15-466
Computer Game Programming

AI Game Architecture

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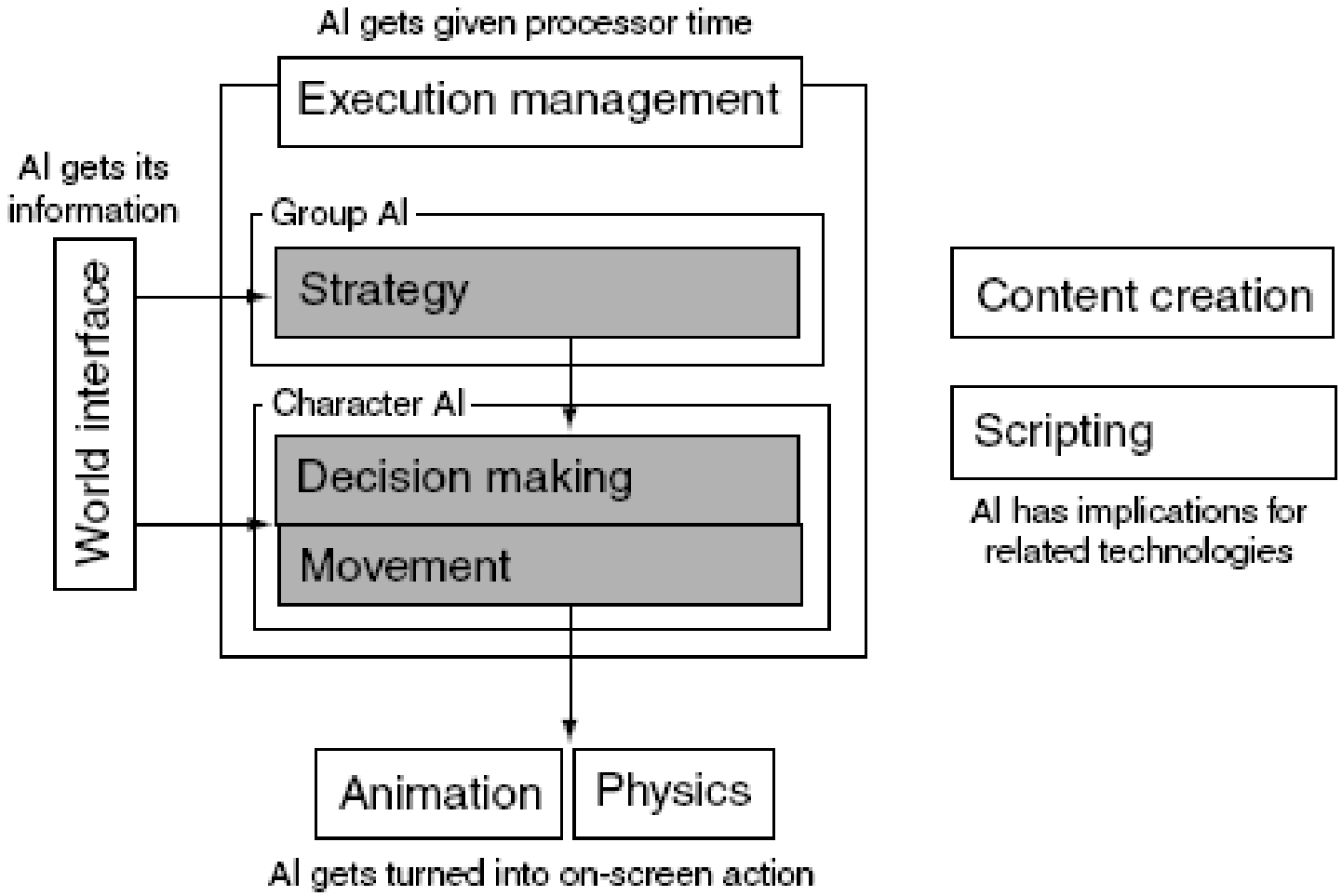
AI in Game Architecture



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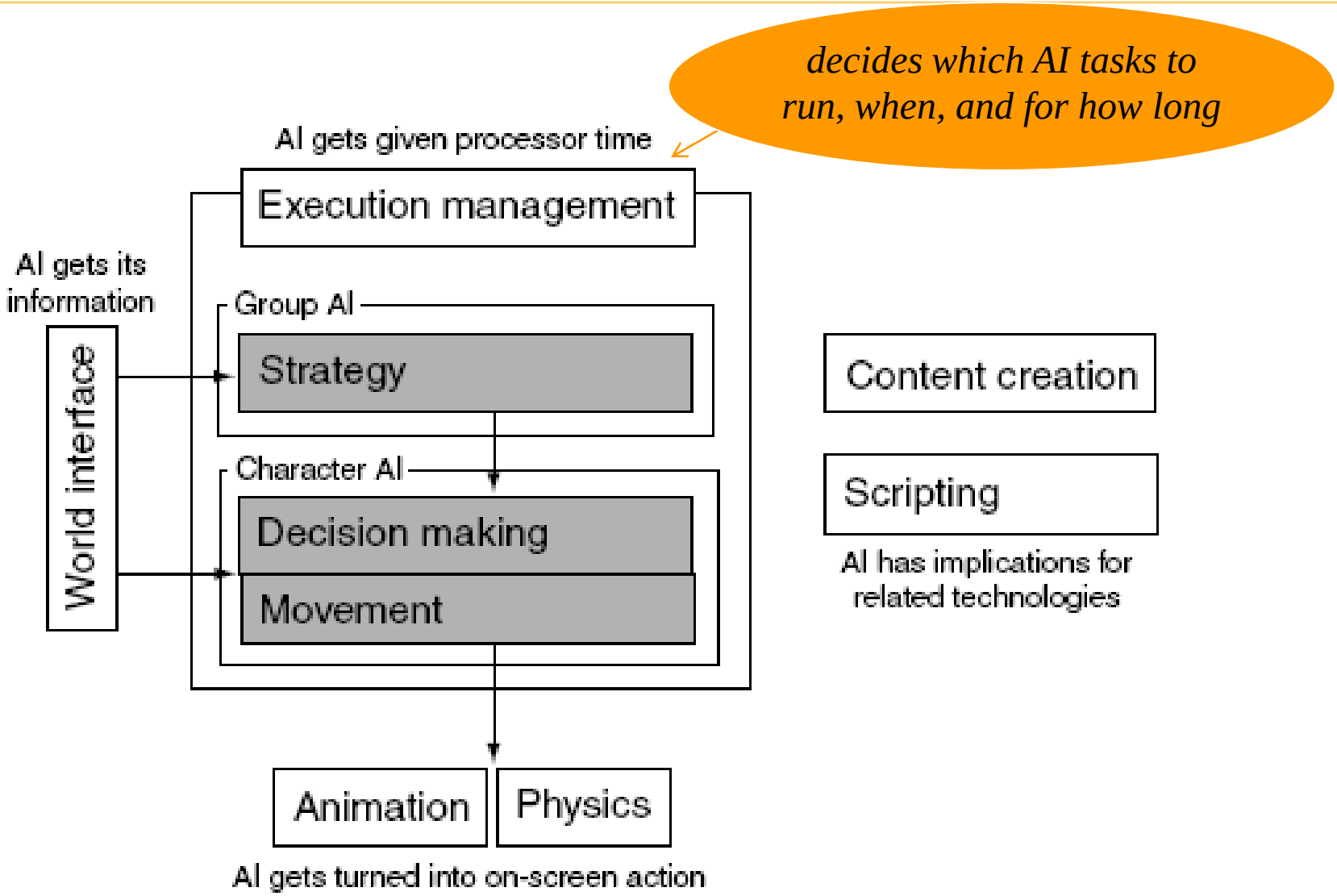
AI in Game Architecture



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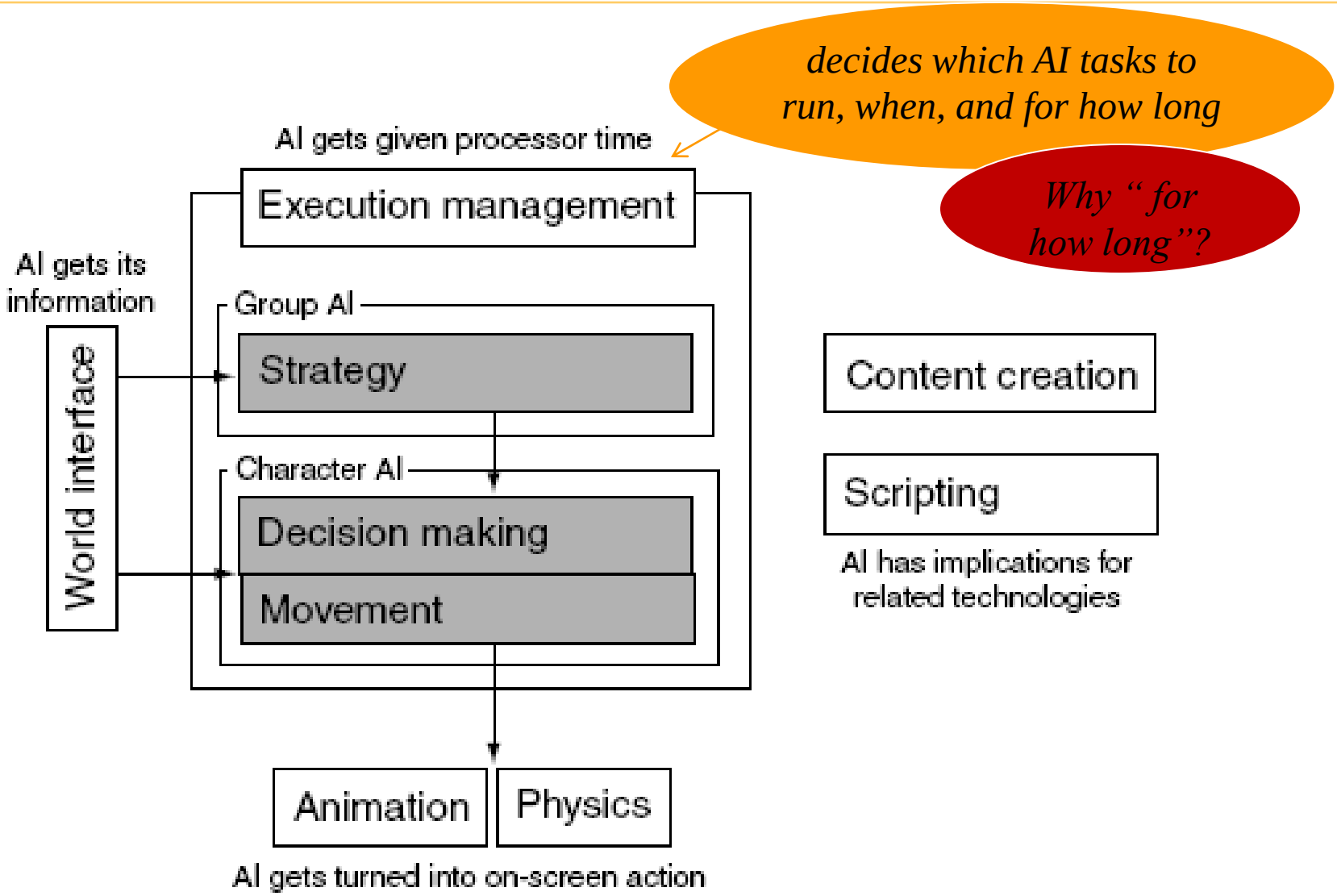

