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

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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

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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

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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

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GlassBox Basics

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

- = ~~$$$~~ Simulation!

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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

Resources
Units
Maps
Globals
Rules
Box

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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

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GLASS BOX

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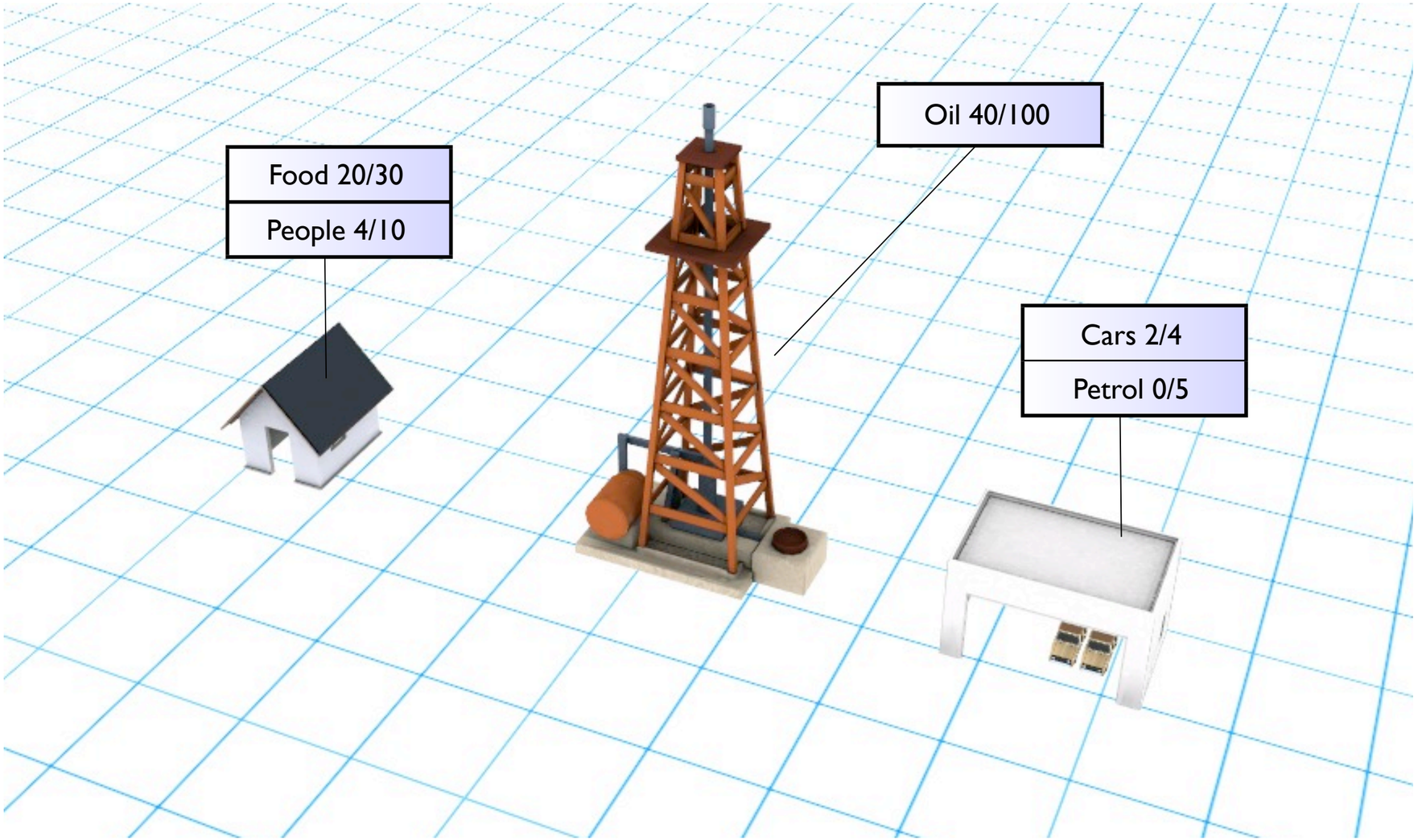
Units



- Resources
- **Units**
- Maps
- Globals
- Rules
- Box

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

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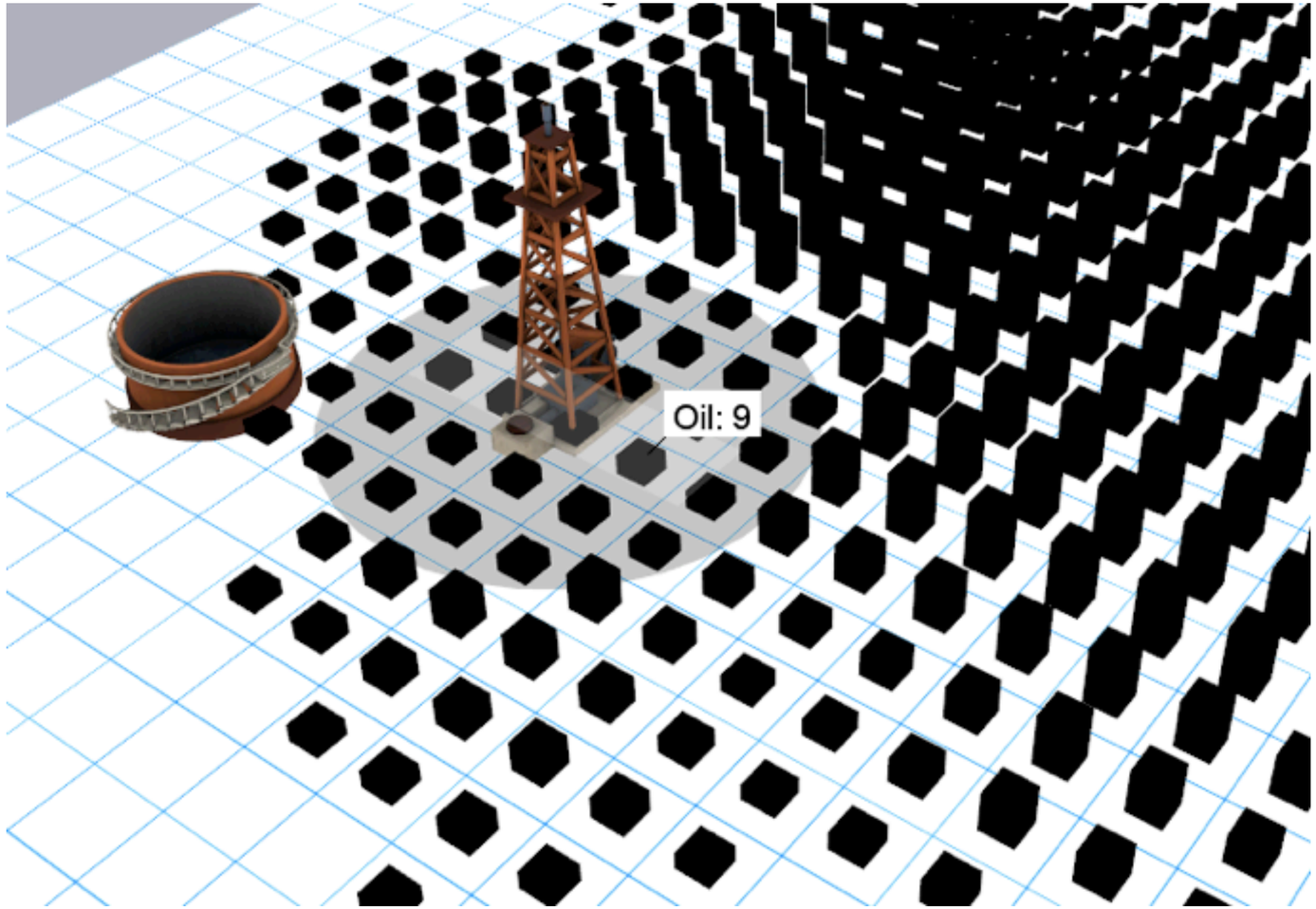
Maps



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- Units
- **Maps**
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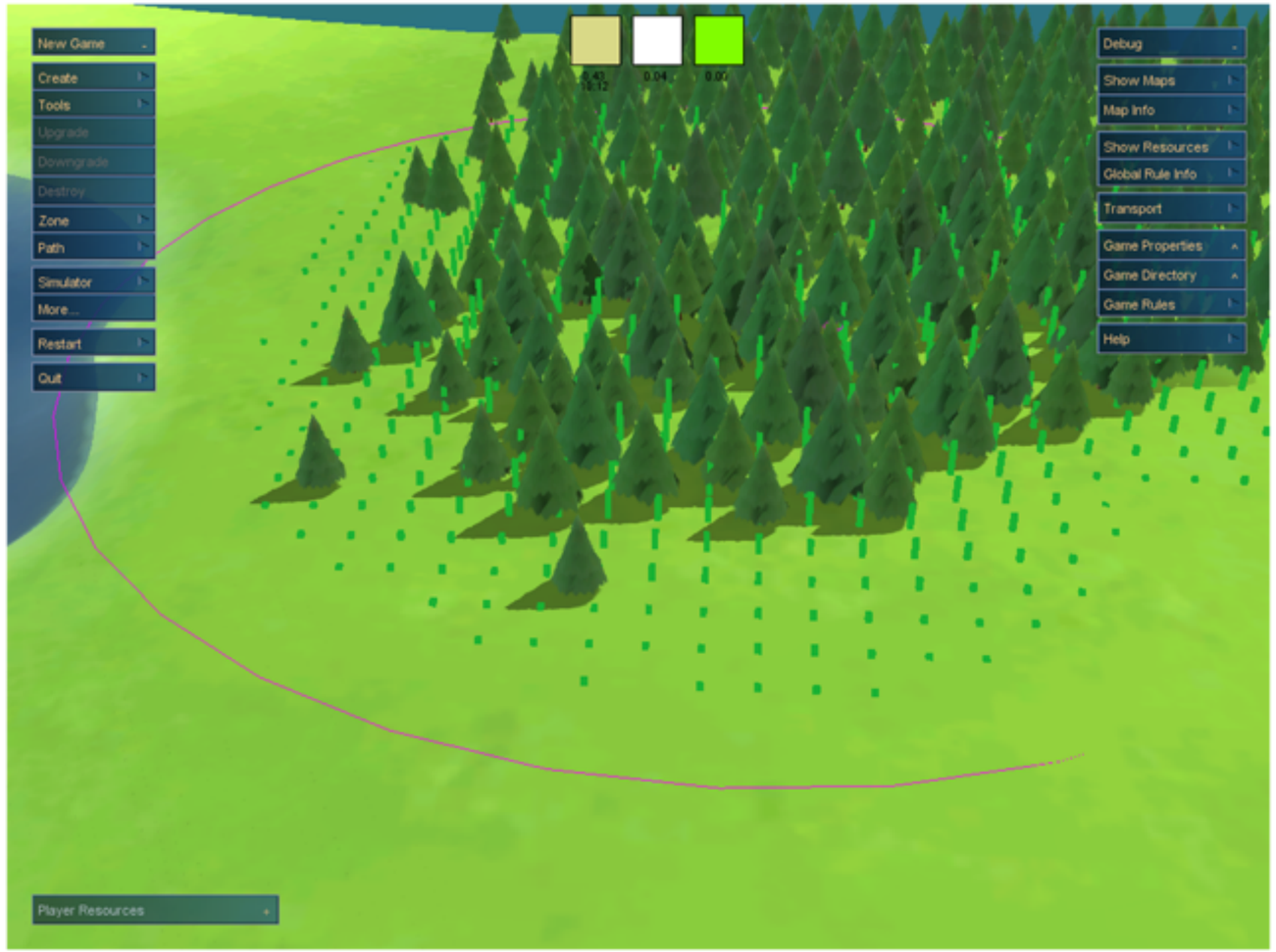
Maps



