Principles of Computer Game Design and Implementation

Lecture 13

We already knew

- Collision detection – overlap test and intersection test
- Detailed view
- Mid-level view

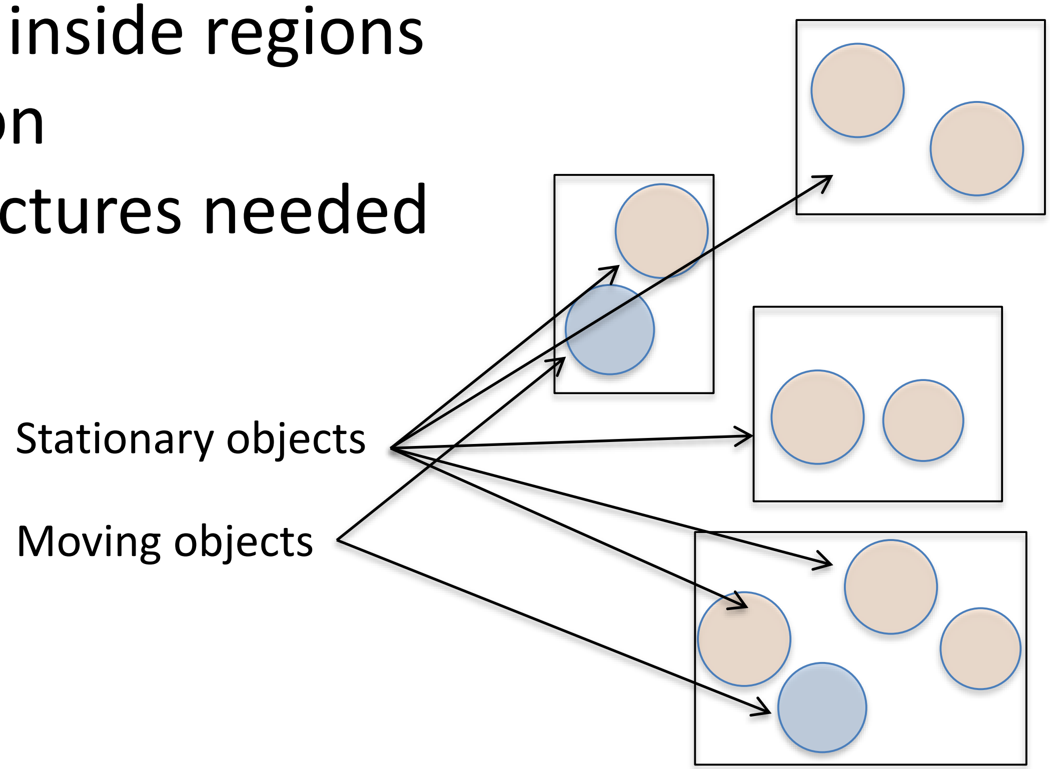
Outline for today

- High-level view for collision detection
  - Uniform grid

High-Level View

Too many objects in the world problem

- Divide the space into regions
- Check for collisions inside regions
    - An approximation
    - Spatial data structures needed

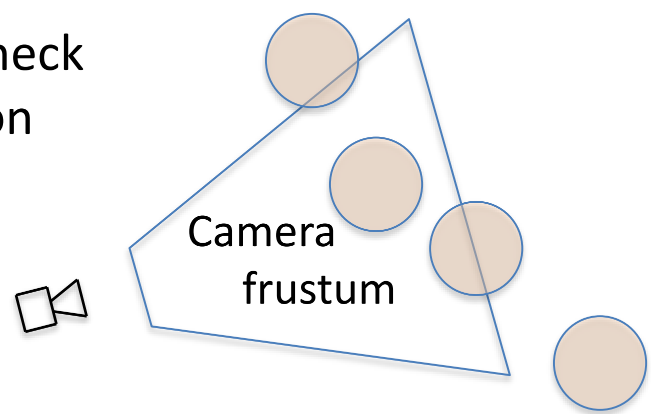


Spatial Data Structures

- Uniform grids
  - Implicit grids
- Non-uniform grids
- Arbitrary space partitions

