the gamedesigninitiative at cornell university

Lecture 22

Character AI: Sensing & Perception

Take Away for Today

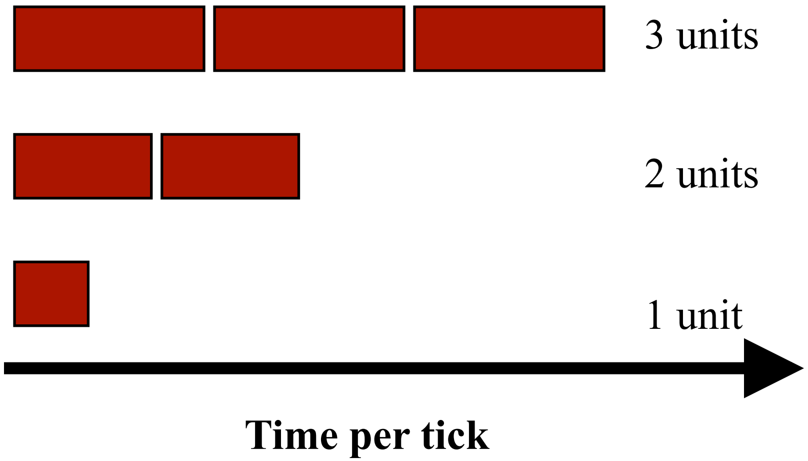
- Sensing as the primary bottleneck
  - Why is sensing so problematic?
  - What types of things can we do to improve it?
- Optimized sense computation
  - Can we improve sense computation performance?
  - Can we share sensing between NPCs?
- Sense event matching
  - What are events and how are they represented?
  - What is the advantage of an event system?

Review: Sense-Think-Act

- **Sense**:
  - Perceive the world
  - Reading the game state
  - **Example**: enemy near?
- **Think**:
  - Choose an action
  - Often merged with sense
  - **Example**: fight or flee
- **Act**:
  - Update the state
  - Simple and fast
  - **Example**: reduce health

Recall: Sensing Performance

- 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



Recall: Sensing Performance

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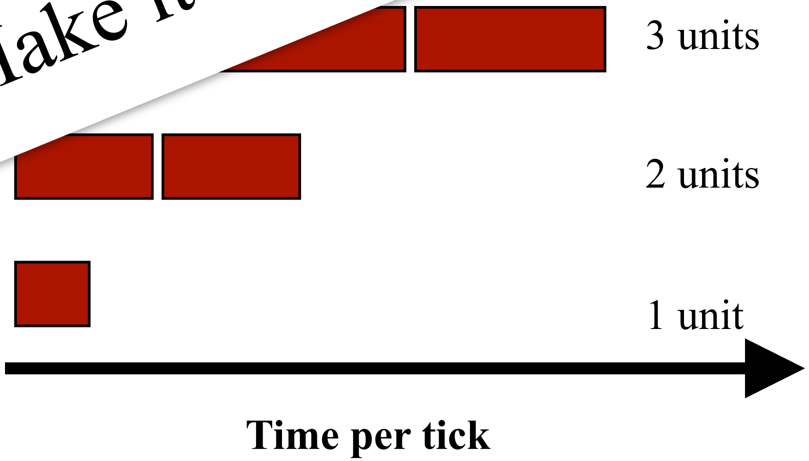
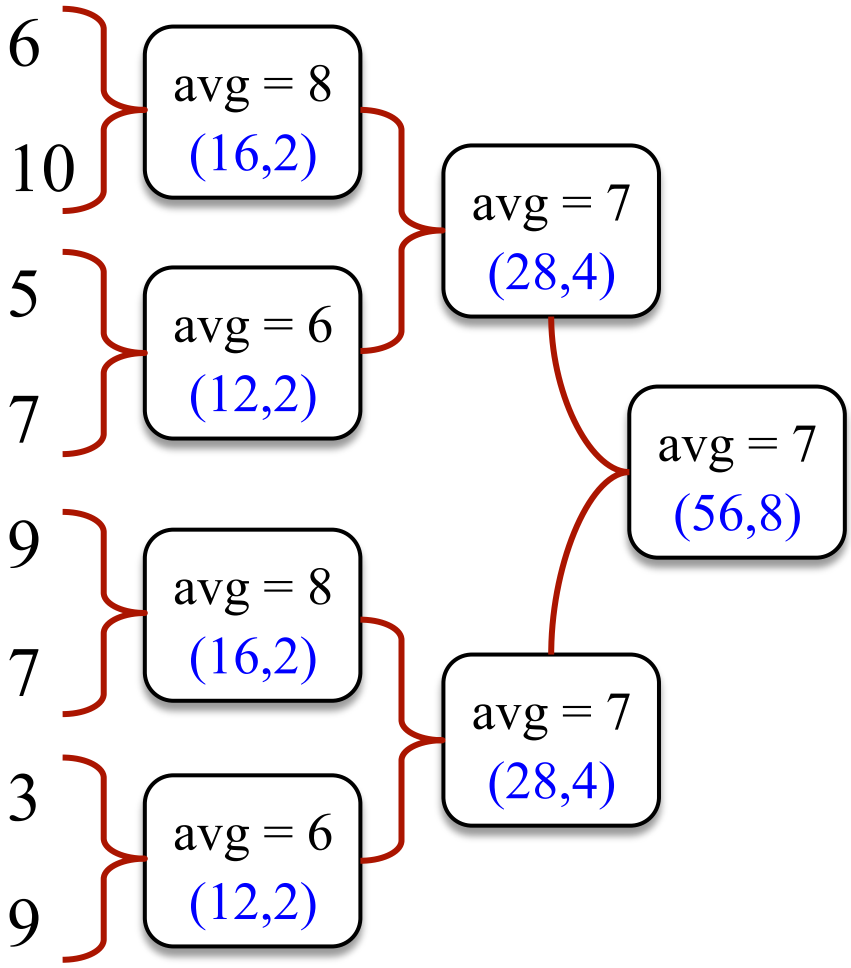
How Do We Make it Faster?



Aggregation

- Idea taken from databases
  - Unordered set of information
  - Combine into single value
  - Used in statistical analysis
  - **Examples**: sum, avg, mode
- **Decomposable Aggregates**
  - Split the set up into subsets
  - Aggregate on each subset
  - Combine values from subsets
  - Only for some aggregates



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  - Split the se ts
  -
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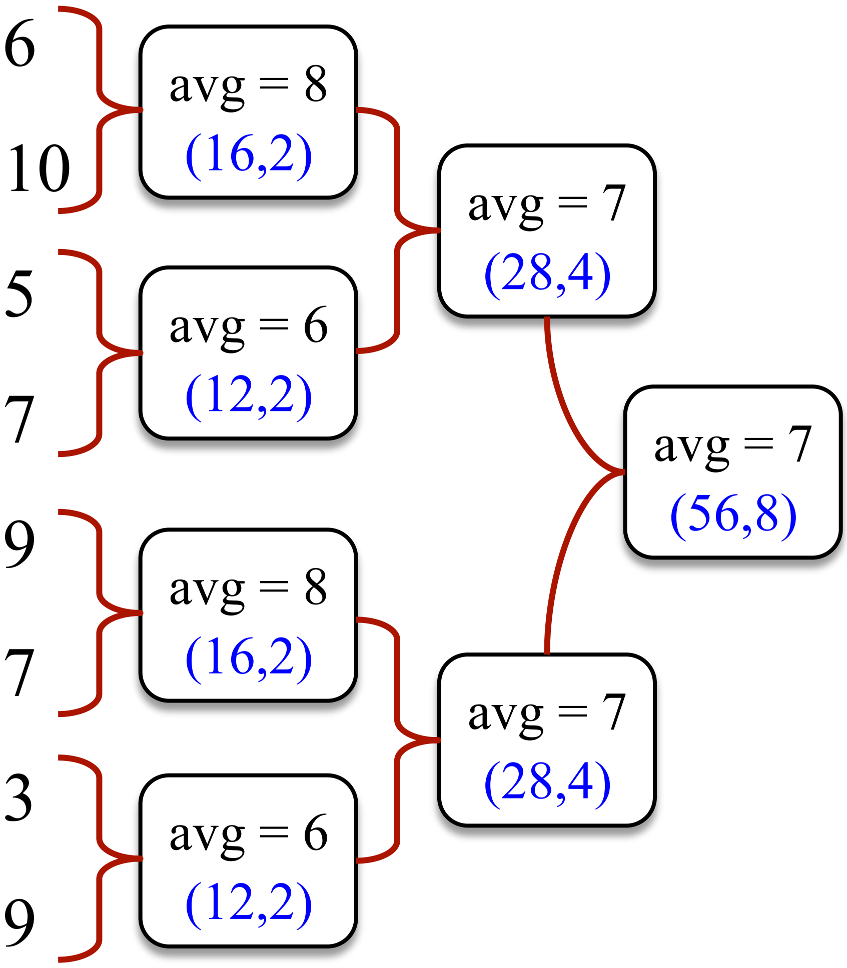
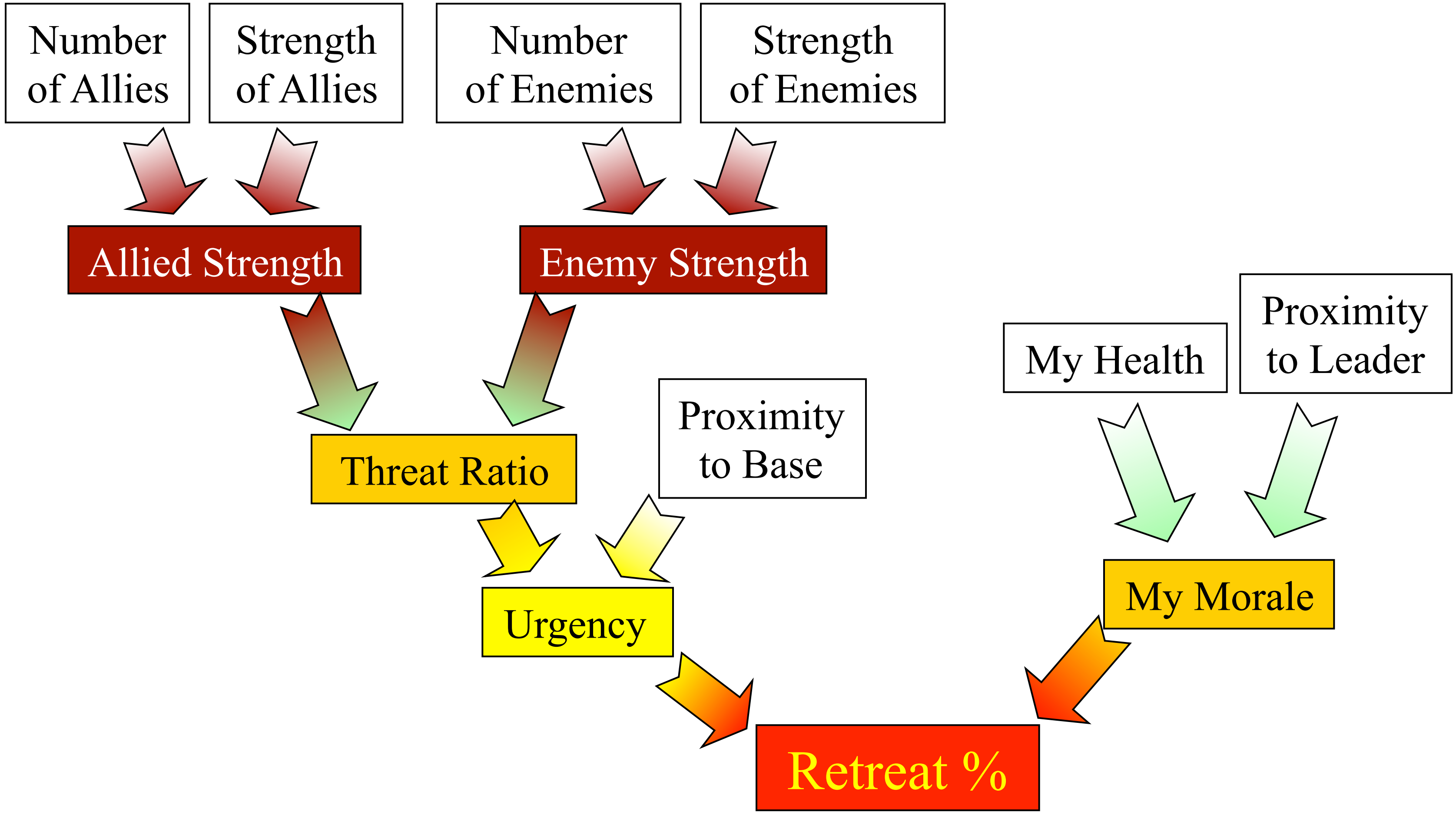
Allows for fast parallel computation