- Resources
- Units
- **Maps**
- Globals
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Globals

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

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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

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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

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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

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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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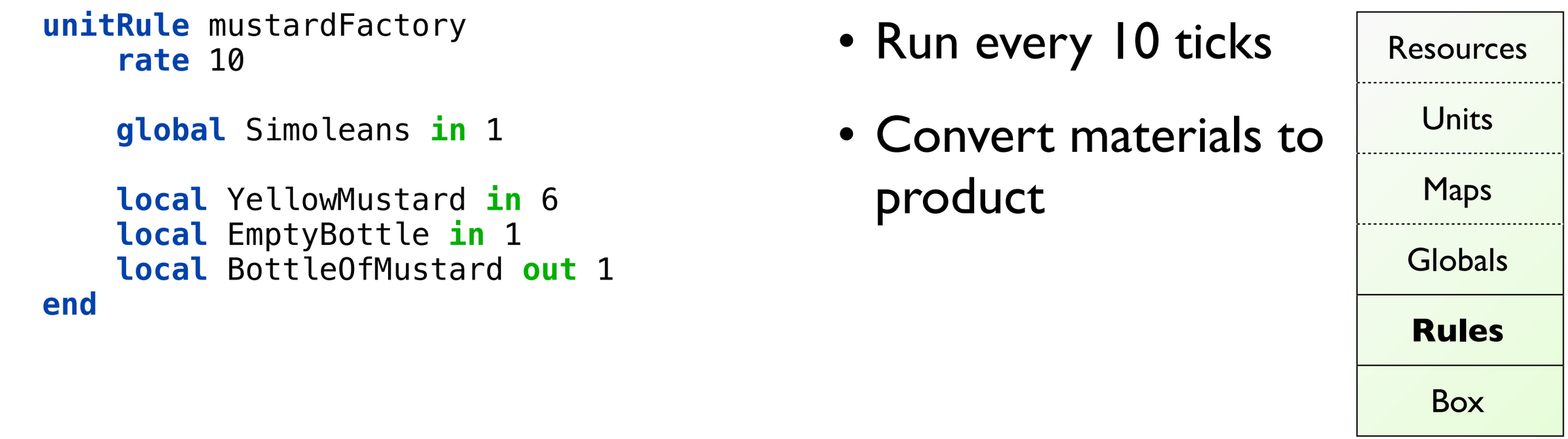
Unit Rule Example

```
unitRule mustardFactory
    rate 10

    global Simoleans in 1

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

- Run every 10 ticks
- Convert materials to product



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- Run every 10 ticks
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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

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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
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

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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

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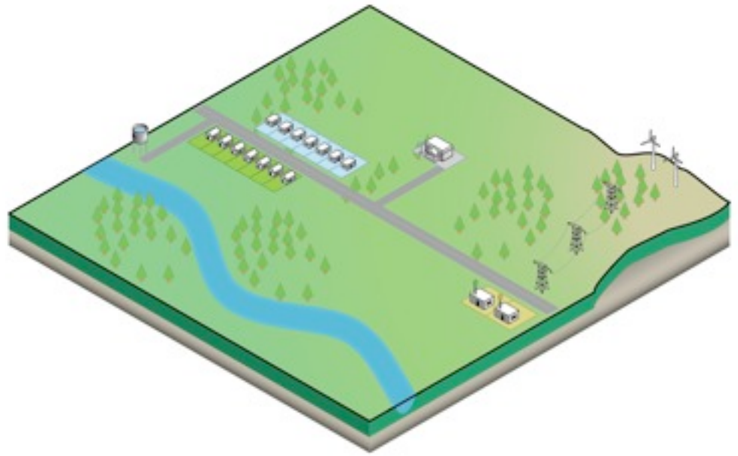
