Technical debt, refactoring, and maintenance (1/2)

Martin Kellogg

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Today's agenda:

- **Finish design pattern slides**
- Technical debt: the costs of bad design
- How to pay off technical debt: refactoring

Creational patterns: example

- Suppose we're implementing a computer game with a **polymorphic Enemy class hierarchy**, and we want to spawn **different versions** of enemies based on the difficulty level.
- e.g., normal difficulty = regular Goomba 
- hard difficulty = spiked Goomba 

Creational patterns: example: anti-patterns

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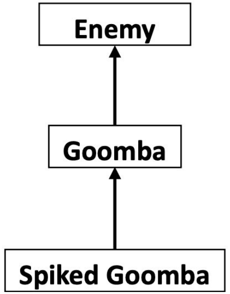

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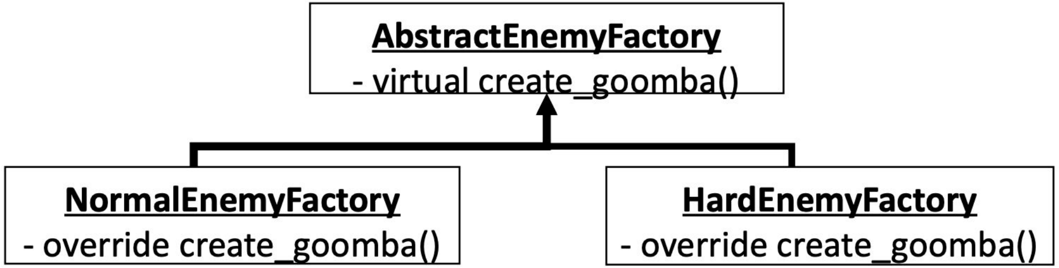

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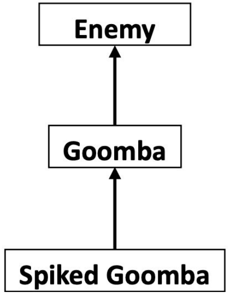

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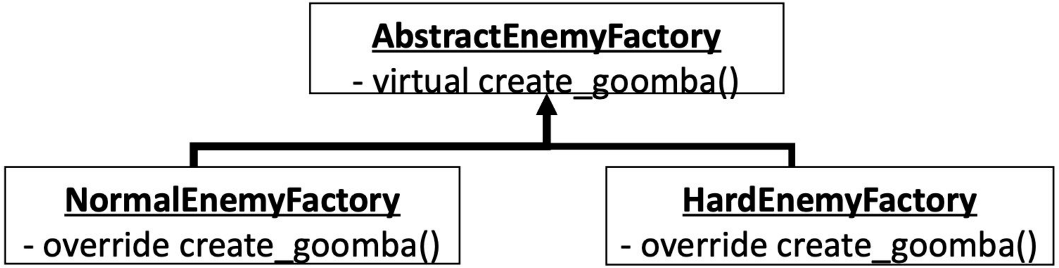


```
// Only have to do this once!
AbstractEnemyFactory* factory = nullptr;
if (difficulty == “normal”)
  factory = new NormalEnemyFactory();
else if (difficulty == “hard”)
  factory = new HardEnemyFactory();
Enemy* goomba = factory->create_goomba();
```

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- The anti-pattern (**bad**) solution is to have an **unprotected global variable** (e.g., a public static field).
    - fails to control access or updates!
- A "less bad" solution is to put all of the state in one class and have a **global instance** of that class.

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        - This is not an argument for using global variables to avoid passing a few parameters.
    - Or if you need to access state stored outside your program (e.g., database, web API)
    - Then global variables **may** be acceptable

Singleton design pattern

- The ***singleton pattern*** restricts the instantiation of a class to **exactly one** logical instance. It ensures that a class has only one logical instance at runtime and provides a global point of access to it.

