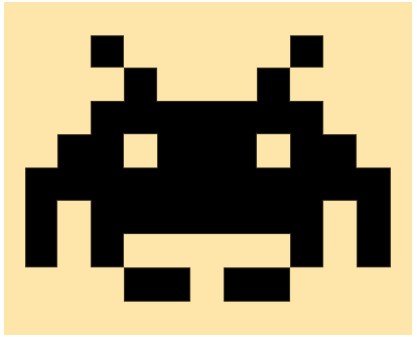
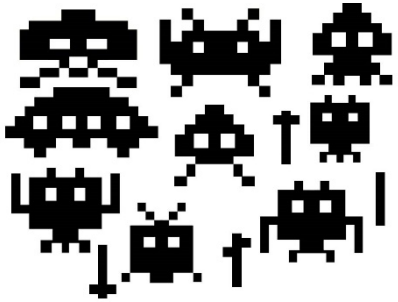
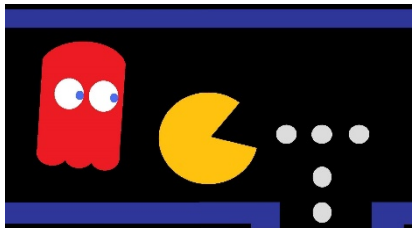
CSCI 1106
Lecture 21



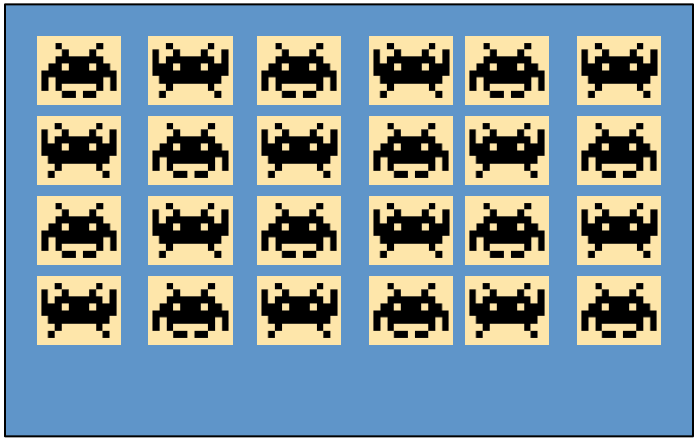
Game Design Review

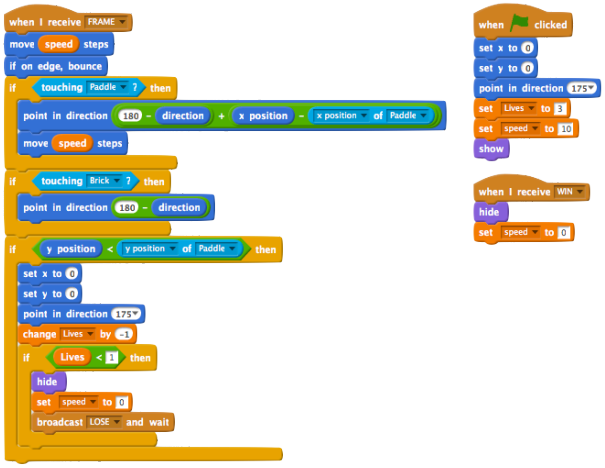




Components of a Game

- Stage: Displays (renders) the game
- Sprites:
  - Graphical objects that interact on the stage
  - Represent various artifacts in the game
    - Characters
    - Projectiles
    - Power-ups, obstacles, etc
- Game Code:
  - Governs interactions between sprites
  - Governs interactions between player and sprites
  - Implements the rules of the game
  - Contains *event handlers* that respond to events in the game
  - Updates the sprites on the stage





