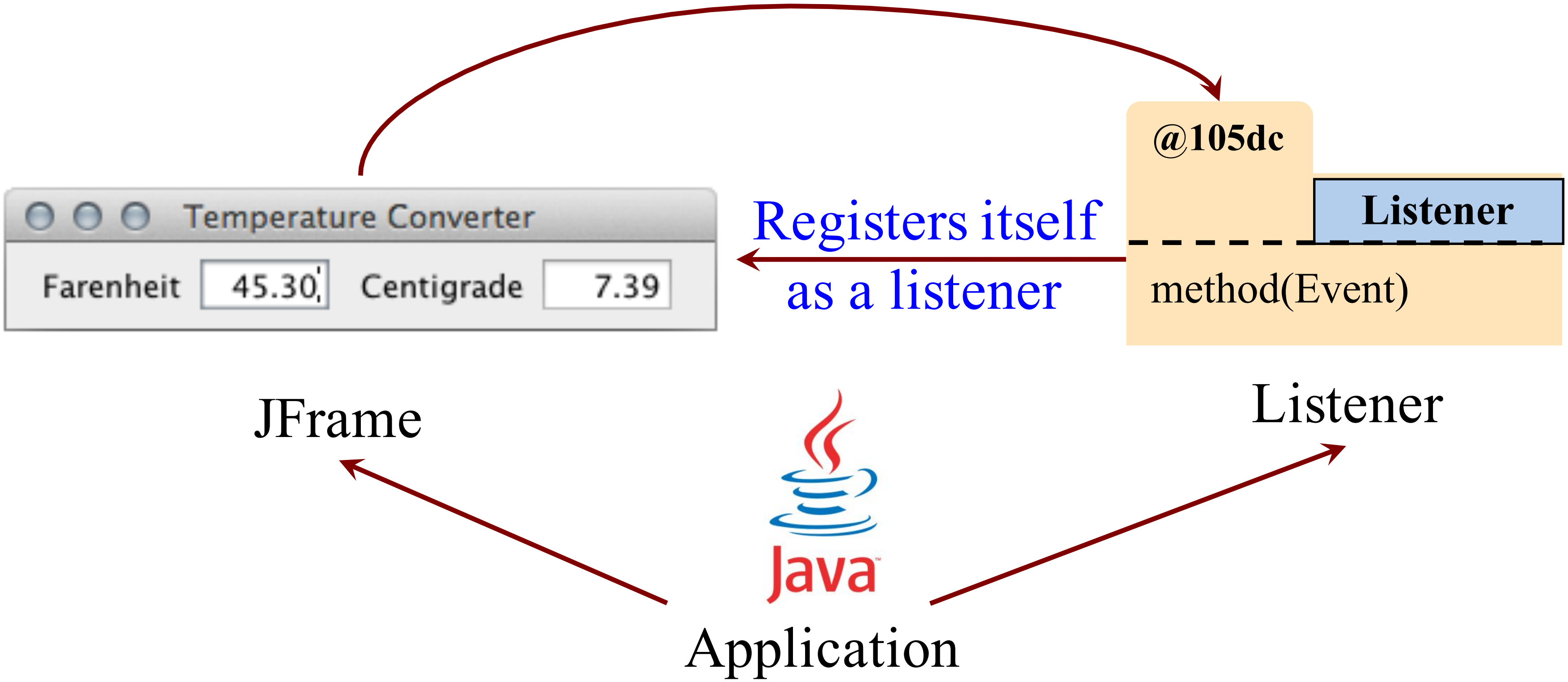
Lecture 10

Game Architecture

2110-Level Apps are Event Driven

Generates event e and then calls method(e) on listener



Temperature Converter

Farenheit 45.30 Centigrade 7.39

@105dc

Listener

method(Event)

Registers itself as a listener

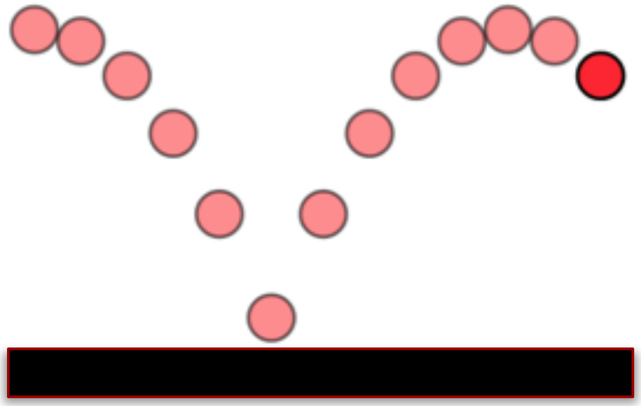
JFrame

Listener

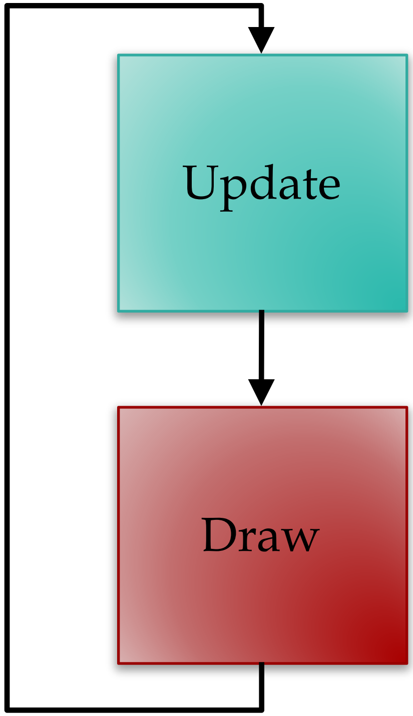
Application

Limitations of the Event Model

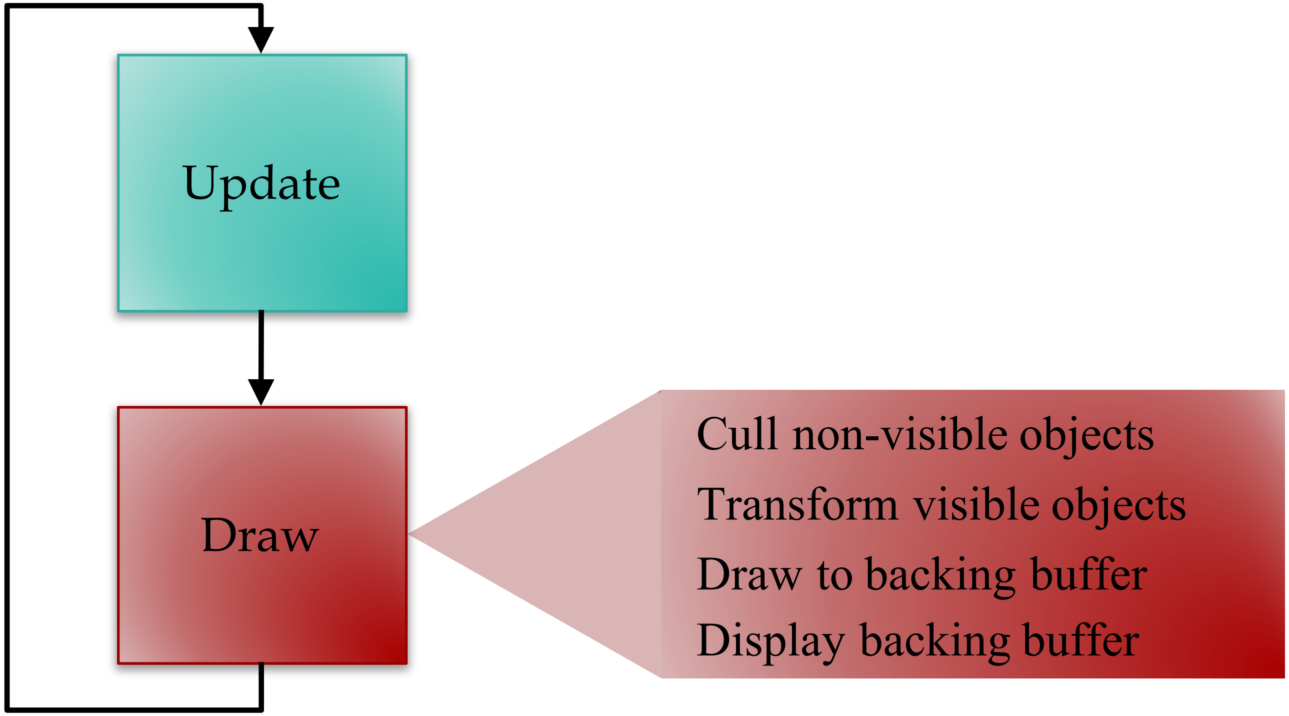
- Program only reacts to user input
  - Nothing changes if user does nothing
  - Desired behavior for productivity apps
- Games continue without input
  - Character animation
  - Clock timers
  - Enemy AI
  - Physics Simulations