AI and Aggregation Trees

Slide courtesy of Dave Mark



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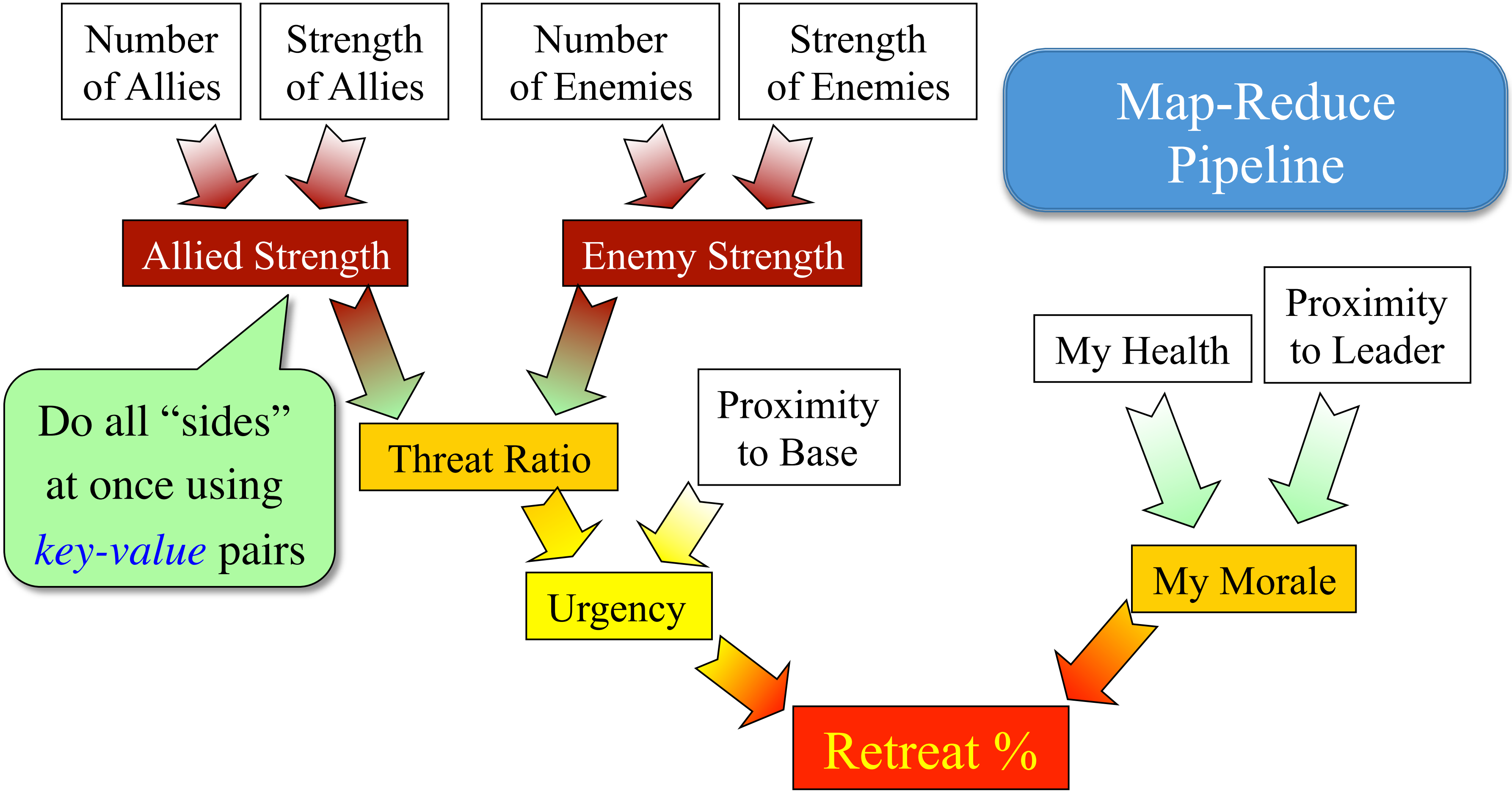
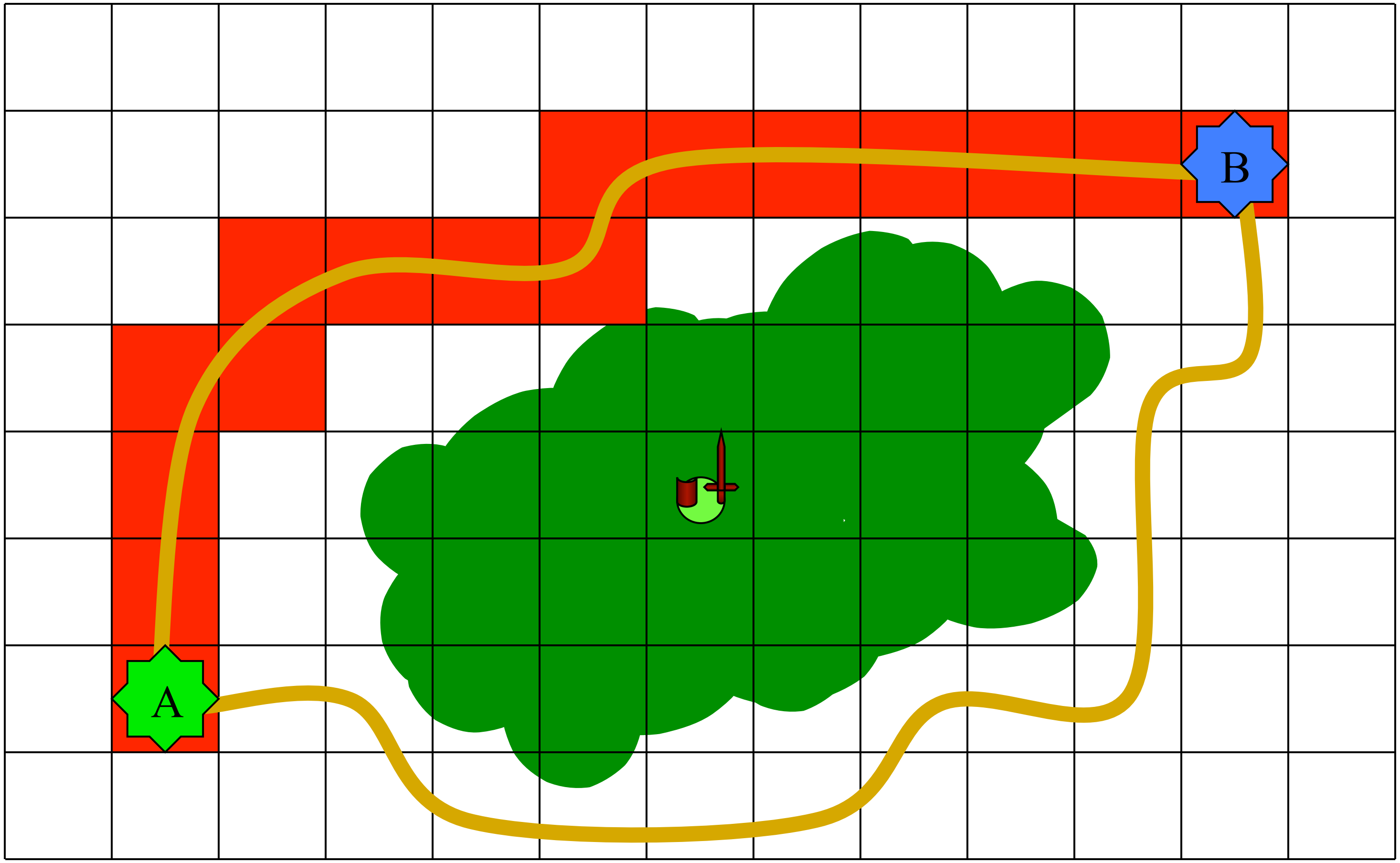


