



GlassBox

A New Simulation
Architecture

What is GlassBox?

- A new data-driven simulation engine for Maxis games
- Learn key lessons from the past
 - Power of data-driven simulation
 - Power of putting logic in game objects (The Sims)
- Being used to ship SimCity



Why?

- Bet for the future
- Adapt to a world dominated by the internet and non-PC devices
- Digital downloads and IAP vs. retail boxed product and one or two expansions
- DLG = Downloadable Gameplay
- Next Generation simulation



Why?

- Get to the gameplay more quickly
 - Build and deploy sim games more quickly
 - Easier iteration for higher quality
 - Allow significant post-ship updates
- Build ecosystems of simulation games
- Deploy same gameplay across multiple devices



Simulation Type

- Our past games have been primarily statistical
 - Heavily random-number based
 - Players good at rationalising random or even buggy behaviour as smart AI
- Good approach with limited CPU resources
 - But, makes it hard for player to understand what's going on with their sim (SimCity 4 traffic system)
 - Leads to gaps between visualisation and behaviour (Cars fading in and out in SimCity)
- We can do better



GlassBox Basics

- **Resources + Units + Maps + Globals**
- Combined with **Rules**
- In a **Box**

- = \$\$\$ Simulation!



Resources

- The basic currency of the game
 - Oil, coal, crops, wood, water...
 - Money, electricity, labour, pollution
- Resources come in **bins**:
 - Bin of resource **R**, has capacity **C**
 - Bin value is an integer, 0..C
 - Capacity is fixed



Citizen



Happiness



Money



Goods



Sickness



Taxes



Water



Trash



Electricity

Resources
Units
Maps
Globals
Rules
Box



Units

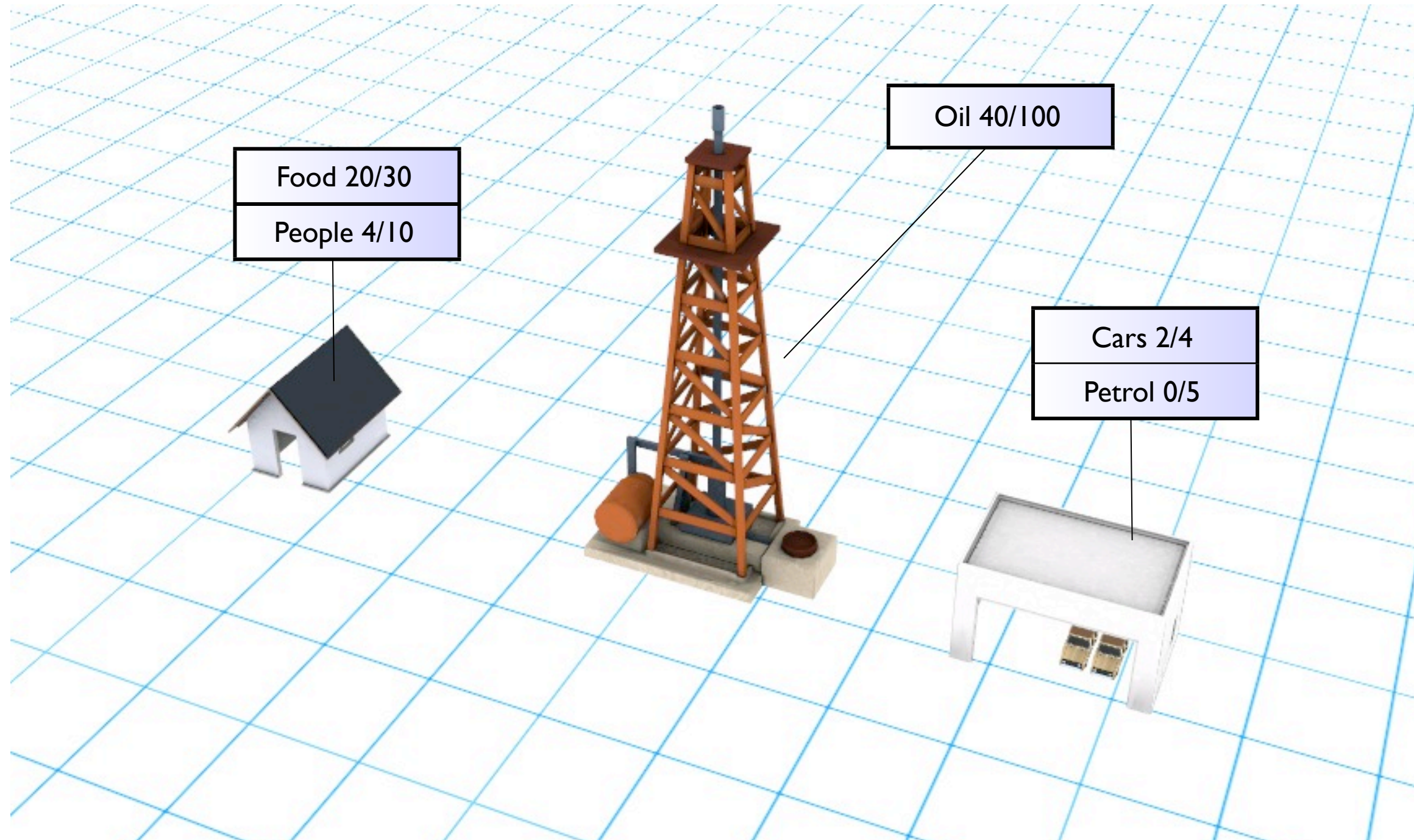
- Represent *things*
 - houses, factories, even people
- A unit has state
 - A collection of resource bins
- Also a well-defined spatial extent
 - Bounding volume
 - Simulation footprint



Resources
Units
Maps
Globals
Rules
Box



Units



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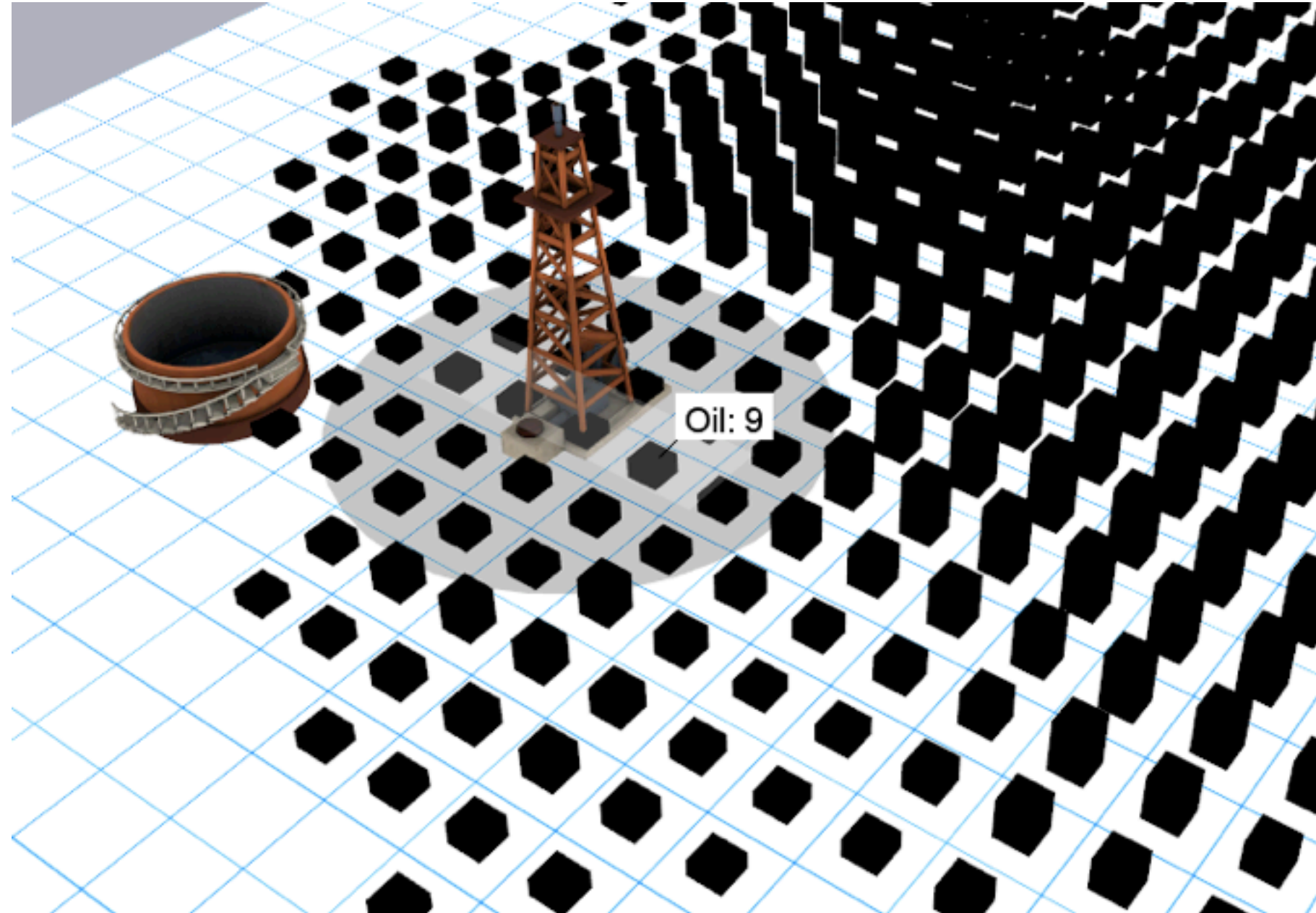
Maps

- Maps represent resources in the environment
 - Coal, oil, forest
 - But also air pollution, land value, desirability
 - Resources are *limited*
- Simple uniform size grids
 - Each cell is a resource bin
- Units interact with maps through their footprint

Resources
Units
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Globals
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Box



