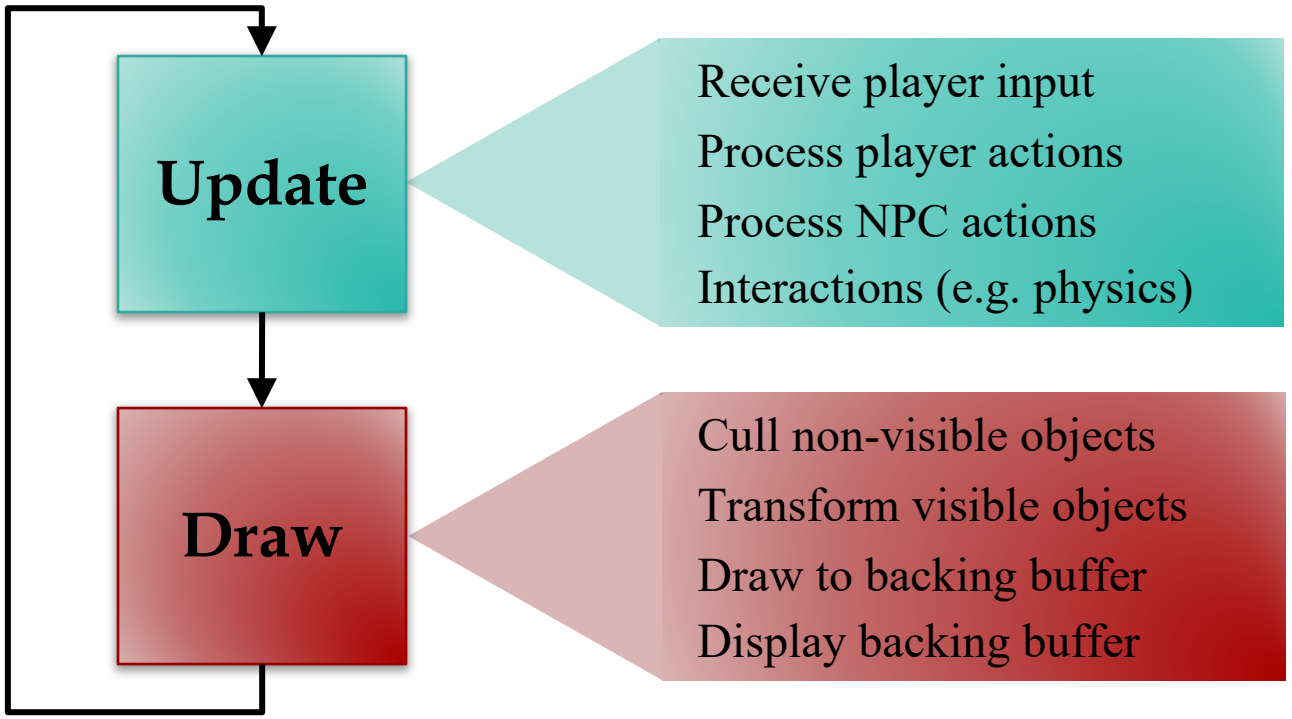
the gamedesigninitiative at cornell university

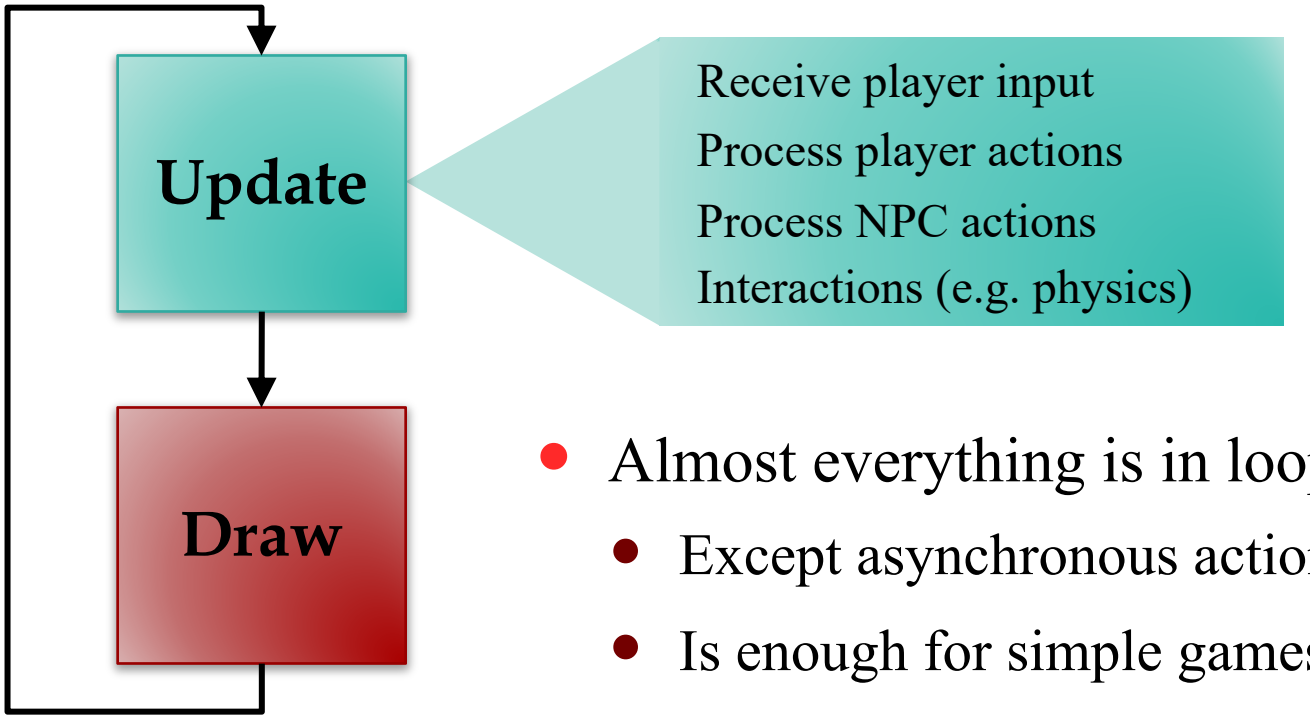
Architecture Revisited

Recall: The Game Loop

60 times/s
=
16.7 ms

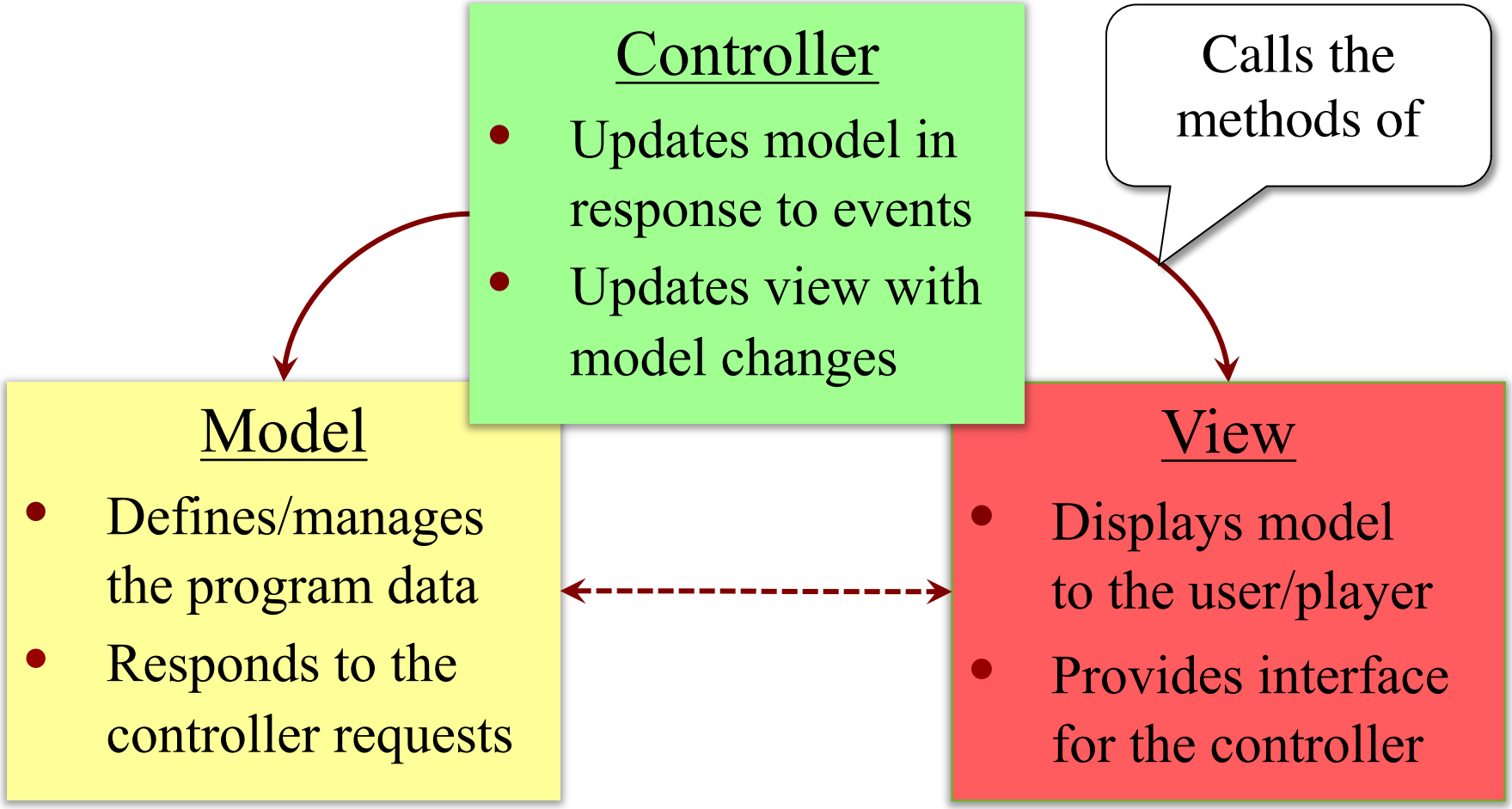


The Game Loop



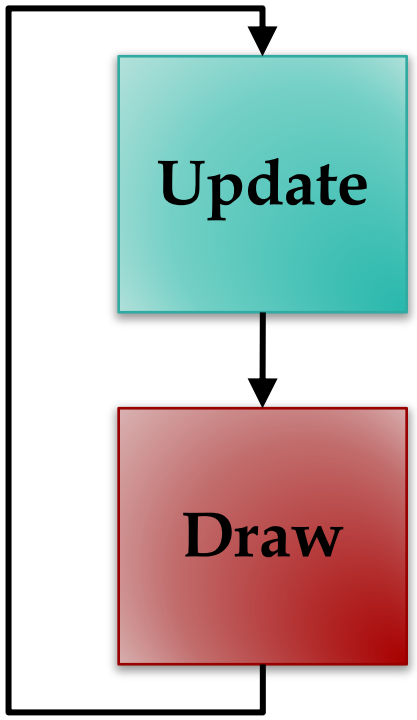
- Almost everything is in loop
  - Except asynchronous actions
  - Is enough for simple games
- How do we organize this loop?
  - Do not want spaghetti code
  - Distribute over programmers