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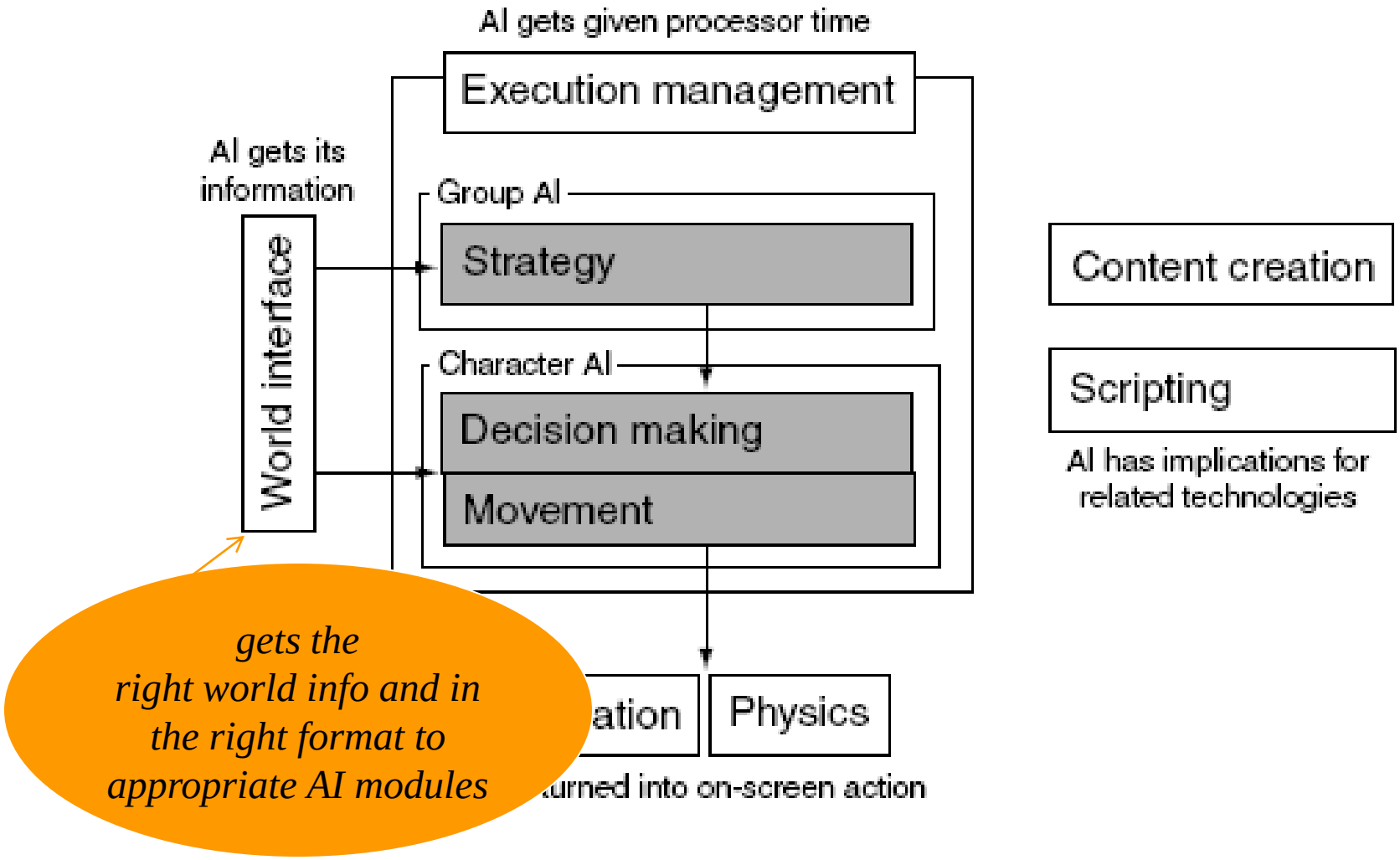

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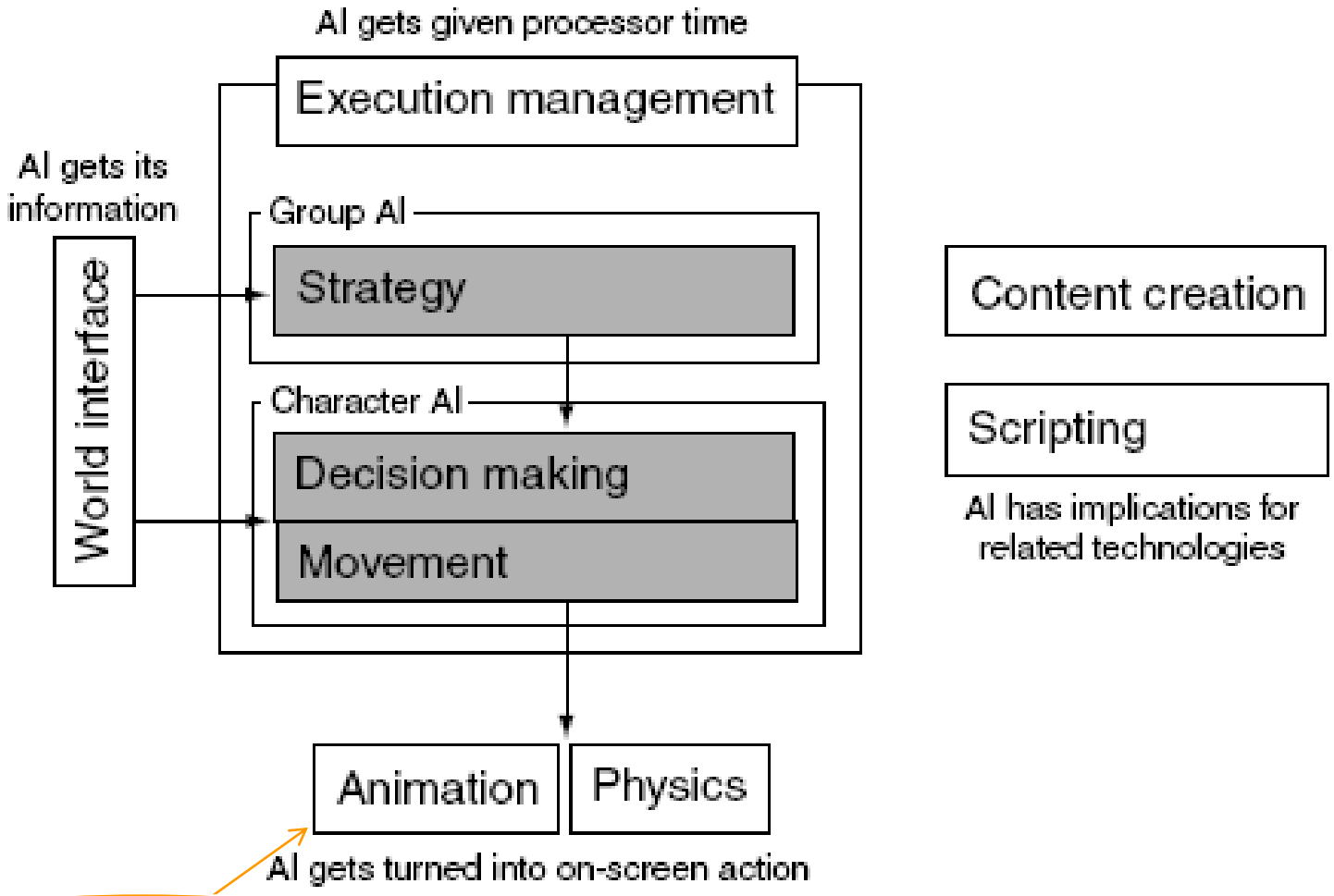
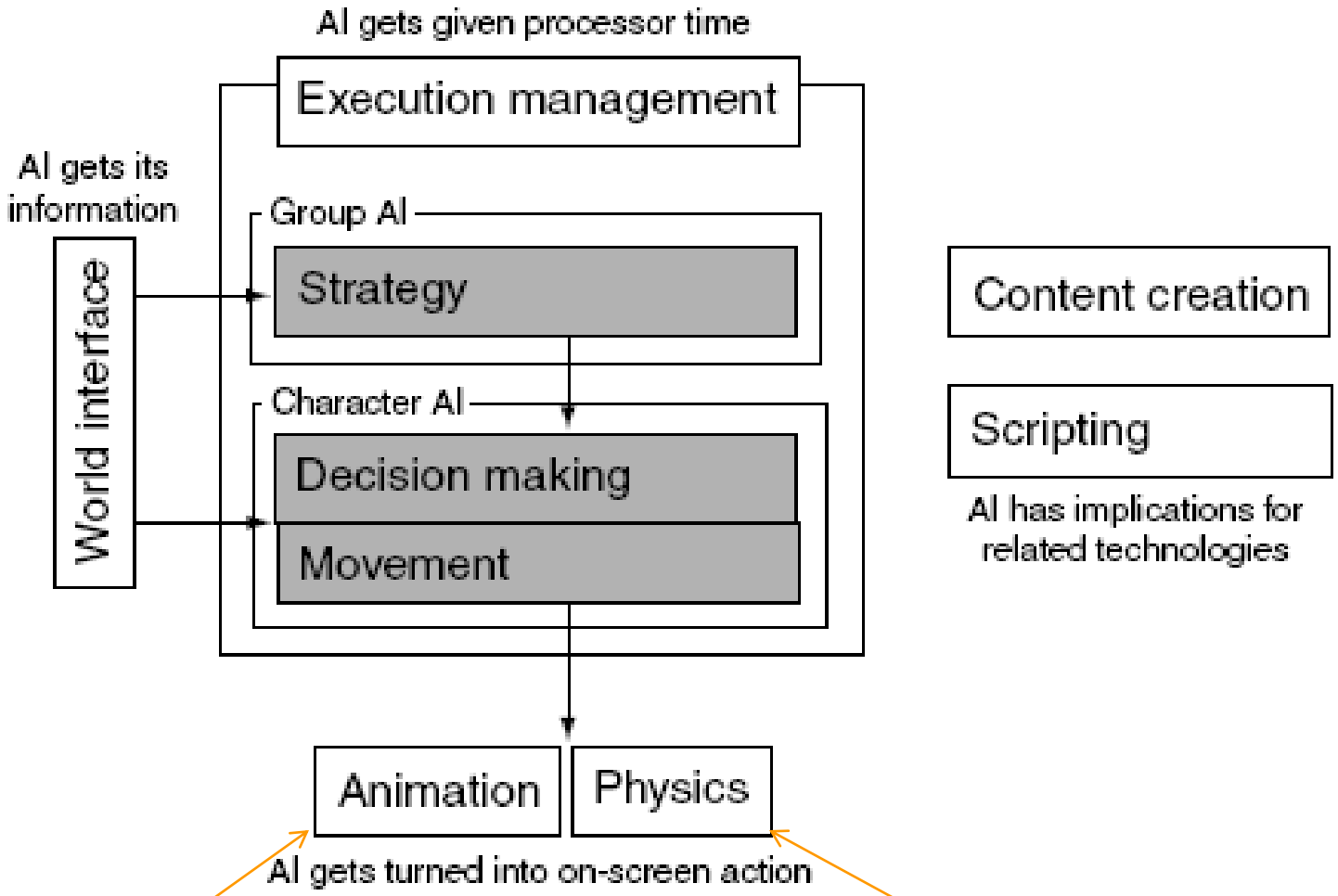