The Movie Metaphor

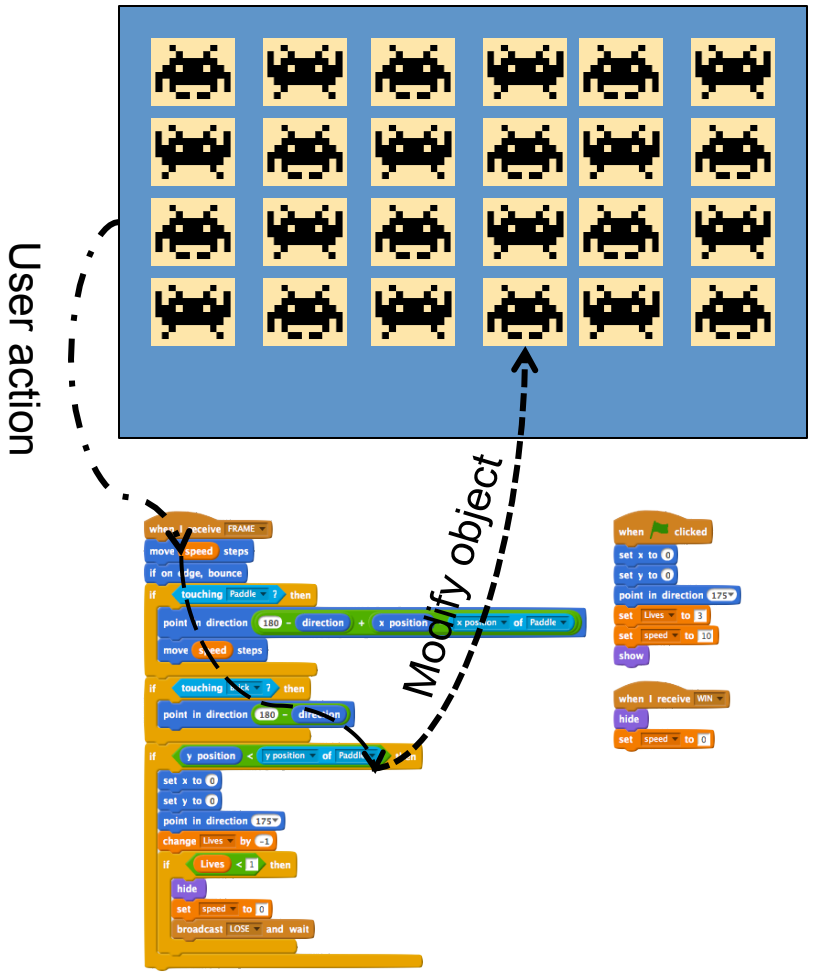
- In a movie the screen is updated 24 times per second
- In a game the stage is updated 30 times per second
- The update is called a *frame*
- A frame occurs every 1/30th of a second
- When a frame occurs
  - Sprites modify their properties
    - Position
    - Look
    - Sound
    - Etc
  - Sprites are redrawn on stage in each frame
- Key Idea: A game is simply an interactive movie!
- What interaction?

Event Driven Paradigm

- Observation: A game performs "some action" when "something" happens
- Idea: Game code simply responds to events
- Possible events:
  - External events: (mouse, keyboard, kinect, etc)
  - Internal events: (Start of game, New Frame, Timer)
- Each event is handled by an *event handler*
- The game code simply consists of event handlers that handle all aspects (behaviours) of the game!

The Main Loop

- Idea: The main loop is implemented for you
- Main Loop:
  - Event (action) occurs
  - Handle (respond to) event
  - Update (modify) object(s)
- All you need to do is
  - generate events and
  - write the event handlers!



Sprites

- A sprite is a graphical object that is placed on the stage
- A sprite has associated with it
  - *costumes*
  - *properties*
  - *variables*
  - *scripts*
- A sprite represents game artifacts
  - Characters
  - Obstacles
  - Projectiles
  - Etc

Properties and Variables

Sprite Name: Invader

Properties

10	x position
42	y position
90	direction
100	size

Costume1

Costume2

Variables (Extrinisic Properties)

Score	123
Level	4
speed	5
Lives	2

The Stage

- Idea: The *Stage* is a special sprite on which all other sprites are displayed.
- The stage has *backdrops* rather than costumes, but they serve the same purpose
- All sprites will always be in front of the stage
- Like other sprites, the stage has
  - properties, sounds, and scripts associated with it

Cloning Sprites

- Idea: We can make multiple copies of a sprite by *cloning* it. 