Model-View-Controller Pattern

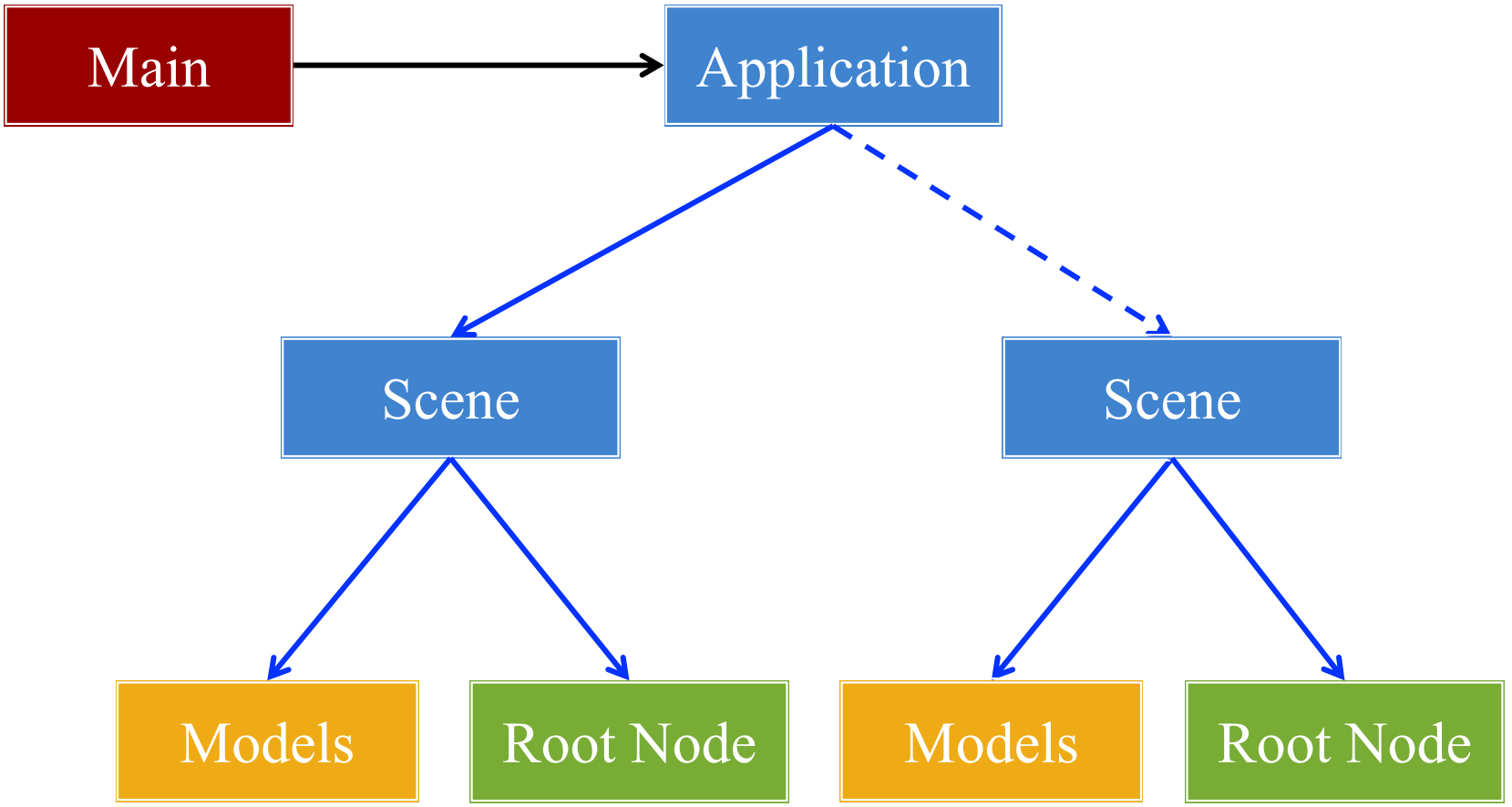


The Game Loop and MVC

- Model: The game state
  - Value of game resources
  - Location of game objects
- View: The draw phase
  - Rendering commands only
  - Major computation in update
- Controller: The update phase
  - Alters the game state
  - Vast majority of your code



Structure of a CUGL Application



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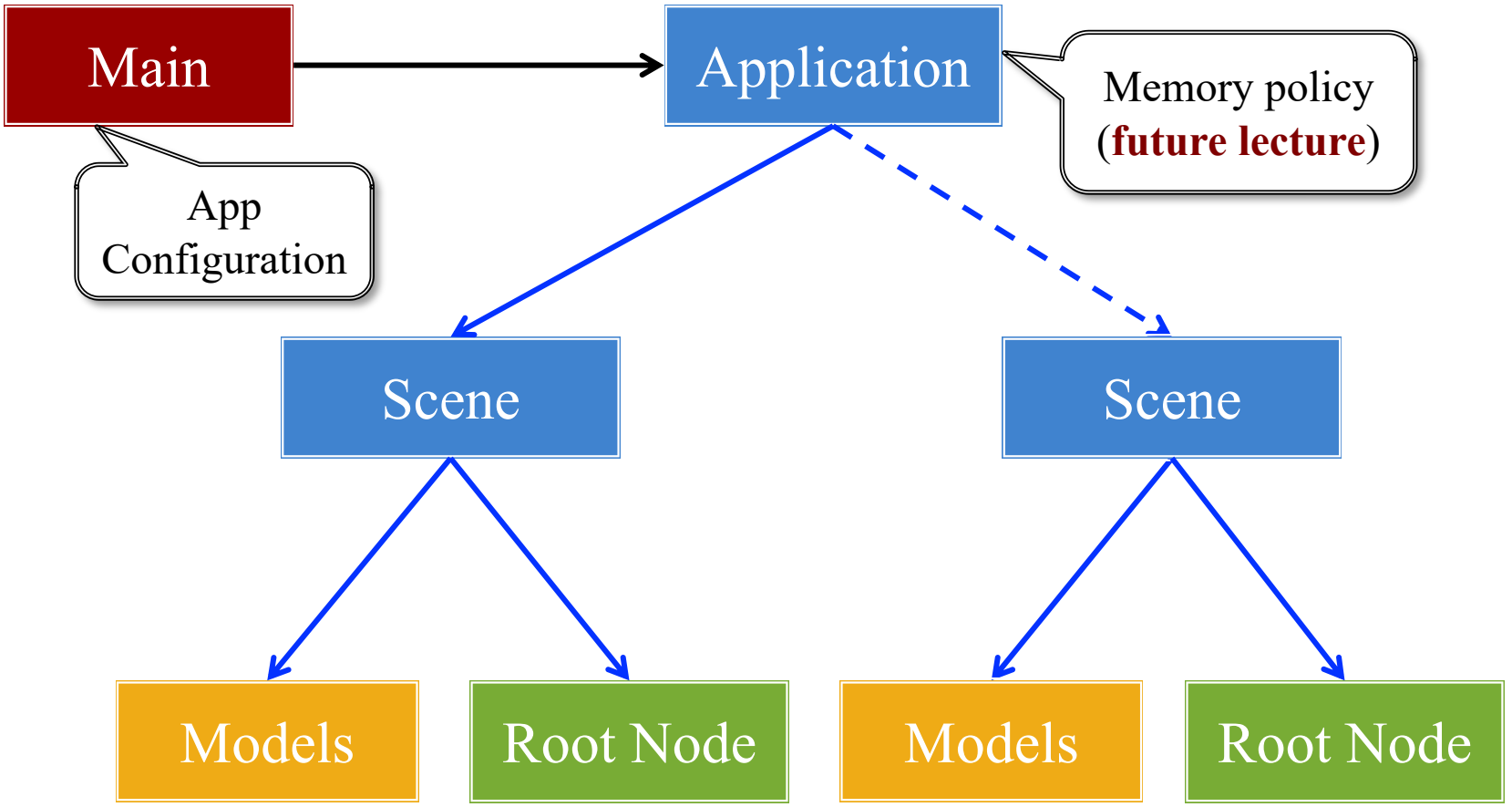