translates AI decisions into the actual (animated) actions

Games" by I. Millington & J. Funge

AI in Game Architecture



translates AI decisions into the actual (animated) actions

translates actions into changes to the world

Games" by I. M.

Execution Management

- Modern AI processing in games can often take 5-50% of processing

- Someone needs to control the limited processing time
  - dividing available time among AI tasks
  - scheduling algorithms to work over time
  - making preferences for “important” characters

Execution Management

- Dividing available time among AI tasks

from Age of Empires

Execution Management

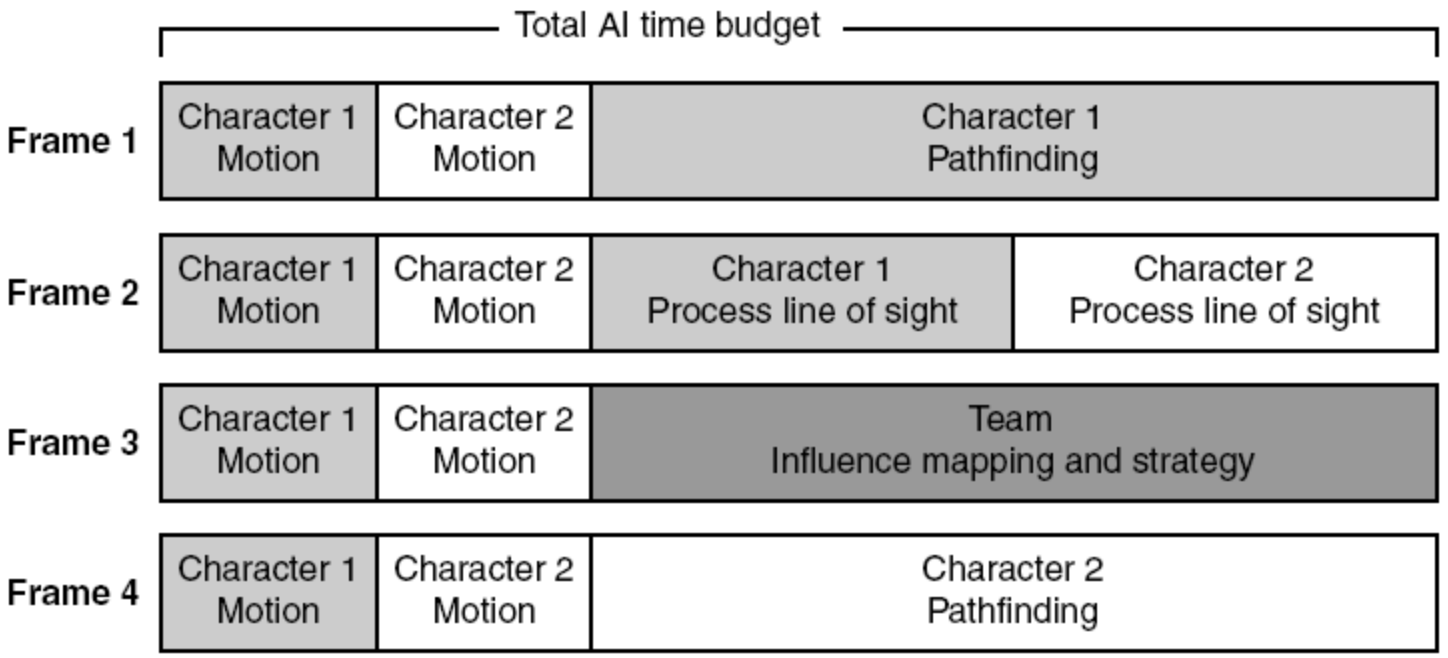
- Dividing available time among AI tasks

How is it different from graphics-related tasks that are also done every frame?

from Age of Empires

Execution Management

- Dividing available time among AI tasks



from "Artificial Intelligence for Games" by I. Millington & J. Funge

Execution Management

• Dividing available time among AI tasks: **Frequency-based scheduler**

-takes in N tasks, each task T_i has execution frequency f_i

-runs each task T_i at its frequency

Any issues?

Execution Management

• Dividing available time among AI tasks: **Frequency-based scheduler**

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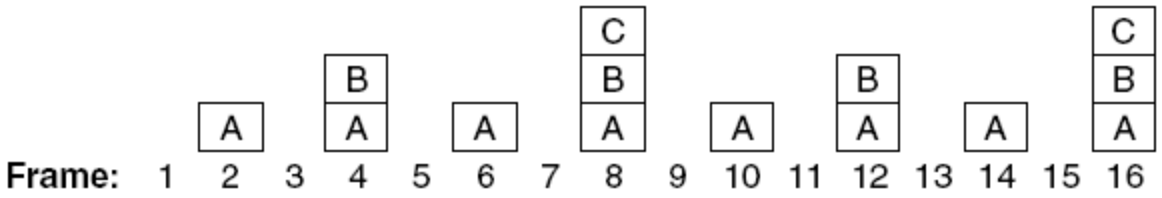
-runs each task T_i at its frequency

Example: f(A) = 2, f(B)=4, f(C)=8



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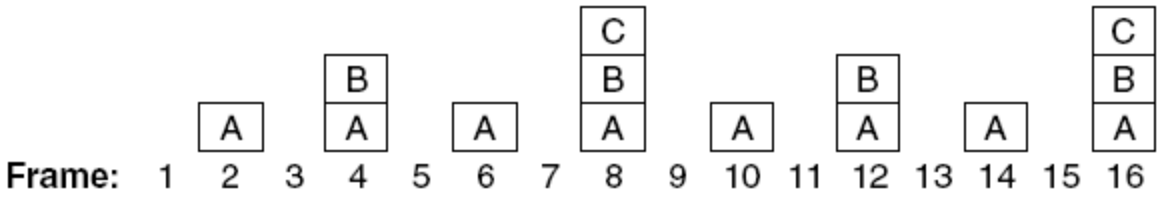
Any ideas how to mitigate this?



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Execution Management

• Dividing available time among AI tasks: **Frequency-based scheduler**

-takes in N tasks, each task T_i has execution frequency f_i

-runs each task T_i at its frequency and with its own phase p_i

Example:

```
Initialization:
        for i =1…100
          task[i].freq = 10;
          task[i].phase = i;

Main Loop:
        for i=1…100
          task[i].freq % (frame+task[i].phase) == 0
                run task[i];
```

Execution Management

• Dividing available time among AI tasks: **Frequency-based scheduler**

-computing a good quality p_i according to Wright's method:

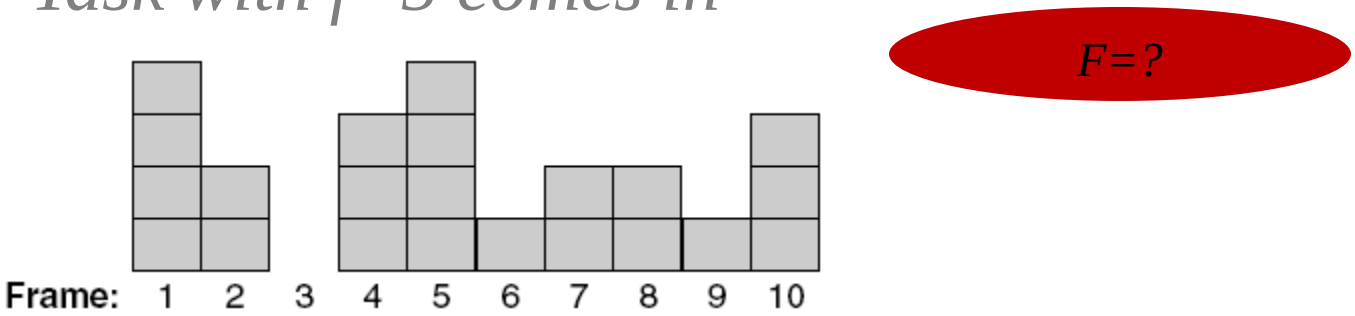
whenever new task T_i with frequency f_i needs to be scheduled

run the scheduler for K frames

pick frame $F < f_i$ with least total # of tasks executed at F,F+fi,...

set phase p_i to F

Example: Task with f=5 comes in



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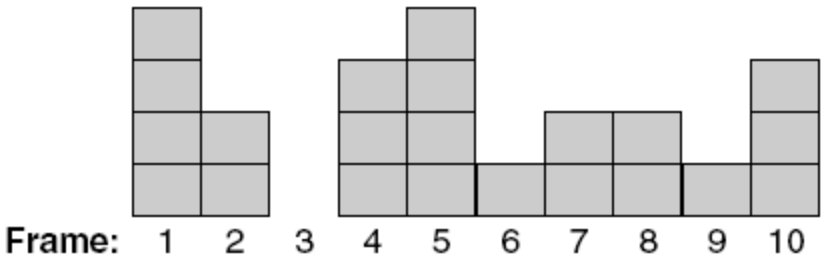
Example: Task with f=5 comes in

F=3



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Execution Management

- Dividing available time among **Interruptible** AI tasks

  -Interruptible tasks can be paused and resumed as time allows

  -can use threads (less common in games)

  -can use software threads (tasks are supposed to return as soon as their time expires)

Load-balancing Scheduler:

during each frame

it distributes time among the tasks scheduled for this frame

Execution Management

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  -Interruptible tasks can be paused and resumed as time allows