Singleton

public:

- static ***get_instance***() *// named ctor*

private:

- static ***instance*** *// the one instance*
- Singleton() *// ctor*

Singleton design pattern: example

```
class Singleton {
 // public way to get “the one logical instance”
 public static Singleton get_instance() {
   if (Singleton.instance == null) Singleton.instance = new Singleton();
   return Singleton.instance;
 }
 private static Singleton instance = null;
 private Singleton() { // only runs once
   billing_database = 0;
   System.out.println("Singleton DB created");
 }
 // Our global state
 private int billing_database;
 public int get_billing_count() { return billing_database; }
 public void increment_billing_count() { billing_database += 1; }
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lazy initializaton of single object

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this constructor can't be called any other way

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all clients share this global state

Singleton design pattern: example

What is the output of this code?

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public:

- static ***get_instance***() *// named ctor*
- get_billing_count()
- increment_billing_count() *// adds 1*

private:

- static ***instance*** *// the one instance*
- Singleton() *// ctor, prints message*
- billing_database

```
class Main {
 public static void main(String[] args) {
   int bills = Singleton.get_instance().get_billing_count();
   System.out.println(bills);

   Singleton.get_instance().increment_billing_count();
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Output:

```
Singleton DB created
0
1
```

Singleton design pattern: get_instance()

- Could we avoid typing Single.get_instance() so many times by doing this at all of the points in our program that use the singleton?

```
Single s = Singleton.get_instance();
System.out.println(s.get_billing_count());
… // later
System.out.println(s.get_billing_count());
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Singleton design pattern: get_instance()

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- Is this a good idea or not?

Singleton design pattern: get_instance()

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```
Single s = Singleton.get_inst
System.out.println(s.get_bill
… // later
System.out.println(s.get_bill
```

- Is this a good idea or not?

This is a **bad idea**. There is **no guarantee** that get_instance() will return the same pointer (same object) every time it is called. (It may return different **concrete copies** of the **same logical item**.)

Singleton design pattern: another example

- Suppose we are implementing a computer version of the card game Euchre. In addition to a few abstract datatypes, we have a Game class that stores the state needed for a game of Euchre. When started, our application prototype plays one game of Euchre and then exits.

- Design question: **should we make Game a singleton**?

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- We should only use the Singleton pattern when current or future **requirements** dictate that only one instance should exist.
  - Singleton is **not** a license to make everything global.

Behavioural Design Patterns

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    - e.g., same underlying algorithm, different interfaces or same interface, different underlying algorithms
  - Examples: strategy pattern, template method pattern, iterator pattern, observer pattern, etc.

Iterator Pattern

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  - e.g., Java's List interface doesn't care whether it's backed by an array or a linked list
- Similar patterns exist for other kinds of data structures
  - e.g., ***visitor pattern*** for tree-like structures

Strategy Design Pattern

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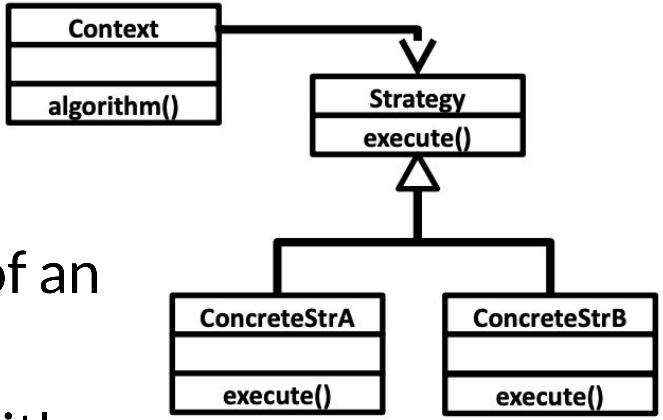