Map-Reduce Pipeline

Do all "sides" at once using *key-value* pairs

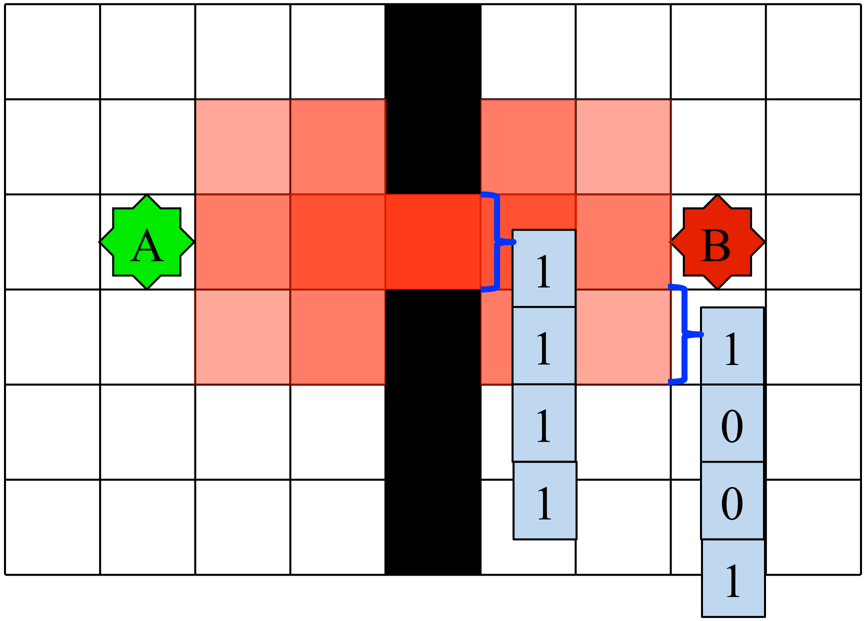
Influence Maps: Pathfinding and AI



Slide courtesy of Dave Mark

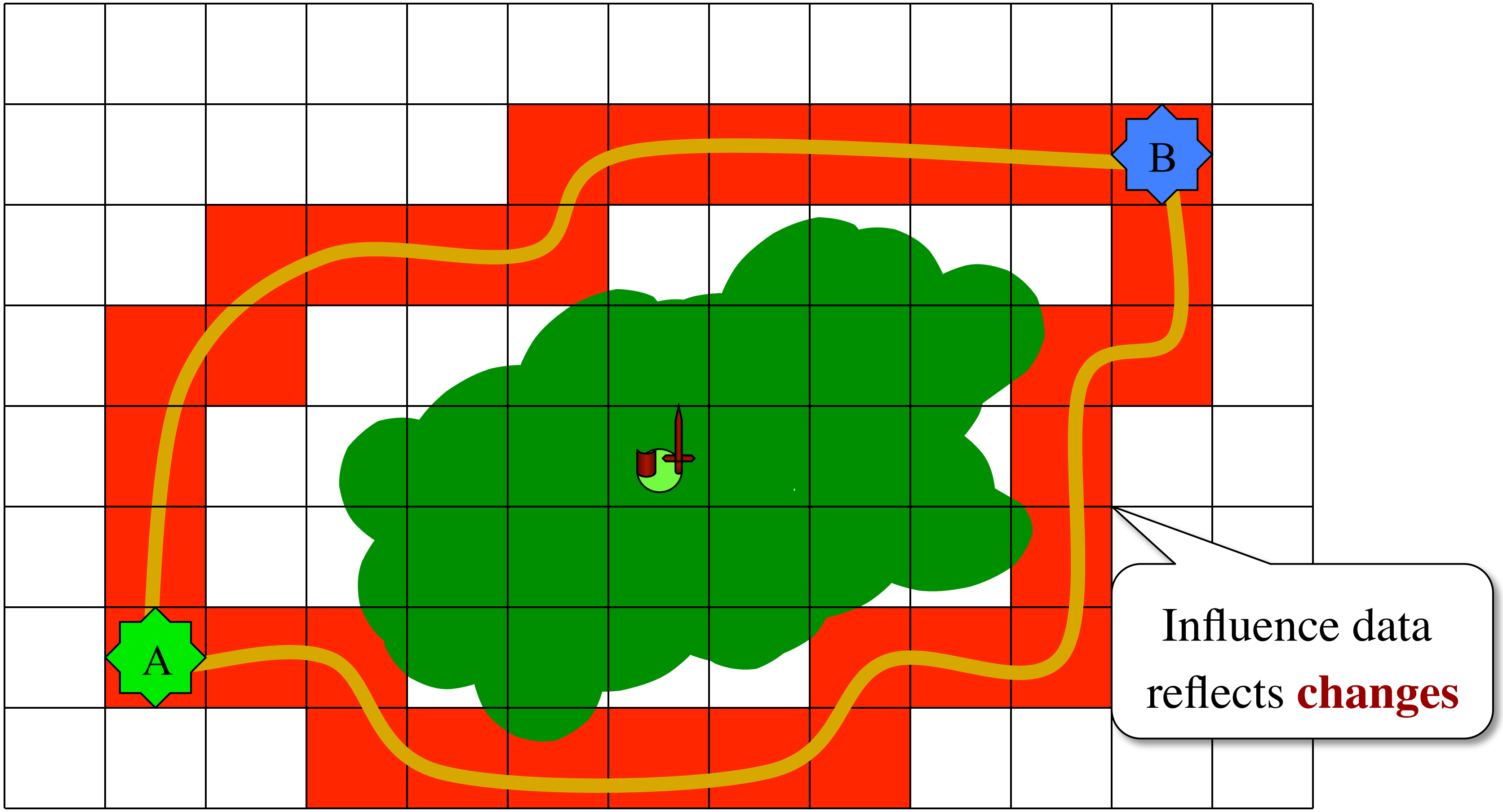
Implementing Influence Maps

- Use the pathfinding **grid**
  - Track movement in square
  - Track if friend or foe
- Keep count as a **queue**
  - Count is sum of queue
  - Allows us to "time out"
  - Otherwise, marked forever
- Use queue as a **predictor**
  - Look at rate of change
  - Also valuable for AI



Sensing is at grid, not NPC

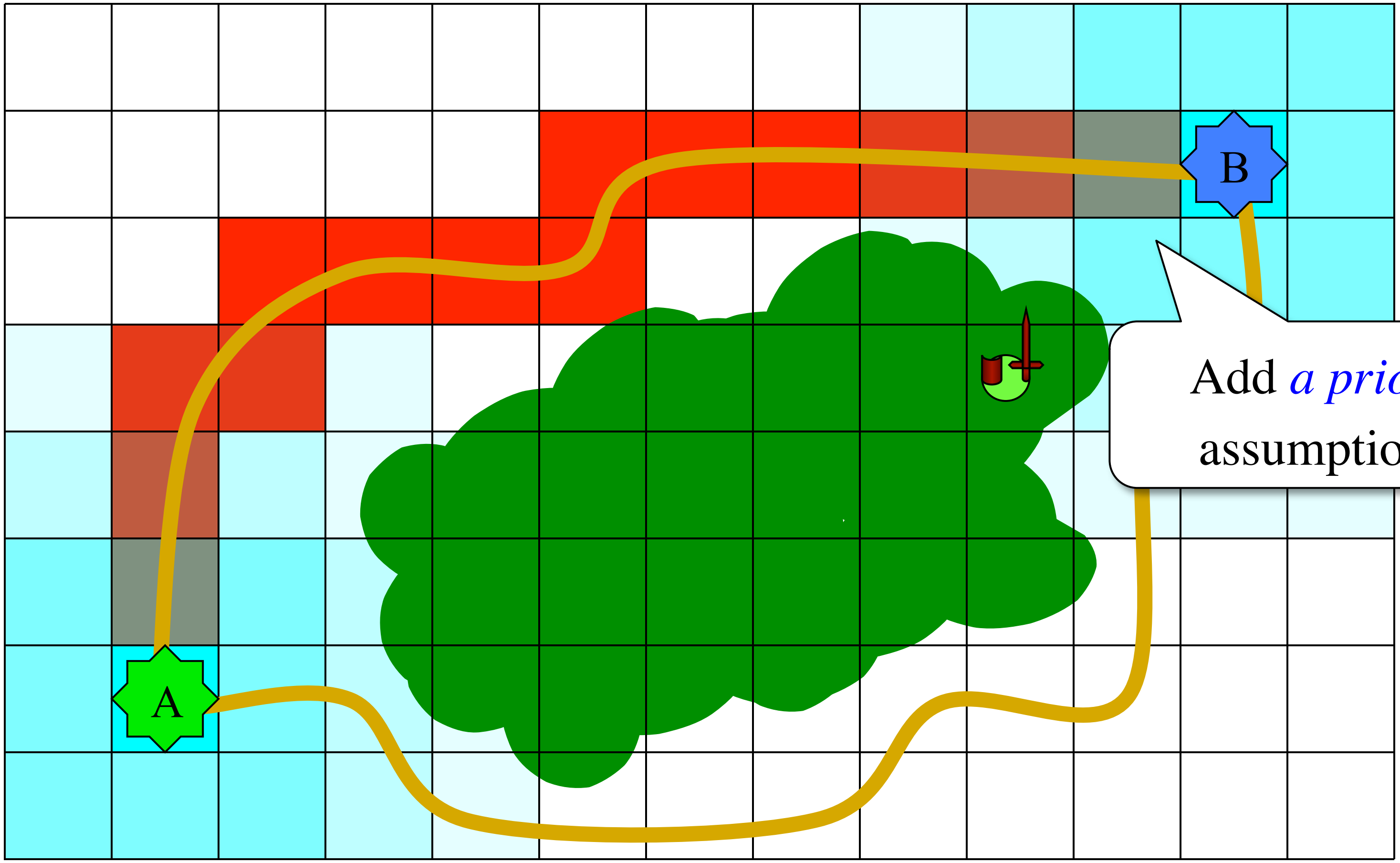
Advantages of Influence Maps



Influence data reflects **changes**

Slide courtesy of Dave Mark

Advantages of Influence Maps



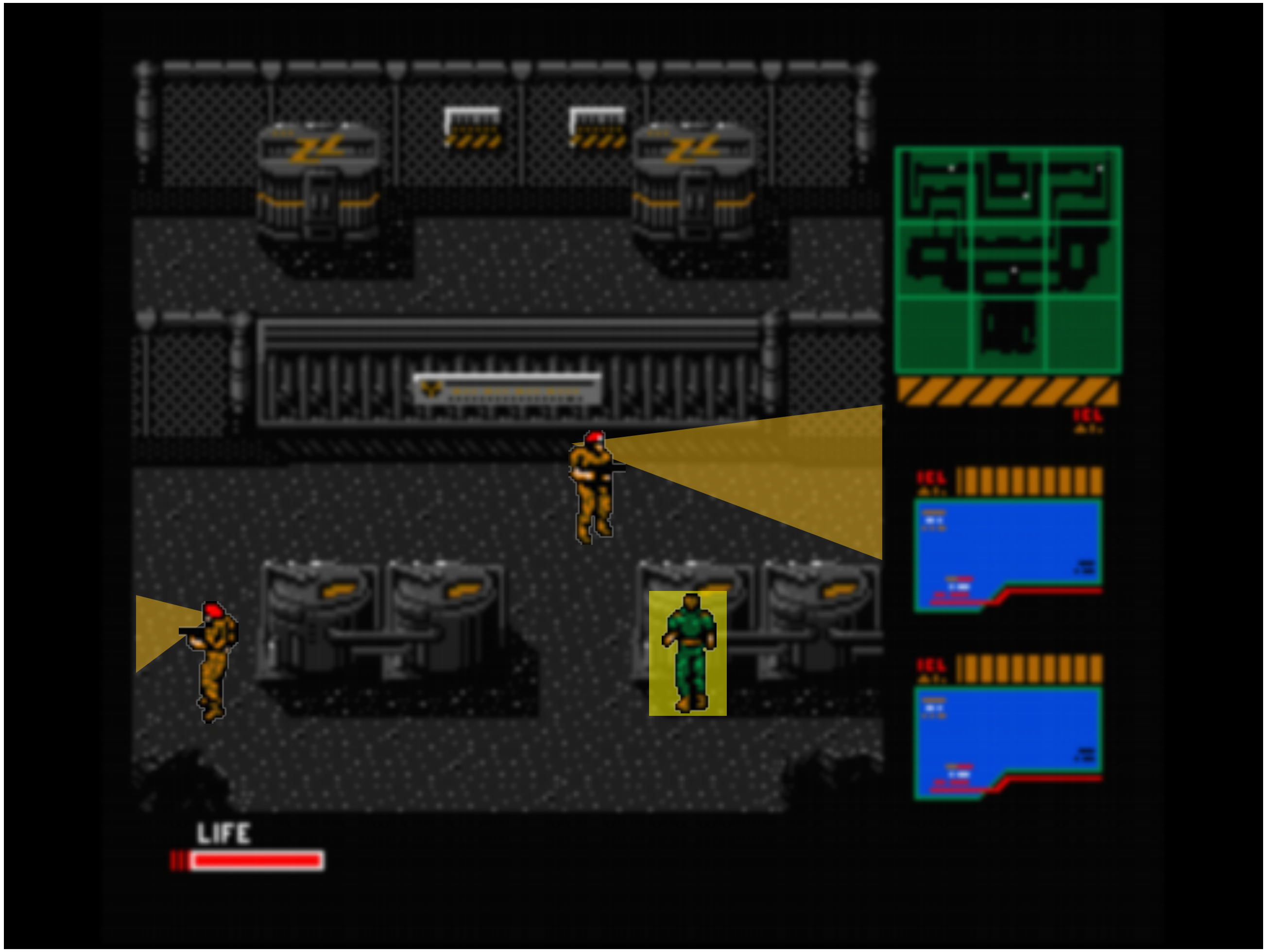
Add *a priori* assumptions

Slide courtesy of Dave Mark

Sensing: Perception Groups

- **Vision**: limited field of view
  - Gives exact object location, information
  - Limited by obstacles and range
  - Little information (motion) at periphery
- **Sound**: omni-directional
  - Gives direction & distances
  - Requires you track the “sounds” actions make
- **Smell**: omni-directional
  - No direction or distance; *proximity* only
  - Requires you track the “smells” actions make