- When a sprite is cloned, everything is copied
  - e.g., properties, variables, costumes, scripts, etc
- Key Idea: Manipulation of the clone or the original does not affect the other
  - e.g., changing the clone's position will not move the original
- Both the clone and the original have the same name
- Two differences between clones and originals
  - clones are notified when they are created 

  - clones can be destroyed

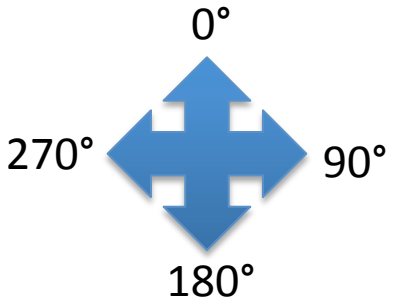
Communication Between Sprites

- Key Idea: Sprites communicate by broadcasting messages (events) 

  - A broadcast means **every** sprite receives the message
    - e.g., Stage broadcasts FRAME 30 times per second
  - A sprite can respond to a specific message (event) by having a script that receives it 

- Messages cannot be directed at a specific sprite unless only that sprite has a script to receive that message

Autonomous Motion



- Set the sprite's speed
  - Number of steps (pixels) per frame
  - *Can be positive or negative*
- Set the sprite's direction property 

- Create a script to respond to the FRAME event
- On each frame change the position of the sprite by its speed 

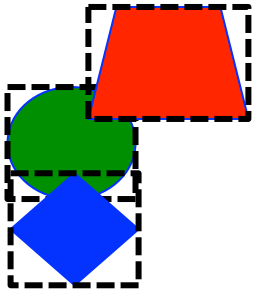
  e.g. move 10 steps per frame at 90°

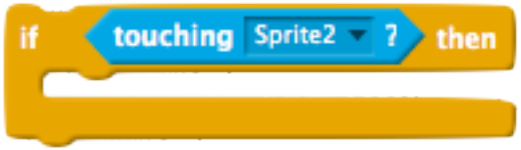
Hitting the Wall

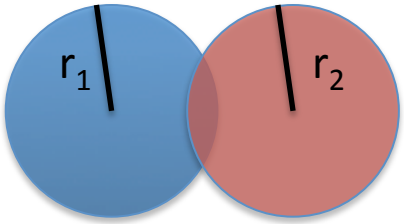
- Fact: If the object keeps moving it will reach the edge of the stage
  - Fall off the edge
  - Bounce back
- Falling off the edge
  - Once object is no longer visible, remove it
- Bounce back
  - Once object touches a wall, reverse velocity
    - If vertical wall, reverse horizontal velocity
    - If horizontal wall, reverse vertical velocity
- This is done in the FRAME handler
  - Why?
- This is a special form of collision detection

Mechanisms for Collision Detection

- Four ways to detect collisions:
  - Cheap and fast: Check if bounding boxes overlap
  - Expensive and slow: Check if the points of one sprite intersect with the other



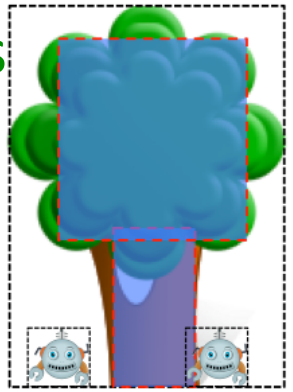




  - Fast but specialized: Use geometry

Distance($circle_1$, $circle_2$) < $r_1 + r_2$

  - More complicated and fast: Use invisible sprites



- For most purposes, the second way suffices

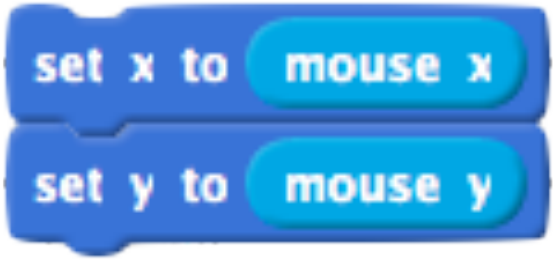
Player Motion

- All interactive games have player movement
  - Players can move their character or avatar on the screen
  - Players can react to the game and move their avatar
- How the avatar moves is dictated by the game's
  - Laws and physics of the game
  - Goals and objectives
  - Environment and level of play
- Common ways to move the avatar are through
  - Mouse
  - Keyboard
  - Dedicated game controllers and joysticks