The Game Loop



The Game Loop



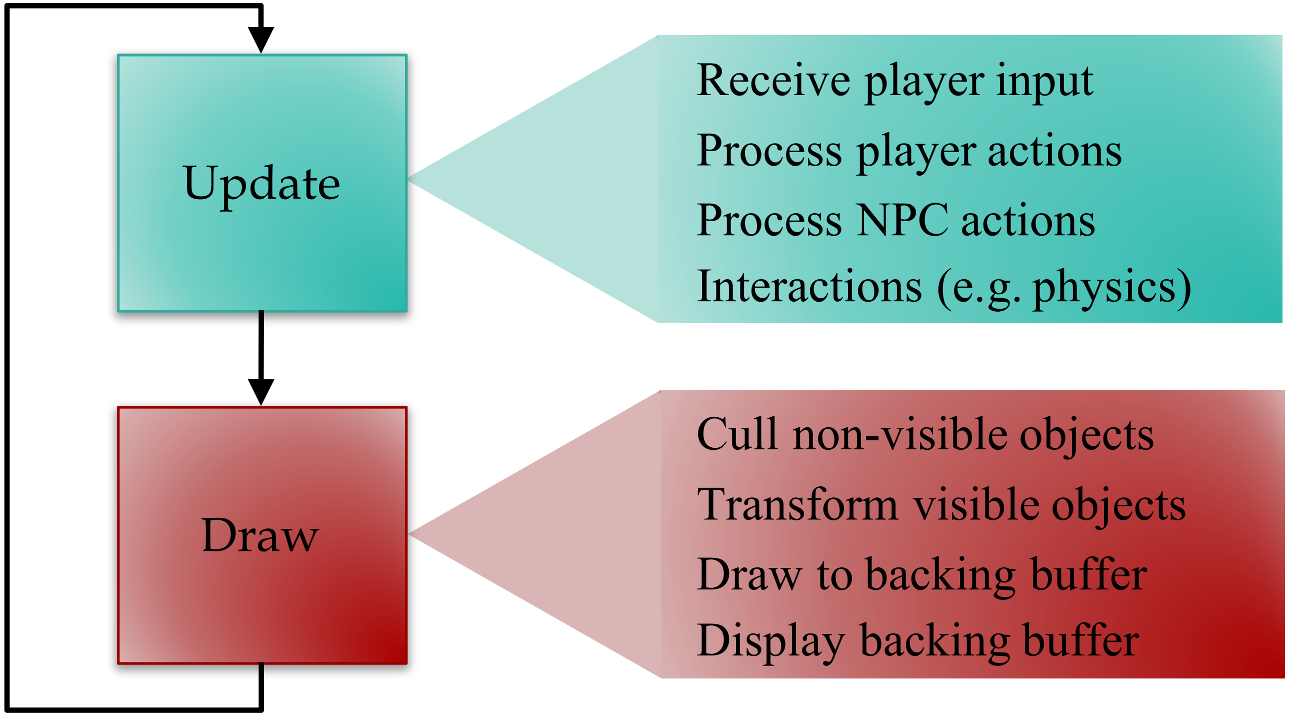
Cull non-visible objects

Transform visible objects

Draw to backing buffer

Display backing buffer

The Game Loop



Receive player input
Process player actions
Process NPC actions
Interactions (e.g. physics)

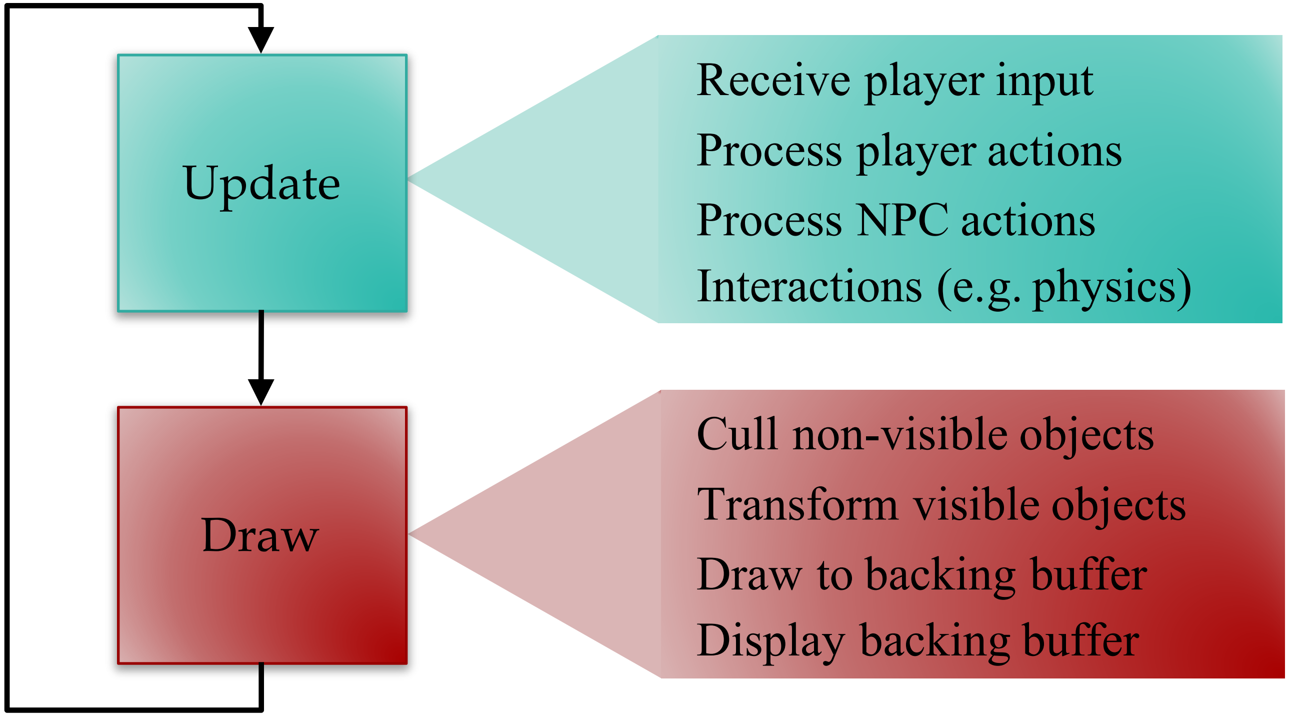
Cull non-visible objects
Transform visible objects
Draw to backing buffer
Display backing buffer

The Game Loop

60 times/s

=

16.7 ms



Update

- Receive player input
- Process player actions
- Process NPC actions
- Interactions (e.g. physics)

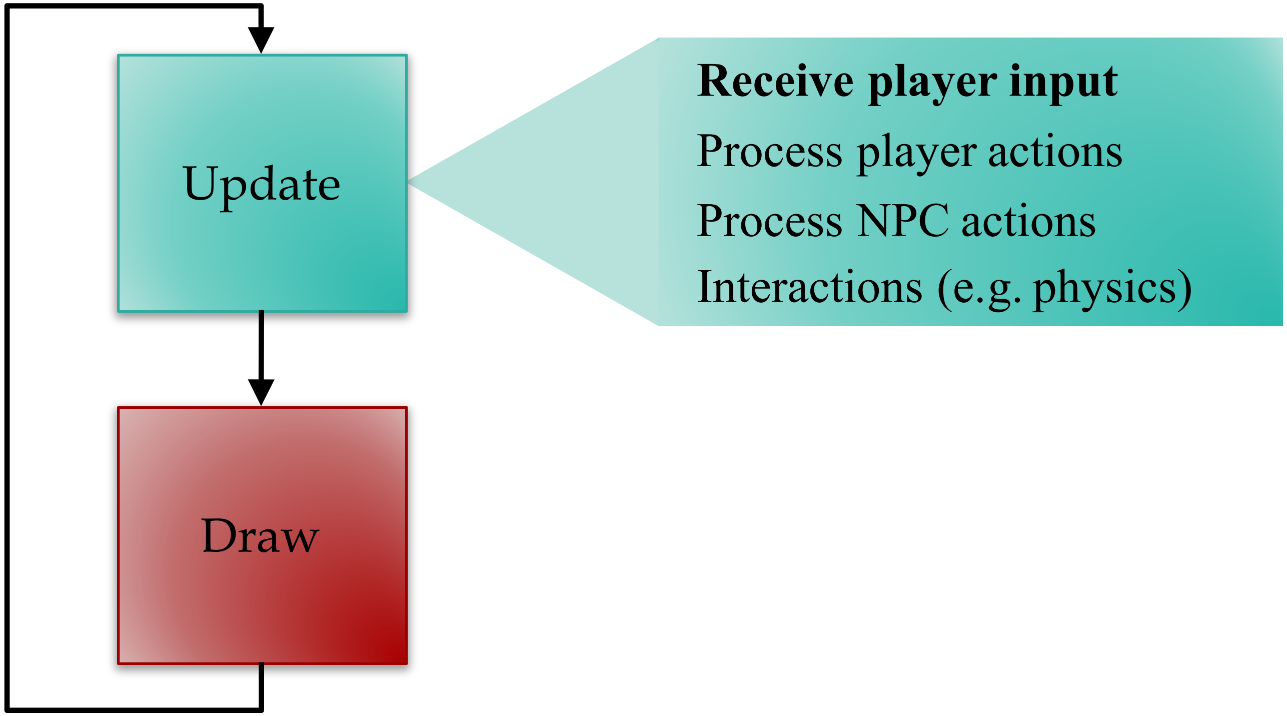
Draw

- Cull non-visible objects
- Transform visible objects
- Draw to backing buffer
- Display backing buffer

Few Words on Drawing

- Drawing needs to be **fast**!
  - Do as little computation as possible
  - But draw as few objects as possible
- Is this a contradiction?
  - Need to compute who to draw
  - So drawing *less* has extra overhead
- **Rule**: do **not** modify game state in draw
  - Any extra computation is local-only

The Game Loop



Receive player input

Process player actions

Process NPC actions

Interactions (e.g. physics)

Player Input

- Traditional input is event-driven
  - Events capture state of controller
  - OS/VM generates events for you
  - Listeners react to events

- Game loop uses **polling** for input
  - Ask for controller state at start of loop
  - **Example**: What is joystick position?
  - If no change, do no actions that loop

Problem with Polling

- Only one event per update loop
  - Multiple events are lost
  - **Example**: Fast typing
- Captures state at beginning
  - Short events are lost
  - **Example**: Fast clicks
- Event-driven does not have these problems
  - Captures all events as they happen

Combining Input Approaches

- LibGDX input is extremely flexible
  - Every input type supports events OR polling
- **Polling**: Input interface
  - Access it through the static class GDX.Input
  - Allows you to read the input state right now
- **Events**: InputProcessor interface
  - Register it with the appropriate input device
  - Works exactly like Swing listeners

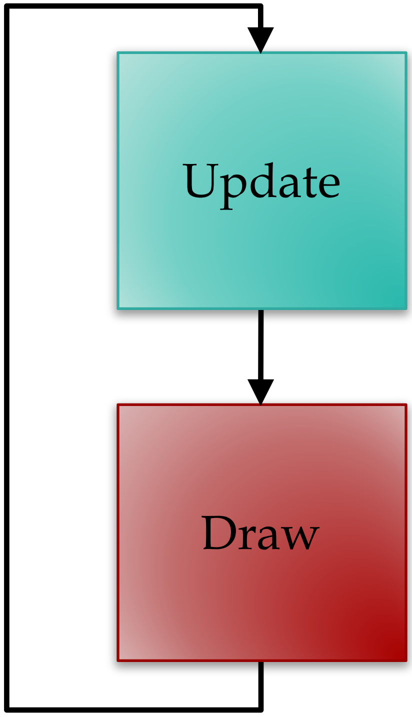
Problem: Timing

```
public class MyProcessor implements
        InputProcessor {

    public void keyTyped(char c) {
        //  Do something with input

    }

}
```



Update

Draw

How do these fit together?

