LECTURE 0

Introduction

Introduction

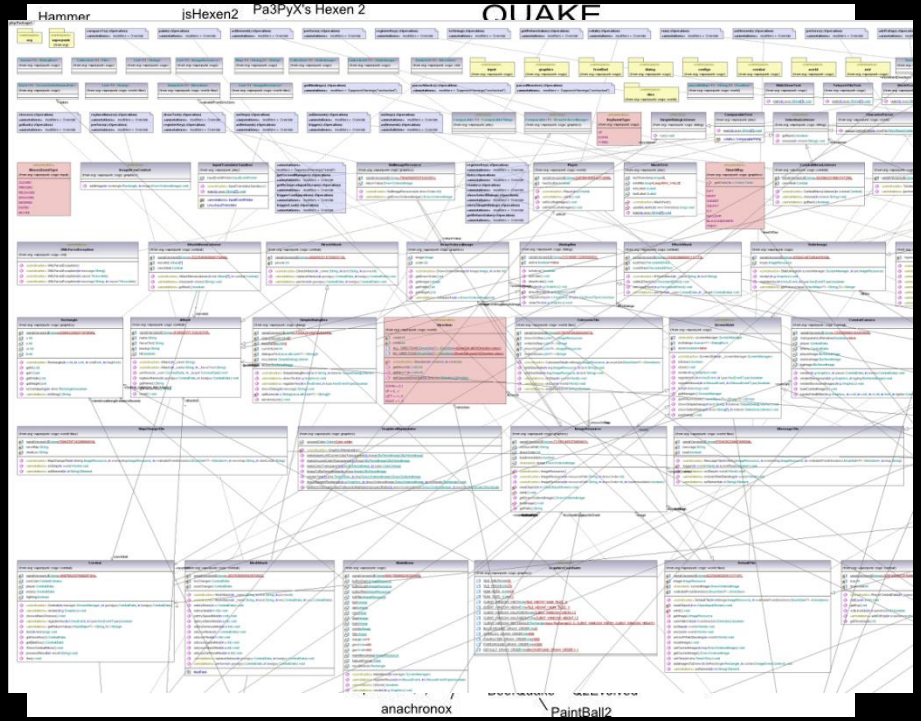
WELCOME!

Introduction

TA STAFF

Class goals

- Build a 2D game engine from scratch!
- Build games on top of your 2D game engine!
- Improve your software design/engineering skills



Class times

- Class: Wed 3:00p-5:20p
  - Lecture 1-1.5 hours (Lubrano)
  - Playtesting ~1 hour (Sunlab)
- Design Checks: Fri - Sat
  - Sign up using cs1971_signup <project>
- TA hours: Sun - Tue
- http://cs.brown.edu/courses/cs1971/

Four projects covering a variety of topics

- Tic
  - UI-only game (Tic-Tac-Toe)
  - Entirely engine based
  - Due next week!
- Tac
  - Grid-based tactical game (StarCraft, Final Fantasy Tactics)
  - Game content/resources, AI, viewports, map loading/generation
- Tou
  - Shoot-'em-up (Touhou, Asteroids, Space Invaders)
  - Collision detection
- M
  - N-like platformer (Metroid, Sonic, Braid, Super Meat Boy)
  - Physics, data-driven game logic

One open-ended final project

- Pick engine feature(s) and gameplay of a game you want to design
  - Pitch them to the class and find teammates
  - Pitch them to the TA's and get a mentor
- Groups allowed and strongly encouraged
- Four weeks of development culminating in final presentation
- Public playtesting required, polish recommended
- All yours afterwards
- More details later
- See previous year Showreels (under Docs & FAQ)

Game Design Mini-Course

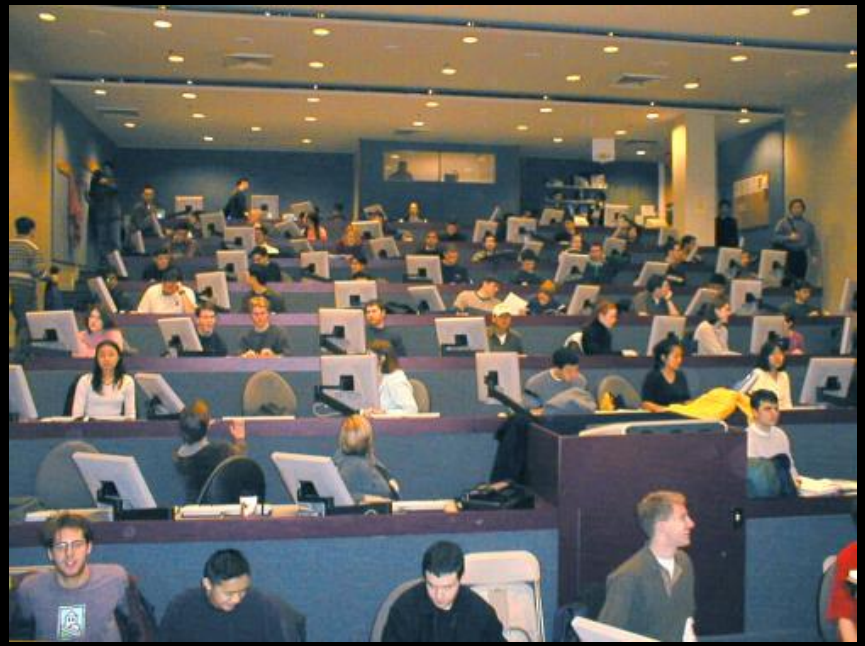
- Starts next week!
- Supplement to 2D Game Engines
- Discuss high-level concepts
- Help create better final projects!

Introduction

GRADING

Simple grading system

- Only projects, no HW/exams
- Every project is broken down into weekly checkpoints
  - Handins due every Tuesday at 11:59:59 PM
- If your handin exists and meets requirements, it is “complete” otherwise it is “incomplete”



(Sunlab at 11:59PM on most weekdays)

Handin requirements include…

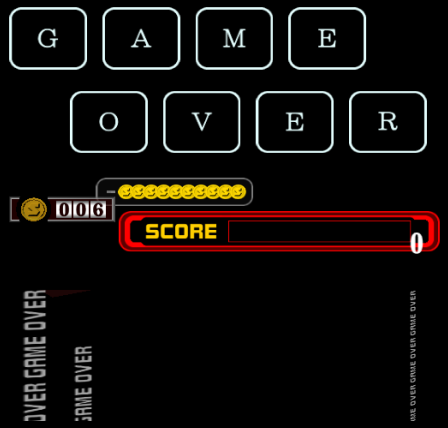
- Global requirements
- Weekly checkpoint requirements
- Design check
  - Sign up using cs1971_signup <project>
  - High level conceptual questions, but not a free pass
- Playtesting other students' games
  - Help each other find bugs
  - Feedback on gameplay

Incomplete handins

- Standard Retry
  - As long as you complete a design check, you are allowed a re-hand in of a checkpoint
- Extra Retries
  - You have two for the whole class
  - Retry a checkpoint that you retried
- You have a week to use each retry

Out of Retries

- Used the standard retry, out of extra retries, now what?
- No credit (NC) for the checkpoint
- All checkpoints must be handed in to pass the class
  - So make sure to finish it by the end of the semester



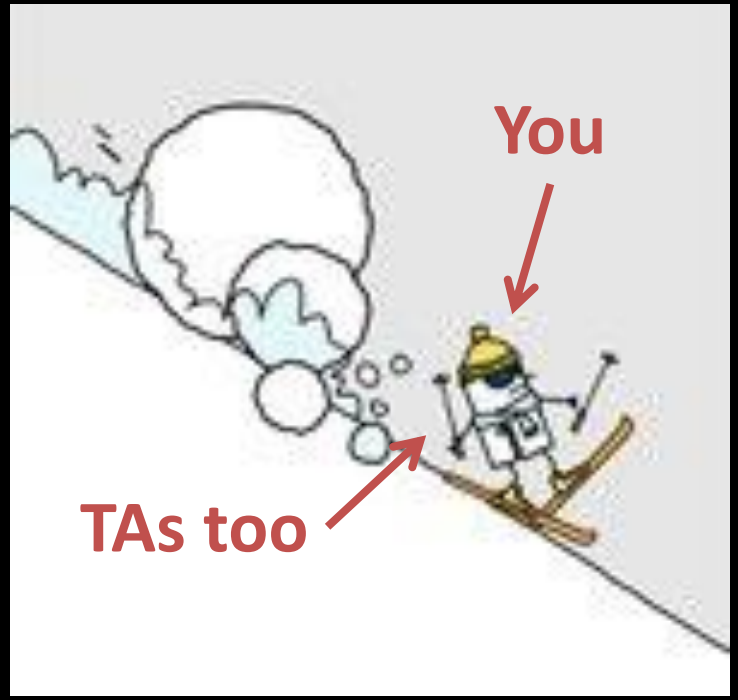
Final grades

- No curve!
  - Do the work, get an A
- Specifically:
  - 0-1 no-credit: A
  - 2 no-credit: B
  - 3-4 no-credit: C
  - >4 no-credit: NC for the course
- Remember you still need a working version of each checkpoint

# NC	% complete	Grade
0	100%	A
1	93%	A
2	86%	B
3	79%	C
4	71%	C
5+	<70%	NC

Please hand in on time!

- Falling behind causes a "snowball of death"
- Grading late handins puts stress on TAs
- If your handin is playable, hand it in even if you're missing some reqs so you can be playtested
- If it isn't, go to sleep! You have another week to retry



Introduction

QUESTIONS?

