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Software Design for Data Science

Software & Use Case Design

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Today's agenda

- Lecture on design
- Design exercise
  - Create a `doc` directory within the root of your project repository
  - Create Markdown files in the `doc` directory
  - Add/commit/push at the end of class
  - Finish up the design exercise for review by instructors next week

Software Design

Software Design

"…a specification of a software artifact intended to accomplish goals, using a set of primitive components and subject to constraints"

- Wikipedia

Why software design?

"The hardest single part of building a software system is deciding precisely what to build. No other part of the conceptual work is so difficult as establishing the detailed technical requirements, including all the interfaces to people, to machines, and to other software systems. No other part of the work so cripples the resulting system if done wrong. No other part is more difficult to rectify later.

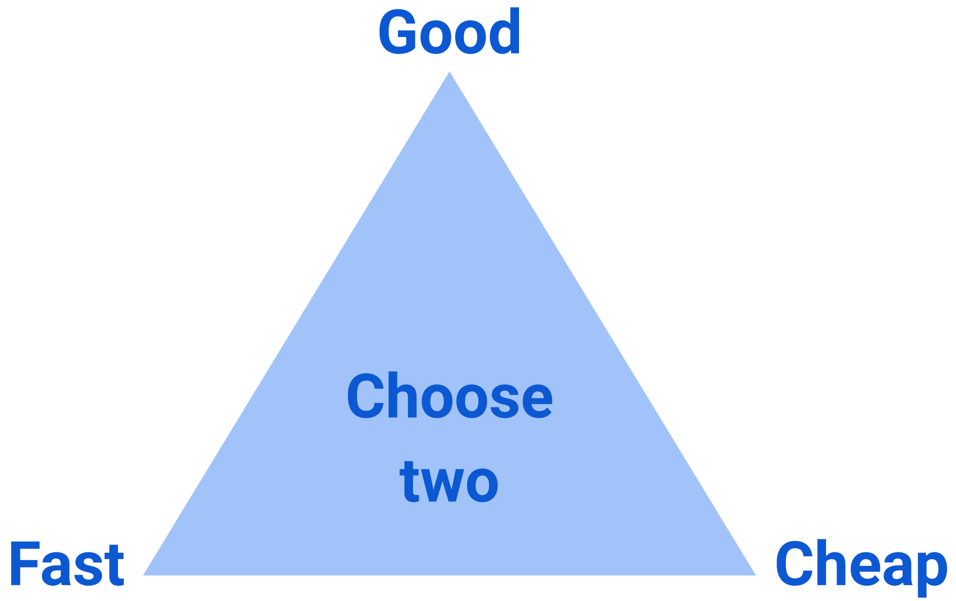
Therefore the most important function that software builders do for their clients is the iterative extraction and refinement of the product requirements."

- Fred Brooks, *The Mythical Man-Month*

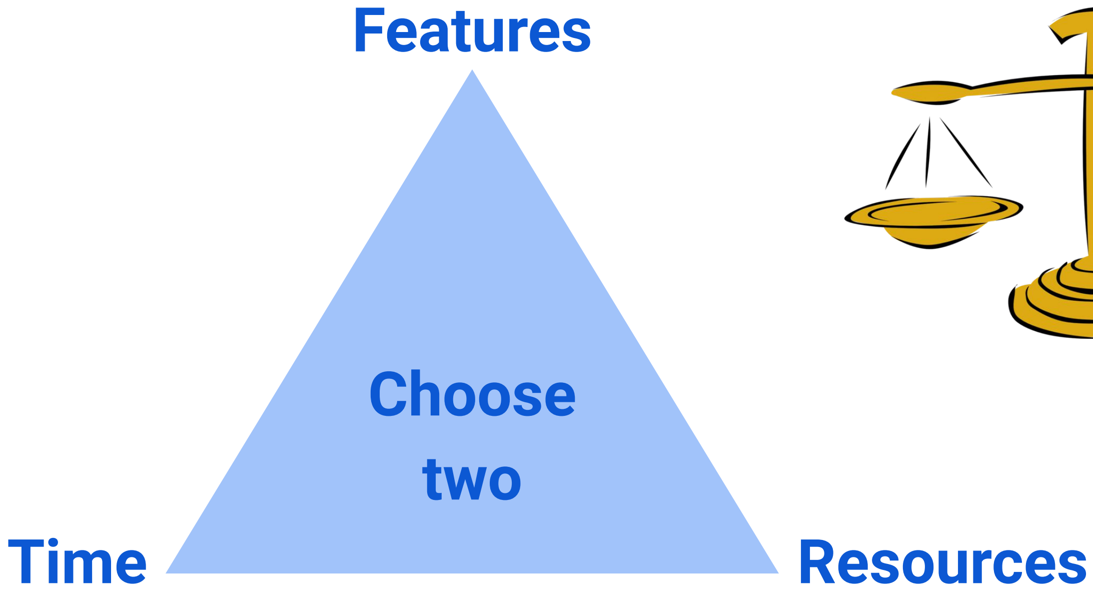
Fred Brooks' suggested planning schedule