Problem: Timing

```
public class MyProcessor implements
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    public void keyTyped(char c) {
        //  Do something with input
    }
}
```
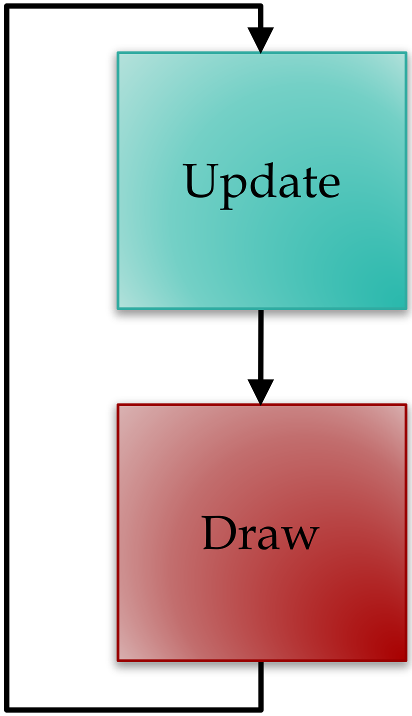
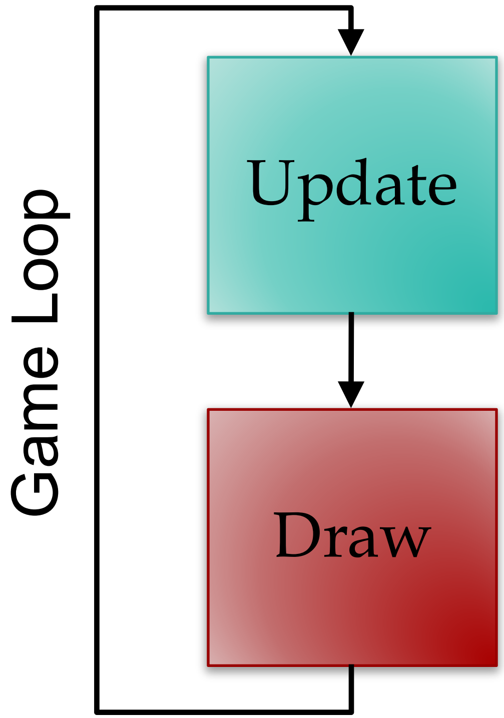



How do these fit together?

No control over when it is invoked

Classic Producer-Consumer Problem

Consumer



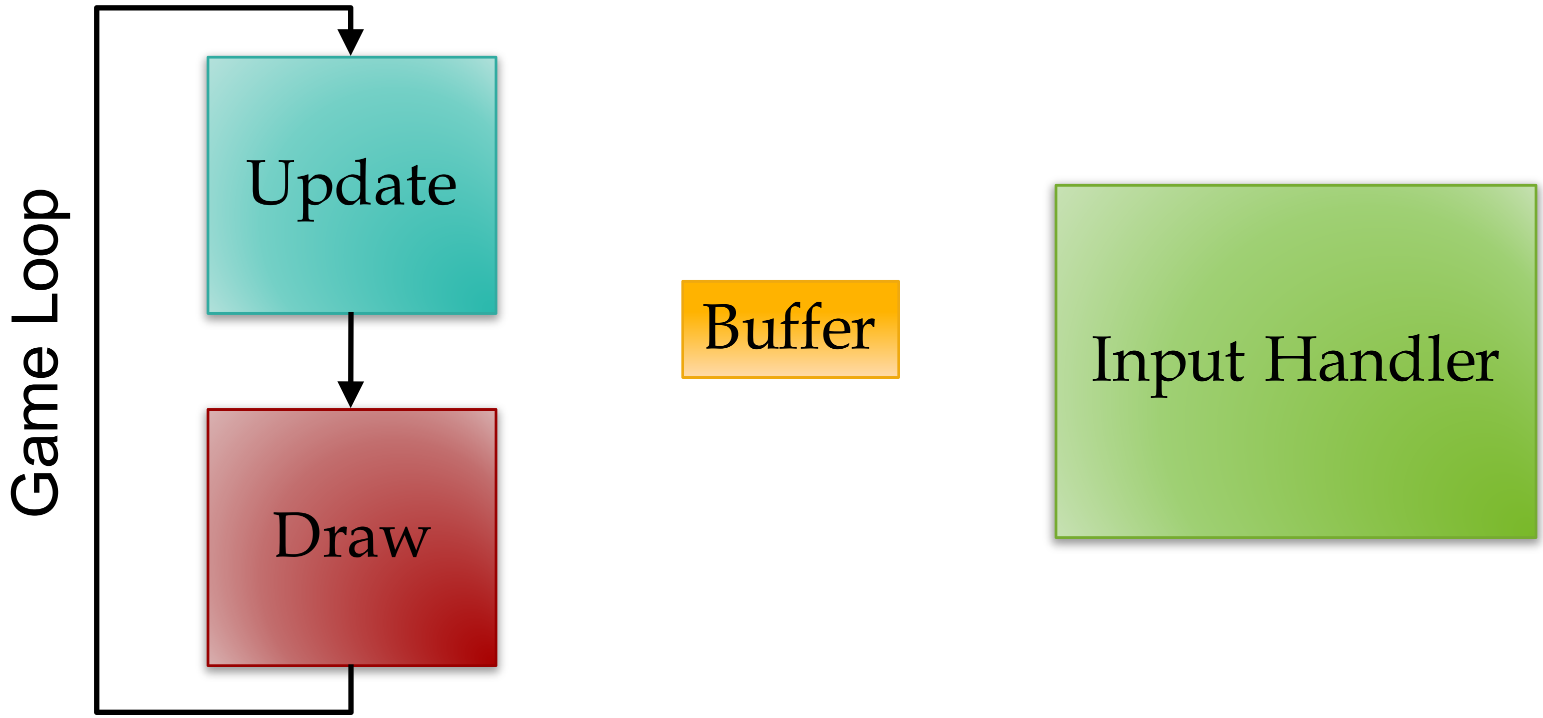
Producer

Input Handler

Classic Producer-Consumer Problem

Consumer

Producer



Classic Producer-Consumer Problem

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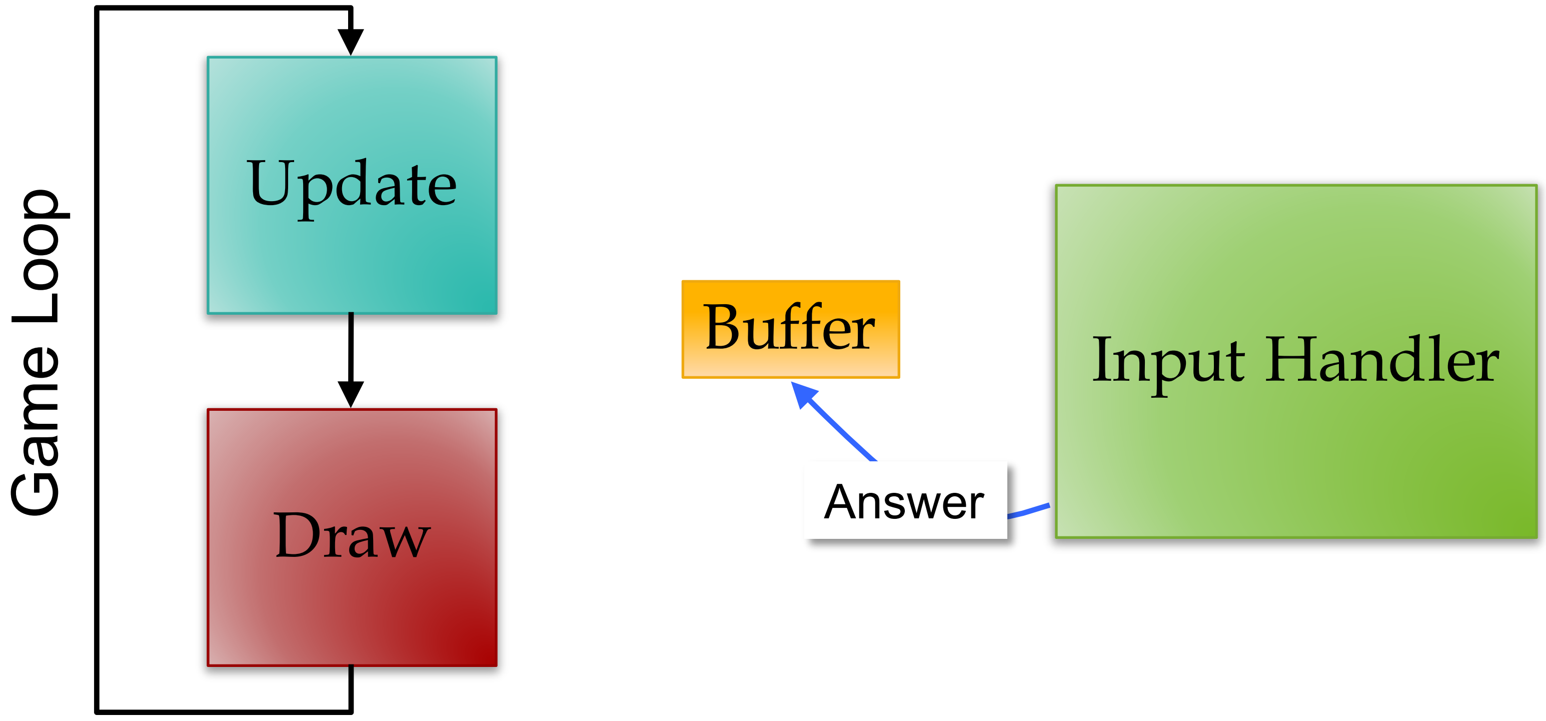
Producer



