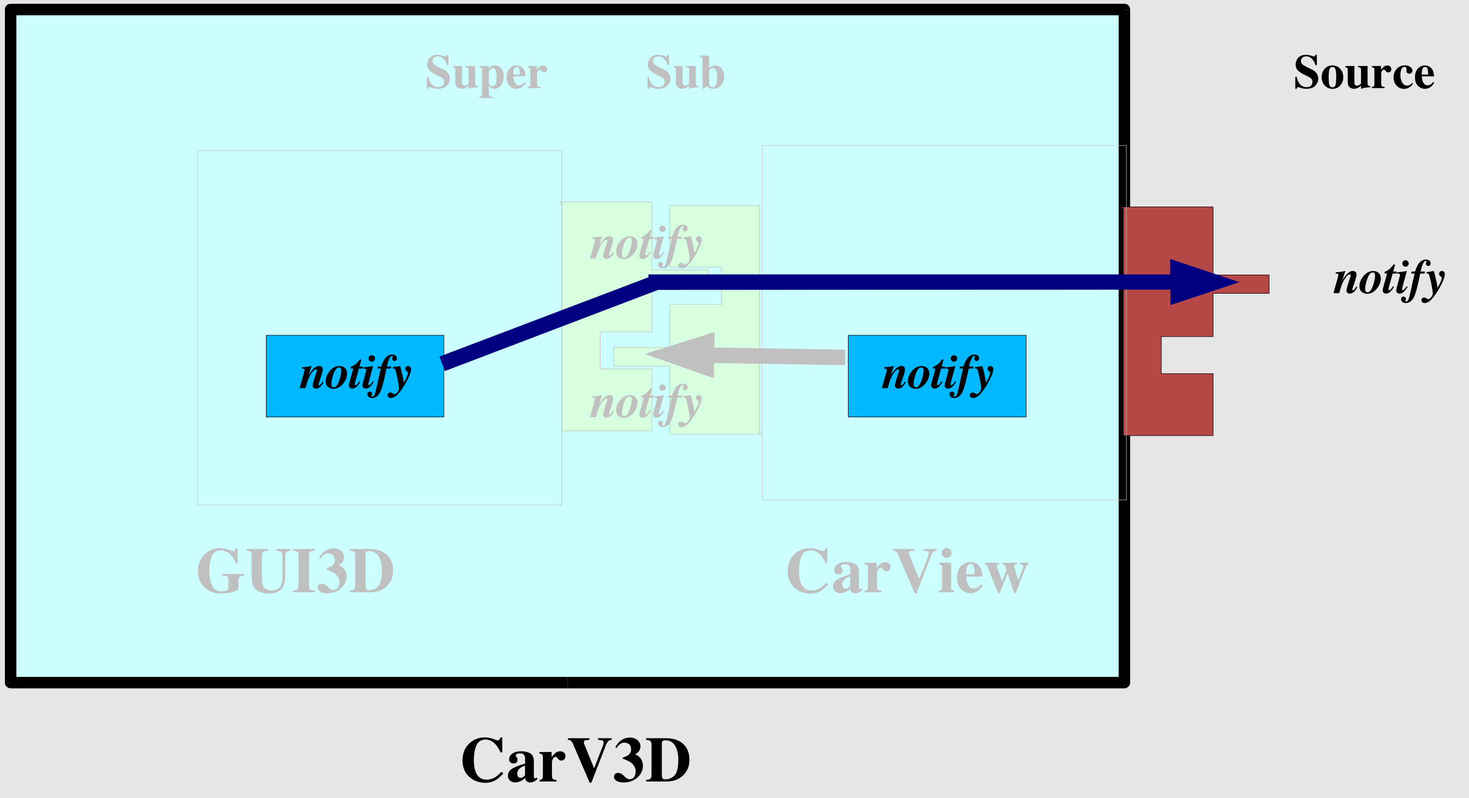
Overridable Method



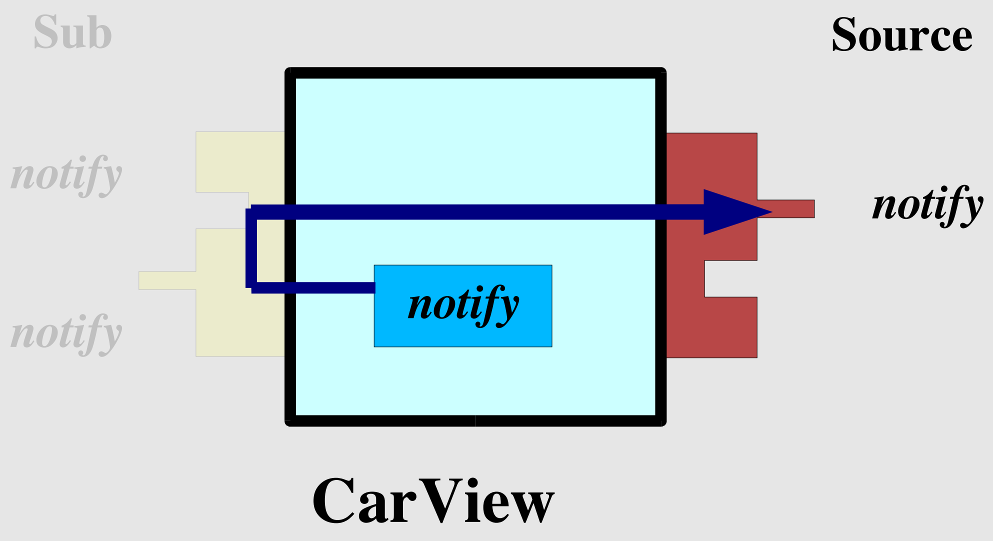
Dynamic Dispatch: CarV3D



Dynamic Dispatch: Objectage CarV3D