Mouse Movement

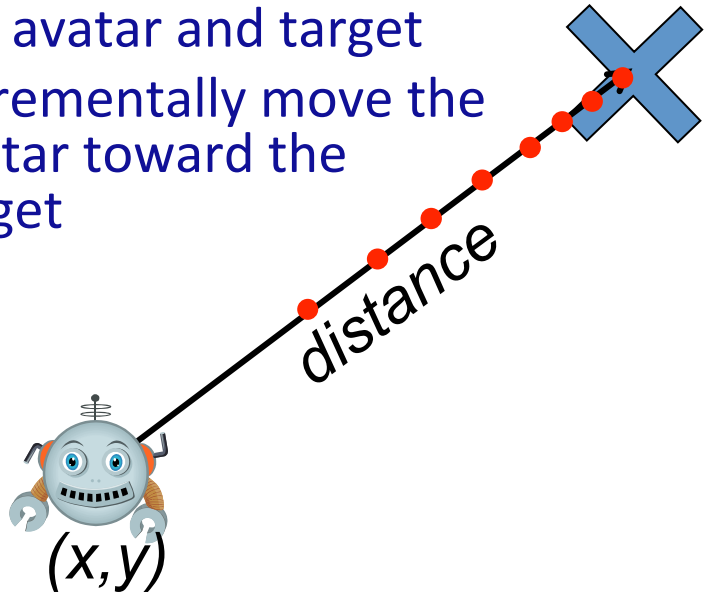
Direct Mouse Movement

- The avatar appears where the mouse is pointing to
- No need to control the velocity of the avatar
- Position and velocity is managed by the mouse movement
- Set the avatar's coordinates to the mouse coordinates at each FRAME event



Easing

- Gradually move avatar toward the location clicked on with the mouse pointer
- A mouse click sets the target to move toward
- Calculate distance between the avatar and target
- Incrementally move the avatar toward the target



Keyboard based Movement

- Idea: Move the player with the keyboard
  - The arrow keys control the direction that the avatar moves
  - These directions allow the player to move diagonally as well
  - Need to respond to the KEY PRESS events or check if keys are being pressed.
  - More than one key can be down at the same time
- On a FRAME event
  - Check which of the arrow keys are pressed and move in that direction

Playtesting

- Playtesting is a game development method for
  - Getting feedback about the game
  - Identifying problems with the game
  - Understanding how players perceive the game
  - Improving the playability and enjoyment of the game
- Playtesting involves
  - Players:
    - Users who typically have never played the game before
    - Recruited by developers to play games
  - Observers:
    - Members of the development team
    - Observe the players as the play games and take notes

Goals of Playtesting

- Identify game play issues
  - Bugs
  - Playability: Player motion and mechanics, Environment, Controls , Speed of the game
  - Understandability: Game objectives, Tactics and strategies, Player information and statistics
- Understand how players perceive the game
  - Difficulty
  - Pace
  - Immersion
  - Interest (story line)
  - Genre
- Get feedback about the game
- Identify possible improvements
  - Extensions
  - Modifications
  - Spin-offs
  - Features

Playtesting Process

Things to do

- Before the playtest
  - Ensure the game is stable
  - Recruit players
  - Setup a “typical” game station
- During the playtest
  - Welcome and **thank** the player
  - Remind the player that they are not being tested
  - Ask the player to talk as they play
  - Remain silent and take notes
  - Thank the player again ensure that you have contact information
- After the playtest
  - Keep track of all the players
  - Categorize your observations

Things to note

- General mood of the player
- Any comments or suggestions made by the player
- Any bugs that occur during play
- Any struggles experienced by the player
- How easily the player learns the game
- How quickly does the player progress through the game
- How quickly does the game become too hard for the player
- Any aesthetical issues
- Any other feedback

High-Level Game Design

- Game Elements
  - Mechanics
  - Story
  - Technology and Aesthetics
- Idea: The elements work together to create a *unifying theme* in the game
  - What experience do you want to convey?
  - Structure your story and mechanics to reinforce the theme

The Game Story

- There's nothing like a good story to pull you in...
- A story is composed of:
  - A "world"
  - Characters
  - A quest
- The story immerses the player and separates great games from ok games
- Story Considerations
  - Depth: How detailed or grand is the story to be?
  - Delivery: How is the story communicated to the player?
  - Pacing: How quickly is the story being told?