Classic Producer-Consumer Problem

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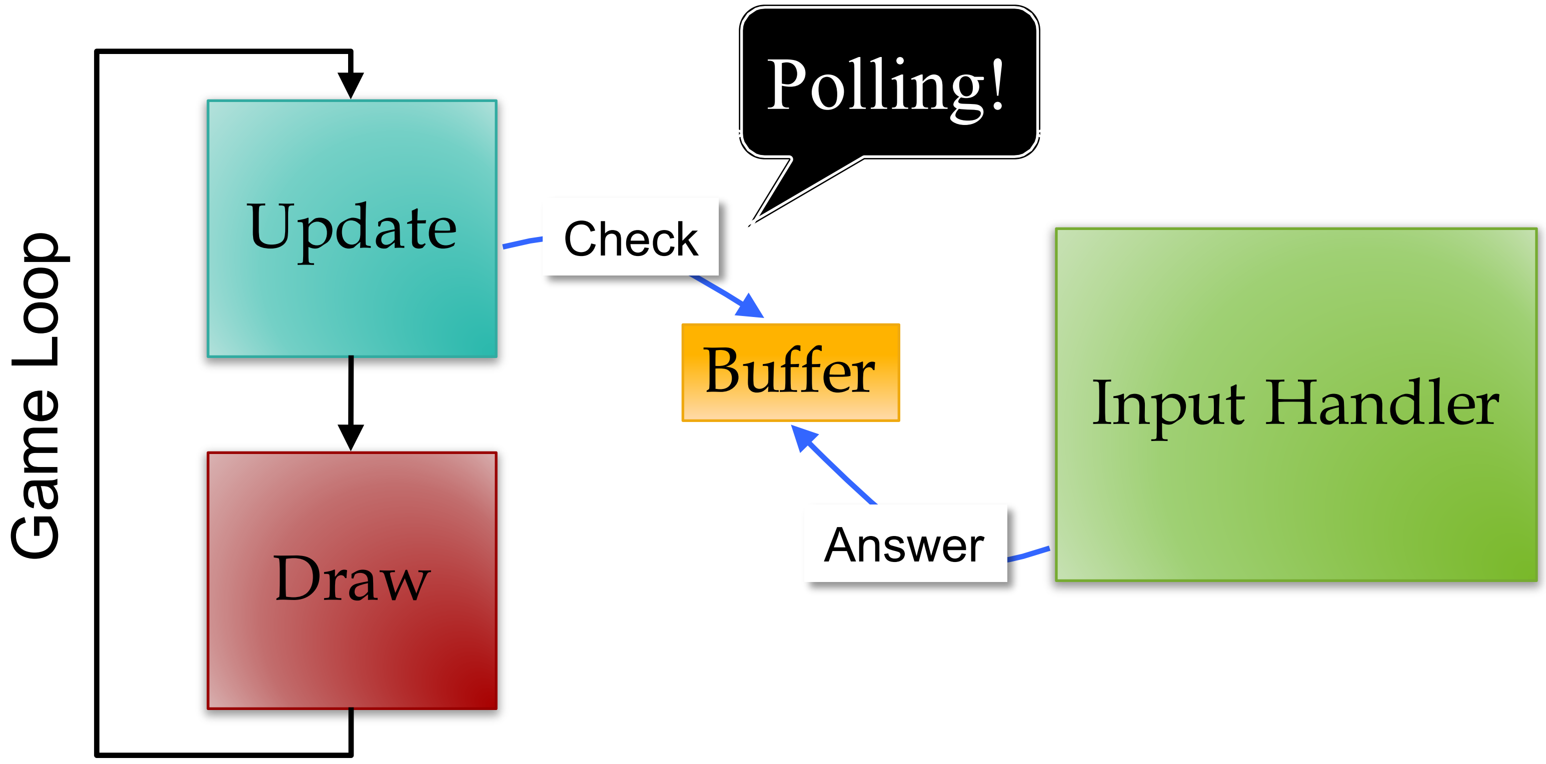
Producer



Classic Producer-Consumer Problem

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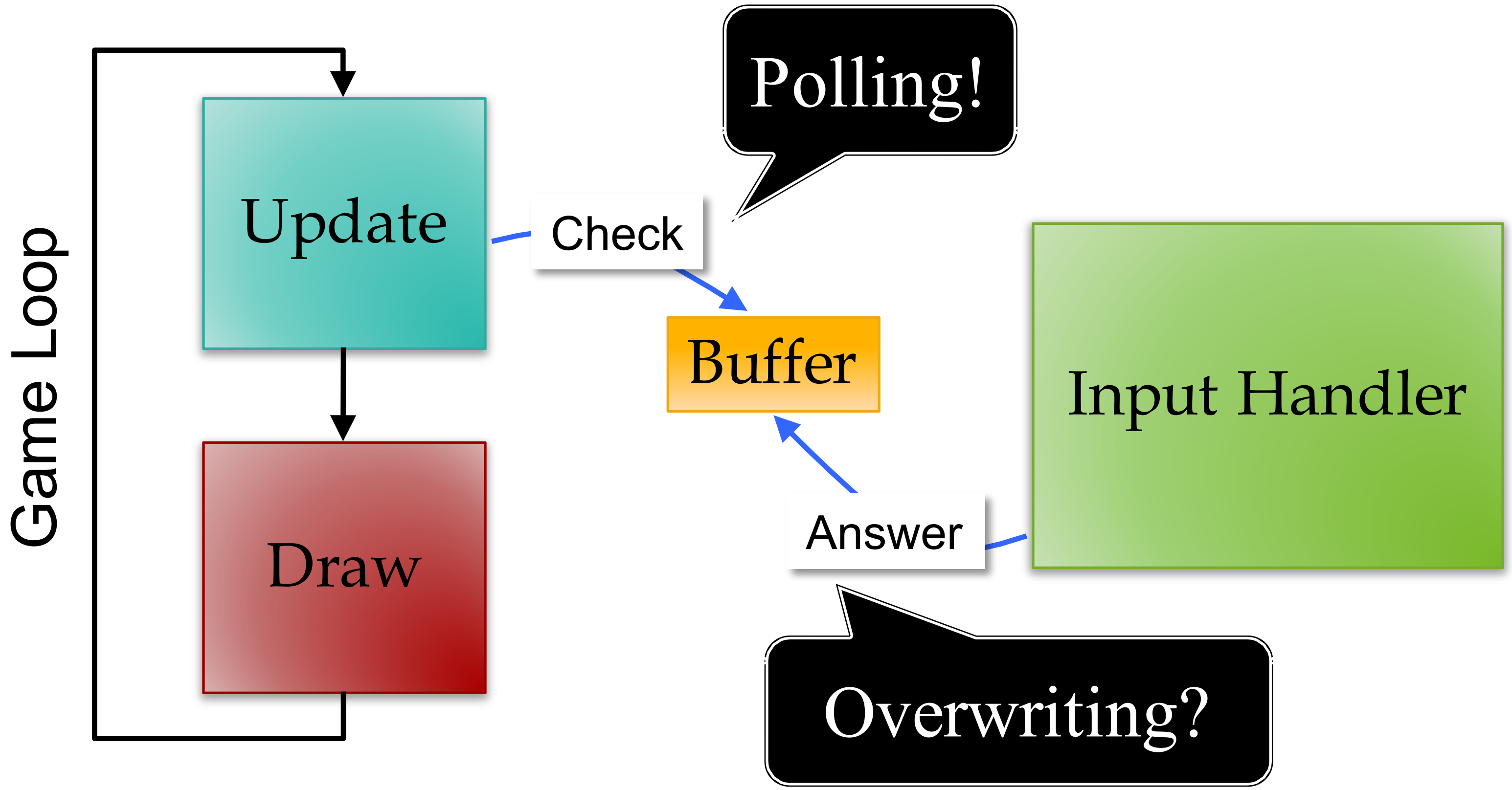
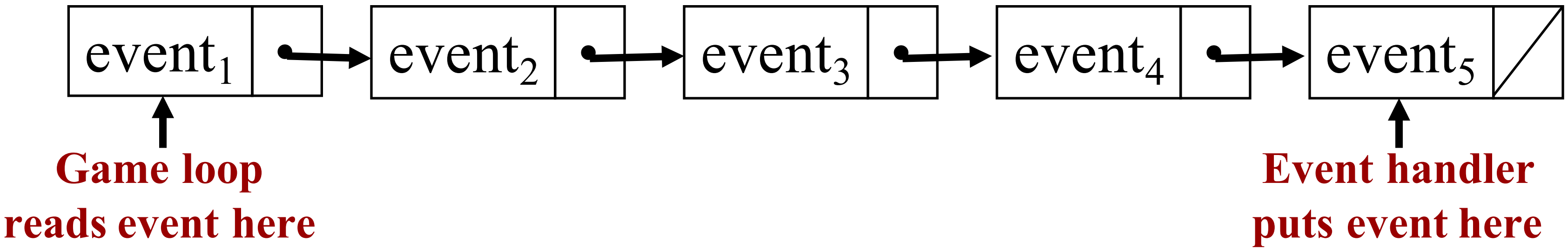
Producer



Buffering Input

- If overwriting an issue, need an event queue
  - Input processor writes at end of the queue
  - Game loop reads from the front of queue



- Generally requires multiple threads
  - Event handler is (usually) OS/VM provided thread
  - Game loop itself is an additional thread

Event Handlers: Really Necessary?