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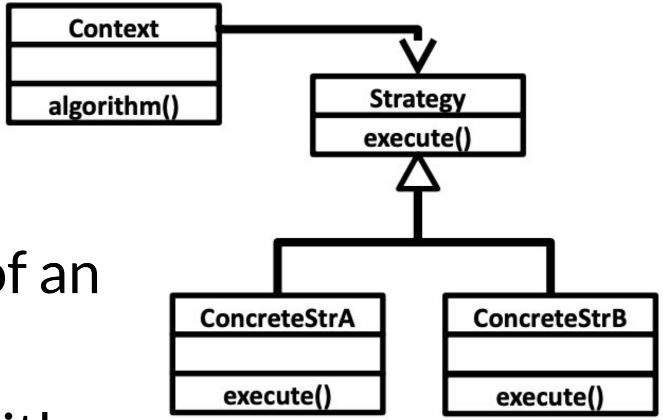

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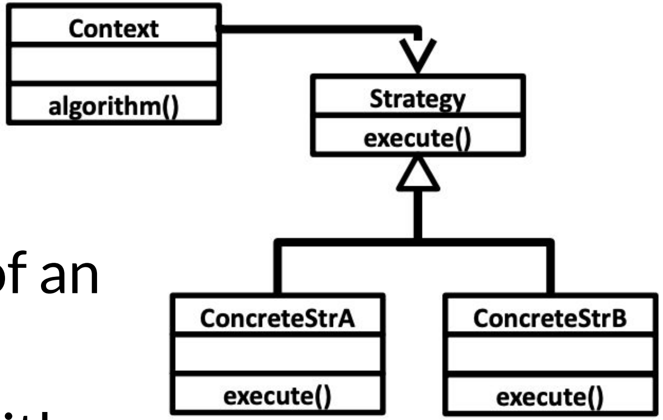

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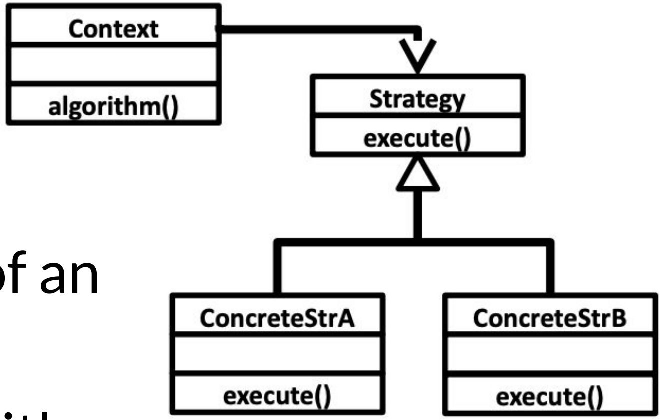

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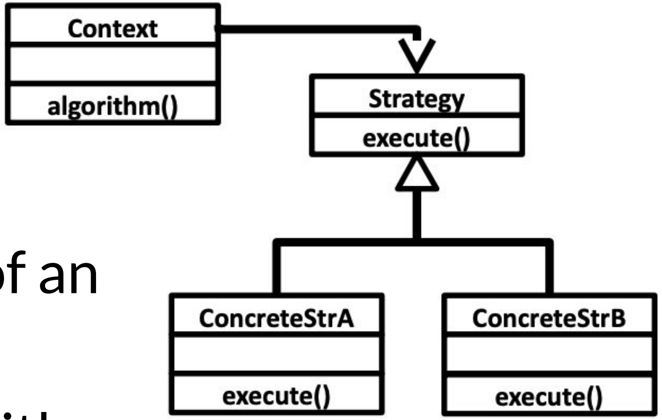

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  - Introduces extra interfaces and classes: code can be harder to understand; adds overhead if the strategies are simple

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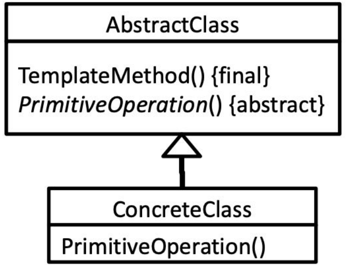

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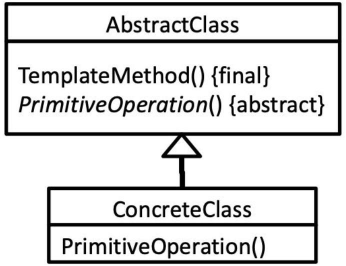

