Observer / Template Methods

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Example

The I.T. systems for the Olympics are complex and represent a software architecture challenge.

Information about the events, such as the detailed scheduling, competitors and results are all stored on a centralized system.

This information must then distributed to various subsystems (views), each used by a different category of people.

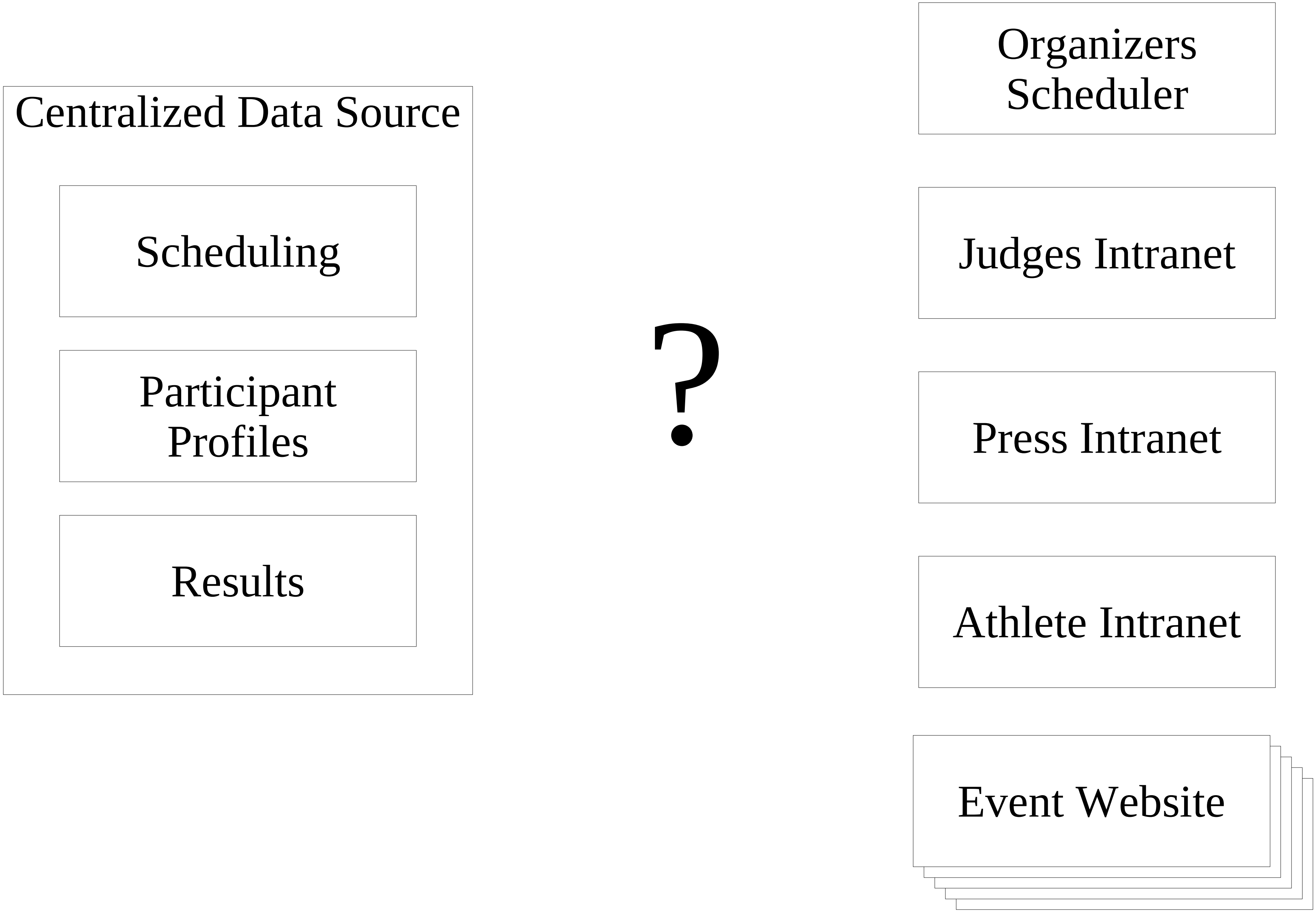
Information Distribution

	Scheduling	Participant Profiles	Results
Organizers			
Judges			
Athletes			
Spectators			
Press			

Information Distribution

	Scheduling	Participant Profiles	Results
Organizers	W		
Judges	R		W
Athletes	R	W	R
Spectators		R	R
Press	R	R	R

Data Source and Subsystems



Concerns

Such a system must

ensure consistency between different views

be efficient (it will have to deal with a high load)

the subsystems cannot continuously poll the data source for content.

Should be event-based: “when change, keep overall consistency by propagation”

the data source cannot push all the content to the subsystems.

Observer Pattern

The Observer Pattern defines an one-to-many dependency between objects so that when one object changes state, all its dependents are notified and updated automatically.

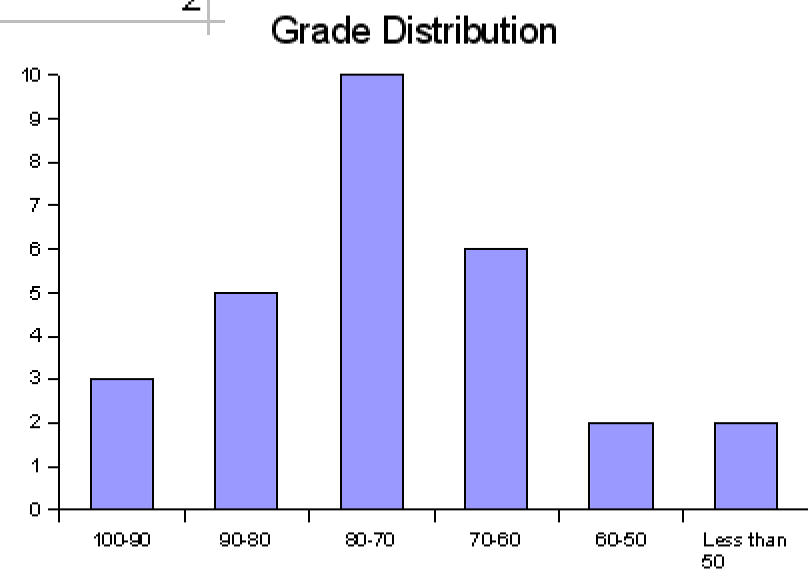
Also known as: Dependents, Publish/Subscribe

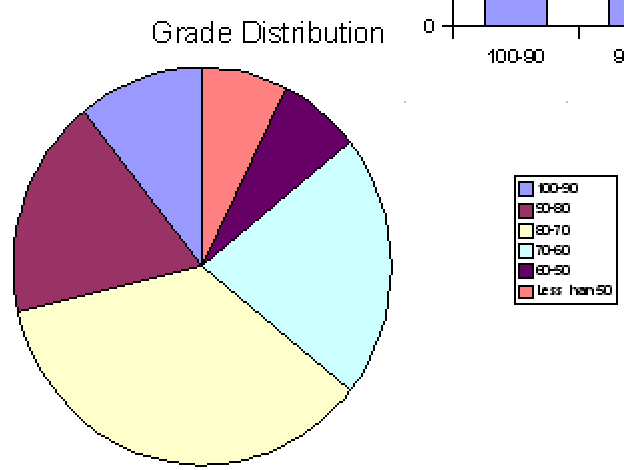
Part of Model/View/Controller (MVC)

Classic Example

Student	Grade
John	85.00%
Bob	95.00%
Jane	72.00%
Mary	63.00%
Cory	56.00%
Adam	90.00%
Nancy	21.00%
Stacy	55.00%
James	73.00%
William	75.00%
David	66.00%
Richard	68.00%
Patricia	78.00%
Linda	84.00%
Barbara	69.00%
Paul	83.00%
Elizabeth	75.00%

Grade Distribution	
Grade	# of students
100-90	3
90-80	5
80-70	10
70-60	6
60-50	2
Less than 50	2