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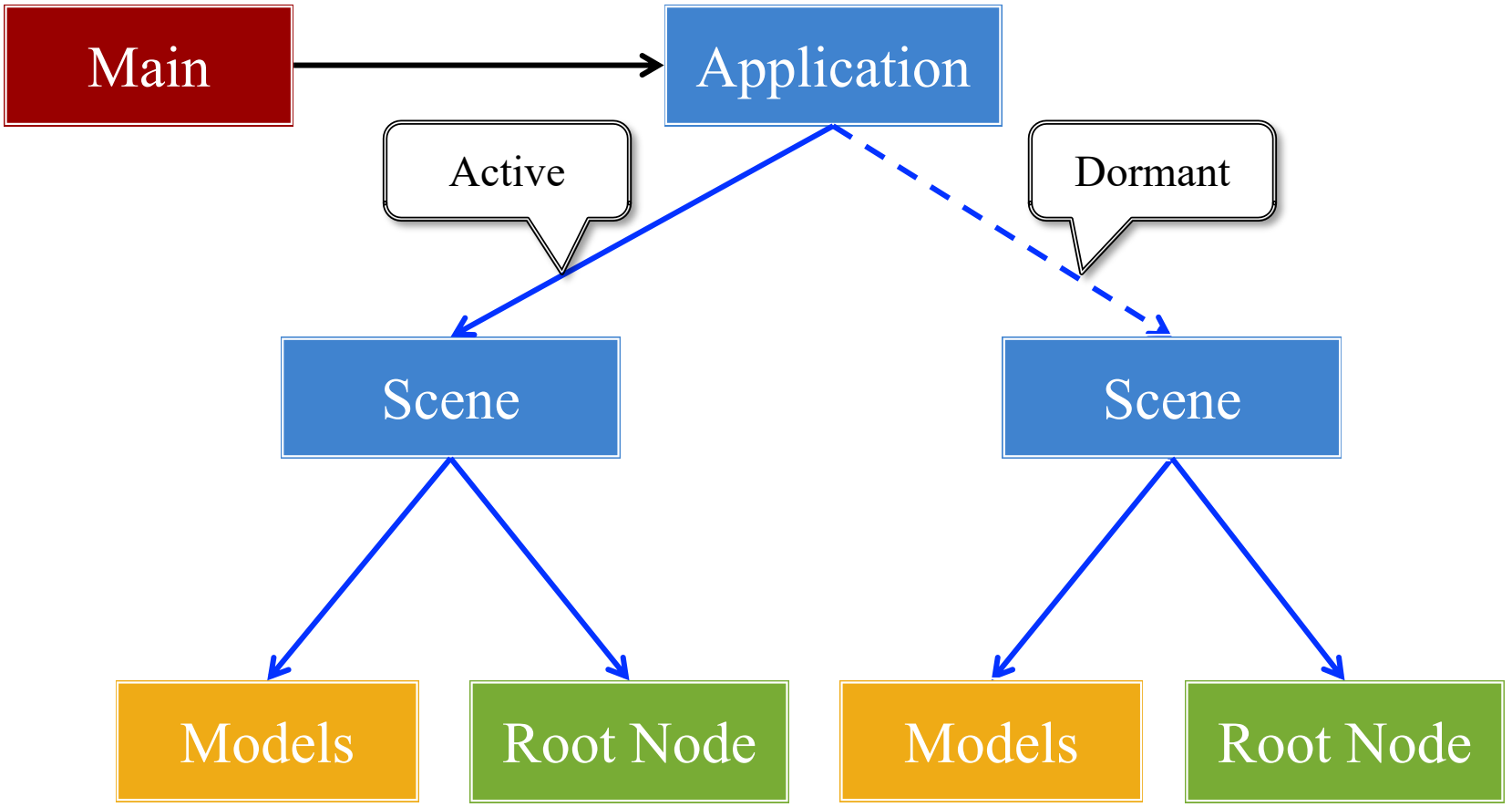

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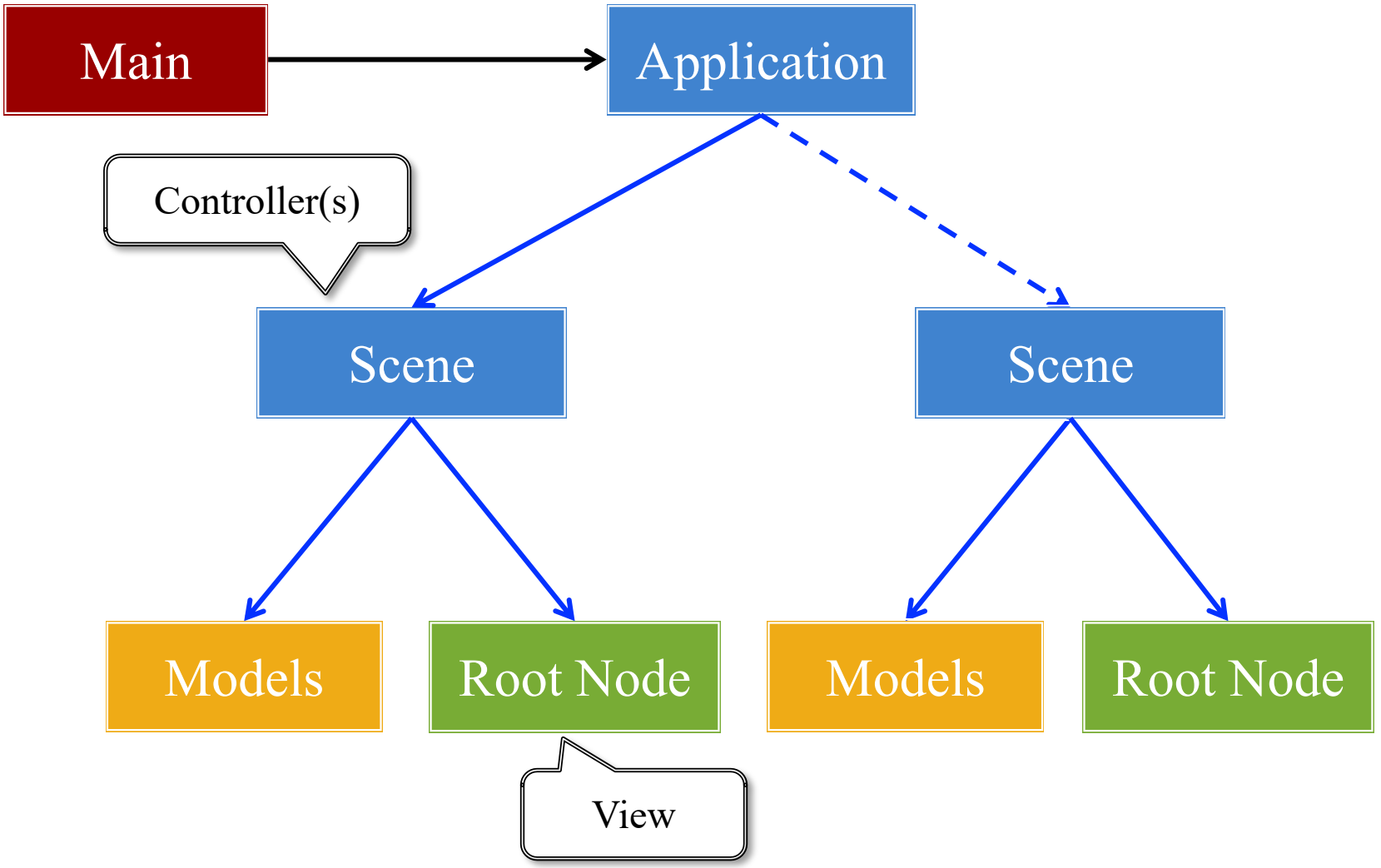

The Application Class

onStartup()

- Handles the game assets
  - Attaches the asset loaders
  - Loads immediate assets
- Starts any global singletons
  - **Example**: `AudioEngine`
- Creates any player modes
  - But does not launch ***yet***
  - Waits for assets to load
  - Like `GDXRoot` in 3152

update()

- Called each animation frame
- Manages gameplay
  - Converts input to actions
  - Processes NPC behavior
  - Resolves physics
  - Resolves other interactions
- Updates the scene graph
  - Transforms nodes
  - Enables/disables nodes

The Application Class

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- Handles the game assets
  - Attaches the asset loaders
  - Loads immediate assets
- S…tons
  - …els
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  - But does not launch *yet*
  - Waits for assets to load
  - Like `GDXRoot` in 3152

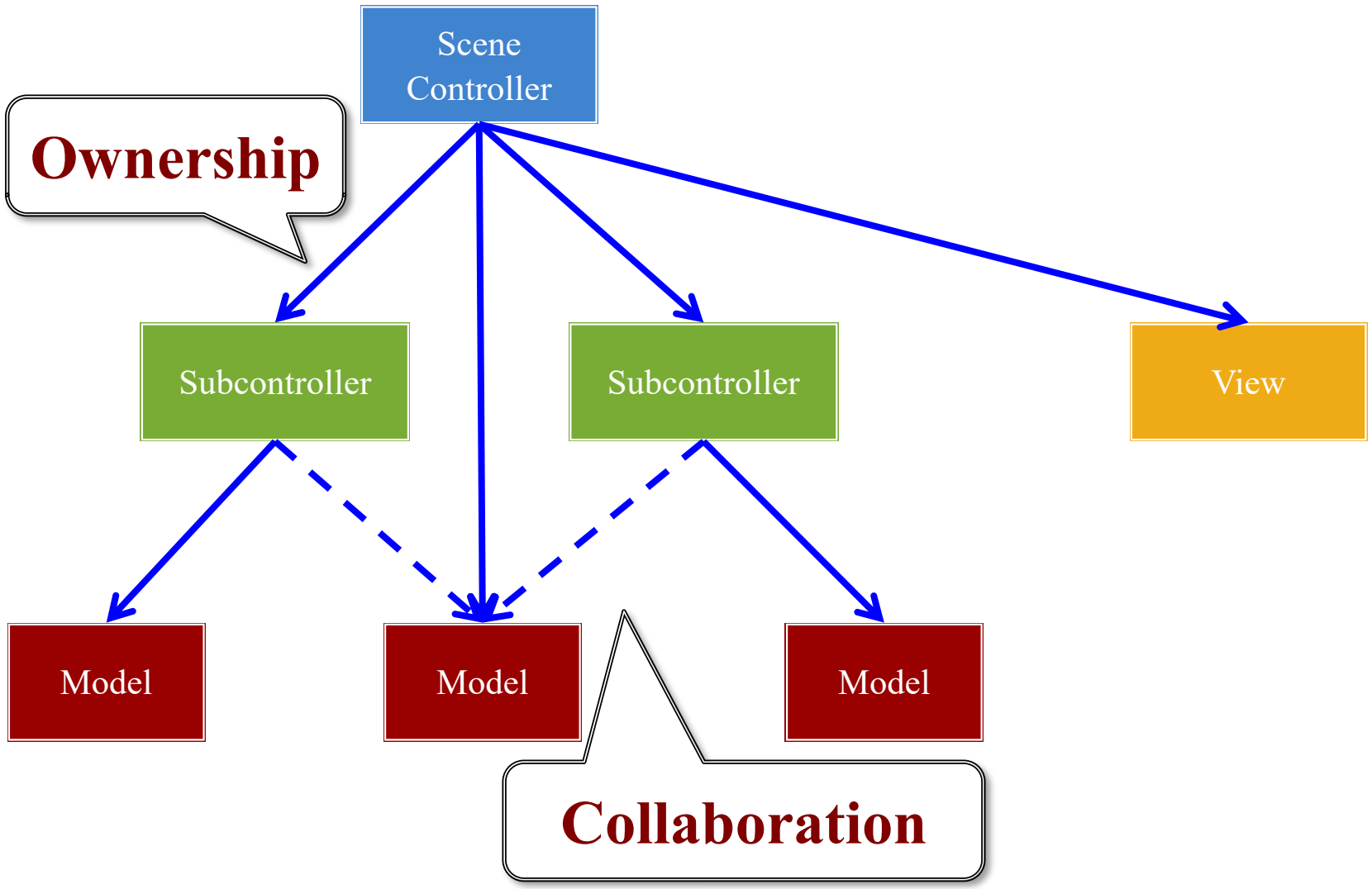
onShutdown() cleans this up

update()