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  -can use software threads (tasks are supposed to return as soon as their time expires)

Priority Scheduler:

during each frame

it distributes time among the tasks scheduled for this frame

proportionally to the priority of the tasks

Execution Management

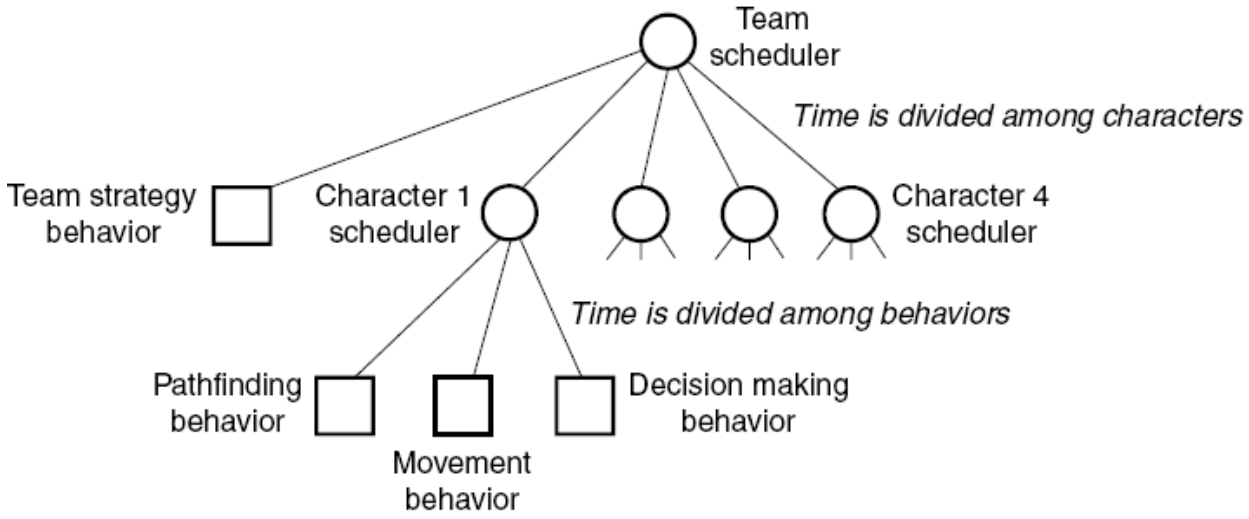
- Dividing available time among **Interruptible** AI tasks

  -Interruptible tasks can be paused and resumed as time allows

  -can use threads (less common in games)

  -can use software threads (tasks are supposed to return as soon as their time expires)

Hierarchical Scheduler:



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Execution Management

- **Anytime AI tasks**

  -compute the best solution they can within provided time

  -can often improve the solution within the subsequent (next cycle) executions

  -common in Path Finding

  - we will learn more about it in the later classes

Execution Management

- **Anytime AI tasks**

  -compute the best solution they can within provided time

  -can often improve the solution within the subsequent (next cycle) executions

  -common in Path Finding

Execution Management

- **Level of Details-based management**

  -less important characters run at lower frequencies

  -less important characters run at lower priorities

  -less important characters get less AI tasks and behaviors to run

Execution Management

- **Level of Details-based management**

  -less important characters run at lower frequencies

  -less important characters run at lower priorities

  -less important characters get less AI tasks and behaviors to run

Example?

World Interfacing

- To be believable, characters need to know the “right” world information at the “right” time

World Interfacing

• Information can be received via polling or event processing

-polling (e.g., Is this door open or closed?)

-events (e.g., need to know whenever the door closes)

-tasks subscribe to events of interest

-other entities send out events

-event manager receives and dispatches messages to those tasks that subscribed to them

World Interfacing

- Getting the “right” information:
  -the believable sensory ability of AI characters

World Interfacing

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  -the believable sensory ability of AI characters

  -typical senses used in games (in the order of popularity): sight, touch, hearing, smell

World Interfacing

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Any others?

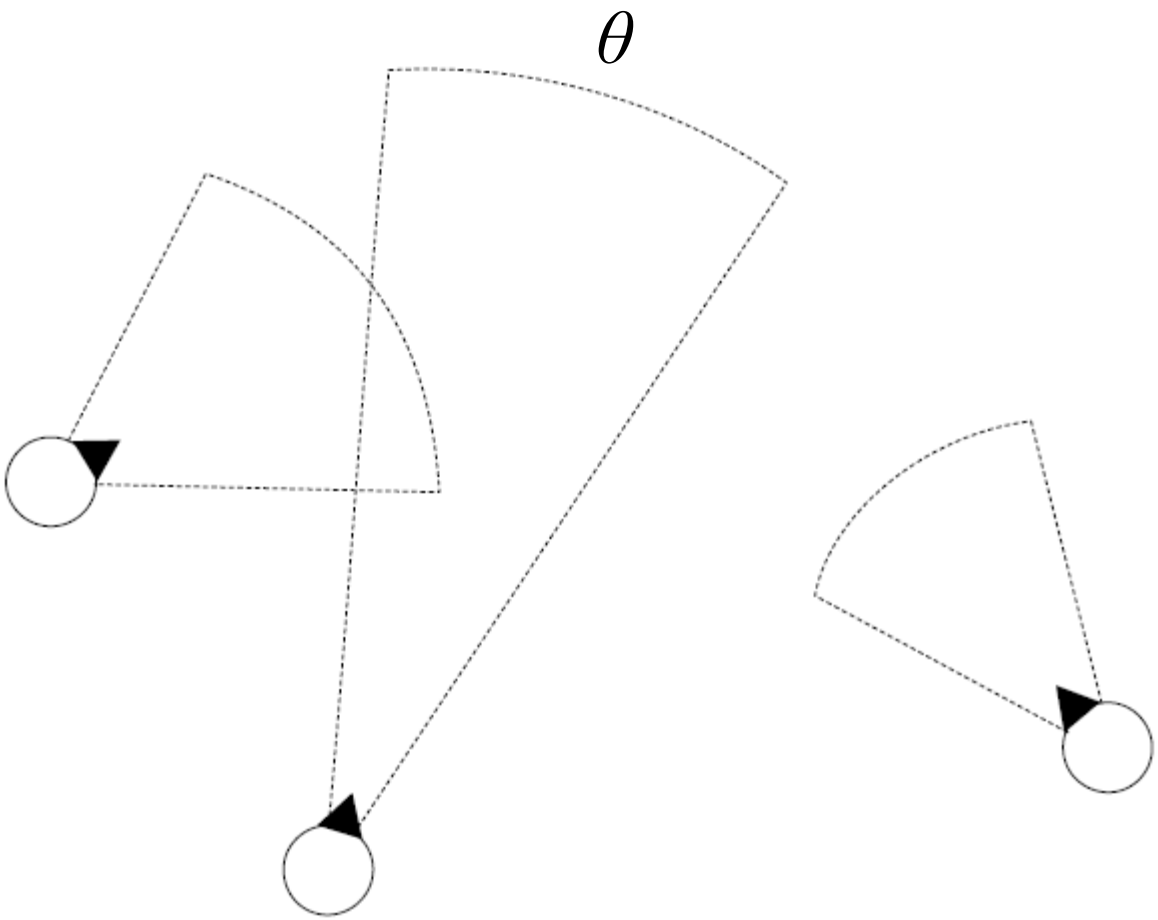
World Interfacing

- Simulating realistic sight
  - sight cone

from Doom

World Interfacing

- Simulating realistic sight
  - sight cone



from "Artificial Intelligence for Games" by I. Millington & J. Funge

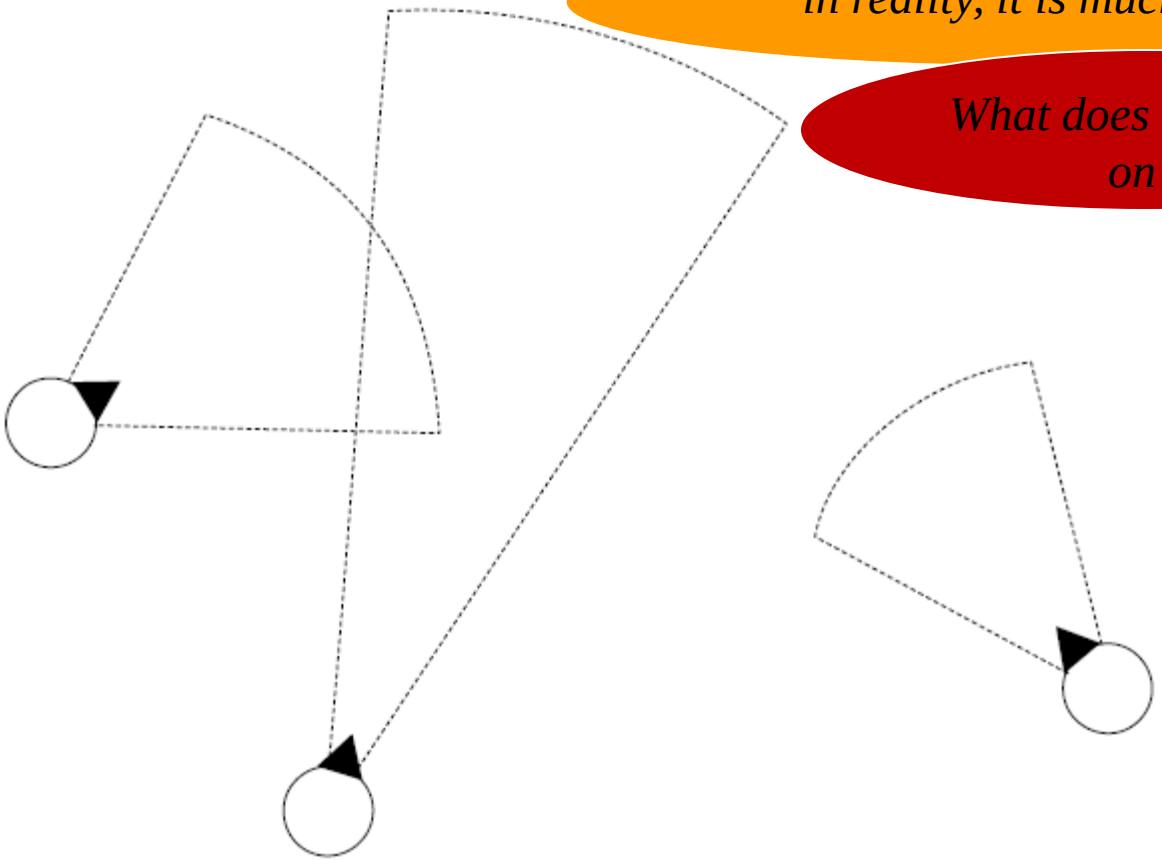
World Interfacing

- Simulating realistic si
  - sight cone

theoretically:
about 120º vertically
about 220º horizontally

in reality, it is much less

What does it depend on?