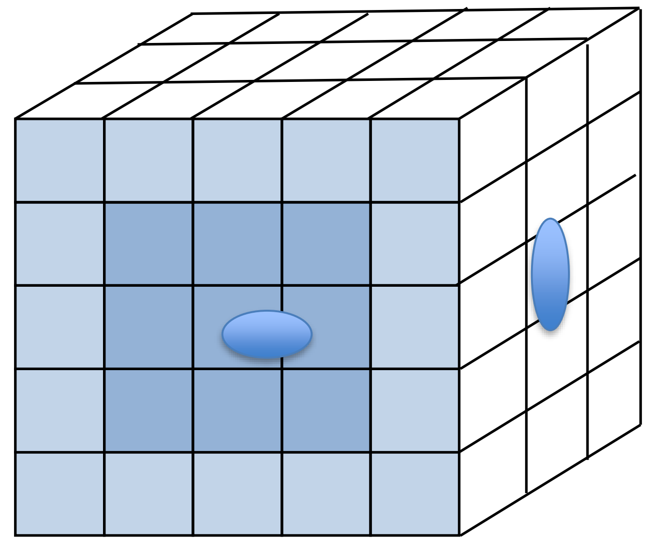
Used for collision detection and various other purposes

Example: Visibility check as collision detection



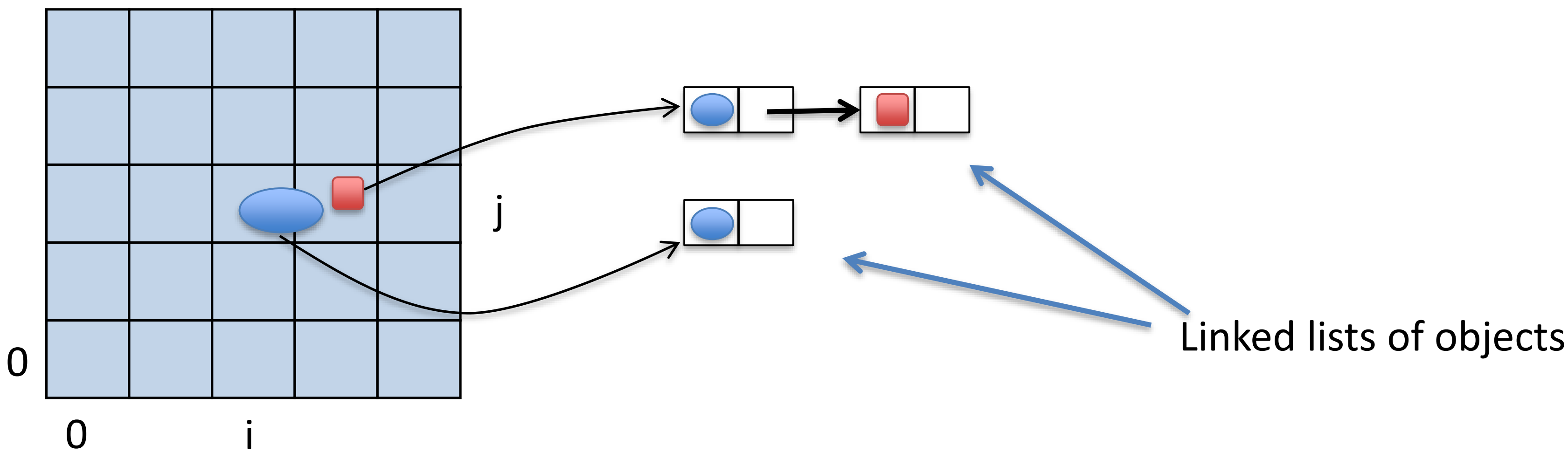
Uniform Grid

- Split the volume into 3-dimentional cells
- For a ***moving object***
  - Identify objects in surrounding cells
  - Test for collision with those objects



From now on all pictures will be in 2D. Same principles apply

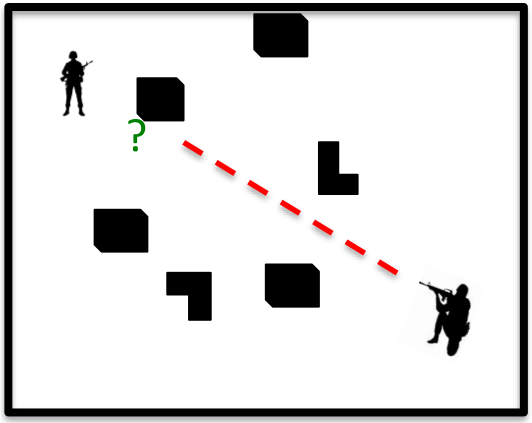
Locating Objects



- i = (int) (x / CellSize); j = (int) (y / CellSize); k = (int) (z / CellSize)
- Array of linked lists
  - Test for collision for every element of the list at `grid(i,j,k)`