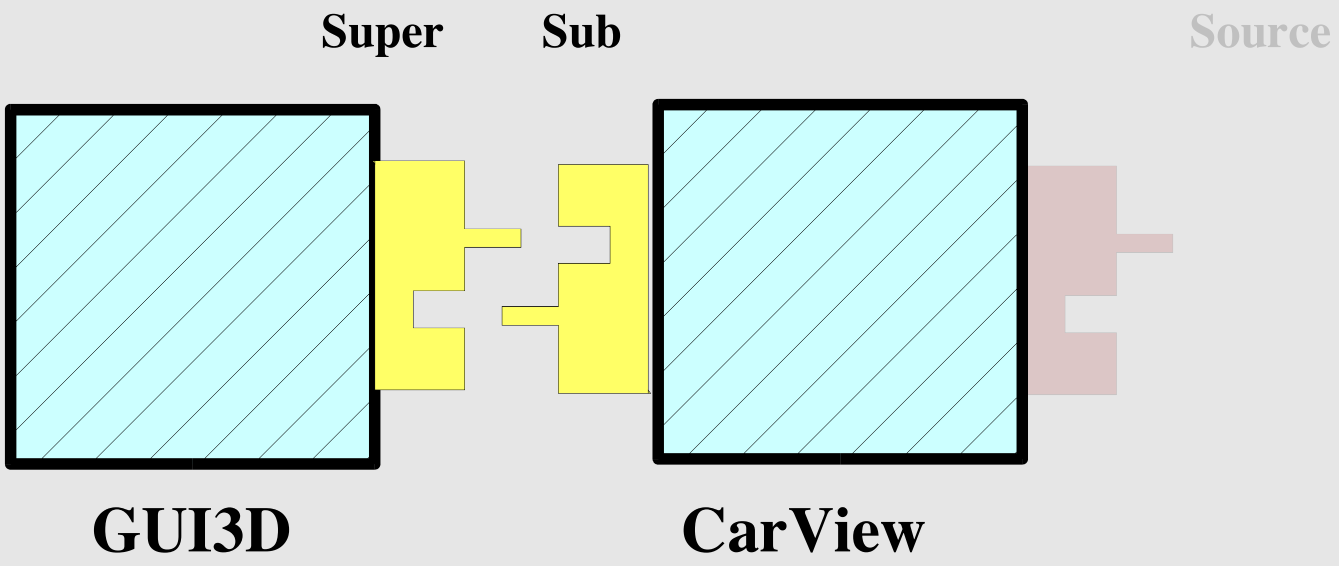
Dynamic Dispatch: Objectage CarView



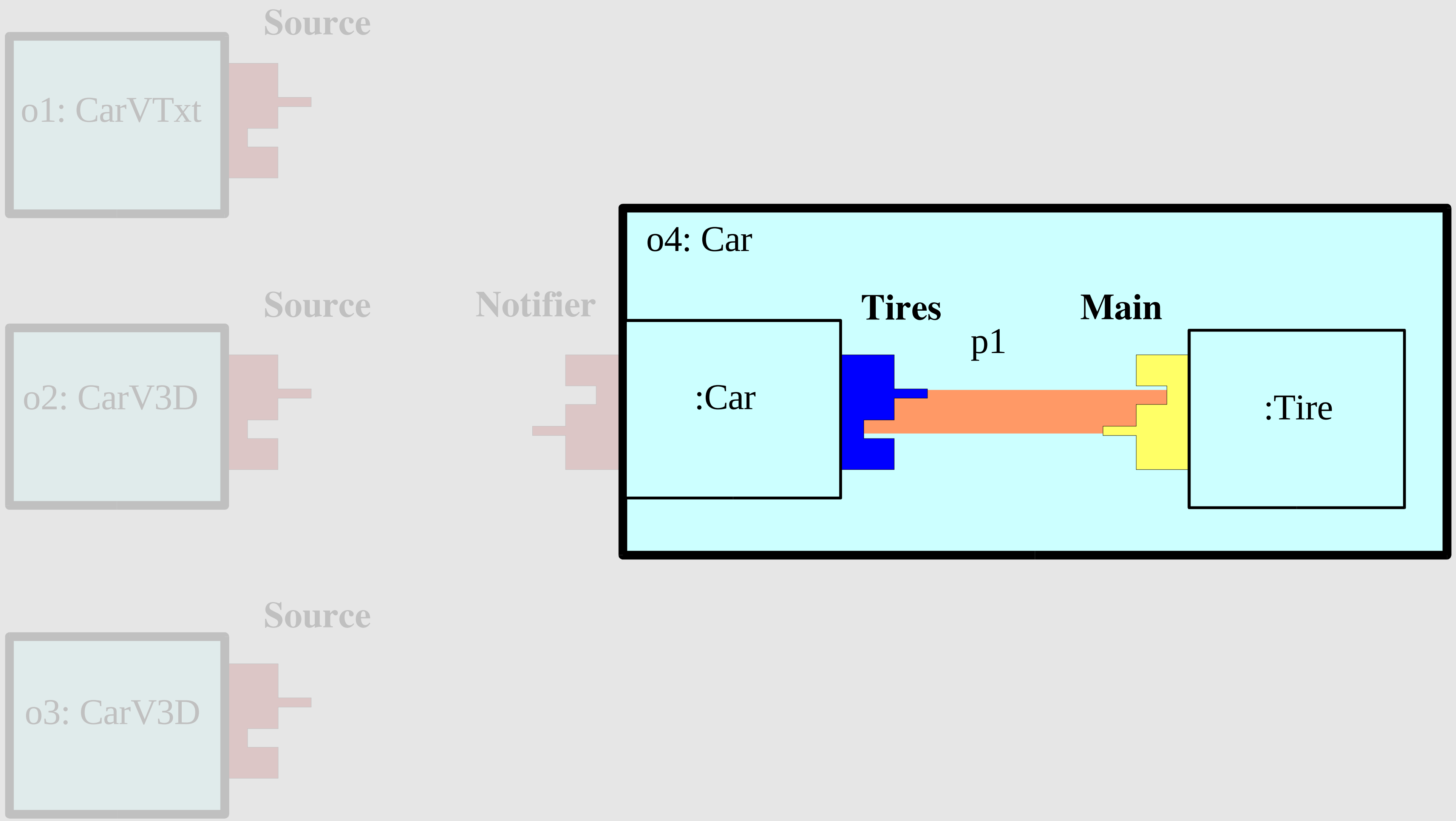
The Type System

- static typechecking for (dynamic) interactions: bi-directional interface match with subtyping.
- protecting internal representation: avoiding plugging handles to escape.
- no connection masquerading: avoiding connection handles to escape.