- 1/3 for design
- 1/6 for coding
- 1/4 for unit/component testing
- 1/4 for system testing

The Classic Dilemma



The Classic Dilemma: Software Edition



Prevent Feature Creep

- **Feature creep**: gradual accumulation of features over time
    - Often has a negative overall effect on a project
- Why does it happen?
    - Features are “fun”!
        - Developers like to code them
        - Marketers like to brag about them
        - Users want them
    - …but…
        - More bugs
        - More testing
        - More time

Improve Your Time Estimation

- **Time** is the most valuable resource for your project
- To spend your team’s time efficiently…
  - …you need to know **what to build**
  - …you need to know what ***not*** to build
  - …you need to know **what order** to build things
- Design can help with this!
- Estimating how long something is going to take is HARD!
  - Almost everything takes longer than you think it will
  - Design will help you order and parallelize your work so you aren’t surprised

Design Benefits

- Systematic approach to a complex problem
- Finds bugs before you code
- Enables parallel work
- Promotes testability
- Build an understandable, extendable, maintainable system

Software Design Process (for this class)

1. Identify the users
   - Who they are, what they want
   - High level
2. Functional design
   - What the system does
   - Specification
3. Component design
   - How the software will work
   - Implementation

Running Example: Design an ATM

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User Stories

Start with your users

- Who are your users?
    - Researchers?
    - Policy makers?
    - Developers?
    - Children?
    - Trained monkeys?
- What do they want to do with your software?
- How are they interacting with it?
- What needs do they have?
- What skill levels do they have?

Example: Ram

Ram is a bank customer.

Ram wants to check his balance, deposit money, take out money.

Ram wants a safe/secure interface for interacting with the ATM.

Ram’s job does not involve technical skills and he values a simple user interface.

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Example: ???

What might be another user story?

Example: Valentina

Valentina is an ATM technician.

She services ATMs as part of preventative maintenance, applies hardware and software updates, and performs emergency repairs.

For maintenance and updates she will follow a standard protocol.

For repairs, she needs access to a diagnostic interface.

Valentina is highly technical and knows how to replace standardized parts.

Exercise: Your User Stories

- You will probably have several different kinds of “users” and a “technician” or two.
  - If you have a machine learning model backing your tool, don’t forget the “technician” who will train the machine learning model or update it.
- Take 10 minutes to write 2-3 user stories with your team.
- Use a Markdown file in the `doc` directory
- Remember
  - Who
  - Wants
  - Interaction methods
  - Needs
  - Skills

Functional Design
(Use Cases)

Example: Ram

Ram is a bank customer. Ram wants to check his balance, deposit money, take out money. Ram wants a safe/secure interface for interacting with the ATM. Ram's job does not involve technical skills and he values a simple user interface.

- Check balance
- Deposit checks
- Deposit cash
- Get cash

What do we do with an ATM?

- Check balance
- Deposit checks
- Deposit cash
- Get cash

These are <u>use cases</u> - from the point of view of a user, how will they use your system?

Implicit use cases

There's an additional <u>implicit</u> use case in Ram's example (not explicitly stated but understood to be the case).

- User authentication!

Describing a use case

1. Objective of the user interaction
2. What information does the user provide?
3. What response does the system provide?

Usually about 3-9 clearly written steps.

This is not code!

Example: ATM user authentication use case

Objective: ATM validates that the user is allowed to access an account

User: insert ATM card into machine

ATM: display “Enter PIN”

User: enter pin on keypad

ATM: [if correct] show main menu

[if incorrect] display “Enter PIN”

Think about edge cases!