Ray Tracing

- Intersection of a *ray* with an object
  - Computer graphics
  - Shooting

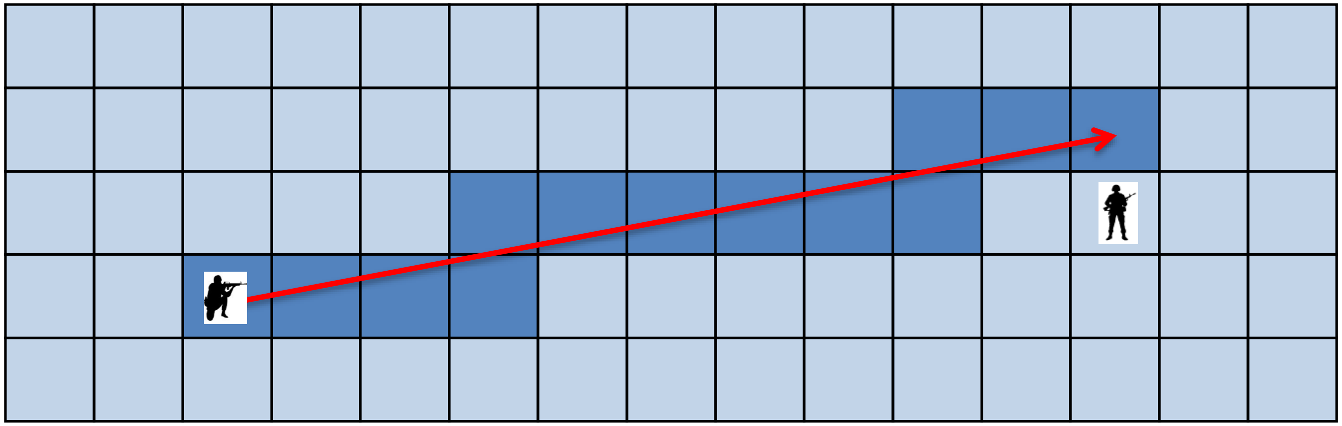


Ray = “half-line”

Ray collision detection:
which object will it intersect with?

Ray Collision Detection

- One can define mathematically
  - Ray to triangle collision
  - Ray to box collision
  - Ray to sphere collision
  - …



Grid is ideally suited for tracing rays

Ray Collision Detection in jME

- jMonkeEngine can detect Ray-Geometry collisions
- See Examples coming with the library

Explicit Uniform Grid

Advantages:

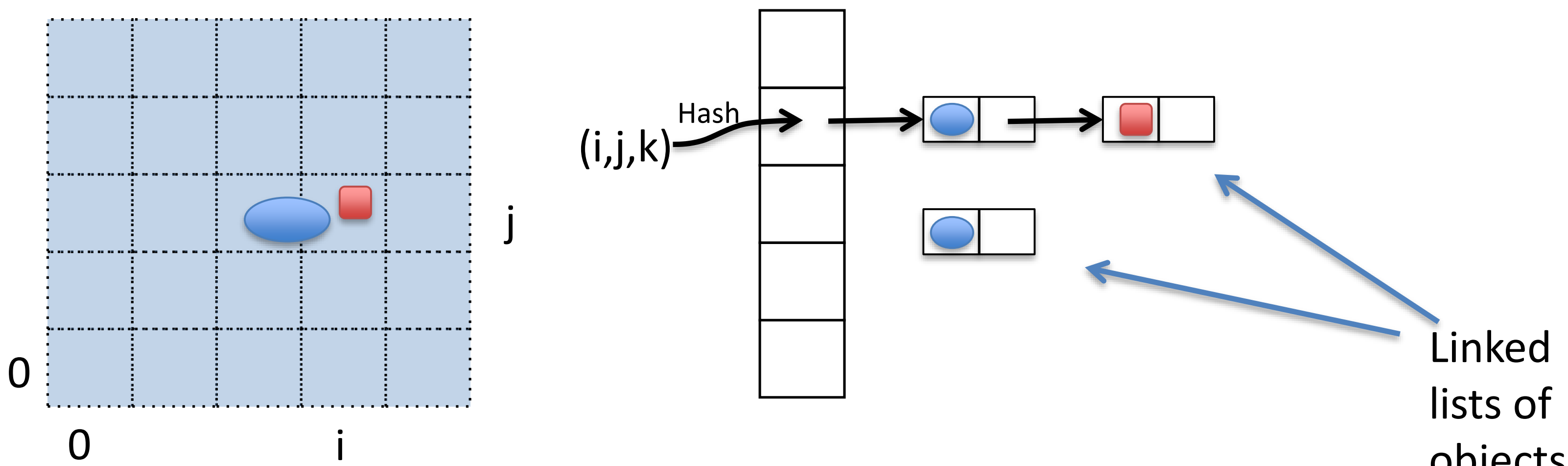
- Very fast
- Easy to implement (especially in C, C++)