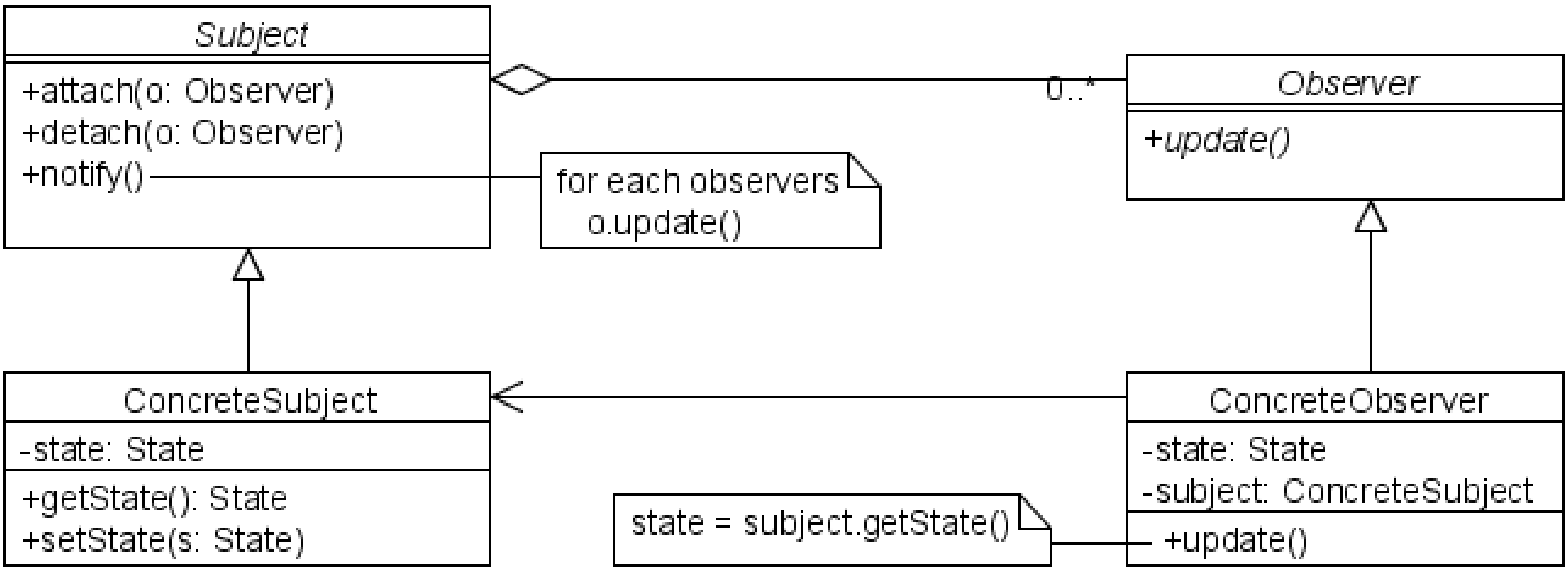
Motivation

The main motivation behind the Observer Pattern is the desire to maintain consistency between related objects without making them tightly coupled.

In our spreadsheet example, we don't want the different representations to be coupled with each other.

However, if the information changes in the spreadsheet, all the different representations should be updated to maintain consistency.

Participants



Actions

attach/subscribe: observer “registers” with subject

detach/unsubscribe: let observer no longer observe subject

notify : subject method called when subject state changes

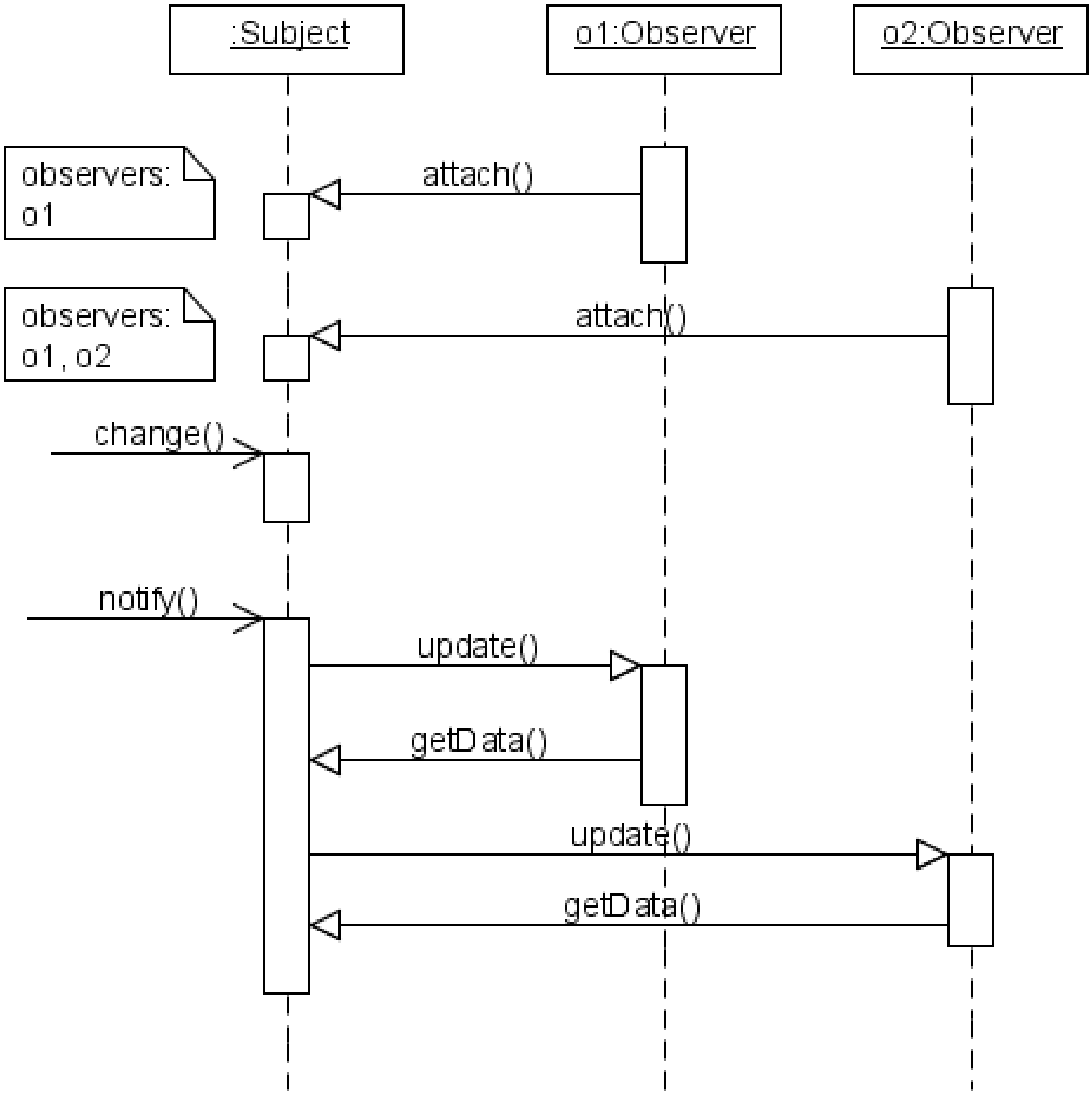
update : inform an observer that new data is available

getState : get subject state after notify (pull method)

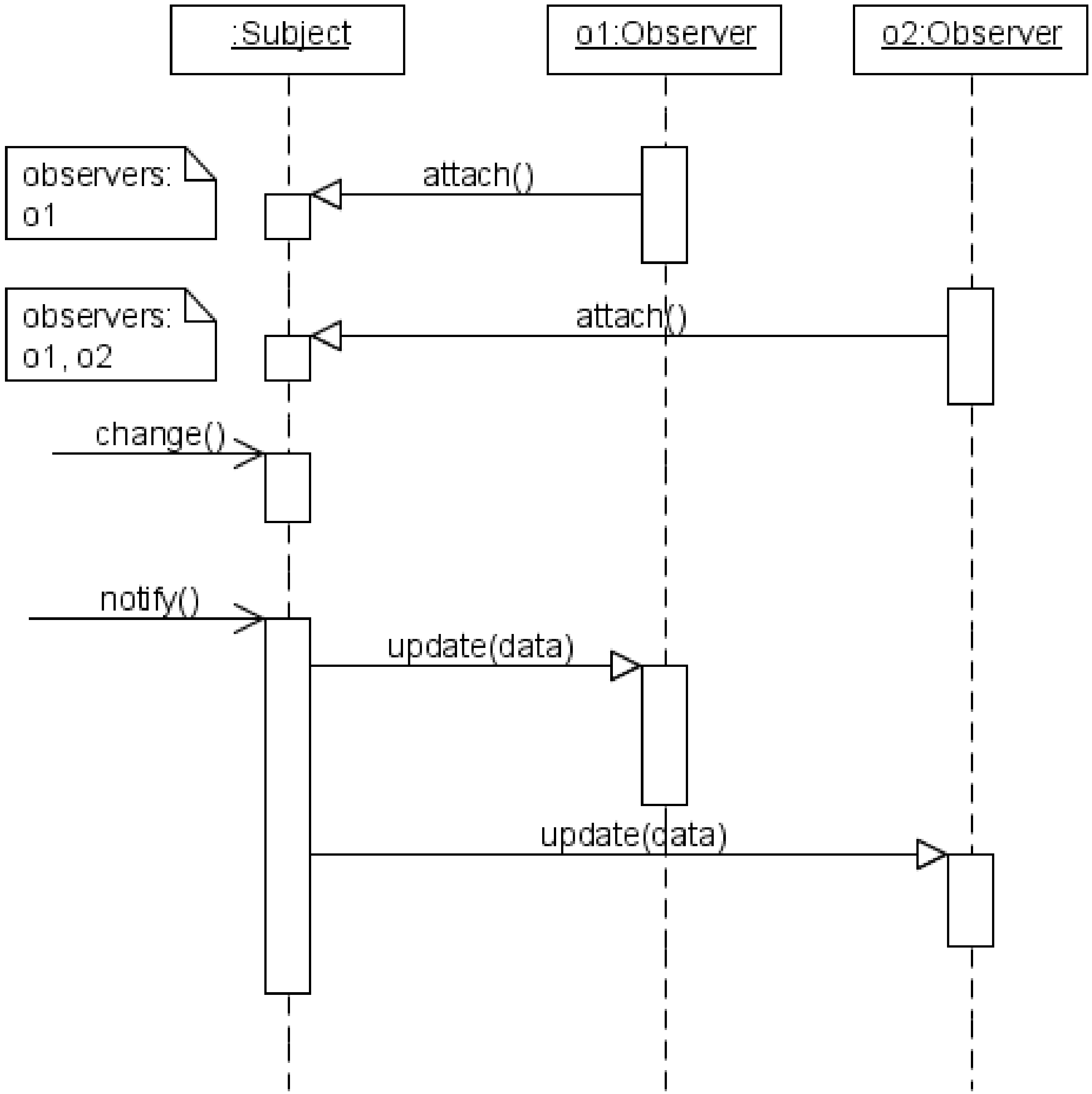
update with data argument :