- Called each animation frame
- Manages gameplay
  - Converts in…ons
  - …or
  - …solves other interactions
- Updates the scene graph
  - Transforms nodes
  - Enables/disables nodes

Does not draw!
Handled separately

Application Structure



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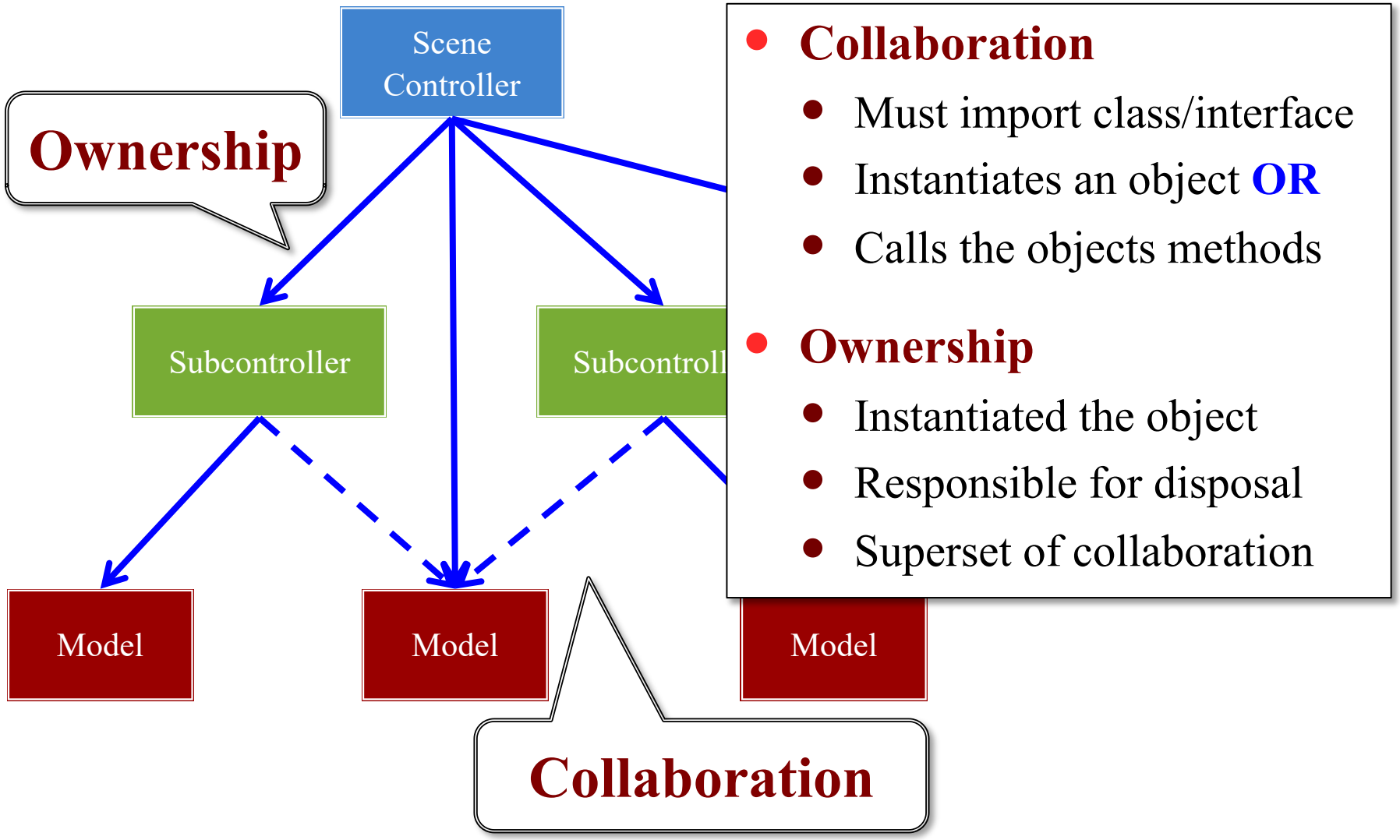
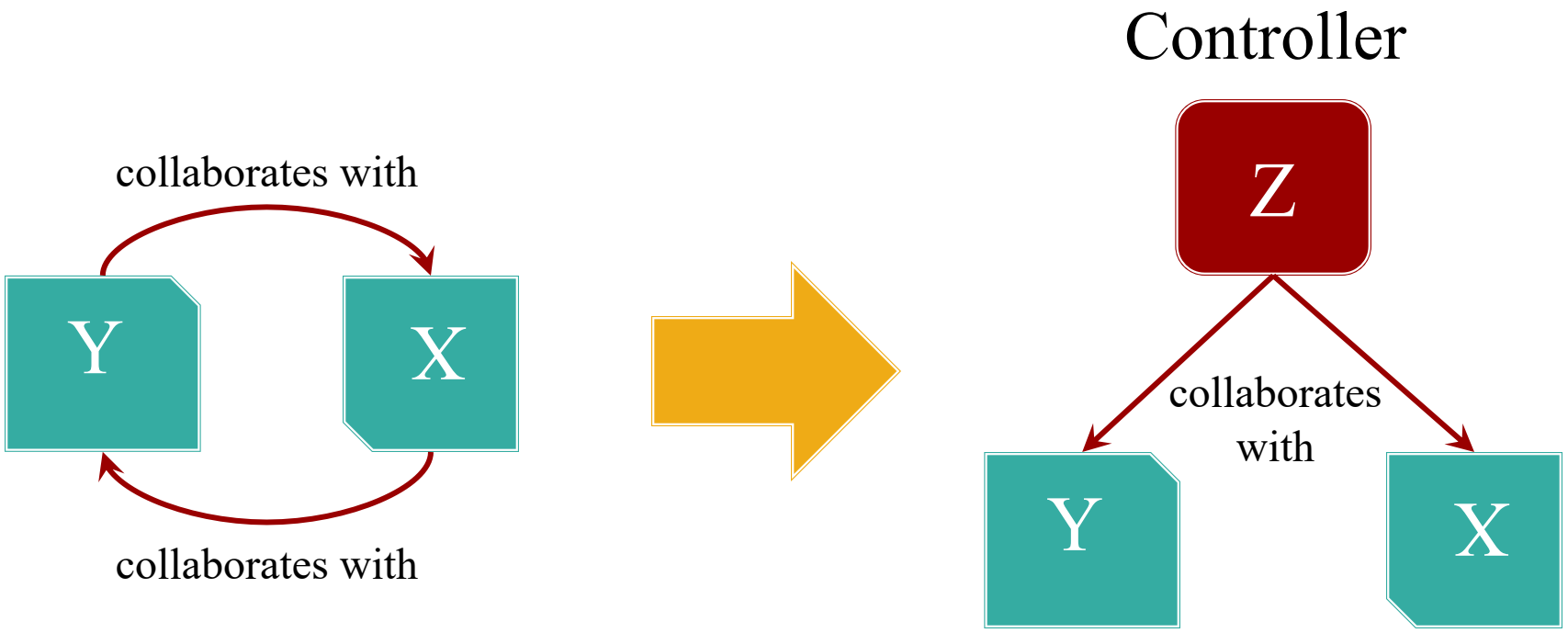
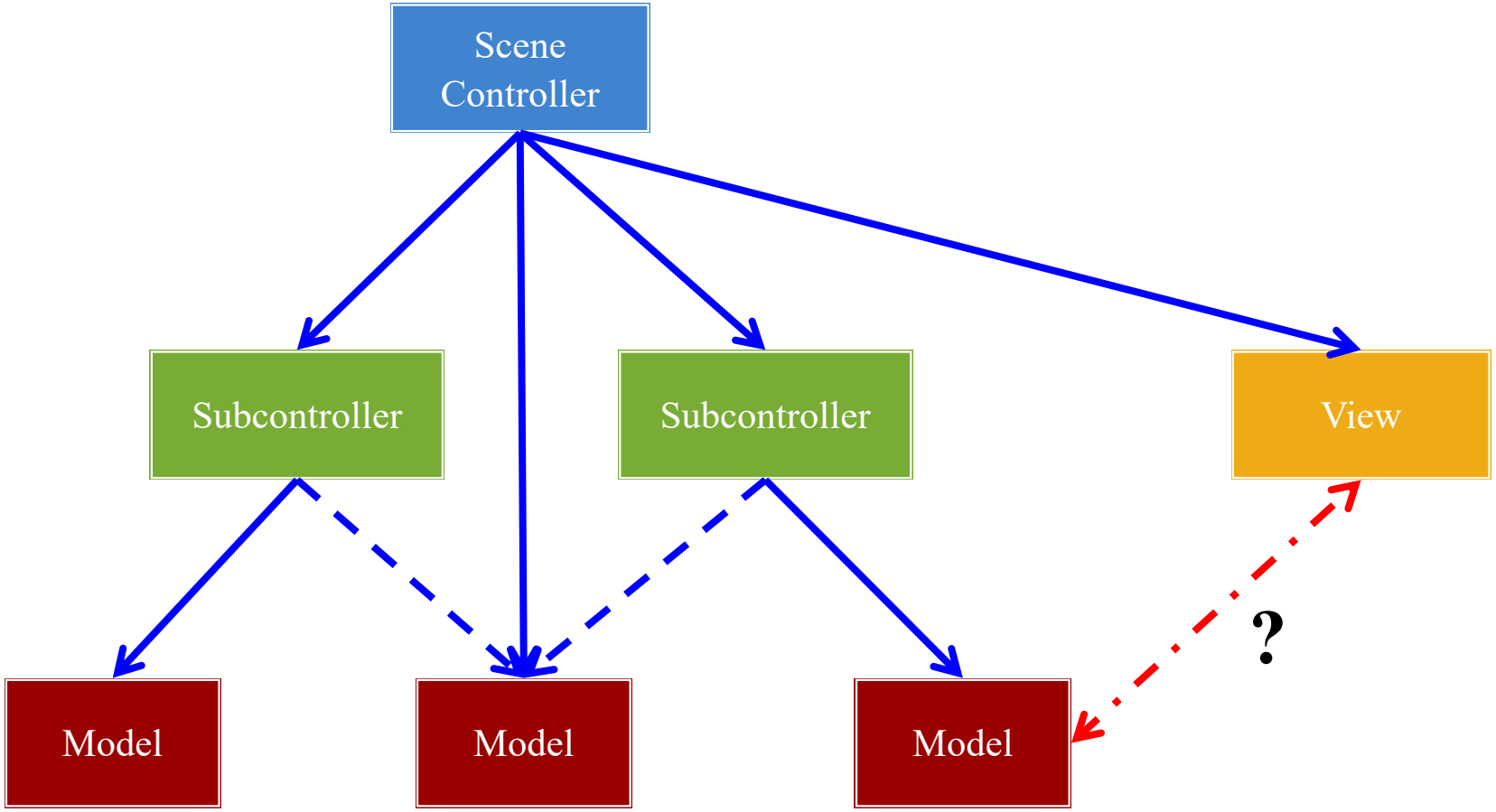


