

SWE 621

FALL 2018

DESIGN AS ABSTRACTION

IN CLASS EXERCISE

- ▶ Today's question:
- ▶ What is an abstraction?

WHAT IS AN ABSTRACTION?

- ▶ The ability to interact with an idea while safely ignoring some of its details.
- ▶ A set of operations on shared state that make solving problems easier.
- ▶ Examples
 - ▶ Data: String
 - ▶ Collections: array, list, stack, queue, map, set, ...
 - ▶ Big data: MapReduce, BigTable, Spanner
 - ▶ AI: TensorFlow
 - ▶ Web: HTTP request, HTTP response
 - ▶ Business: Person, Party, Organization

LOGISTICS

- ▶ HW1 due today
- ▶ HW2 due in two weeks

ABSTRACTION AS MECHANISM FOR REUSE

- ▶ Abstractions serve as a mechanism for reuse of functionality
- ▶ Stakeholders in reuse
 - ▶ Author: developer implementing the abstraction
 - ▶ User: developer that is using the abstraction in their own code
- ▶ Often, a developer may be both an author and a user
- ▶ May have multiple authors, who may change over time
- ▶ For important abstractions, usually many more users than authors

CRAFTING ABSTRACTIONS

- ▶ Where do elements come from?
 - ▶ Last time: from the domain model
- ▶ But... sometimes there are technical implementation considerations that lead to better ways of grouping functionality into elements
- ▶ Goal: choose elements that make solving the underlying problem easier

IN-CLASS ACTIVITY

- ▶ Write a function to reverse a List
- ▶ Available operations on elements in linked list
 - ▶ getNext
 - ▶ setNext

IN CLASS ACTIVITY

- ▶ Write a function to reverse a list
- ▶ Available operations on a list
 - ▶ `get(i)`
 - ▶ `set(i)`
 - ▶ `remove(i)`

IN-CLASS ACTIVITY

- ▶ Write a function to reverse a List
- ▶ Available operations on elements in linked list
 - ▶ getNext
 - ▶ setNext
 - ▶ getPrev
 - ▶ setPrev

EXAMPLE: LIST

- ▶ State: an ordered set of elements
- ▶ Key operations
 - ▶ add
 - ▶ set
 - ▶ get
 - ▶ contains
 - ▶ remove
 - ▶ size

```
List<Integer> l1 = new ArrayList<Integer>();  
l1.add(0, 1); // adds 1 at 0 index  
l1.add(1, 2); // adds 2 at 1 index  
System.out.println(l1); // [1, 2]
```

EXAMPLE: LIST

- ▶ User can be oblivious about how state is stored
 - ▶ Could be linked list, could be array, could be stored locally, could be stored on another computer
- ▶ Supports a wide range of typical interactions with a list
- ▶ Abstraction author has wide range of implementation options

EXAMPLE: MAPREDUCE

- ▶ Organize computation into a map function that generates a new list from an old list and a reduce function that generates one (or a few) elements from a whole list
- ▶ Operations
 - ▶ $\text{Map}(k1, v1) \rightarrow \text{list}(k2, v2)$
 - ▶ $\text{Reduce}(k2, \text{list}(v2)) \rightarrow \text{list}(v3)$

<https://storage.googleapis.com/pub-tools-public-publication-data/pdf/16cb30b4b92fd4989b8619a61752a2387c6dd474.pdf>

EXAMPLE: MAPREDUCE

- ▶ Can distribute computation down to elements in the list to separate servers, which can work in parallel.
- ▶ Infrastructure
 - ▶ marshals distributed servers
 - ▶ runs tasks in parallel
 - ▶ manages communication
 - ▶ provides redundancy and fault tolerance
- ▶ Lets abstraction users focus on the computation to be done and let infrastructure worry about how to parallelize it
- ▶ Applicable for parallelizing a wide variety of typical computations

EXAMPLE: REACT COMPONENT

<https://reactjs.org/>

- ▶ State: properties (readonly, initialized by parents), state (changes over time)
- ▶ Operations
 - ▶ render
 - ▶ event listeners
 - ▶ set state
- ▶ Whenever state changes, render function is automatically called.
- ▶ Components organized into hierarchical trees. When data changes, generates new child components.

```
class Timer extends React.Component {
  constructor(props) {
    super(props);
    this.state = { seconds: 0 };
  }

  tick() {
    this.setState(state => ({
      seconds: state.seconds + 1
    }));
  }

  componentDidMount() {
    this.interval = setInterval(() =>
this.tick(), 1000);
  }

  componentWillUnmount() {
    clearInterval(this.interval);
  }

  render() {
    return (
      <div>
        Seconds: {this.state.seconds}
      </div>
    );
  }
}

ReactDOM.render(<Timer />, mountNode);
```