A Box

- 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

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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**

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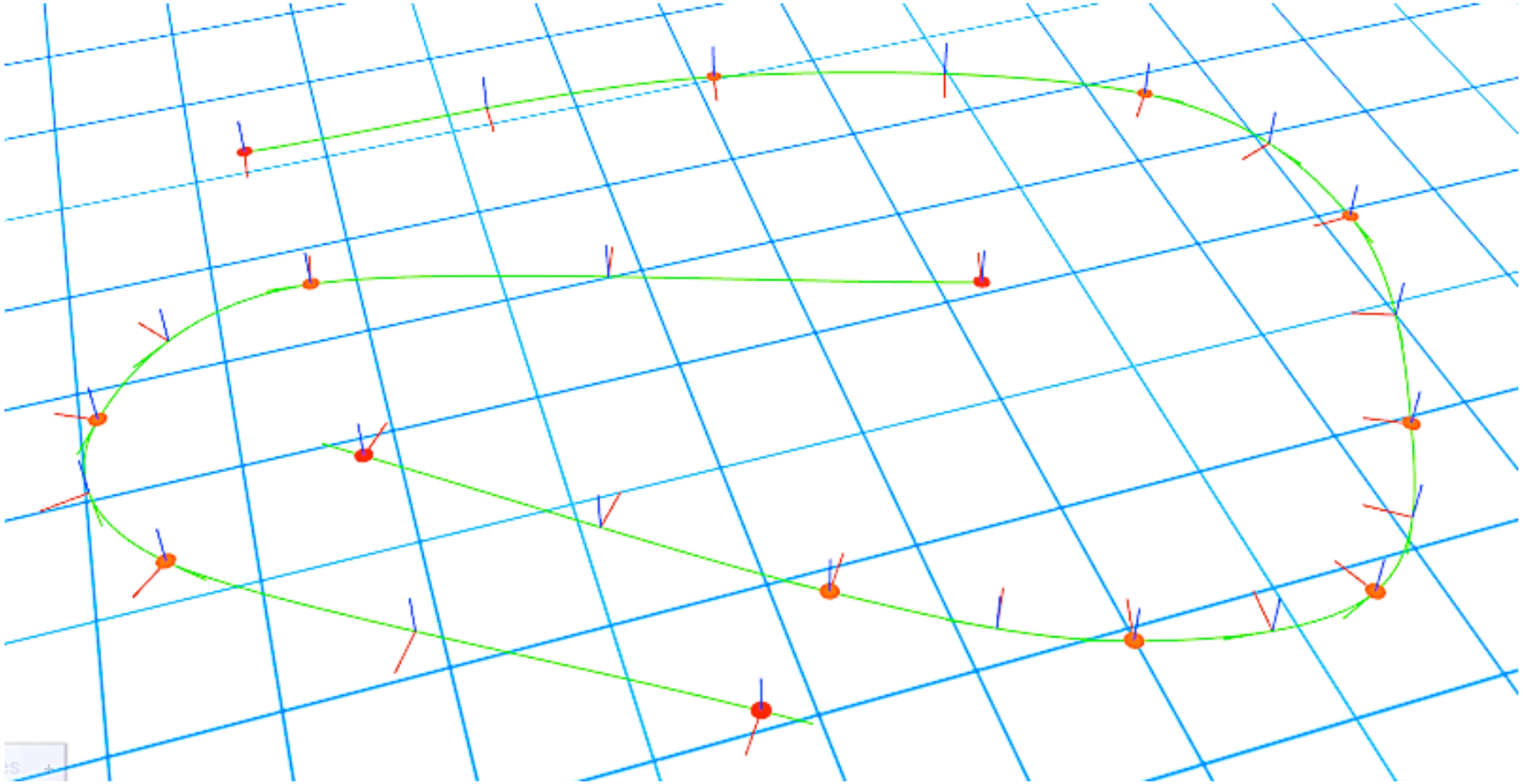
Paths



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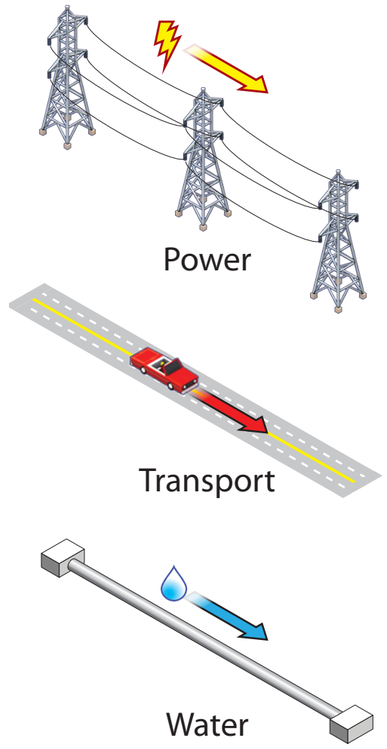
Paths

- **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



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Zones

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

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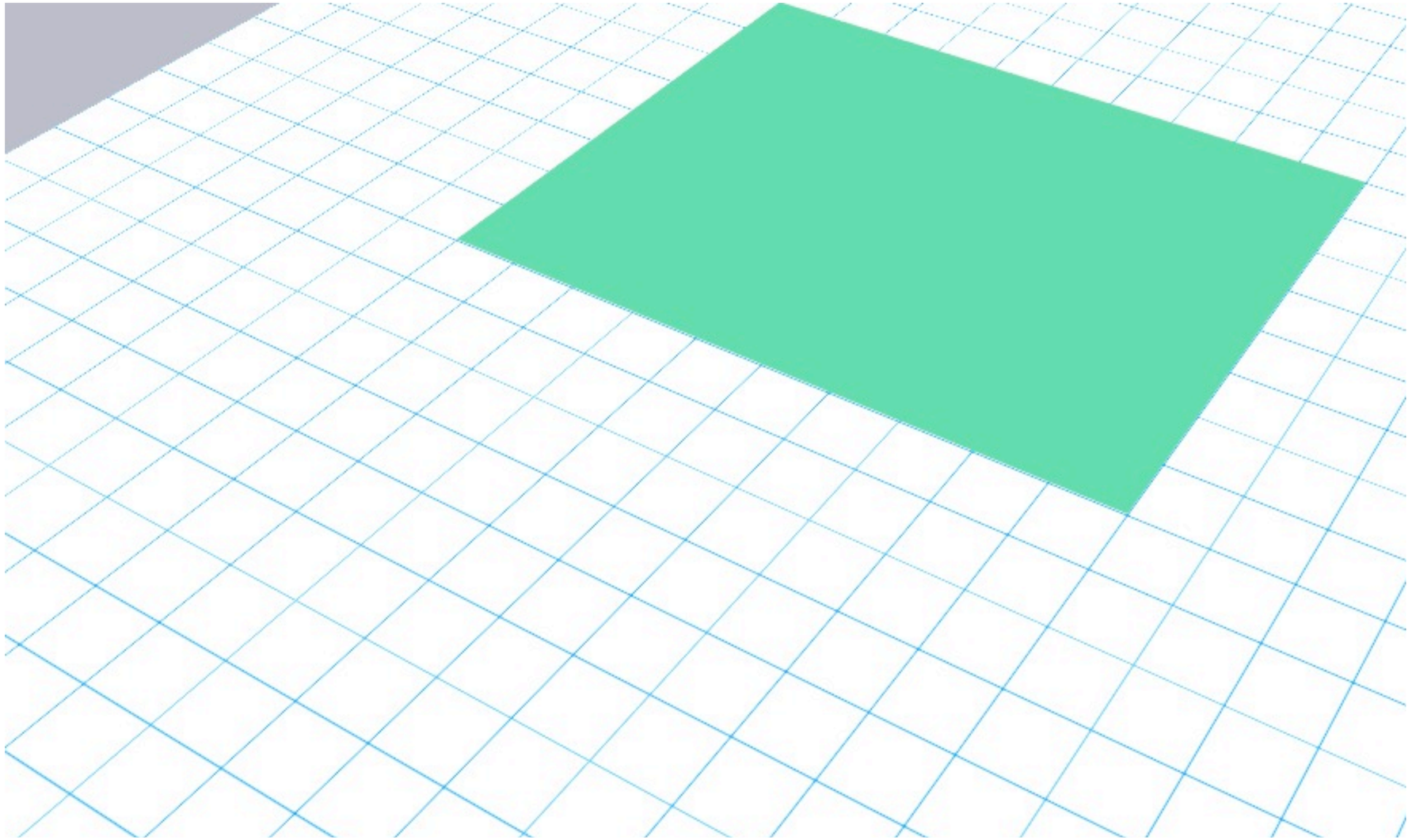
Zones



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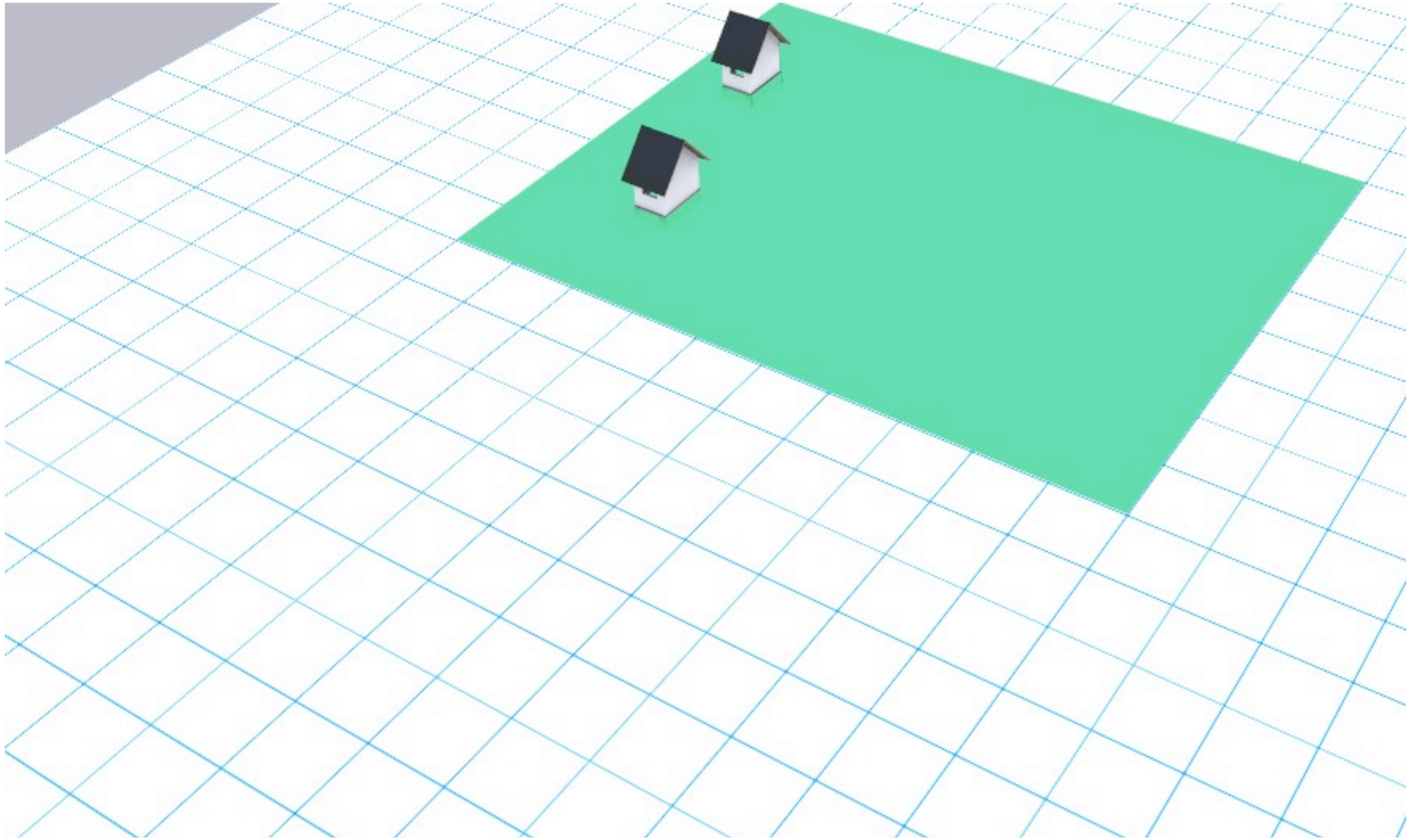
Zones



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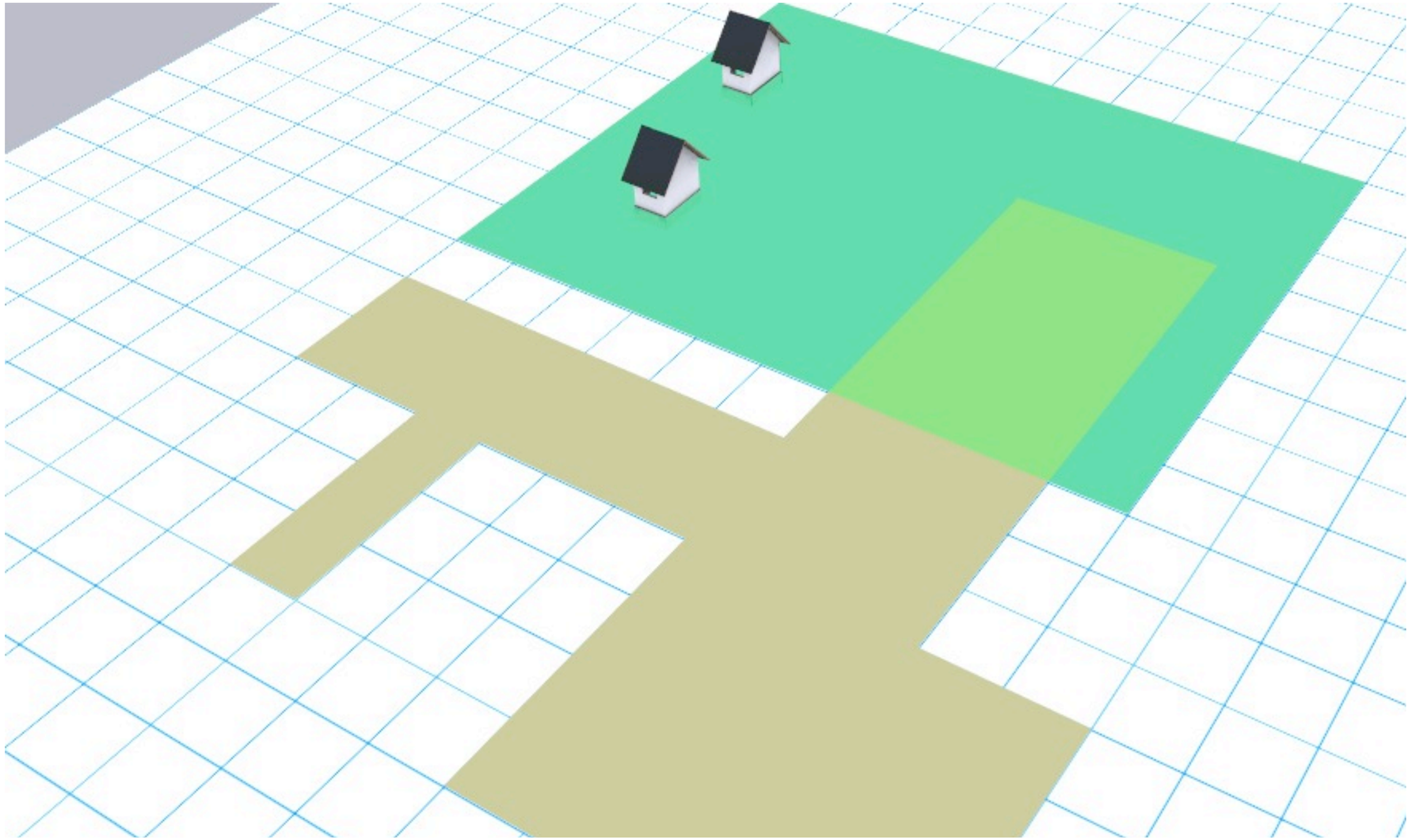
Zones



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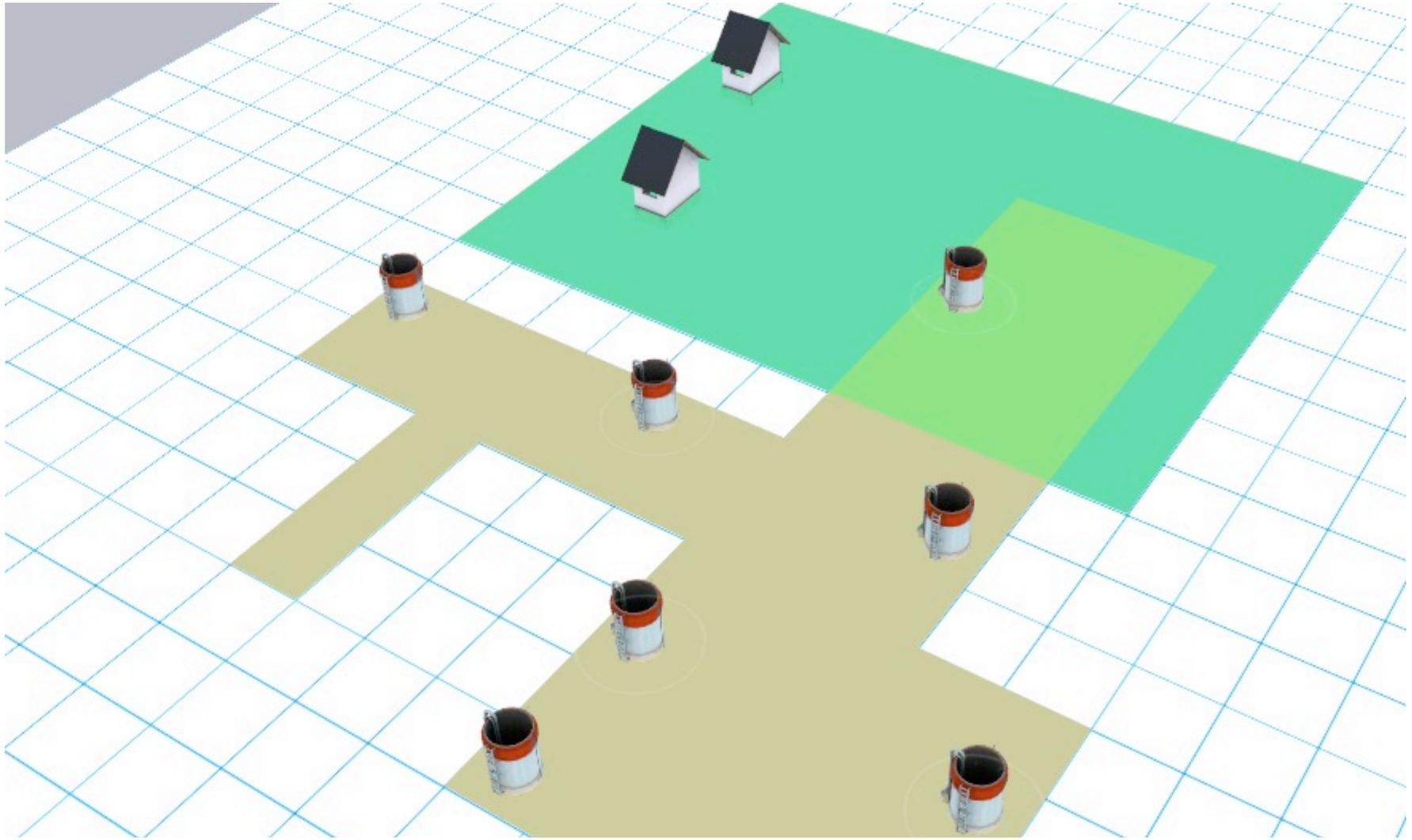
Zones



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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

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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

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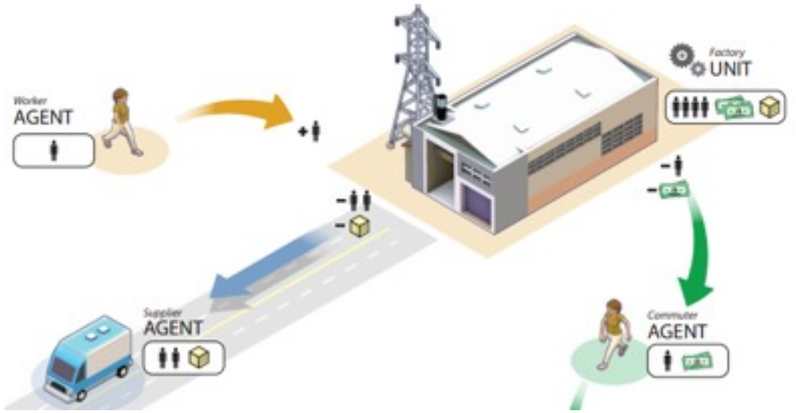
Agents

- 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
```