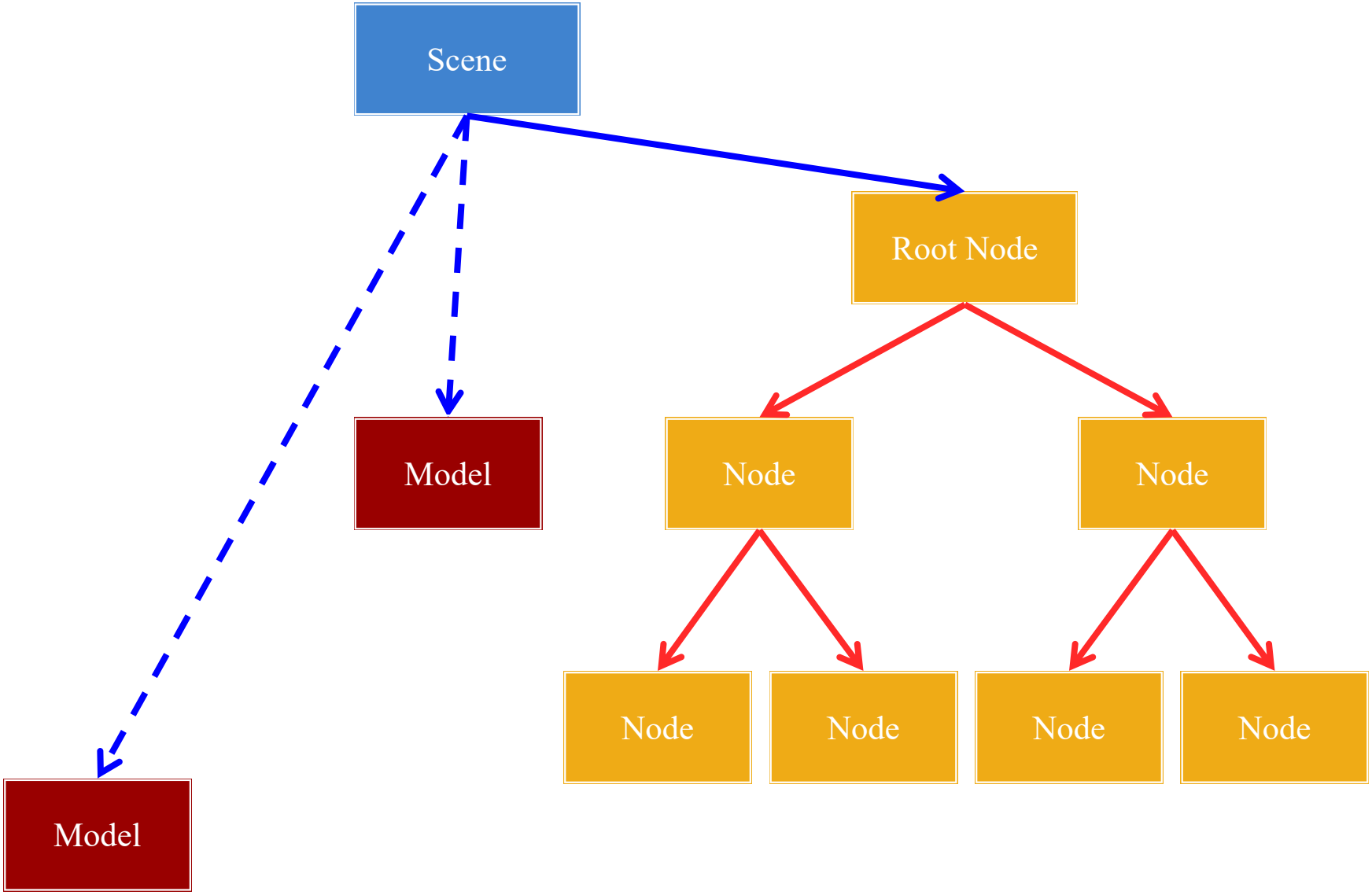
Avoid Cyclic Collaboration



Scene Structure



CUGL Views: Scene Graphs



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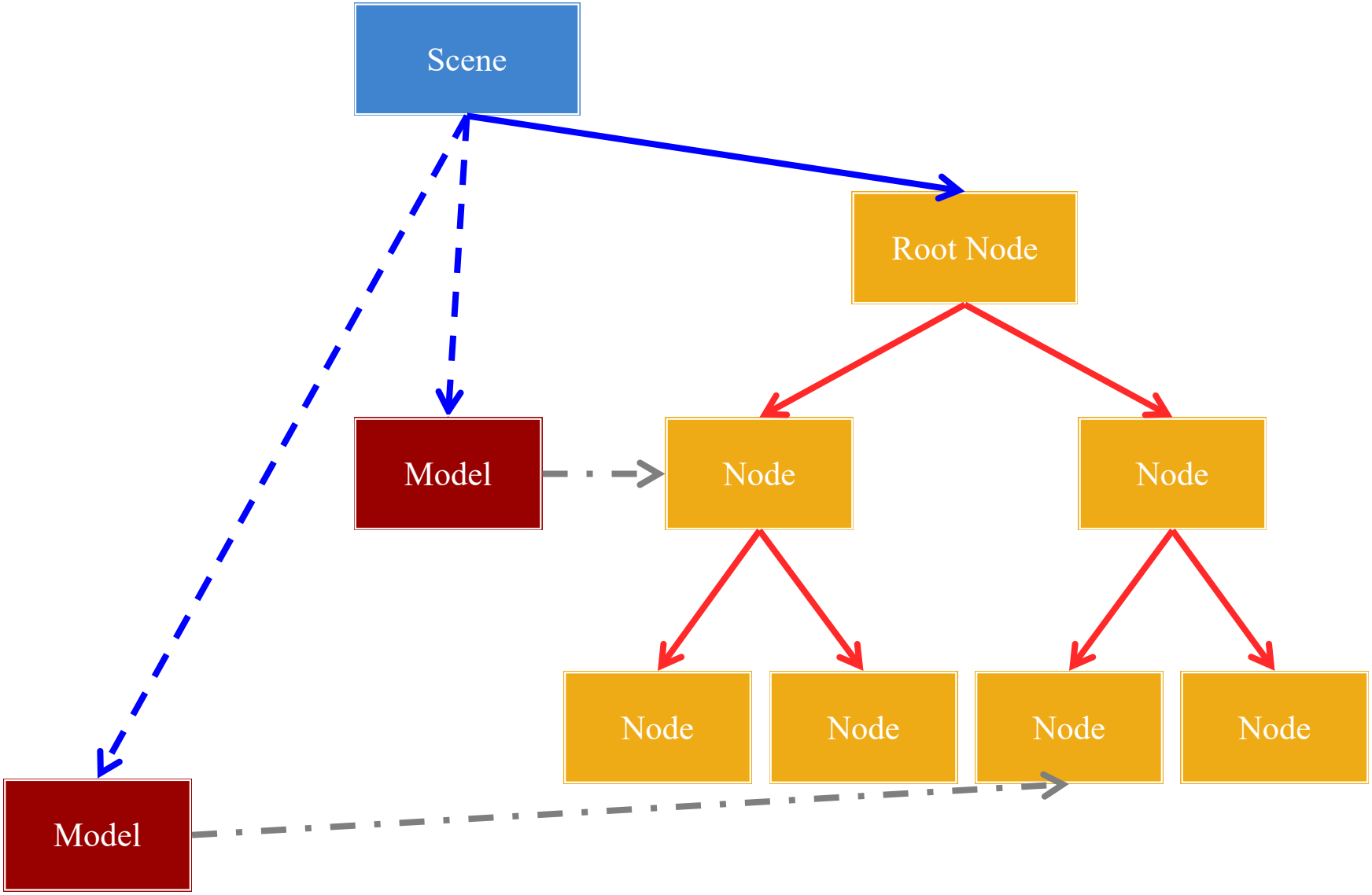