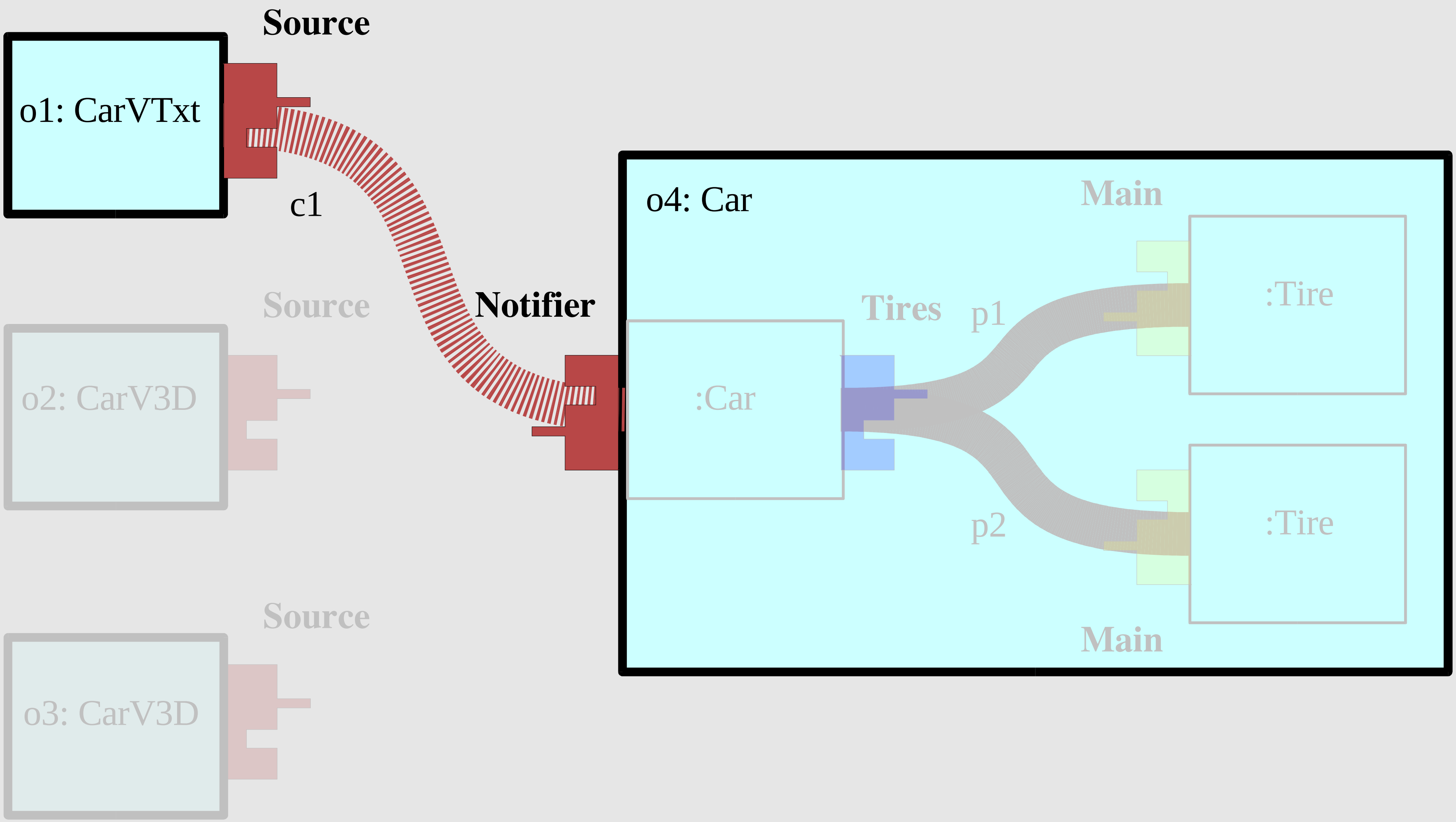
Mixing: The Class Interaction



Plugging: The Whole-Part Interaction