- Most of the time: **No**
  - Frame rate is short: 16.7 ms
  - Most events are > 16.7 ms
  - Event loss not catastrophic

- Buffering is sometimes undesirable
  - Remembers every action ever done
  - But may take a longer time to process
  - If takes too long, just want to abort

Picking the Right Input

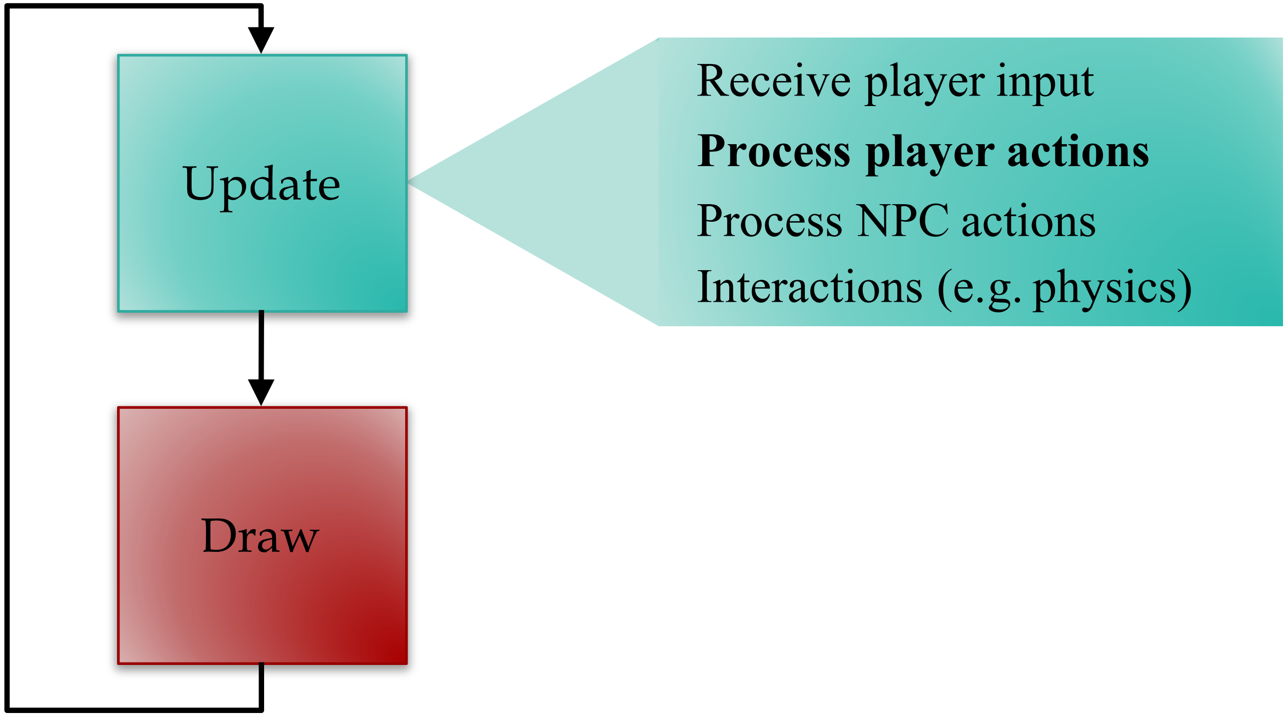
Polling

- When game loop is explicit
  - Actively animating screen
  - Must time input correctly
- **Example**: playing the game

Event Driven

- When game loop is implicit
  - Art assets are largely static
  - Nothing to do if no input
- **Example**: a menu screen

The Game Loop



Update

Draw

Receive player input

Process player actions

Process NPC actions

Interactions (e.g. physics)

Player Actions

- Actions alter the game state
  - Can alter player state: movement
  - Can alter opponent state: damage
- Player actions correspond to user input
  - Choice is determined by input controller
  - Else action is performed by computer
- These are your game **verbs**!

Abstract Actions from Input

- **Actions**: functions that modify game state
  - `move(dx,dy)` modifies `x`, `y` by `dx`, `dy`
  - `attack(o)` attacks opponent `o`
- Input controller **maps** input to actions
  - Read input state from controller
  - Pick an action and call that function
- Input handler should never alter state directly!

Abstract Actions from Input

- **Actions**: functions that modify game state
  - `move(dx,dy)` modifies `x`, `y` by `dx`, `dy`
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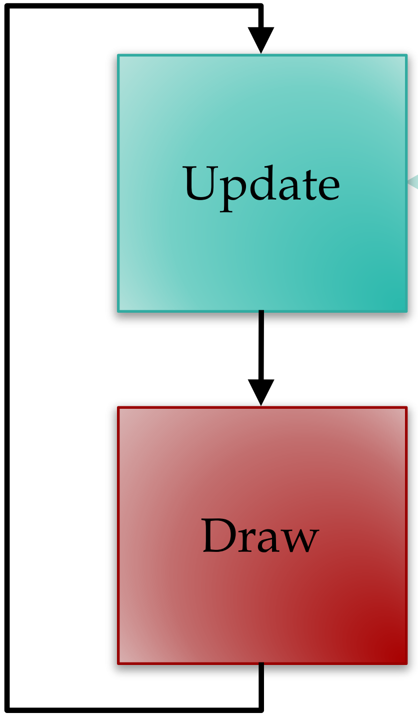
Design versus **Implementation**

- Input controller **maps** input to actions
  - Read input state from controller
  - Pick an action and call that function
- Input handler should never alter state directly!

The Game Loop



Receive player input

Process player actions

Process NPC actions

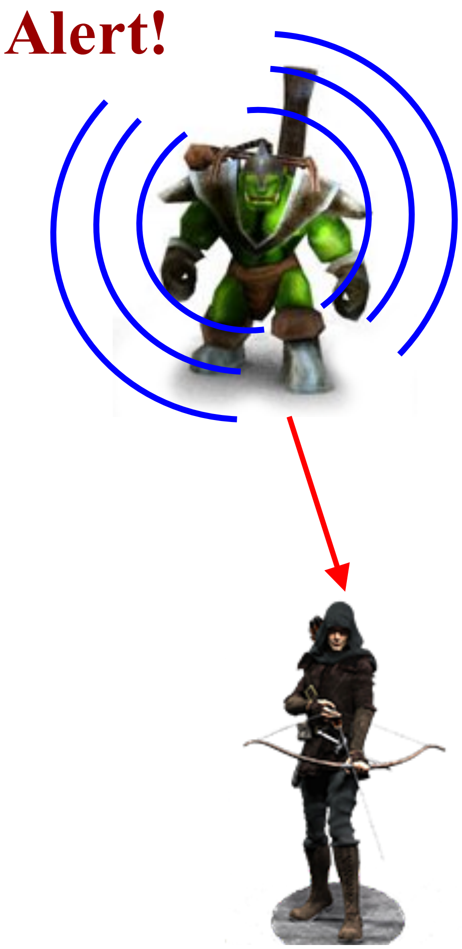
Interactions (e.g. physics)

NPC: Non-Player Character

- NPC is an intelligent computer-controlled entity
  - Unlike a physics object, it can act, not just interact
  - Sometimes called an *agent*
- NPCs have their own actions/verbs
  - But no input controller to choose
- Work on sense-think-act cycle
  - **Sense**: perceive the world around it
  - **Think**: choose an action to perform
  - **Act**: update the game state

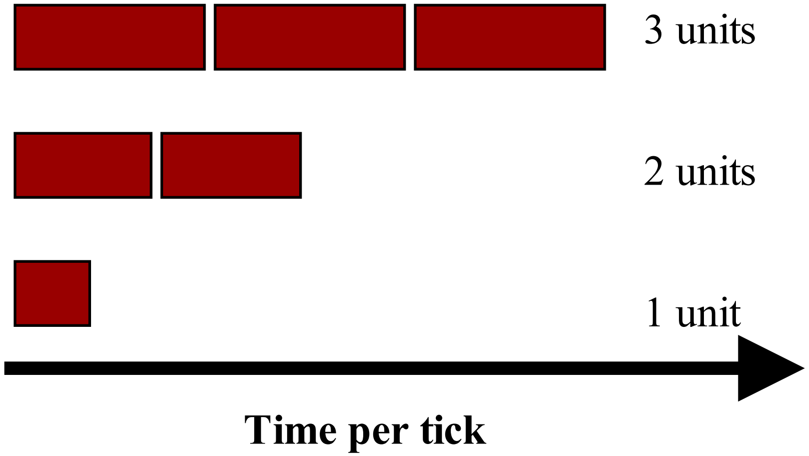
Act versus Sense-Think

- Act should be *very* fast!
  - Function to update state
  - **Example**: apply velocity
  - Exactly like the player
- Sense-think unique to NPC
  - The *hard* computation
  - Focus of AI lectures
- Multiplayer: Replace sense-think with human decision



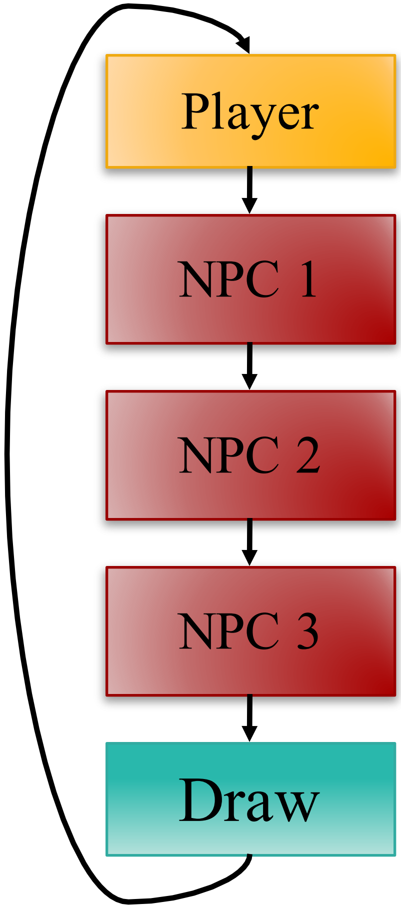
Problem with Sensing

- Sensing may be slow!
  - Consider *all* objects
- Example: morale
  - *n* knights, *n* skeletons
  - Knights fear skeletons
  - Proportional to # seen
- Count skeletons in view
  - O(*n*) to count skeletons
  - O(n^2) for all units



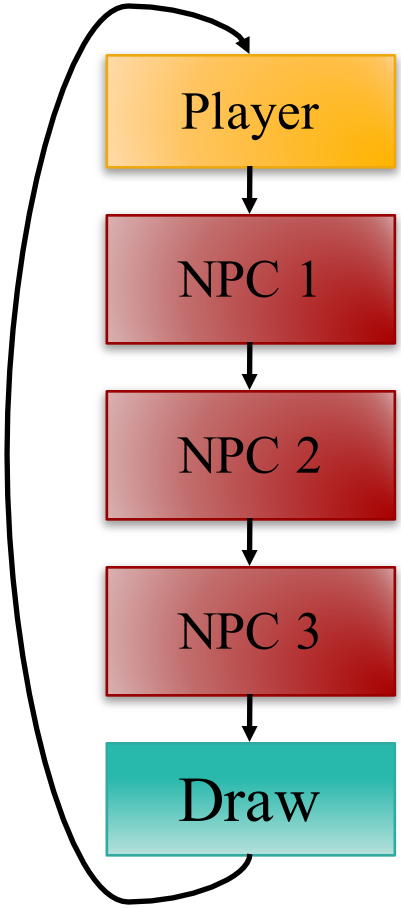
Processing NPCs

- Naïve solution: sequentially
- **Problem**: NPCs react too fast!
  - Each reads the actions of previous
  - Even before drawn on screen!