Disadvantages

- May be difficult in Java (generic /non-generic type mixes)
- Use a lot of memory (proportional to the number of cells)

Spatial Hash

- Represent grids implicitly



- i = (int) (x / CellSize); j = (int) (y / CellSize); k = (int) (z / CellSize)

```
class Triple {int x,y,z; Triple(..){..}};
HashMap<Triple,LinkedList<Spatial>> grid;
```

Side Remark: Maps

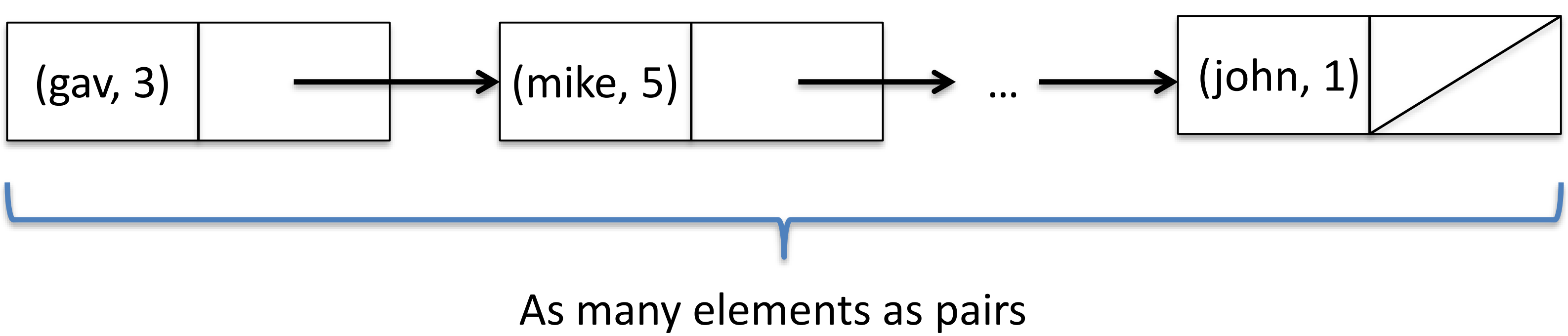
- How to store *associations* of the form

  (*key*, *value*)?

  – For example,

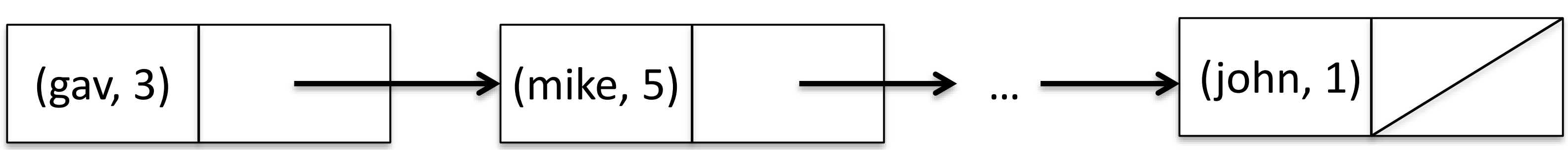
    (gav, 3)
    (mike, 5)
    (john, 1)

List them



Maps As Lists

- Storing information in a list is memory efficient…
- … but *search* is expensive
  - Queries like "what age is john" potentially will go through all the stored elements