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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
```

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Transport Handlers

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

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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

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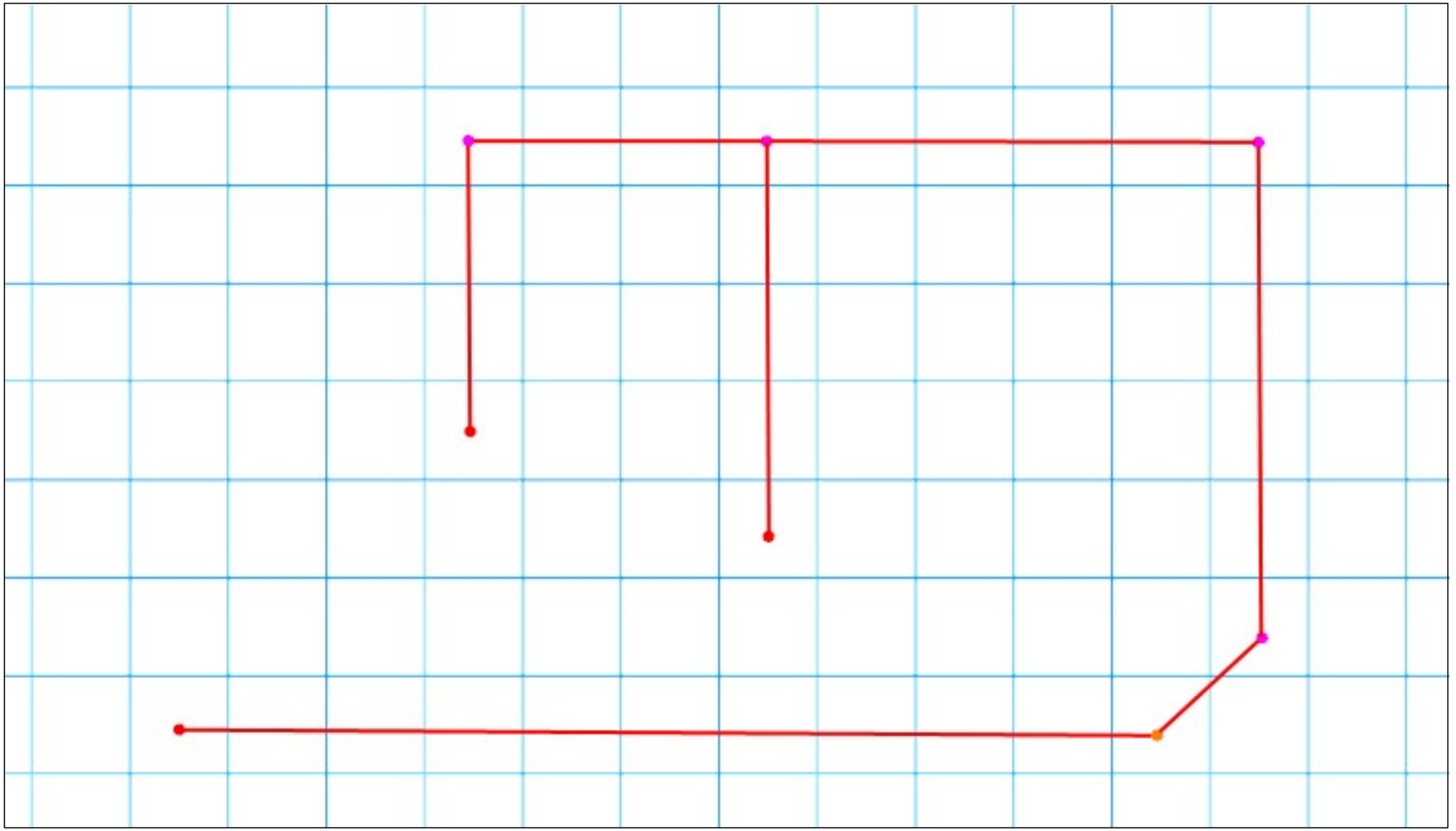
Virtual Distance Field