send data to observers (push method)

Sequence Diagram (Pull)



Sequence Diagram (Push)



Applicability

Abstraction has multiple aspects/views, each independent

- Separation allows independent modification/re-use

Unknown number of observers

- may change dynamically

No assumptions made about observers

- except for presence of update()

Consequences

- Minimal coupling between Subject and Observer.
  - The subject does not require knowledge of the observer.
  - The observer only needs to know how to get new data.
- Support for broadcast communication.
  - An update() triggers a broadcast communication across all observers.
- Unexpected updates.
  - The subject is blind to its observer. Thus, the cost of an update() is unknown.
  - Observers have no control over when they will receive updates.

Implementation Concerns

The Observer pattern has numerous alternative variants:

- Push vs. Pull
- Observing more than one subject.
- Who stores the subscription?
- Who triggers update?
- Deleting subjects and observers?
- Subject's self-consistency
- Complex subscriptions
- Observer/Subject combo

Push vs. Pull

What are the advantages, disadvantages?

Pull

In the pull model, observers are responsible for acquiring the new state after an update() is called.

+ Better transparency, subject doesn't need to know about observer.

+ Observer is free to determine whether it wants to acquire the new state.

- Observer must determine what is new without help from the subject.

Push

In the push model, information about the subject's state change is sent in the update message.

+ Efficient: observer does need to determine what was updated.

- Requires the subject to know more about the observer (breaks abstraction).

- Observer always automatically receives the update, whether it wants it or not.

Observing more that one subject

In some situations, it might make sense that an observer be attached to more than one subject.

Our current infrastructure is very poor for this.

We don't know which of the observed subjects called the update method.

How can we fix this?

Who stores the subscriptions?

In a traditional Observer Pattern, the subject manages the collection of observers (subscribers).

This adds overhead to that class:

Clutters the API.

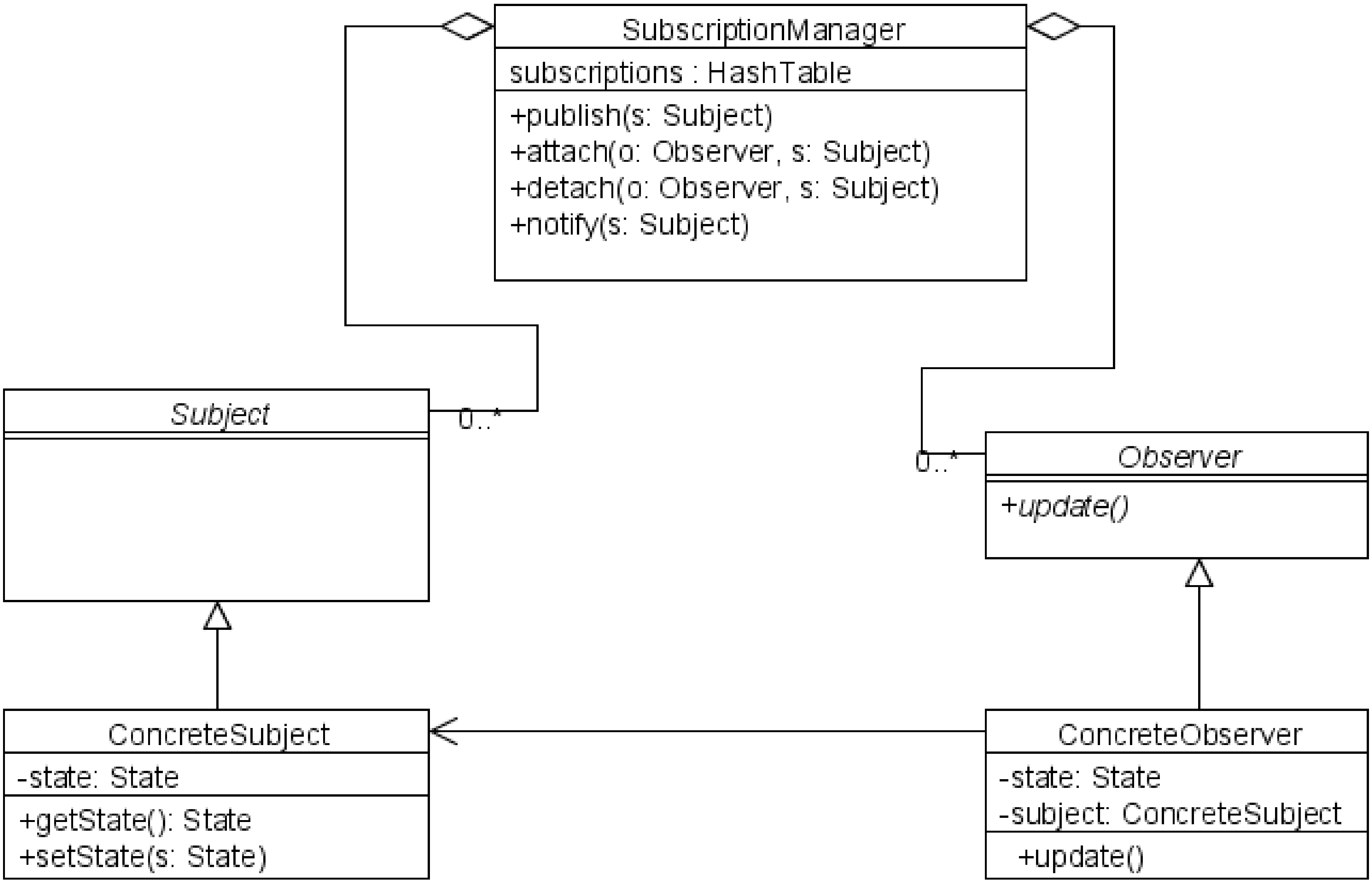
Forces it to deal with attach/detach method calls.

In a system with a low number of subscriptions, this is not a problem.

However, this is a burden to the subject if there are many subscriptions.

Solution?

Subscription Manager



Notify()

Who can/should trigger notify?

When do we call a notify?

Who triggers notify?

safety vs. performance tradeoff.

Safety: after every setState(), notify() is called (and hence update() messages are sent).

+This ensures a consistent state at all times.

- It's very expensive when there are many setState() calls.

Performance: we do a nofity() after having completed an appropriate number of setState() calls.

+ We don't flood the system with update() calls (performance).

- There is a danger of having inconsistencies.
- There is a danger that the call to notify() is forgotten.

Deleting the Subject

If a subject is deleted, what should happen to its observers?

Deleting the Subject

We could delete the observers, but ...

- Other objects might refer to those observers.
- The observers might be attached to other subjects.

Subject should notify the observers before its destruction?

Deleting the Observer

If an observer is deleted, what should happen to its subject?

Deleting the Observer

detach() the observer before deleting it
(in observer's destructor)

Observer / Subject

An object could be both a subject and an observer.