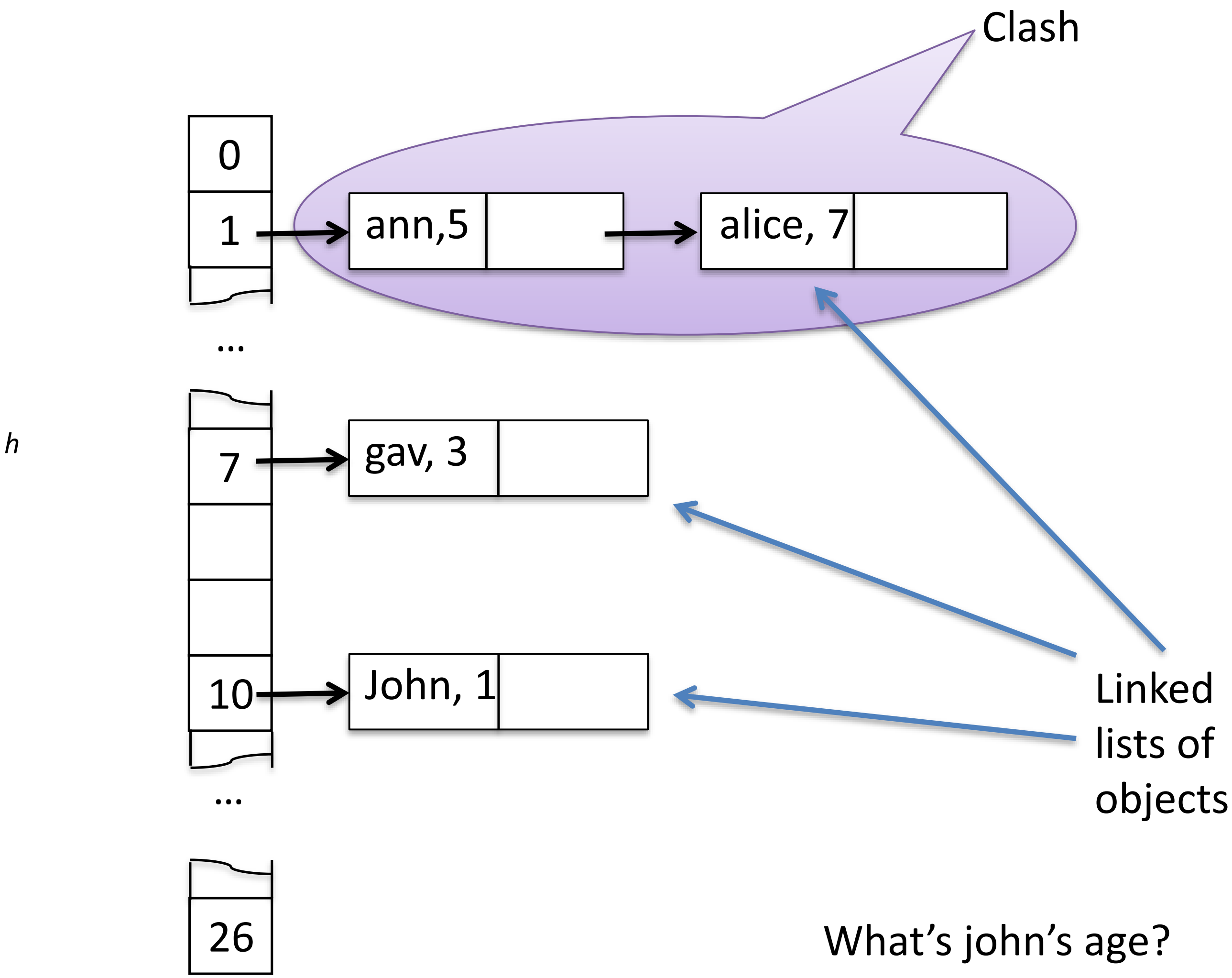


Hash Function

- Let *h*(x) maps the key to a number between 0 and N
  - E.g. name -> number of first letter in alphabet
    - gav -> 7
    - john -> 10
    - mike -> 11

Bad idea!