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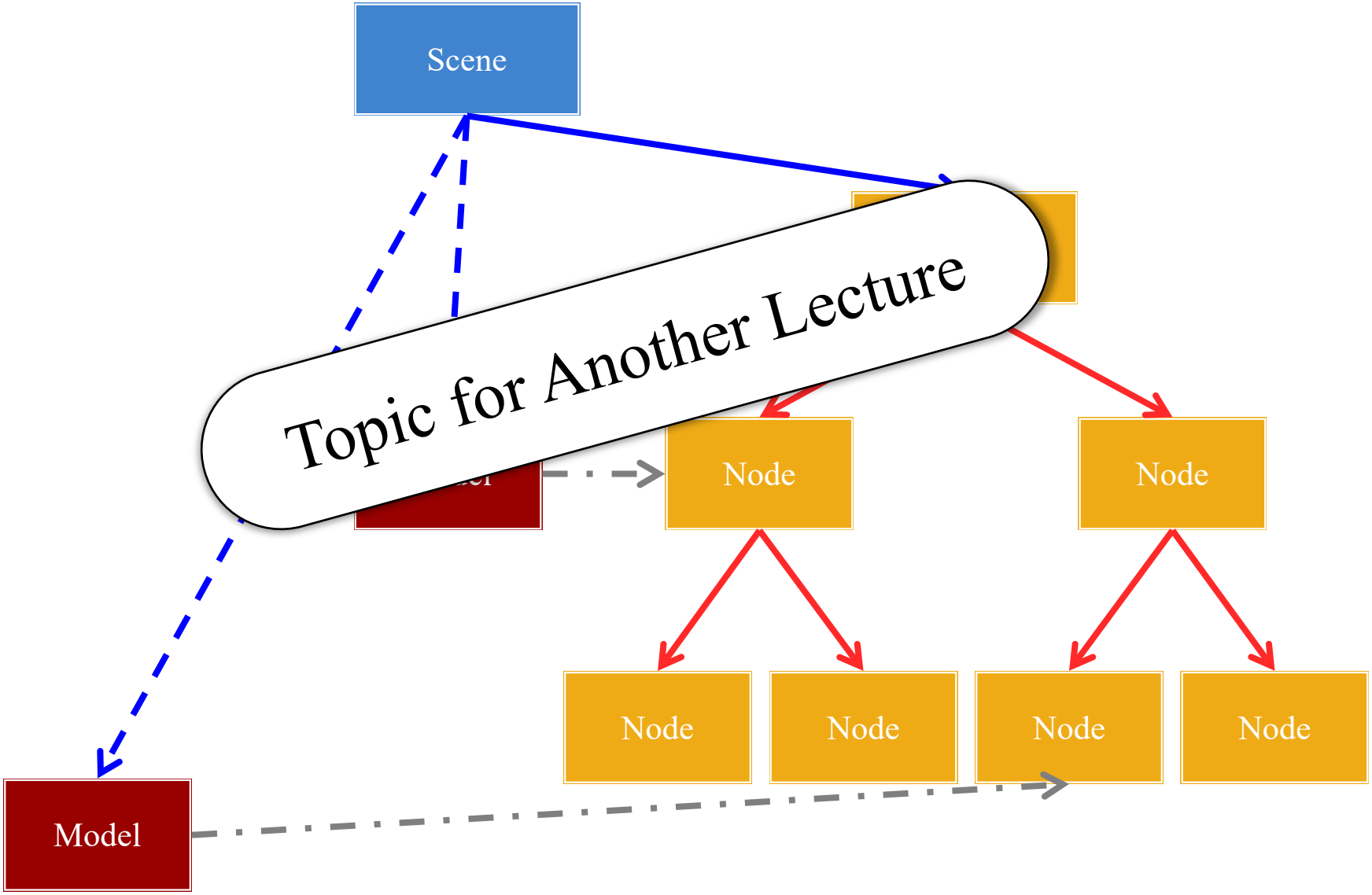


Model-Controller Separation (Standard)

Model

- Store/retrieve **object data**
  - Limit access (getter/setter)
  - Preserve any invariants
  - Only affects this object
- Implements **object logic**
  - Complex actions on model
  - May affect multiple models
  - **Example**: attack, collide

Controller

- Process **user input**
  - Determine action for input
  - **Example**: mouse, gamepad
  - Call action in the model

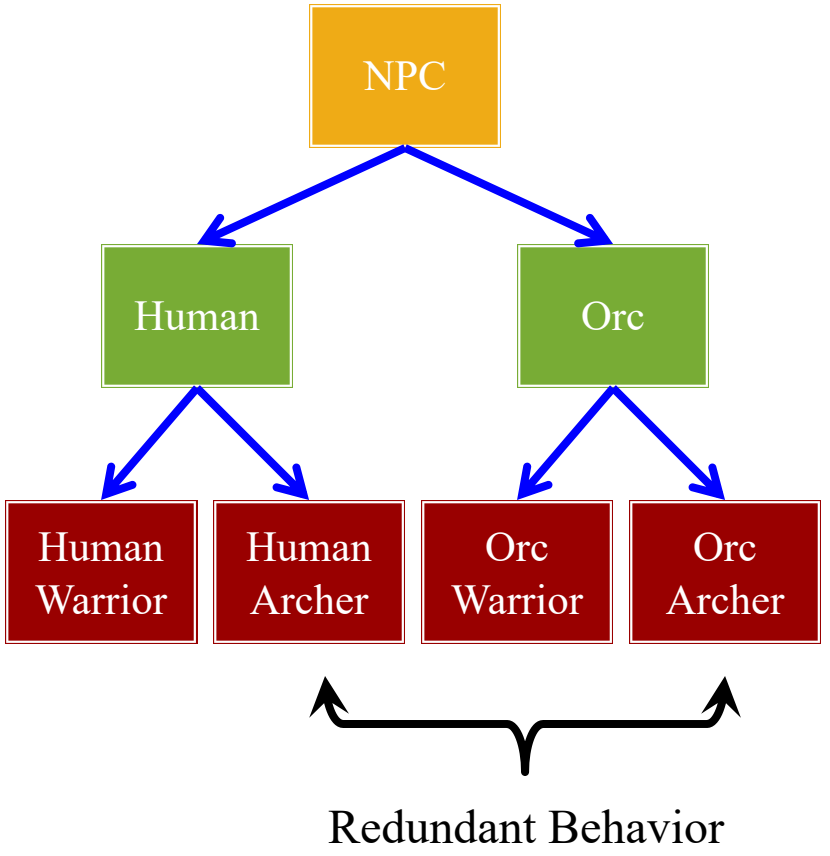
Traditional controllers are “lightweight”

Classic Software Problem: Extensibility

- **Given**: Class with some base functionality
  - Might be provided in the language API
  - Might be provided in 3rd party software
- **Goal**: Object with *additional* functionality
  - Classic solution is to subclass original class first
  - **Example**: Extending GUI widgets (e.g. Java)
- But subclassing does not always work…
  - How do you extend a *Singleton* object?

Problem with Subclassing

- Games have *lots* of classes
  - Each game entity is different
  - Needs its own functionality (e.g. object methods)
- Want to avoid **redundancies**
  - Makes code hard to change
  - Common source of bugs
- Might be tempted to **subclass**
  - Common behavior in parents
  - Specific behavior in children



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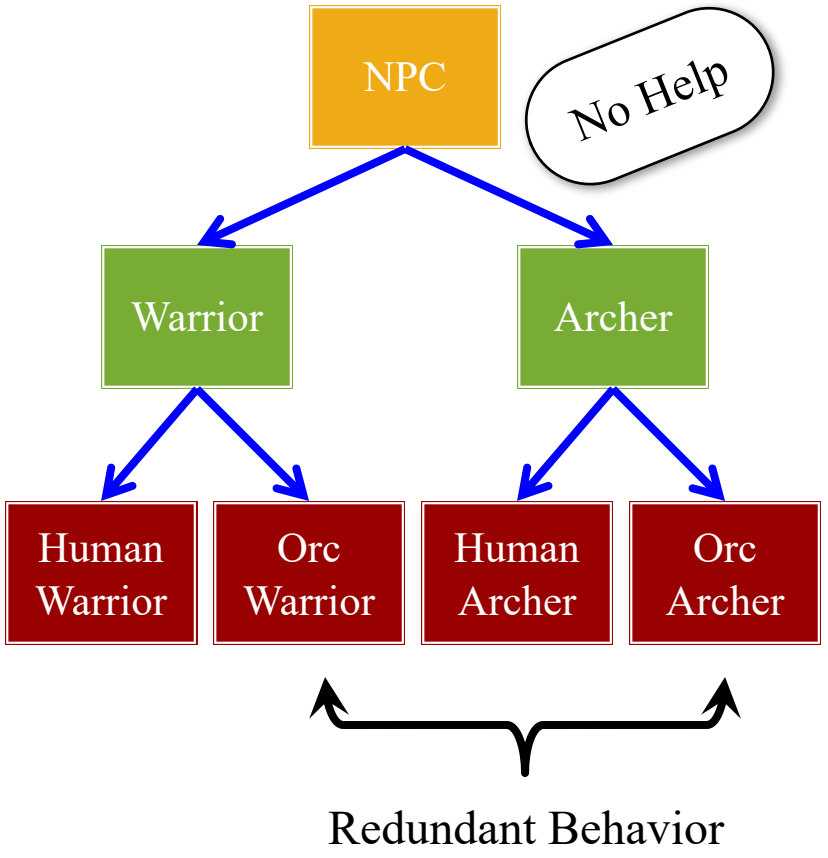

