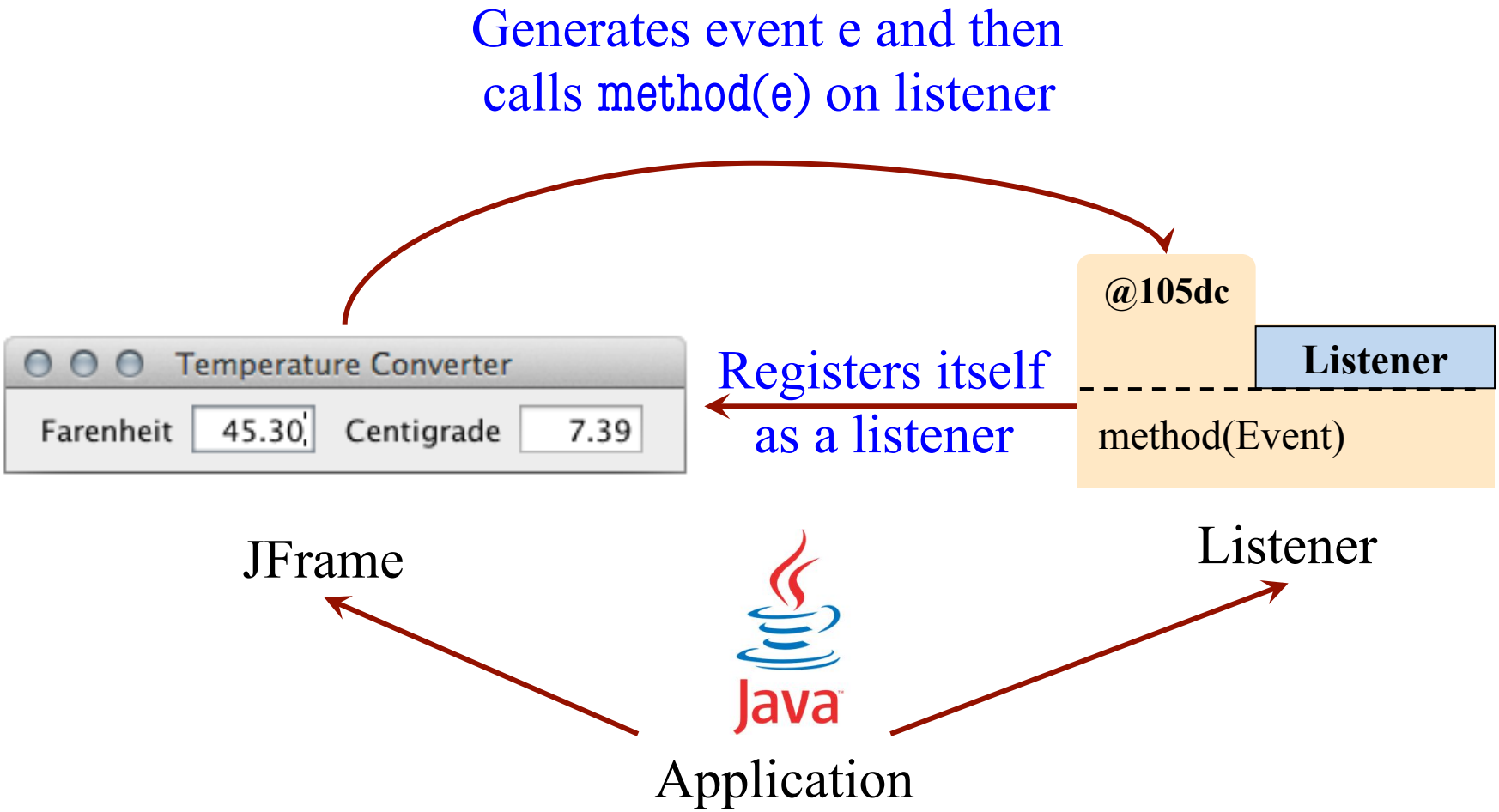
the gamedesigninitiative at cornell university