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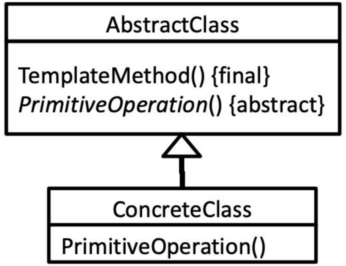

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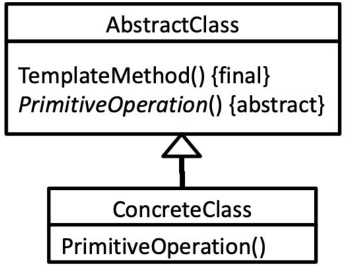

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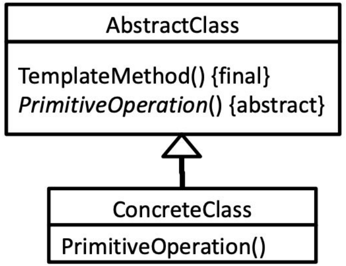

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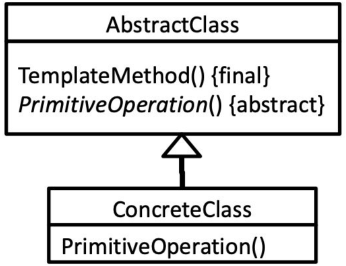

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  - Customization is restricted to the primitive operations
  - Inverted (“Hollywood-style”) control for customization: “don’t call us, we’ll call you” (cf. comparison function in sorting)
  - Invariant parts of the algorithm are not changed by subclasses

Template vs. Strategy Design Pattern

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Template vs. Strategy Design Pattern

- Both support variation in a larger context
- **Template method** uses inheritance + an overridable method
- **Strategy** uses an interface and polymorphism (via composition)
    - Strategy objects are reusable across multiple classes
    - Multiple strategy objects are possible per class

Scenario: binge-watching

- Suppose we're implementing a video streaming website in which users can “binge-watch” (or “lock on”) to one channel. The user will then see that channel's videos in sequence. When the last such video is watched, the user should stop binge-watching that channel.

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 public void release_binge_watch(Channel c) {
   if (c == binge_channel) {
     binge_channel = null;
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```
class Channel {
 // Called when the last video is shown
 public void on_last_video_shown() {
   // Global accessor for the user
   get_user().release_binge_watch(this);
 }
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- What are some problems with this approach?

Scenario: binge-watching: anti-patterns

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What can we do instead?

Observer Pattern

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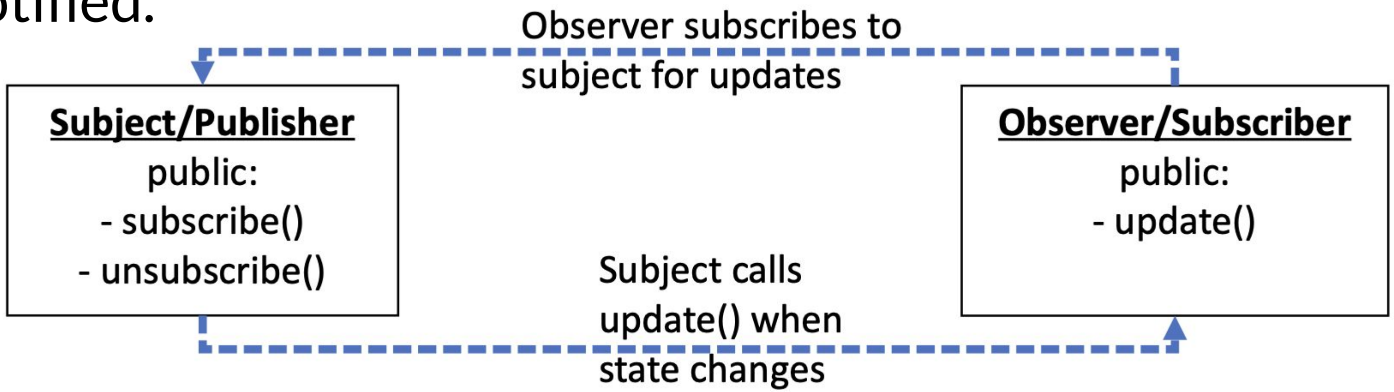