Maps



Resources

Units

Maps

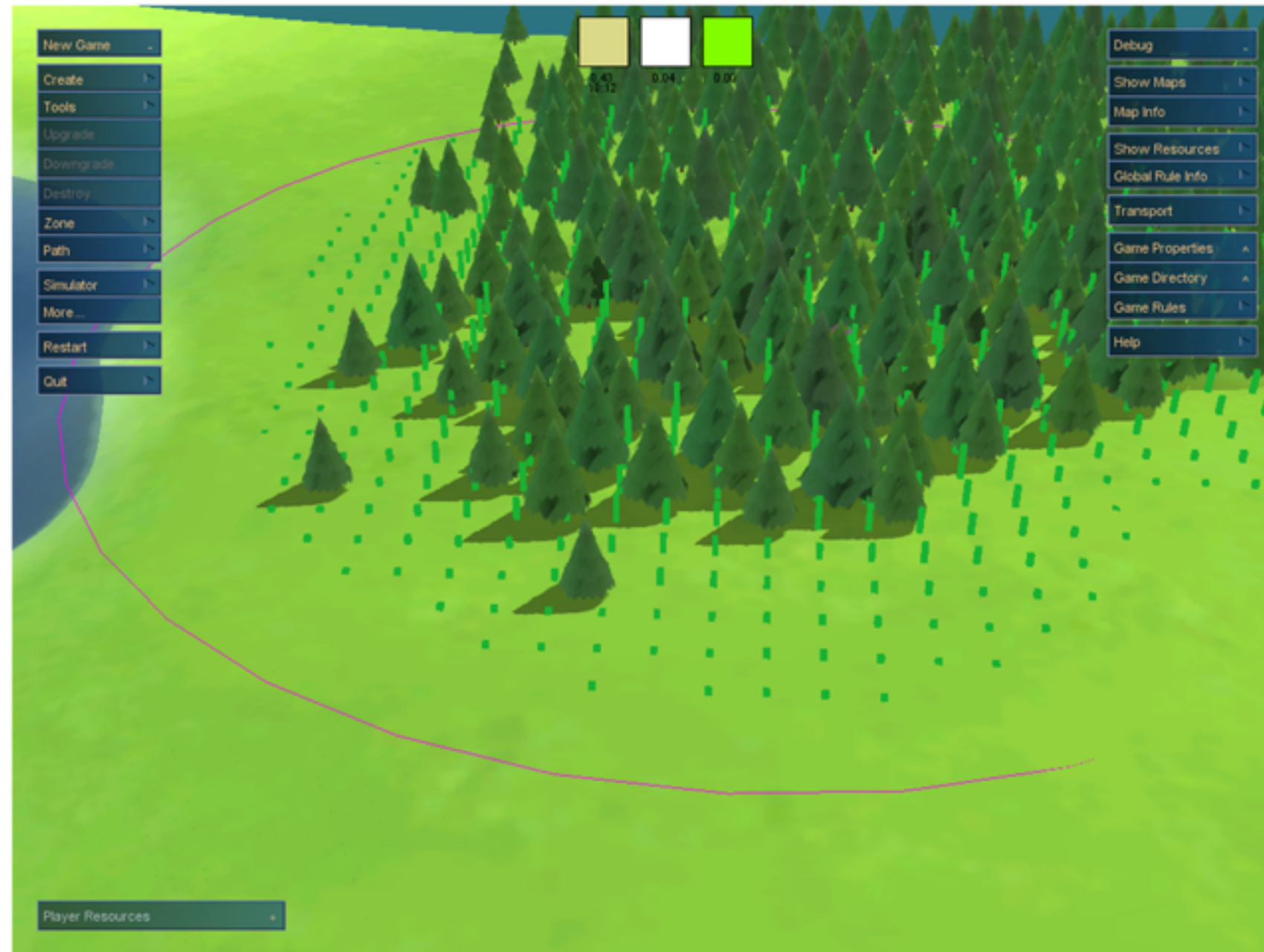
Globals

Rules

Box



Maps



Resources

Units

Maps

Globals

Rules

Box



Globals

- Just a global set of resource bins
- Values associated with the game as a whole
- Next!

5000 Oil	
280 Money	
20 Electricity	
Player Resources	-

Resources
Units
Maps
Globals
Rules
Box



Rules

- We have the *nouns*, rules provide the *verbs*
- Rules operate on resources:
 - Move resources from one place to another
 - Convert resources to other resources
 - Have **inputs** and **outputs**
- Attached to the entity that runs them

Resources
Units
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Box



Rule Example

```
rule harvestWood
  Money in 10
  Wood out 2

  People in 1
  People out 1
end
```

- Money is converted to wood, *if* a person is available
- Applied in its entirety
 - Only if the end result is valid
 - A rule can be applied multiple times

Resources
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Rule Example

```
rule harvestWood
  Money in 10
  Wood out 2

  People in 1
  People out 1

  applyCount 1 10
end
```

- Money is converted to wood, *if* a person is available
- Applied in its entirety
 - Only if the end result is valid
 - A rule can be applied multiple times

Resources
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Unit Rules

- Different targets:
 - **Local** (unit) bins
 - **Global** bins
 - **Map** cells covered by the unit
 - Bins in **nearby** units
- Can chain to other rules
- Trigger game actions

Resources
Units
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Rules
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Unit Rule Example

```
unitRule mustardFactory
  rate 10

  global Simoleans in 1

  local YellowMustard in 6
  local EmptyBottle in 1
  local BottleOfMustard out 1
end
```

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Unit Rule Example

```
unitRule mustardFactory
  rate 10

  global Simoleans in 1

  local YellowMustard in 6
  local EmptyBottle in 1
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end
```

- Run every 10 ticks
- Convert materials to product

Resources
Units
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Unit Rule Example

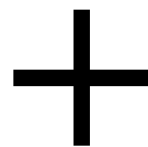
```
unitRule mustardFactory
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local EmptyBottle in 1
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end
```

- Run every 10 ticks
- Convert materials to product

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Unit Rule Example

```
unitRule mustardFactory
  rate 10

  global Simoleans in 1

  local YellowMustard in 6
  local EmptyBottle in 1
  local BottleOfMustard out 1

  map Pollution out 5
end
```

- Run every 10 ticks
- Convert materials to product
- Emit some pollution

Resources
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Box



Unit Rule Example

```
unitRule mustardFactory
  rate 10

  global Simoleans in 1

  local YellowMustard in 6
  local EmptyBottle in 1
  local BottleOfMustard out 1

  map Pollution out 5

  successEvent effect smokePuff
  successEvent audio chugAndSlurp
end
```

- Run every 10 ticks
- Convert materials to product
- Emit some pollution
- Game feedback

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Unit Rule Example

```
unitRule mustardFactory
  rate 10

  global Simoleans in 1

  local YellowMustard in 6
  local EmptyBottle in 1
  local BottleOfMustard out 1

  map Pollution out 5

  successEvent effect smokePuff
  successEvent audio chugAndSlurp

  onFail buyMoreMustard
end
```

- Run every 10 ticks
- Convert materials to product
- Emit some pollution
- Game feedback
- Chaining

Resources
Units
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Map Rules

- Operate on entire map, or a collection of random cells
- Run resource rule per cell
 - Can reference multiple maps at once
- Or, perform more specialised operations:
 - Diffusion (controlled by a second map)
 - Advection (e.g., by wind direction)

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Map Rule Example

```
mapRule growGrass
  rate 200

  map Soil atLeast 20

  map Water in 10
  map Nutrients in 1

  map Grass out 5

end
```

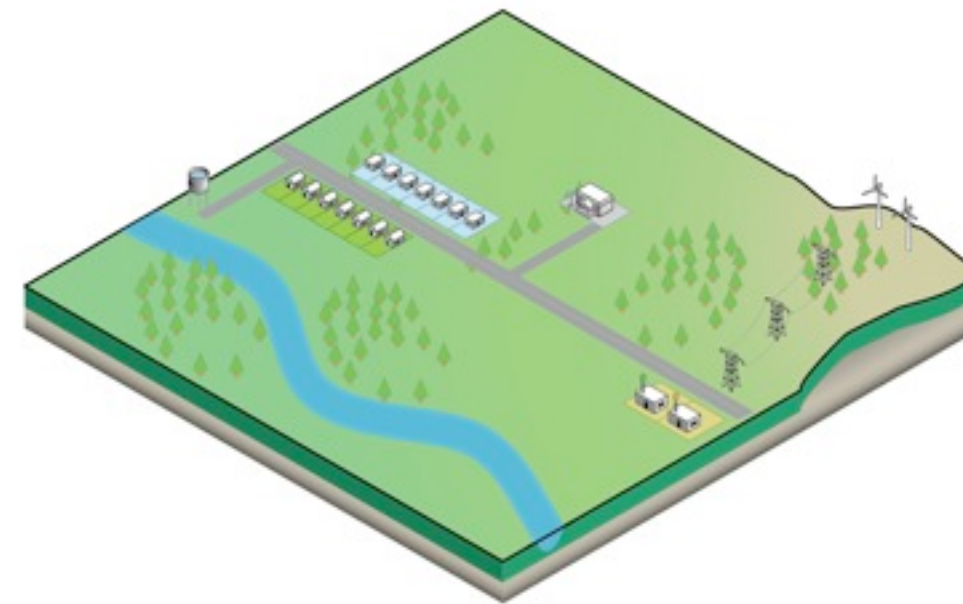
- Grass will grow only where there's soil, water, and nutrients
- Water and nutrients must be replenished

Resources
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A Box

- Everything that makes up a game
- **Game Scripts**
 - Play Area and other properties
 - Unit types, Map types, Global bins
 - Rule scripts
- **Game State**
 - Bin and cell values
 - Unit locations



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Key ideas

- Units contain their own simulation logic
 - You can drop in new units with new behaviours
 - Units can be combined to get aggregate behaviour
- Iteration, iteration, iteration
 - Hotloading for everything
 - Have an idea, implement, test, evaluate, ASAP
- Data-driven
 - Entirely defined by rule scripts and property lists



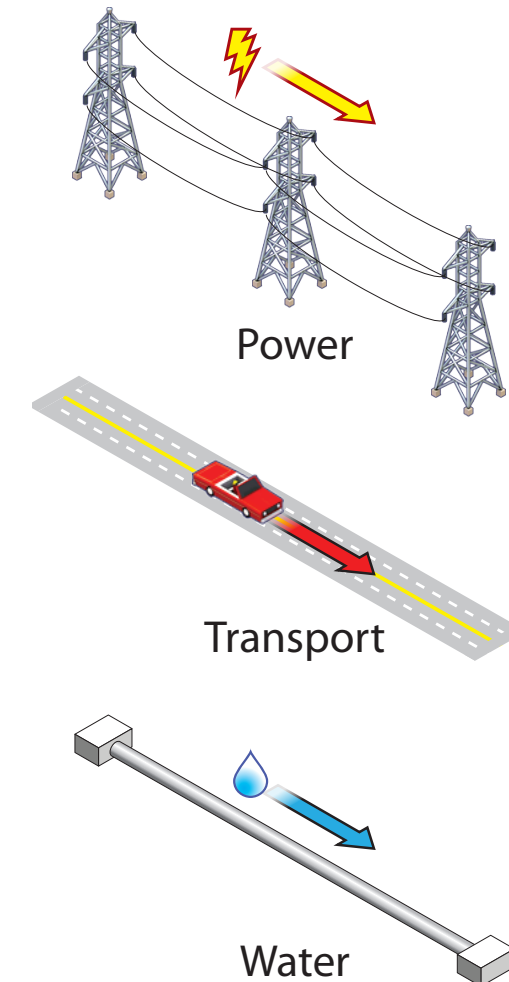
But wait... there's more

- This is enough to build a basic resource-based simulation game.
 - Have had fun building various mini games
 - Work in progress for future
- But not enough for SimCity-style sims
- Need: **Paths + Zones + Agents**