Introduction

COURSE REQUIREMENTS

In order to take this class, you must…

- Be very comfortable with object-oriented design
- Be very comfortable with the Java language

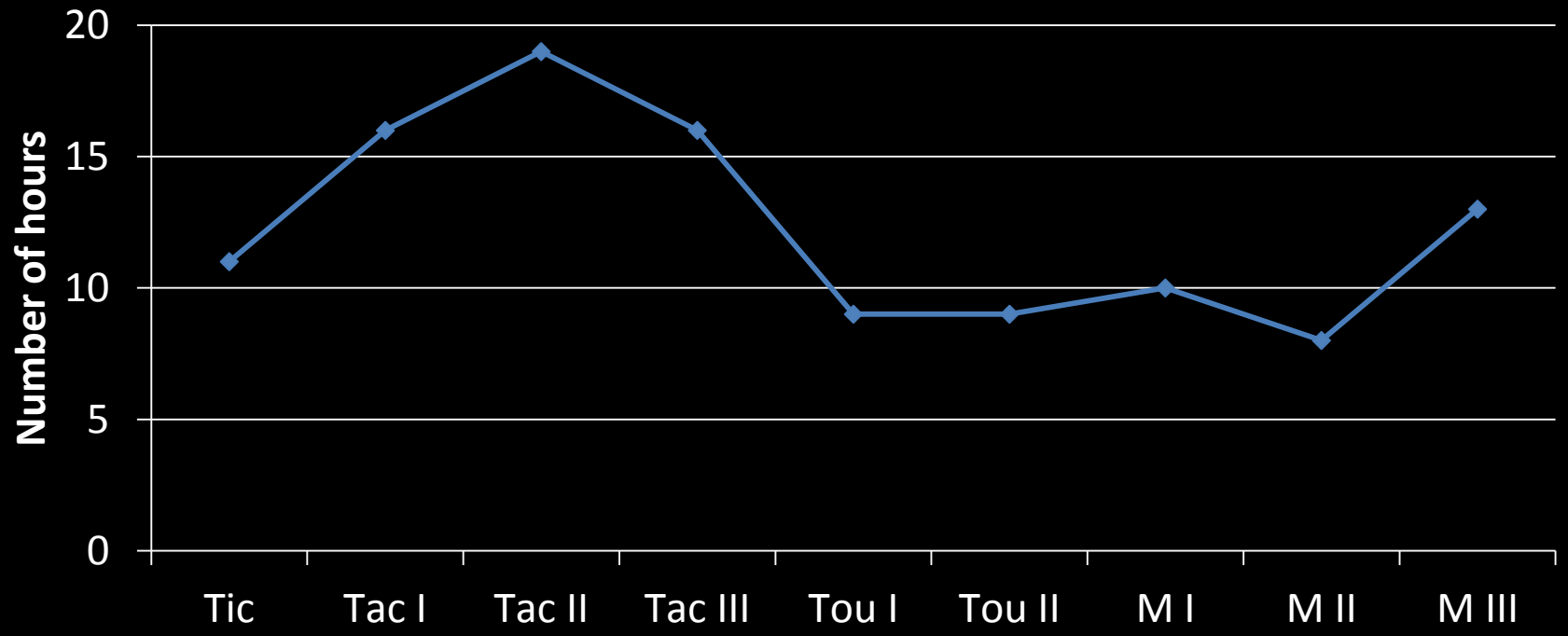
It's helpful but not required that you…

- Have experience with large Java projects
- Are comfortable with vector arithmetic
- Have basic knowledge of high-school physics
- Have experience with version control

Introduction

DIFFICULTY

Median number of hours spent



*** These times may not apply ***

Introduction

ABOUT SECTIONS

Registering for 1971

- We NEED to know how many of you are really, really planning on taking this course
  - If you're 75% sure, that's enough
- PLEASE give us your CS login on the way out
- If you ARE NOT registered on banner, don't register yet
- If you ARE registered on banner, leave yourself registered until further notice
- We will get back to you soon.

Introduction

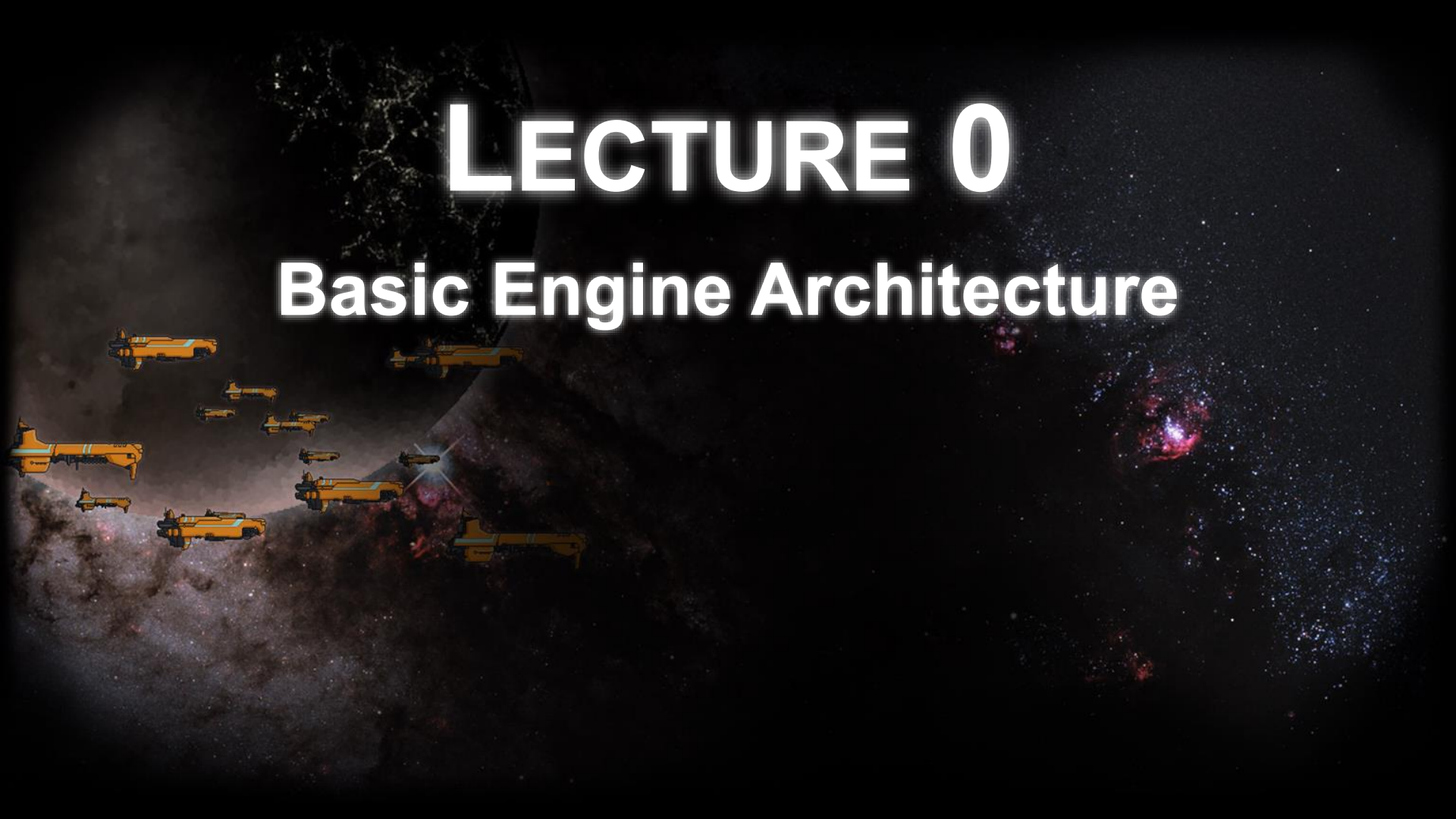
QUESTIONS?

Introduction

A WORD FROM OUR SPONSOR

Lecture 0

Basic Engine Architecture



Basic Engine Architecture

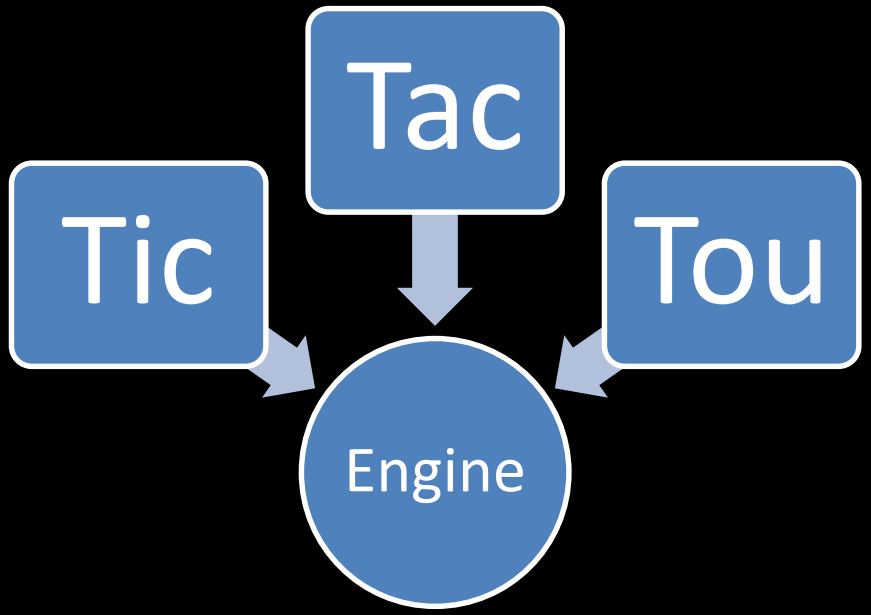
WHAT IS AN ENGINE?

What is an engine?

- “The things that games are built on” - zdavis
- Games tend to have a lot of functionality in common
  - Even beyond the superficial
- Solution: create “engines” that abstract out common functionality
- Implemented as a library or a framework
  - Frameworks dictate flow of control, e.g. callbacks in AWT/Swing
  - Libraries do not dictate flow of control, e.g. `java.lang.Math`

What is an engine?

- Should be usable by many games
  - If you gave your engine to someone, could they more easily write a game without modifying engine code?
- Should be general
  - No game-specific logic!!!
- Should be useful
  - If the logic isn't specific to the game, put it in the engine!



What does this look like?

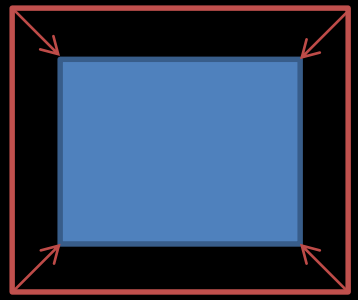
- Sample package hierarchy:
  - src/
    - engine/
      - Screen.java
    - game/
      - TouScreen.java
- Any code in your game package SHOULD NOT be referenced in your engine package.