Lecture 10

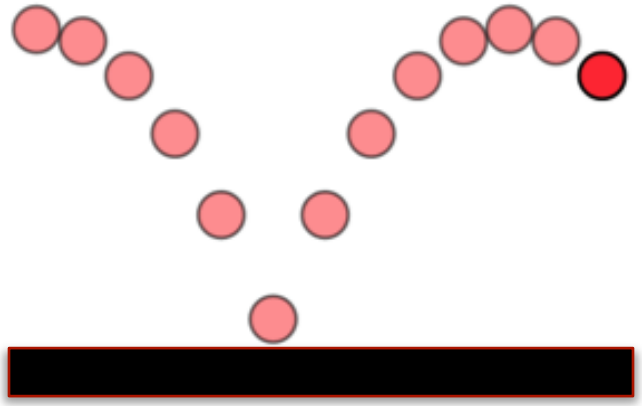
Game Architecture

2110-Level Apps are Event Driven

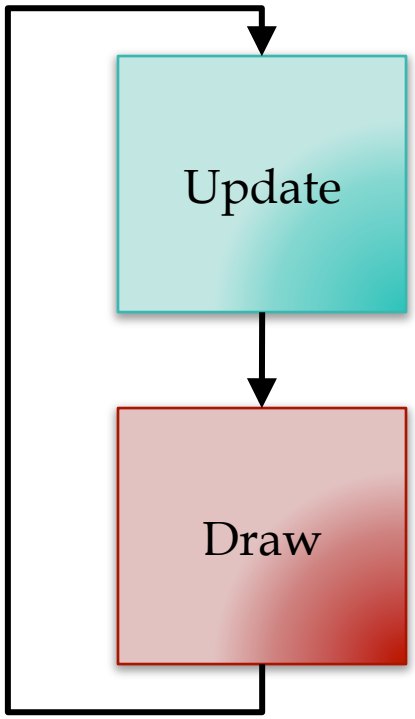


Limitations of the Event Model

- 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



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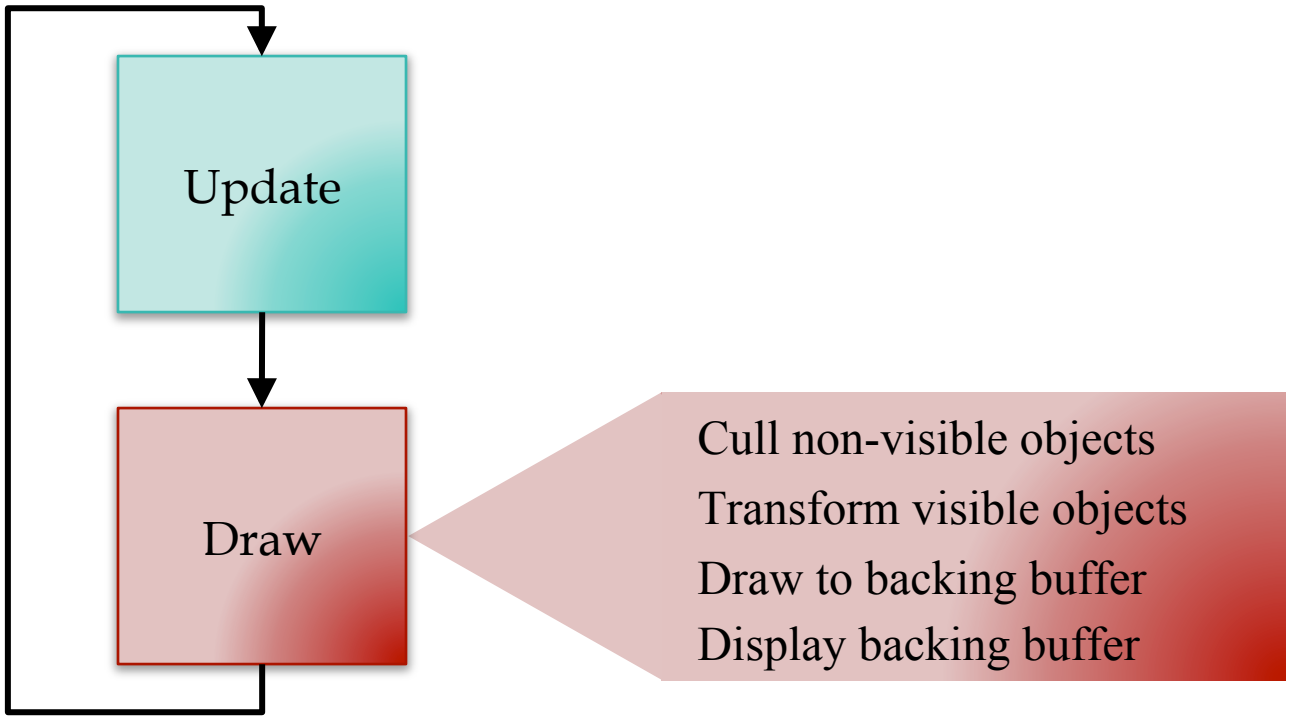

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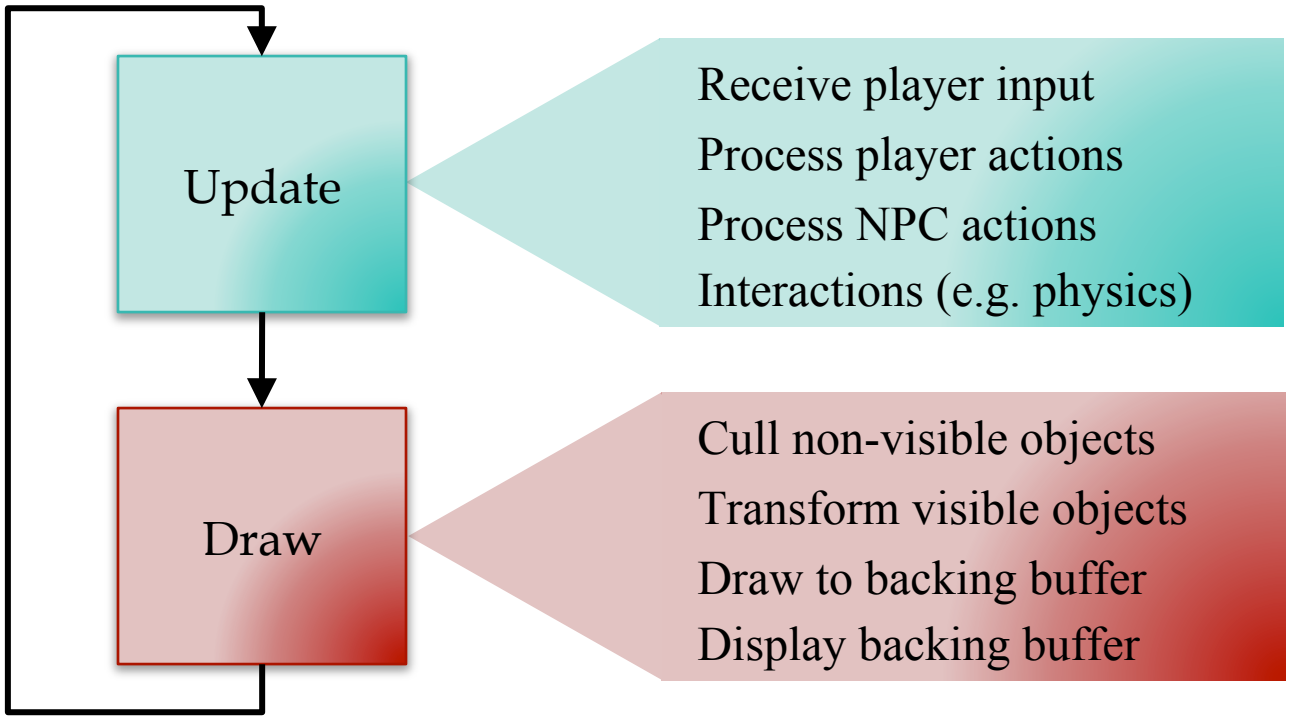
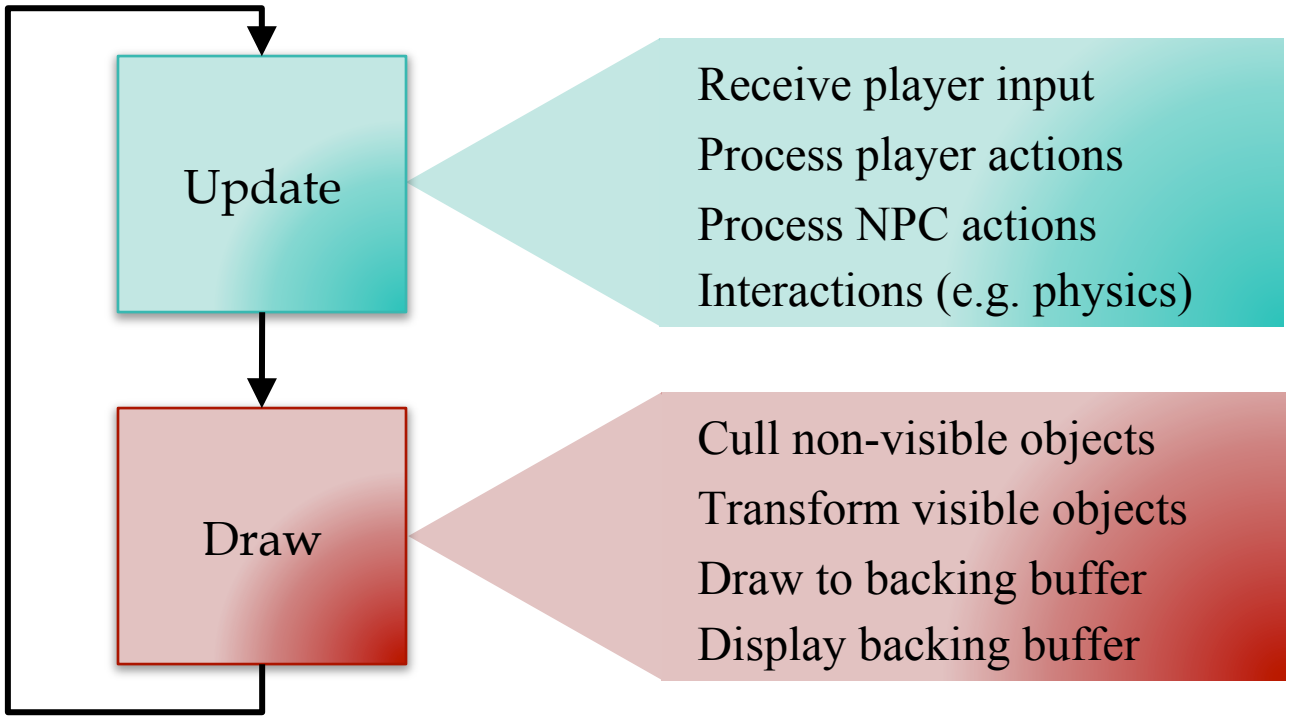