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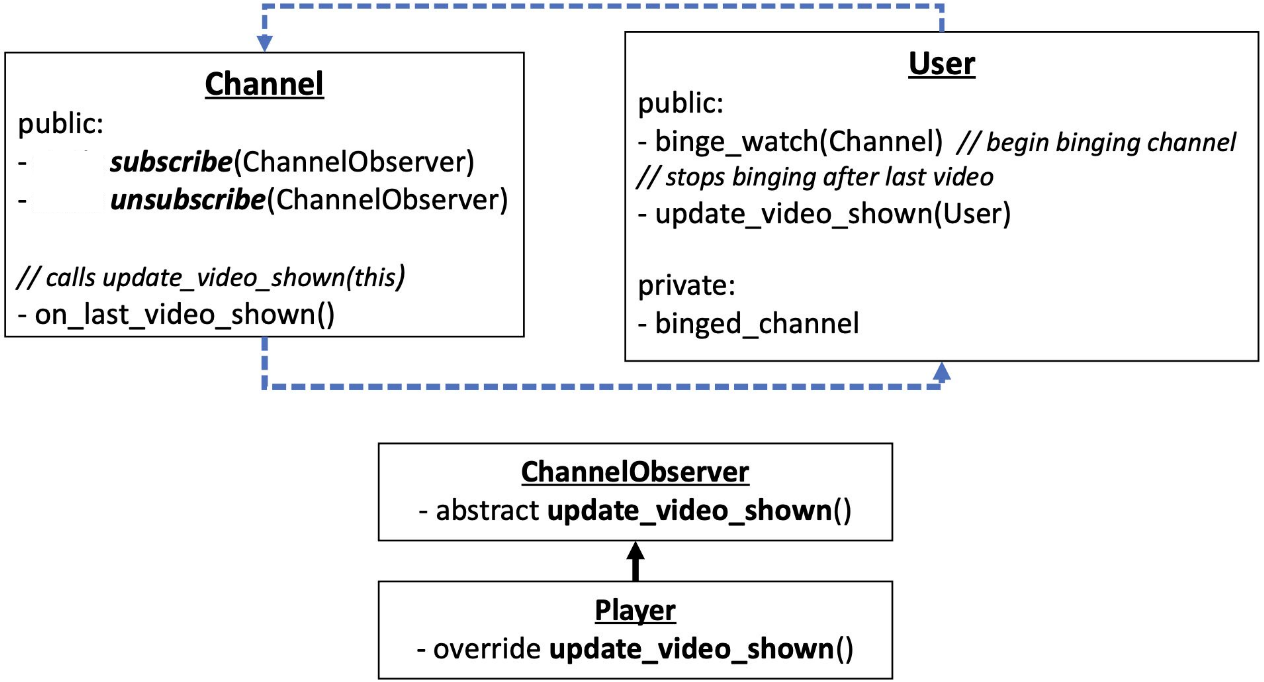