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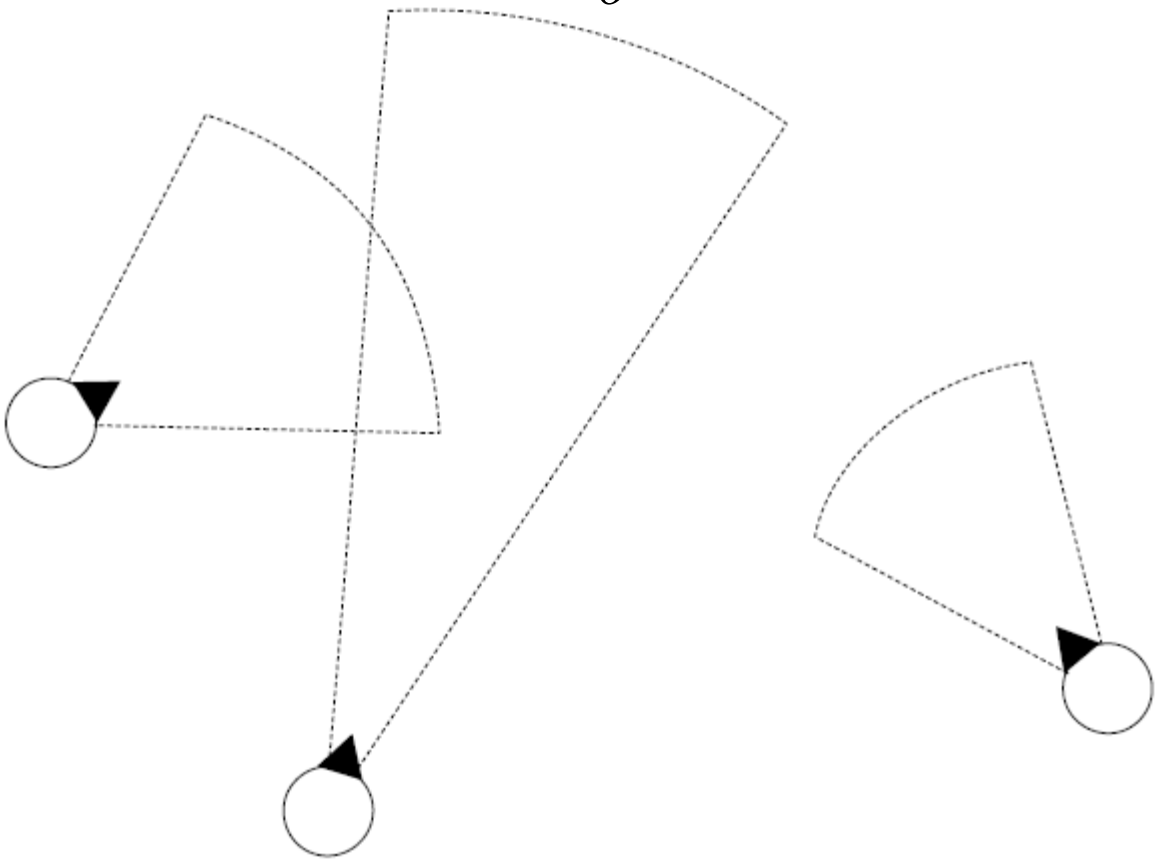
World Interfacing

- Simulating realistic sight
  - sight cone

commonly used cone: 60°

θ



from "Artificial Intelligence for Games" by I. Millington & J. Funge

World Interfacing

• Simulating realistic sight, other factors (in the order of popularity):

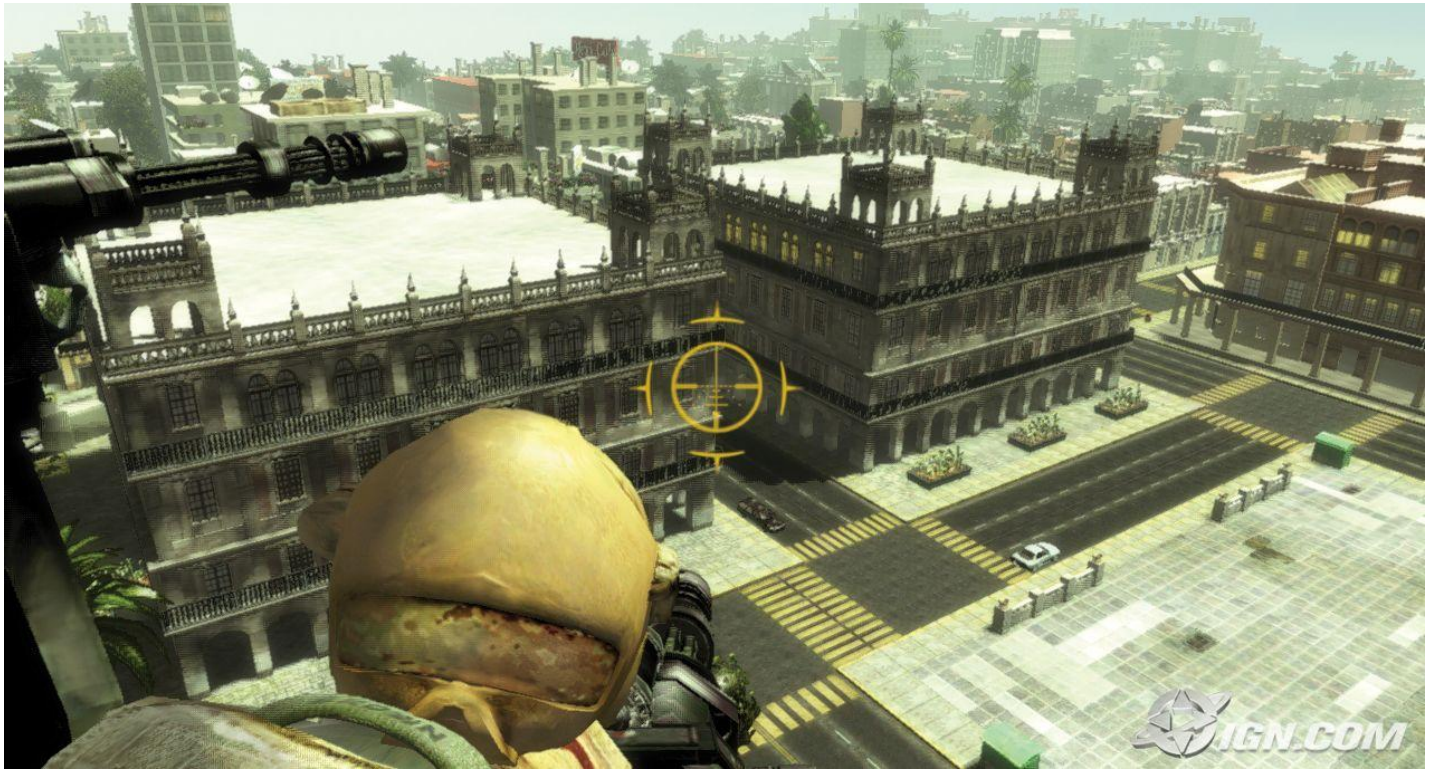
- line-of-sight

from Splinter Cell

World Interfacing

• Simulating realistic sight, other factors (in the order of popularity):

- line-of-sight
- distance (typically, hard limit)



from Ghost Recon

World Interfacing

• Simulating realistic sight, other factors (in the order of popularity):

- line-of-sight
- distance (typically, hard limit)
- brightness

from Splinter Cell

World Interfacing

• Simulating realistic sight, other factors (in the order of popularity):

- line-of-sight
- distance (typically, hard limit)
- brightness
- contrast with background

from Ghost Recon

World Interfacing

- Simulating realistic hearing

  - if implemented, then it typically travels at 100m/sec for some distance

from Conflict: Desert Storm

World Interfacing

- Simulating realistic touch
  - typically, limited to collision checking
  - sometimes used in stealthy games

from Thief: The Dark Project

World Interfacing

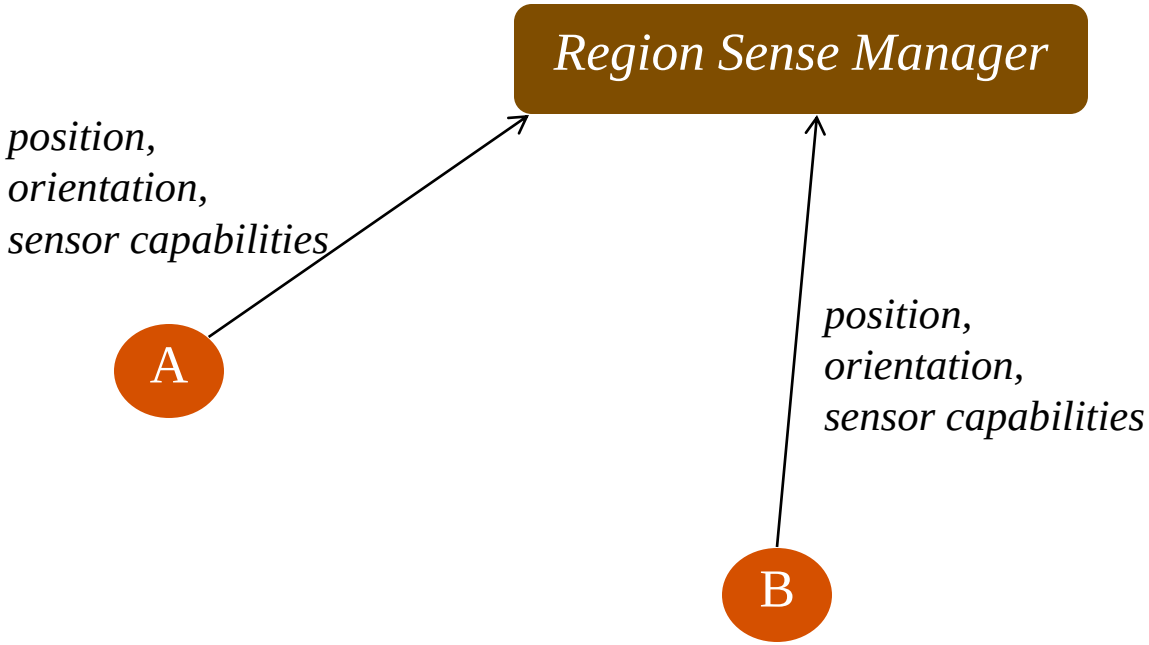
- Simulating smell
  - distance-limited, slow-speed propagation
  - rarely used in games