The Game Loop

60 times/s
=
16.7 ms

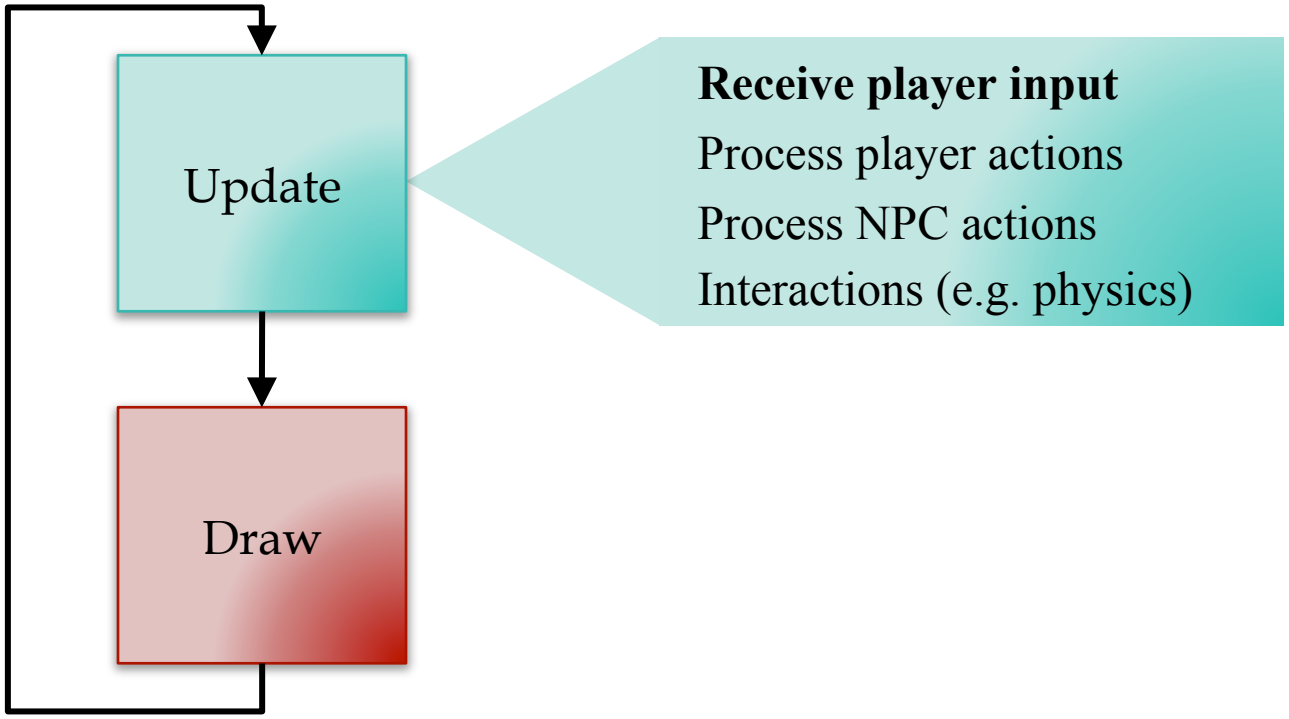


Few Words on Drawing

- 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



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

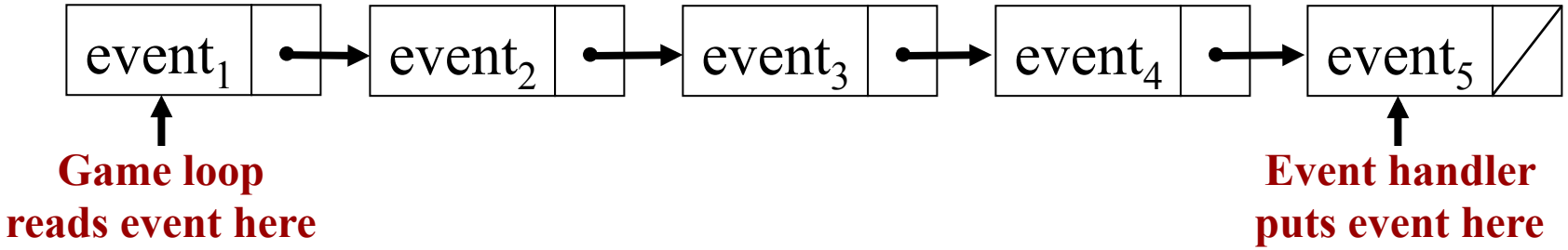
Problem with Polling

- 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

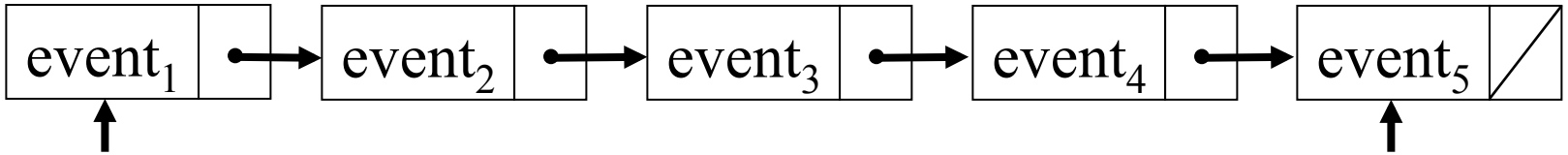
- Can combine using an event queue
  - Listeners write at end of the queue
  - Game loop reads from the front



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

Warning: Thread Coordination

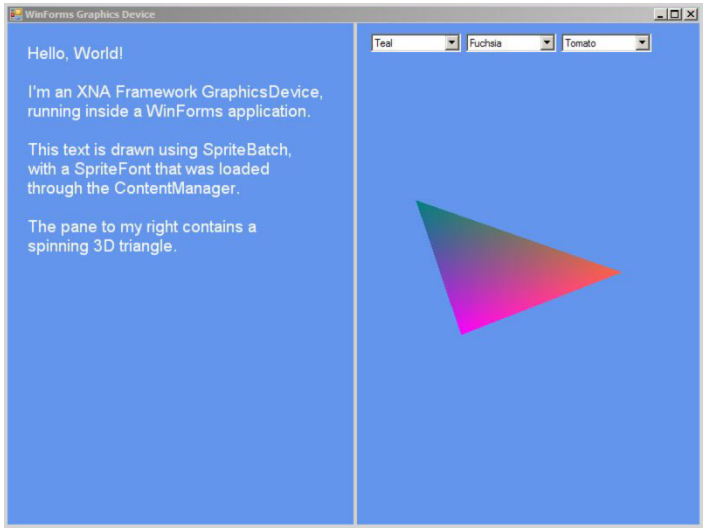
- Threads are tricky if you do not know how
  - Queue is shared between two threads
  - Most queues are not thread safe!
  - What if threads modify queue at same time?