Paths

- **Points** connected by **Segments** make up **Paths** make up **Path Sets**
- Fully 3D, spline-based, rich set of operations
- Typically player created
- Curvy roads!
- But also: power lines, water pipes, flight paths

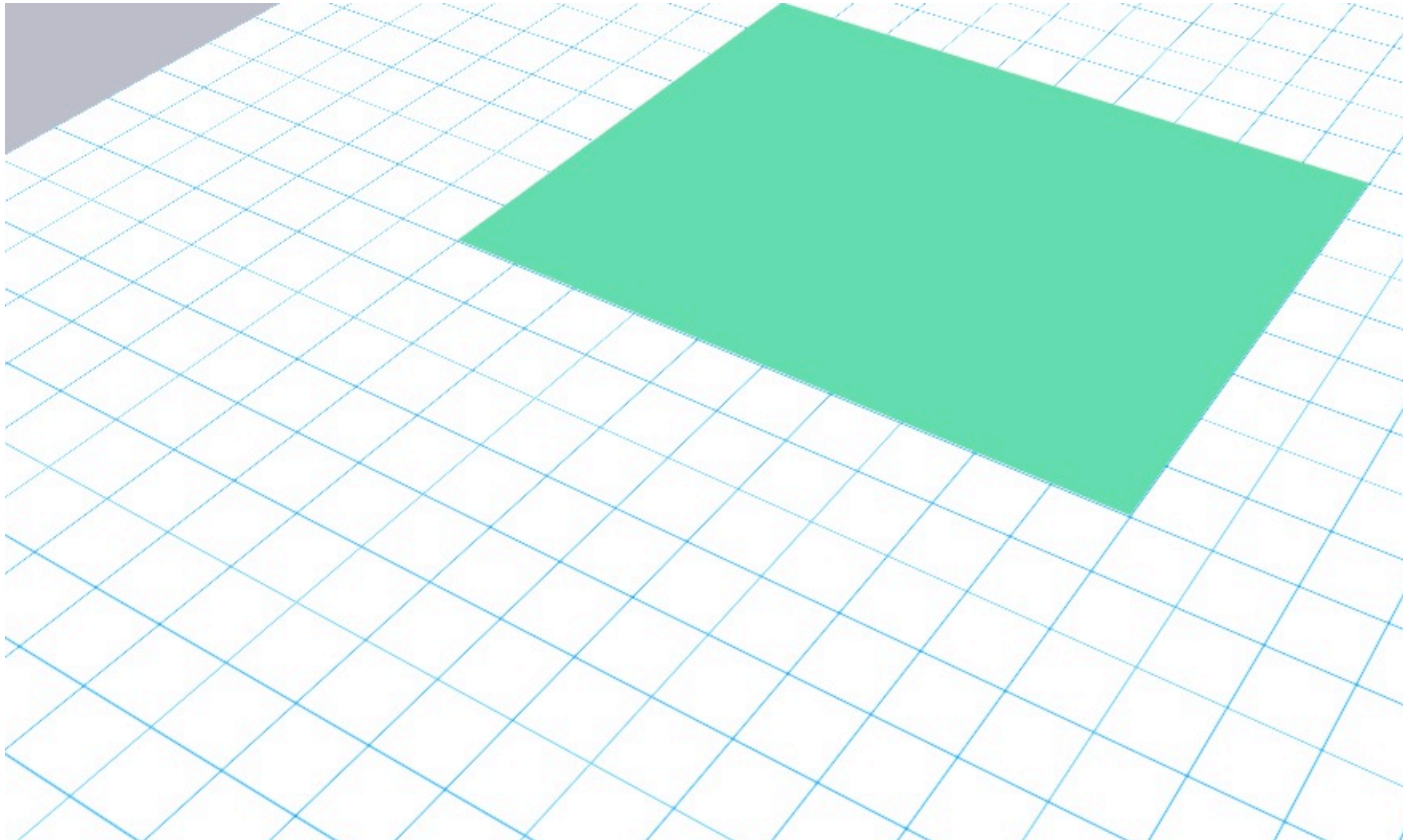


Zones

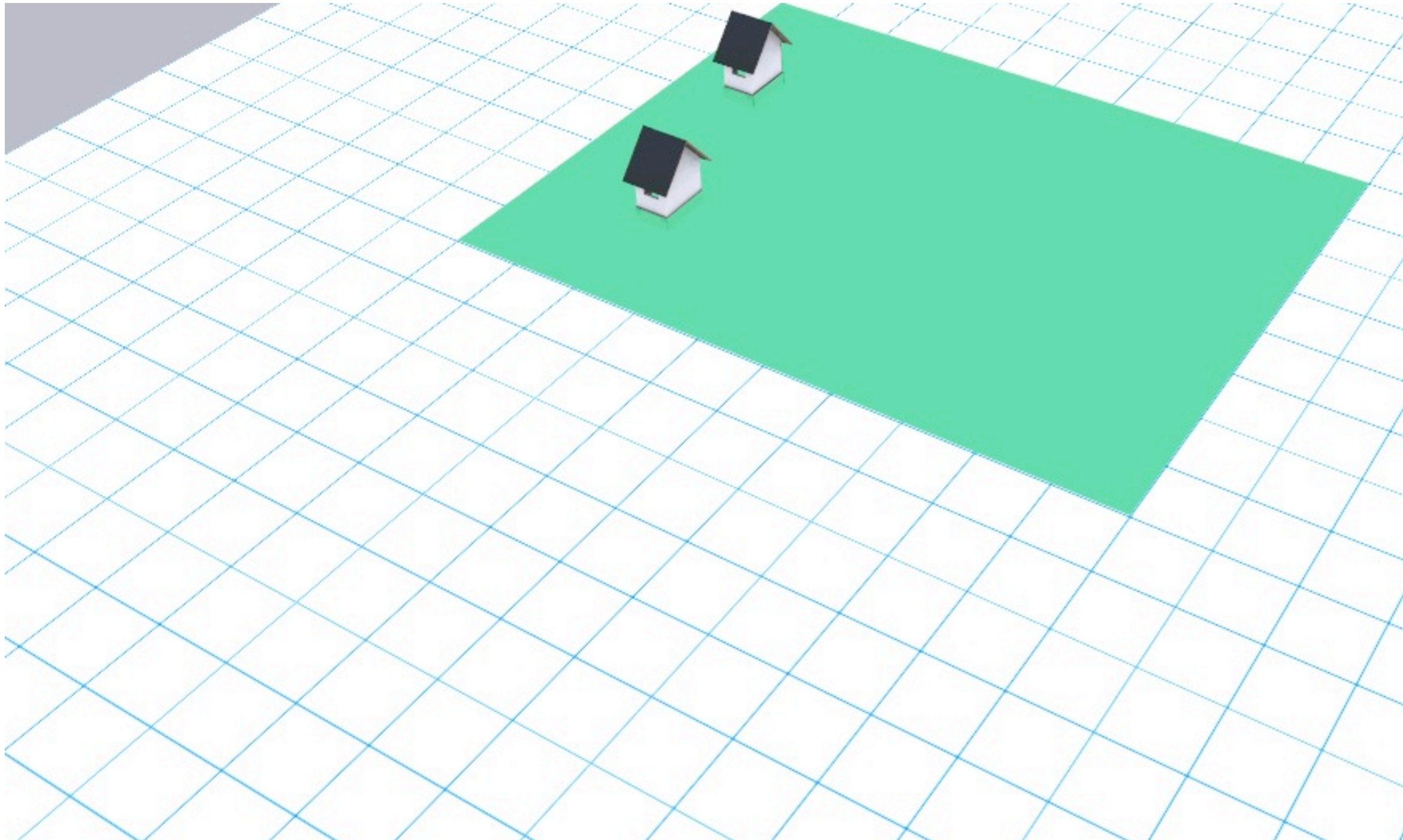
- Cover some well-defined area
- Run zone rules:
 - Create new units
 - Upgrade/downgrade existing units
 - Destroy units
- Provide "gardening" aspect of simulation