Basic Engine Architecture

THE MOST ESSENTIAL INTERFACE

A game generally needs…

- Timed updates (“ticks”)
- Ability to render to the screen (“draws”)
- Input events (in some form or another)
- Knowledge that it has been resized (more info later)



Ticks

- General contract:
  - `public void tick(long nanos)`
  - Nanos is the most precision most computers have
  - Tip: Many people prefer to convert to `float seconds`

- Simply notifies the engine that a given amount of time has elapsed since the previous “tick”
  - But this is hugely important
  - Nearly all logic takes place during “ticks”

- Updates per second (UPS) is how many ticks occur in a second
  - Keeps track of how smoothly the game world is updated
  - We require 20 UPS in all projects

Draws

- General contract:
  - `public void draw(Graphics2D g)`
  - Convert game state into viewable form

- Provides a “brush” object (attribute bundle) for drawing into
  - Frequently just changes pixels in a `BufferedImage`
  - Might do hardware acceleration sometimes
  - It’s an interface, you shouldn’t care or need to know

- MUST BE FREE OF SIDE EFFECTS!
  - Two subsequent draw calls should produce identical results

- More information coming up in Graphics I section

Input Events

- Most APIs provide input events rather than making you poll
- Exact contract differs depending on type, but usually of the form:
  - `public void onDDDEEE(DDDEvent evt)`
  - DDD = device type (e.g. mouse, key)
  - EEE = event type (e.g. moved, pressed)
- Event object contains information about the event
  - How far the mouse moved; what key was pressed…
  - Why not just use arguments?
- More info coming up in Input section

Putting it together

- Basic methods of a game application:
  - (note: support code calls these, you implement them)

```
public class Application {
      public void onTick(long nanos)
      public void onDraw(Graphics2D g)

      public void onKeyPressed(KeyEvent evt)
      // more device and event types...
      public void onMouseDragged(MouseEvent evt)
}
```

Basic Engine Architecture

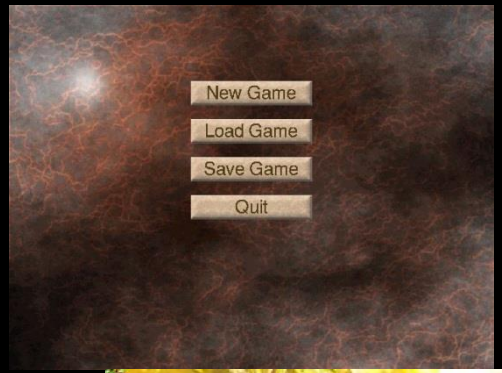
QUESTIONS?

Basic Engine Architecture

APPLICATION MANAGEMENT

We know the external interface

- But how does one build an engine around that?
- Drawing/ticking/event handling is very different depending on what's going on!
  - Menu system
  - The actual game
  - Minigames within game

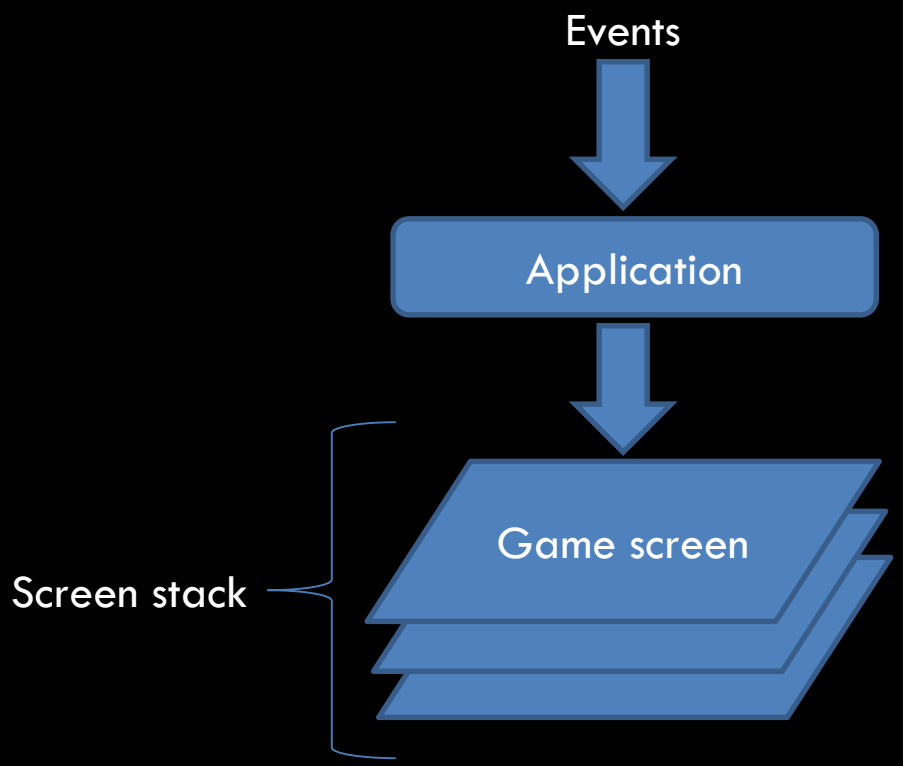


Solution: `Screen`s within `Application`

- Rather than keeping track of “modes”, separate each game screen into a dedicated `Screen` subclass
- A `Screen` has similar methods to the `Application`
  - `onTick`
  - `onDraw`
  - Input event methods

Keeping track of Screens

- Simplest way:
  - Single `Screen` in `Application` at a time
  - Current `Screen` calls `setScreen()` on `Application`
- Alternative way:
  - Stack of `Screen`s maintained by the `Application`
  - Topmost `Screen` gets events
  - Advanced: "Transparent" `Screen`s can forward calls down to other `Screen`s



A note about `main`...

- Get out of it ASAP!
- Make a dedicated game class, not in the engine
- A wholesome, healthy `main` class is < 10 lines long:

```
public class MyGameMain {
        public static void main(String[] args) {
                MyApplication a = new MyApplication();
                a.setScreen(new MyMainMenu());

                a.startup(); // begin processing events
        }
}
```

Basic Engine Architecture

QUESTIONS?

LECTURE 0

Graphics I

Graphics I

SCREEN SIZE

Long ago…

- The screen size of a game was hardcoded at a fixed resolution
  - Especially in consoles
- This allowed absolute sizing and positioning!
  - Ugly but effective!
- Modern games must support many resolutions

How do we know the screen size?

- There's another method in `Application`...
  - `public void onResize(Vec2i dim)`
  - `dim` is the new width, height of the draw area

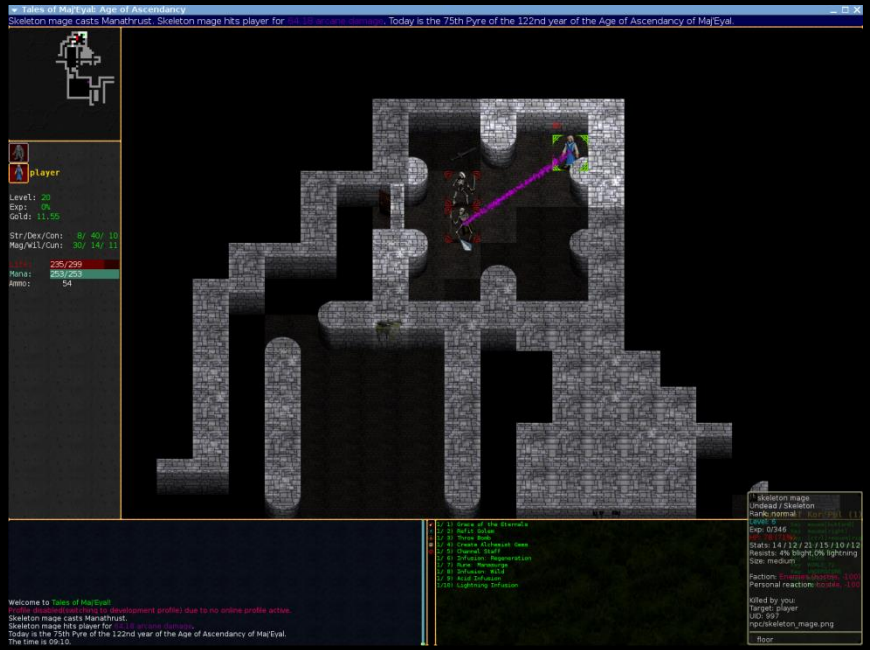
- Called when the size of the screen changes
  - Window resizes
  - Fullscreen is toggled
  - Storing the current size in your `Application` is a good idea

Strategies for handling different sizes

- Blindly draw at fixed size anyway
  - Unacceptable, even if centered
- Better?: blindly scale to fit
  - Uses all space, but really gross
- Much better: scale up maintaining aspect ratio
  - Acceptable, but still causes letterboxing/pillarboxing

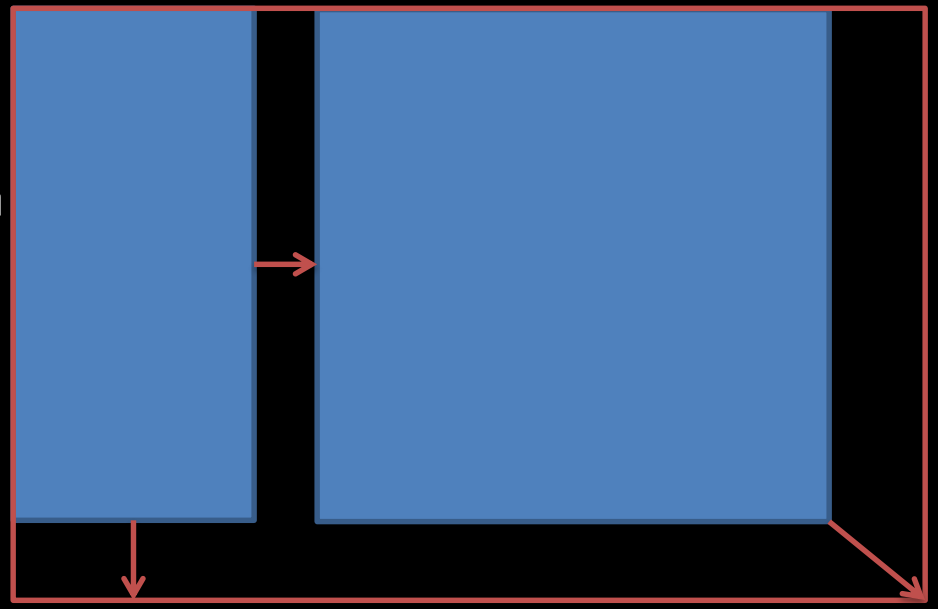
Strategies for handling different sizes

- Best: distribute extra screen space to objects in the game as needed
  - Like a GUI toolkit
- Not always possible
  - Especially if the size of the game area has impact on the gameplay
- This is what's required in Tic