- Classic *critical section* problem
  - Threads need to lock queue when access
  - But locking every frame can be expensive

Warning: XNA Event Handling

- XNA and Windows Forms are different
  - XNA: game loop thread, no event handlers
  - Forms: event handlers, no game loop thread
- Combining is a lot of work
  - Many low-level details
  - Do it only if necessary
  - Sample on web page
- Ruins X-Box compatibility

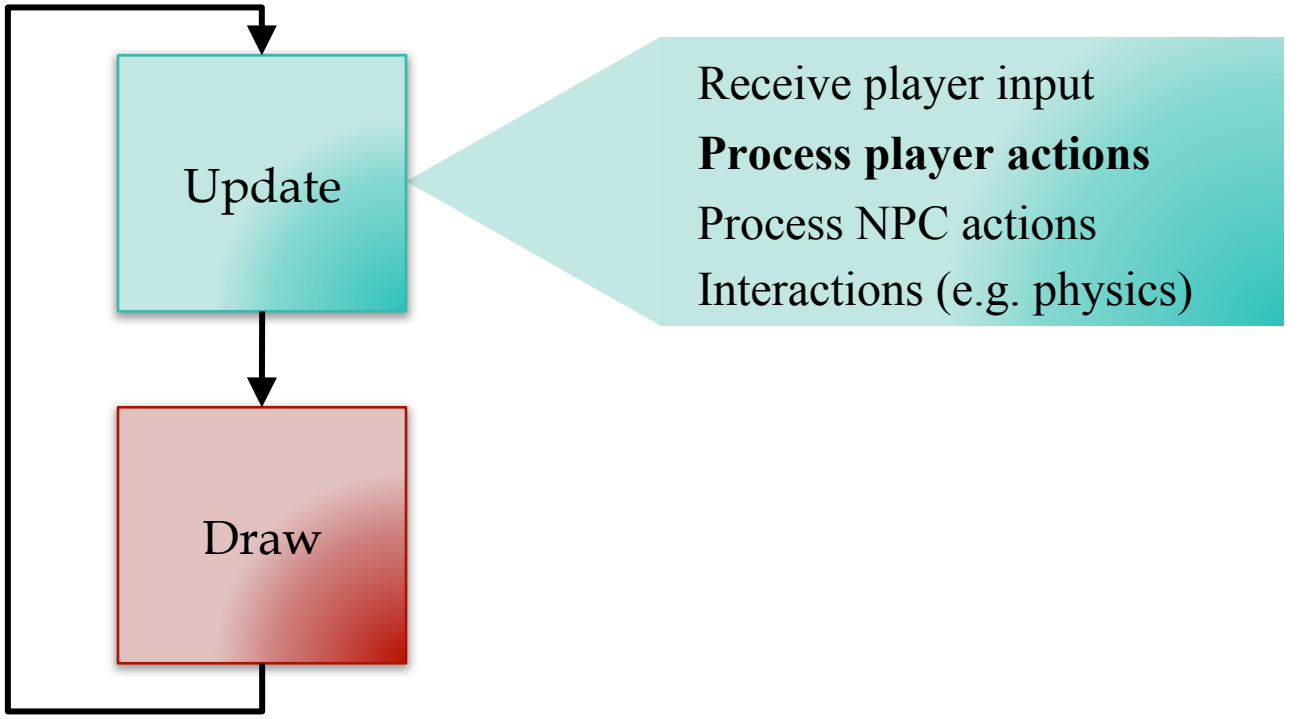


Handlers: Really Necessary?

- 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

The Game Loop



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!

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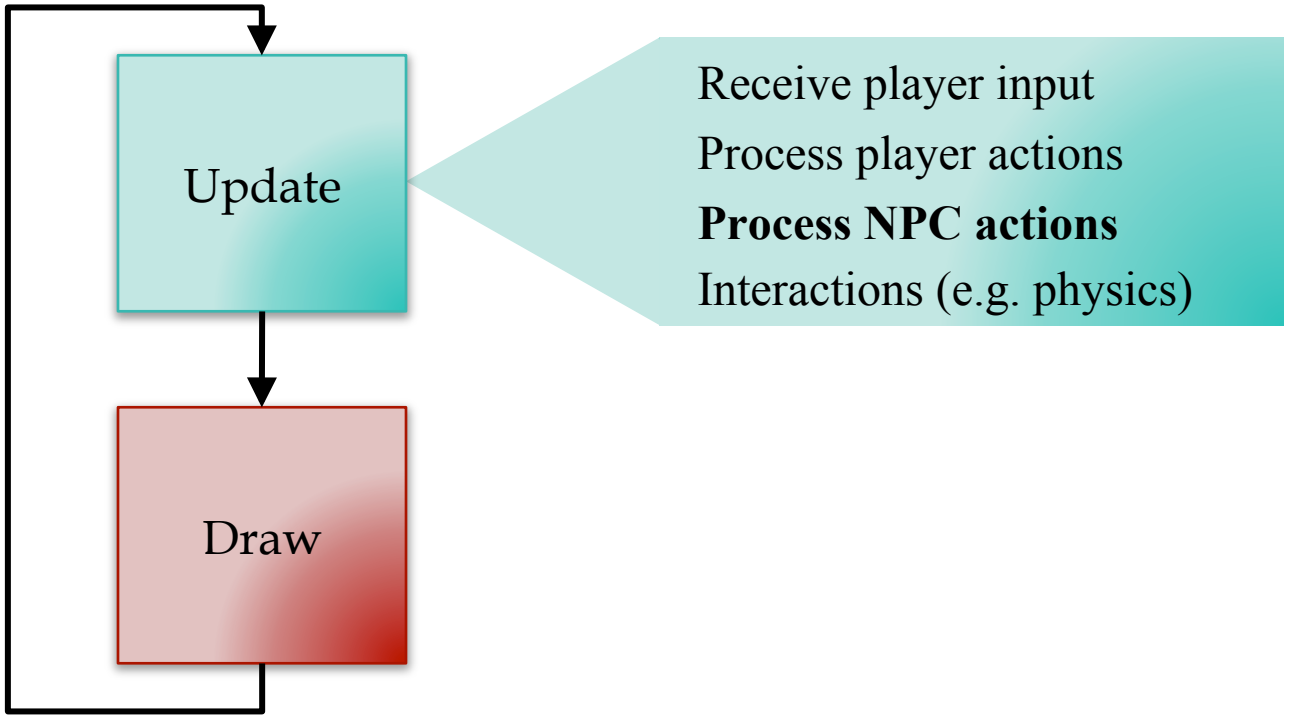
Design versus **Implementation**