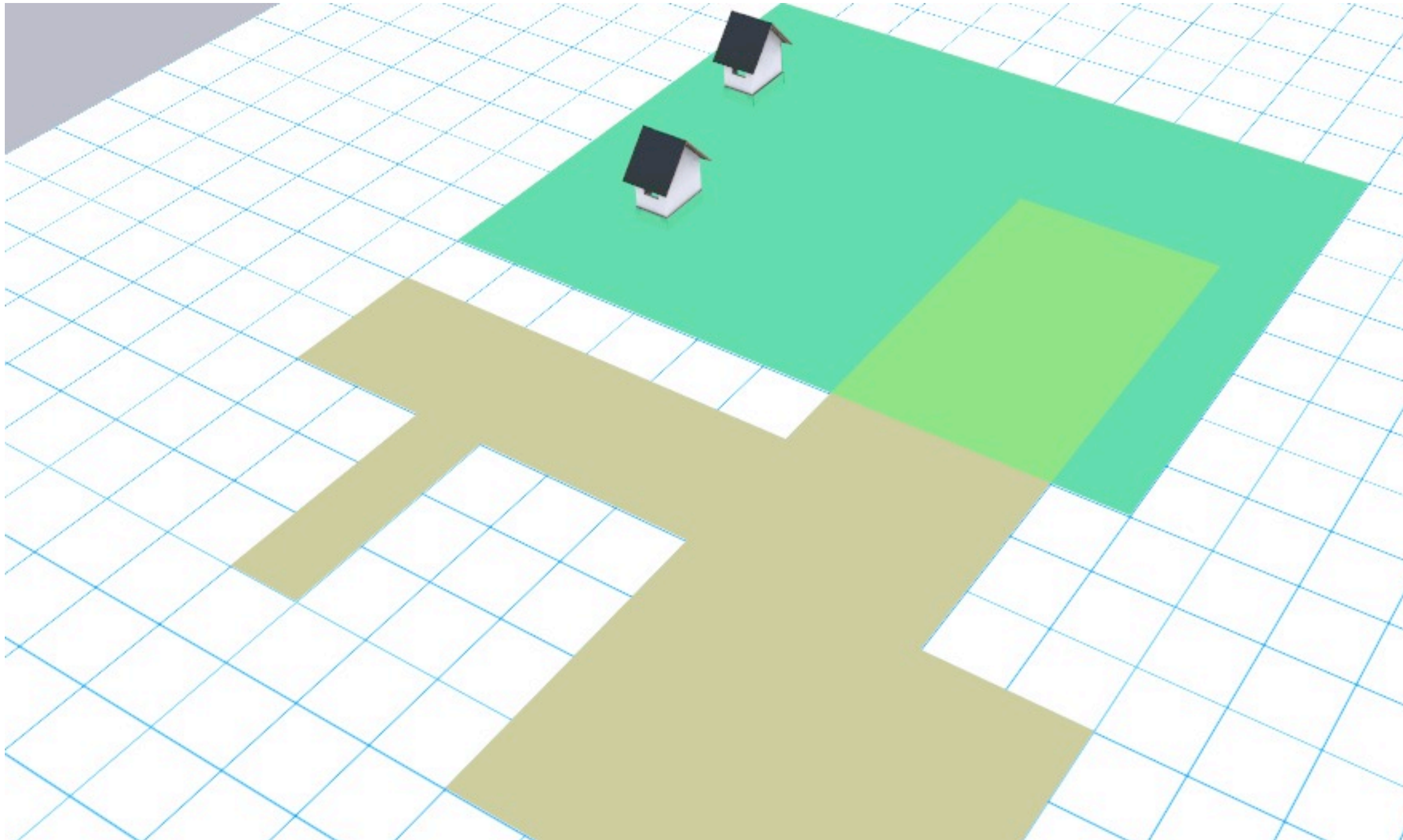
Zones



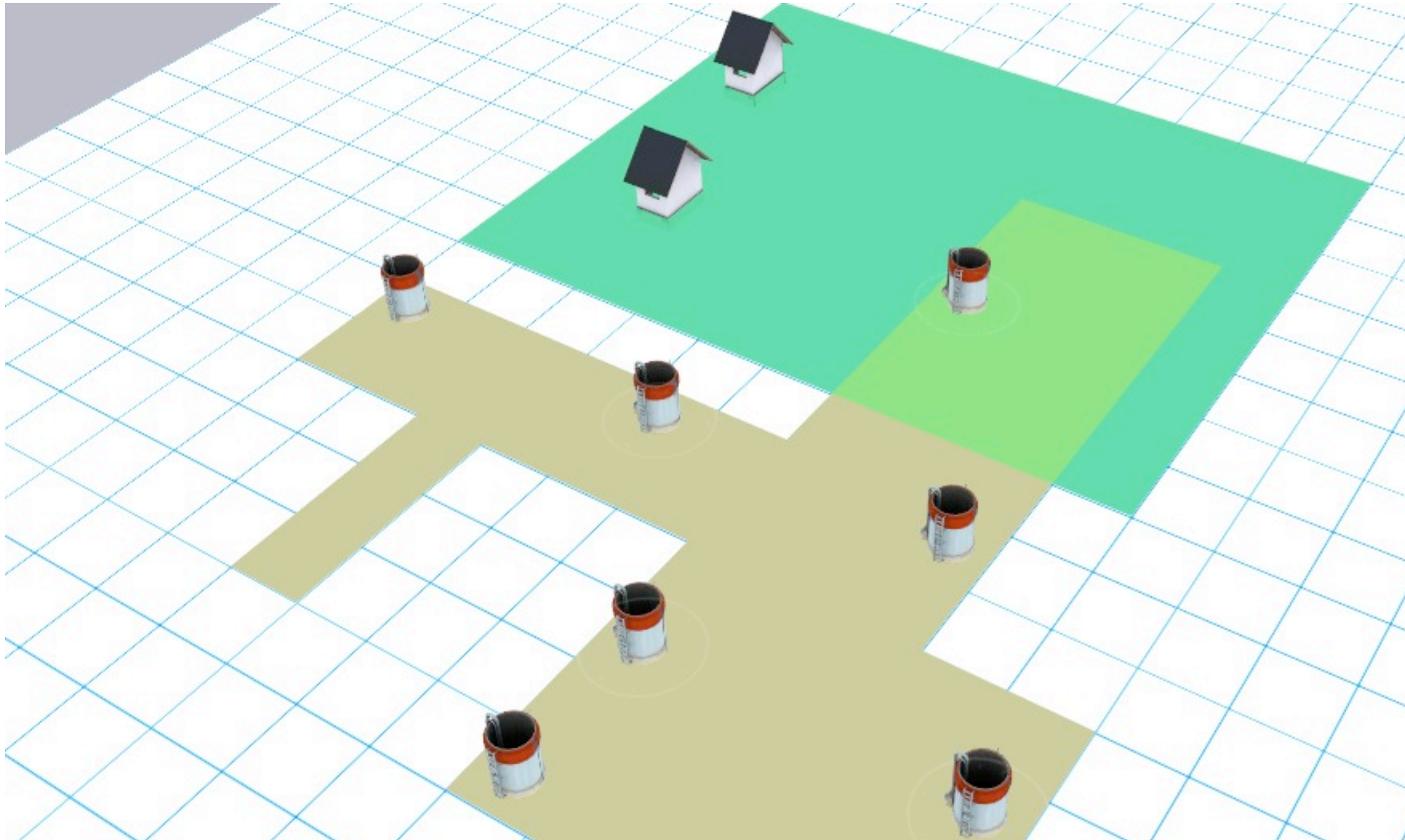
Zones



Zones



Zones



Zone Rule Example

```
zoneRule developHouses
  timeTrigger Day 0.5

  sample random -count 3

  test global Builders greater 5
  test map Forest is 0

  createUnit -id Bungalows

end
```

- Try to create three houses a day
- Only if we have enough builders
- Only where the zone doesn't overlap with forest



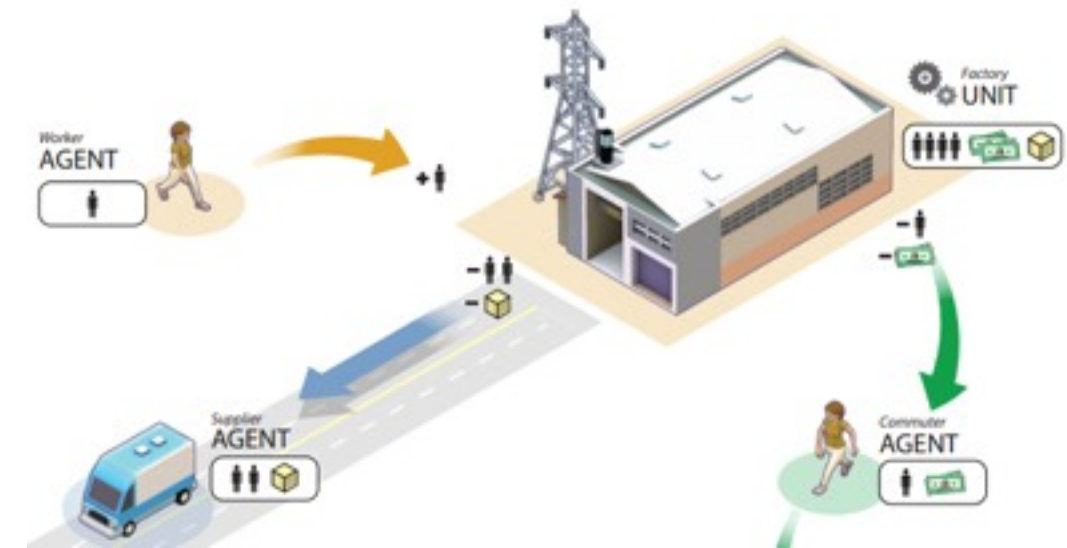
Agents

- Carry resources from one unit to another
 - Each has a set of resource bins
 - Do **not** run rules (10,000s of agents)
- Controlled by Transport Handlers
 - Agents handed over when emitted from unit
 - Handler responsible for delivering to a destination unit



Agents

- Created by unit rules
- Each agent is given a destination
 - Home, Work, Fire, Sickness
- Units can have **sinks** advertising the corresponding destinations
- Creation rule can set simple destination instructions



Unit Agent Rule

```
unitRule goToWork  
  options -sendTo Work -via Car -using Road  
  
  local People in 2  
  agent People out 2  
end
```



Unit Agent Rule

```
unitRule goToWork  
  options -sendTo Work -or Park  
           -switchTo Home 10  
           -repeatAfter 10  
           -via Car -using Road  
  
  local People in 2  
  agent People out 2  
end
```



Transport Handlers

- Predominantly path-oriented
 - Vehicles driving along paths
 - Resource flow through pipes
- But also
 - Helicopters, boats, aircraft
 - Free-routing sims