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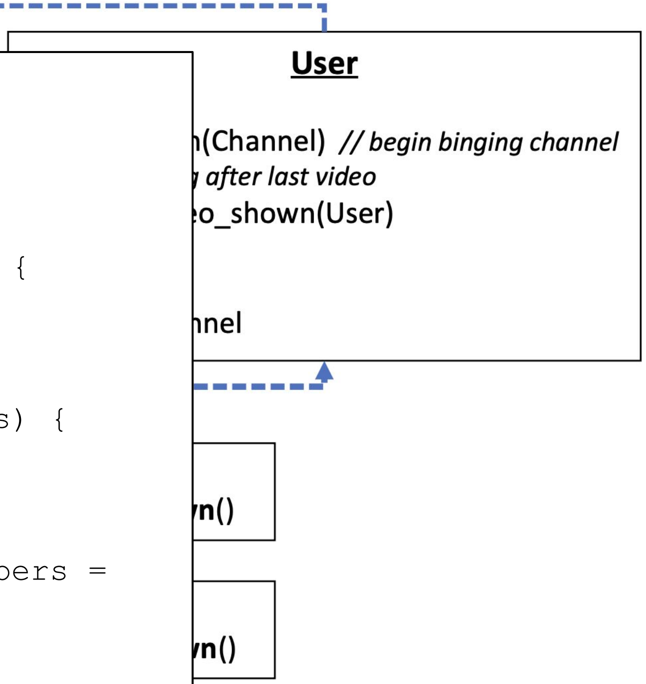
```
class Channel {
 public void subscribe(ChannelObserver obs) {
   subscribers.Add(obs);
 }
 public void unsubscribe(ChannelObserver obs) {
   subscribers.Remove(obs);
 }
 public void on_last_video_shown() {
   foreach (ChannelObserver obs in subscribers) {
     observer.update_video_shown(this);
   }
 }
 private static List<ChannelObserver> subscribers =
          new List<ChannelObserver>();
}
```



Observer Pattern: bing-watch scenario

```
interface ChannelObserver {
 void update_video_shown(Channel channel);
}
```

```
class Channel {
 public void subscribe(ChannelObserver obs) {
   subscribers.Add(obs);
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ı(Channel) *// begin binging channel*

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```
class User: ChannelObserver {
 public void update_video_shown(Channel c) {
   if (c == binged_channel)
     binged_channel = null;
 }
 public void binge_watch(Channel c) {
   binged_channel = c;
 }
 private Channel binged_channel;
}
```

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- Having multiple “update_” functions, one for each type of state change, keeps messages **granular**
  - Observers that do not care about a particular type of update can ignore it (via an empty implementation of the update function)
- Generally it is better to pass the newly-updated data as a parameter to the update function (**push**) as opposed to making observers fetch it each time (**pull**)

Design patterns: takeaways

- Thinking about design before you start coding is usually worthwhile for large projects
  - Design around the most expensive parts of the software engineering process (usually maintainence!)
- Design patterns are re-usable solutions to common problems
- Be familiar with them enough to recognize when they're being used
  - and to know when to use them yourself
  - you can look up details of a pattern if you remember its name!
- Be mindful of and avoid common anti-patterns

Tech debt, refactoring, and maintenance (1/2)

Today's agenda:

- Finish design pattern slides
- **Technical debt: the costs of bad design**
- How to pay off technical debt: refactoring

Reading quiz: technical debt

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Q1: **TRUE** or **FALSE**: the article argued that it is both possible and desirable to avoid technical debt entirely.

Q2: The cost of taking on a financial debt is interest. The cost of taking on technical debt is increased ____________________ costs.

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- analogy to **financial debts**:
  - you gain some immediate benefit
    - in a financial debt, you gain a large sum of money
    - in a technical debt, you gain implementation speed, etc.
  - you pay for it over time
    - in a financial debt, you pay interest
    - in a technical debt, your maintenance costs increase

Technical debt: benefits

- Why might you **intentionally** make a sub-optimal design decision?

Technical debt: benefits

- Why might you **intentionally** make a sub-optimal design decision?
  - Cost
    - either in dev time or because the code isn't done yet
  - Need to meet a deadline
  - Avoid premature optimization
  - Code reuse
  - Principle of least surprise
  - Organizational requirements/politics
  - etc.

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  - make the system easy to extend, modify, etc.
- **Implication**: a system with technical debt is **harder** to change and reuse

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- code smells

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- need to spend time to figure out how to system works
- may need to take over maintenance of old system
- lose potential customers

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  - whether this is worthwhile varies **case by case**

Whether to take on technical debt is often one of the **most consequential** choices you get to make as an engineer. **Take it seriously!**