Game Mechanics

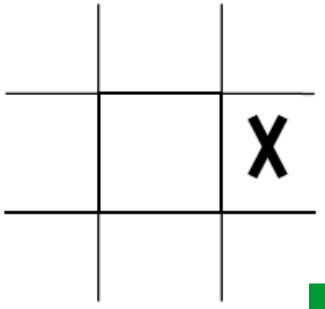
- Idea: Use game mechanics to
  - Implement the game story
  - Support the unifying theme of the game
- Game mechanics comprise
  - Rules: Written/Unwritten/Game objective
  - Environment: Space/Number of players/Physics
  - Actions: Primitive vs Strategic
  - Chance (Randomness): “Secret of fun”
  - Skills: Physical/Mental/Social
- Idea: A set of stock (standard) mechanics that are used by similar games is called *genre*
  - Card games, Racing games, First-person shoot-em up
- Idea: Use state transition diagrams to model game mechanics

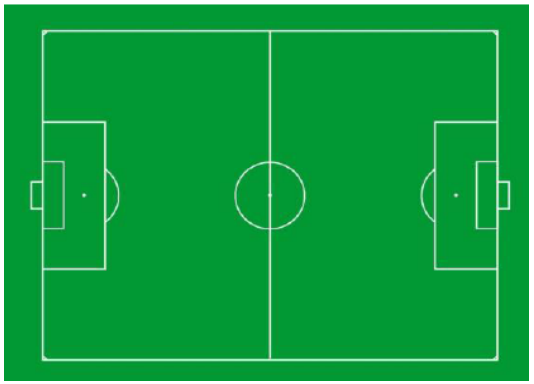
Game Mechanics: Rules

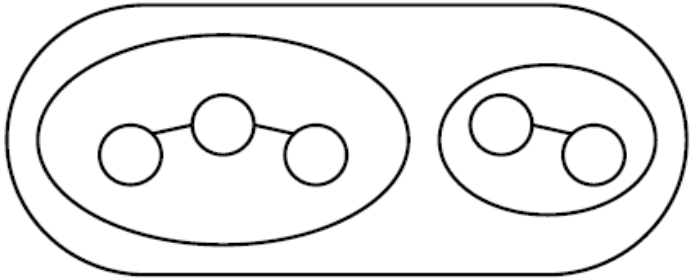
- Written rules of play (what happens when I...)
  - User manual
  - Game code
- Unwritten rules
  - Etiquette
  - Sportsmanship
- Object of the game (how do I win the game)
  - Clear
  - Achievable
  - Rewarding/Fun

Game Mechanics: Environment

- Spaces
  - Discrete or continuous?
  - Boundaries?
  - Nested Spaces?
- Number of players
  - Computer
  - Human
- Physics
  - Interaction of objects







Game Mechanics: Actions

- Primitive Actions (private's view)
  - Moving the player
  - Shooting
- Strategic Actions (general's view)
  - Protecting a zone
  - Ambushing

- Most games require combination of both types of actions

Game Mechanics: Chance

- Adds a surprising or unexpected elements
  - The so called "secret of fun”
- Consider how probabilities will factor into the play over the duration of the game
  - Power-ups
  - Density of projectiles
- Some predictability is useful! Why?
- The “chance trade-off”
  - A lot of randomness: game is about tactics, short term
  - A little randomness: game is about strategy, long term
  - Good games have the right mix

Game Mechanics: Skills

- Idea: The right amount of challenge will keep the player interested
- Three types of skills:
  - Physical Skills
    - Strength, dexterity, coordination, and endurance
    - E.g. How fast can I hit that button?
  - Mental Skills
    - Memory, observation, and problem solving
    - E.g., The answer is …
  - Social Skills
    - Reading and fooling opponents
    - Coordinating with teammates
- Many successful games combine skills from multiple categories

Project Management

The Problem

- A project consists of many parts
  - Tasks
  - Goals and milestones
  - Dependencies
  - Resources
  - Risks
- To complete a project
  - Finish all tasks on time
  - Accomplish all goals
  - Satisfy all dependencies
  - Use only the allocated resources
  - Adapt to things going wrong