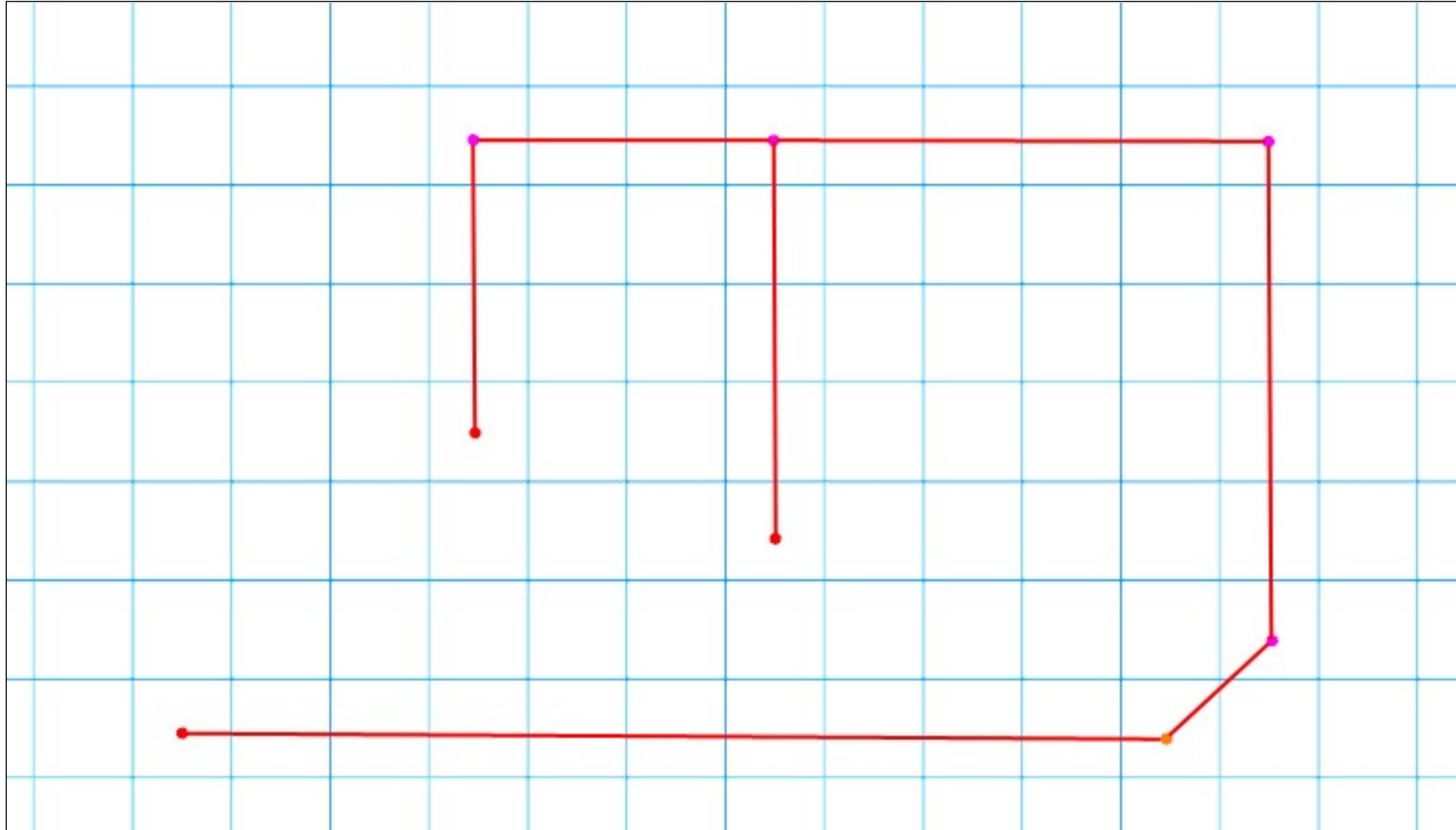


Path-based Routing

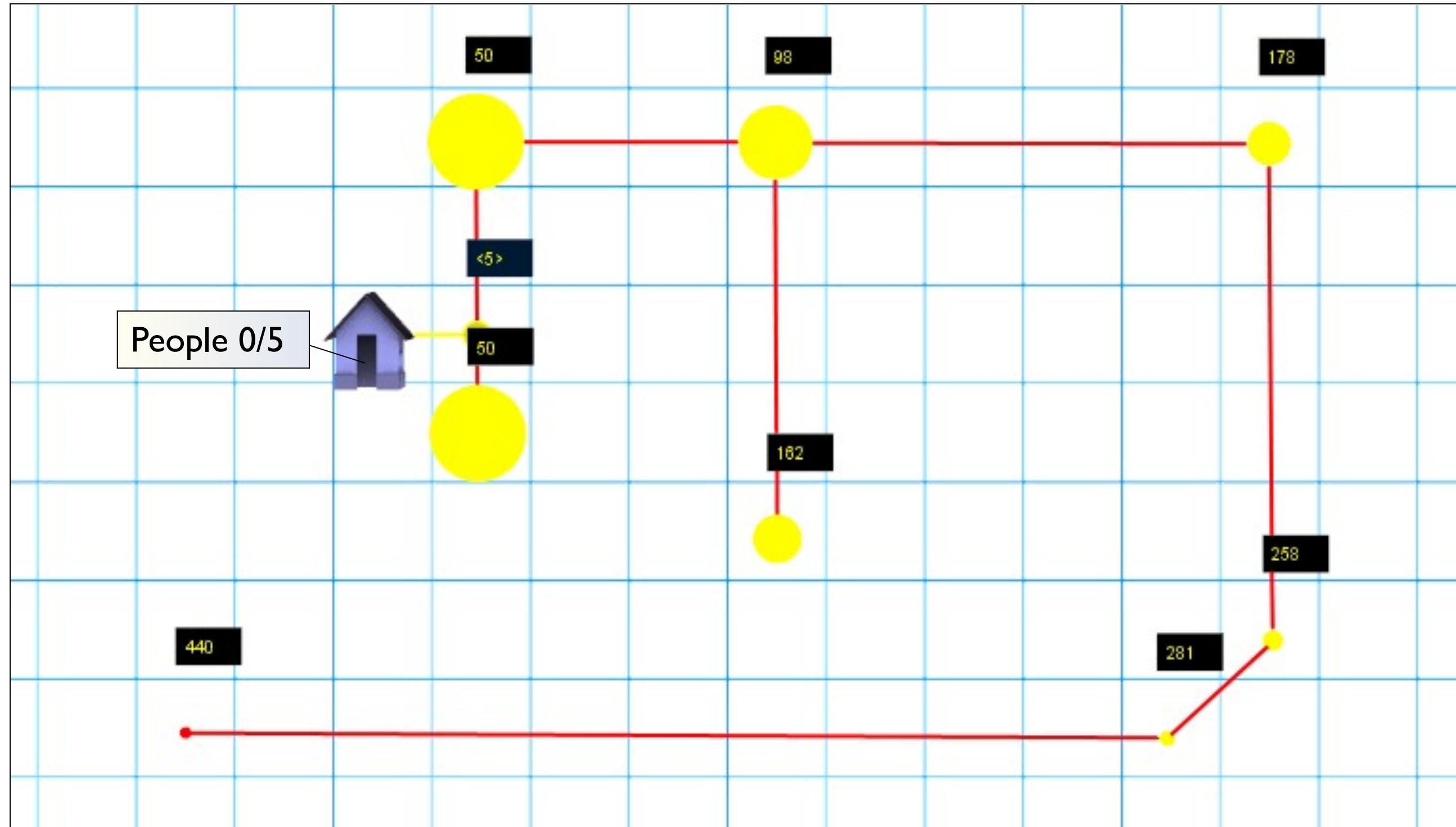
- Virtual Distance Field
 - D*-Lite based algorithm - wavefront updates
 - Calculates cost-to-nearest-sink at vertices
 - Steer towards vertex with least cost
 - No per-agent routing info
- Distance modified by
 - Sink strength: advertises a capacity
 - Modifiers such as congestion and speed limit