from Alien vs. Predator

World Interfacing

• Managing sense signals and sensors: **Region Sense Manager**

-potential sensors are registered

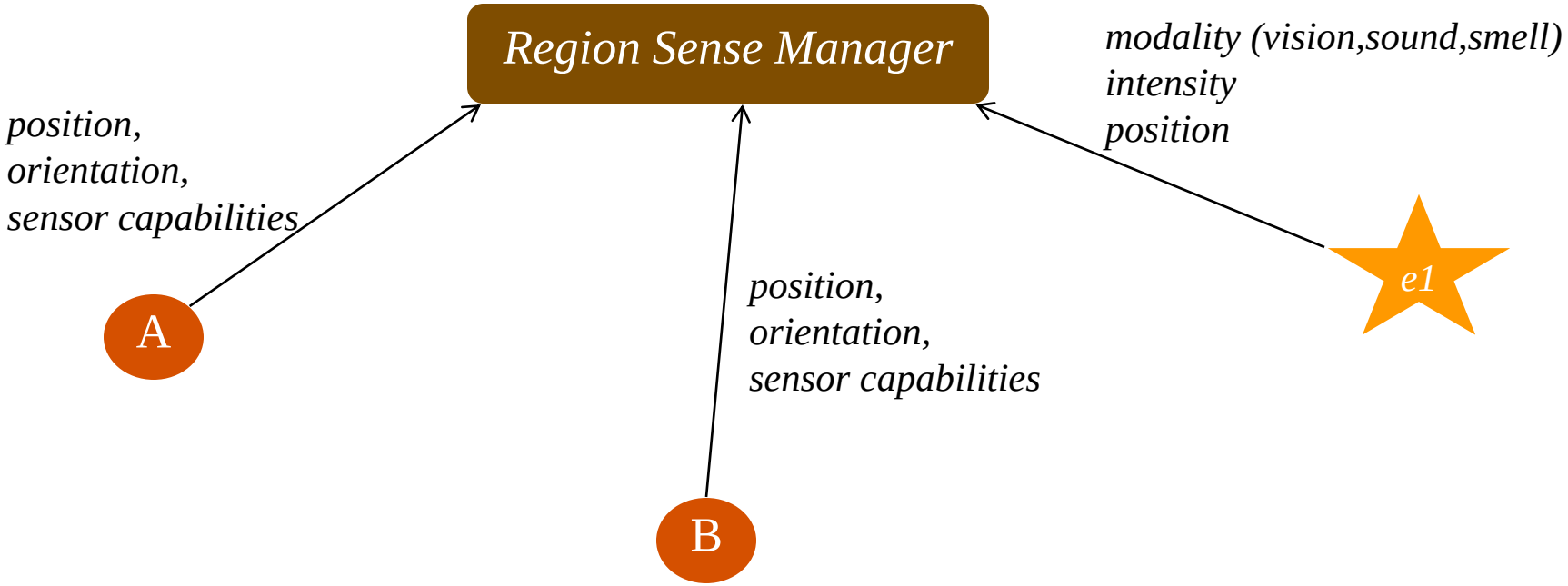


World Interfacing

• Managing sense signals and sensors: **Region Sense Manager**

-potential sensors are registered

-signals from emitters received

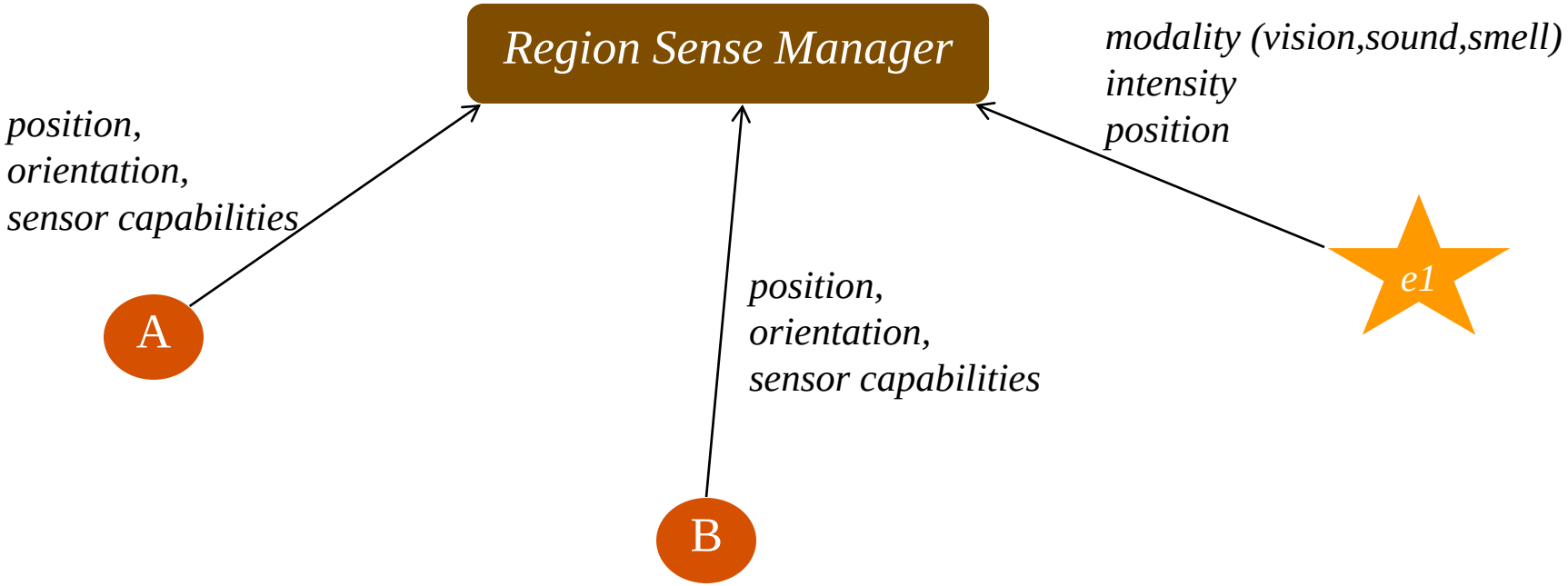


World Interfacing

- Managing sense signals and sensors: **Region Sense Manager**

  -aggregation phase: find all sensors within the max range of the emitter given its modality

  -testing phase: test against their sensor capabilities



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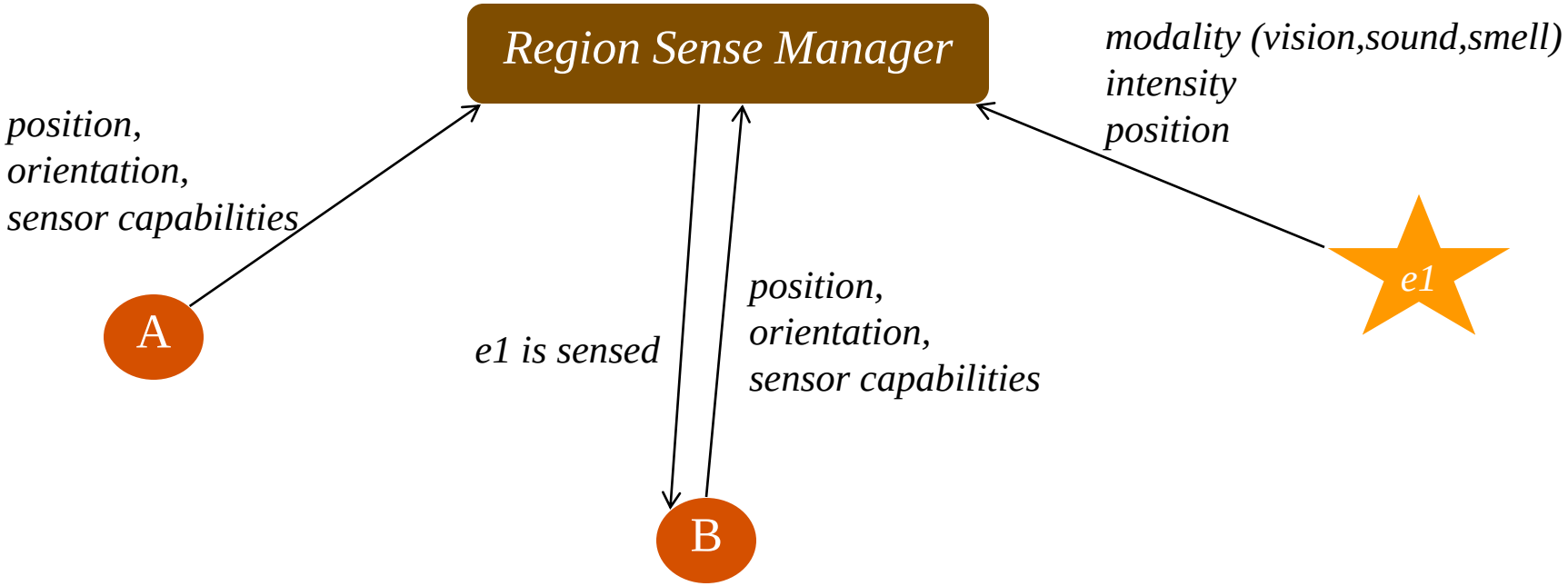

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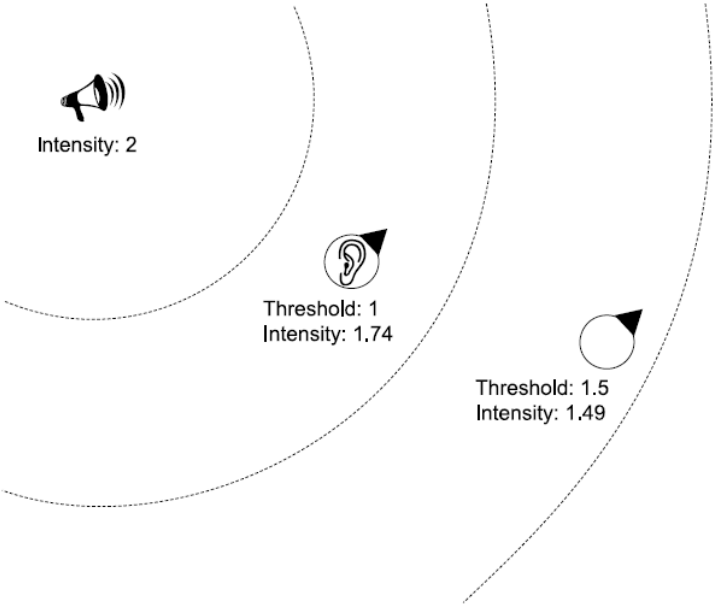
Example: attenuation=0.9/meter