The Game Loop



NPC: Non-Player Character

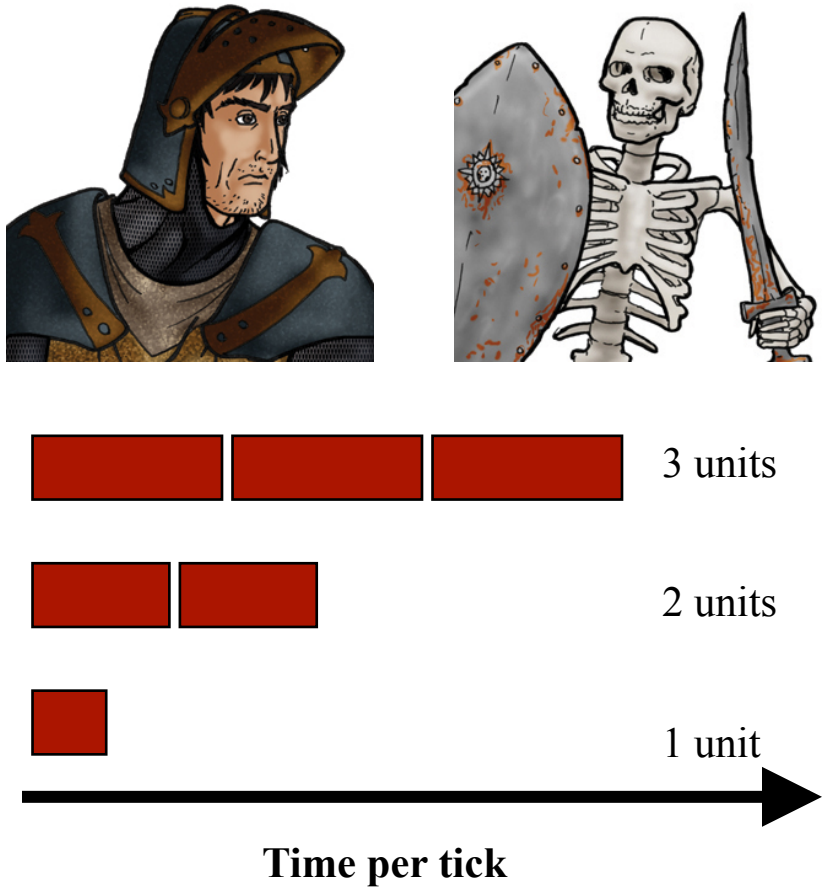
- NPC is an intelligent computer-controlled entity
  - Unlike a physics object, it can act, not just interact
  - Sometimes called an *agent*
- NPCs have their own actions/verbs
  - But no input controller to choose
- Work on sense-think-act cycle
  - **Sense**: perceive the world around it
  - **Think**: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

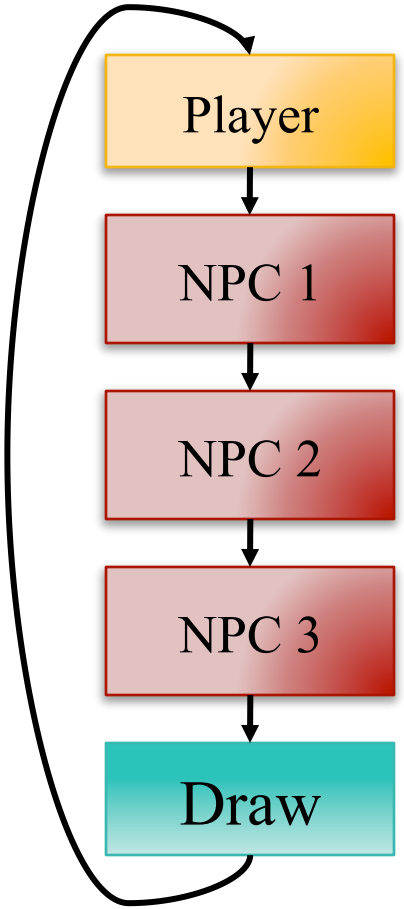
Problem with Sensing

- 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



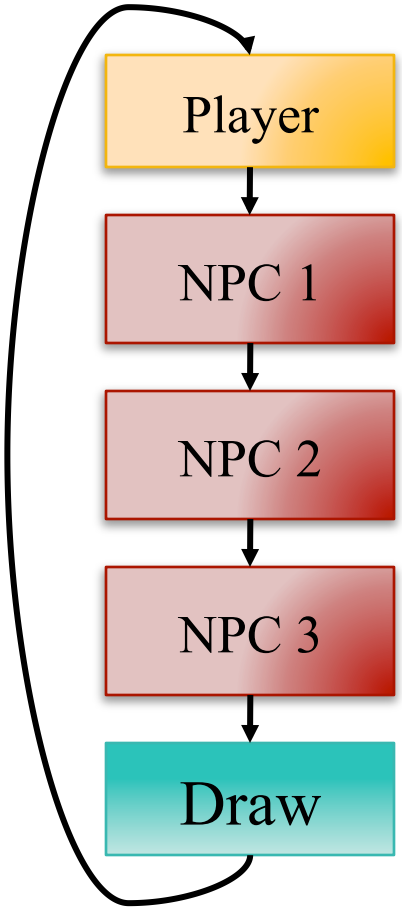
Processing NPCs

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

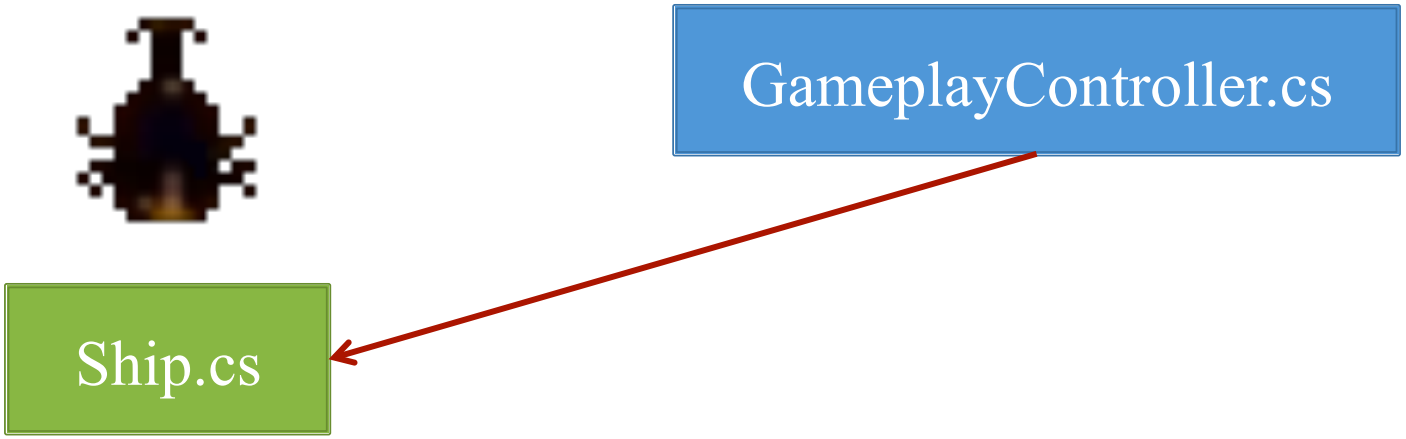


Processing NPCs

- 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

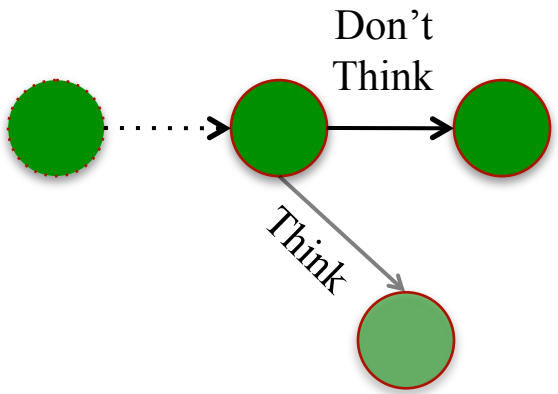


- Decides whether to shoot
- Stores intent in the object
- But **DOES NOT** shoot