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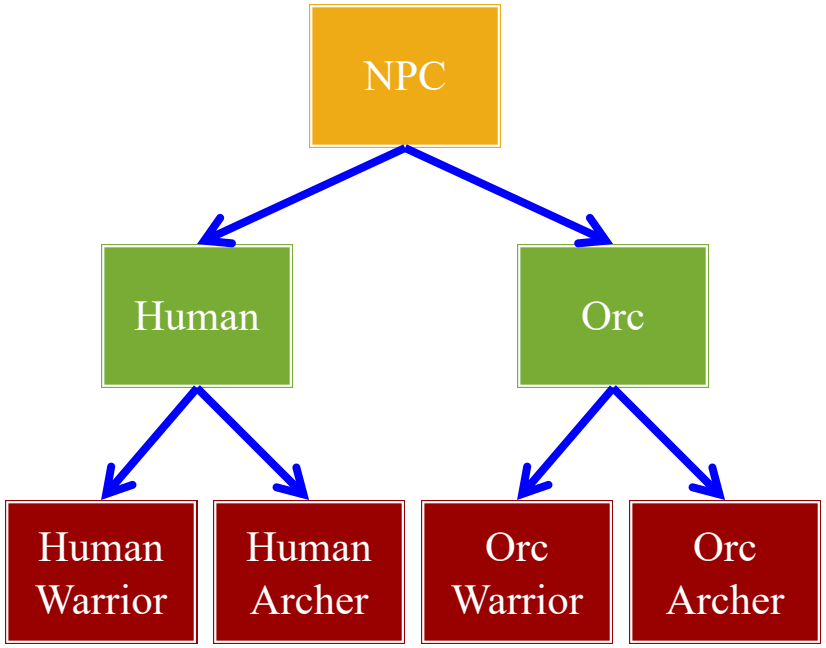

Redundant Behavior

Model-Controller Separation (Alternate)

Model

- Store/retrieve **object data**
  - Limit access (getter/setter)
  - Preserve any invariants
  - Only affects this object

In this case, models are lightweight

Controller

- Process **game actions**
  - Determine from input or AI
  - Find *all* objects effected
  - Apply action to objects
- Process **interactions**
  - Look at current game state
  - Look for "triggering" event
  - Apply interaction outcome

Model-Controller Separation (Alternate)

Model

- Store/retrieve **object data**
  - Limit access (getter/setter)
  - Pr
  - Or

Controller

- Process **game actions**
  - Determine from input or AI
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Motivation for the Entity-Component Model

In this case, models are lightweight

Does Not Completely Solve Problem

- Code **correctness** a concern
  - Methods have specifications
  - Must use according to spec
- Check correctness via **typing**
  - Find methods in object class
  - **Example**: `orc.flee()`
  - Check type of parameters
  - **Example**: `force_to_flee(orc)`
- **Logical** association with type
  - Even if not part of class

Issues with the OO Paradigm

- Object-oriented programming is very **noun-centric**
  - All code must be organized into classes
  - Polymorphism determines capability via type
- OO became popular with **traditional MVC pattern**
  - Widget libraries are nouns implementing view
  - Data structures (e.g. CS 2110) are all nouns
  - Controllers are not necessarily nouns, but lightweight
- Games, interactive media break this paradigm
  - View is animation (process) oriented, not widget oriented
  - Actions/capabilities only loosely connected to entities

Programming and Parts of Speech

Classes/Types are Nouns

- Methods have verb names
- Method calls are sentences
  - `subject.verb(object)`
  - `subject.verb()`
- Classes related by *is-a*
  - Indicates class a subclass of
  - **Example**: String is-a Object
- Objects are class *instances*

Actions are Verbs

- Capability of a game object
- Often just a simple function
  - `damage(object)`
  - `collide(object1,object1)`
- Relates to objects via *can-it*
  - **Example**: Orc can-it attack
  - Not necessarily tied to class
  - **Example**: swapping items

Duck Typing: Reaction to This Issue

- "Type" determined by its
  - Names of its methods
  - Names of its properties
  - If it "quacks like a duck"
- Python has this capability
  - hasattr(<object>,<string>)
  - True if object has attribute or method of that name
- This has many **problems**
  - Correctness is a *nightmare*

Java:

```
public boolean equals(Object h) {
    if (!(h instanceof Person)) {
        return false;}
    Person ob= (Person)h;
    return name.equals(ob.name);
}
```

Python:

```
def __eq__(self,ob):
    if (not (hasattr(ob,'name'))
        return False
    return (self.name == ob.name)
```

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```
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                                rson)) {
                                )h;
                                (ob.name);
                                name'))
    return False
return (self.name == ob.name)
```
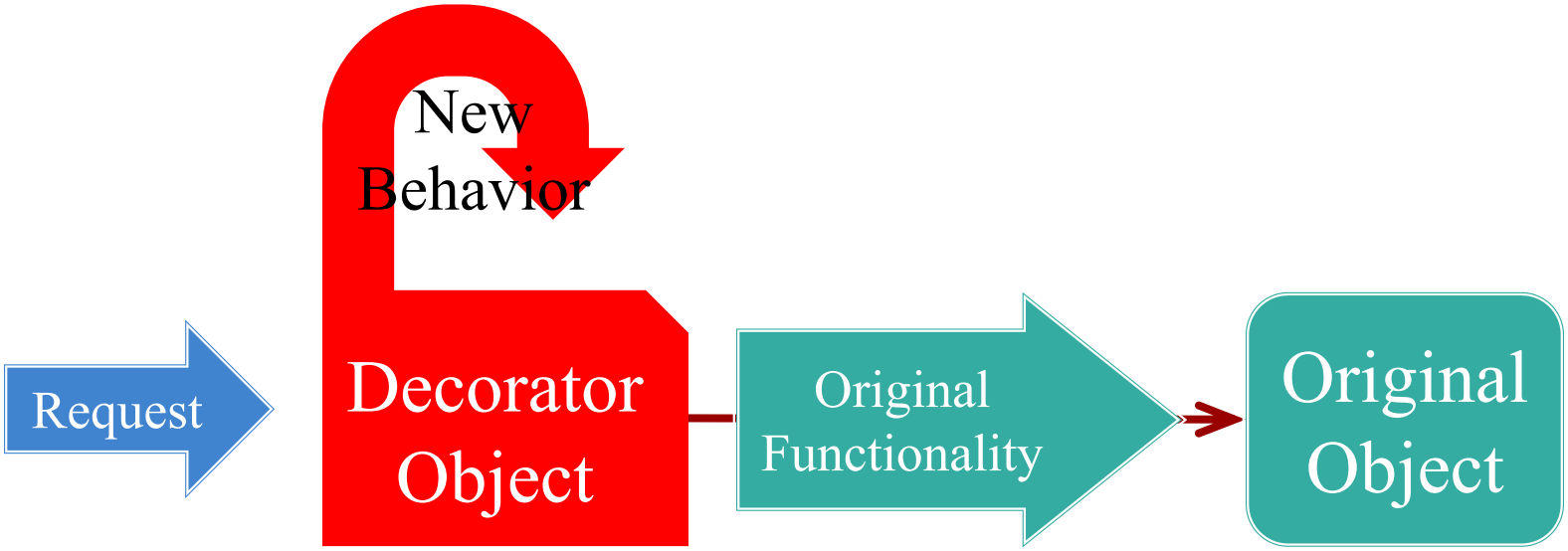

- What do we really want?
  - Capabilities over properties
  - Extend capabilities without necessarily changing type
  - Without using new languages
- We use *software patterns*

Possible Solution: Decorator Pattern



Java I/O Example

```
InputStream input = System.in;
```

Built-in console input

```
Reader reader = new InputStreamReader(input);
```

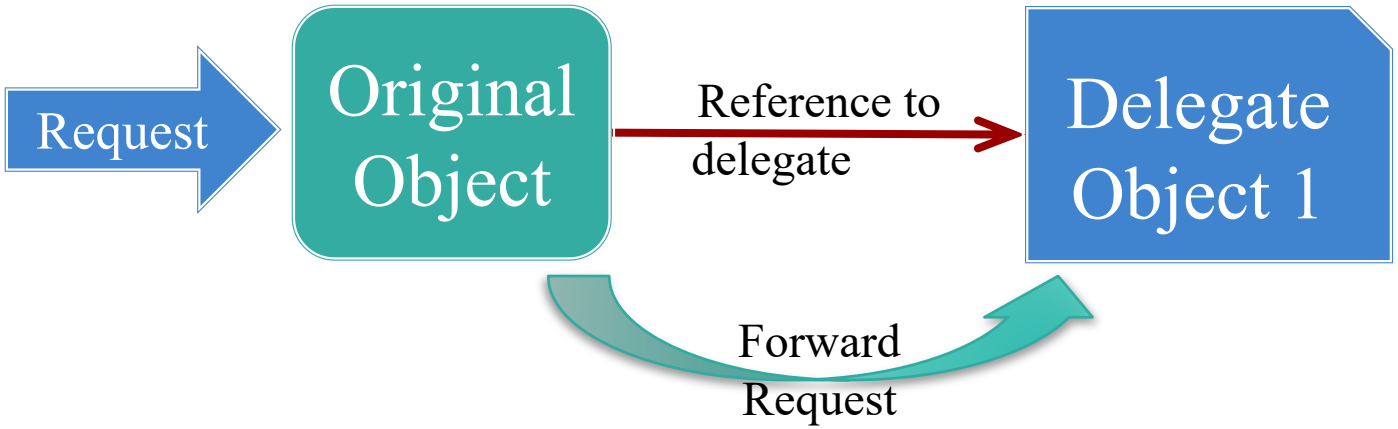
Make characters easy to read

```
BufferedReader buffer = new BufferedReader(reader);
```

Read whole line at a time

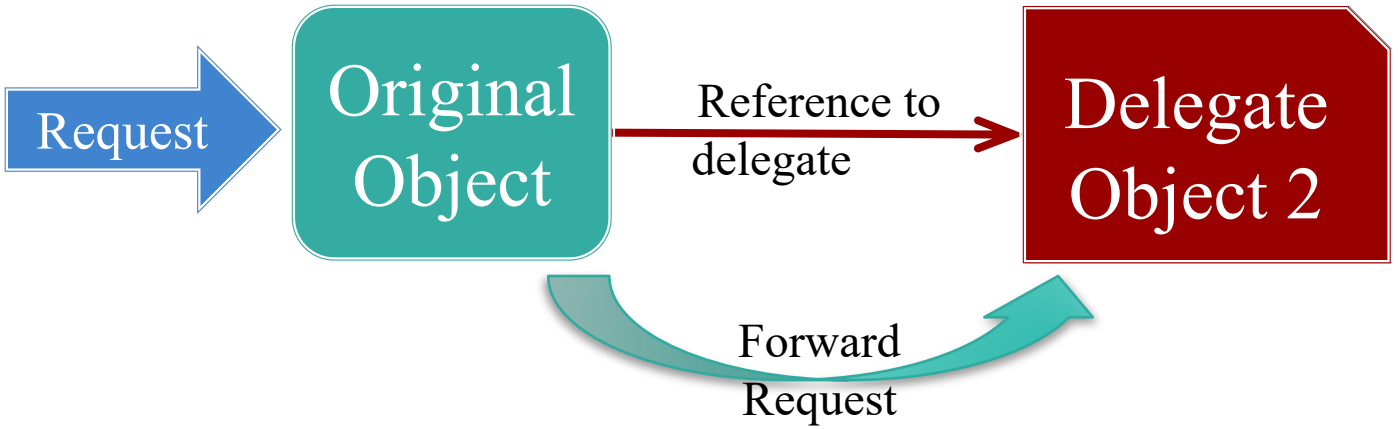
Most of java.io works this way

Alternate Solution: Delegation Pattern



Inversion of the Decorator Pattern

Alternate Solution: Delegation Pattern



Inversion of the Decorator Pattern

Example: Sort Algorithms

