Introduction to GAMA-platform
Toward a traffic model

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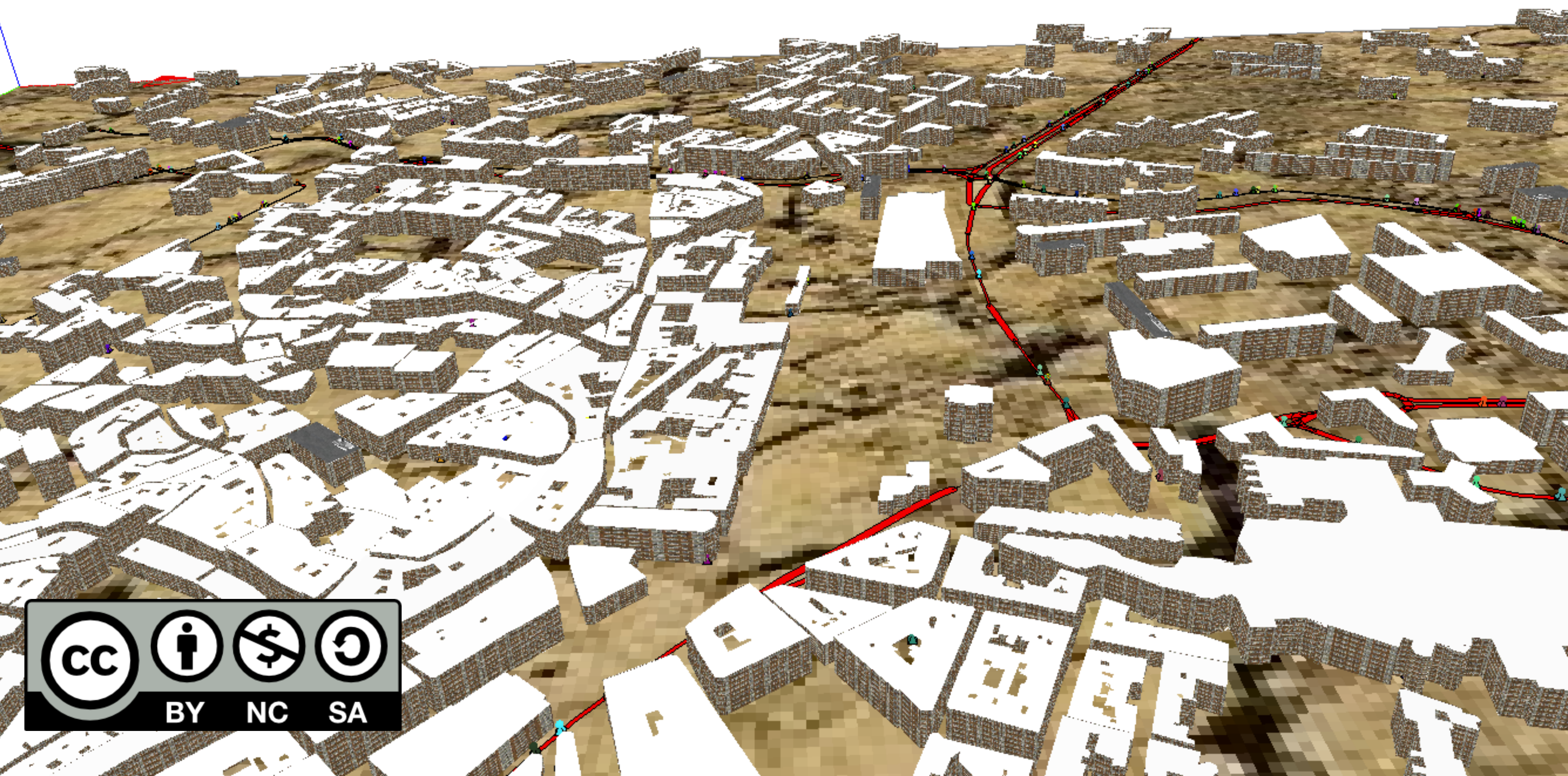
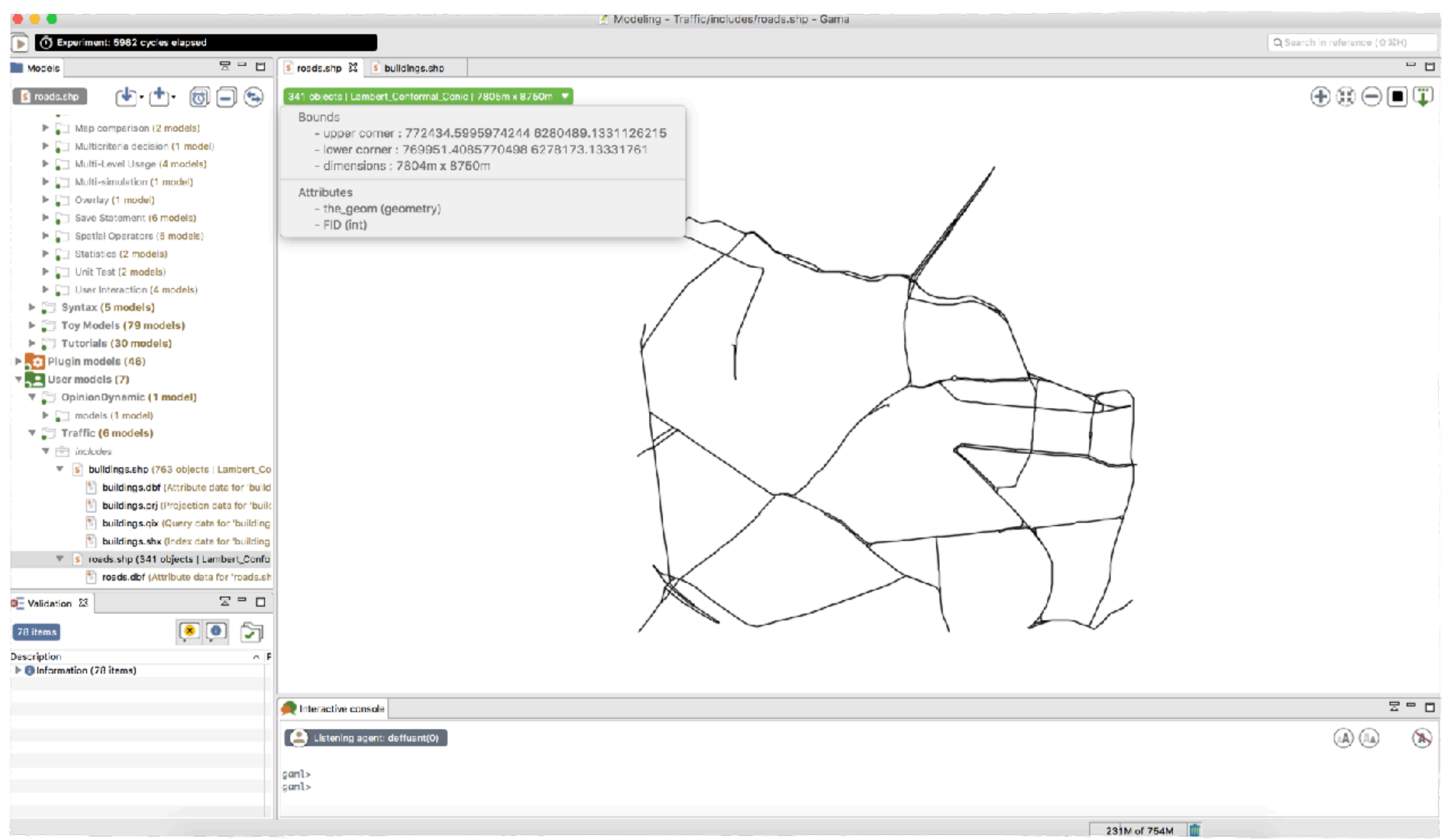
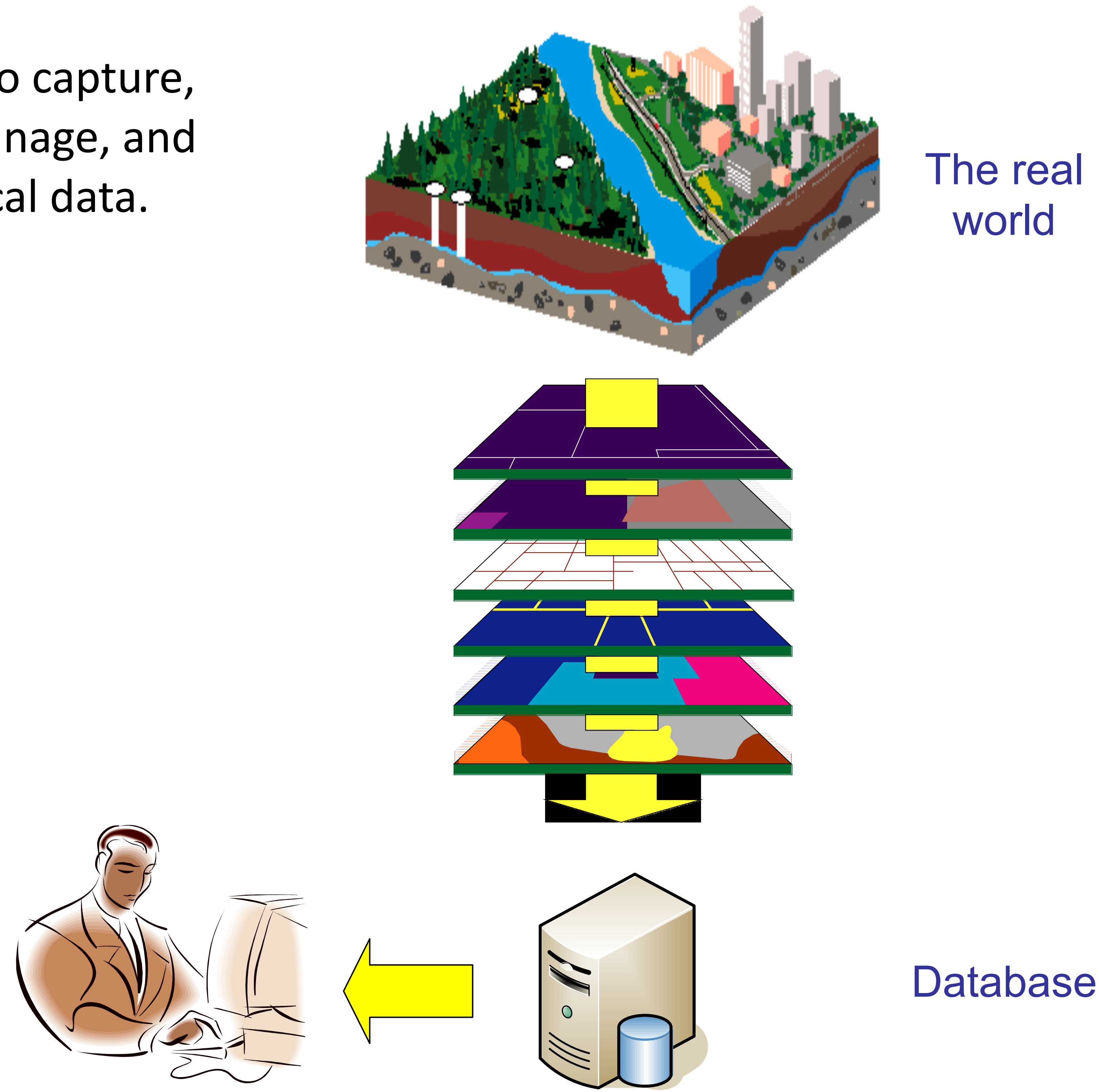