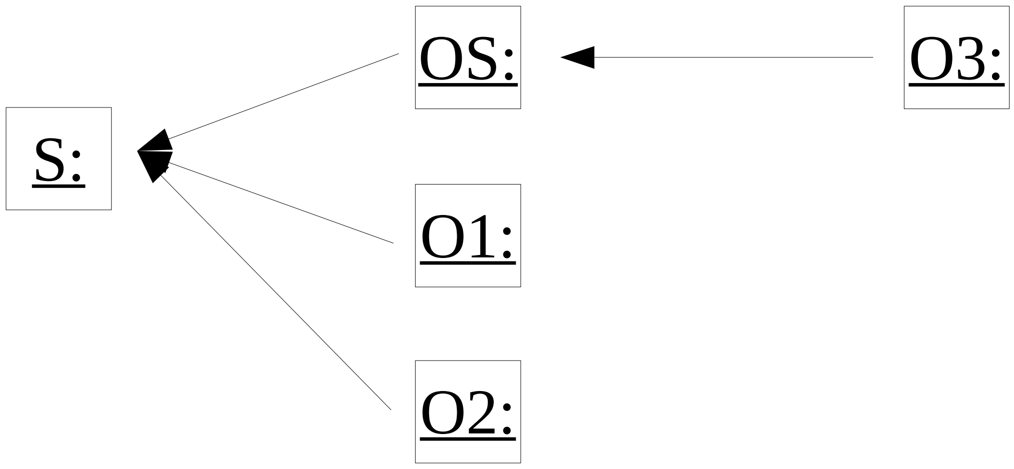
In our example, OS is an observer and a subject.

What happens when OS calls S.getState()?

Most likely it will update its state, triggering a notify() and subsequently an update() call to O3.

What happens if S observes O3? We would get a loop.

If an object can be both an observer and a subject, we need to deal with (detect/handle) loops. How?



Specific Interest

As already mentioned, the subscription mechanisms could be altered to deal with specific interests.

In other words, an observer could specify what part of the state it is interested in.

In a game, register with a player object, but only wish to receive updates about positions.

In an online investment application, register with the stock exchange object, but only wish to receive updates about stocks trading for more that 10$.

Trade-off: while the complete state does not need to be sent, we have to keep track of what each observer wants.

Increased overhead

In the scenario where different observers have specific interests, each observer must be tracked separately.

When the state of a subject is modified, each observer must be checked.

Information sent to the observers depends on their individual subscriptions.

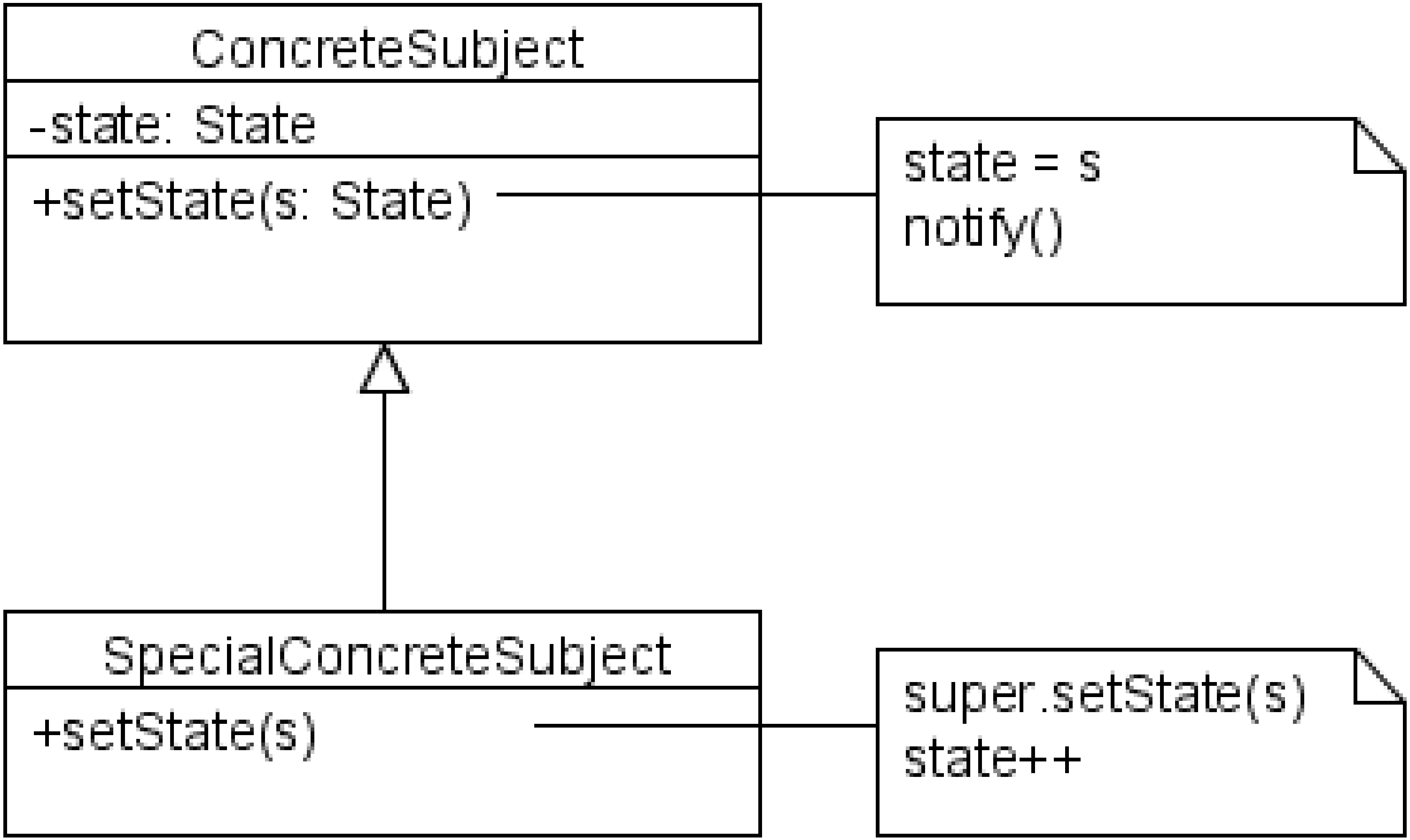
In some cases, update() not even have to be called.

- This means we are no longer broadcasting information in a generic fashion.

- Preparing and sending each of these updates is very time consuming.

Self-consistency

Do you see a problem?



Self-consistency

Special care must be taken when extending the subject object.

The trick is that every method must respect self-consistency as a pre-condition and post-condition.

This means that before the state is changed, the system should be consistent.

This also means that after the state is changed, the system should also be consistent (or at least converge towards a consistent state).

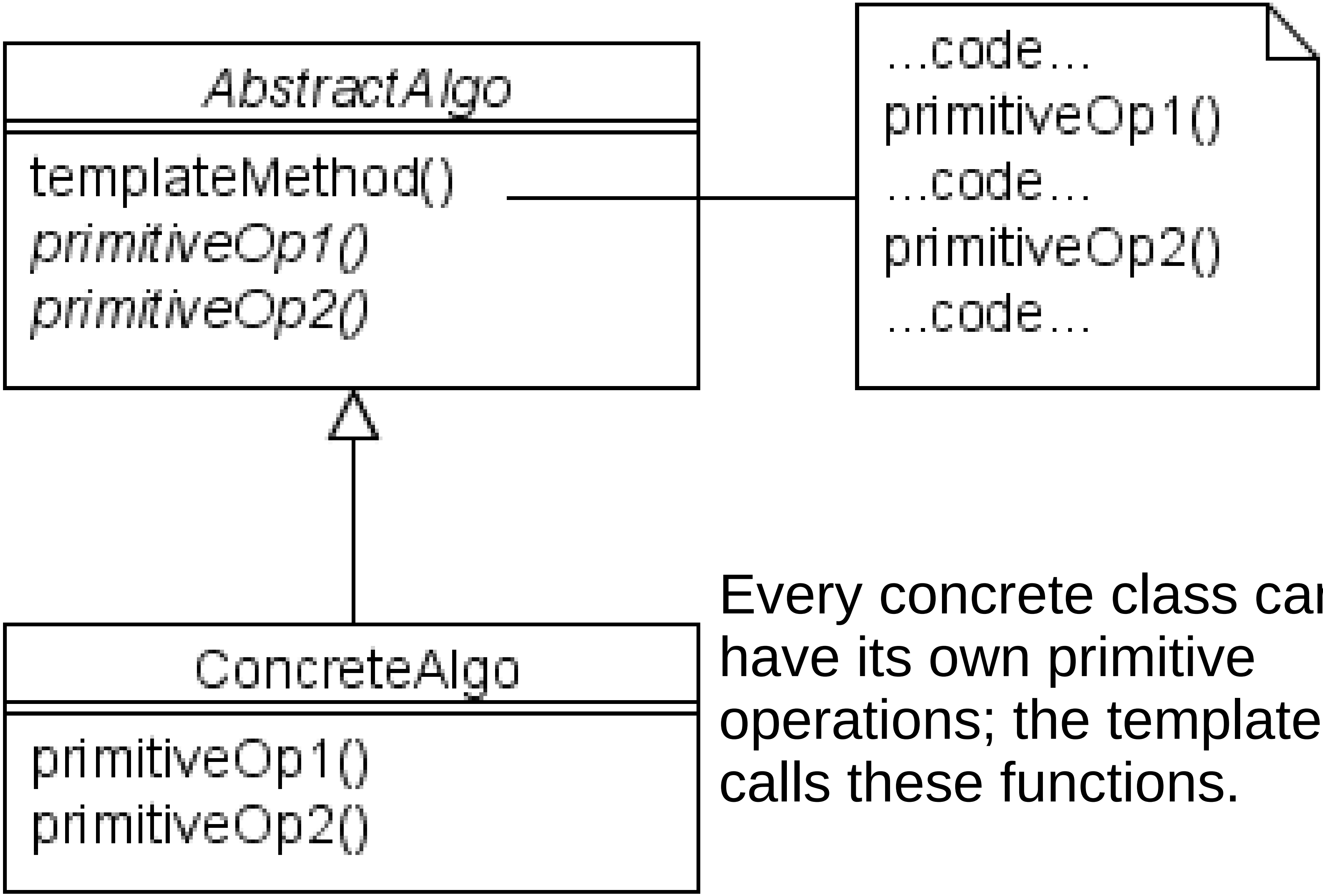
Instead of sub-classing, the template method design pattern is much more secure (against inadvertedly introducing inconsistency).