Exercise: Your Use Cases

- Translate your user stories into use cases (functional designs)
- Use a Markdown file in the `doc` directory
- Remember
    - Explicit use cases
    - Implicit use cases

Component Design

What is a component?

"An individual software component is a software package, a web service, a web resource, or a module that encapsulates a set of related functions (or data)."

- Wikipedia

Specifying components

Describe components with sufficient detail so that someone with modest knowledge of the project can implement the code for the component.

- Name
- What it does
- Inputs (with type information)
- Outputs (with type information)
- Assumptions
- How it uses other components

Sound familiar? Check out Lecture 3 on Interface Specifications!

Developing Component Specifications

1. What are the components in the use cases?
   a. Packages
   b. Modules
   c. Resources
   d. Data
   e. Functions
2. What components are already available?
3. What are the sub-components needed to implement those components that aren't already available?

Do 1-2 for each such component

Example: ATM authentication use case

Components:

- Database with account => PIN data
- User interface to read an ATM card
- User interface to read a user PIN
- Control logic

Example: ATM authentication control logic

- Name
    - `authenticate`
- What it does:
    - Verifies a user is in the database & the pin supplied by the user is correct
- Inputs (with type information)
    - *Card number*, a string that is the user's card number
    - *Pin*, an integer
- Outputs (with type information)
    - Boolean: True if success, False if failure
- Assumptions: none

Example: ATM withdrawal use case

Components:

- Database with account cash balance
- User interface to read how much cash the user is requesting
- Cash drawer interface to dispense cash
- Control logic

Example: ATM withdrawal control logic

- Name
    - `withdraw`
- What it does:
    - Verifies that the withdrawn amount is available in the user's account and debits the account if so
- Inputs (with type information)
    - *Account*, the user's account ID
    - *Amount*, an integer representing how many dollars to withdraw
- Outputs (with type information)
    - Boolean: True if success, False if failure
- Assumptions
    - User is already authenticated

Pseudocode

- Helpful to gain insight into how components interact
- Not really code - mostly readable English with some flow control & variables

```
withdraw(account, amount):
    find account balance in the database
    if amount <= balance
        subtract amount from the balance
        save the updated amount in the database
        return True
    else
        return False
```

Another component!

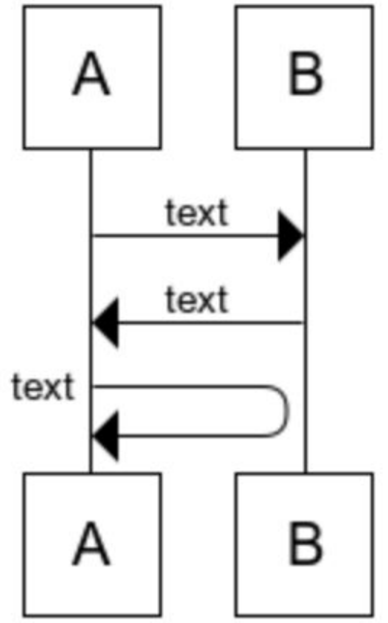
Specifying component interactions

Diagrams are very helpful!

Web tool for making these:

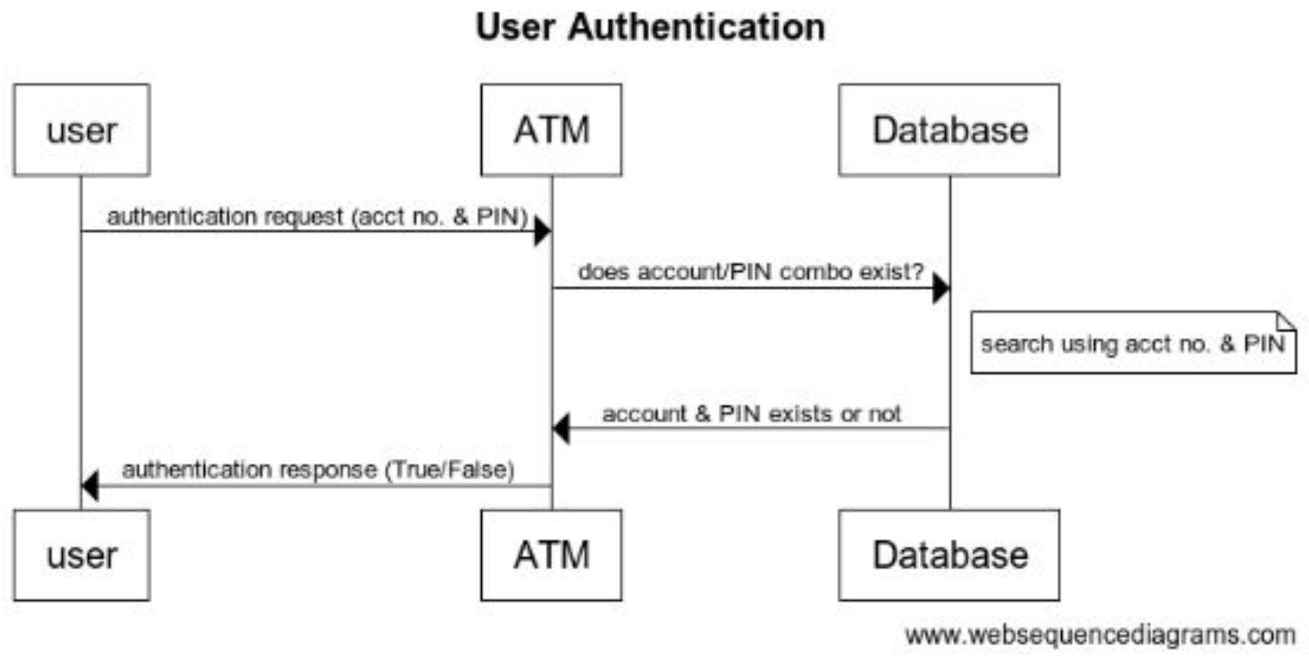
https://www.websequencediagrams.com/

Random Interaction



equencediagrams.com

Example: user authentication component interactions


User Authentication
user
ATM
Database
authentication request (acct no. & PIN)
does account/PIN combo exist?
search using acct no. & PIN
account & PIN exists or not
authentication response (True/False)
user
ATM
Database
www.websequencediagrams.com

Example: user authentication component interactions

```
title User Authentication


user->ATM: authentication request (acct no. & PIN)

ATM->Database: does account/PIN combo exist?

note right of Database: search using acct no. & PIN

Database->ATM: account & PIN exists or not

ATM->user: authentication response (True/False)
```

Another diagram option: draw.io

https://app.diagrams.net/

We're not picky on the format you use!

Component Design: Summary

1. Identify components
2. Specify each component
3. Specify component interactions

From Design Onwards

Milestones

- What are you actually going to *do* and in what *order*?
- Are there any *dependencies* between components such that you must build Component A before Component B?
- What will success look like?
- This is not specific tasks - these are broad strokes

Example: ATM milestones

1. **Build account infrastructure**
   Success: account database and middle control layer exist that can access an account
2. **Build user authentication flow**
   Success: manually authenticate a user with a PIN by calling the Python functions directly
3. **Build user interface**
   Success: user can log onto their account with their account no. and PIN
4. **Build account withdrawal/deposit features**
   Success: user can fully access funds in their account

Breaking down a milestone

Once you have milestones, you need to break them down into tasks:

- Which components do you need to implement?
- What packages do you need to incorporate?
- What tests or validation do you need to do?

Suggestion: use GitHub Issues!

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Implementing a component

Recommended approach:

1. Write the *interface* for the component.
2. Write some *tests* for the component.
3. Write the *implementation* of the component.
4. Iterate on the tests as you identify more.

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Dividing up work

- Components can be a good natural division of work
- Example:
  - Melissa builds the user interface components
  - Amrit builds the machine learning model
  - Tara builds the control logic layer

This is not the only way to divide up work!

Dividing up responsibilities

Besides actual coding work, there are other responsibilities to divvy up. Everyone is encouraged to contribute to everything as they like, but dividing up who is ultimately accountable for making sure everyone does their part of the project is helpful. Common roles:

- Designers (system design, documents, communication)
  - Keep everyone accountable for documentation, design, & communication with instructors
- Developers ("devs")
  - Focus on making sure everyone makes good implementation decisions
- Testers
  - Ensure everyone keeps up with good code testing and style practices
- A project manager a.k.a. "PM"
  - Run standups & keep track of milestone progress

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More details on expected output: https://uwdata515.github.io/projects.html

Exercise: Your Components

1. Translate your use cases into components
2. Create a specification for each component

   Potentially including pseudocode

3. Create interaction diagrams for how components interact

Use a Markdown file in the `doc` directory

Go as deep as you can!