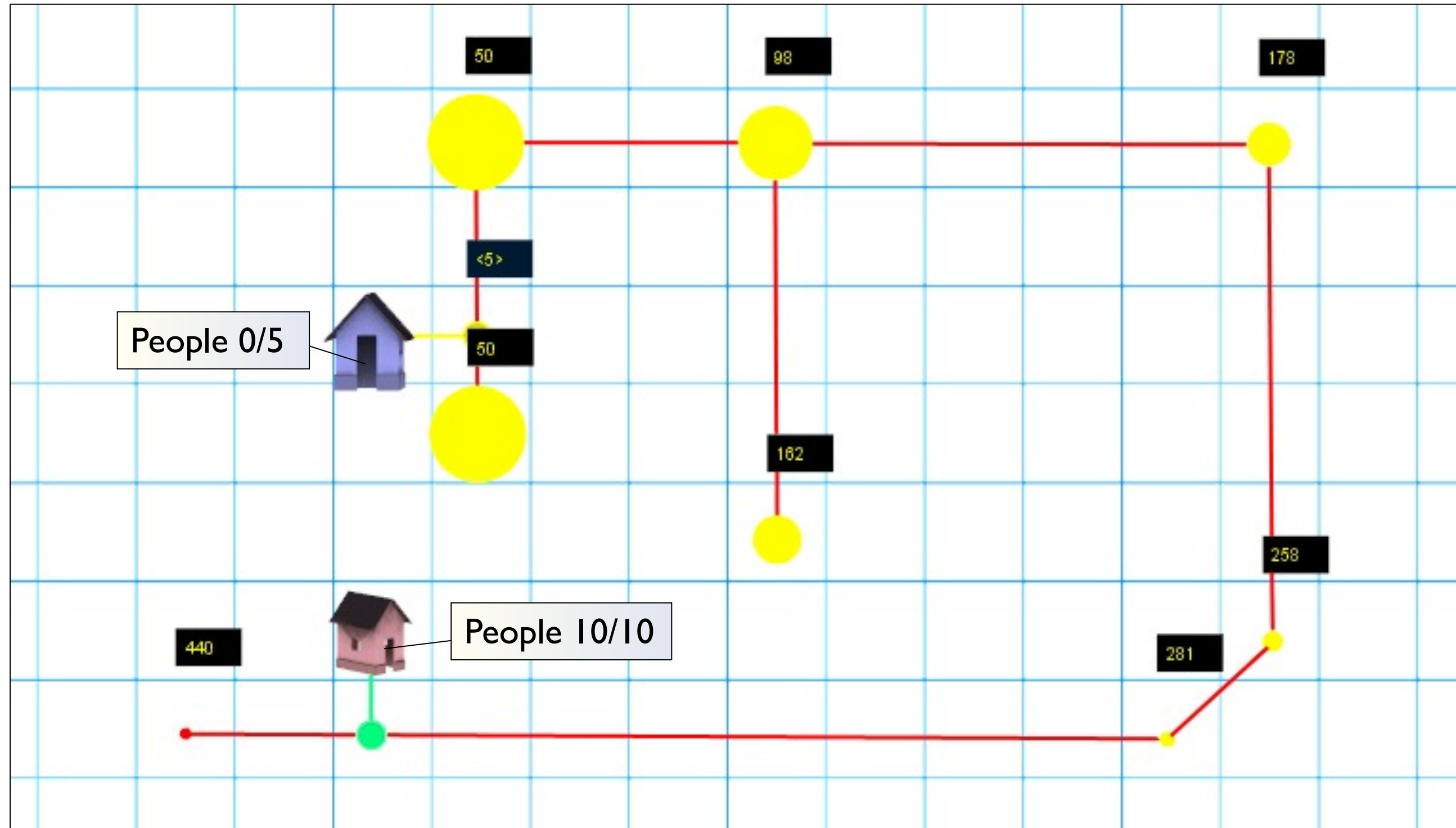
Virtual Distance Field



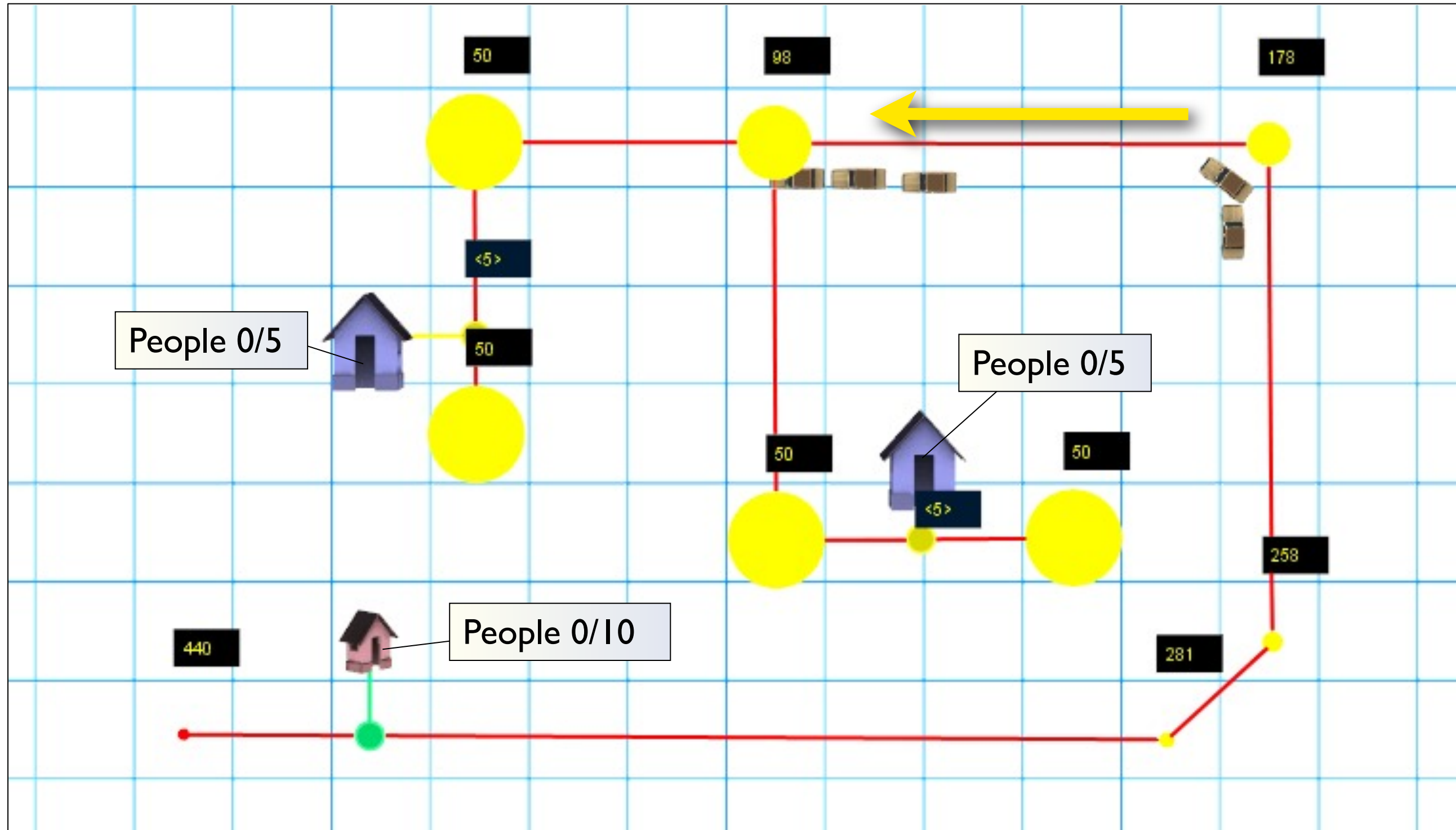
Virtual Distance Field



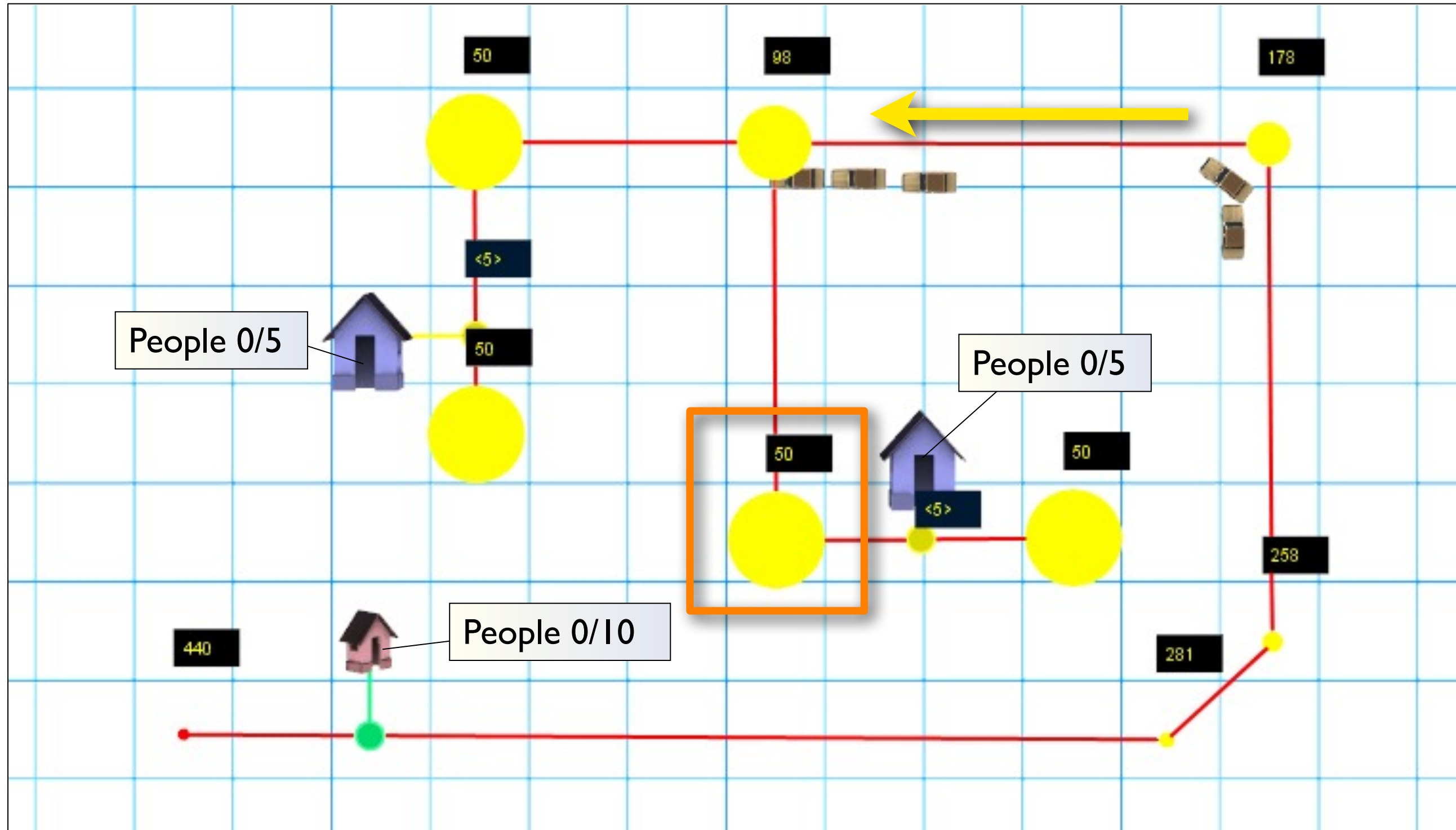
Virtual Distance Field



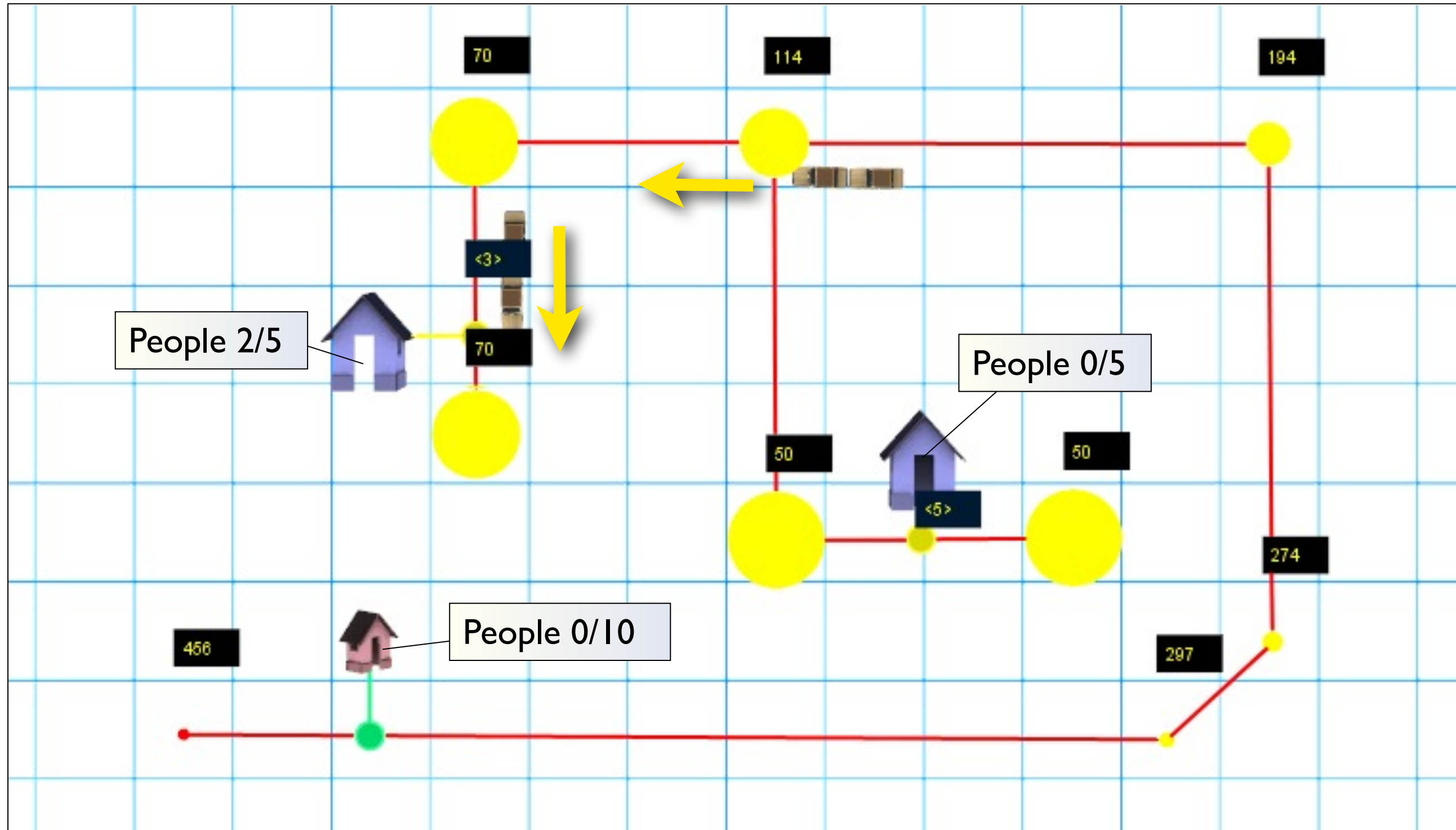
Virtual Distance Field



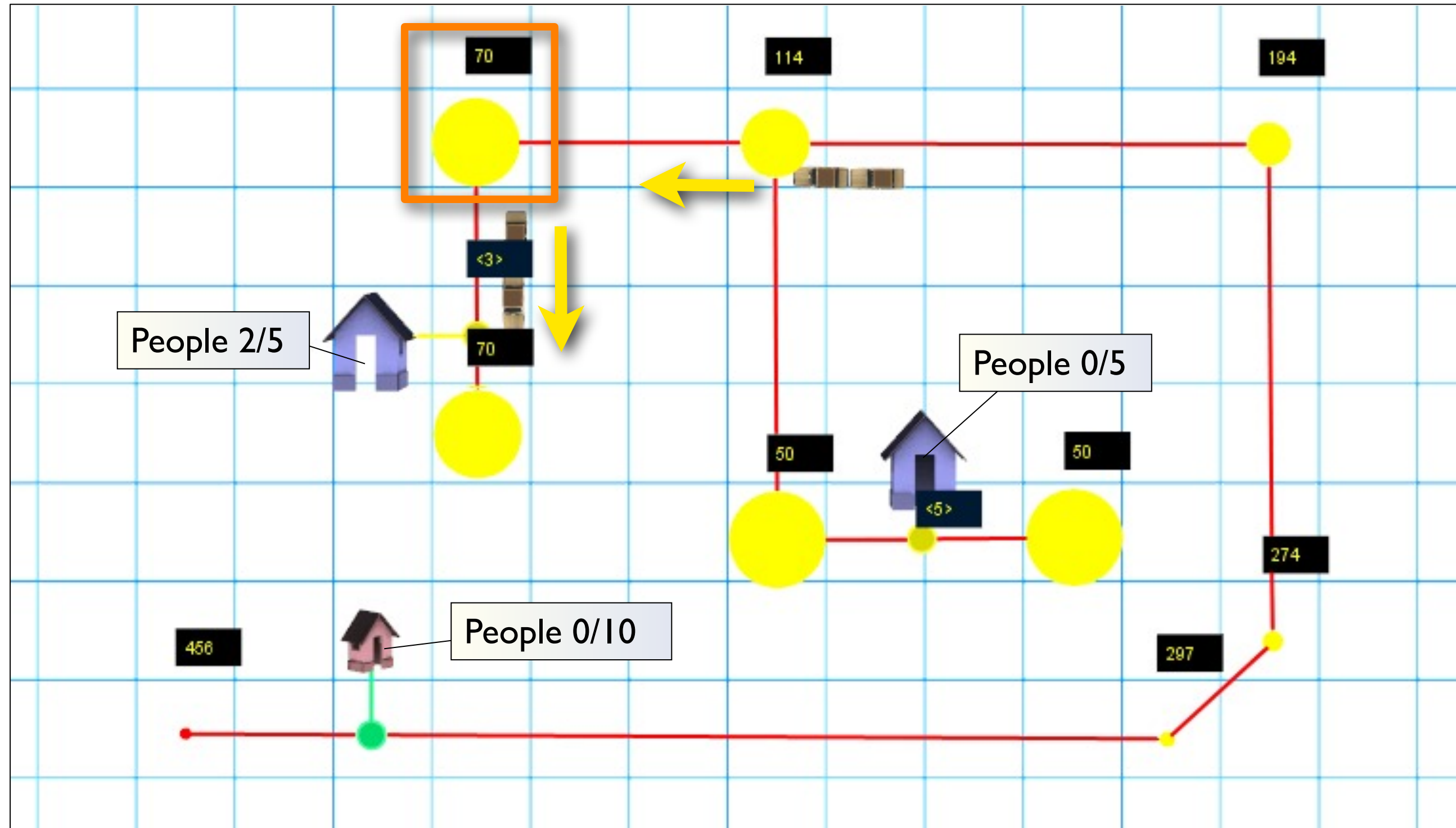
Virtual Distance Field



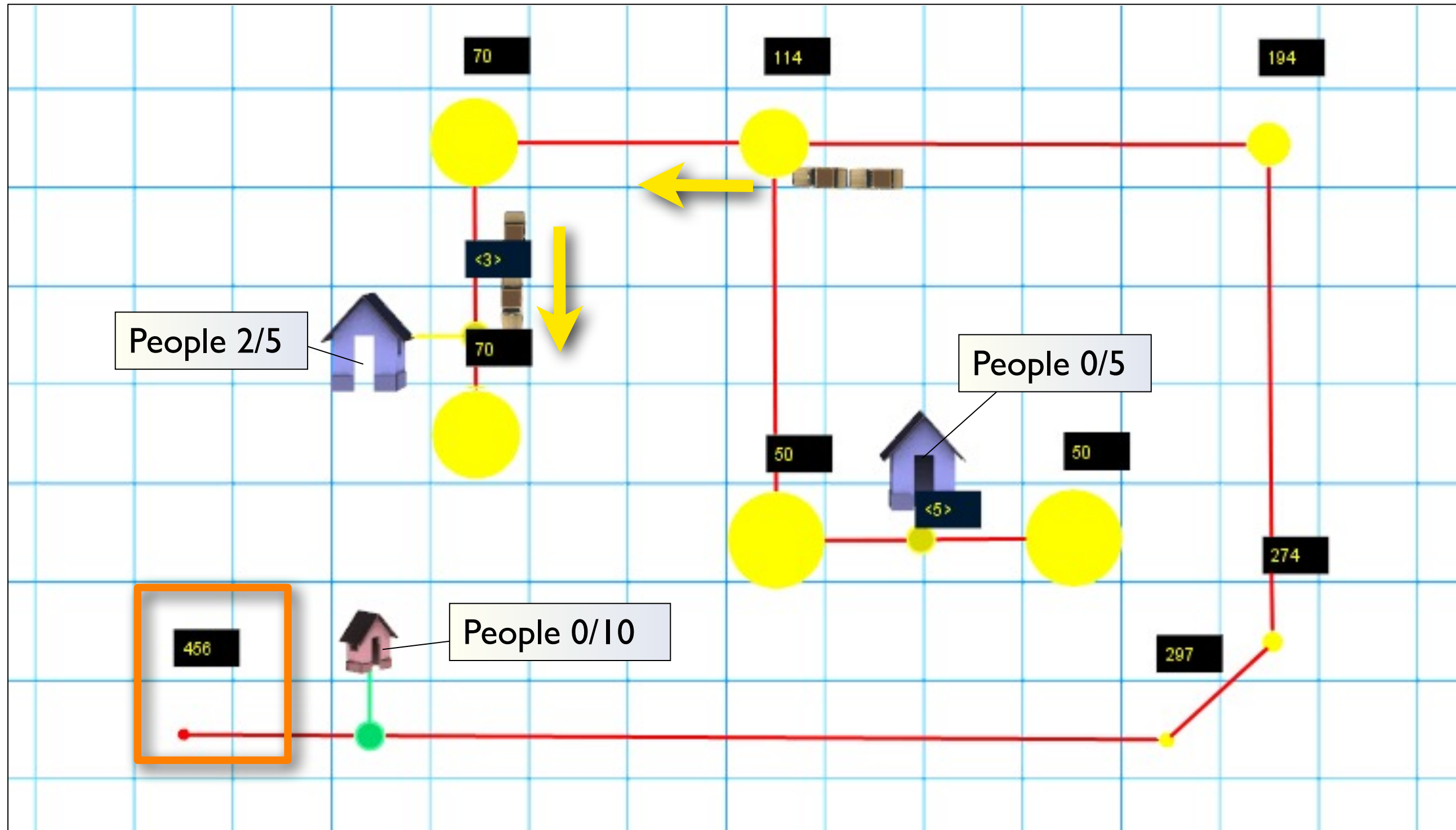
Virtual Distance Field



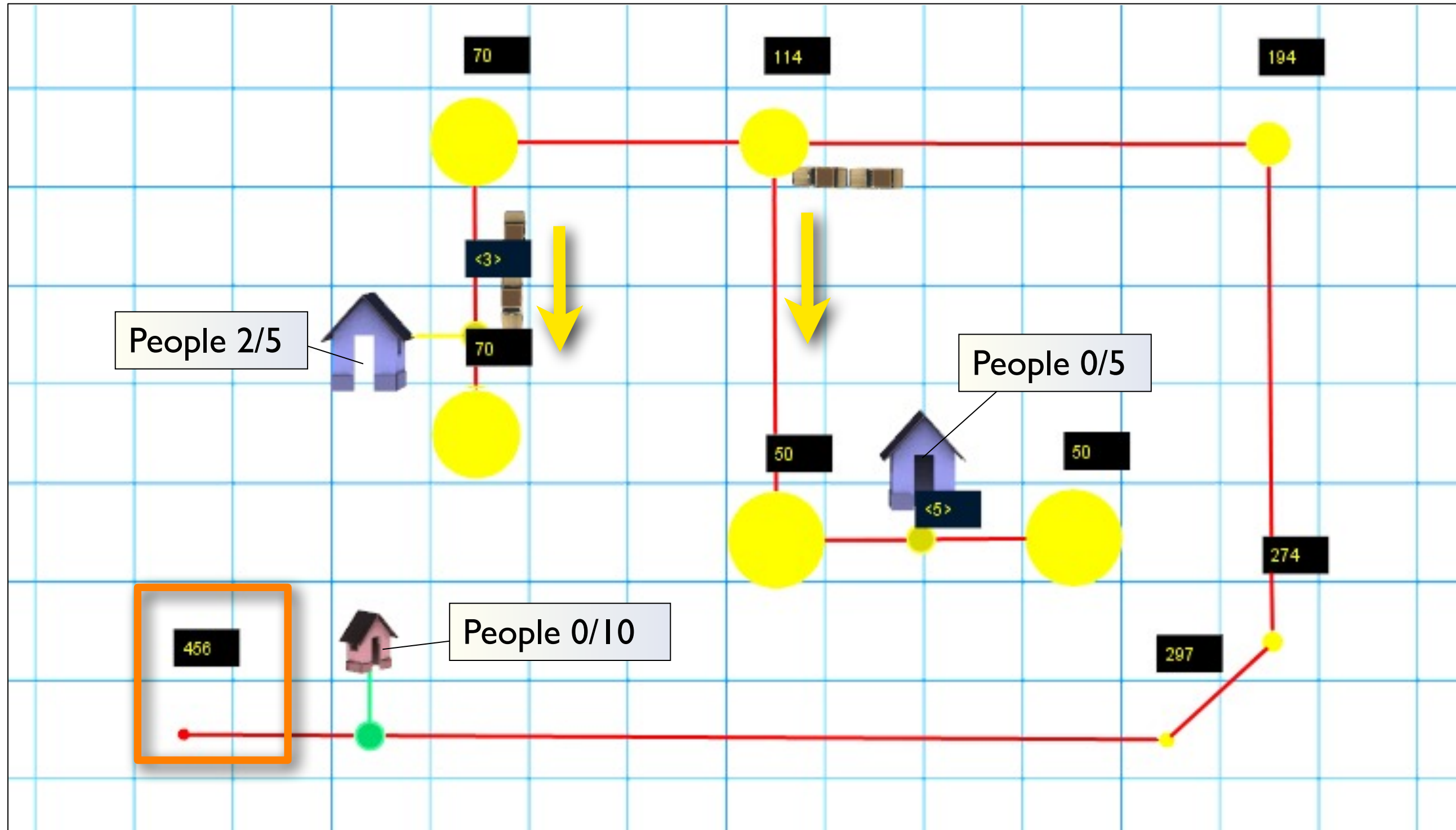
Virtual Distance Field



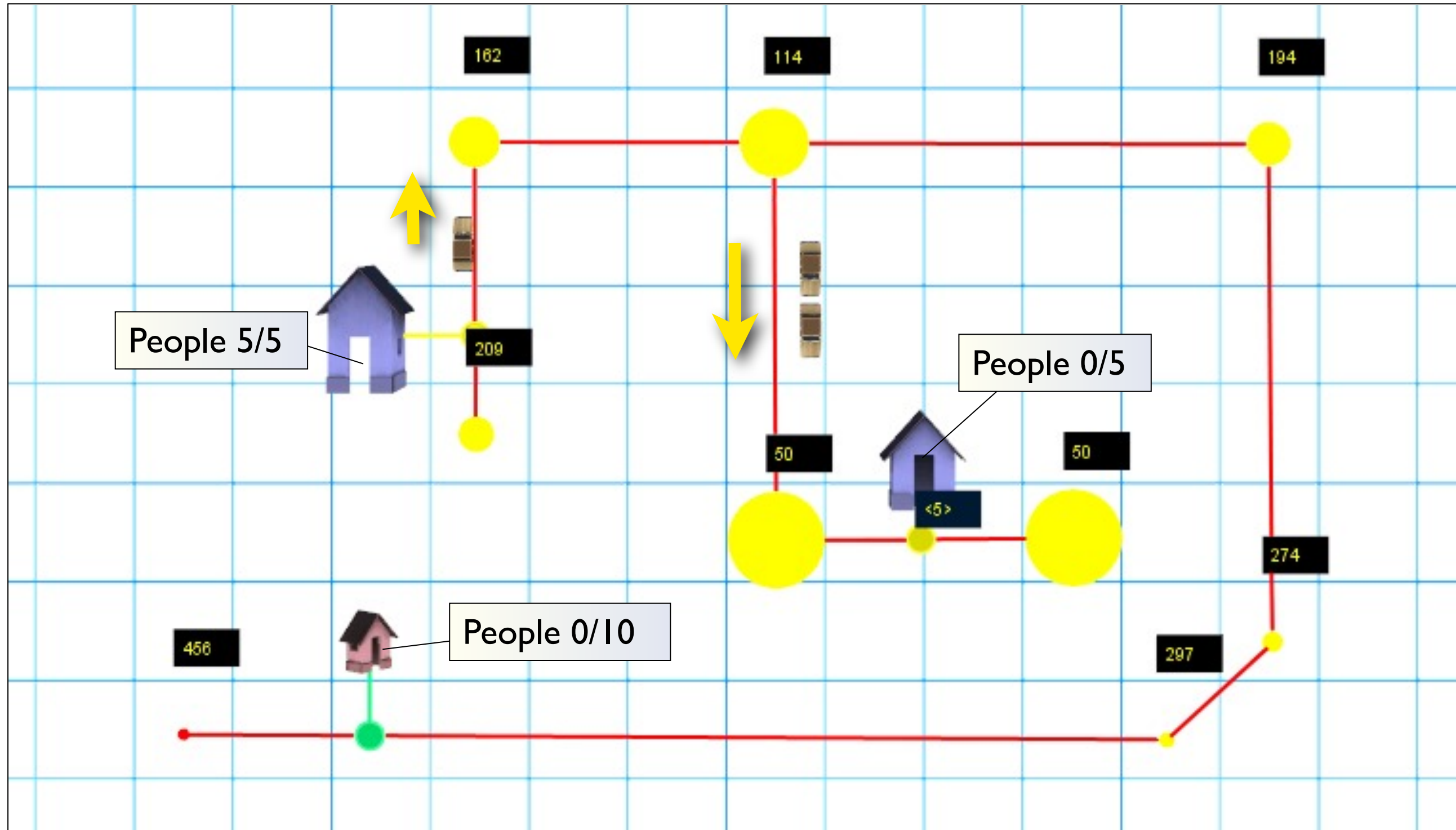
Virtual Distance Field



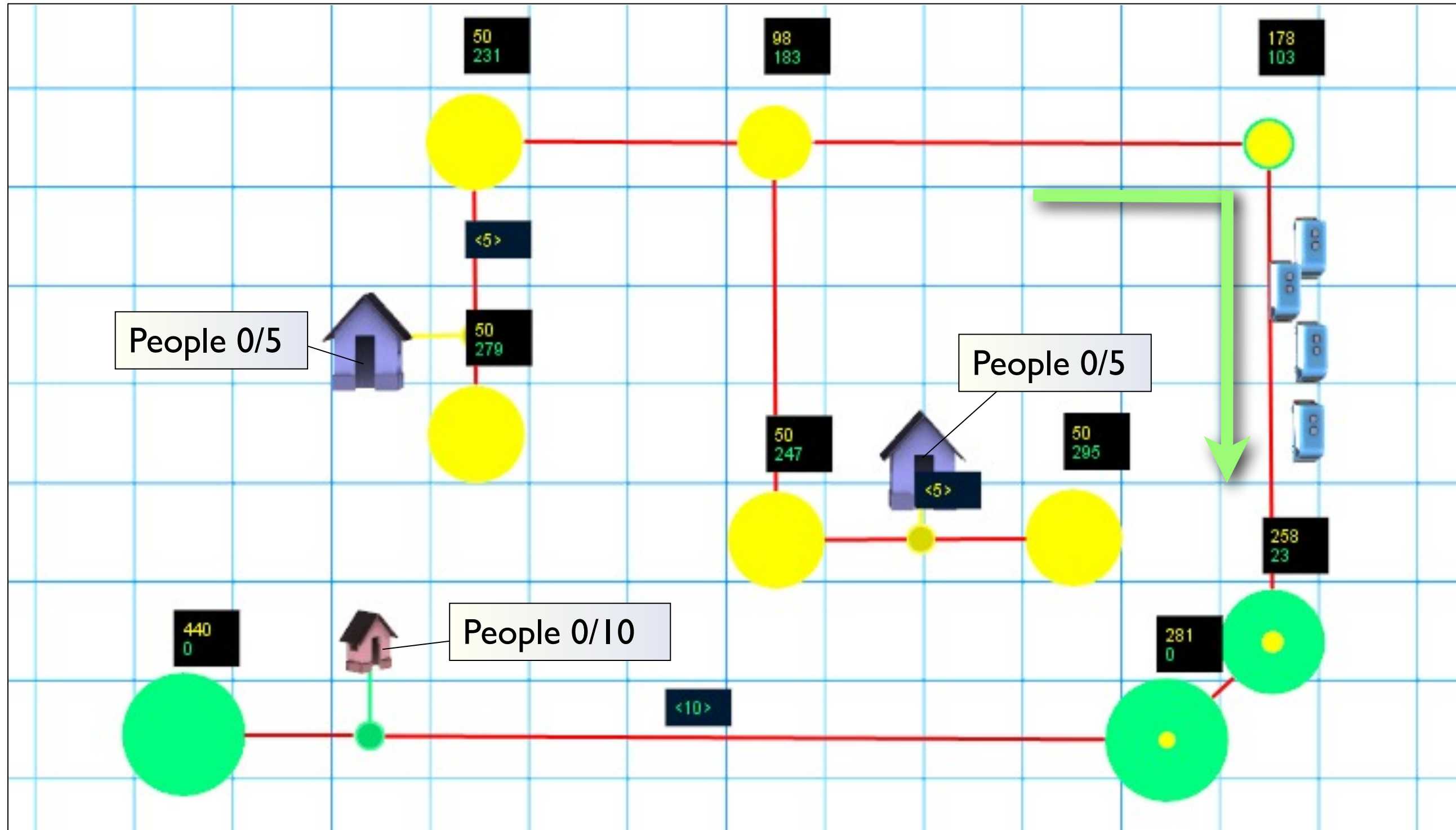
Virtual Distance Field



Virtual Distance Field



Virtual Distance Field



GlassBox Simulation