Introduction to GIS data and its management in GAMA



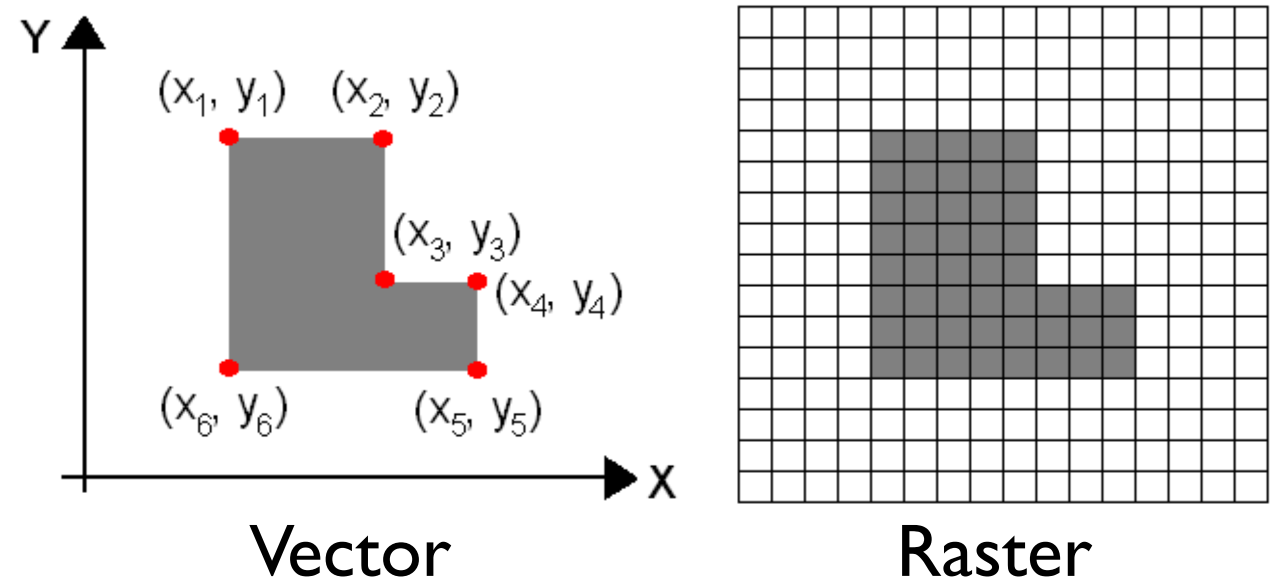
What are Geographic Information Systems (GIS)?

- A computer system designed to capture, store, manipulate, analyse, manage, and present all types of geographical data.