Template Method Pattern

Define the skeleton of an algorithm in an operation, deferring some steps to subclasses.

Template methods refine certain steps of an algorithm without changing an algorithm's structure.

Example



Every concrete class can have its own primitive operations; the template calls these functions.

Concerns

- The main challenge in template methods is making sure the method is used properly.
  - Users need to know and understand which methods need to be overridden and which method is the template.
- Luckily, most OO programming have constructs that help us out with this.
  - Abstract methods, final methods, etc.
- One of the most important things to keep in mind is to minimize the number of primitive operations.
  - Keeps things simple and easier to implement.

Solution to the Observer Problem

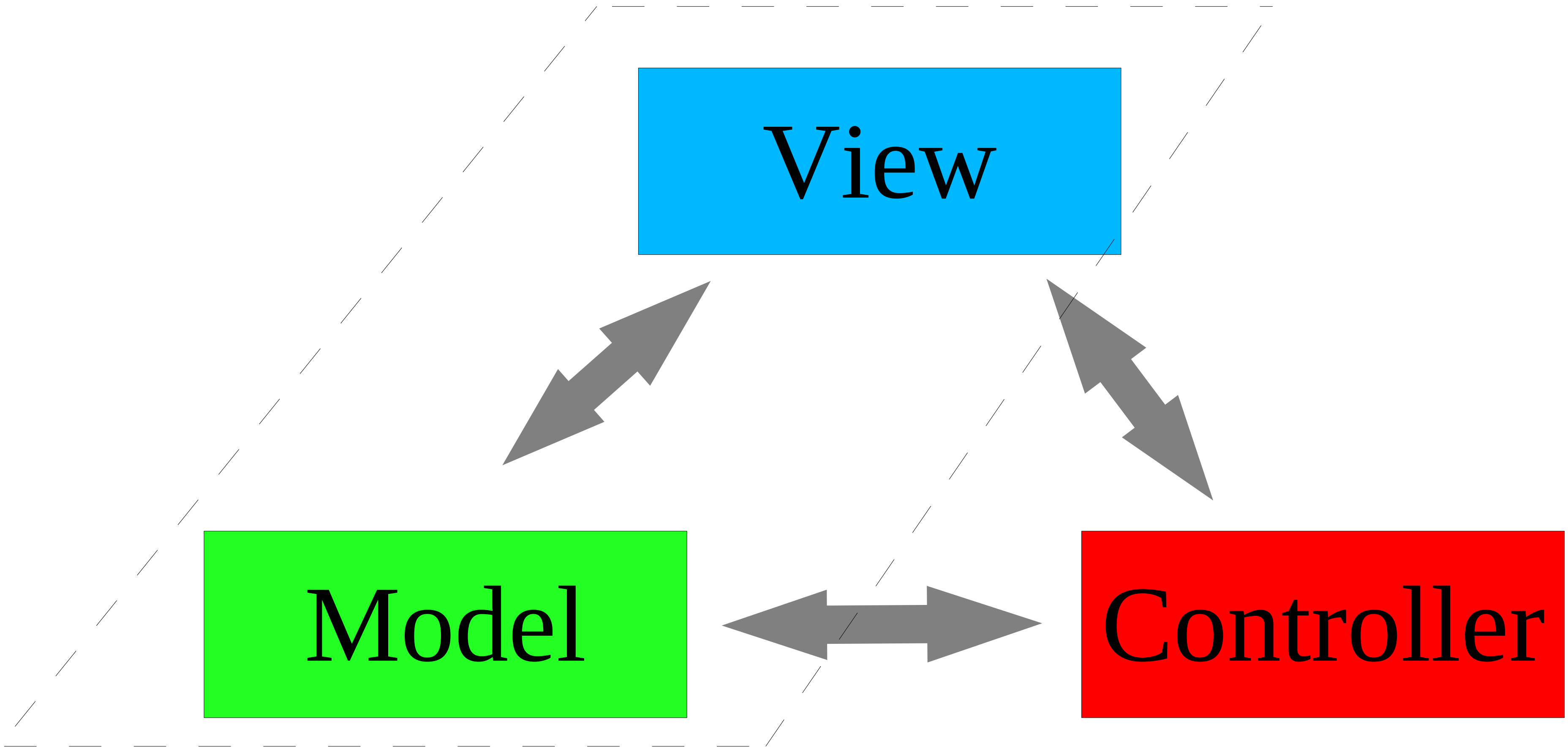
Template Method allows us to solve the self-consistency problem.

The idea is that the setState() method should be a template method with notify() as its last line.

Sub-classes can then vary the behaviour of the subject by changing the primitive operations.

Model View Controller

Model View Controller (MVC) is an application architecture that heavily depends on the observer pattern.