```
public class SortableArray extends ArrayList{

   private Sorter sorter = new MergeSorter();   new QuickSorter();

   public void setSorter(Sorter s) { sorter = s; }

   public void sort() {
        Object[] list = toArray();
        sorter.sort(list);
        clear();
        for (o:list) { add(o); }
    }
}
```

```
public interface Sorter {
    public void sort(Object[] list);
}
```

Comparison of Approaches

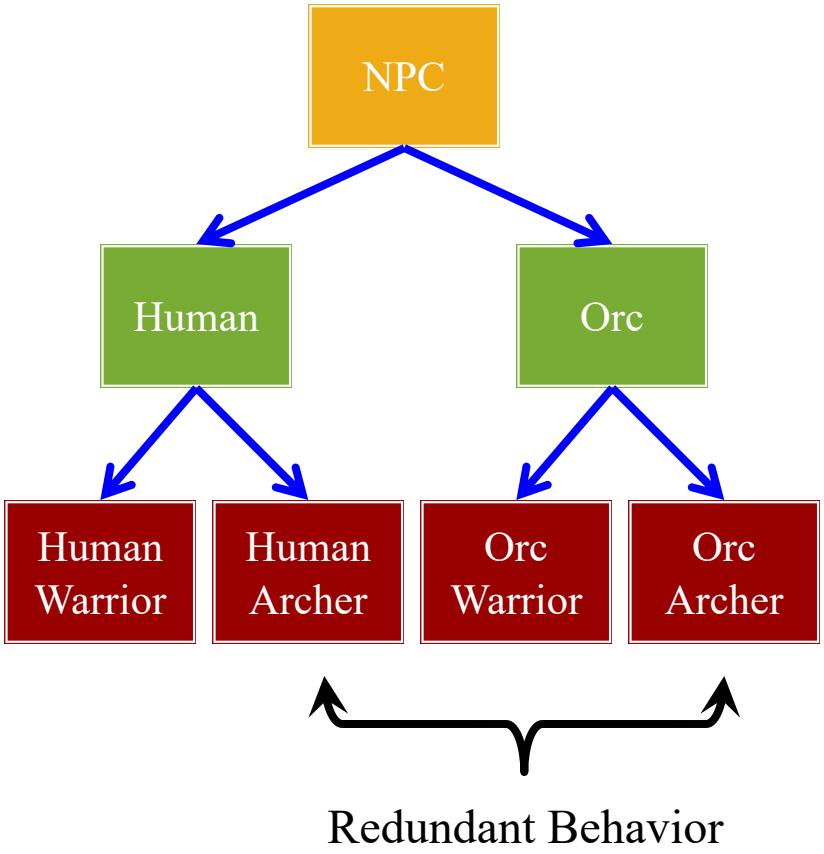
Decoration

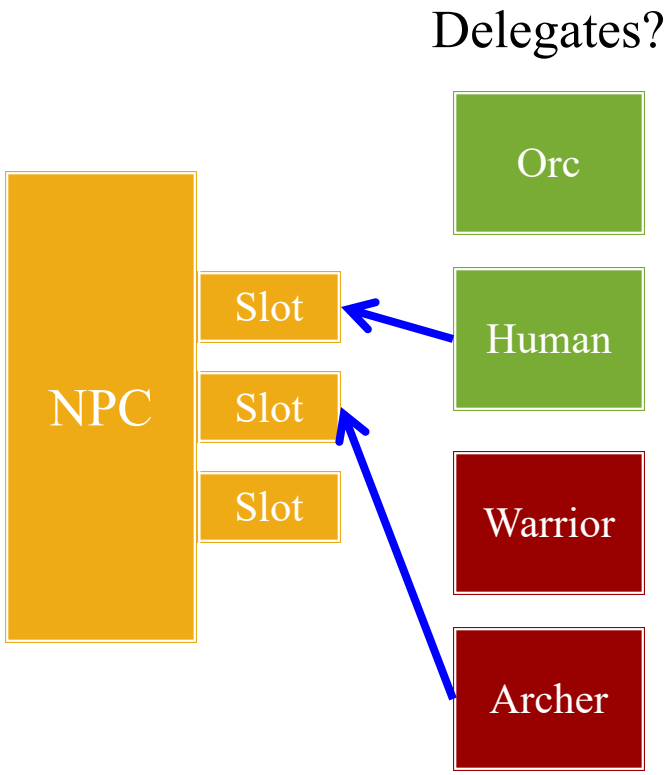
- Pattern applies to *decorator*
  - Given the original object
  - Requests through decorator
- **Monolithic** solution
  - Decorator has all methods
  - "Layer" for more methods (e.g. Java I/O classes)
- Works on *any* object/class

Delegation

- Applies to *original object*
  - You designed object class
  - All requests through object
- **Modular** solution
  - Each method can have own delegate implementation
  - Like higher-order functions
- Limited to classes you make

The Subclass Problem Revisited





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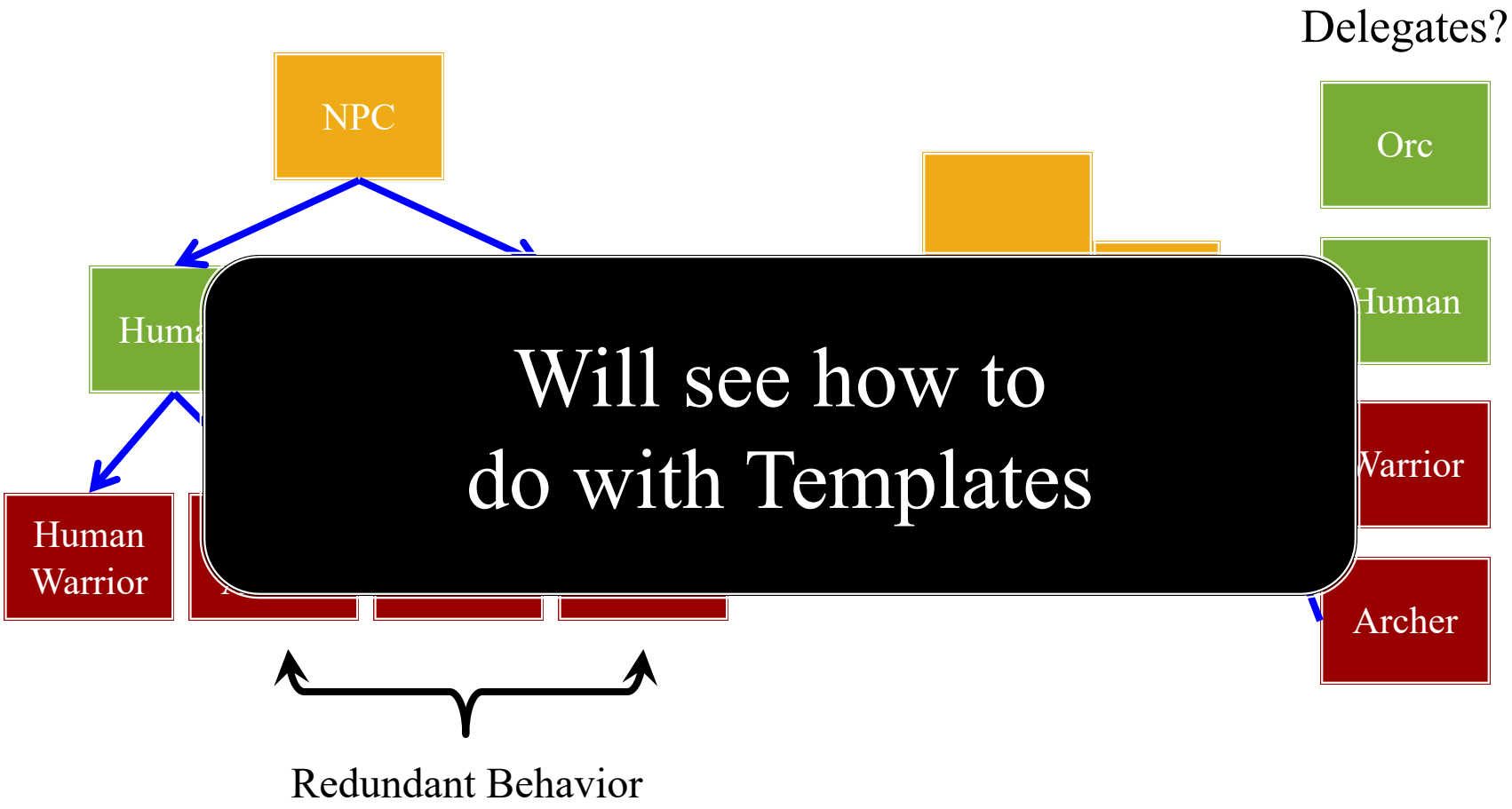

Summary

- CUGL supports the traditional game loop
  - Has root controller for primary app control
  - Root separates into `update`/`draw` steps
- CUGL view is handled in scene graphs
  - Scene is a game mode or logical unit
  - Scene graph is hierarchical arrangement of scene
- Games naturally fit a **specialized MVC** pattern
  - Want *lightweight* models (mainly for serialization)
  - Want *heavyweight* controllers for the game loop
  - **Component-based design** better models actions