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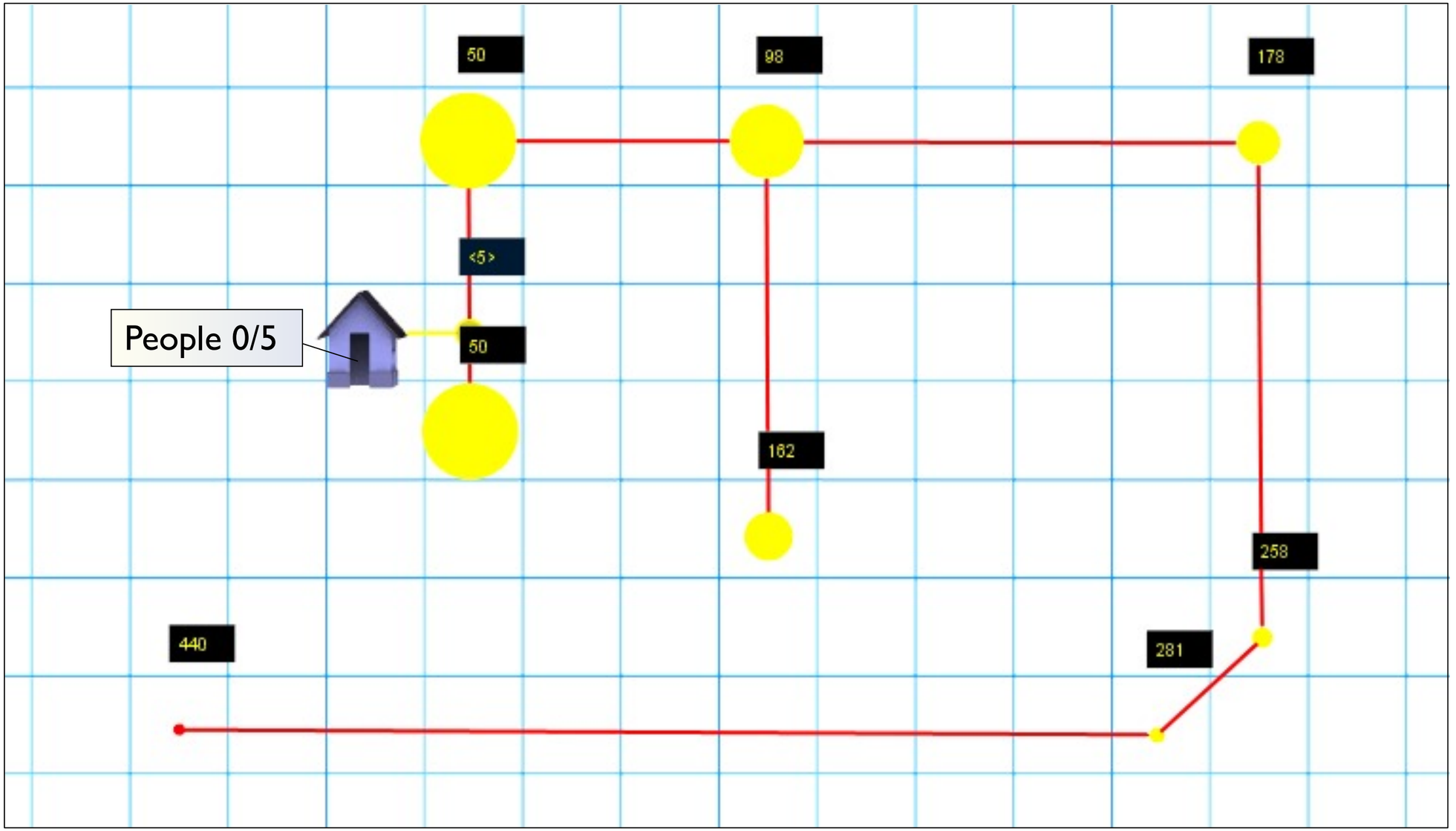

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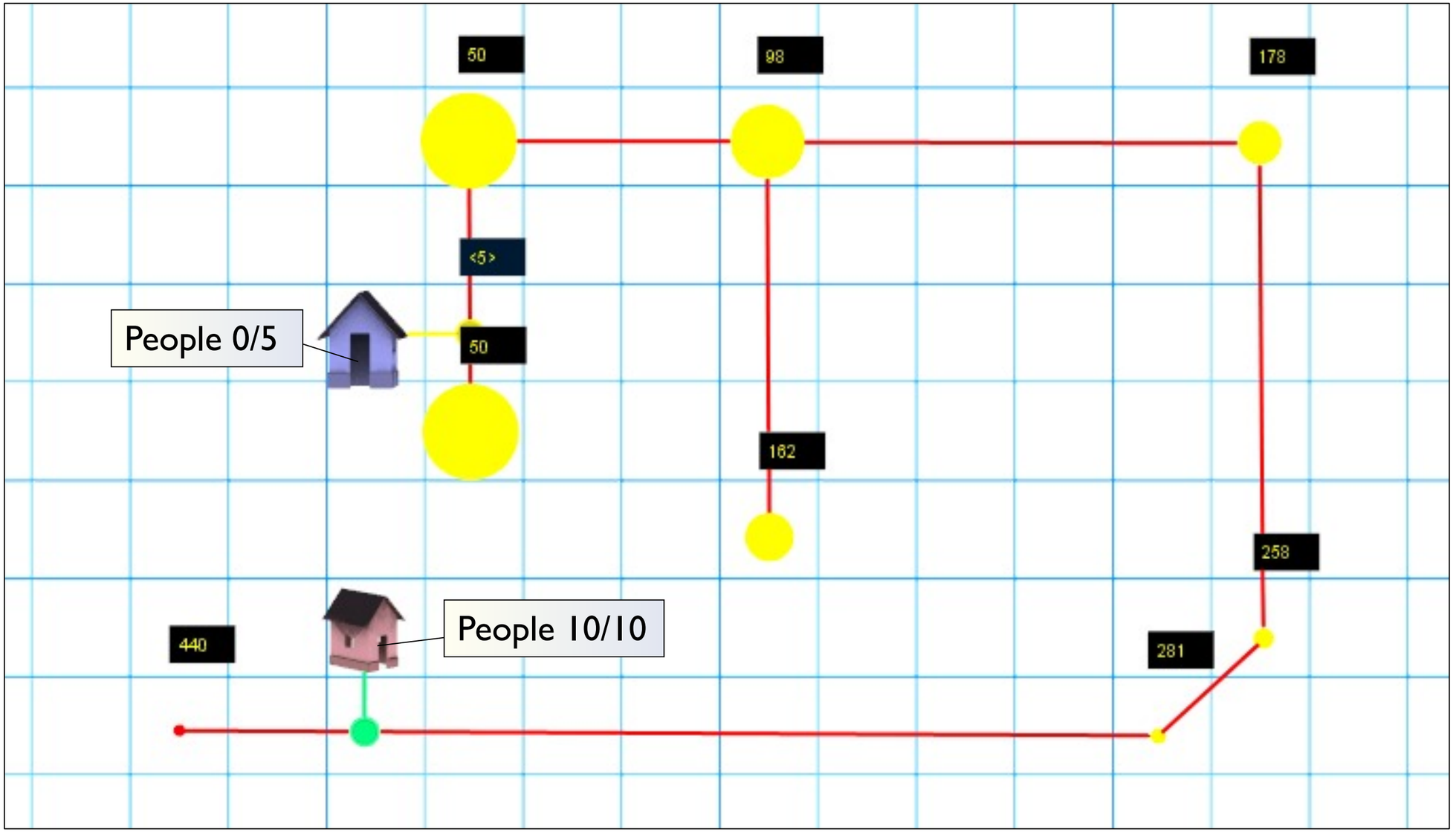

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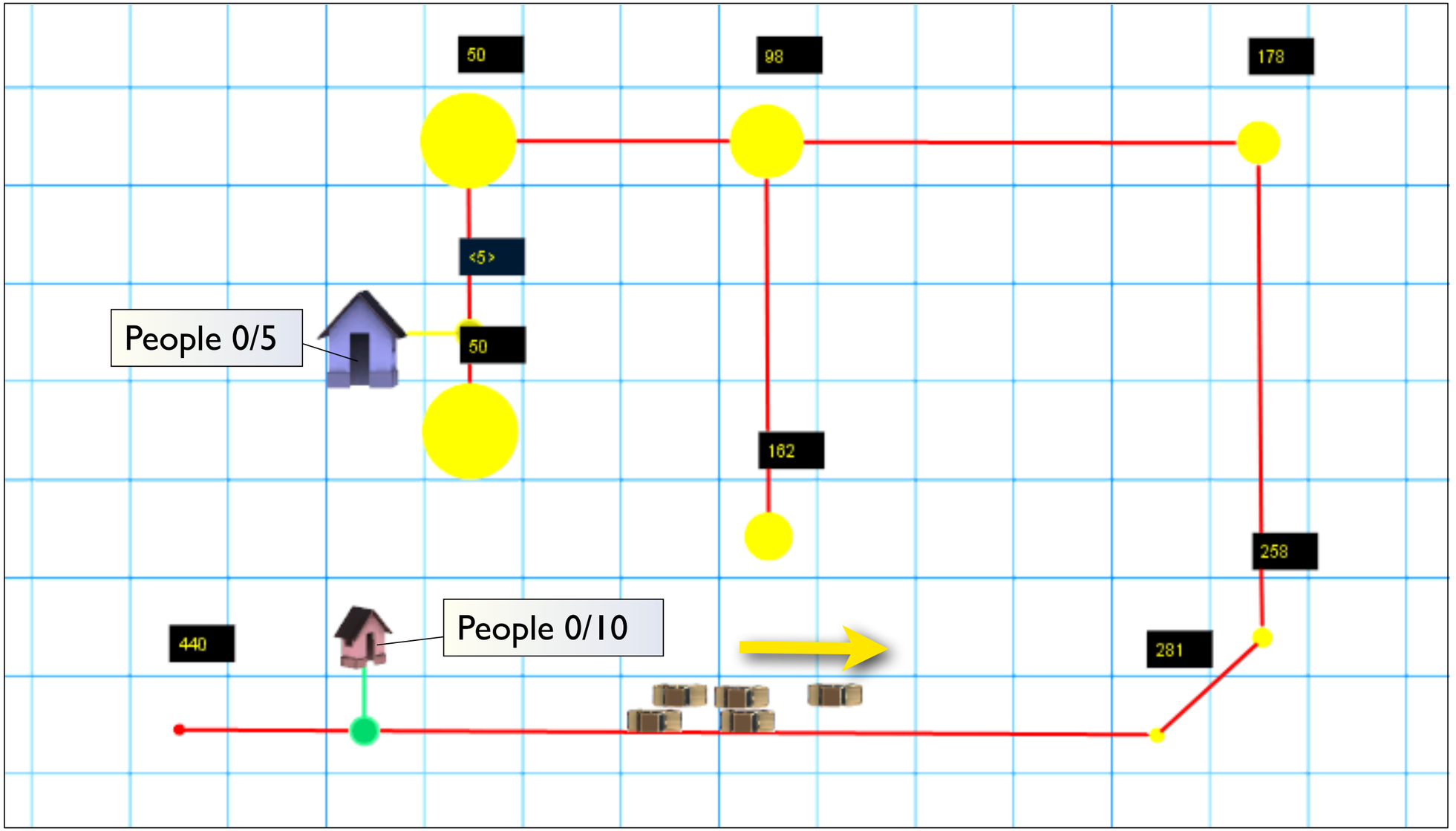

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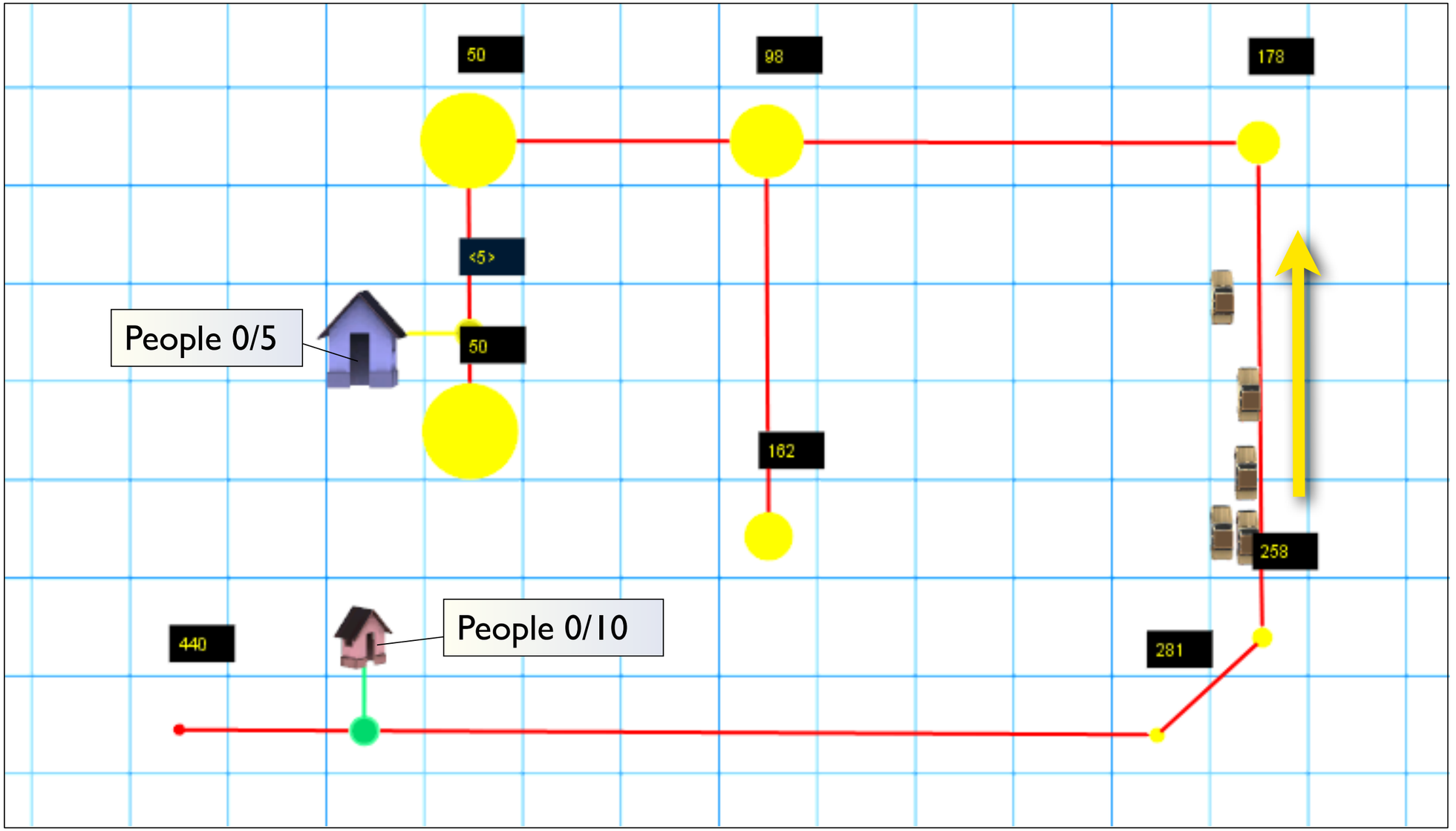

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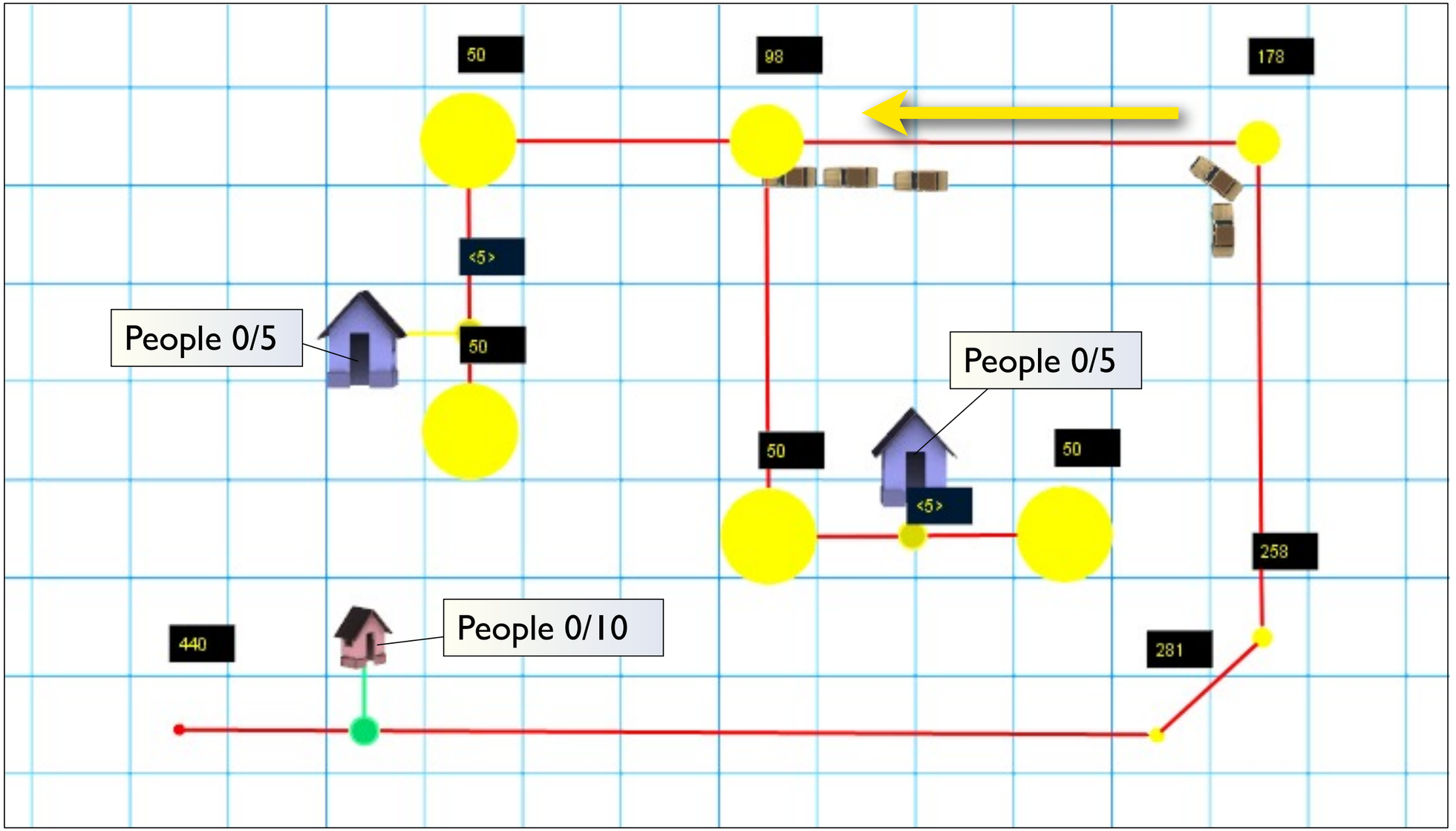

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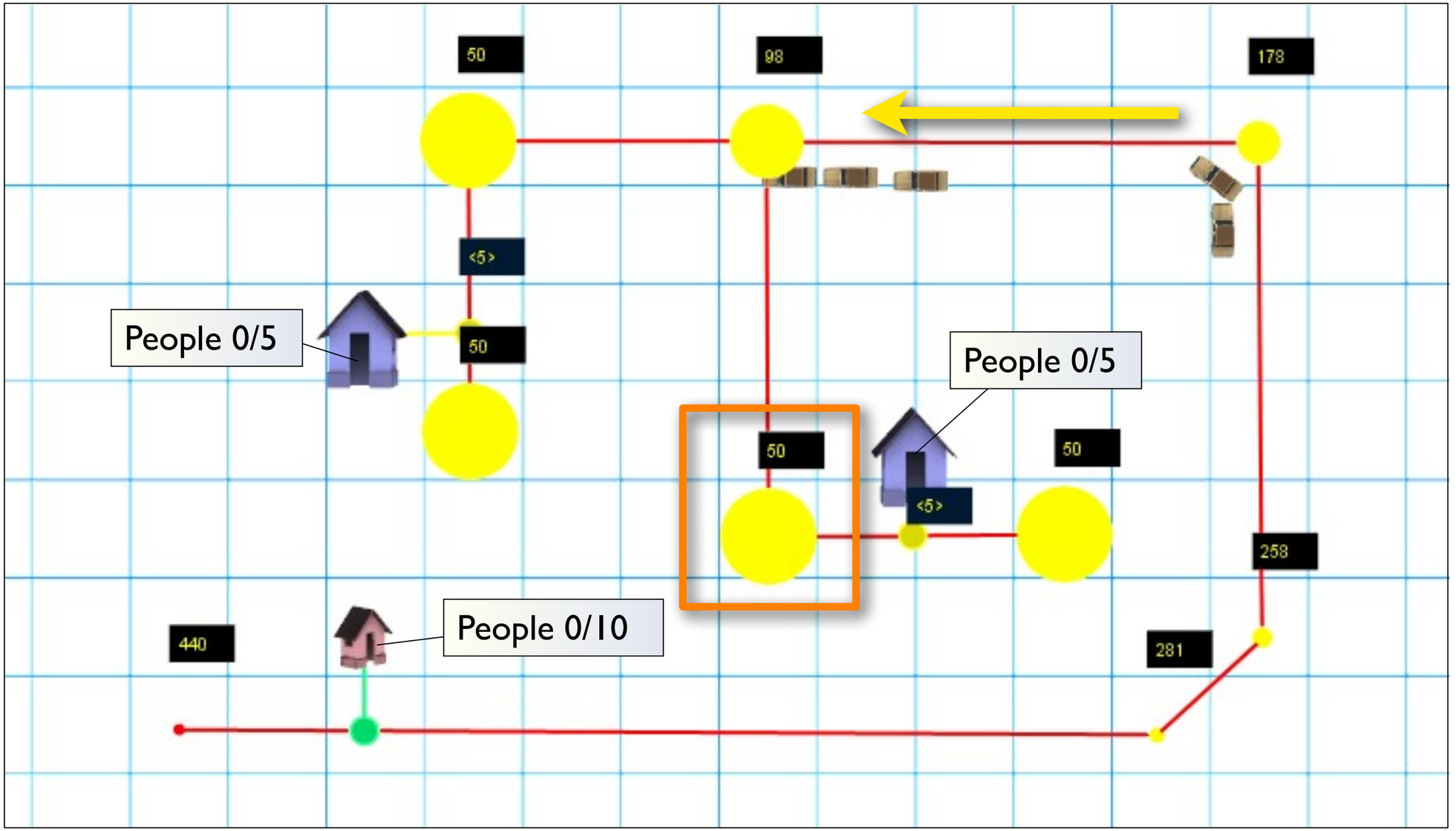