EXAMPLE: REACT COMPONENT

- ▶ React components do not need to worry about incrementally changing output in response to every event
 - ▶ Would be complicated to figure out for every possible state change how to update output
- ▶ Instead, simply generate all new output whenever state no longer consistent with output
- ▶ Components focus on state and output for single element of interface
 - ▶ Can be reused in many contexts because loosely coupled to parent and other ancestors

IN CLASS ACTIVITY

- ▶ Form a group of 2
- ▶ What's an abstraction you use frequently?
- ▶ What state does it have?
- ▶ What are the key operations?
- ▶ How does the abstraction simplify typical scenarios that occur?

BENEFITS OF GOOD ABSTRACTIONS

- ▶ Interoperability - can pass common data structures around
 - ▶ Really important for library interop
- ▶ Can think about the problem without having to think about some low level details
 - ▶ How is your data stored
 - ▶ How computation is distributed to different servers in cluster
- ▶ Can predict behavior of operations, without reading implementation
 - ▶ If common abstraction, that users are likely to be familiar with already

CHARACTERISTICS OF A GOOD ABSTRACTION

- ▶ Should do one thing and do it well
 - ▶ If hard to name, that's a bad sign
- ▶ Implementation should not leak into abstraction
 - ▶ If there's details that do not need to be exposed, do not
- ▶ Names matter
 - ▶ Be self-explanatory, consistent, regular

CHALLENGES

- ▶ What operations to include? (a.k.a., interface)
 - ▶ Choices of operations has many consequences
- ▶ Not supporting necessary operations with state may make it impossible to use it in desired way, or lead to inefficient client code
- ▶ Supporting fewer operations may cause client code to be repetitive
- ▶ Operation choices may constrain design space of implementations
- ▶ If different users have slightly different needs, how do you balance conflicts?

IN CLASS ACTIVITY

- ▶ What's the most annoying abstraction you've ever used?
- ▶ What made it so hard to use?

HOW TO DESIGN A GOOD ABSTRACTION

Adapted from How to Design a Good API and Why it Matters, Joshua Bloch
<https://static.googleusercontent.com/media/research.google.com/en//pubs/archive/32713.pdf>

GATHER REQUIREMENTS

- ▶ Often get proposed solutions instead
- ▶ Your job is to extract true requirements
 - ▶ Should exist as scenarios where you abstraction will be used
 - ▶ What does user want to accomplish in this scenario?

START WITH SHORT 1 PAGE DRAFT

- ▶ Focus on key ideas rather than completeness
- ▶ Bounce draft off as many people as possible
- ▶ What additional scenarios do they suggest?
- ▶ How well does your abstraction support these scenarios?
- ▶ How can it support these better?

RULE OF THREES

- ▶ Should try out abstraction with at least three scenarios
- ▶ Iterate design based on scenarios, ideally before publicly releasing
- ▶ How can you make these typical scenarios easier for users?
- ▶ How can you enable more efficient implementations?

SUMMARY

- ▶ Abstractions shape how you write code and think about a problem
- ▶ Design abstractions that cleanly capture typical operations on element at the right level of detail
- ▶ Good abstractions reduce boilerplate and let you focus on core problems.
- ▶ May require refactoring, as you have deeper insight into how to represent key ideas more clearly
- ▶ Important to keep abstractions consistent across team. Having similar but competing abstractions leads to confusion and conversion boilerplate.

IN CLASS ACTIVITY, STEP 1: BUILD ABSTRACTION

- ▶ Form groups of 2 or 3
- ▶ Build a abstraction(s) for a company org chart.
 - ▶ Each employee has a 0 or 1 bosses and 0 to n subordinates
 - ▶ Employee may direct a operating unit, division, group, or team
 - ▶ Operating units contain divisions
 - ▶ Divisions contain groups
 - ▶ Groups contain teams
- ▶ Deliverable: for each element you create, describe an interface including
 - ▶ State: what member variables does it contain
 - ▶ Operations: what methods does it define and what is their signature

STEP 2: USE ABSTRACTION

- ▶ Switch abstractions with another group
- ▶ Sketch an algorithm to promote a division to an operating unit. Each group inside division remains a group.

DESIGN ACTIVITY: DISCUSSION

- ▶ What did you learn about the practice of design from this activity?