Reacting to resizes

- Every time a resize occurs, repeatedly subdivide space according to desired layout
- In Tic, the board must remain square
  - Can fill as much space as possible with the board and center the timer in the remaining space
- When drawing, just use the computed rectangles

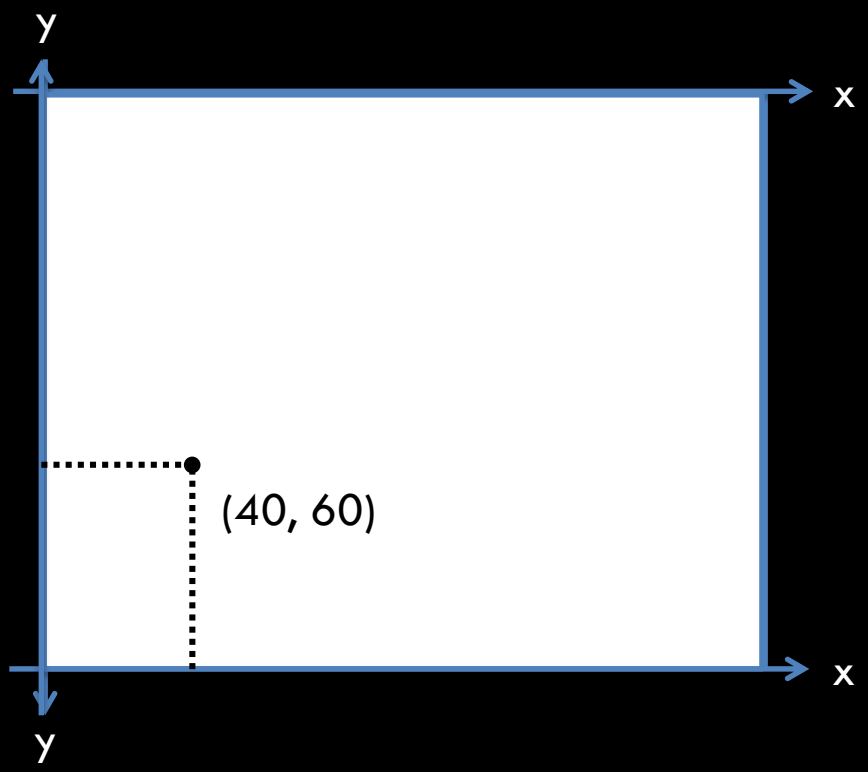


Graphics I

DRAWING THINGS

Window coordinate system

- Standard window coordinates:
  - Origin in upper left
  - X axis extends right
  - Y axis extends down
  - Convention initially set up to follow English text (left-right, top-bottom)
- Alternative: "Math-like" coordinates
  - Origin in lower left, Y axis extends up
  - To use, just replace all Y arguments in draw calls with (height – y)
  - Better ways to do this by manipulating the `Graphics2D` object – experiment!
- Use whichever is more intuitive!
  - Don't do standard because it's "easier"



Actually drawing things

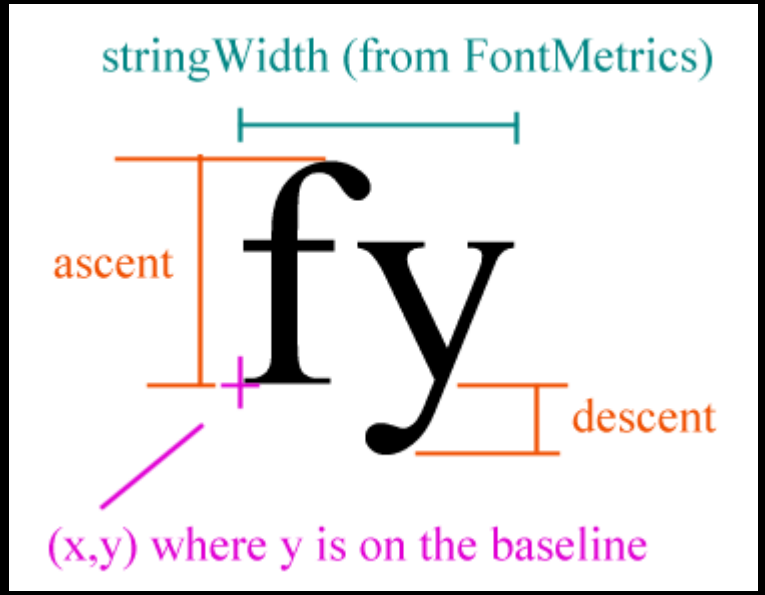
- Two types of draw methods in `Graphics2D`
  - Ones that take `java.awt.geom.Shape` objects: `draw(Shape)`, `fill(Shape)`
  - Ones that take a bunch of `int` parameters

- `int`s will not be precise enough in future assignments
  - Use the ones that take `Shape`s, but don't store `Shape`s! Write your own package of shape classes and translate them to `java.awt.geom` shapes when drawing
  - Important for flexibility in future projects

- Only use floats for drawing
  - Otherwise, the next project might be much more difficult

Drawing text

- Use `FontMetrics.getStringBounds()` to determine how much space a piece of text will take up
- When drawing text, the y coordinate indicates the baseline rather than the bottom
  - Be wary of tails getting cut off
  - Add `FontMetrics.getDescent()` to the lowest point you want the text to extend
  - (`FontMetrics.getAscent()` if using the math-like coordinate system)



Graphics I

QUESTIONS?

Lecture 0

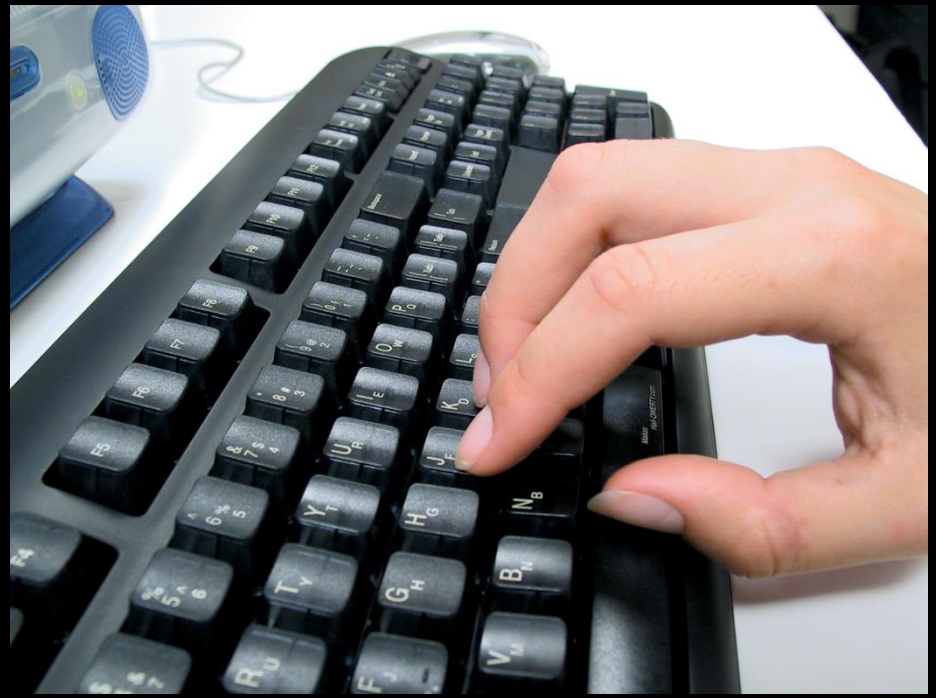
Input

Input

THE KEYBOARD

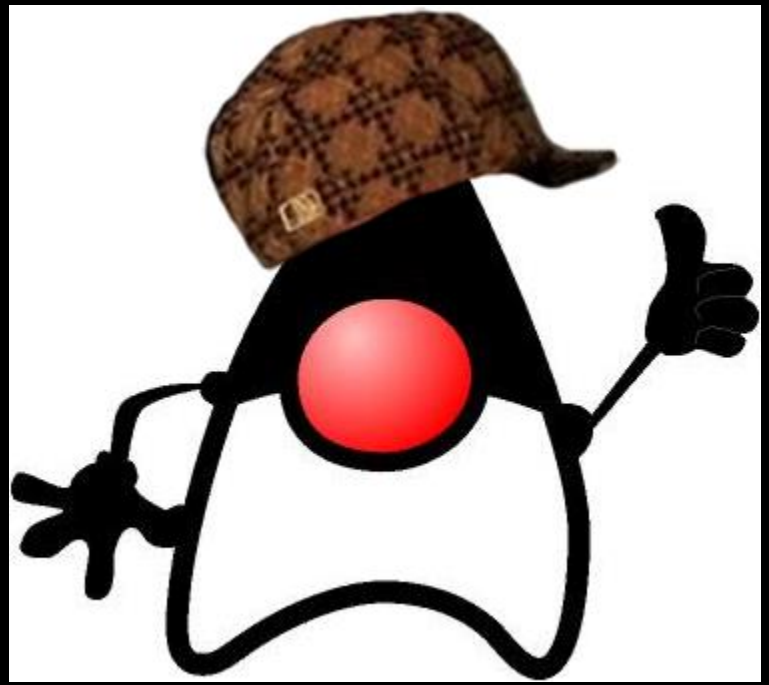
AWT KeyEvents

- AWT would have you believe that there are three key event types
  - `onPressed`
  - `onReleased`
  - `onTyped`
- What do those actually mean?