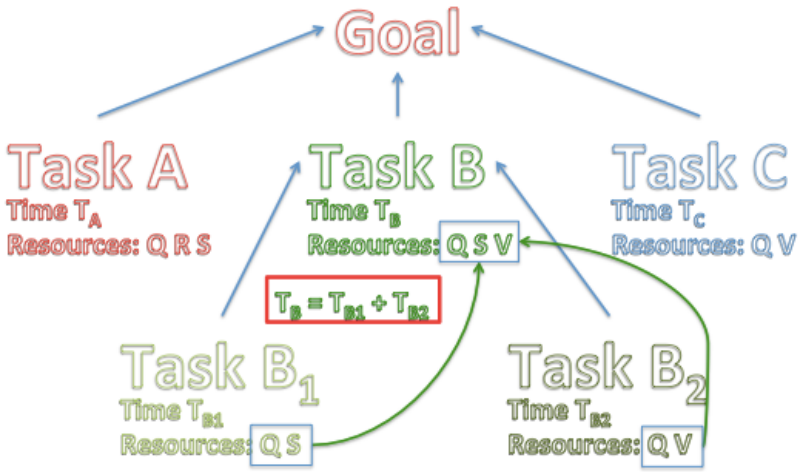
The Solution

- Things to consider
  - Tasks take a set amount of time
  - Some task must precede other tasks
  - Resources are limited
  - Things go wrong
- Things to do
  - Identify and schedule tasks
  - Allocate resources
  - Anticipate and manage risks
  - Complete a project on time and on budget

Identifying the Tasks

- A task
  - Takes a minimum amount of time to complete
  - Requires specific resources
  - Requires certain other tasks to be completed first
  - Must be completed before other tasks can begin
  - May take longer than expected due to unanticipated events
- For each task identify
  - What the task is
  - What resources it requires
  - What tasks does it depend on
  - How much time it will take

- Idea: Work backwards (reverse engineering)
  - Start with the end goal
  - Ask what task(s) are needed to achieve the goal
  - Ask what resources are needed for the tasks
  - For each task break it down into subtasks and repeat



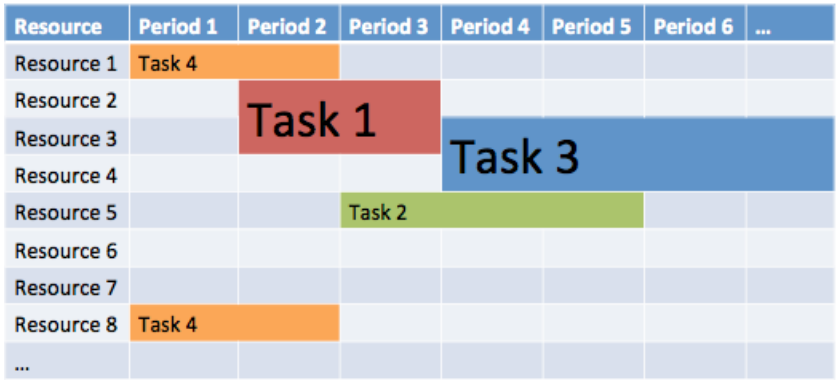
Scheduling Tasks

- Problem
  - There are many tasks
  - There are many resources
  - Each task may have multiple dependencies
- Need to
  - Organize all tasks in one place
  - Sort dependencies
  - Check for resource contention
- Idea: Use a Gantt chart

The Gantt Chart

The Purpose

- Represent all tasks
- Represent resource use
- Represent dependencies
- Represent time of tasks



Gantt Chart Rules

- Time is represented horizontally (left to right)
- Resources are denoted vertically
- A task requires both time and resources
  - Represented by one or more rectangles
- If two tasks require the same resource, they cannot overlap
- If task A depends on task B, task A must follow task B
- The minimum amount of time needed to fit in all the tasks is the minimum amount needed for the project