- **Resources**
- **Units + Maps + Globals + Zones**
 - Rules for each
- **Paths + Agents**



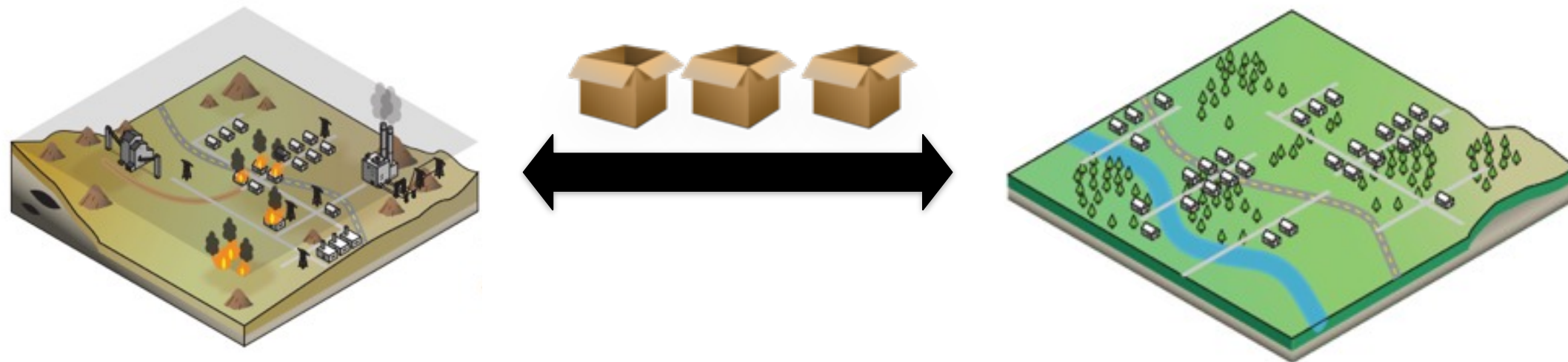
Online

- GlassBox built from ground up to support online
 - Data-driven means small downloads
 - Small upload bandwidth
- Game save is in the cloud: continuous save
- Play anywhere
- Rich online presence



Multiplayer

- Boxes communicate by sending **packages** back and forth
 - Online form of agents
- Can host boxes inside other boxes
 - SimCity regions are just another box



Online Buzzwords

- Asynchronous server model
 - No reliance on dedicated live server running to support your play session
 - Graceful degradation if we have server issues
- All-HTTP REST API
- Any cloud service supported: S3, EC2, etc.



Physics

- Assumed that units can move at will, and will be controlled by a physics simulation
- Simulator built around this assumption
- Avoid sim chugging to a halt during disasters



Visualisation

- Rather than visualise game statistics, show actual game state
 - Show cars instead of traffic density
 - Actual people in house rather than expected
- Ensure cause and effect is obvious:

What You See Is What You Sim



Conclusion

- The GlassBox simulation architecture is built out of very simple pieces
- But, the emergent behaviour is rich
- Now for SimCity...