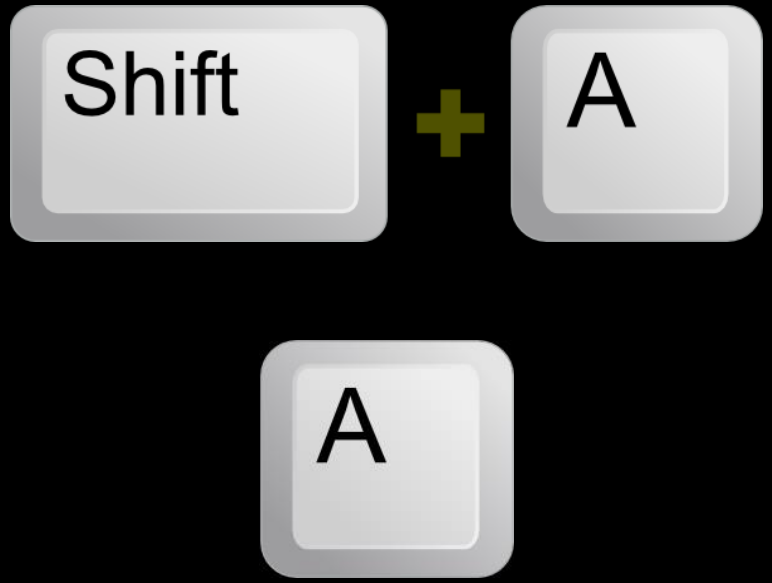
AWT KeyEvents

- Pressed gets fired once when you press the key
  - NOPE! Fired multiple times when held (key repeat)
- Released gets fired once when you release the key
  - Usually yes
  - But on X-based unix systems such as the department machines, fired multiple times when held (key repeat)
  - Support code handles this case



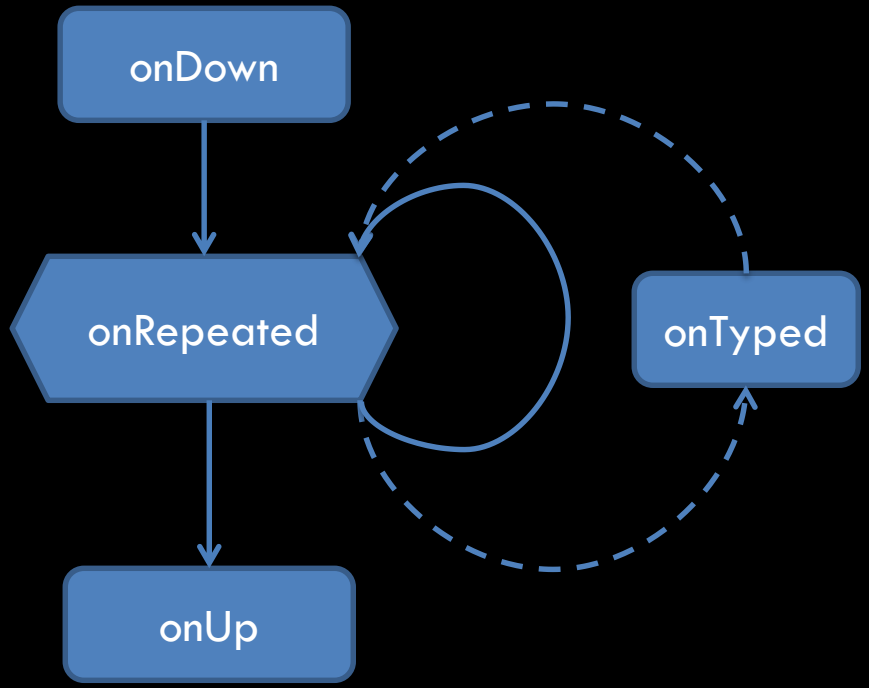
Then what is keyTyped?!

- Actually a very important distinction that was correctly implemented
- Fired when a character has logically been typed
  - E.g. Shift+A results in one keyTyped event for a capital ‘A’ while A without shift results in ‘a’
  - Especially nice for non-Latin characters
- Ultimately only useful if manually implementing text input (not required in this course)
  - NOT useful for detecting key repeat!



Better key events

- Four events:
  - onDown
  - onUp
  - onRepeated
  - onTyped
- onTyped same as AWT
- onDown/onUp only fired once per key press
- onRepeated for key repeats



Input

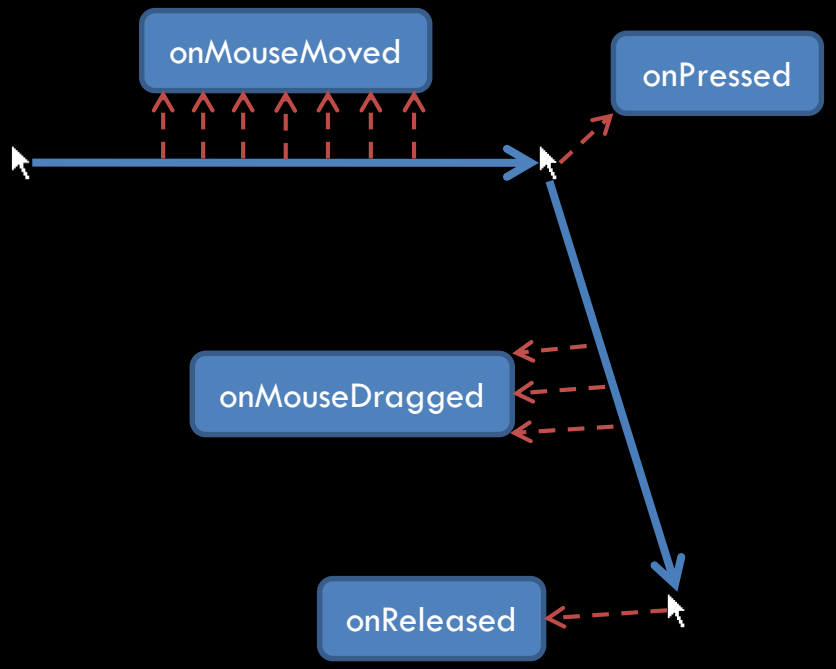
THE MOUSE

AWT `MouseEvents`

- Button events
  - `onPressed`, `onReleased` actually do what they advertise!
  - `onClicked` is when a “click” occurs—a press quickly followed by a release
    - Includes `clickCount` (2 for double click, 3 for triple etc.)

AWT MouseEvents

- Cursor position events
  - `onMouseMoved` when the cursor moves and no button is held
  - `onMouseDragged` when the cursor moves and at least one button is held
- Note that AWT only gives you one at a time, so if keeping track of the cursor position, listen to both.

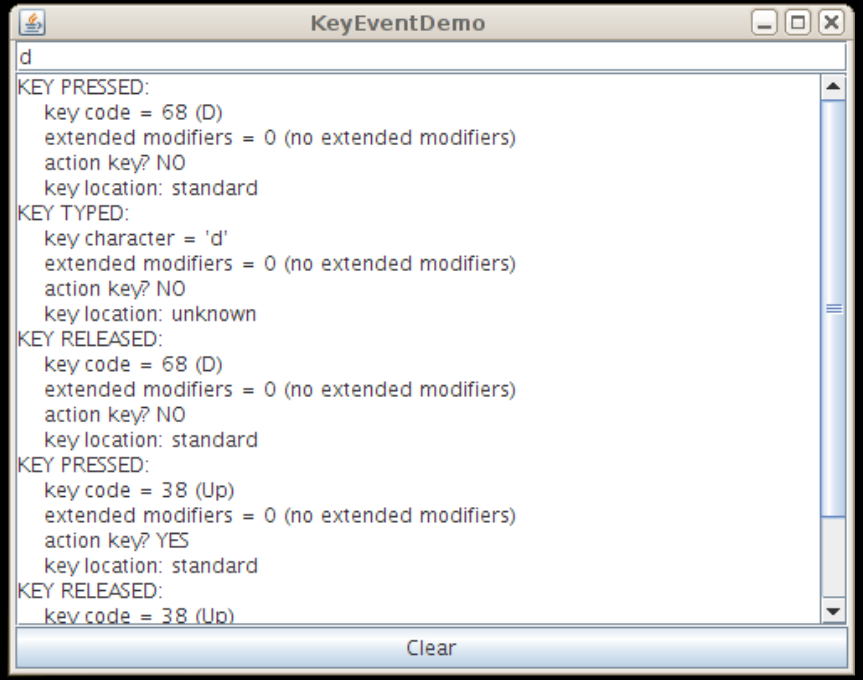


Better mouse events

- May want to unify mouse button+key presses and releases
- DragStart and DragEnd events are not difficult to implement and are nice to have

General Input Advice

- Mess with `println`'ing events for a while to get a sense of them
  - Better understand their contracts
- Wrap AWT events in your own event classes
  - Extend functionality and prevent AWT references from polluting your code