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World Interfacing

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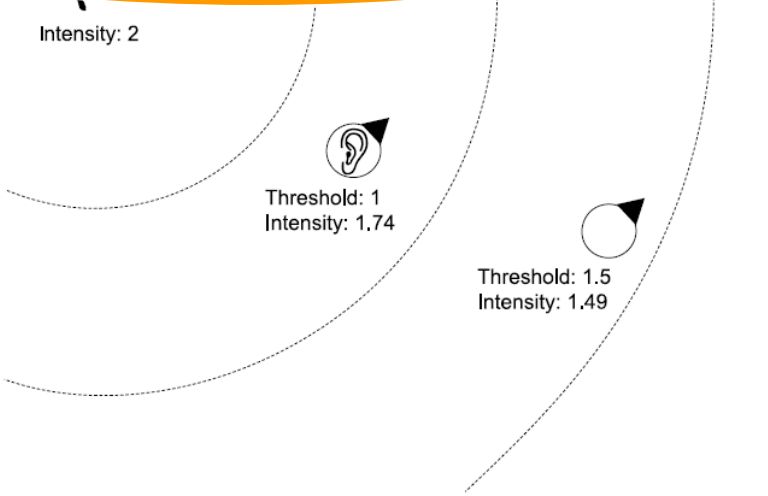
  -notification phase: notify

Issues leading to non-realistic effects?

vision signals are tested for other line-of-sight, sight cone, …

Example: attenuation=0.9/meter



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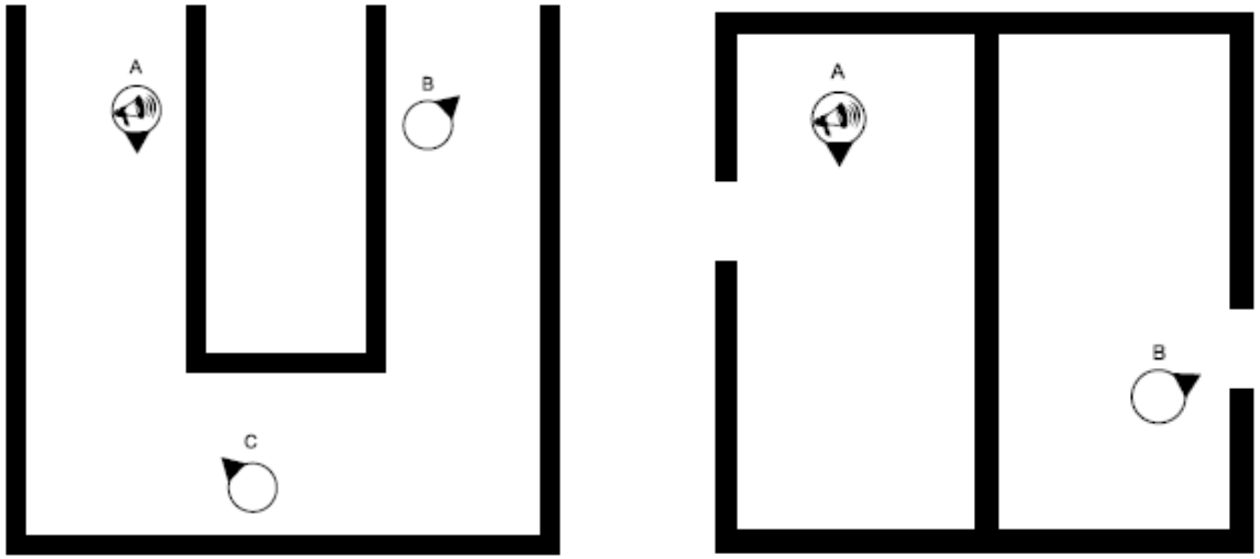

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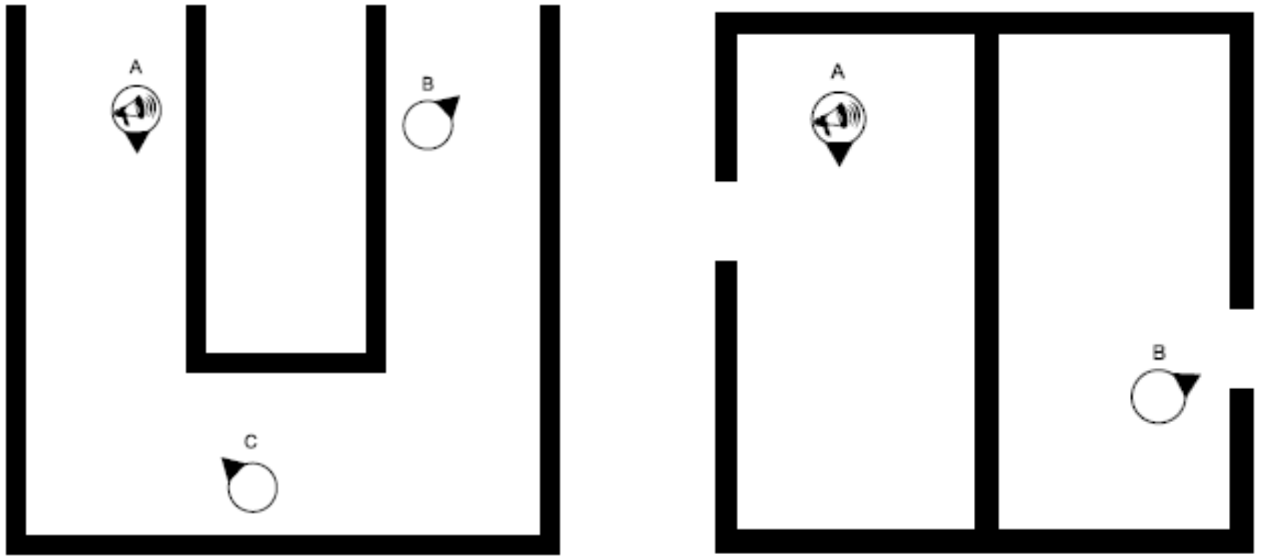
Solutions?



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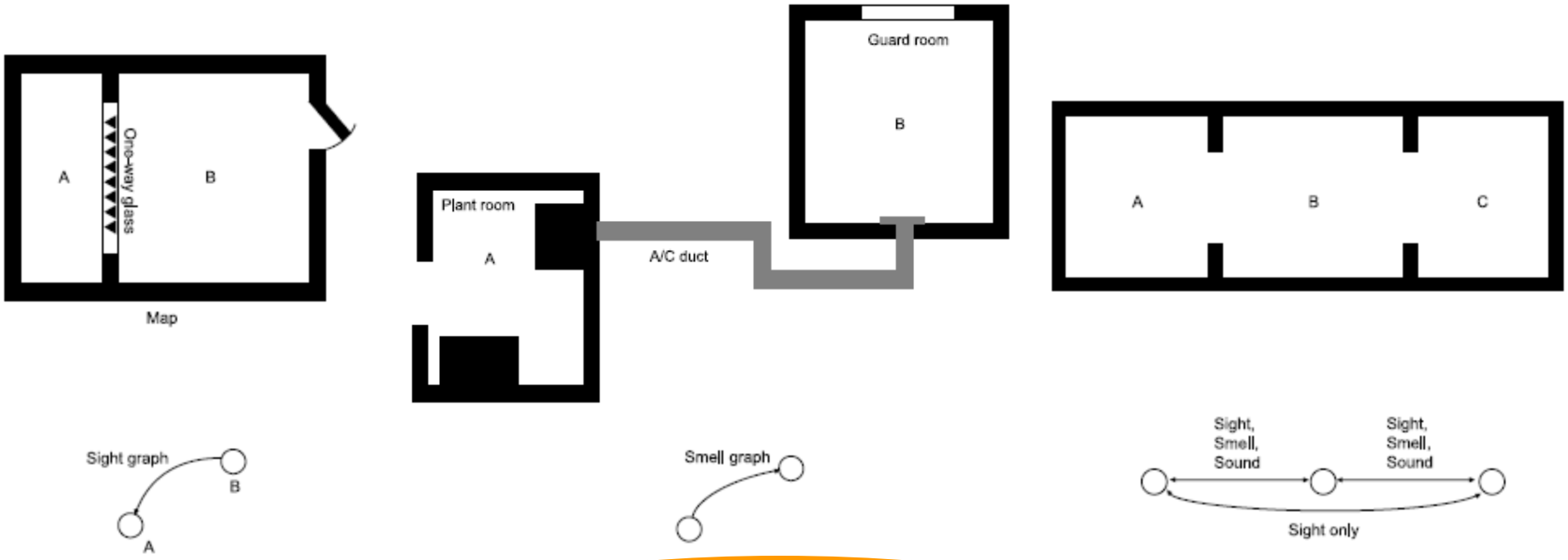
World Interfacing

- Managing sense signals and sensors: **Finite Element Model Sense Manager**

-split the space into nodes (e.g., rooms)
-compute sense graphs (sight, sound and smell graphs)
-edges have attenuation and distance values



Similar for modeling video cameras in Sight graph

World Interfacing

- Managing sense signals and sensors: **Finite Element Model Sense Manager**
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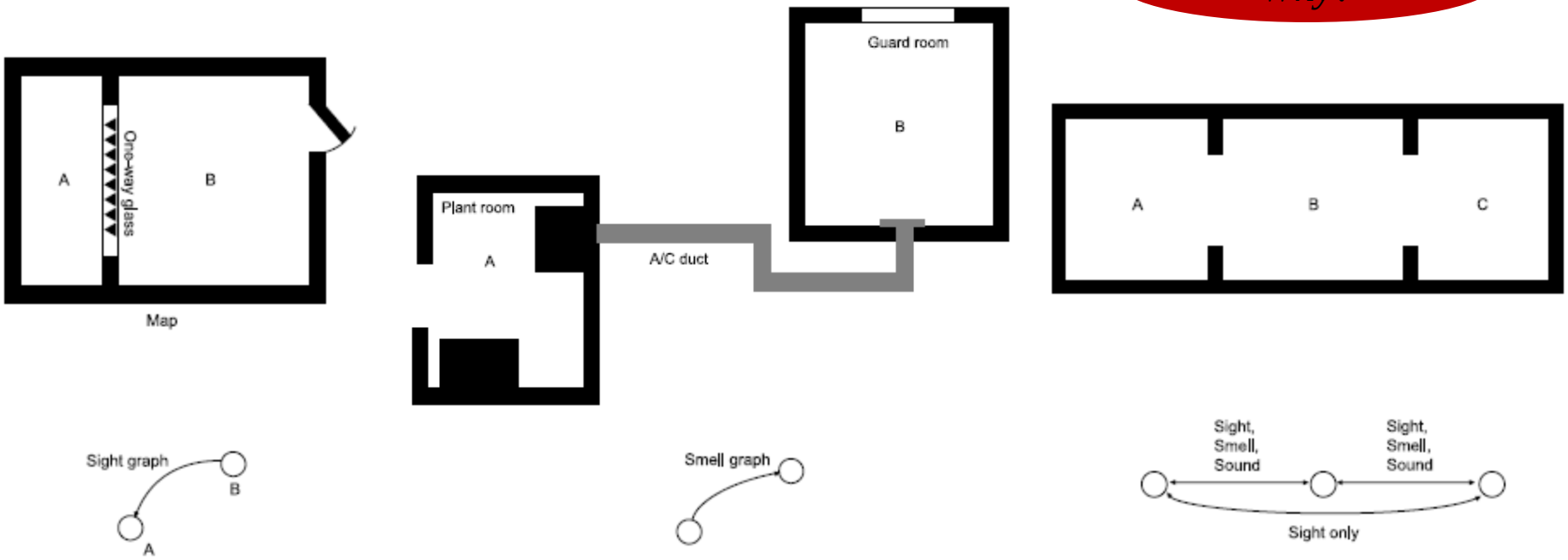
  - -compute sense graphs (
  - -edges have attenuation and distance valu

For sight graph, no intermediate nodes – all line-of-sight nodes have direct edges

Why?