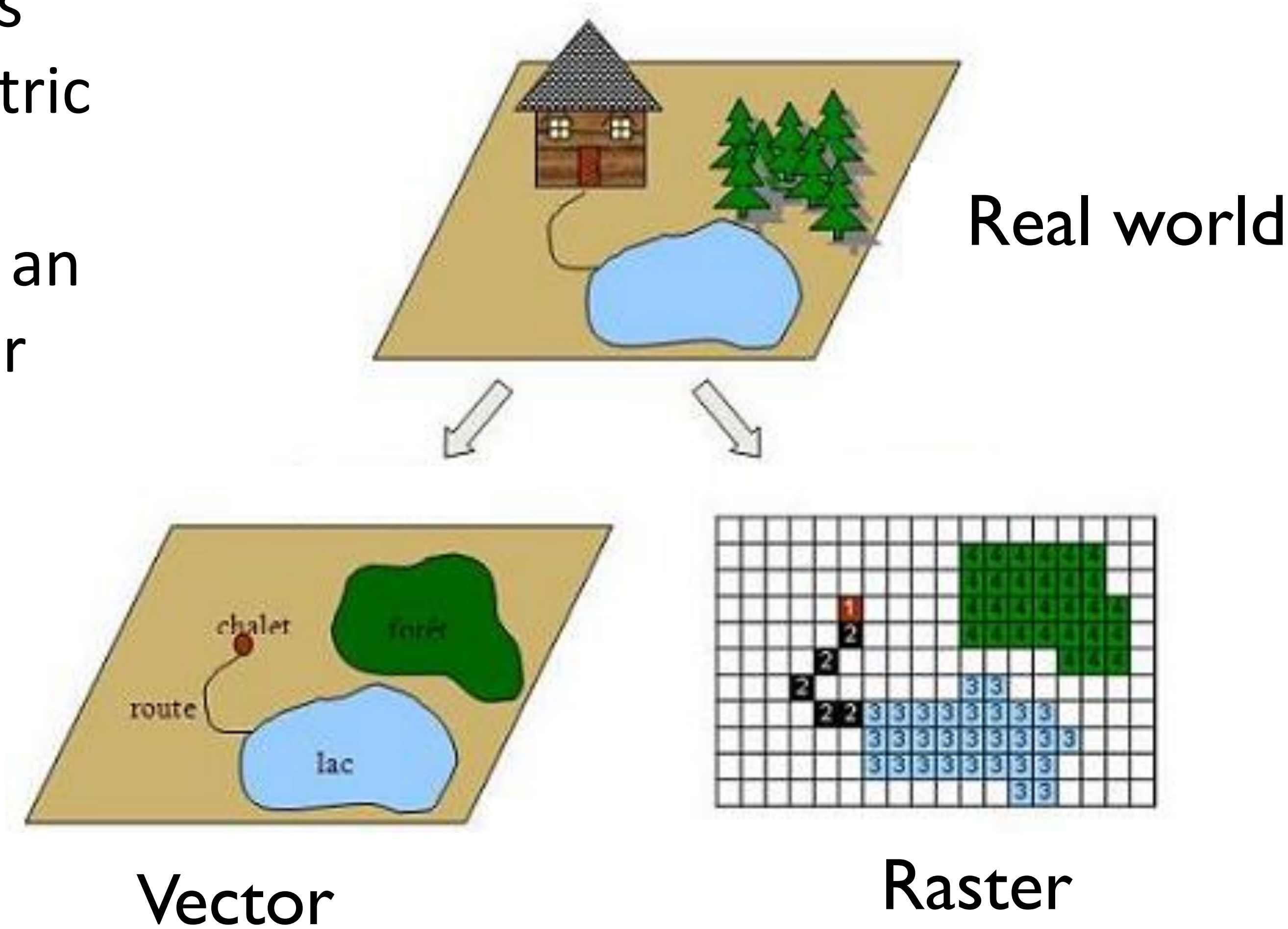


Representation of geographical data

- **Raster** (grid or image): A geographical phenomena is represented as a partition (in cells) of the geographical space. Each cell has one or several attributes that define its content.

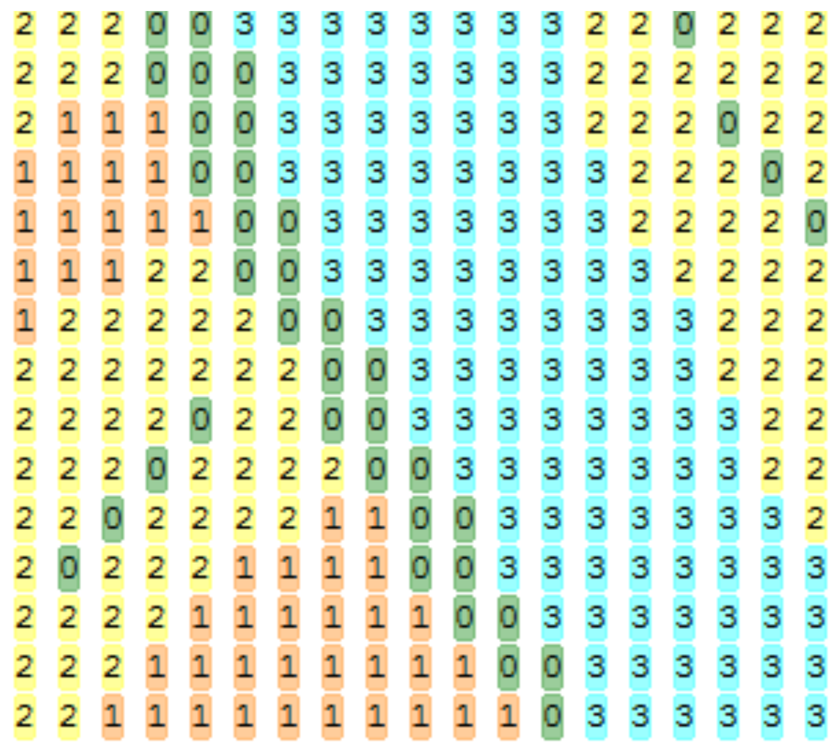


- **Vector**: A geographical phenomena is represented by one or several geometric primitives (point, line, polygons), described by a list of coordinates and an interpolation function. A classic vector format filed is the **shapefile**: it is composed of 4 main files: .shp, .dbf, .shx, .prj