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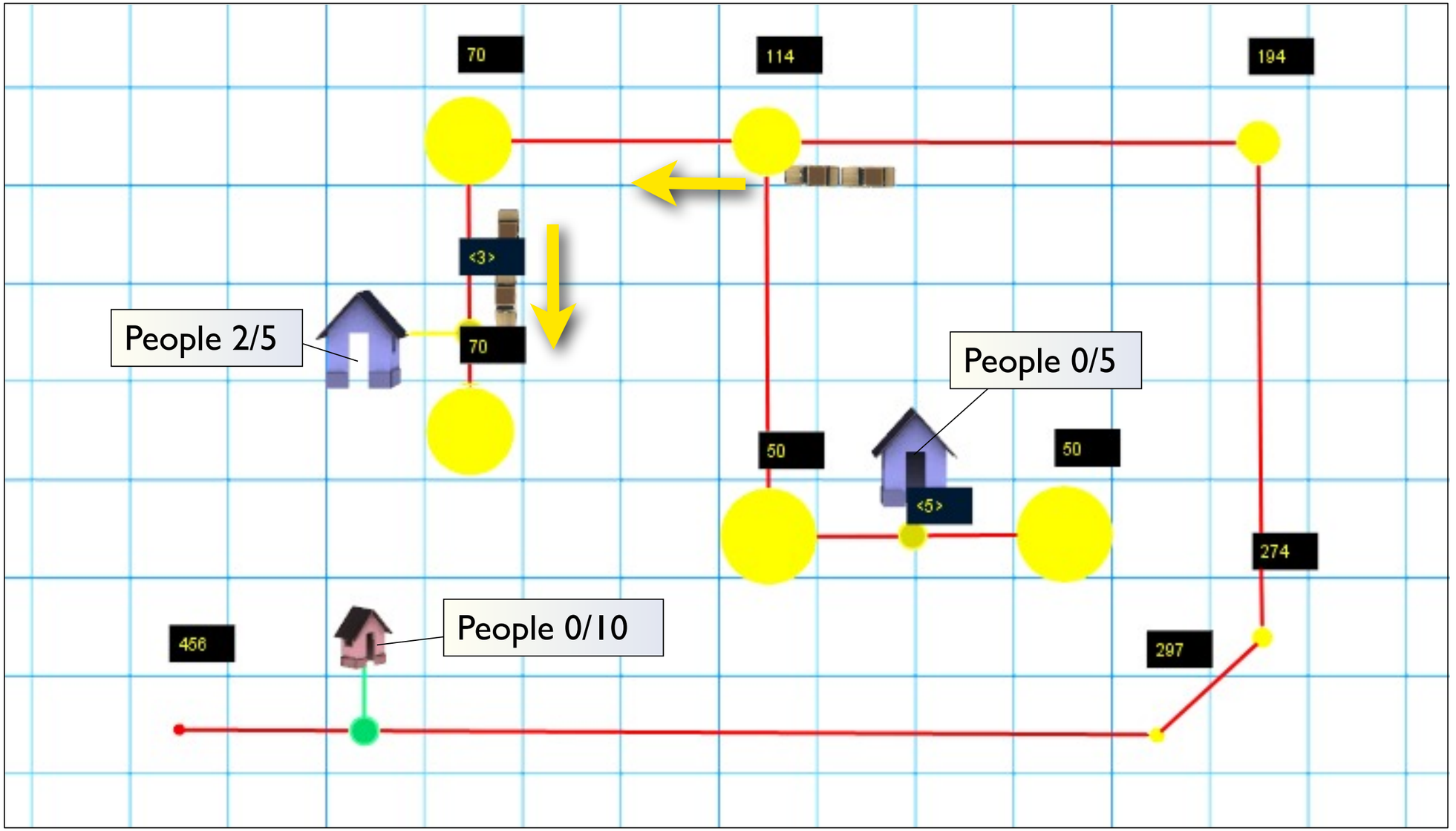

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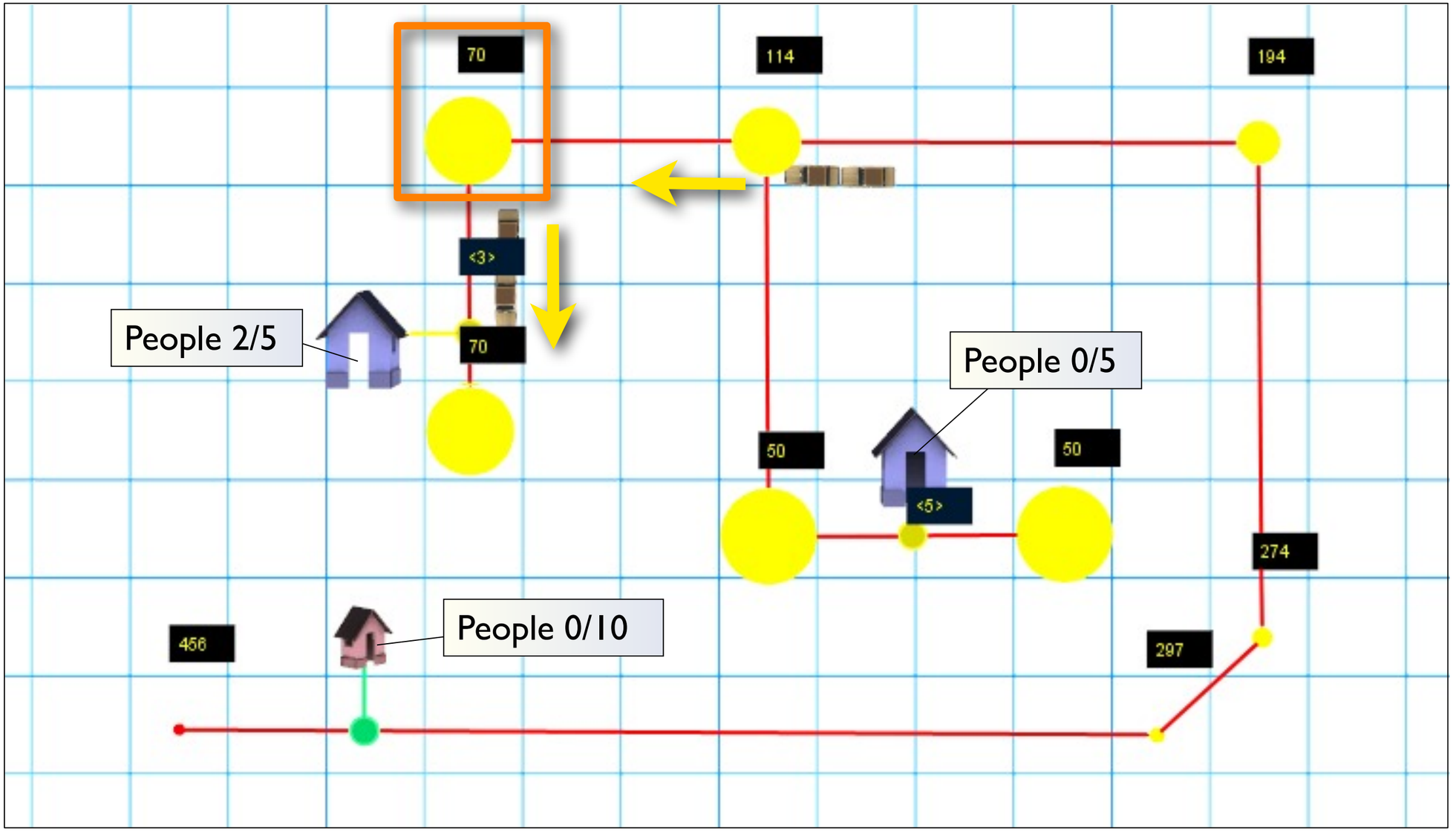

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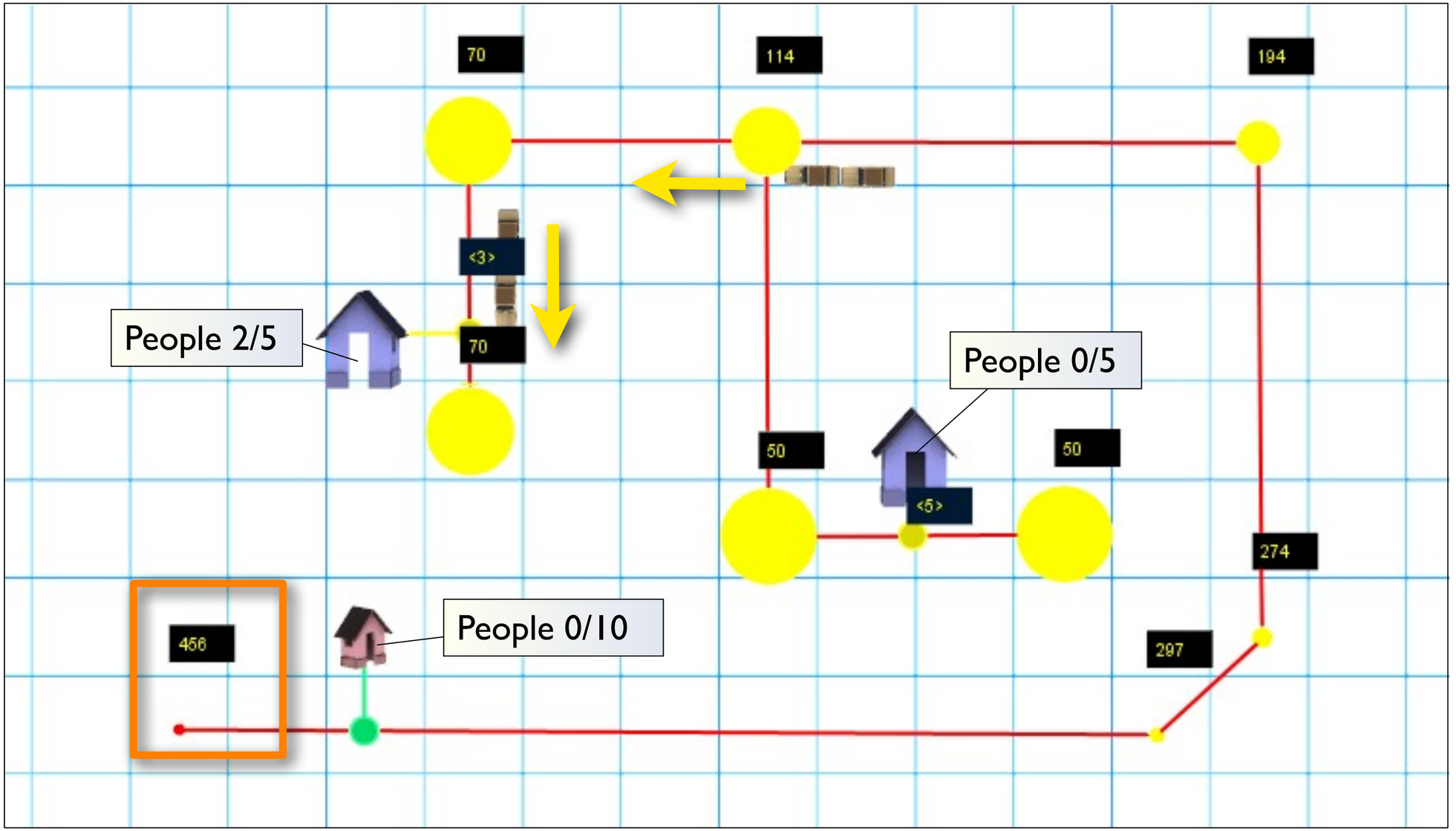

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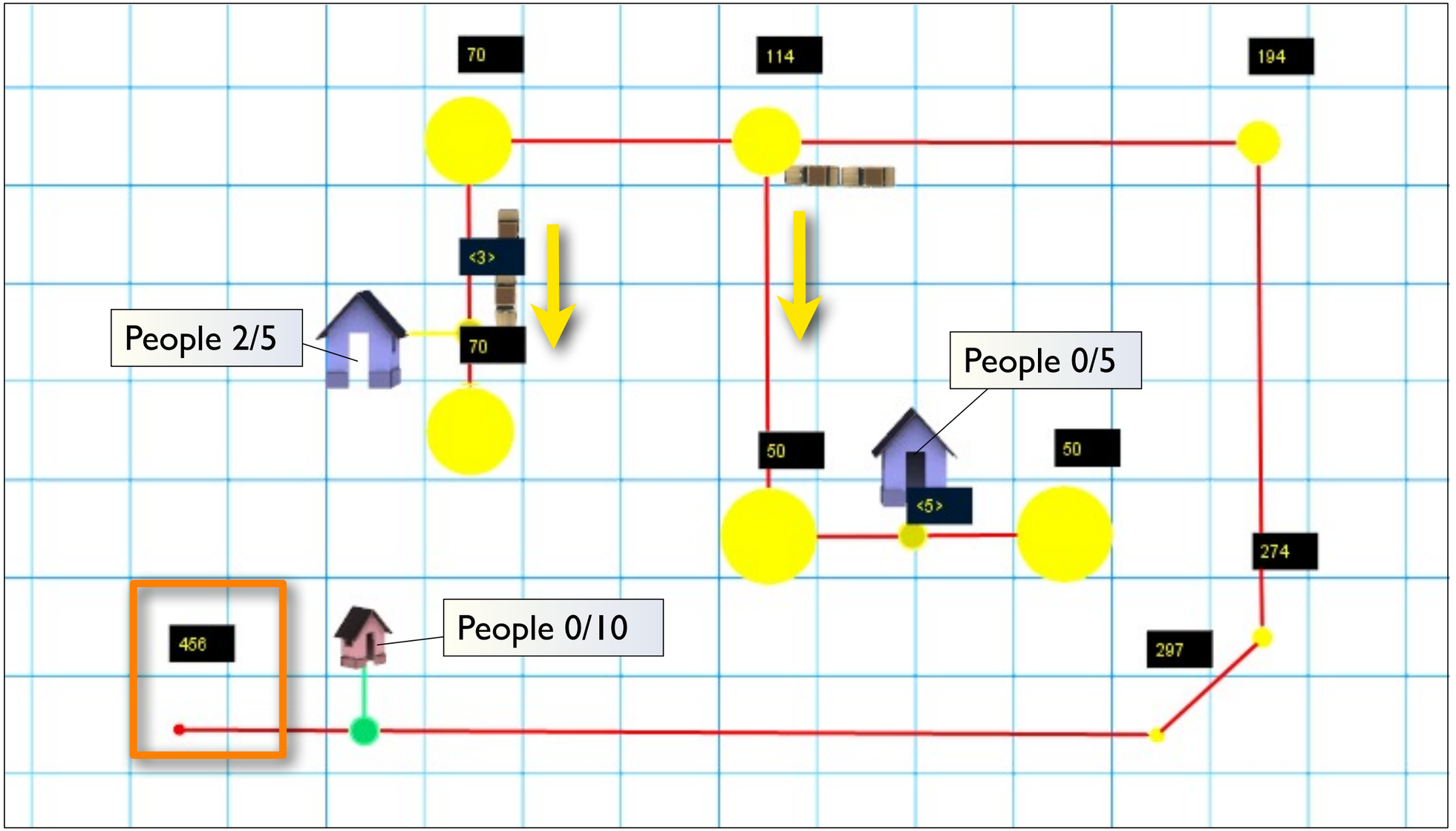

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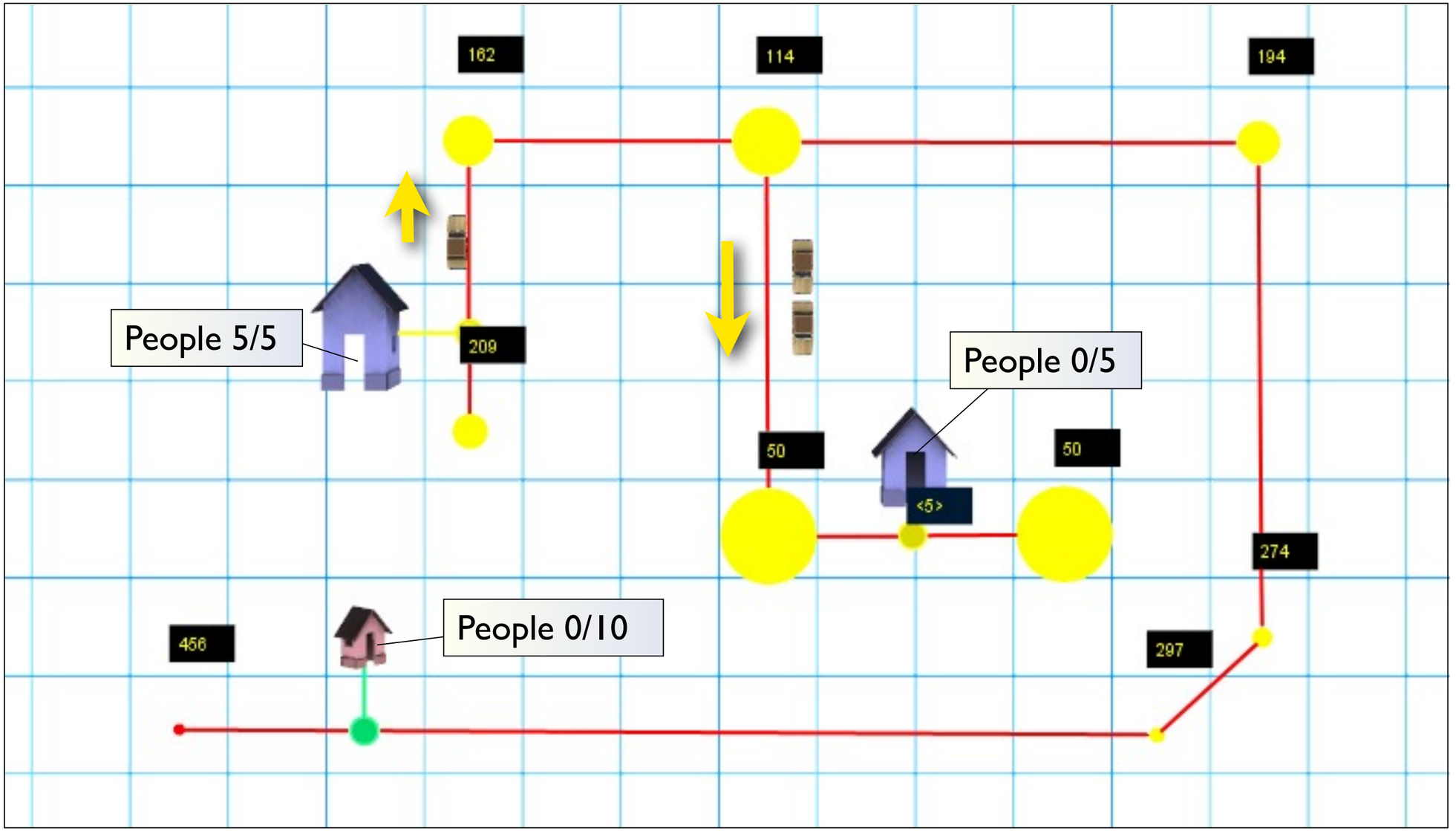