Sensing: Line-of-Sight



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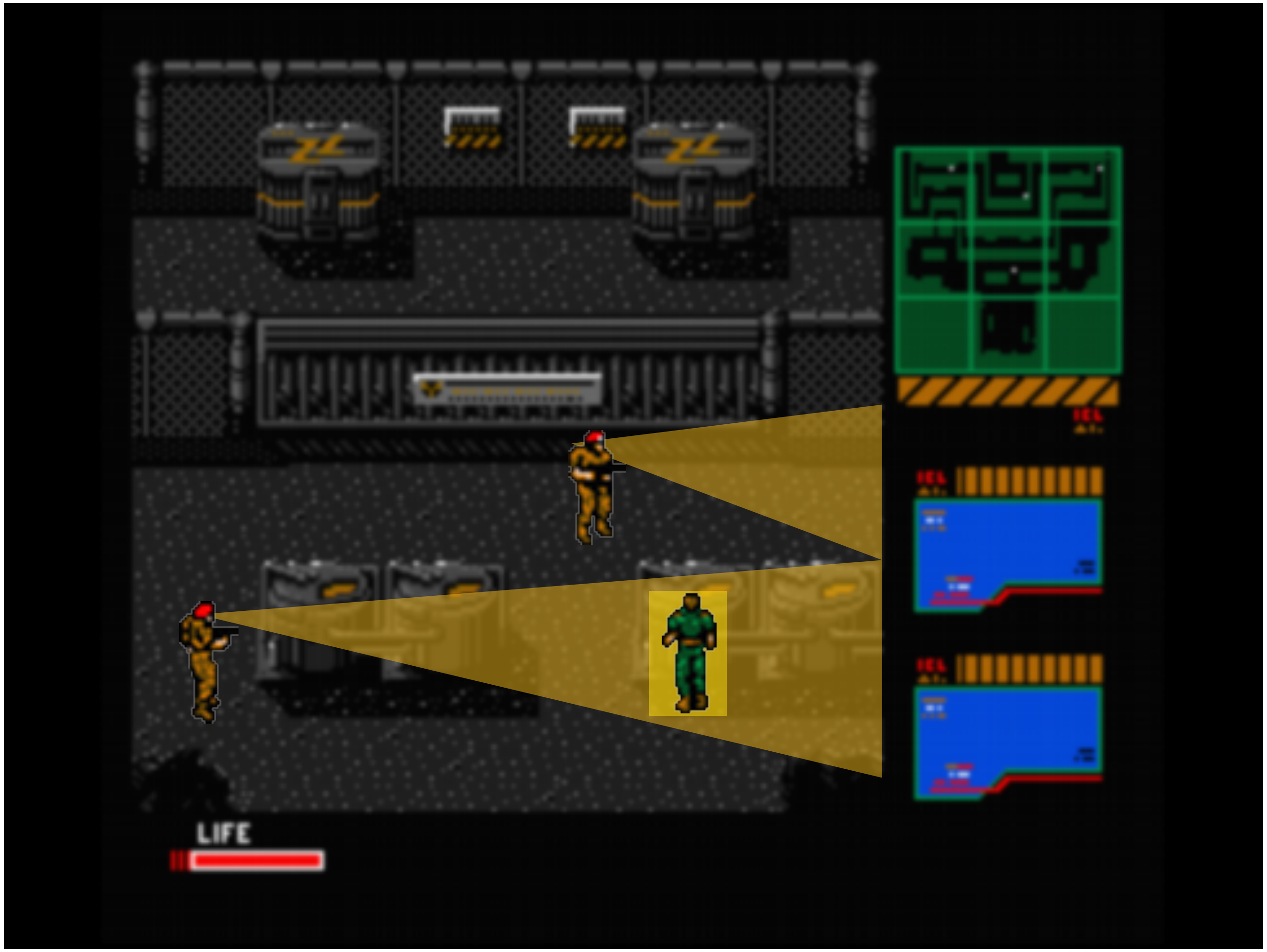
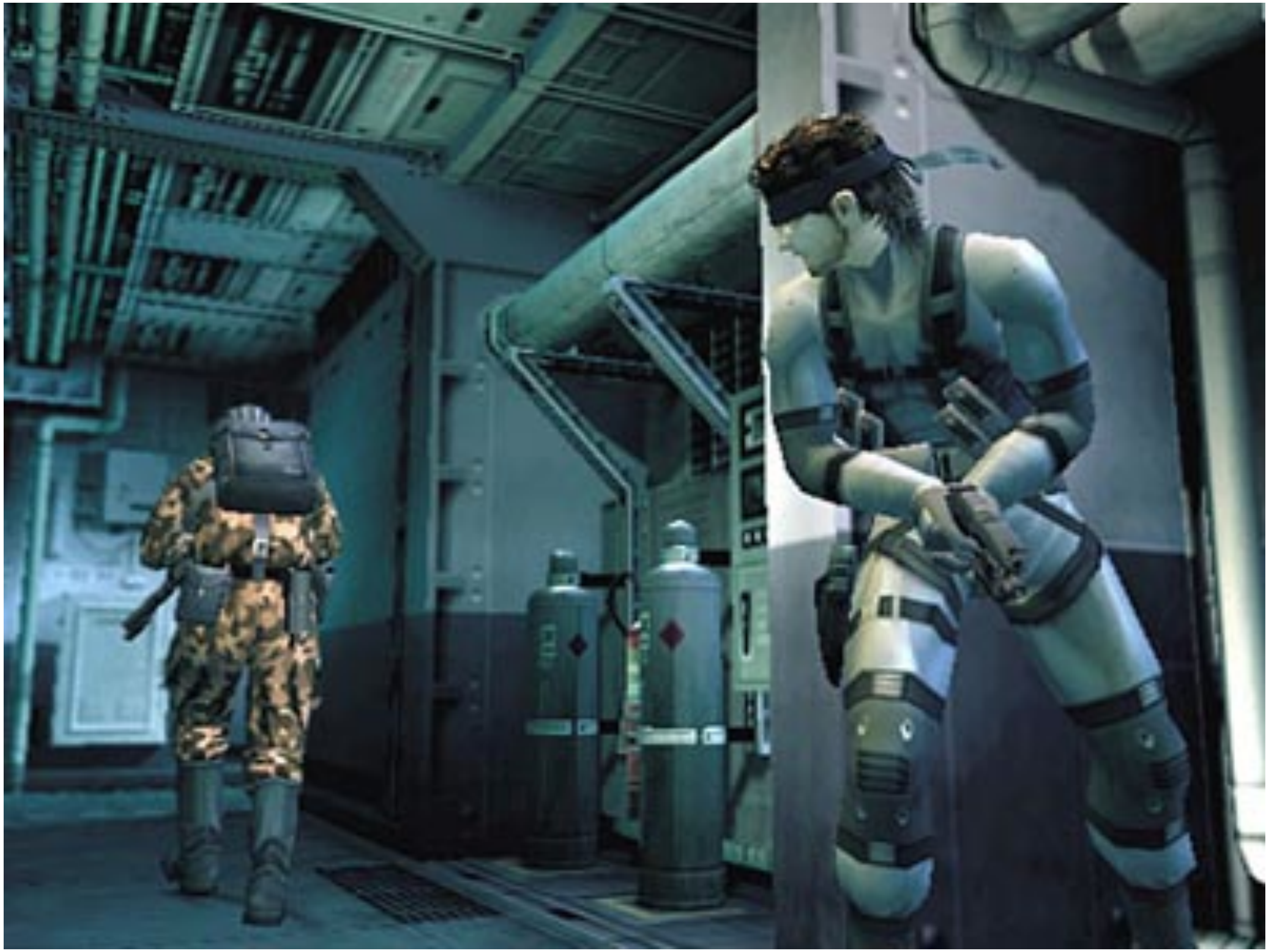


3D Line-of-Sight: Ray Casting



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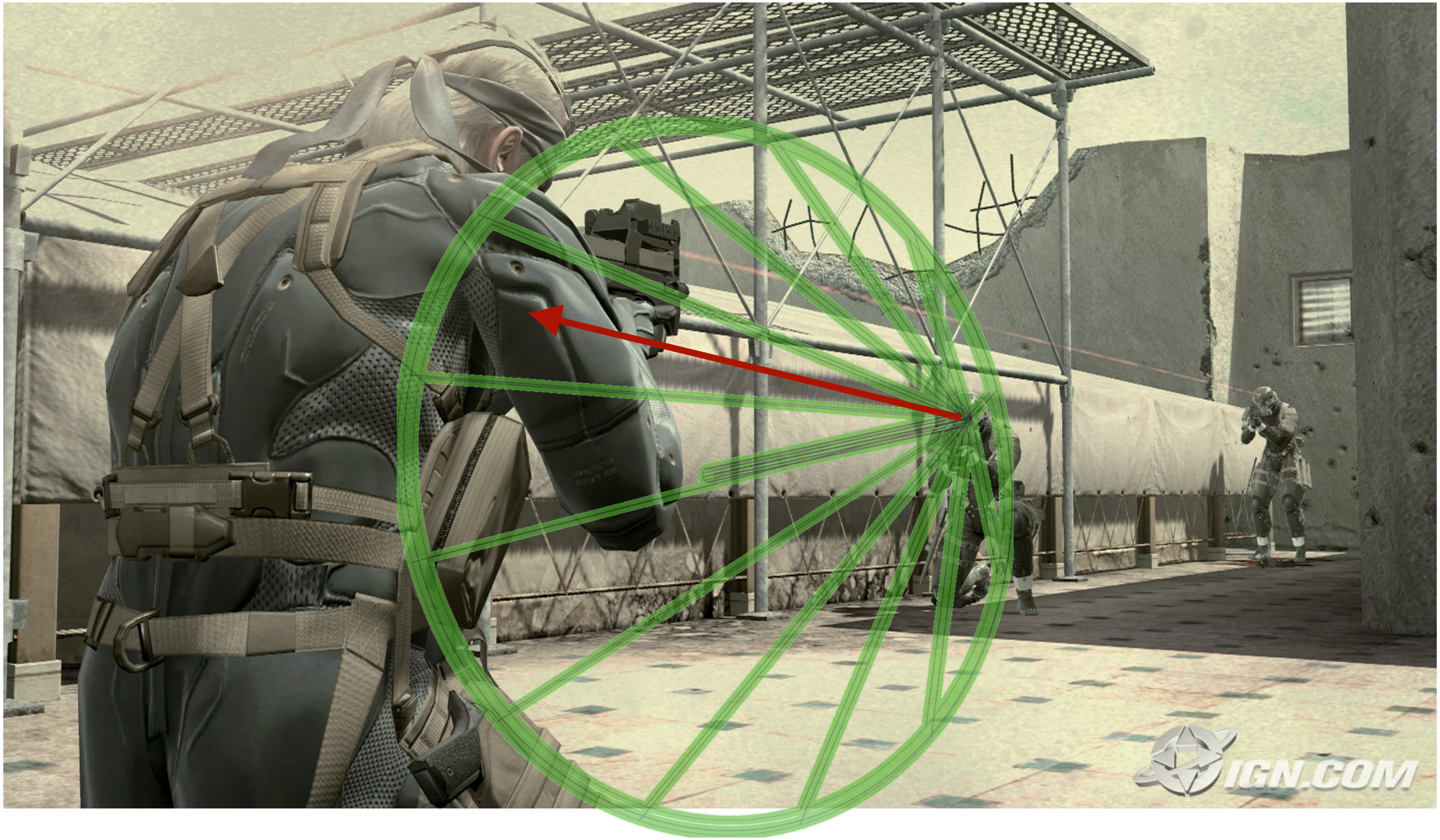

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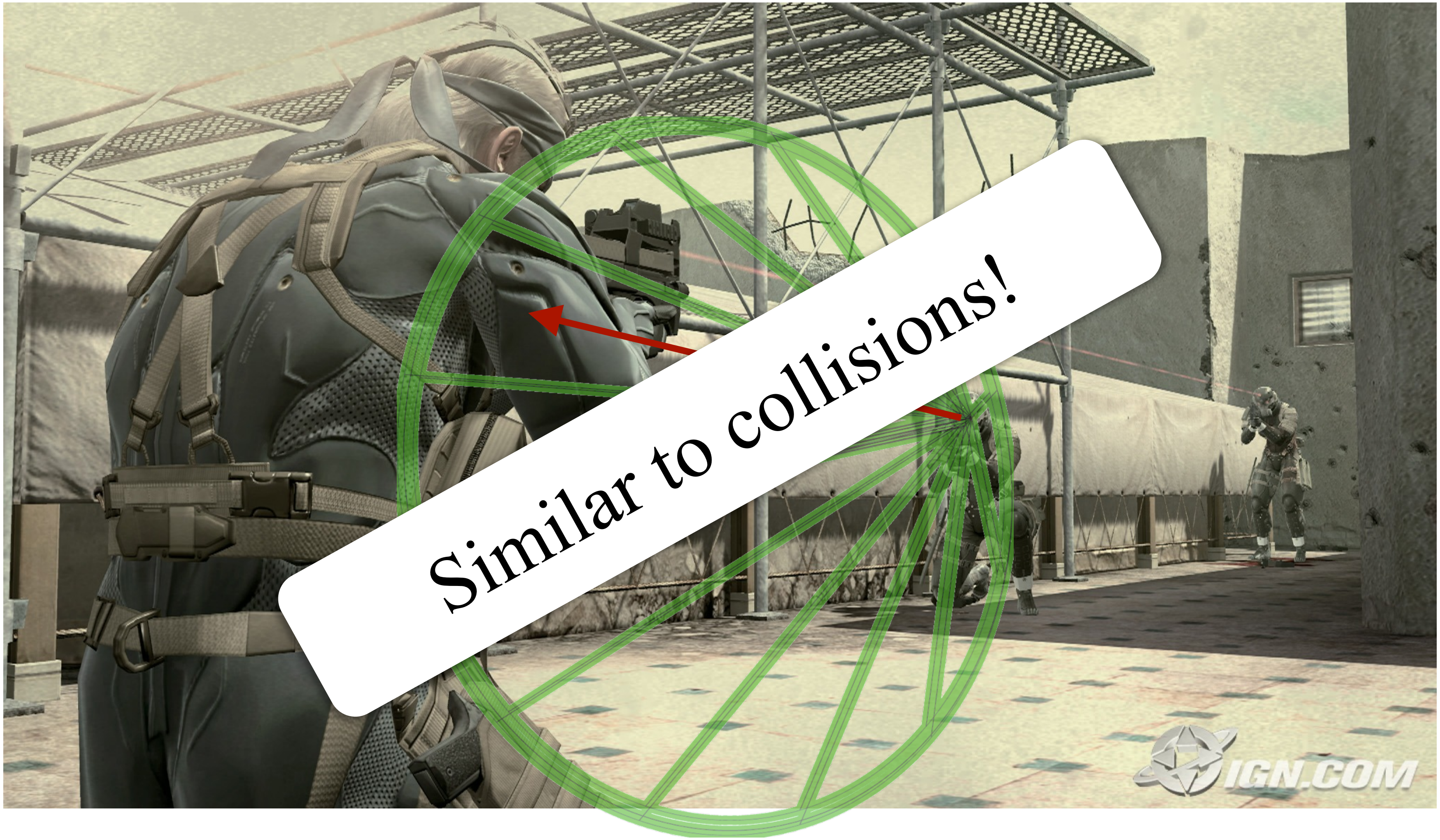


Similar to collisions!