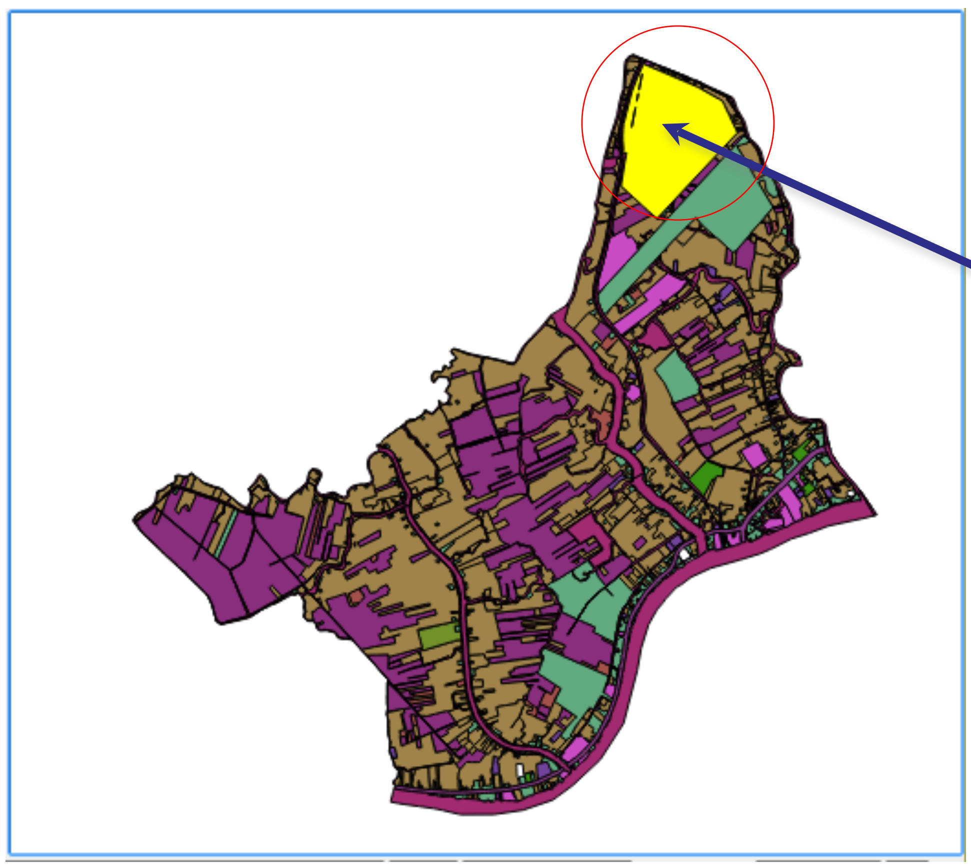


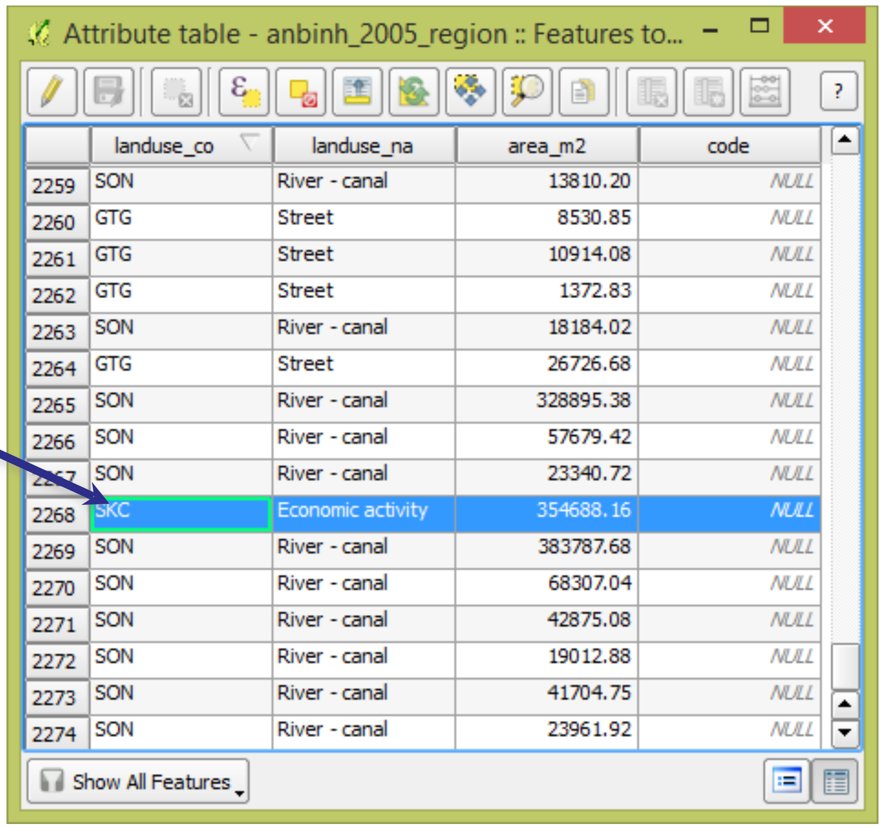
Attribute data – non spatial data

- In raster datasets, information associated with each unique value of a raster cell.
- In vector dataset, data stored in a table and linked to each object by a unique identifier