- 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

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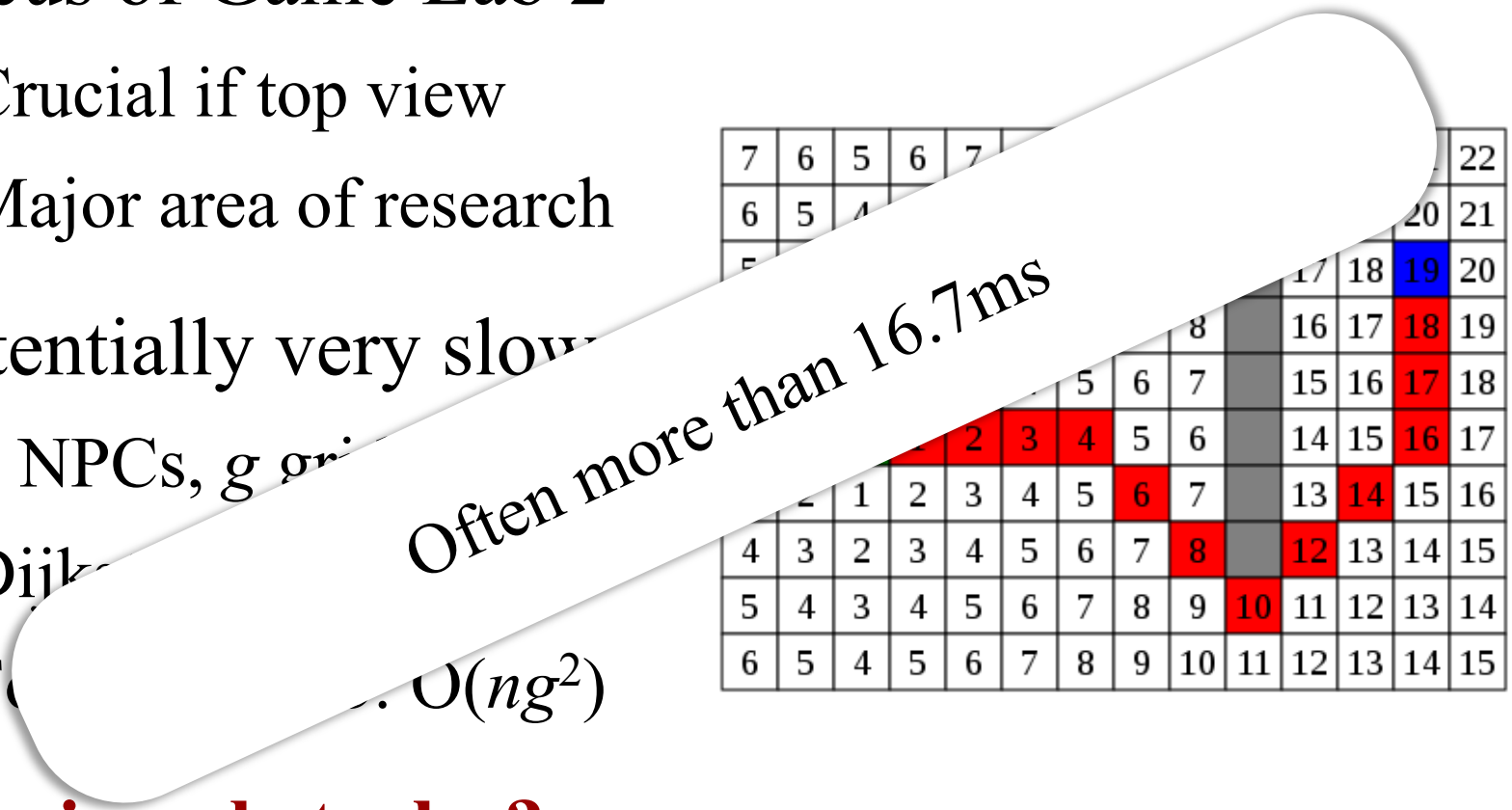
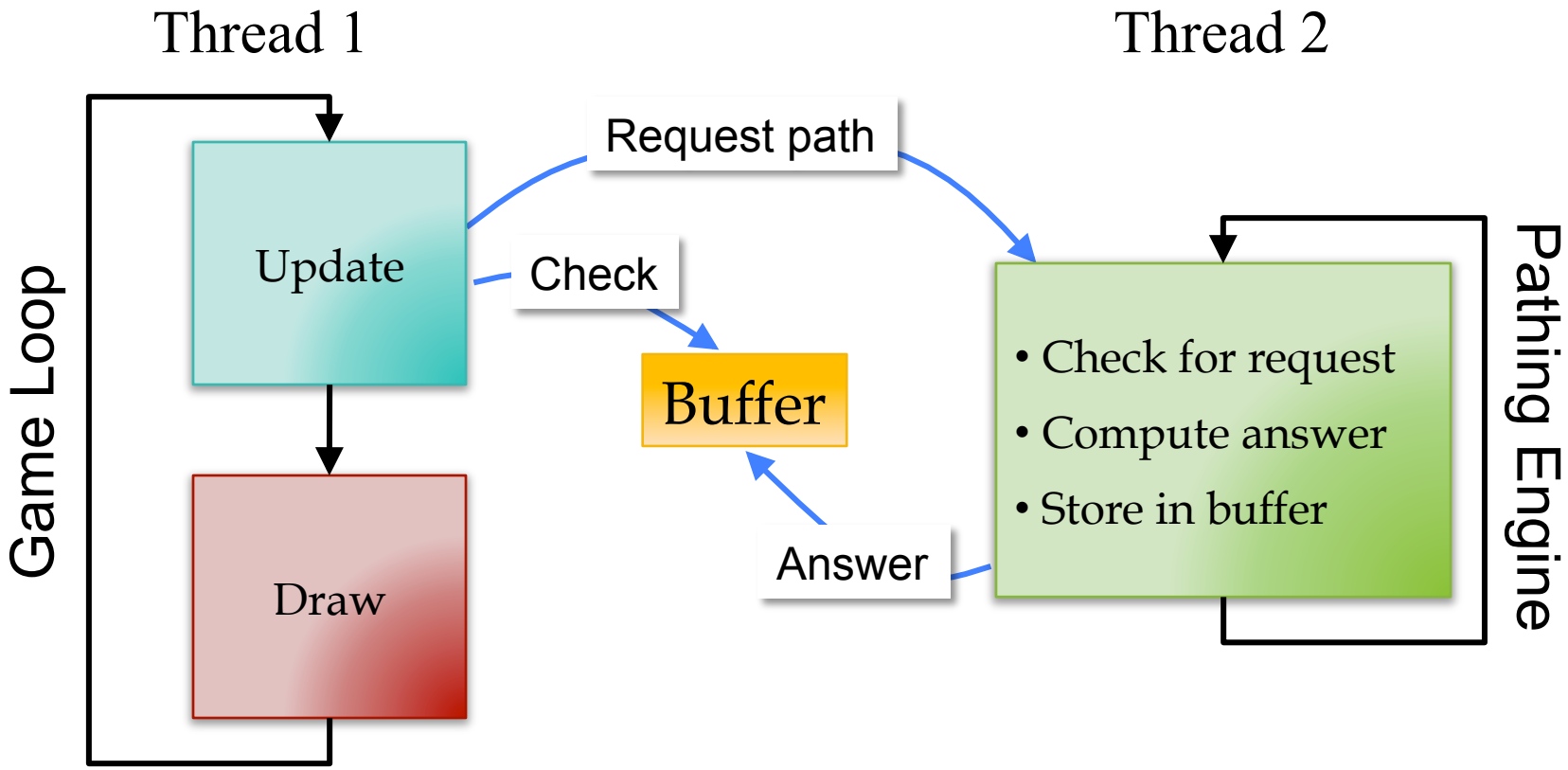