Sense Events

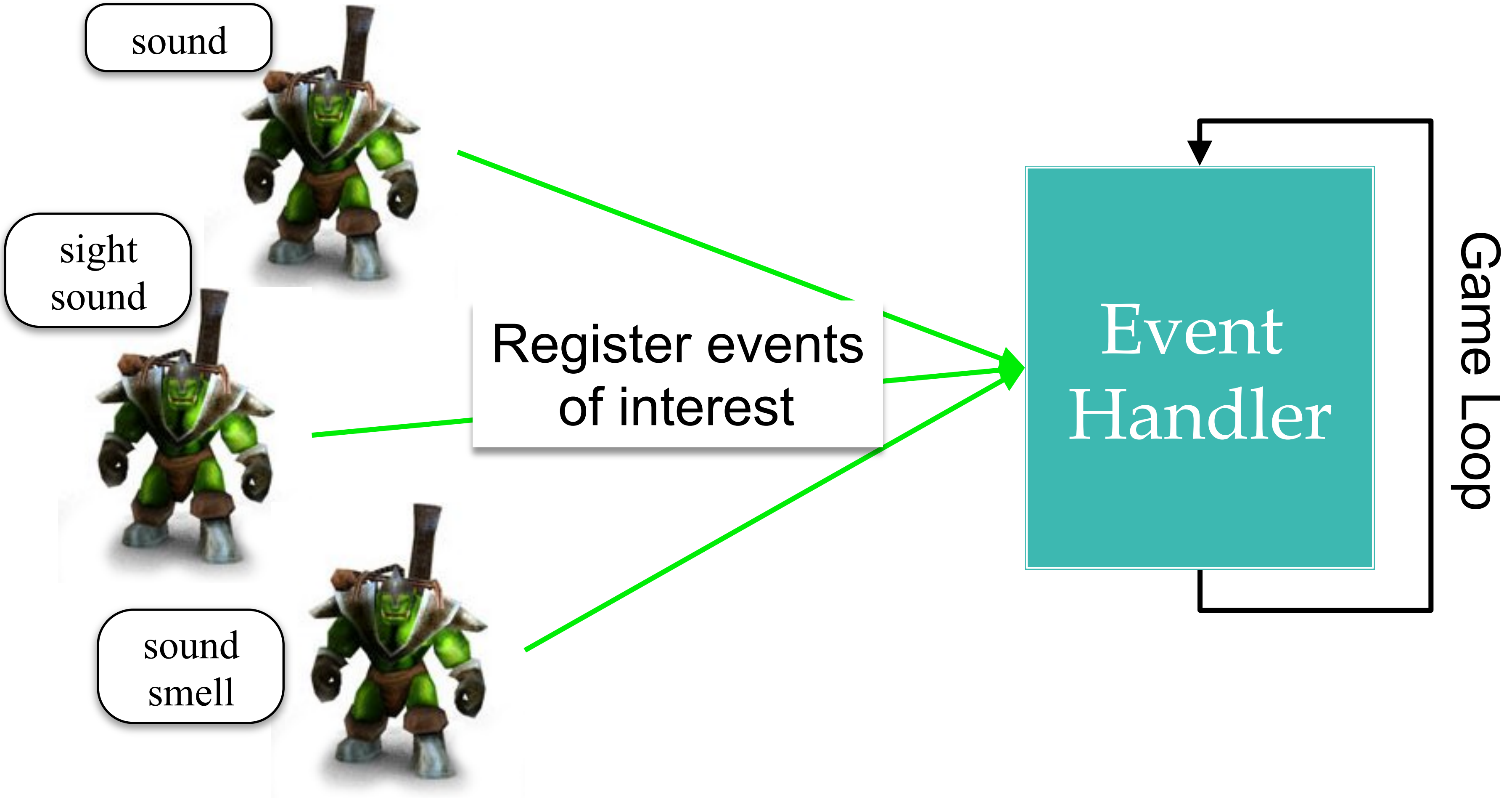
- **Event**: encoded sense data
  - Tagged with sense type
  - Information self-contained
    - Object with methods
    - Class is sense type
- Sensing is **event matching**
  - Each event has a type
  - NPCs "register" for a type
  - Send NPC registered events
  - Check if event is relevant

Pre-aggregated information

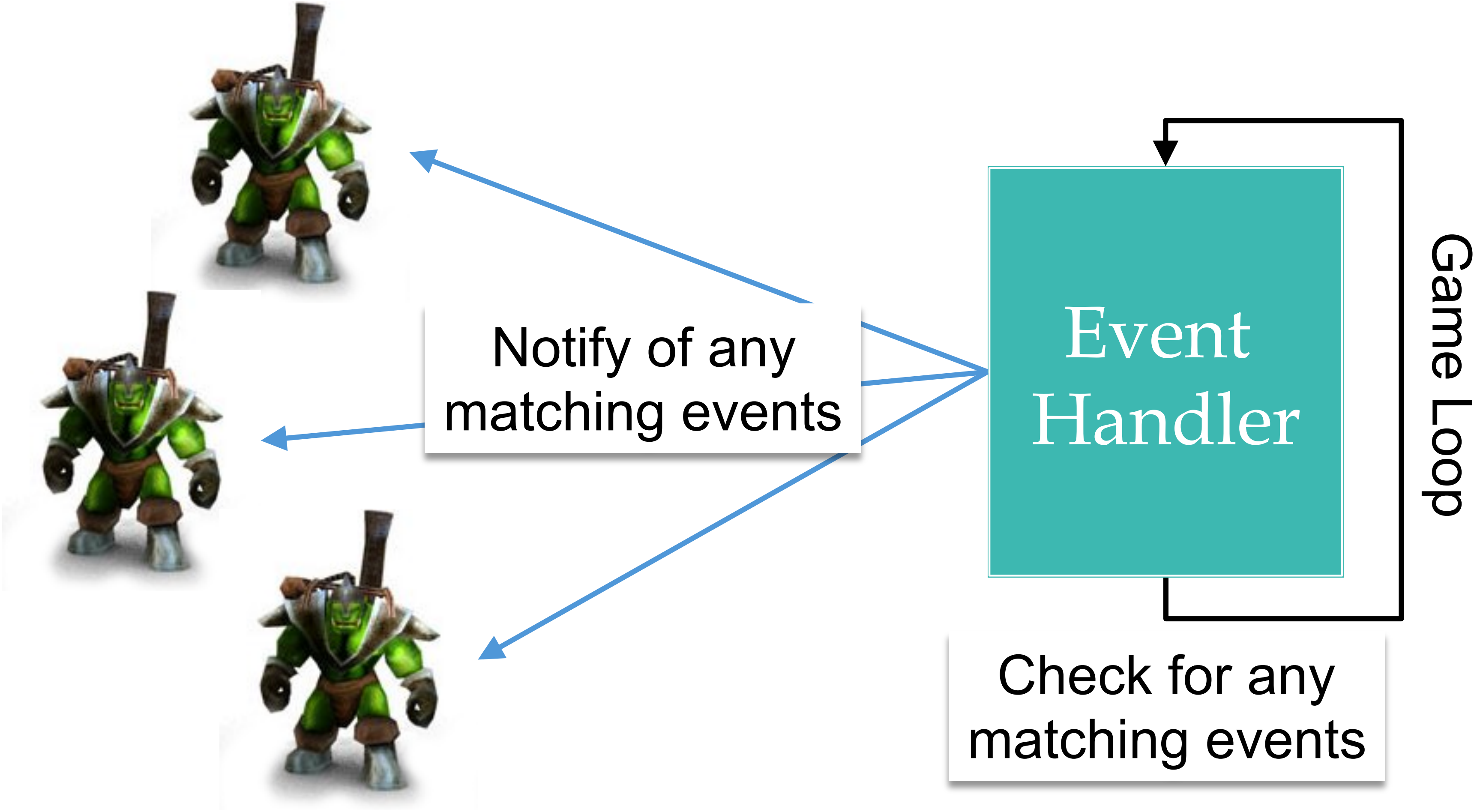
Event: CharacterExposed

```
boolean isSeen(NPC guard);

float distanceTo(NPC guard);

Vector moveDirection();
```