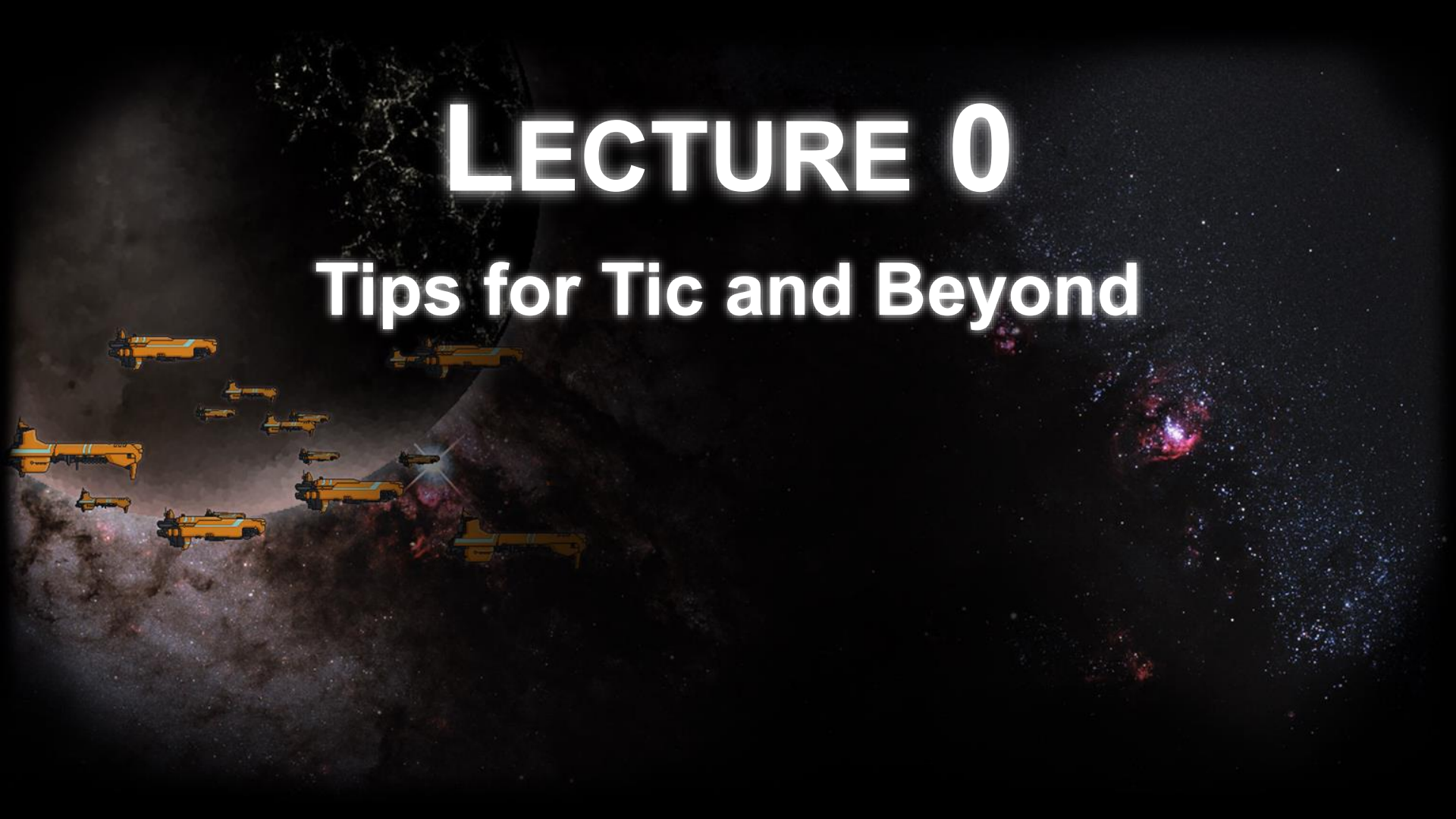


Input

QUESTIONS?

Lecture 0

Tips for Tic and Beyond



Tips for Tic and Beyond

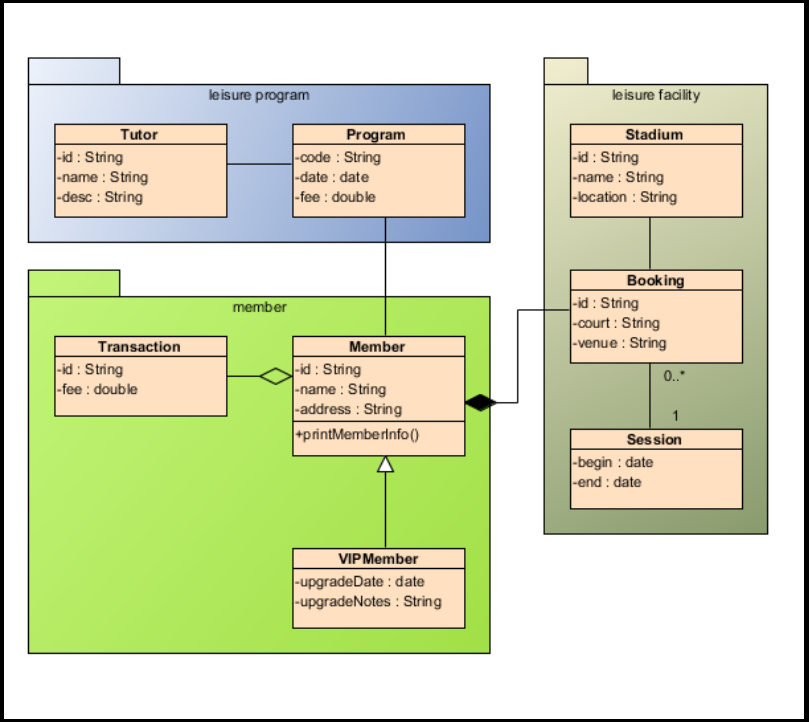
SOFTWARE ENGINEERING TIPS

Plan.

- You are about to embark on a large software adventure!
  - So make a map
- You will have to maintain the code you write, or rewrite it
  - Find weaknesses in your design before they ever become code

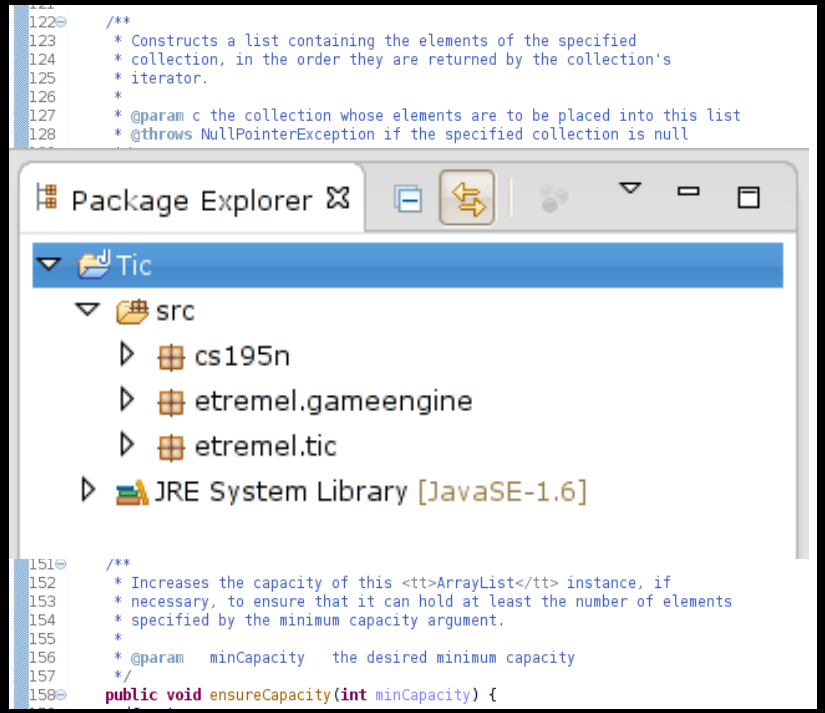
Program abstractly.

- Split your code into black boxes defined by contracts (interfaces)
  - For example, have a concept of a UI element that can resize and draw itself
- Separate capability
  - For example, don't draw your entire board in the screen's draw method, have separate drawCell, drawX, drawO…
- Really bad code = incomplete



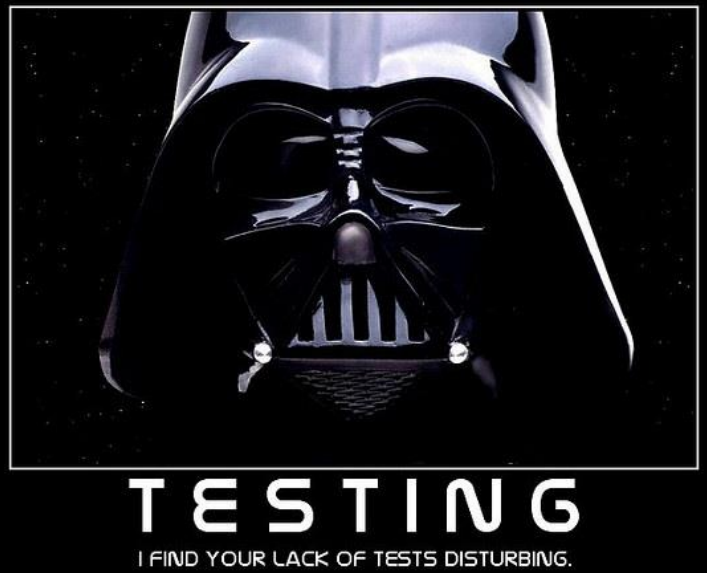
Use good practices.

- Comment your code!
  - For yourself as much as us!
- Use packages to separate your engine code from your game code!
  - This is actually a global req
- Copy your engine code into each new project rather than making a dependent project



Test often and incrementally.

- NEVER write a whole week from scratch and then run it
  - There will be a problem, and it can be anywhere
- Write one part at a time, stubbing out or putting `println` calls where necessary
  - Bug source is now bounded
- E.g. implement and test input and drawing separately



Deal with bad design decisions.

- At some point you will make a bad design decision
  - If you never make a bad design decision, you didn't need to take this course!