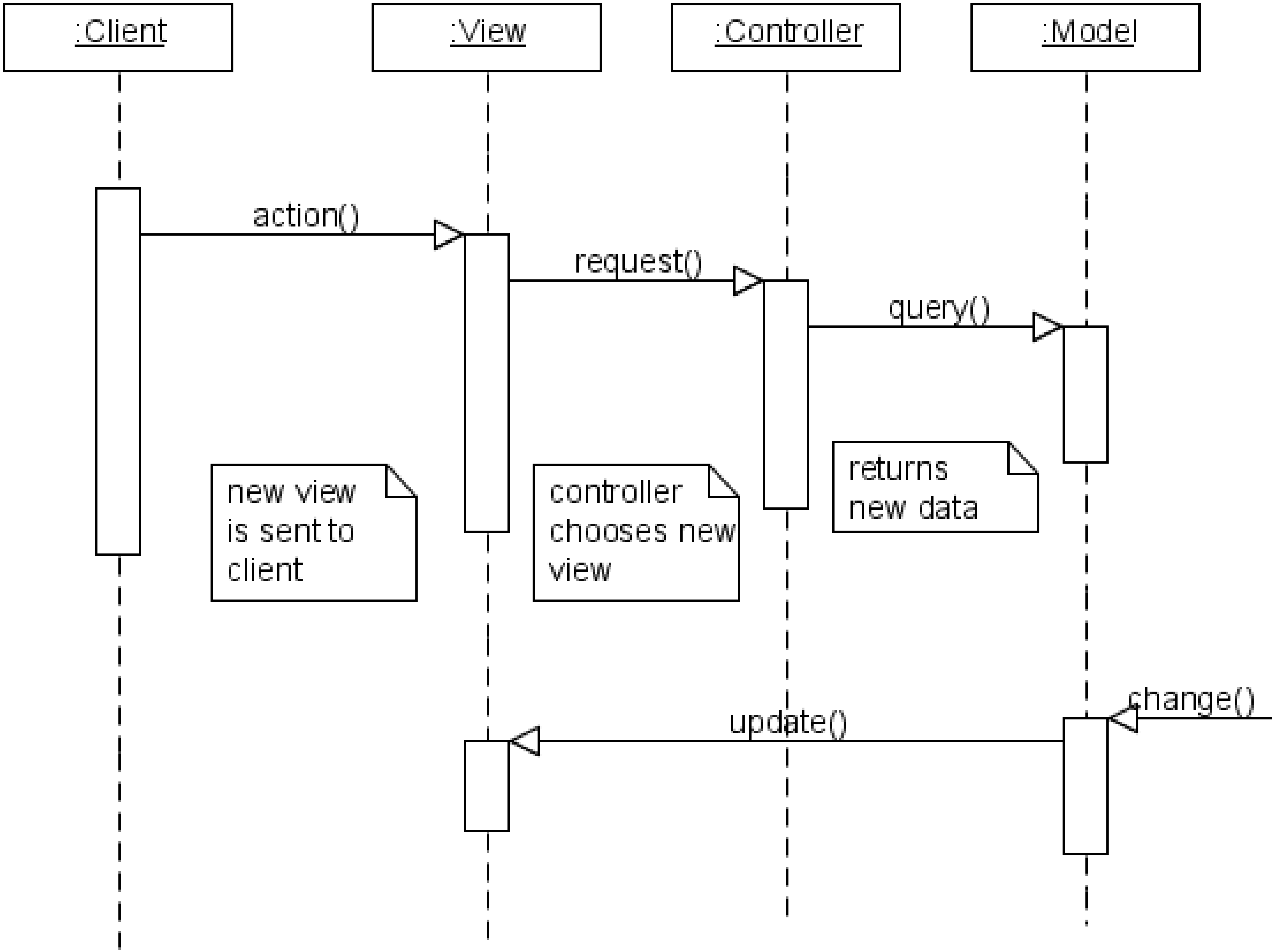
MVC Explained

Model : The domain-specific representation of the information on which the application operates.

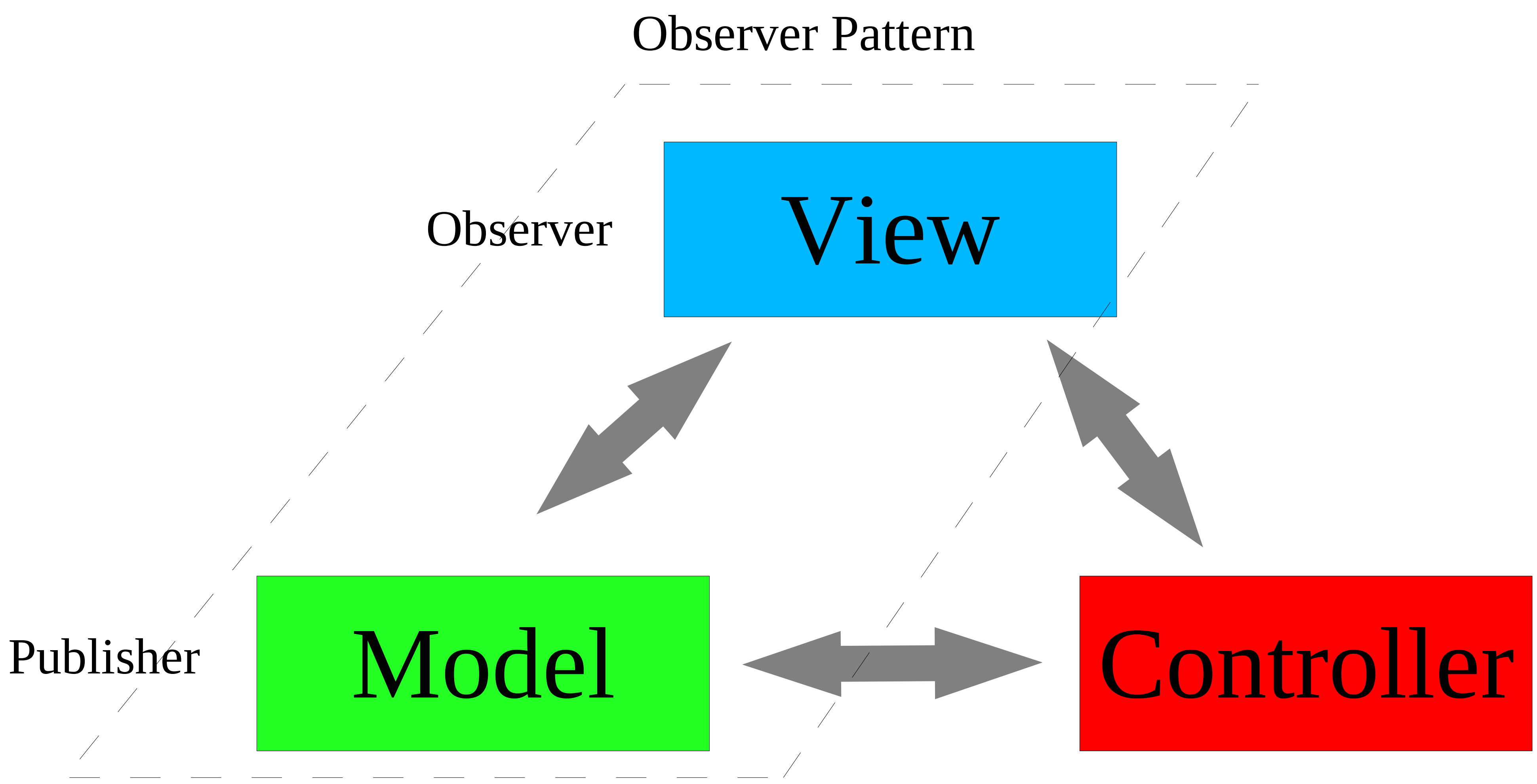
View : Renders the model into a form suitable for interaction, typically a user interface element.

Controller : Processes and responds to events, typically user actions, and may invoke changes on the model.

MVC in action



Observer in MVC



Where is MVC used?

MVC is highly used in web application frameworks

Such as Struts, Spring, Django, Ruby on Rails, etc

Observer Pattern in Games

Most multi-player use a networking scheme that implements the observer pattern ... or a slight variation of it.