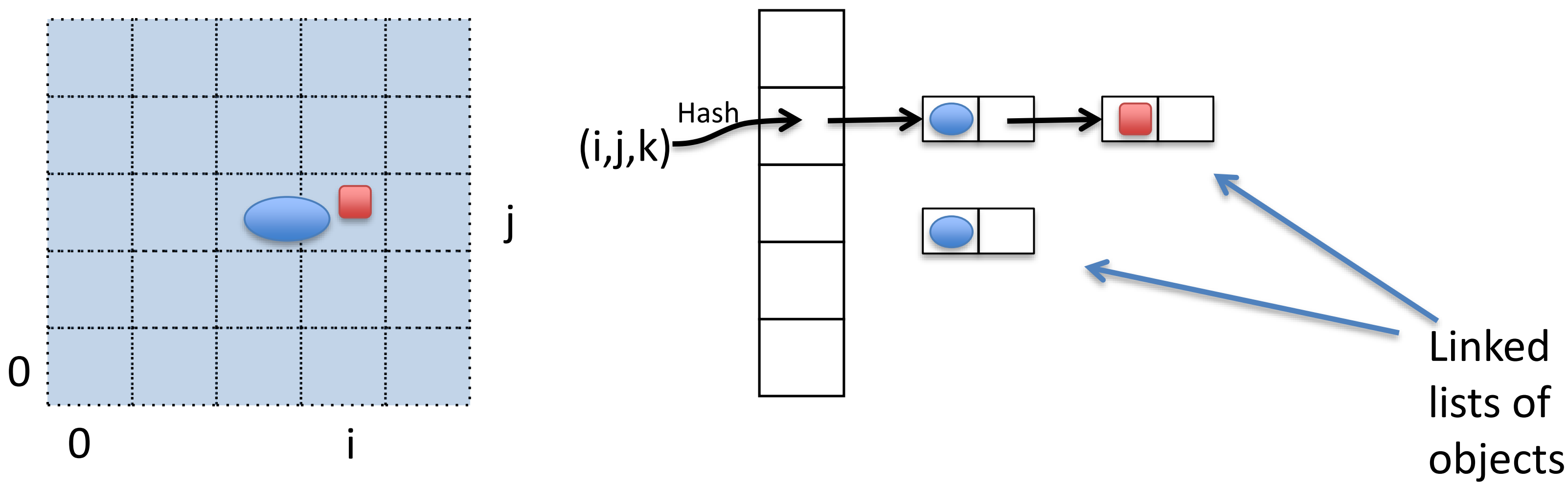
Hash Map



What's john's age?
What's alice's age?

Spatial Hash

- Represent grids implicitly



- For example,

$$h(i,j,k) = i+j+k \bmod 100$$

Very bad choice

Good Hash Function

- Ideally, for two keys k_1, k_2 there shouldn't be a clash, that is,

$$h(k_1) \neq h(k_2)$$

- This is impossible to achieve
- Writing a "good" hash function is hard

- Java has in-built support (but you may wish to supply your own implementation of hash function)

(see javadoc on HashMap)

Spatial Hash

Advantages

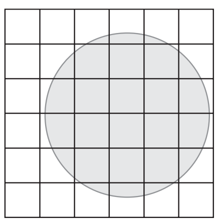
- Moderate memory use (proportional to the number of objects)
- Fast access
- Easy in Java

Disadvantages

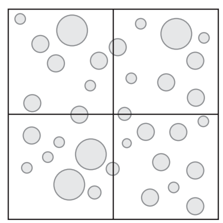
- Slower than array lookup
- Trickier in C/C++

Cell Size

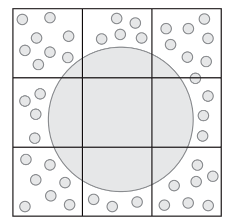
- How fine should the grid be?



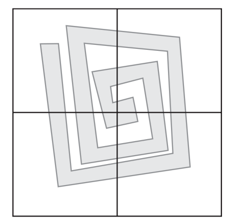
Too fine



Too coarse



Too coarse **and** too fine?



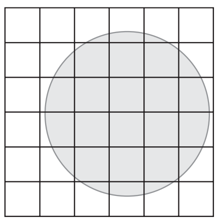
Inadequate

Cell size should roughly be the size of an object.

- Works in some cases
- Does not work in others

Cell Size

- How fine should the grid be?



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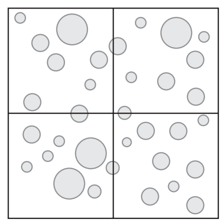
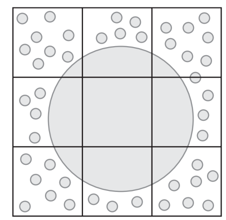


Too coarse



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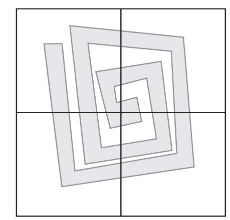

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