Attribute of a raster format

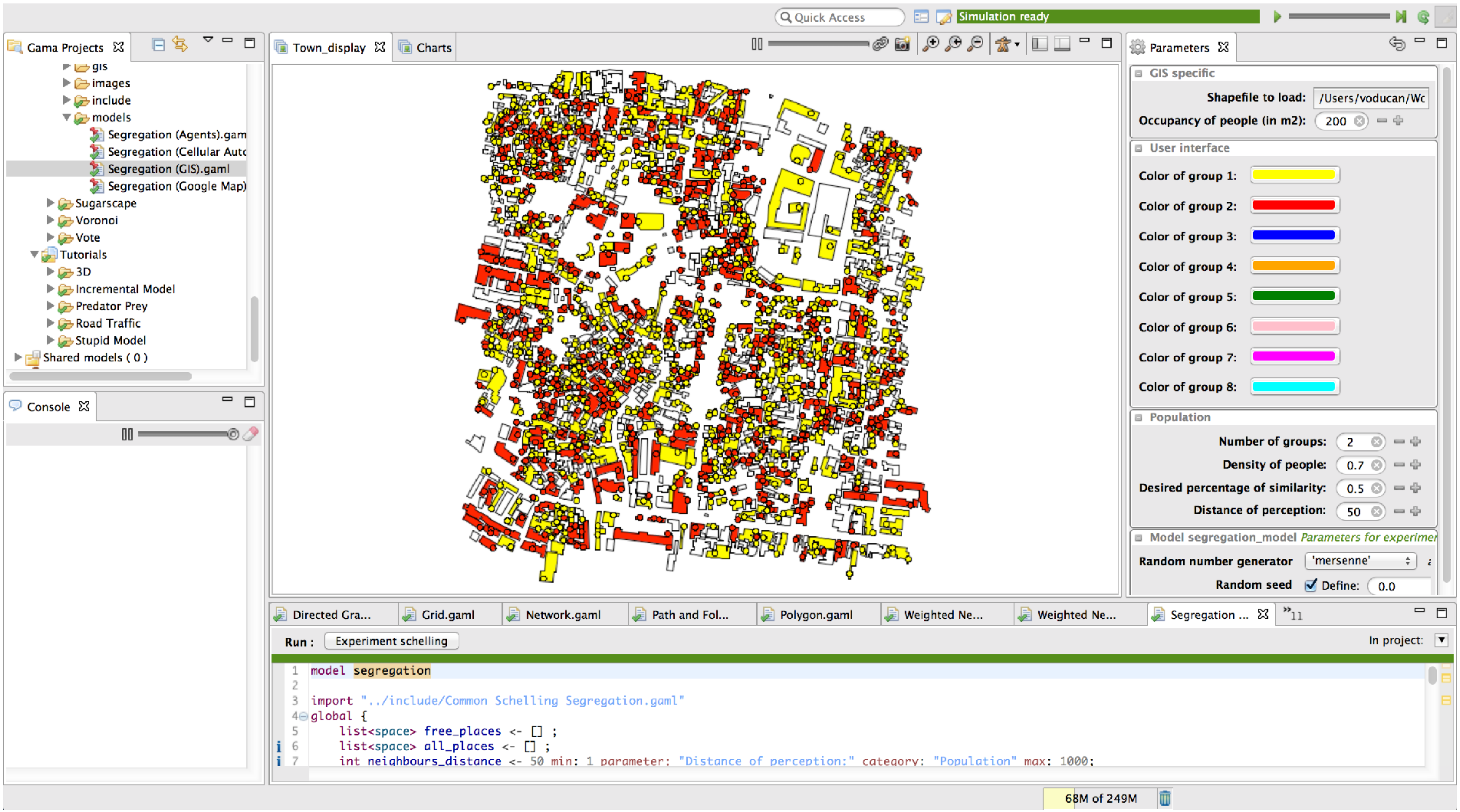




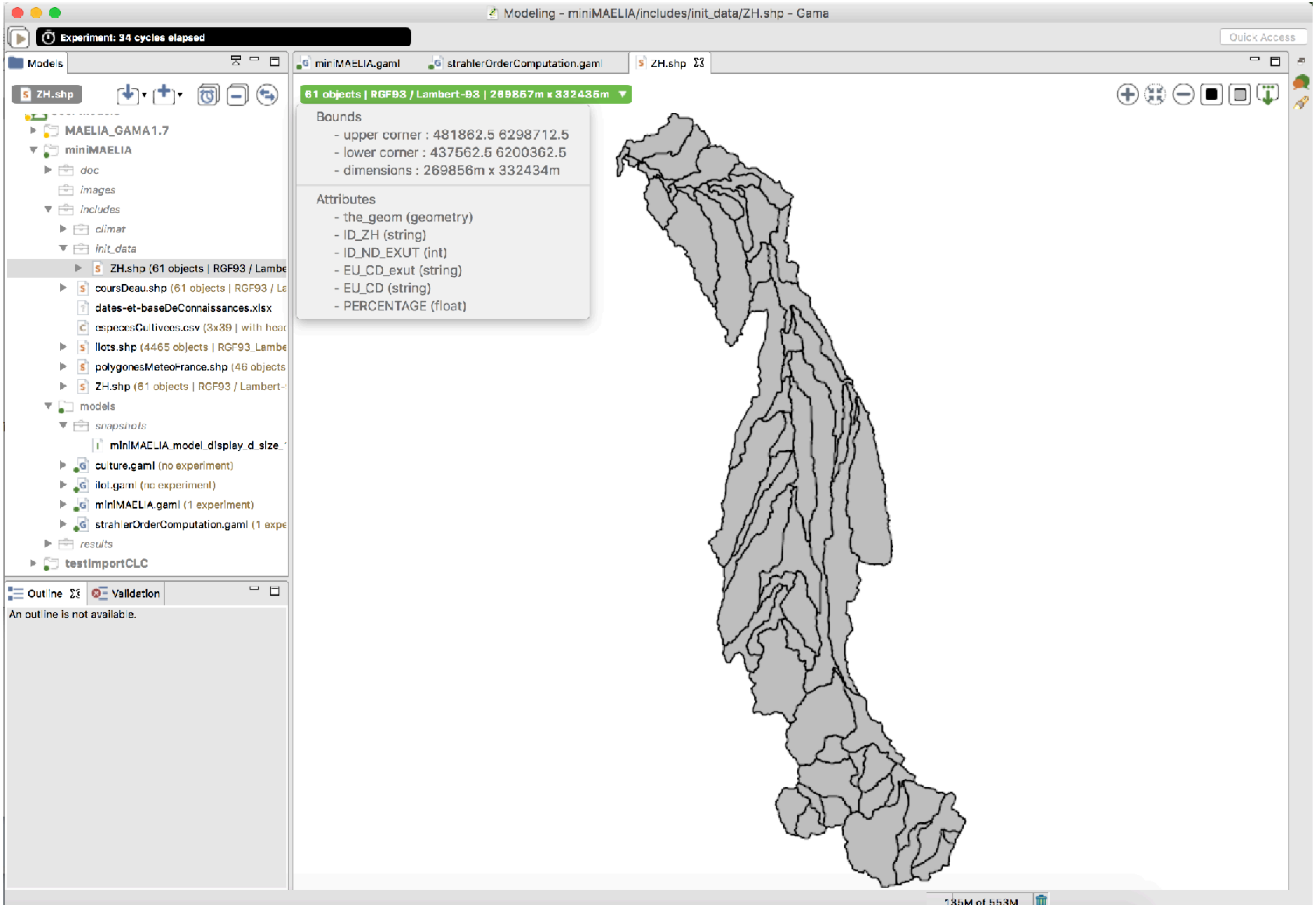
	landuse_co	landuse_na	area_m2	code
2259	SON	River - canal	13810.20	NULL
2260	GTG	Street	8530.85	NULL
2261	GTG	Street	10914.08	NULL
2262	GTG	Street	1372.83	NULL
2263	SON	River - canal	18184.02	NULL
2264	GTG	Street	26726.68	NULL
2265	SON	River - canal	328895.38	NULL
2266	SON	River - canal	57679.42	NULL
2267	SON	River - canal	23340.72	NULL
2268	SKC	Economic activity	354688.16	NULL
2269	SON	River - canal	383787.68	NULL
2270	SON	River - canal	68307.04	NULL
2271	SON	River - canal	42875.08	NULL
2272	SON	River - canal	19012.88	NULL
2273	SON	River - canal	41704.75	NULL
2274	SON	River - canal	23961.92	NULL