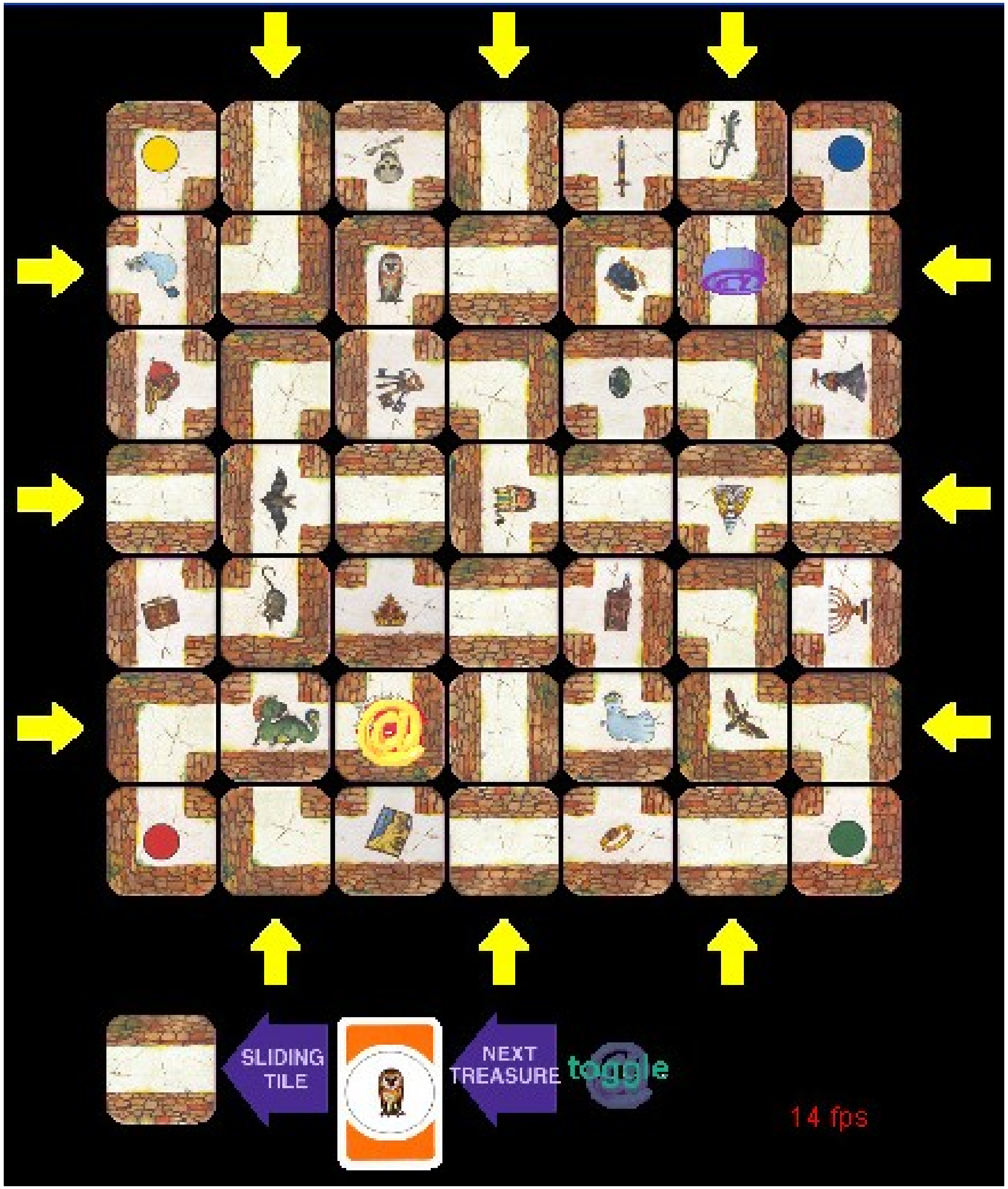
In this architecture

Game objects (players, items, surroundings) are the subjects

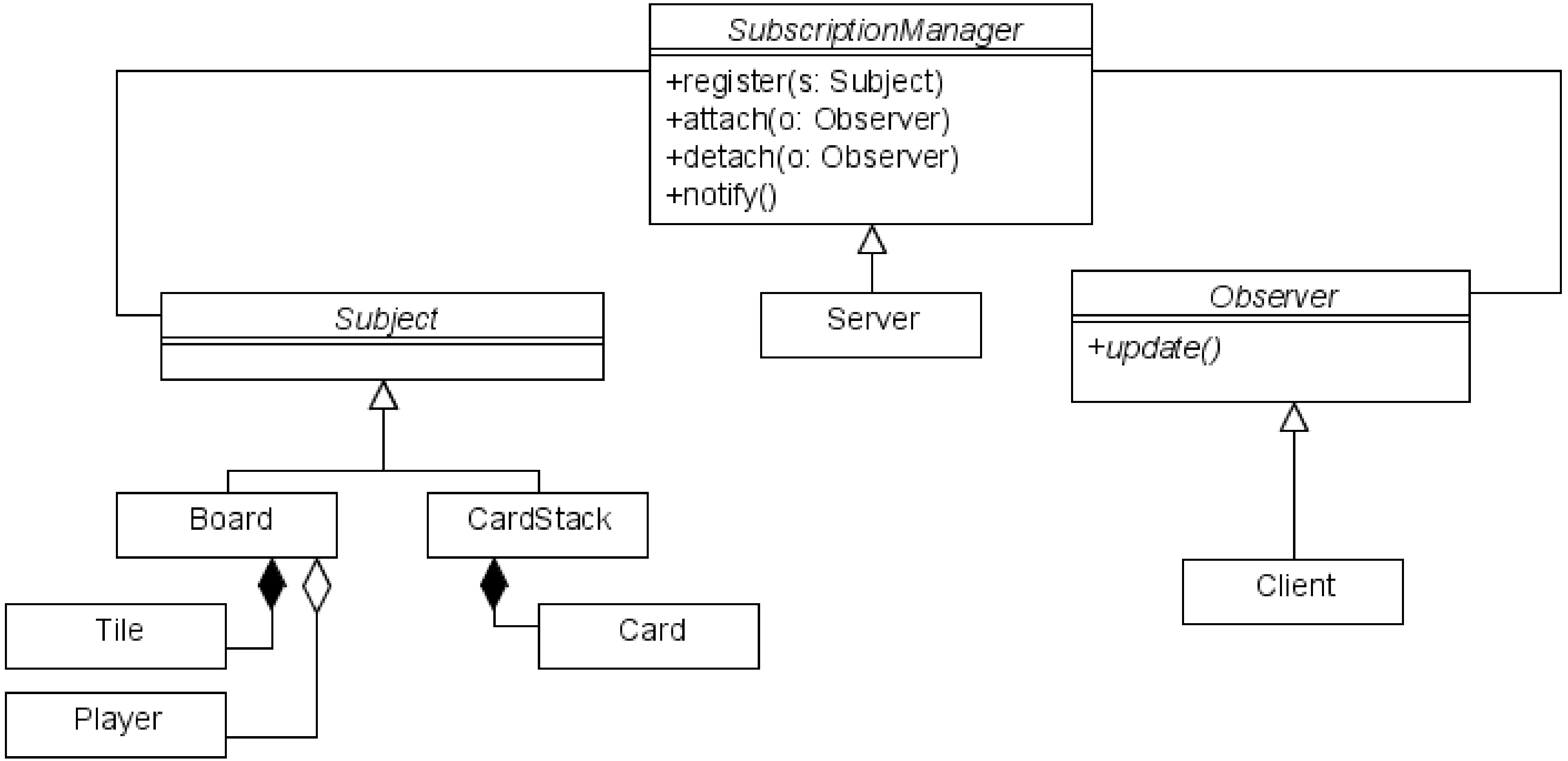
Game clients are the observers.

Board Games

Implementation



Participants



In another popular game …

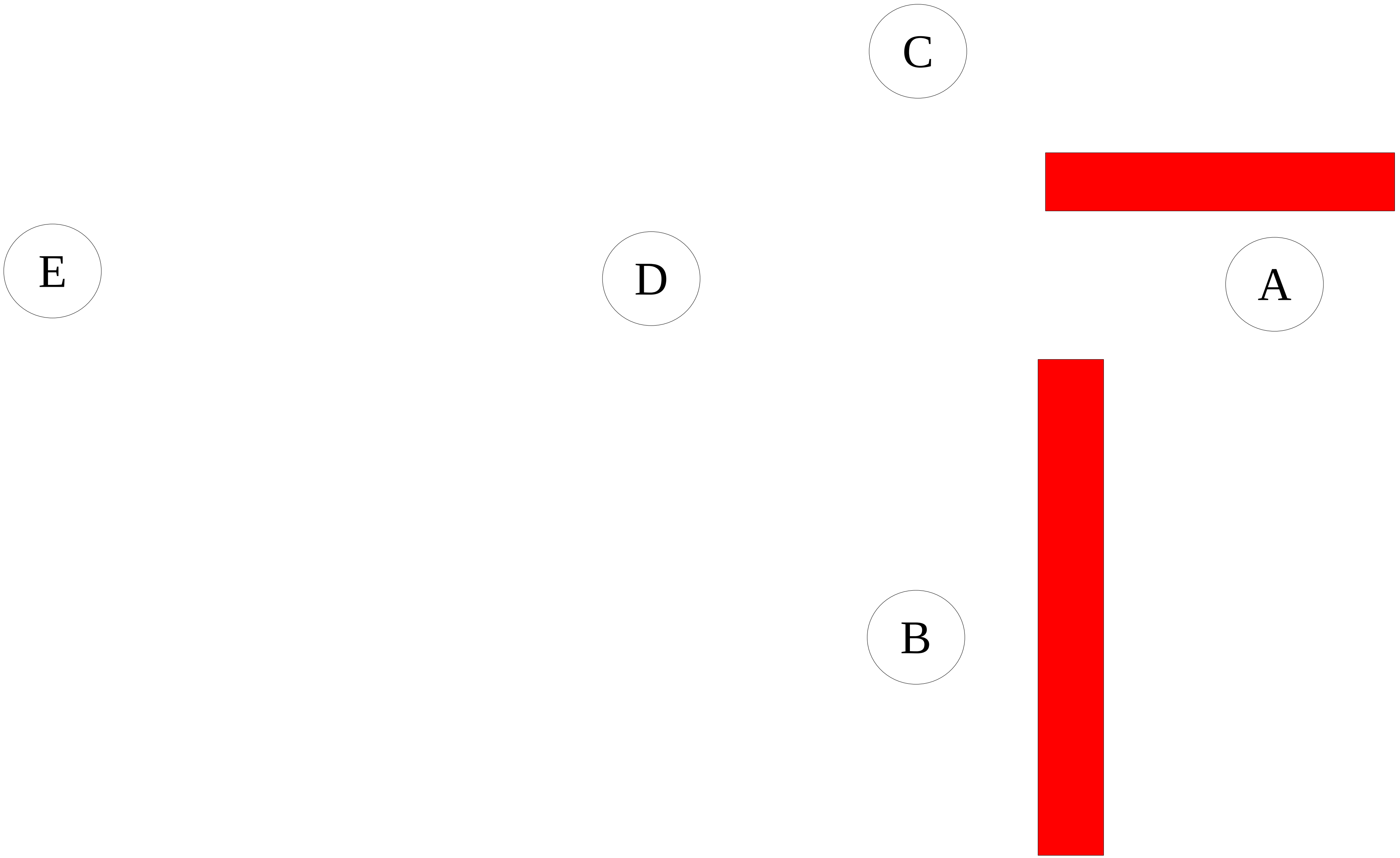
Interest Management

In a massively multi-player distributed game, broadcasting all state changes to every player of a game is not a viable solution.