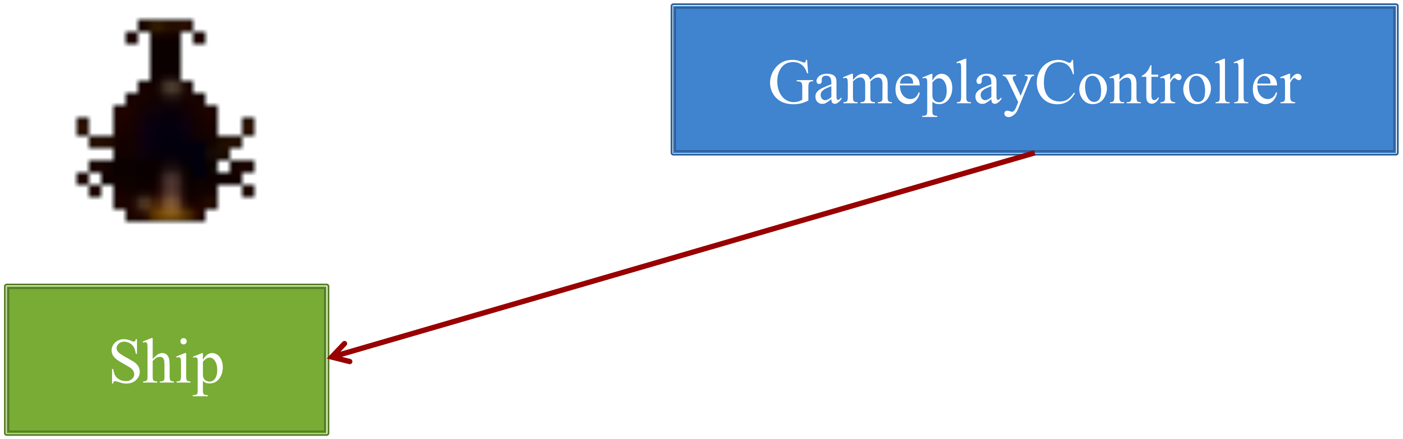


Processing NPCs

- Naïve solution: sequentially
- **Problem**: NPCs react too fast!
  - Each reads the actions of previous
  - Even before drawn on screen!
- **Idea**: only react to what can see
  - *Choose* actions, but don't perform
  - Once all chosen, then perform
  - Another reason to abstract actions



Processing Actions in Lab 3



GameplayController

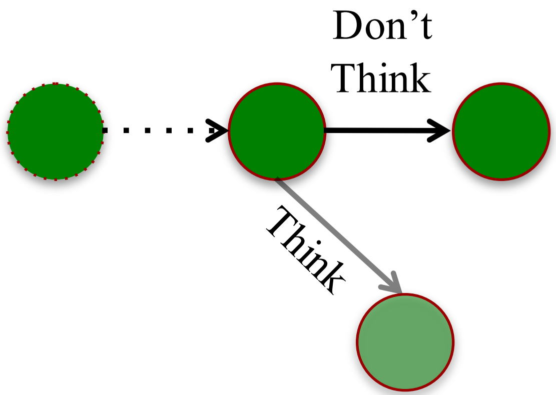
Ship

- Decides whether to shoot
- Stores intent in the object
- But **DOES NOT** shoot

- Waits until objects commit
- Checks intent in Ship object
- Performs action for intent

Acting Without Thinking

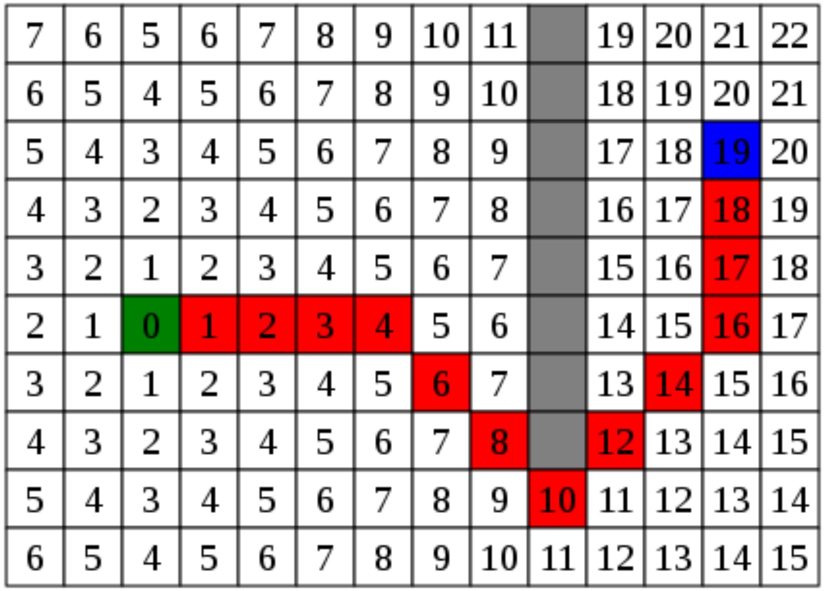
- Save time: don't think
  - Think every *few* frames
  - Unless then, just act
- Remember last action
  - Keep doing that action!
  - Use verb **and** parameters
- **Example**: Movement
  - Keep track of velocity
  - Apply each game loop



- Called **dead reckoning**
  - From nautical term
  - Important to networking
  - Will cover later in course

Problem: Pathfinding

- Focus of Game Lab 2
  - Crucial if top view
  - Major area of research
- Potentially very slow
  - *n* NPCs, *g* grid squares
  - Dijkstra: O(g^2)
  - For each NPC: O(ng^2)
- **Moving obstacles?**



7	6	5	6	7	8	9	10	11	▨	19	20	21	22
6	5	4	5	6	7	8	9	10	▨	18	19	20	21
5	4	3	4	5	6	7	8	9	▨	17	18	19	20
4	3	2	3	4	5	6	7	8	▨	16	17	18	19
3	2	1	2	3	4	5	6	7	▨	15	16	17	18
2	1	0	1	2	3	4	5	6	▨	14	15	16	17
3	2	1	2	3	4	5	6	7	▨	13	14	15	16
4	3	2	3	4	5	6	7	8	▨	12	13	14	15
5	4	3	4	5	6	7	8	9	10	11	12	13	14
6	5	4	5	6	7	8	9	10	11	12	13	14	15

Problem: Pathfinding

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  - Crucial if top view
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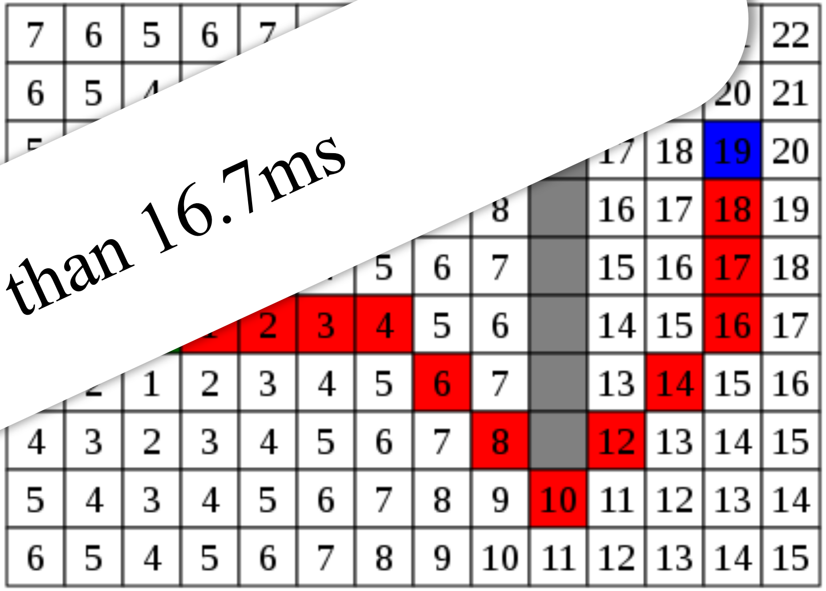
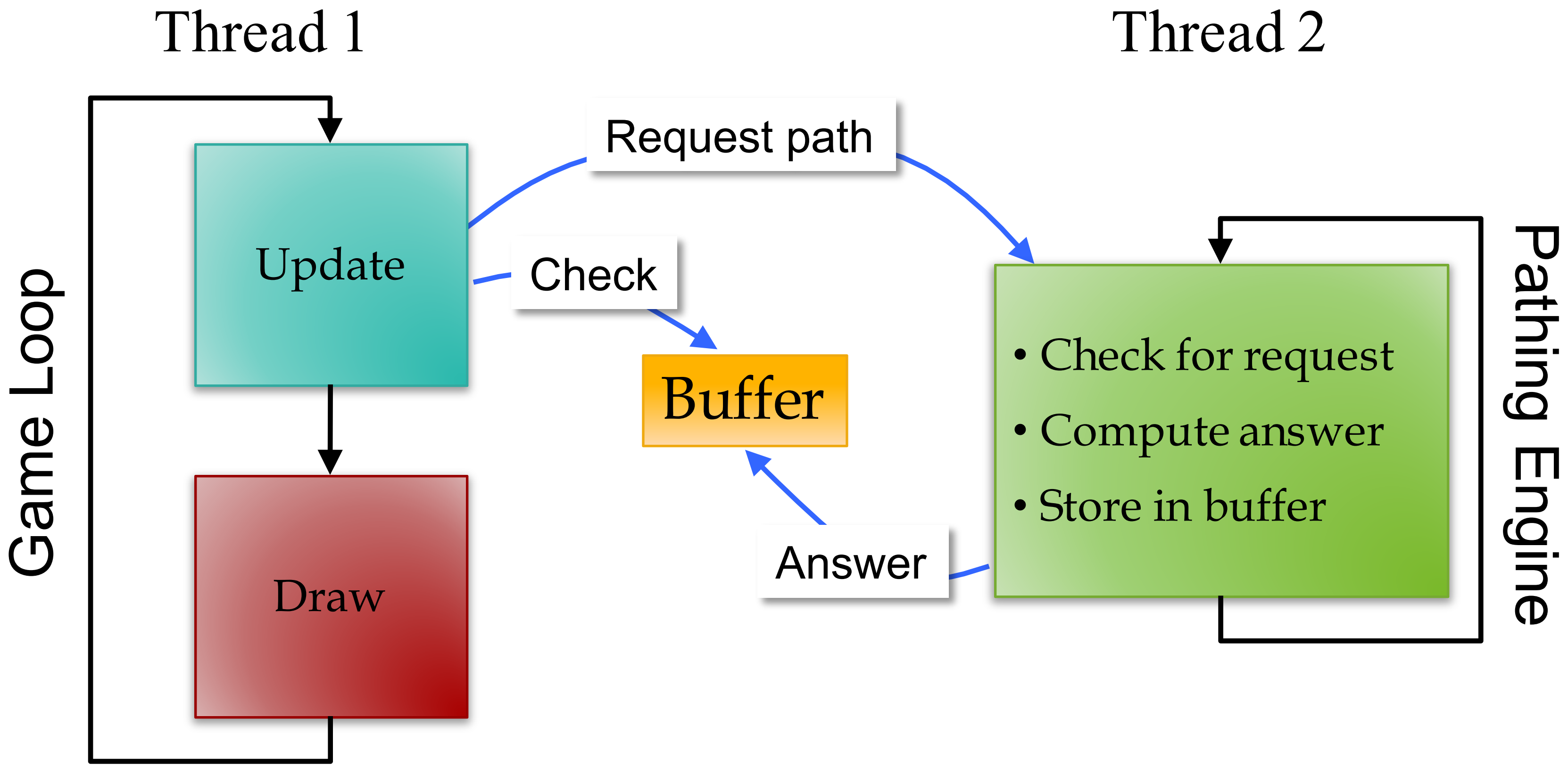