Sense Event Matching



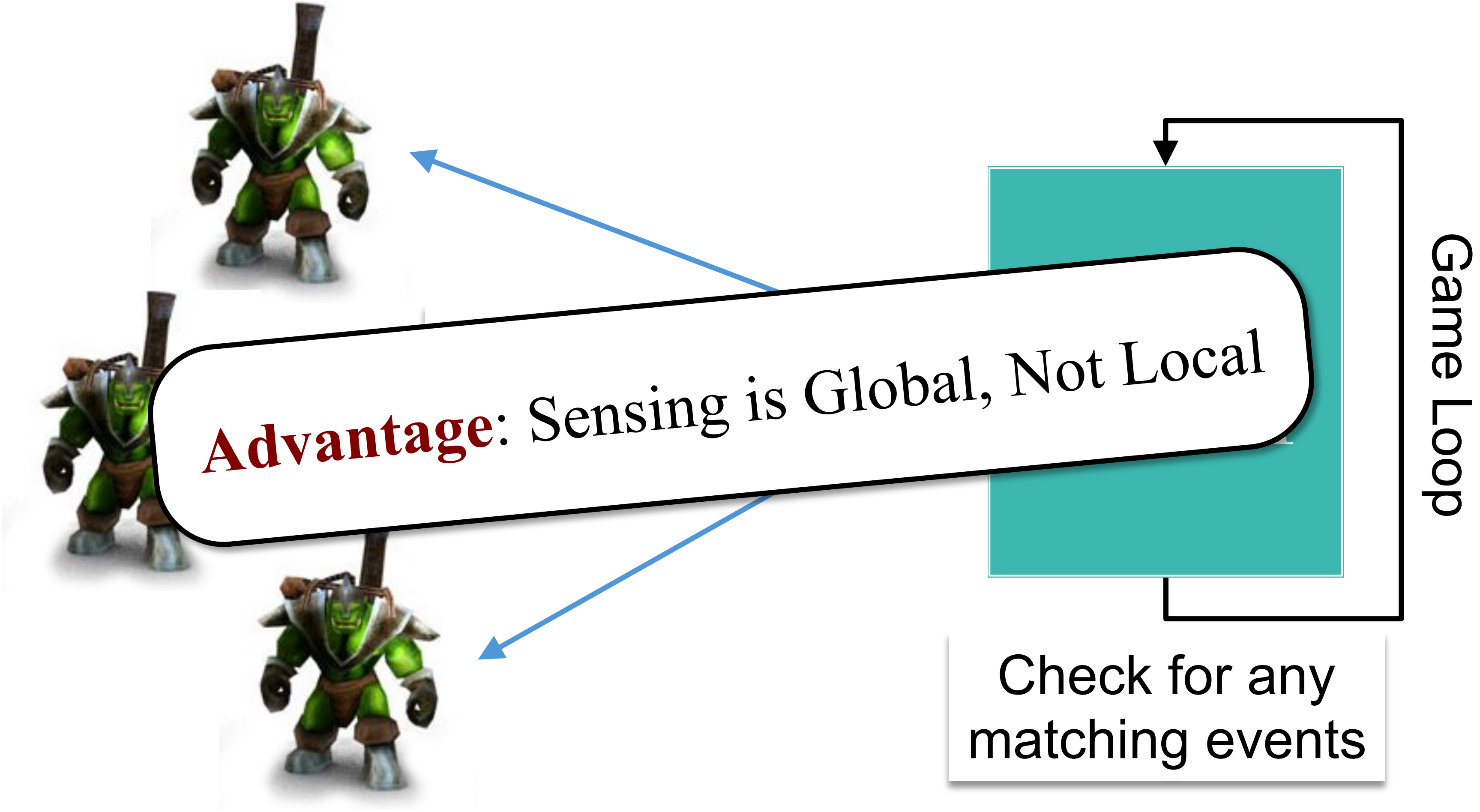
Sense Event Matching



Notify of any matching events

Check for any matching events

Sense Event Matching

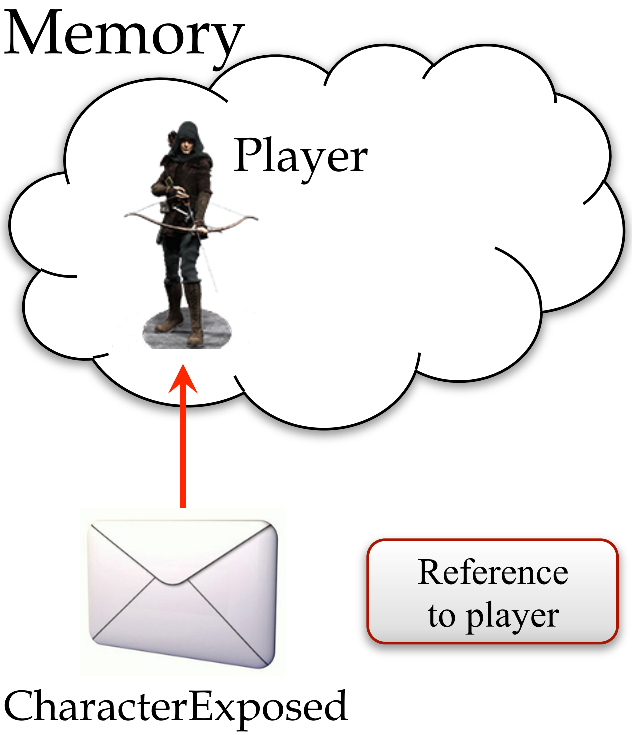


Check for any matching events

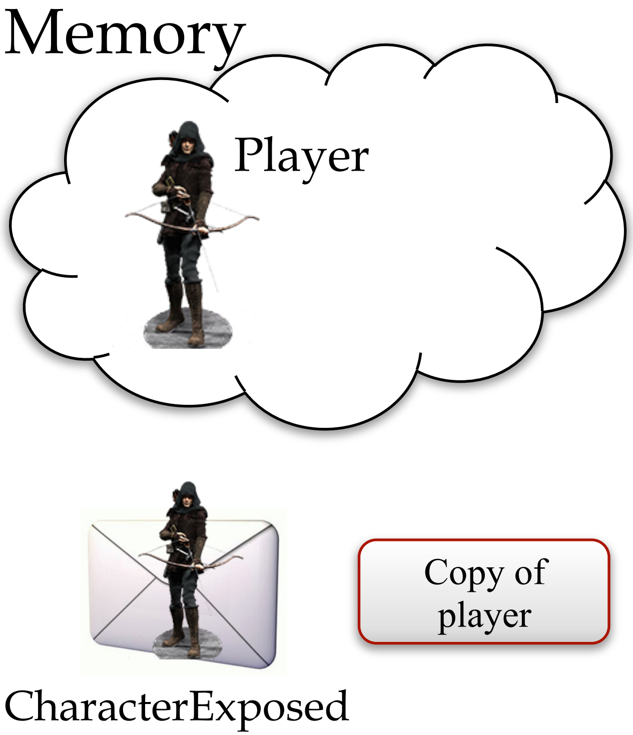
Advantage: Sensing is Global, Not Local

Representing Events

Lightweight



Heavyweight



Representing Events

Lightweight

```
class Event {
    Player ref;
    Event(Player p) {
        ref = p;
    }
}
```

- **Advantages**
  - Fast to create event
  - No additional memory

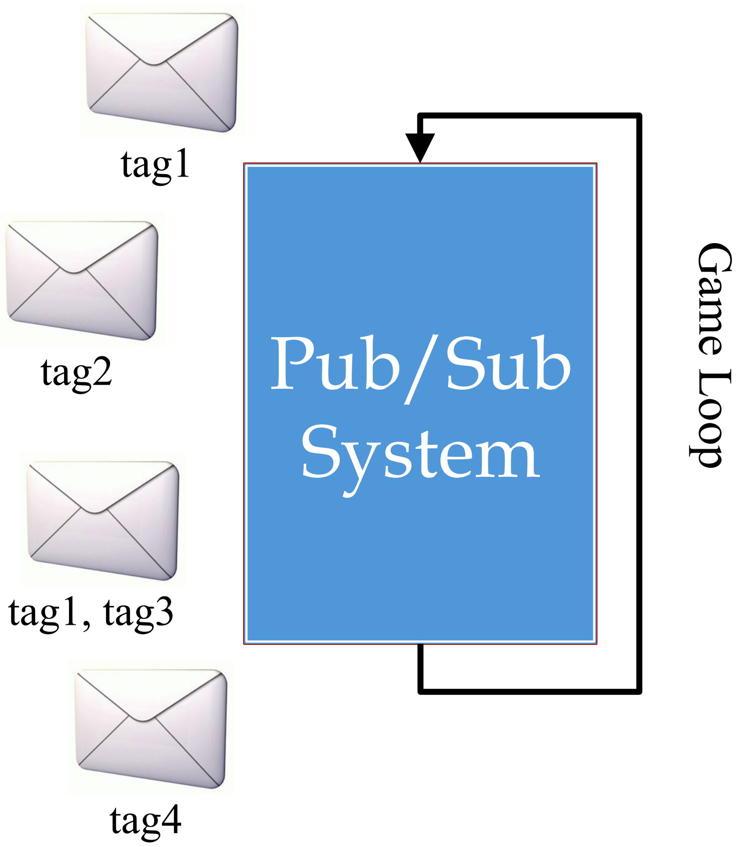
Heavyweight

```
class Event {
    Player ref;
    Event(Player p) {
        ref = p.copy();
    }
}
```

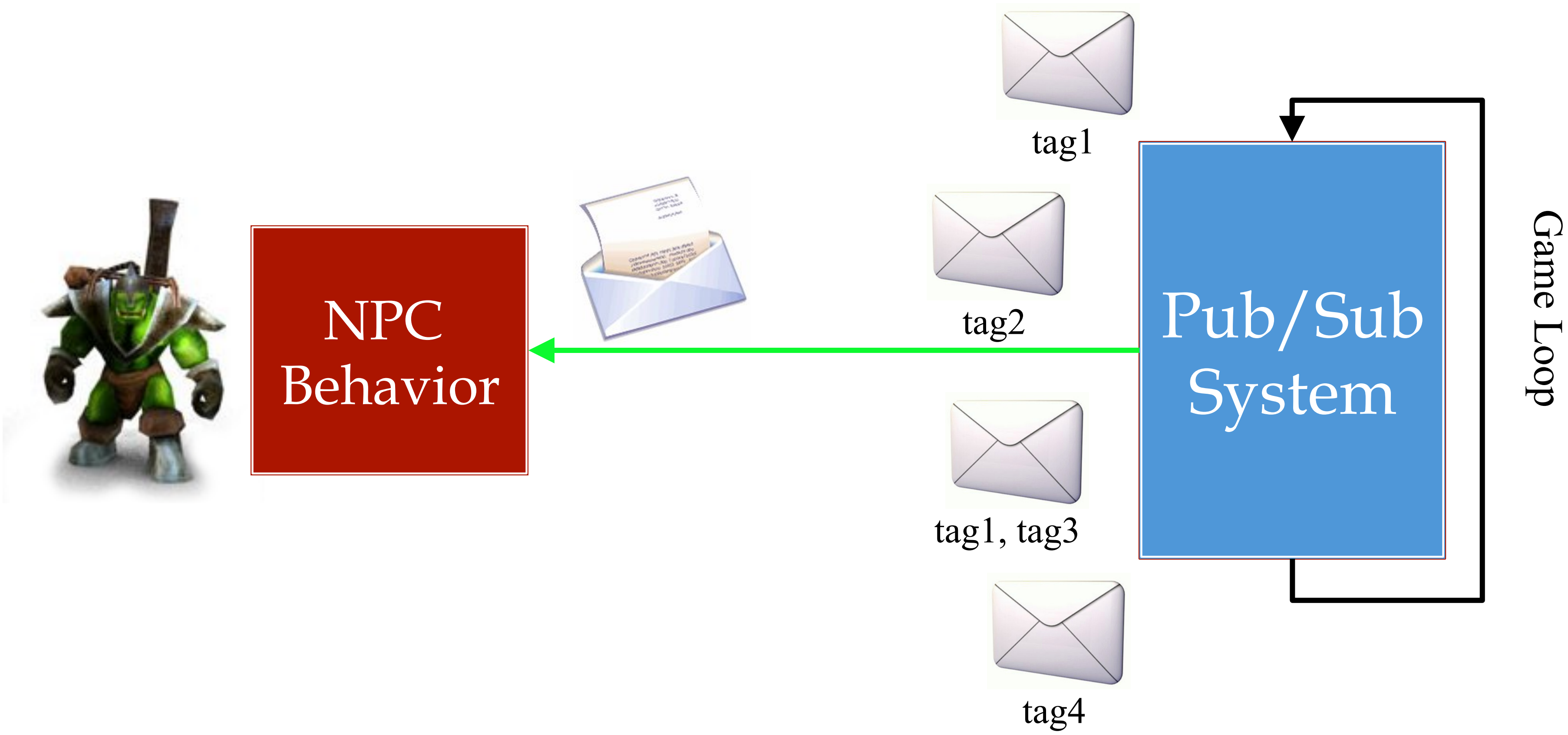
- **Advantages**
  - Stores past events
  - Can be **communicated**

Simple Pub/Sub Architecture

- NPC Hashtable
  - Event types are keys
  - Values are lists of NPCs
  - Say NPC subscribes to *e*
- Each **update cycle**…
  - Generate all of the events
  - Get NPCs for each event
  - Send those events to NPC
  - Process NPCs normally