Connection: The Peer-to-Peer Interaction



The Type System

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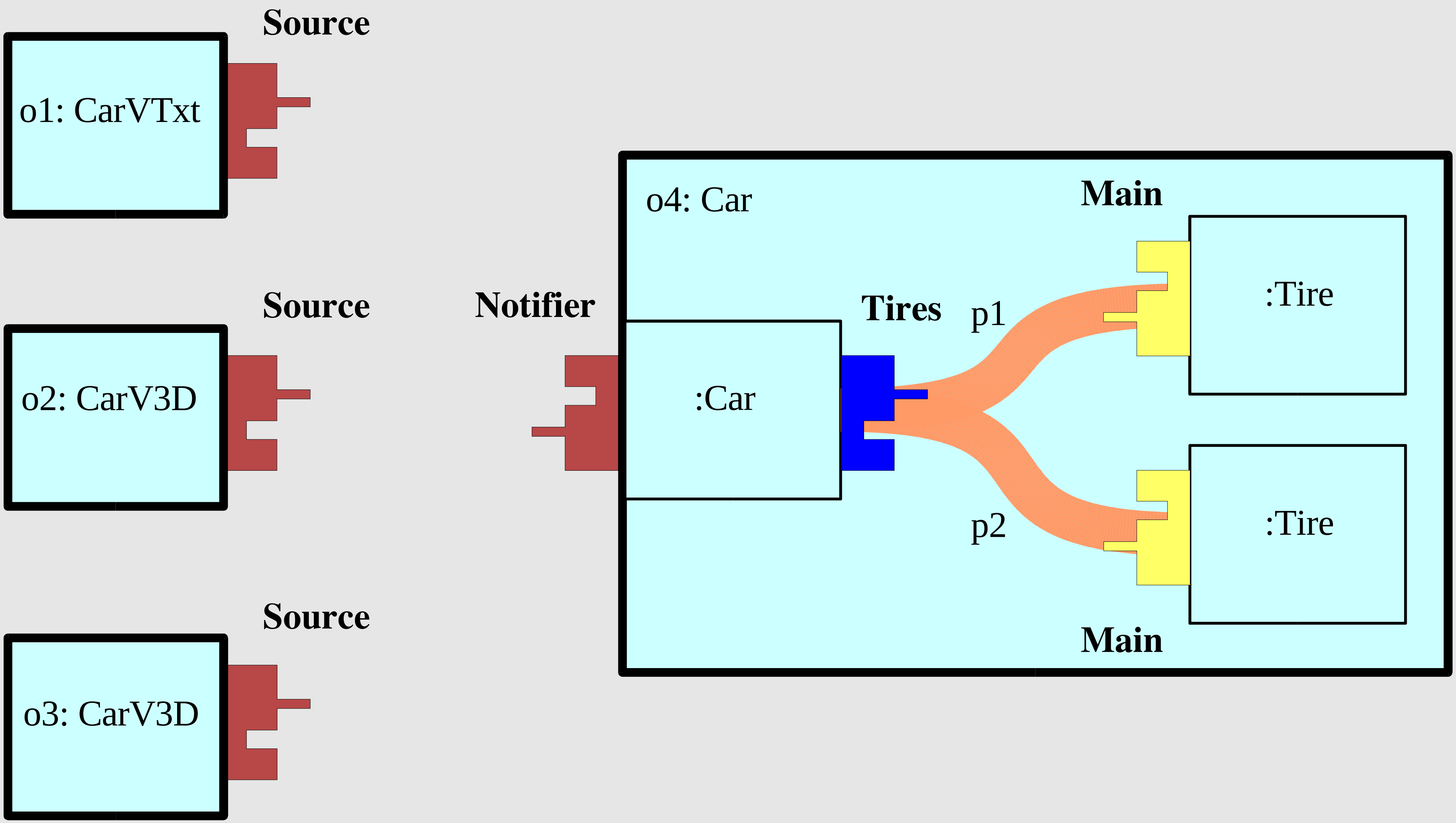
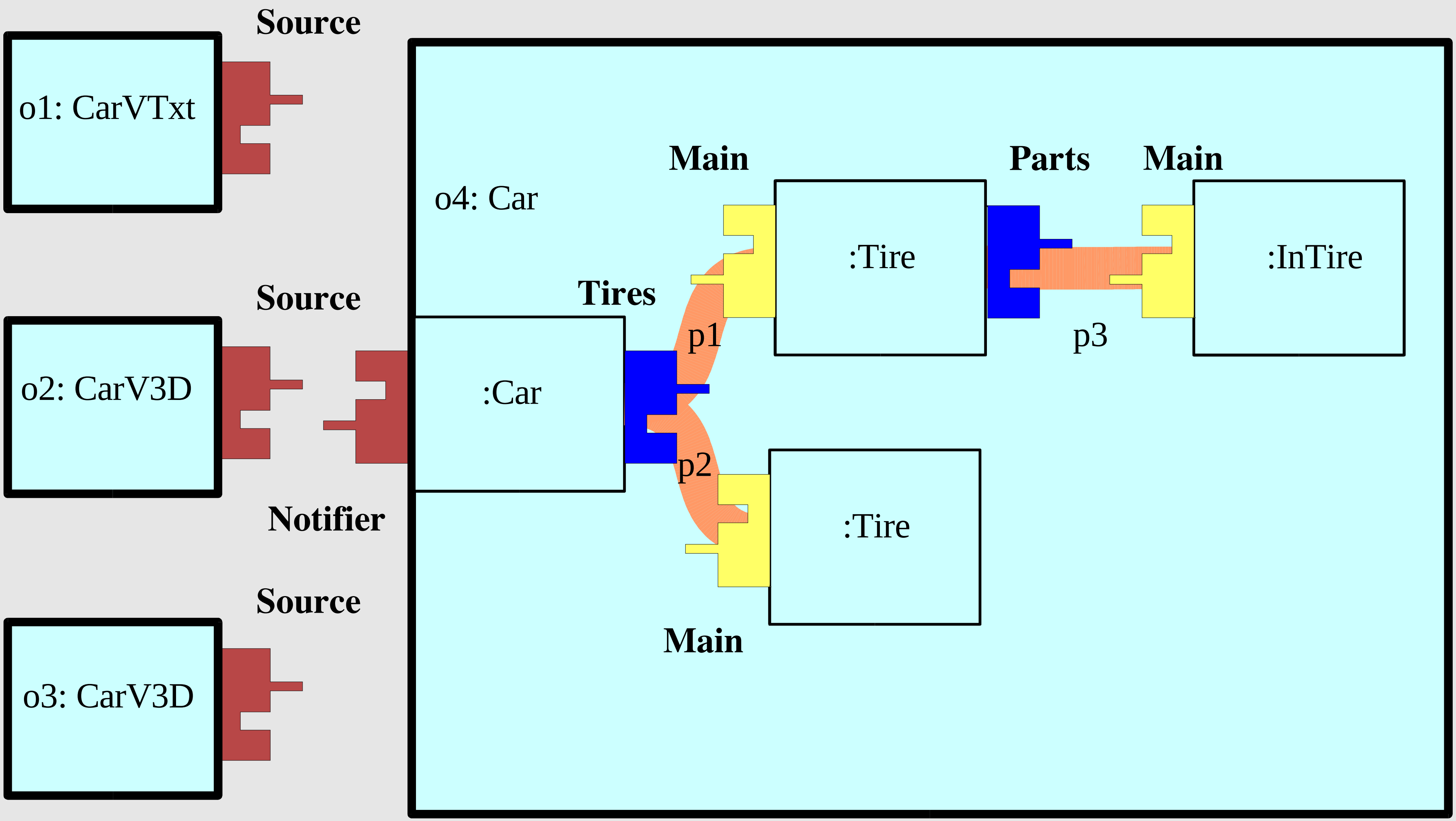
Protecting Internal Representation