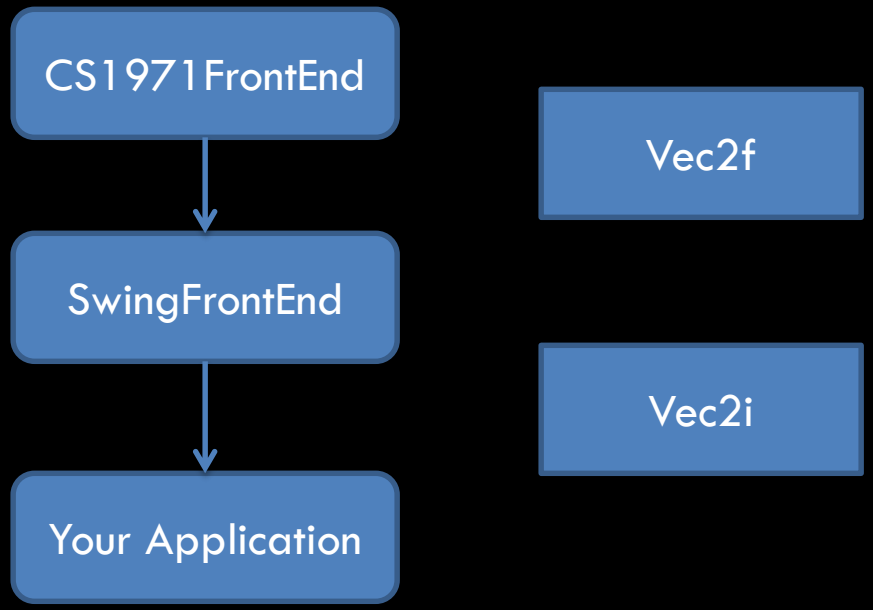
- Don't be afraid to redesign/refactor your code
  - It will only get worse if you try to hack around your old design

Tips for Tic and Beyond

SUPPORT CODE OVERVIEW

Four support code classes

- SwingFrontEnd
  - Class which you will extend and implement onTick, onDraw, etc.
- CS1971FrontEnd
  - Base class of SwingFrontEnd
- Vec2f, Vec2i
  - Contain nearly all basic vector operations you will need.
  - Familiarize yourself!
  - DON'T ADD FIELDS

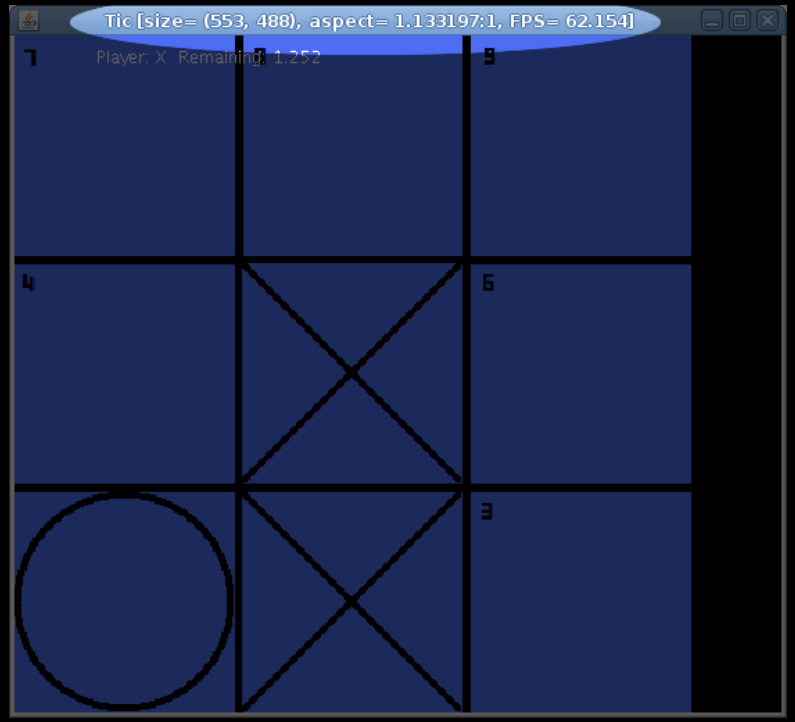


No Swing

- SwingFrontEnd is used to set up the frame and events, but that’s all we are using Swing for
- Never use JPanels, JLabels, JButtons, etc
- Make it all yourself
- You're welcome ☺

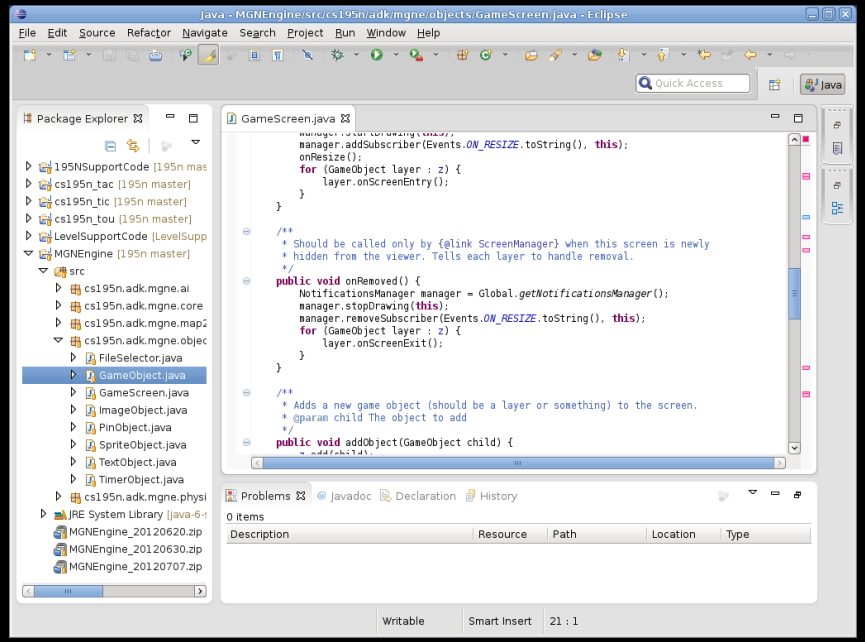
CS1971FrontEnd “Debug” mode

- Enabled by default
- Displays screen size, aspect ratio, and UPS in title bar
- F11 toggles fullscreen
- F12 allows resizing



Development Environment

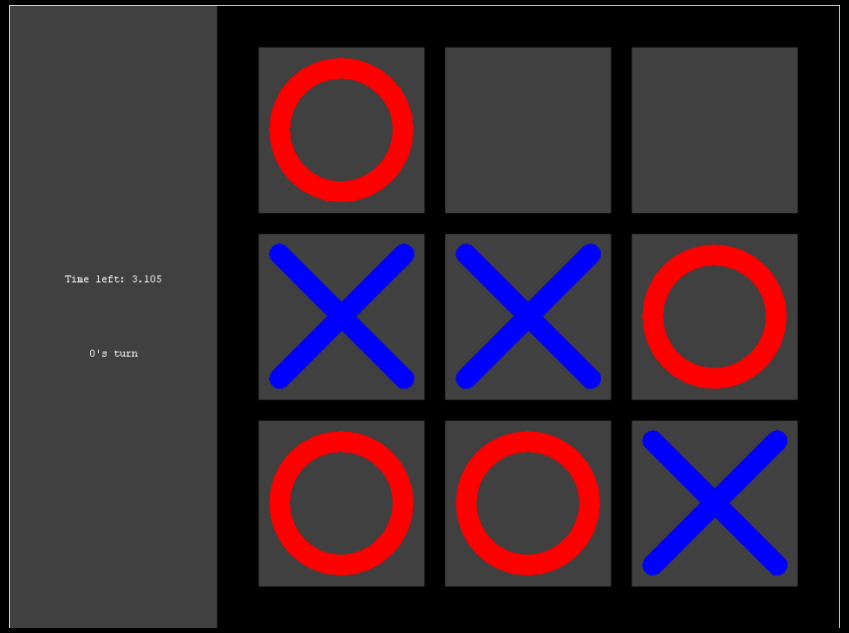
- eclipse
  - Brand new, shiny version of Eclipse (Mars)
  - (only) TA-supported IDE
  - Is pretty much just a swell program all around
- Build instructions required for anything else
  - Lets us debug your program if we think we know a quick fix



You can run demos!

cs1971_demo tac3 ebirenba

cs1971_demo tic gtrousda

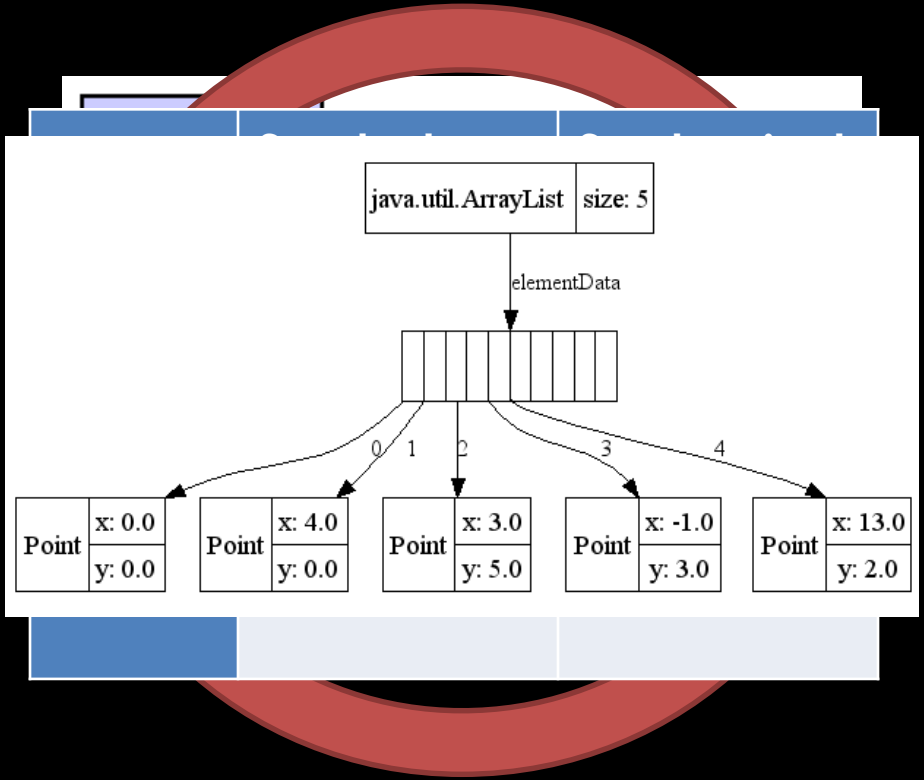


Tips for Tic and Beyond

JAVA TIP OF THE WEEK

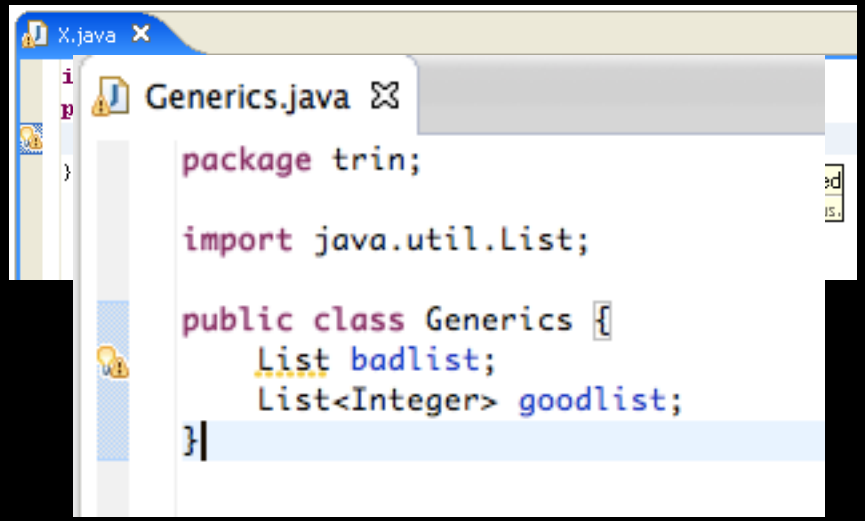
Use the standard Java collections!