Attribute of vector format

GAMA provides many features to manage GIS data and vector geometries



GAMA allows modellers to display shape files and attributes information



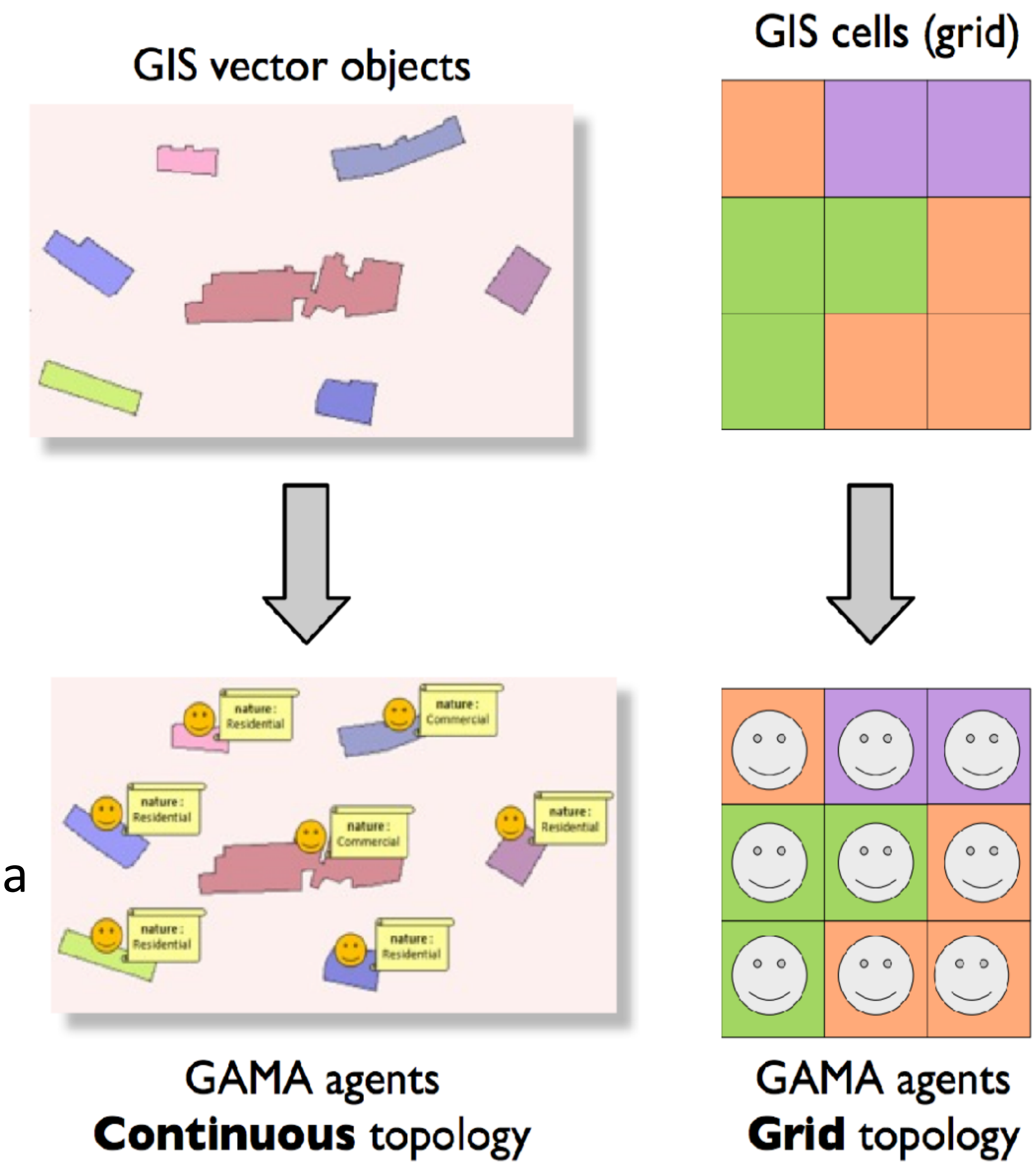
Every agent in GAMA has a geometry (its shape).

An agent's geometry can be:

- a **point** (default),
- a **polyline**,
- a **polygon** or
- a complex geometry (2D-3D)

An agent geometry is accessible through GAML thanks to the "shape" built-in attribute.