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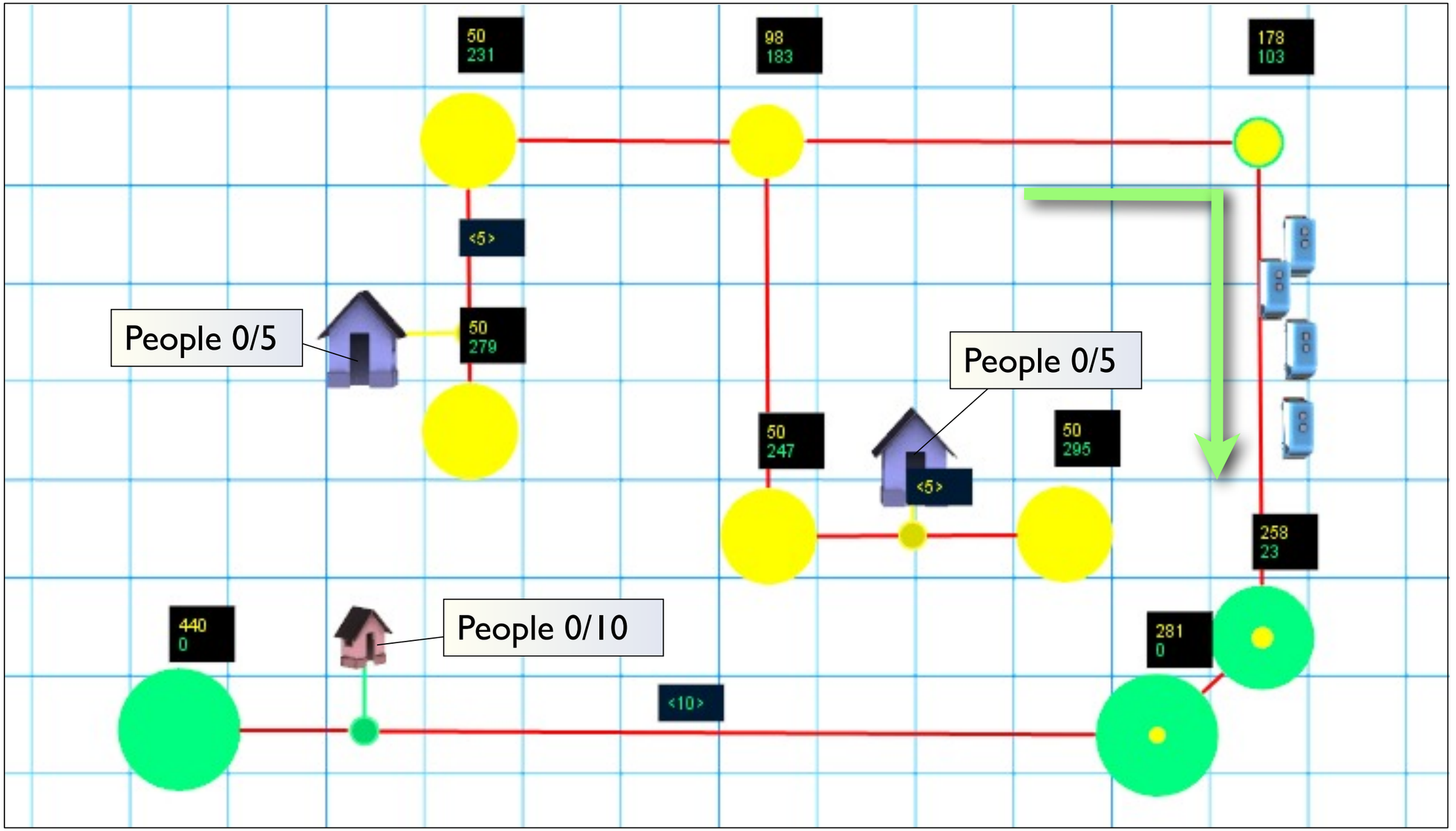

GlassBox Simulation

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

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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

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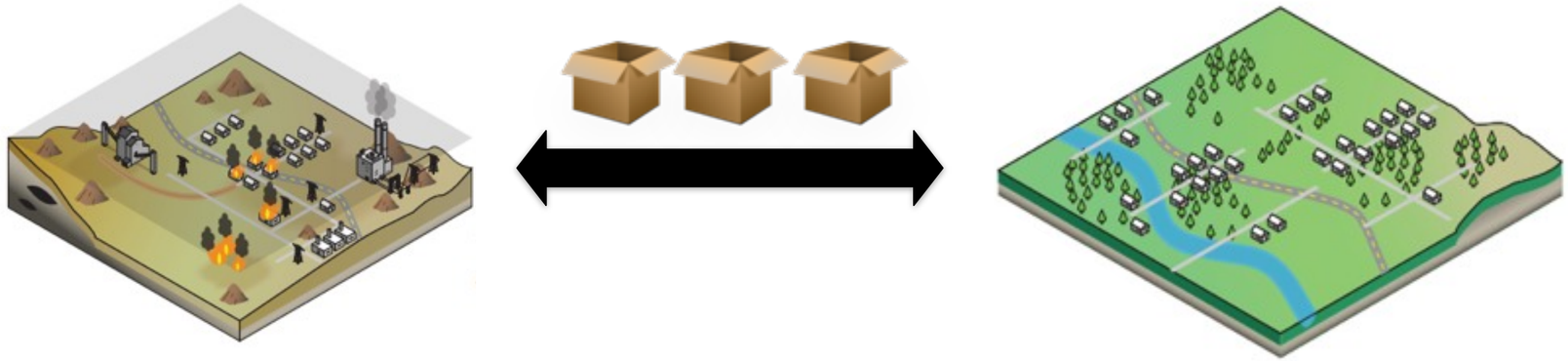
Multiplayer

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



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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.

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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

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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 **Y**ou **S**ee **I**s **W**hat **Y**ou **S**im

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Conclusion

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

- Now for SimCity...

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