Asynchronous Pathfinding

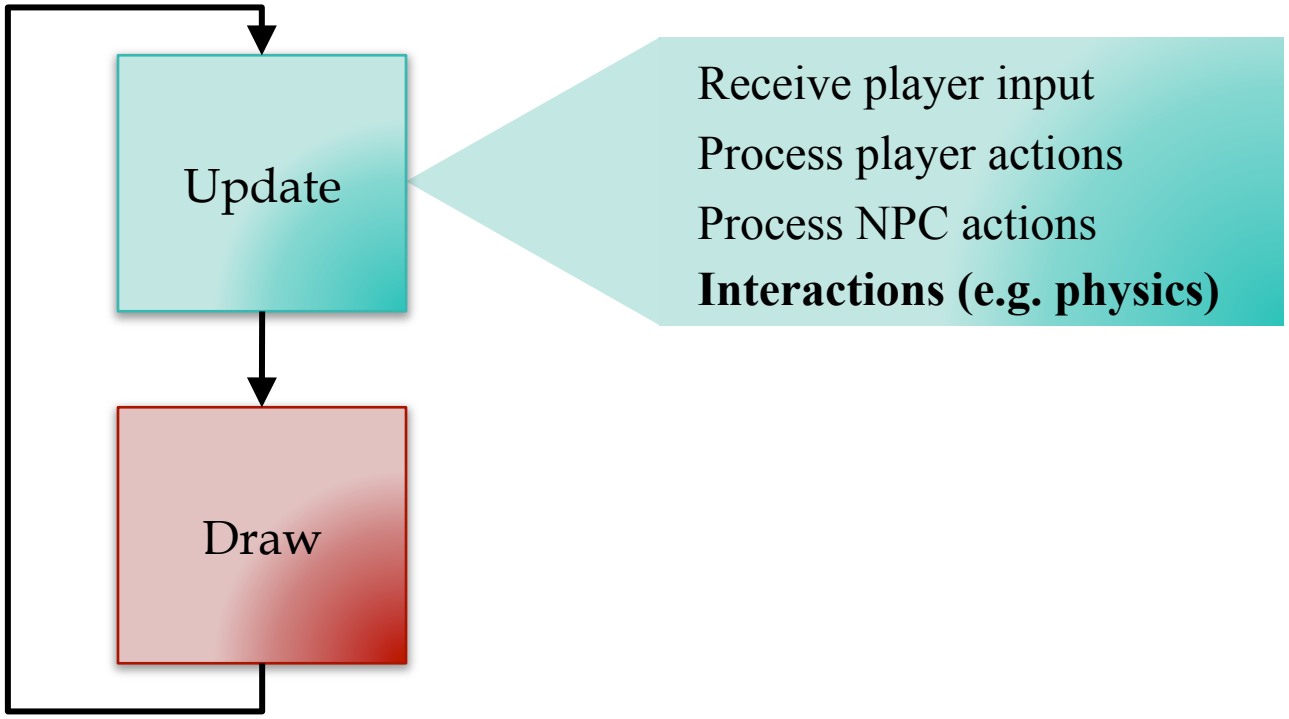


Looks like input buffering!