Scheduling Issues

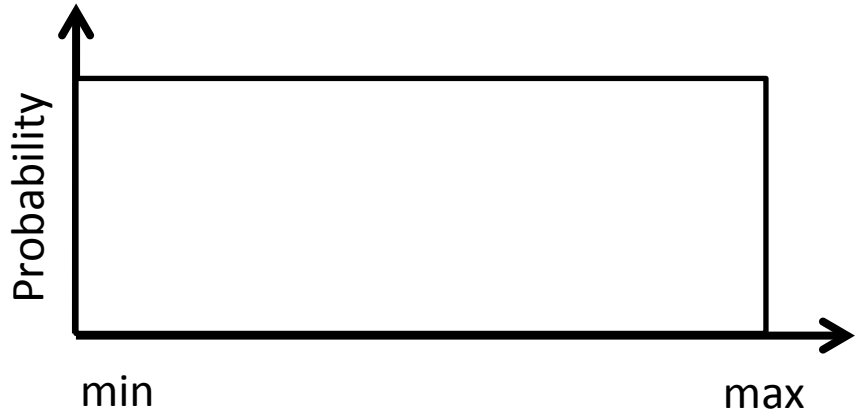
- Dependency chains
  - Task A depends on B depends on C depends on D …
  - Time of longest chain is the minimum time of the project
  - Place longest chain first
  - Then the next longest …
- Resource contention
  - Tasks cannot use a resource at the same time
  - A *bottleneck* occurs when many tasks need the same resource
  - Stagger tasks to avoid resource contention
  - Add more resources to reduce contention
- Risk Management
  - Schedule tasks as early as possible to provide time to deal with unforeseen events
  - Schedule extra time for each task

Using Randomness

- Idea: Most systems have a pseudorandom source of values
  - The source is an infinite sequence of values
  - The values look random
  - Are sufficiently random for our purposes
- Each system is a little different, but all work similarly
  - Each system provides a `Random` function
  - The function returns a value chosen randomly from a fixed range

pick random 1 to 10 in Scratch

- Scratch has a pick random 1 to 10 function
- Returns a value in the range min ≤ n ≤ max
- Value is selected at random from a *uniform distribution*
- What does a uniform distribution mean?



Projectiles

- A projectile
  - Appears on the stage when the player/opponent does something
  - Appears initially at the player/opponent's location
  - Moves away from the player/opponent in a set direction
  - Disappears when it hits something
  - Causes opponent/player to react in some way
- Projectile Life-Cycle
  - Initiation: Determine when the projectile is to be created
  - Creation: Create, position, and launch the projectile
  - Motion: Move the projectile along the stage
  - Collision: Check if collisions occur and respond to them
  - Elimination: Remove projectile if it collides or leaves the stage

Projectile Initiation and Creation

Initiation

- Idea: A projectile is initiated as a result of an event
- Player events:
  - Mouse click or key press
  - Collision with another object
- Game (opponent) events:
  - Random or regular time intervals
  - Collision of objects within the game
  - Start of game or level (e.g., the ball in BrickBreaker)
- Idea:
  - Broadcast NEW_PROJECTILE when a projectile is needed
  - The projectile sprite will receive the event and create the projectile

Creation

- Idea: Projectiles are created by an event listener
- To create a projectile
  - Projectile sprite
    - Receives NEW_PROJECTILE
    - If sprite is not a clone and a projectile can be created
      - Set position
      - Set speed
      - Set direction
      - Clone self
  - Projectile clone
    - Marks itself as a clone
    - Set itself as visible

Projectile Motion and Collision

Motion

- Idea: Projectiles move just like all other objects
  - Add velocity to position on each `FRAME event`
- Idea: `FRAME` handler may also
  - Adjust velocity of projectile as game mechanics dictate
- Note: The original projectile sprite should never move and always remain hidden

Collision

- Idea: Purpose of projectiles is to collide!
- Idea: On FRAME events
  - If projectile has collided with a game object
    - Create some special effects
    - Adjust state of game object
    - Remove projectile from stage
  - if projectile has moved off-stage
    - Remove projectile from stage