Often more than 16.7ms

Asynchronous Pathfinding

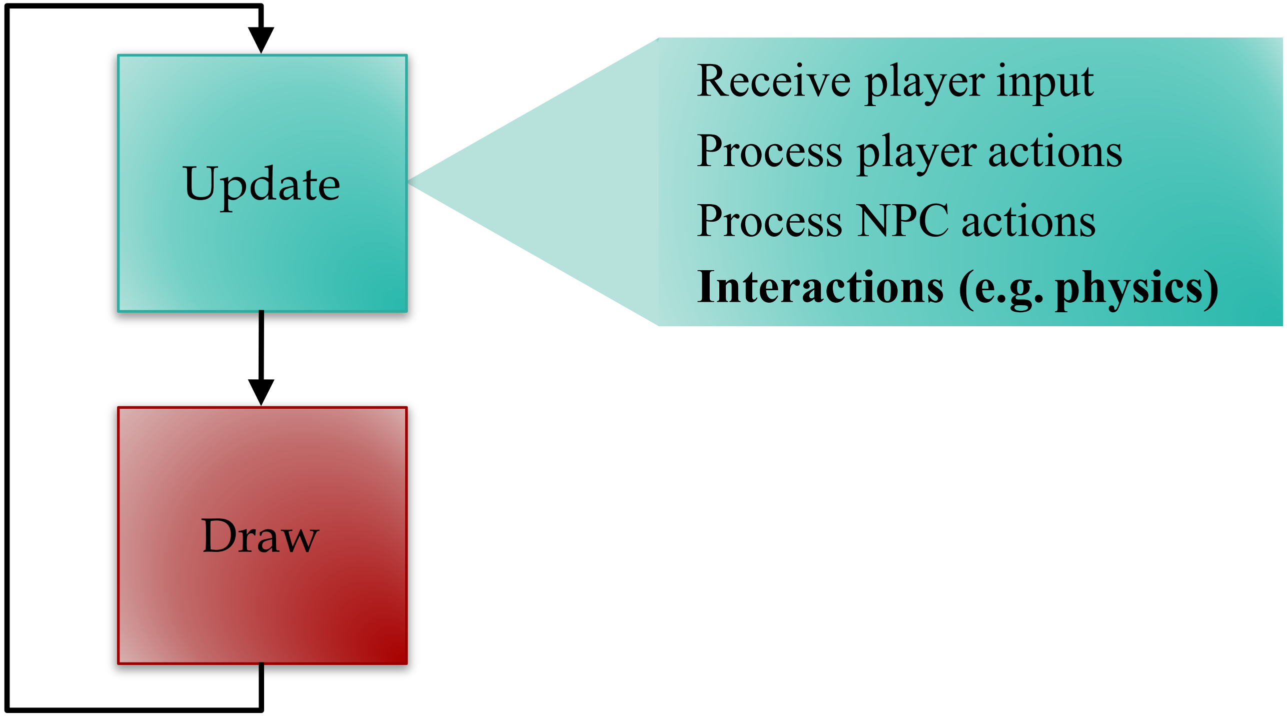


Looks like input buffering!

Asynchronous Pathfinding

- NPCs do not get answer right away
    - Check every loop until answered
    - Remember request; do not ask again
- What to do until then?
    - Act, but don't think!
    - If nothing, **fake** something
    - "Stomping Feet" in RTSs

The Game Loop



Receive player input

Process player actions

Process NPC actions

Interactions (e.g. physics)

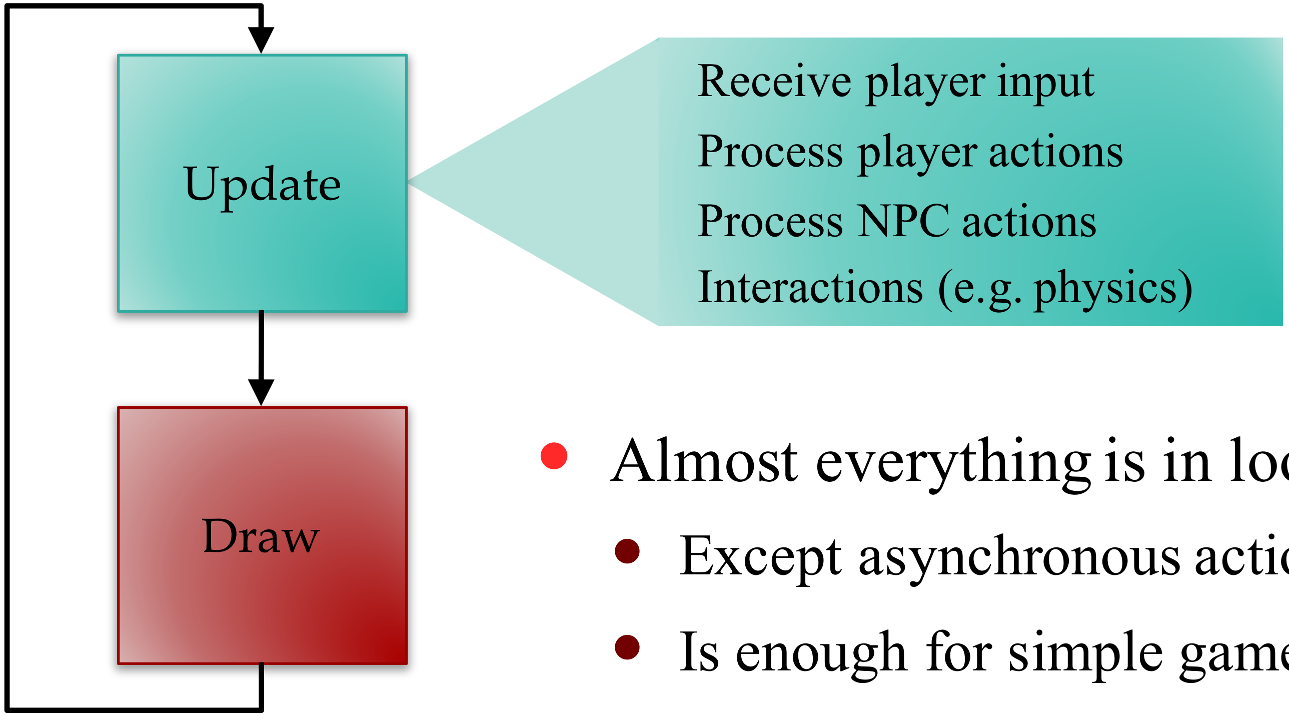
Purpose of a Physics Engine

- Moving objects about the screen
  - **Kinematics**: Without regard to external forces
  - **Dynamics**: The effect of forces on the screen
- Collisions between objects
  - **Collision detection**: Did a collision occur?
  - **Collision resolution**: What do we do?
- More on this issue later (~Spring Break)

Physics Engines: Two Levels

- **White Box**: Engine corrects movement errors
  - Update object state ignoring physics
  - Physics engine nudges object until okay
- **Black Box**: Engine handles everything
  - Do not move objects or update state
  - Give forces, mass, velocities, etc. to engine
  - Engine updates to state that is *close enough*