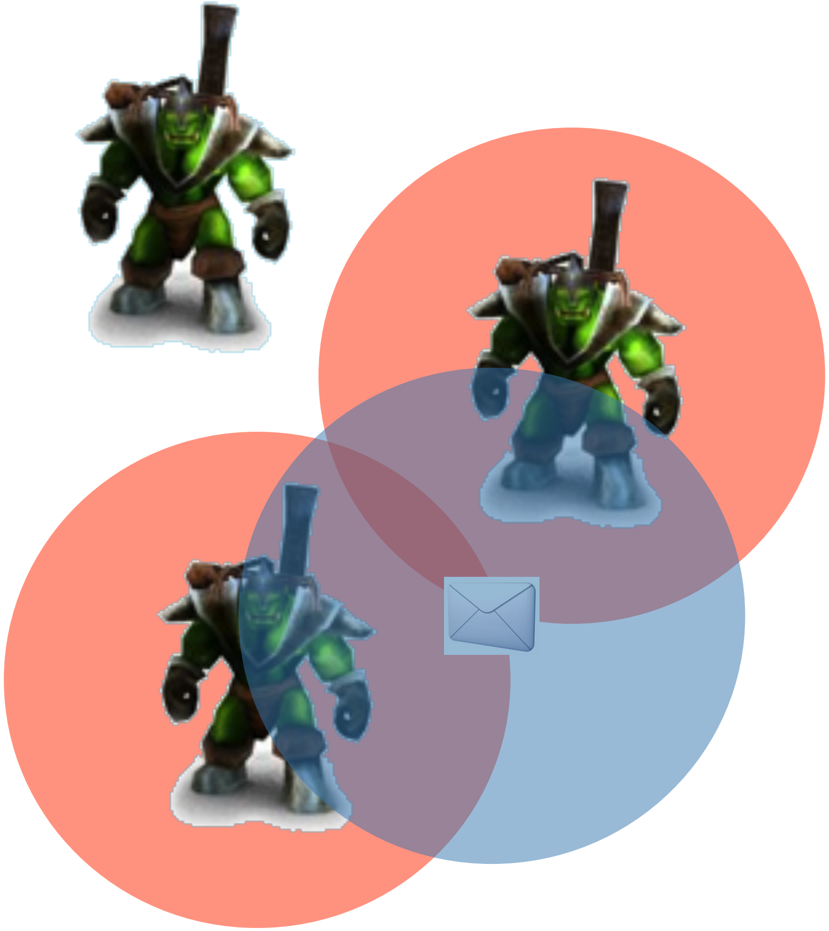


Simple Pub/Sub Architecture

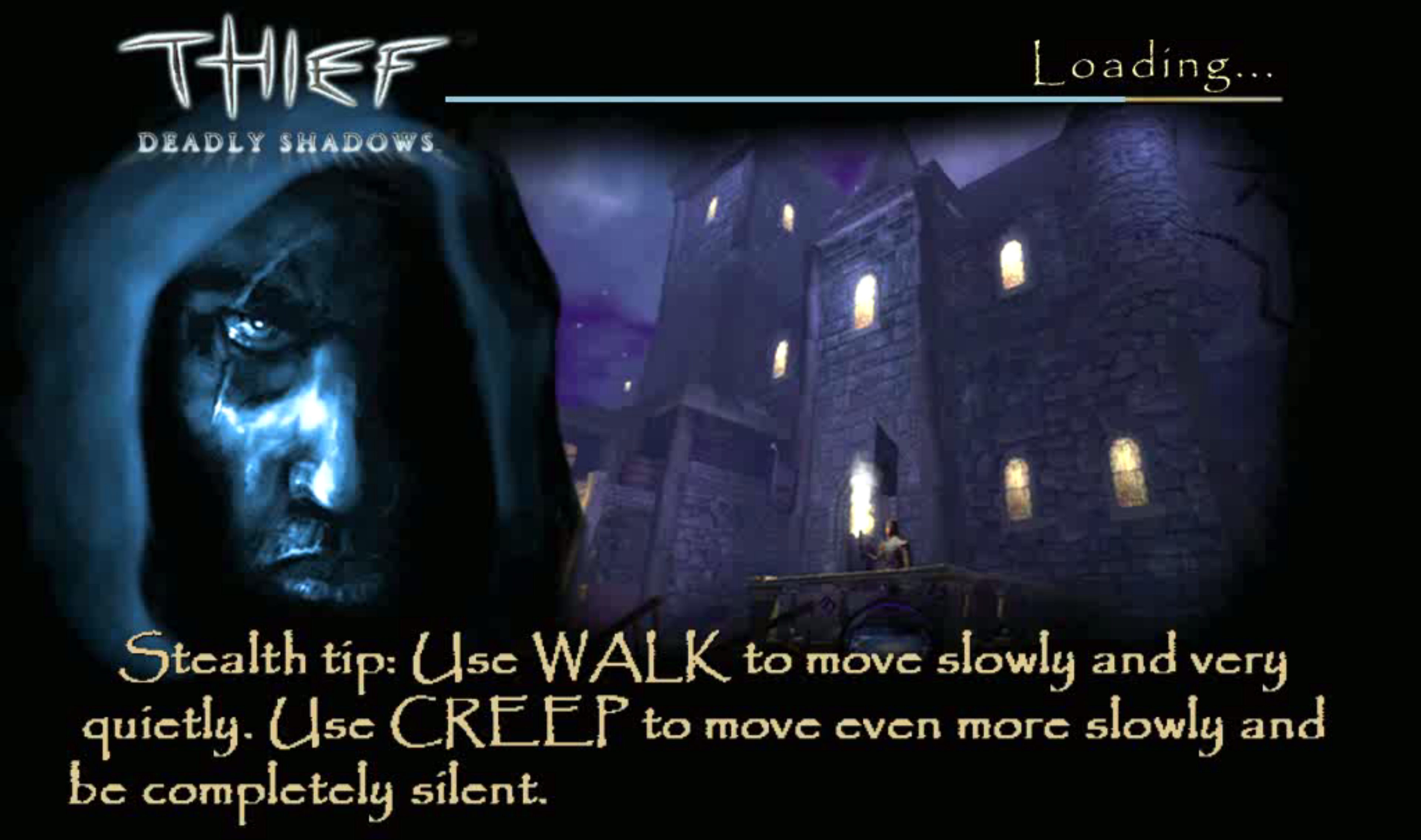


Spatial Optimizations

- Restrict to nearby NPCs
  - Have detection range
  - Limits events sensed
  - Easy to combine with event matching system
- Works in both directions
  - Nimbus: “can see” radius
  - Aura: “can be seen” radius
  - **Area of interest** management

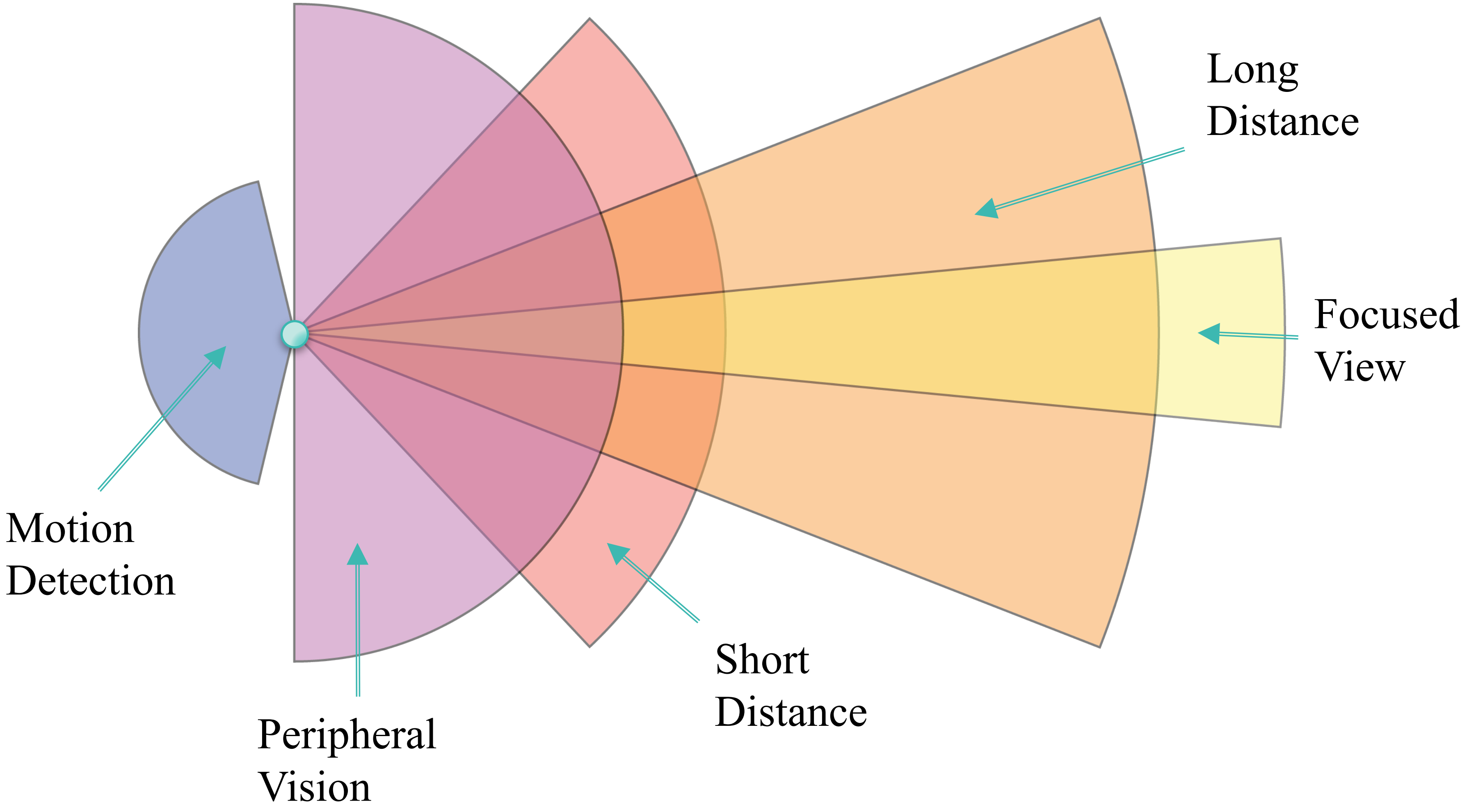


Case Study: *Thief* Series



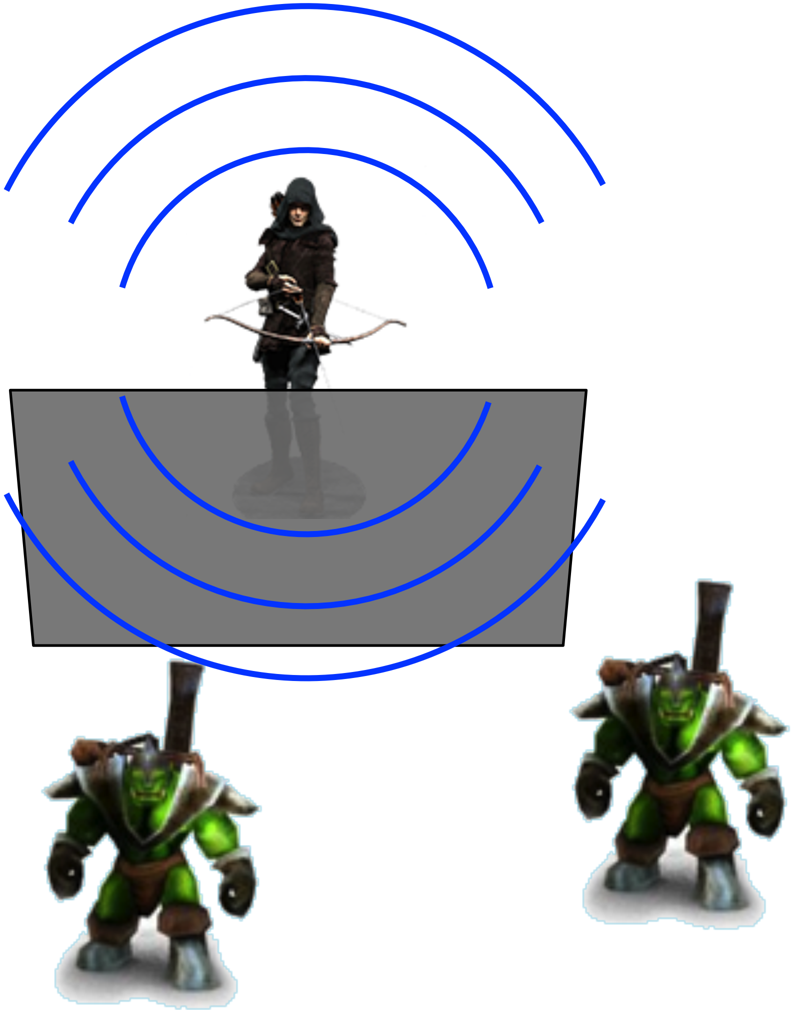
Stealth tip: Use WALK to move slowly and very quietly. Use CREEP to move even more slowly and be completely silent.