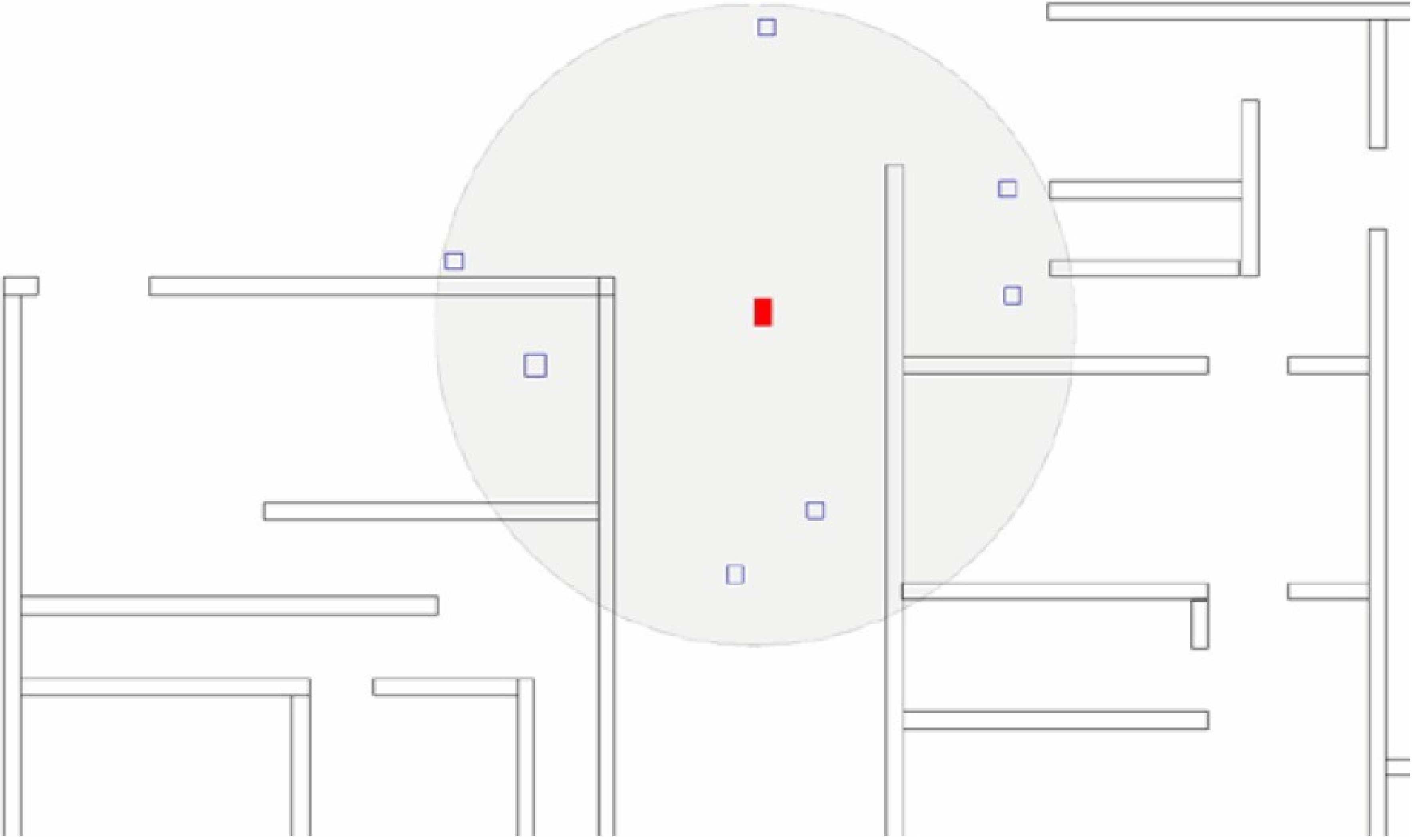
Interest management is a techniques that only sends relevant state changes to each player.

Overhead ...

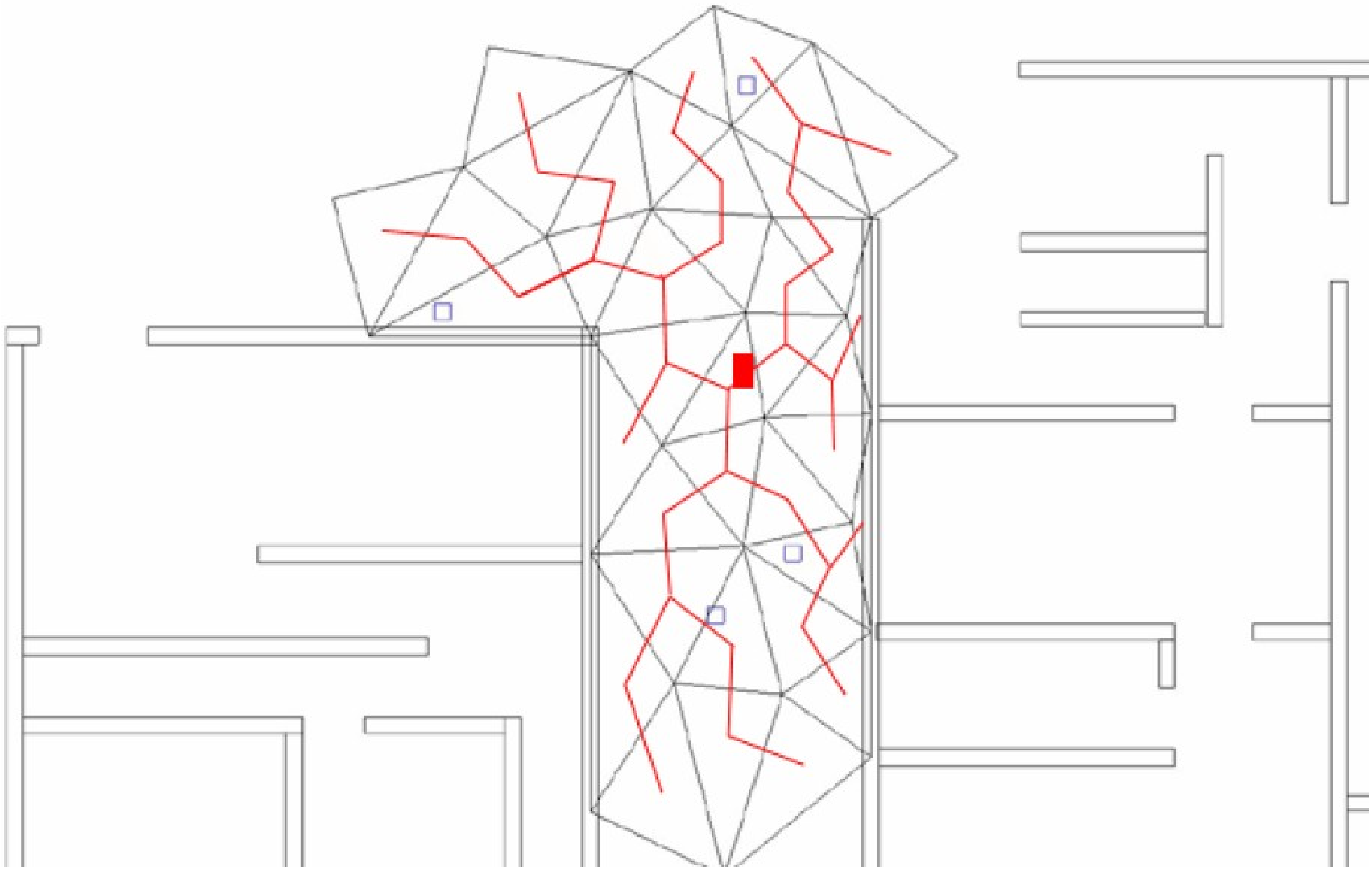
Who should see who?



Radius



Tiles



Replication

The Observer pattern is heavily used in data replication.

In data replication, there exists one master copy of the data and several replicas.

- The master copy is considered the subject.
- The replicas are observers, attached to this subject.
- When the master copy is updated, so are the replicas.
- If the master copy is lost, then one of the replicas becomes the new subject.

Group Communication

The primitive operations in group communications are:

- Join a group
- Leave a group
- Send a message to the group.

These primitive operations are very similar to those found in the observer pattern.

- Attach, detach, notify

It turns out that networked observer patterns are often implemented using group communication protocols.