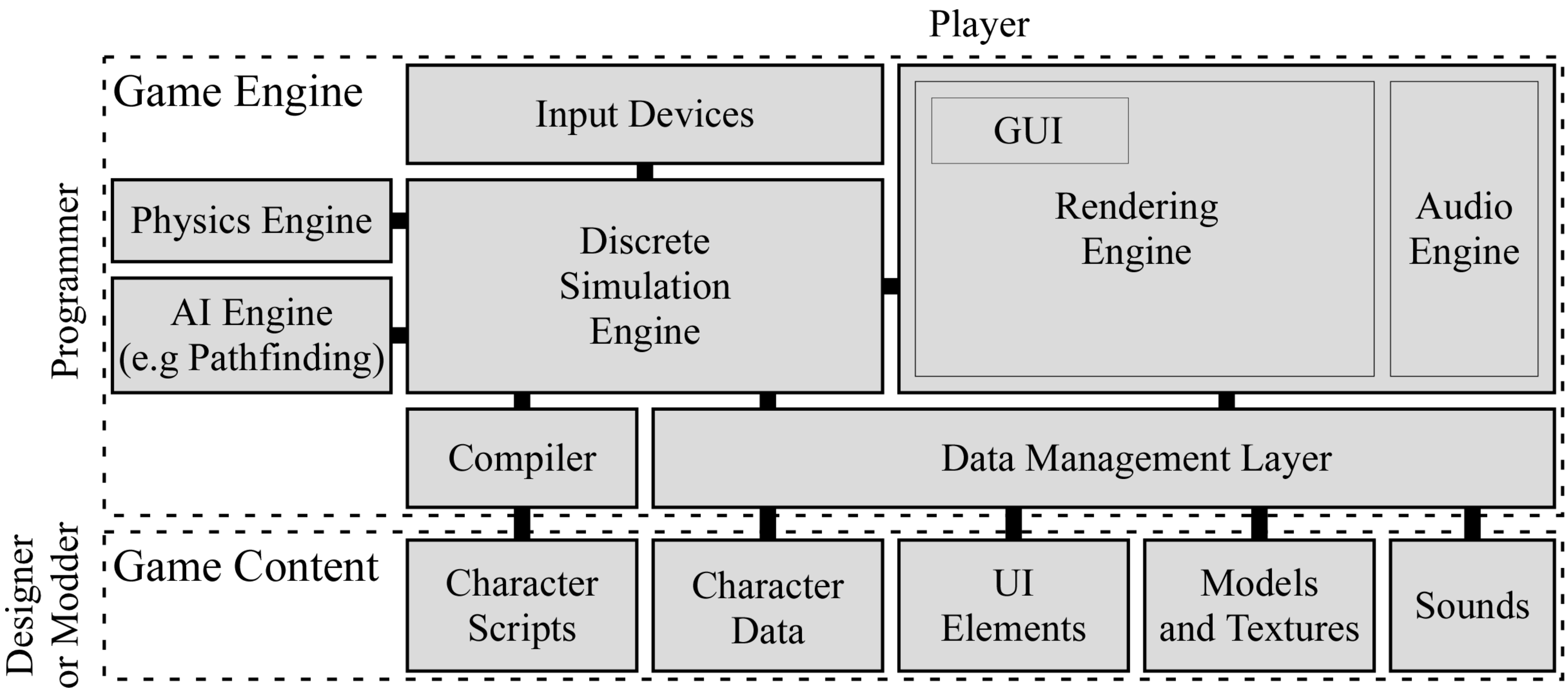
The Game Loop



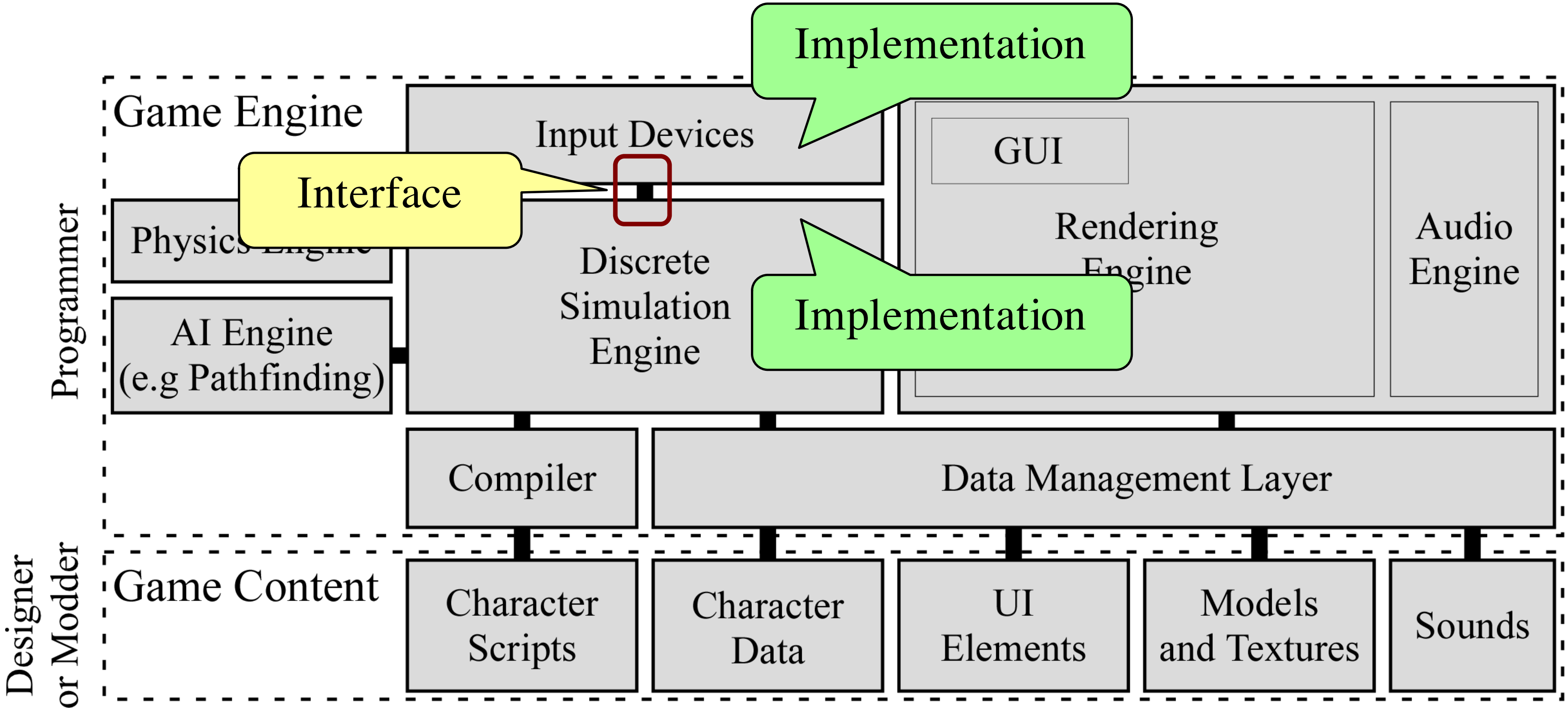
Receive player input
Process player actions
Process NPC actions
Interactions (e.g. physics)

- Almost everything is in loop
  - Except asynchronous actions
  - Is enough for simple games
- How do we organize this loop?
  - Do not want spaghetti code
  - Distribute over programmers

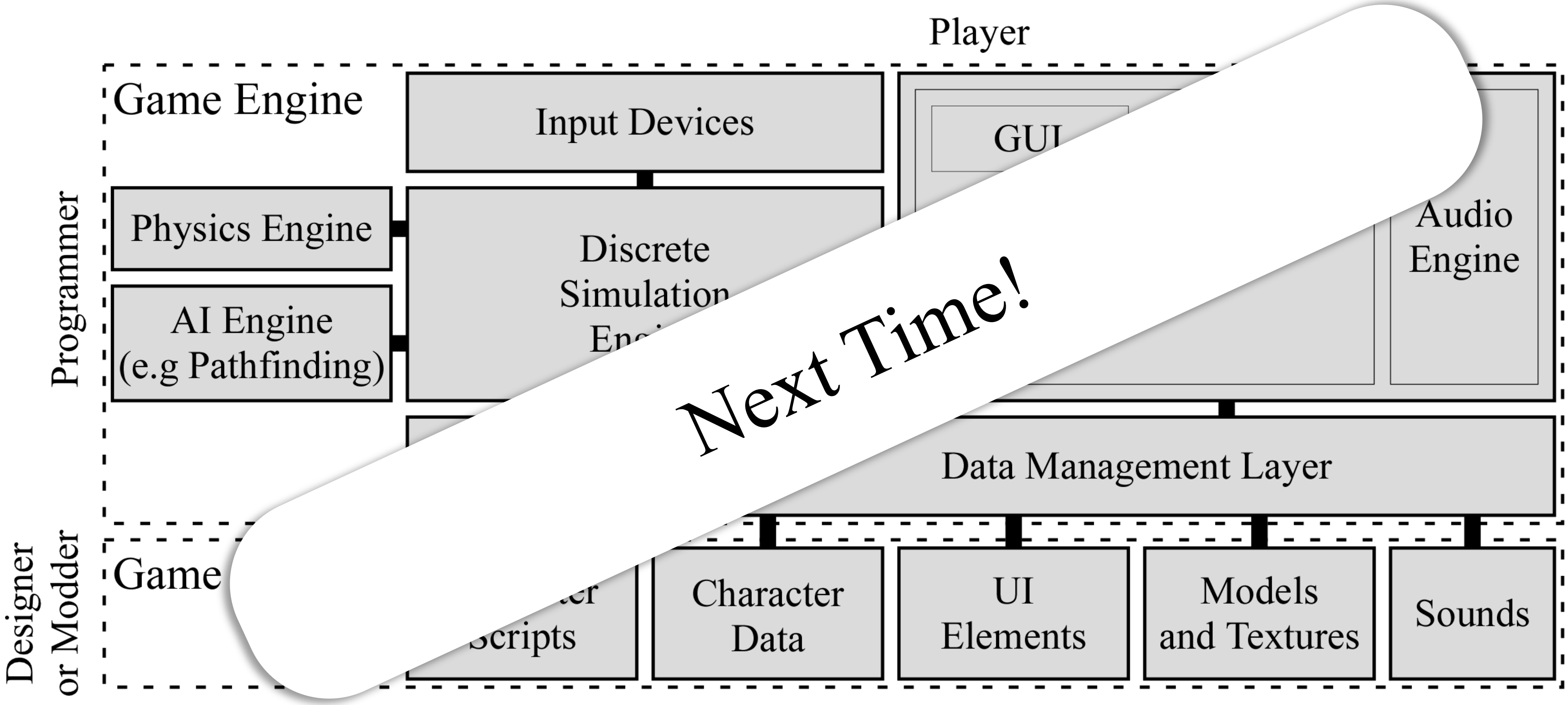
Architecture: Organizing Your Code



Architecture: Organizing Your Code



How Do These Relate?


Player
Game Engine
Programmer
Input Devices
GUI
Physics Engine
AI Engine
(e.g Pathfinding)
Discrete
Simulation
Eng
Audio
Engine
Data Management Layer
Designer
or Modder
Game
ter
Scripts
Character
Data
UI
Elements
Models
and Textures
Sounds
Next Time!