- Need an easy way to clump objects of some type?
  - Use a `List<E>`
  - Note: Almost no reason to use `LinkedList<E>` over `ArrayList<E>`
- Need a mapping from one class of objects to another?
  - Use a `Map<K,V>`
  - Usually `HashMap<K,V>`
- Avoid synchronized counterparts `Vector<E>` and `Hashtable<K, V>`
  - Unnecessary overhead



Use generics!

- Use the *generified* versions of the standard Java collections!
- This means don't use raw types!
  - If you use raw types we may give you an incomplete for poorly designed code
- Be particularly careful of instanceof – it is a sign of poor design



Java Math Tips

- Use float literals instead of casting
  - `(1.0f)` or `(1f)` is better than `((float)1.0)`
- Avoid Math.pow() if possible
  - `x*x` is WAY better than `Math.pow(x, 2)`
- Don’t pass around logical pairs of numbers
  - Use Vec2i/f to represent sizes or coordinates

Tips for Tic and Beyond

QUESTIONS?

Tips for Tic and Beyond

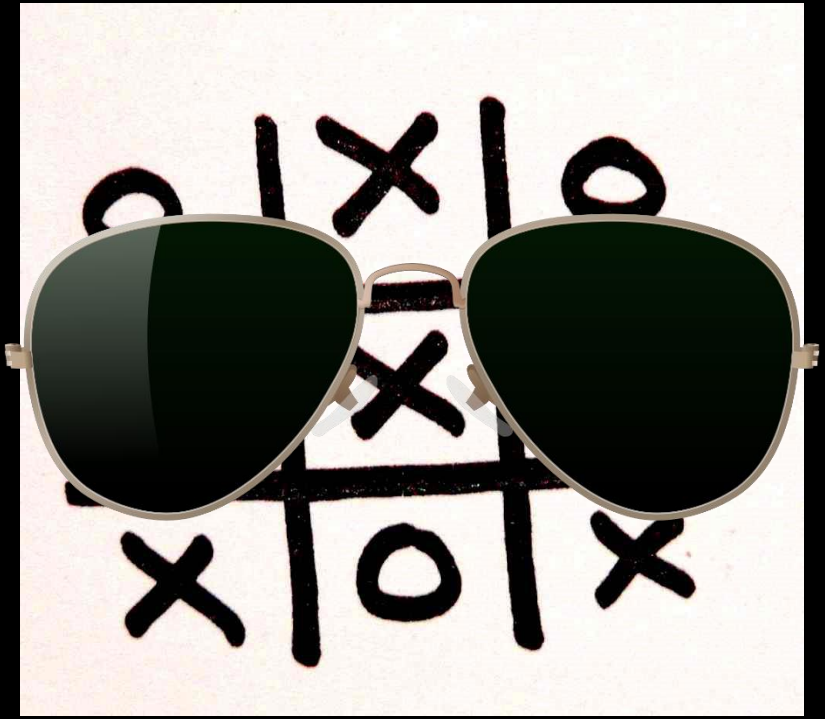
GAME DESIGN TIPS FOR TIC

Weekly Game Design Tips!

- Playtesting is less enjoyable when the games are boring, ugly, or hard to figure out
- Quick easy ways to make your games more fun for others to playtest
- Specific to each project, as opposed to the game design mini-course

Tic-Tac-Tou

- No real gameplay design this week – it's tic-tac-toe
- Instead, let's focus on making tic-tac-toe look good!

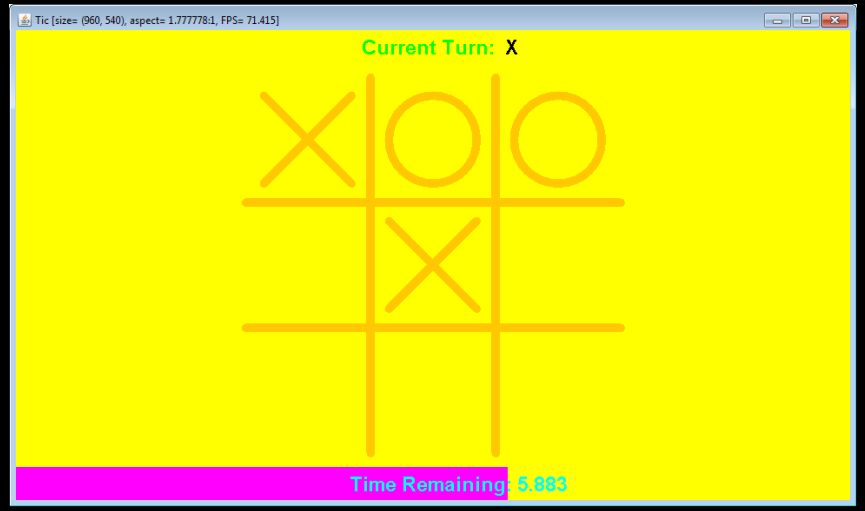


Color Schemes

- Players will judge your game immediately based on how it looks
- Bad color schemes are an easy way to lose your player's favor…
- But good color schemes will draw them in!

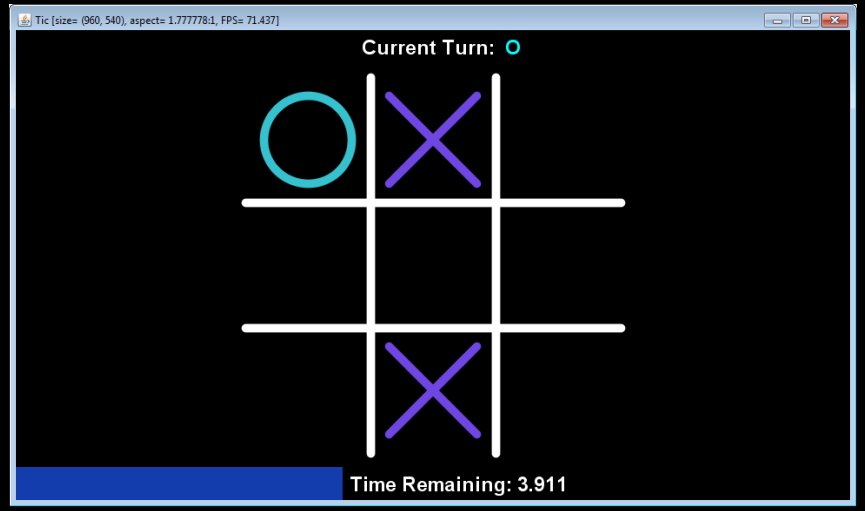
Here’s an ugly Tic…

- Board sort of fades into the background
- Colors don’t feel like they go together at all
- X and O are the same color



And here's a better one!

- Board pops from the background and is clearly the focus
- Colors feel more cohesive
- X and O are different colors



How to pick a color scheme

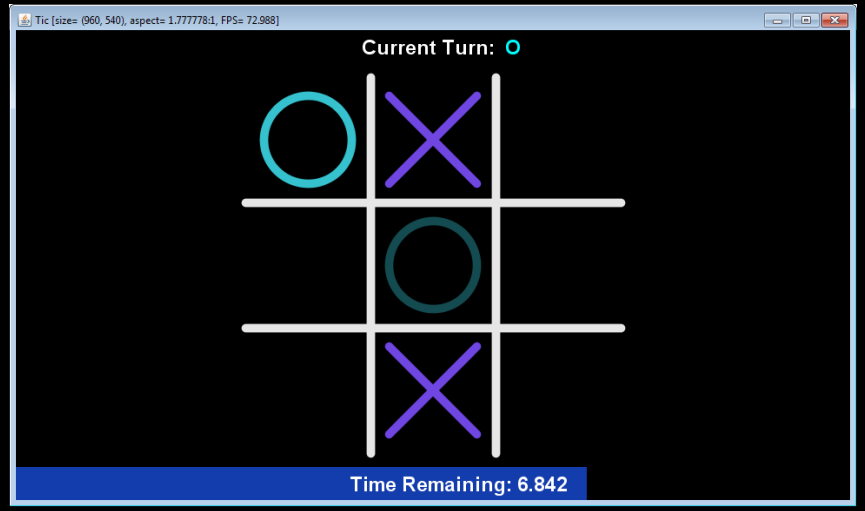
- Less tends to be more
- Easiest: white on black with a few accent colors
  - Just like these slides!
- Use http://colorschemedesigner.com/ to get colors that go well together
  - Plenty of similar tools are out there

Juice

- “A juicy game feels alive and responds to everything you do”
  - From *How to Prototype a Game in Under 7 Days*
- How can we make Tic juicy?

Basic Juice: Mouse Hover

- Mouse hover effects make software feel much more responsive
- Have your buttons change slightly when hovered
- Show ghost pieces on the tic-tac-toe board



Recap

- Use a good color scheme
- Add juice with mouse hover effects
- Also, turn on anti-aliasing
  - `g.setRenderingHint(RenderingHints.KEY_ANTIALIASING, RenderingHints.VALUE_ANTIALIAS_ON);`
- <u>Do these things last – finish requirements first!</u>

Game Design Tips for Tic

QUESTIONS?

‘Till next week!

REMEMBER TO GET US YOUR LOGIN! GOOD LUCK!