Line-of-Sight in *Thief*



Sounds in *Thief*

- "Easier" than vision
  - Primarily distance-based
  - Decays probabilistically
  - Tag with level of interest
- Sounds can be blocked
  - Not same as line-of-sight
  - Use alternate level map
  - Or **tag** your visible map
- Not physically realistic
  - Echoes? Reflections



Sounds in *Thief*

- Sounds are general purpose
  - Resuable framework
  - Code is lightweight
  - Encodes other senses
- **Example**: Smell
  - Treated as “pseudo-sound”
  - Generate like any sound
- Again, ignores other factors
  - Wind direction
  - Masking smells

Representing Events

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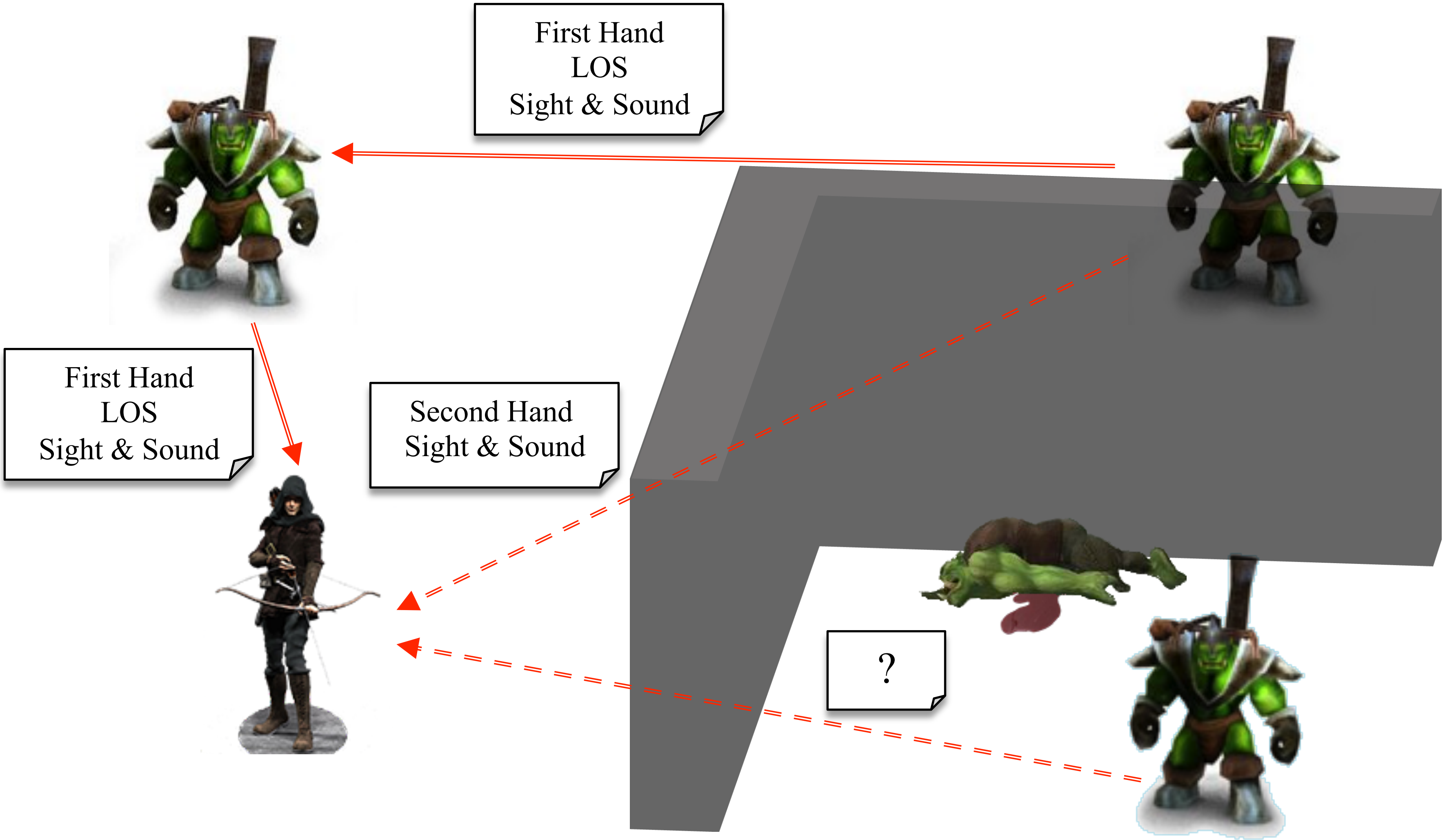
Communicating Senses



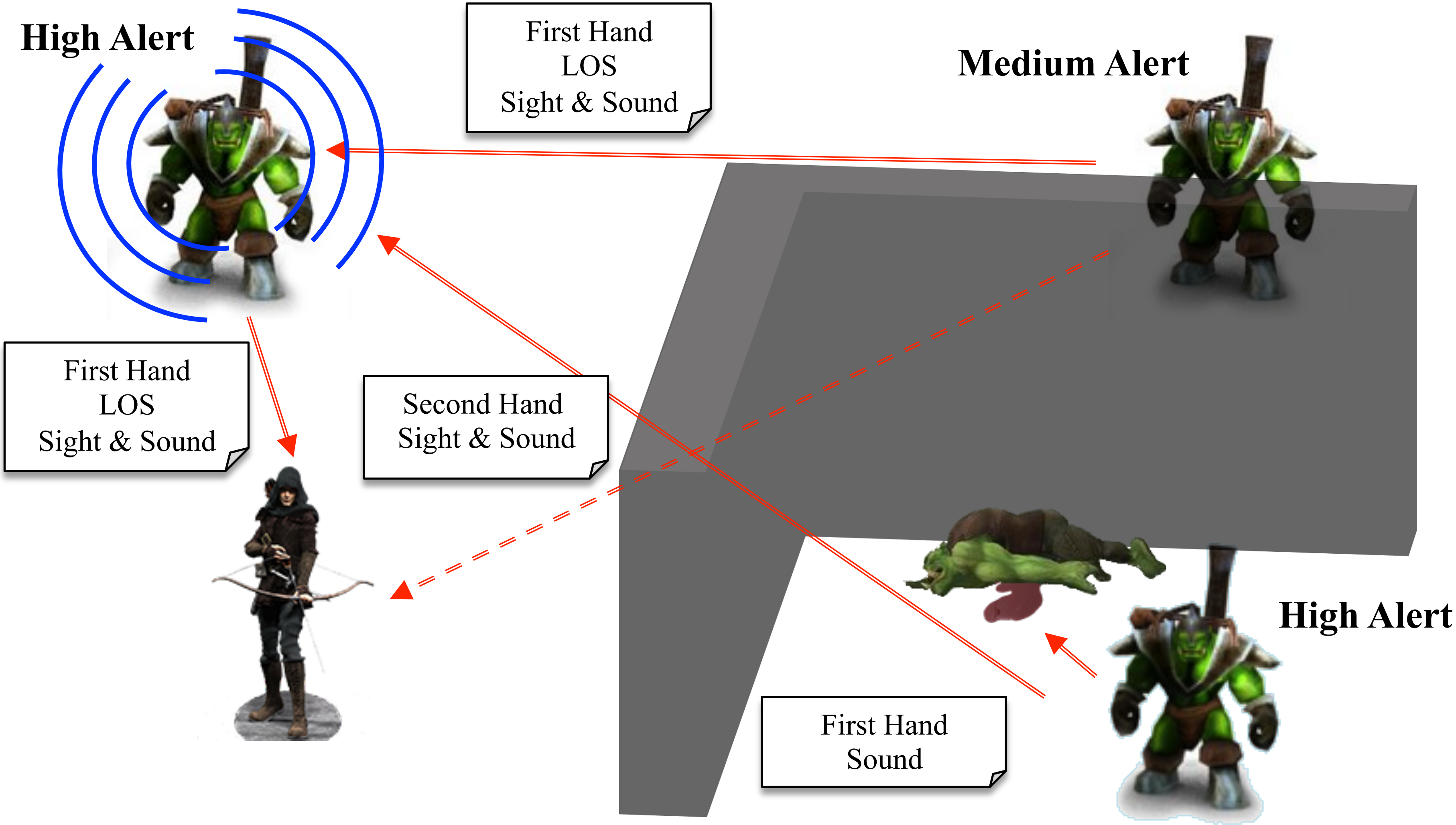
First Hand
LOS
Sight & Sound

First Hand
LOS
Sight & Sound

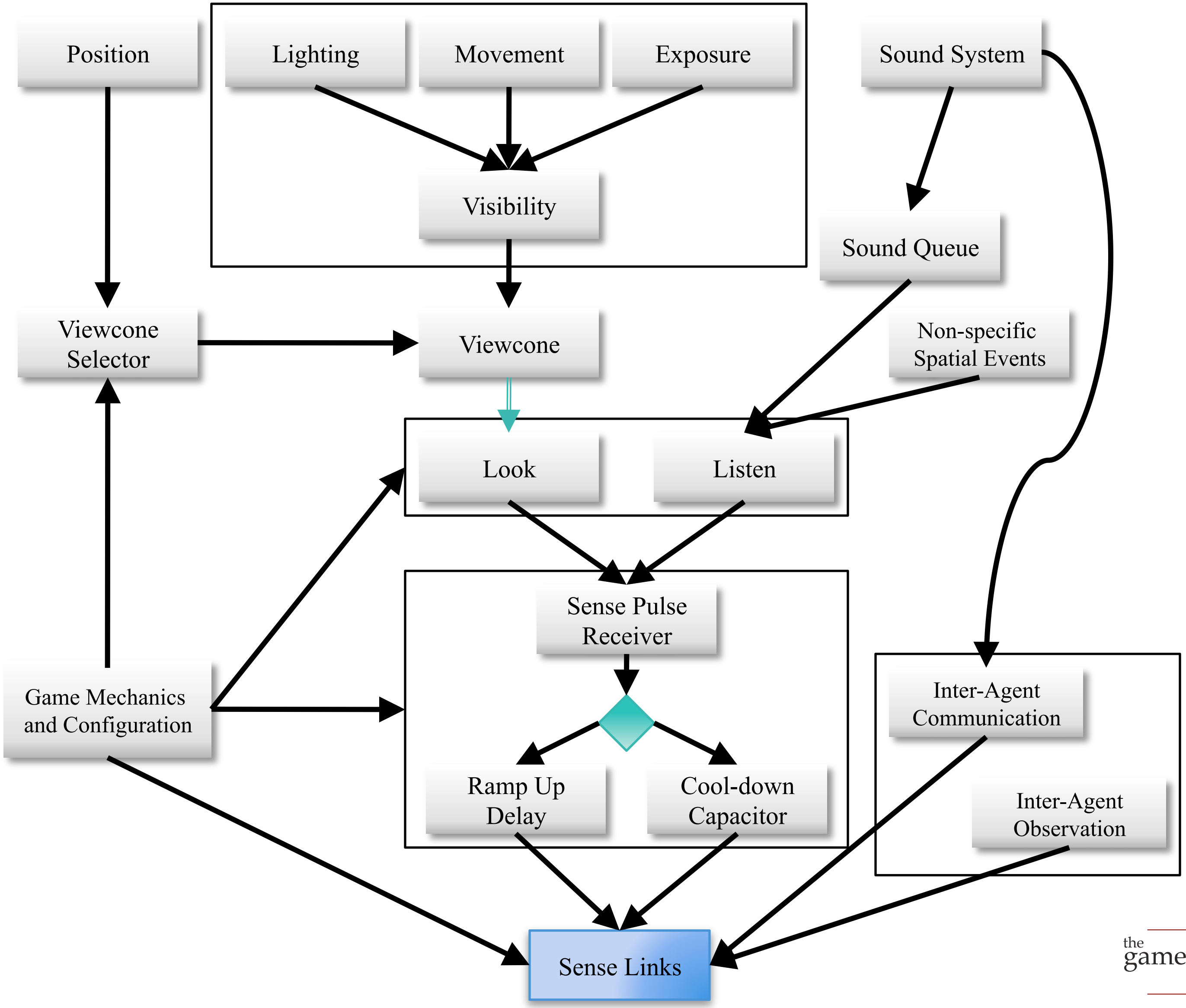
Second Hand
Sight & Sound

?

Alertness: Active Senses



Thief: Sense Events and Aggregation



Summary

- Sensing is the most expensive part of AI
  - Each character “looks” at every object in game
  - Often leads to O(n^2) behavior (bad!)
- Can **optimize** sense gathering
  - Aggregation is amenable to parallelization
  - Can piggyback some data onto pathfinding
- Event matching **inverts** the sensing problem
  - Creation of sense makes a data event
  - Forward event to “relevant” NPCs