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



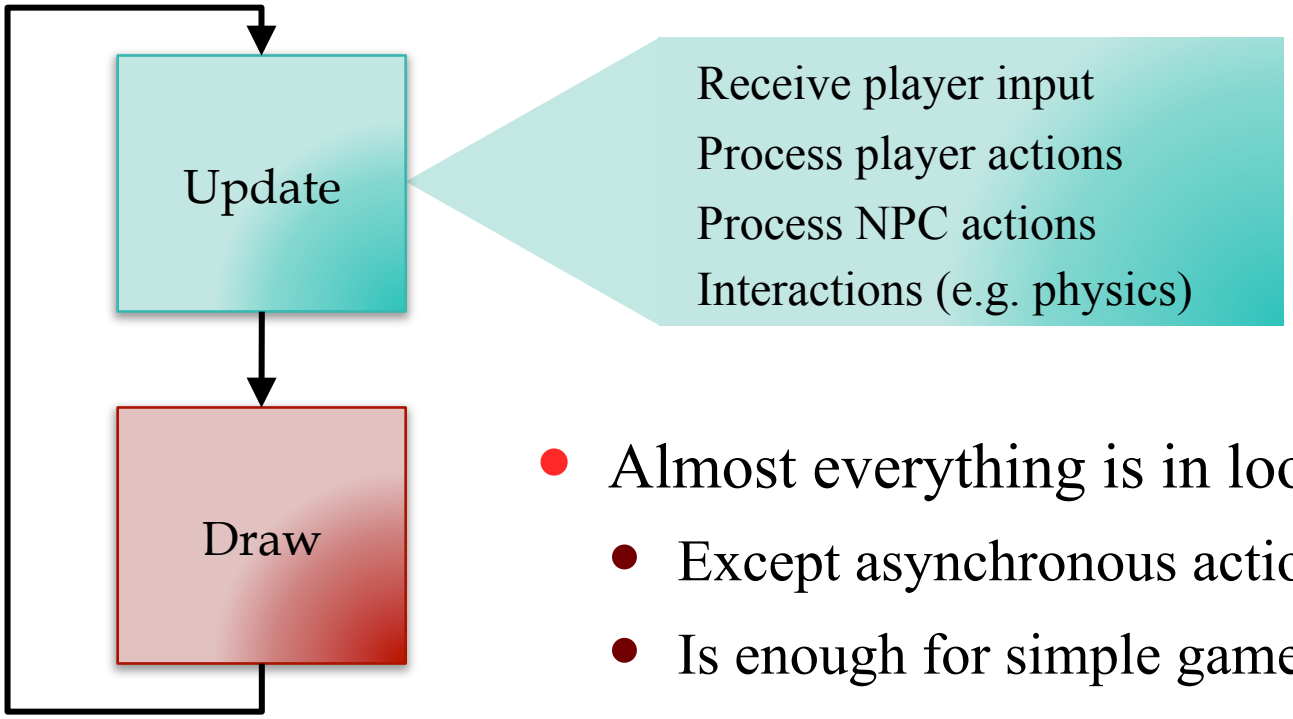
Purpose of a Physics Engine

- 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

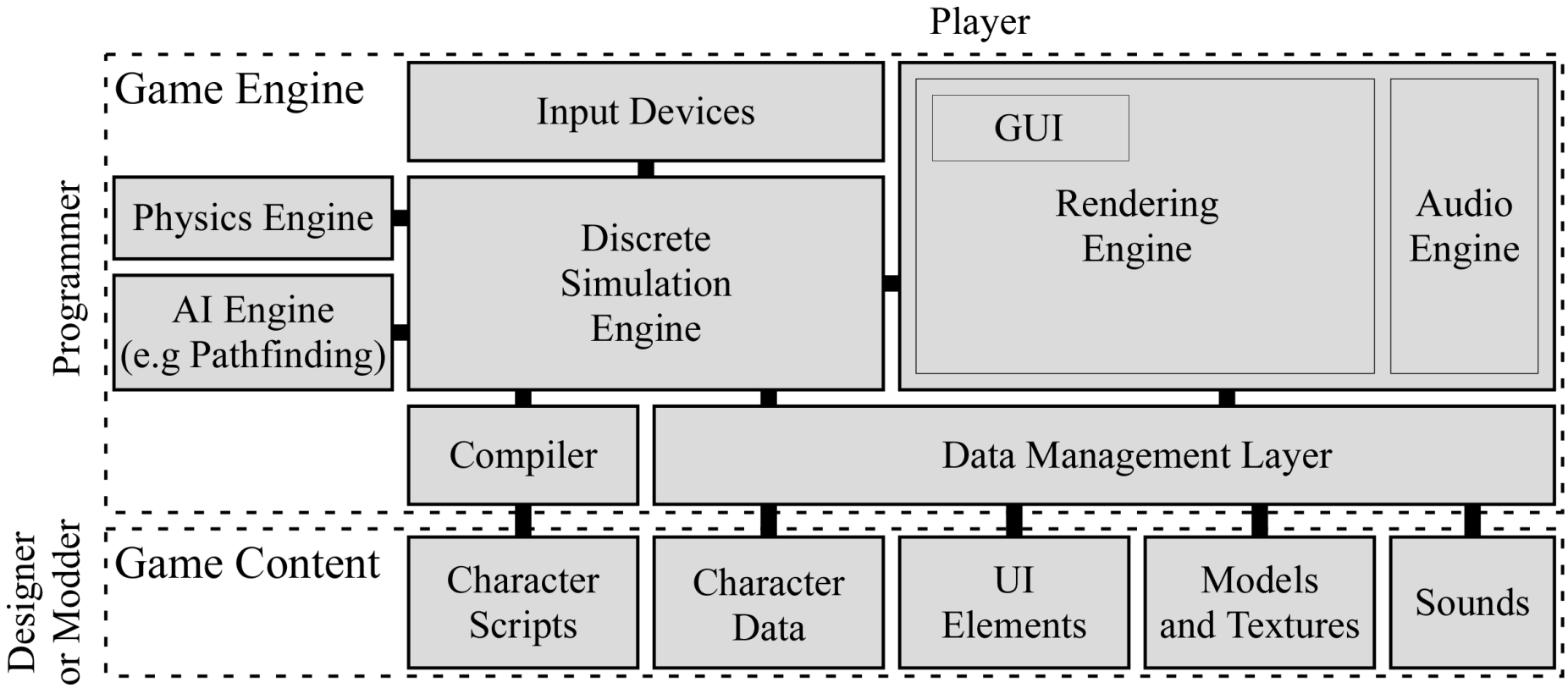
- **White Box**: Engine corrects movement errors
  - Update object state ignoring physics
  - Physics engine nudges object until okay
- **Black Box**: Engine handles everything
  - Do not move objects or update state
  - Give forces, mass, velocities, etc. to engine
  - Engine updates to state that is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

The Game Loop



- 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



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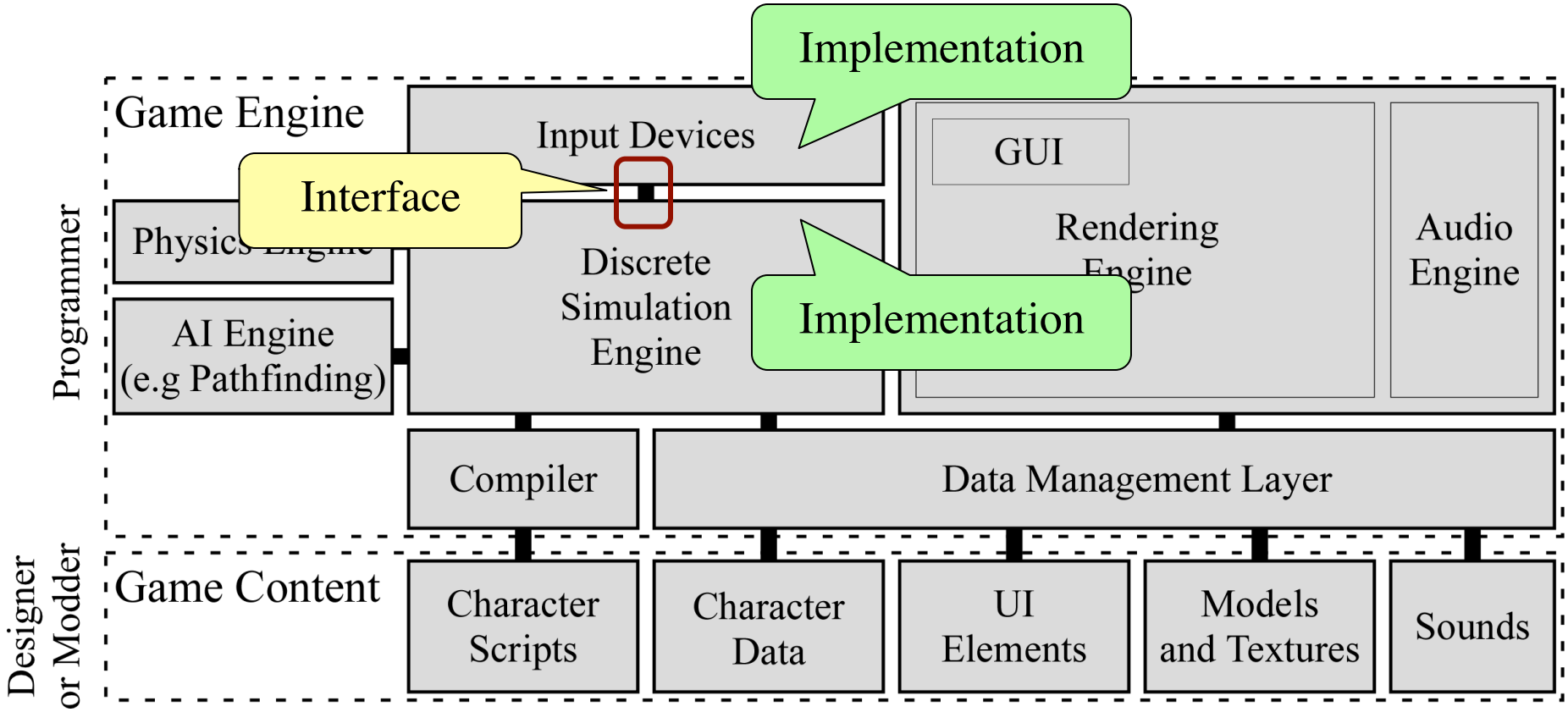

How Do These Relate?