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For sight graph, additional line-of-sight tests have to be done in real-time

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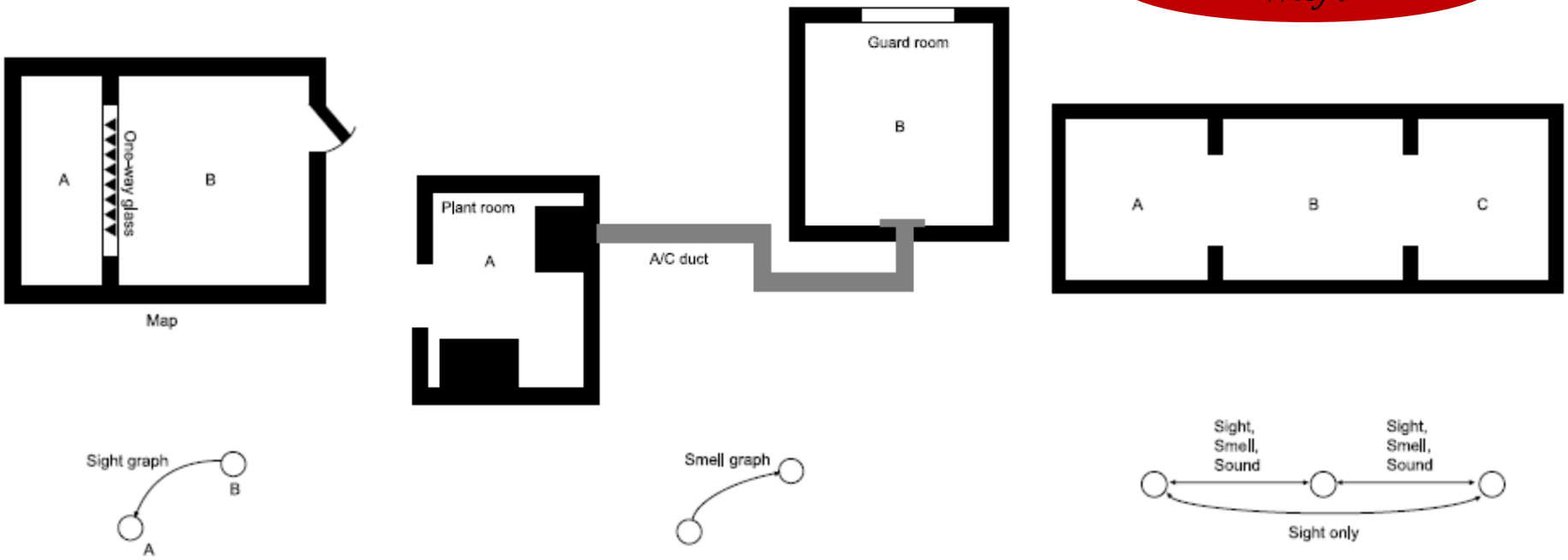

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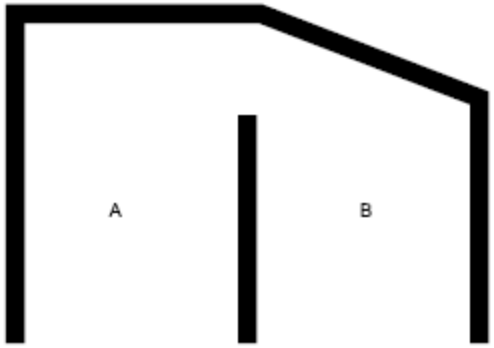
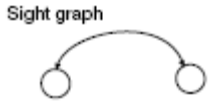


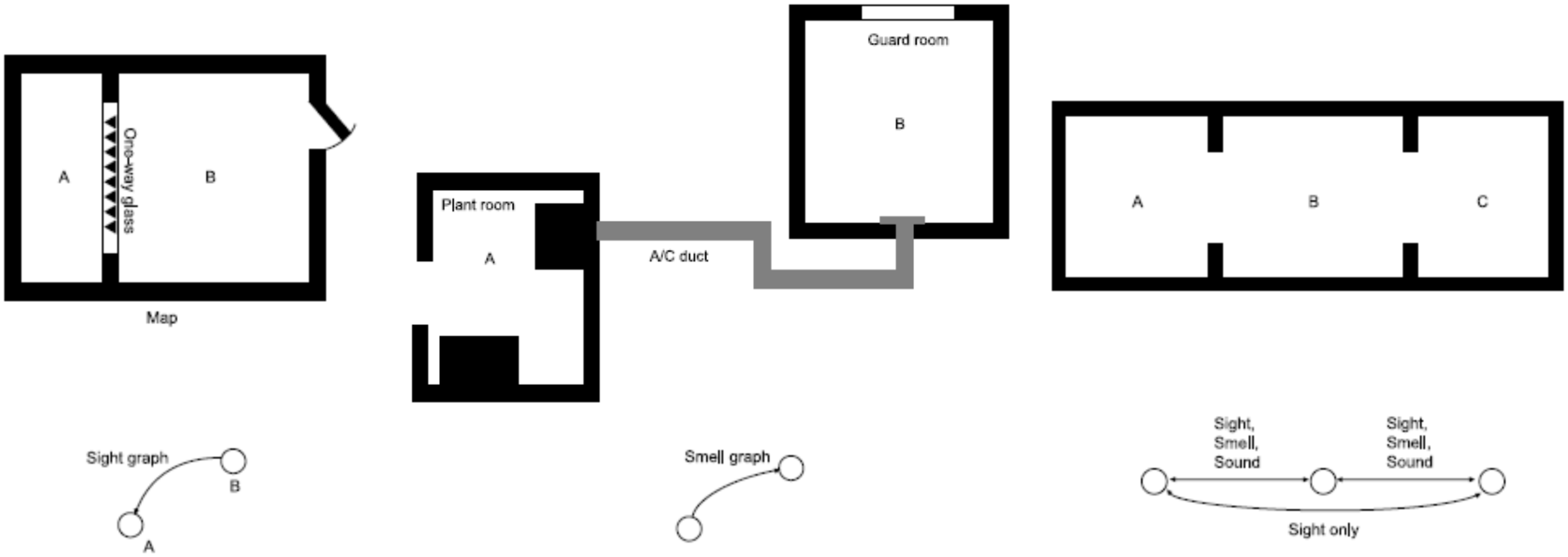


World Interfacing

• Managing sense signals and sensors: **Finite Element Model Sense Manager**

-similar aggregation, testing, notification phases except…

-for Sight: all aggregated nodes of signal in *u* are: sensors in *u* and its immediate neighbors according to Sight graph



World Interfacing

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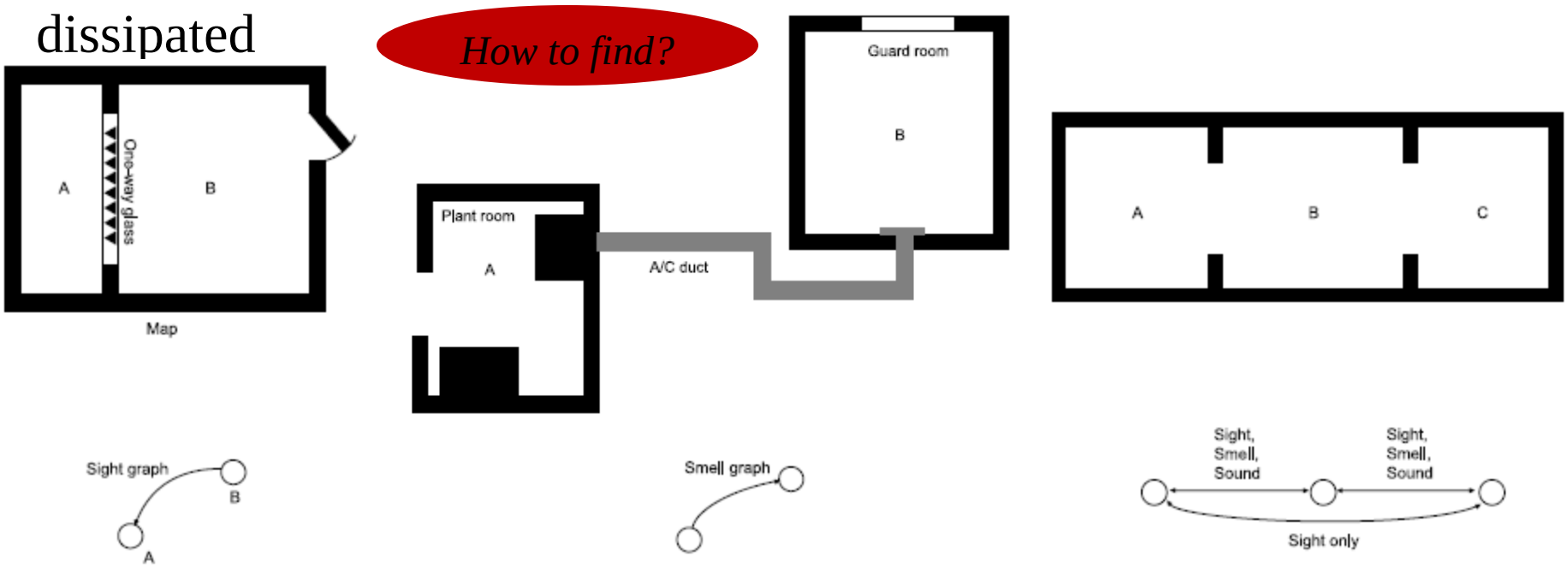
-for Sound: all aggregated nodes of signal in *u* are: sensors in *u* and its descendants reachable in Sound graph without fully dissipated



World Interfacing

• Managing sense signals and sensors: **Finite Element Model Sense Manager**

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-for Smell: at every frame, smell is being dissipated and propagated to all successors, and aggregated nodes with value > threshold