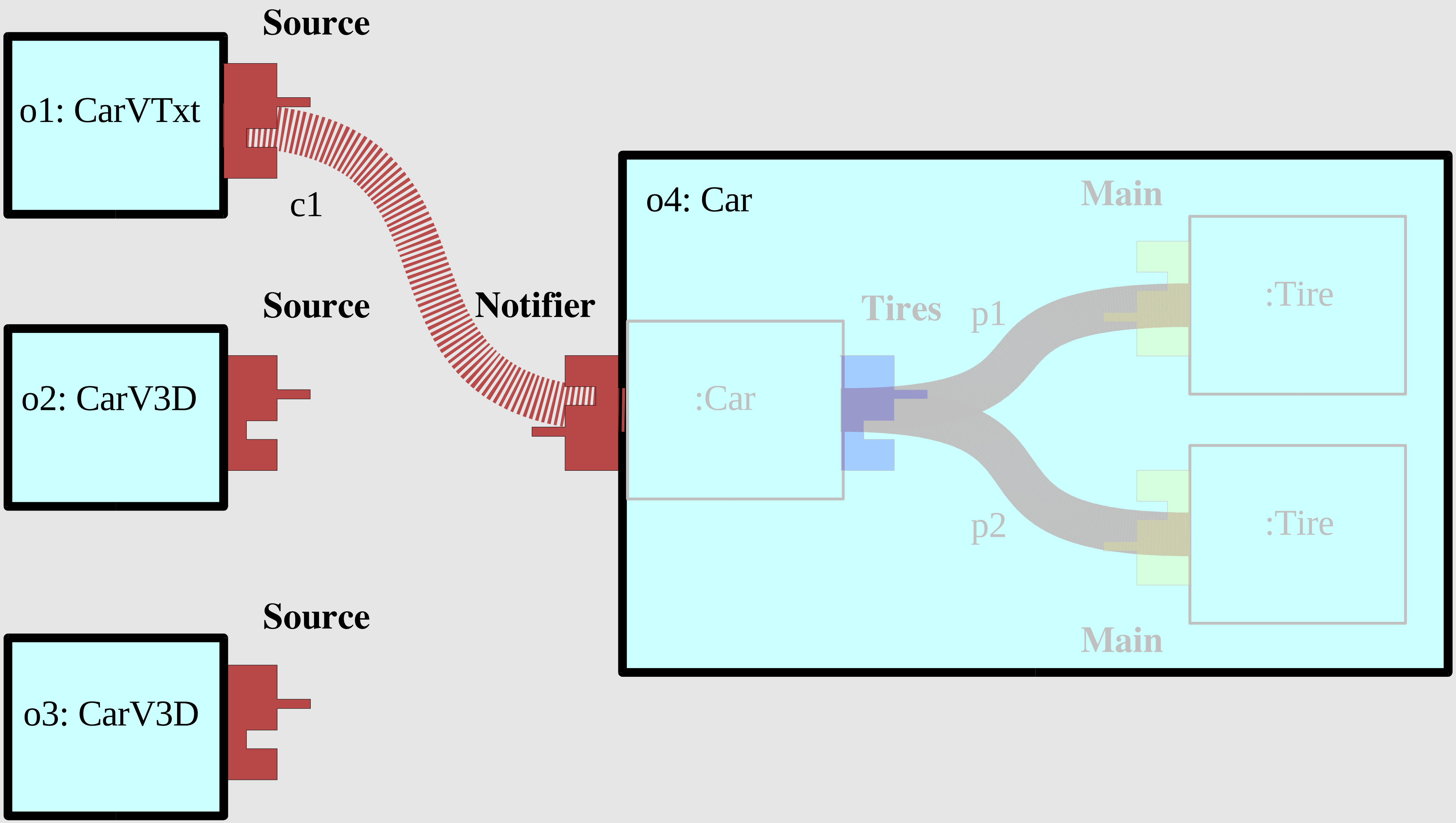
Protecting Internal Representation



The Type System

- static typechecking for (dynamic) interactions: bi-directional interface match with subtyping.
- protecting internal representation: avoiding plugging handles to escape.
- no connection masquerading: avoiding connection handles to escape.

No Connection Masquerading



Related Work

- explicit interfaces
    - component systems
    - architectural description languages
- object ownership, alias protection
- composition: mixins, Traits, module systems
- relationship representation
- environmental acquisition [Gil & Lorenz], [Cobbe & Felleisen]

Classages Design Principles

- Static interactions and dynamic interactions are fundamentally different.
- Internal interactions and external interactions are fundamentally different.
- Interactions fundamentally have a lifespan.
- Interactions are fundamentally bi-directional.
- Interactions always happen on explicitly defined interfaces.

Download

http://www.cs.jhu.edu/~yliu/Classages