Projectile Elimination

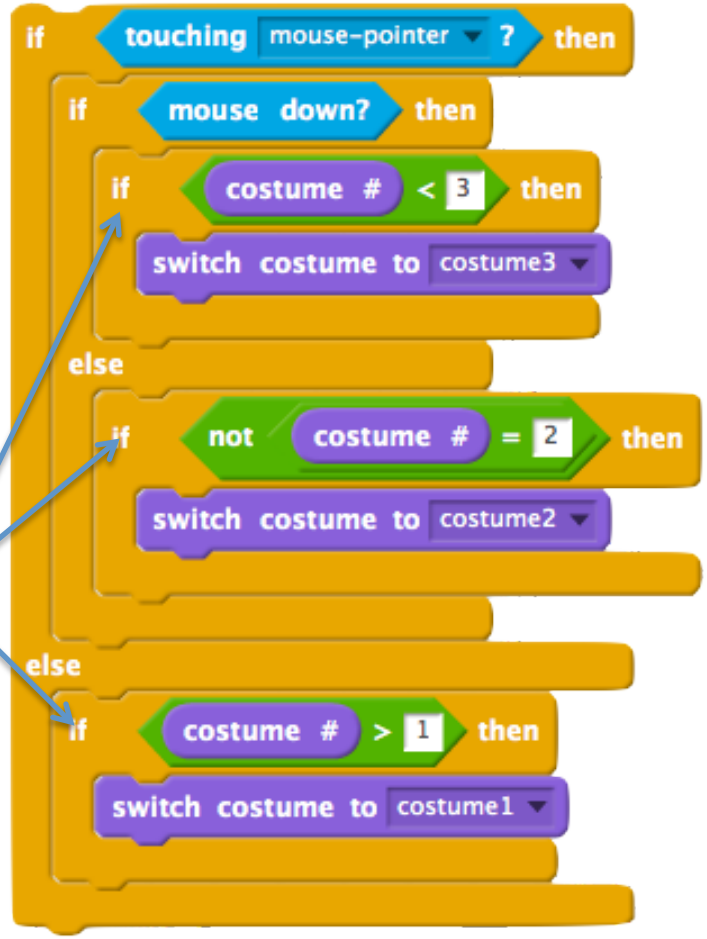
- Idea: Once a projectile moves off-stage or has collided, remove it!
- Your game will slow down if you do not!

Buttons

- Buttons are screen objects that identify an action and how to perform it
- Buttons identify an area for a user to click on
- Buttons generate an event that the application can respond to by running a listener
- A button has three (3) states
  - **Up** is the normal state of the button
  - **Over** is when the mouse is hovering on the button
  - **Down** is when the button is pressed
- Idea: For each of the three states the button can have a different look
- Idea: When the button changes state, it generates an event

Creating Buttons

- Create *sprite with three costumes*
  - *Up*
  - *Over*
  - *Down*
- Have sprite receive `FRAME` event
  - If the mouse is touching the button
    If clicked **[Down]** use Costume 3
    Otherwise **[Over]** use Costume 2
  - Otherwise **[Up]** use Costume 1
- Only change costumes if necessary!
- When should we actually execute action associated with button?



Text

- It is useful for games to display text
  - Instructions
  - Player information (score, health, level, etc)
  - Dialogue
- There are two types of text that we can dislpay
  - *Static* text, which does not change during the game
    - Instructions
    - Dialogue
  - *Dynamic* text, which changes as the game progresses
    - *Player information*

Game Polish: Motivations

- A polished game is
  - More compelling and immersing
  - More likely to be played longer
  - More appealing to new players
- A polished game will
  - Get better reviews
  - Get more praise on social media and word of mouth
  - More likely become popular
  - Likely sell more copies
- It's in our interest to make sure that games are as polished as possible!

Game Polish

- Defn: A process to reduce the number of minor issues associated with the game
- This involves
  - Fixing minor bugs and anything that detracts from the consistency of the game
  - Touching-up graphics
  - Refining game mechanics
  - Adding minor features and special effects
- Idea: Schedule game polishing as part of your overall development plan
- Should be done throughout the game development cycle
- Done in concert with playtesting

Types of Game Polish

- Resolution of issues (1st Priority)
  - Stability
  - Consistency
  - Playability
  - Understandability
- Refinement of the game mechanics (2nd Priority)
  - Realism, environment, and actions
  - Graphics
  - Audio
- Additional features (3rd Priority)
  - Special effects
  - Side stories and bonus rounds
  - Easter eggs
  - Special objects