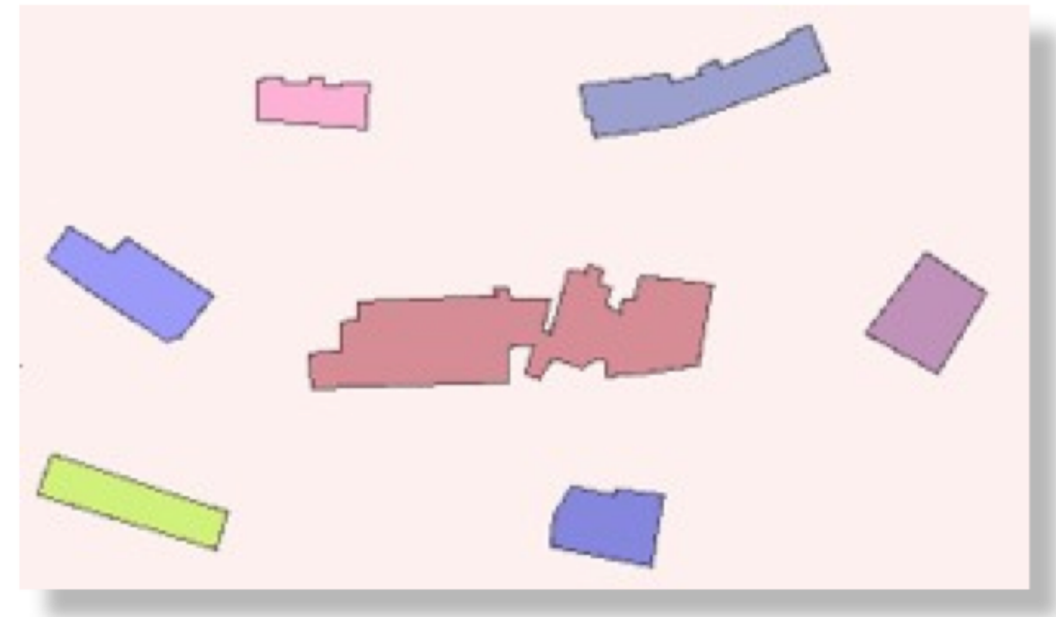
World agent (<<global>> species) have also a "shape" built-in attribute which define the shape of environment



Agents can be created directly from GIS shapefile

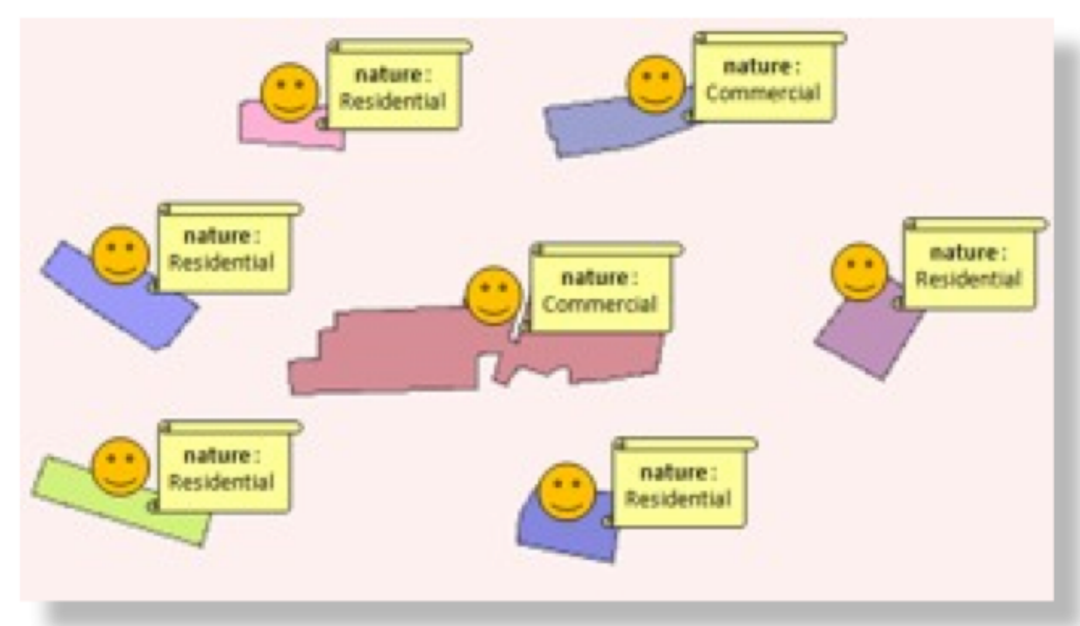
create my_species from: my_shapefile;

my_shapefile



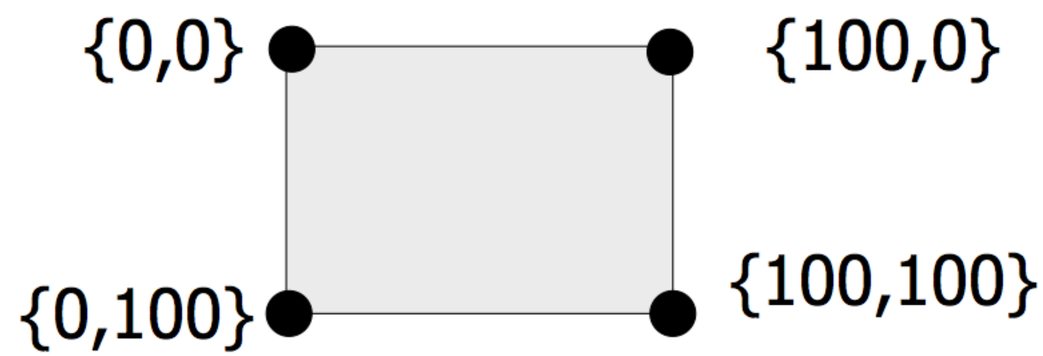
Each GIS object becomes an agent of the specified species

my_species



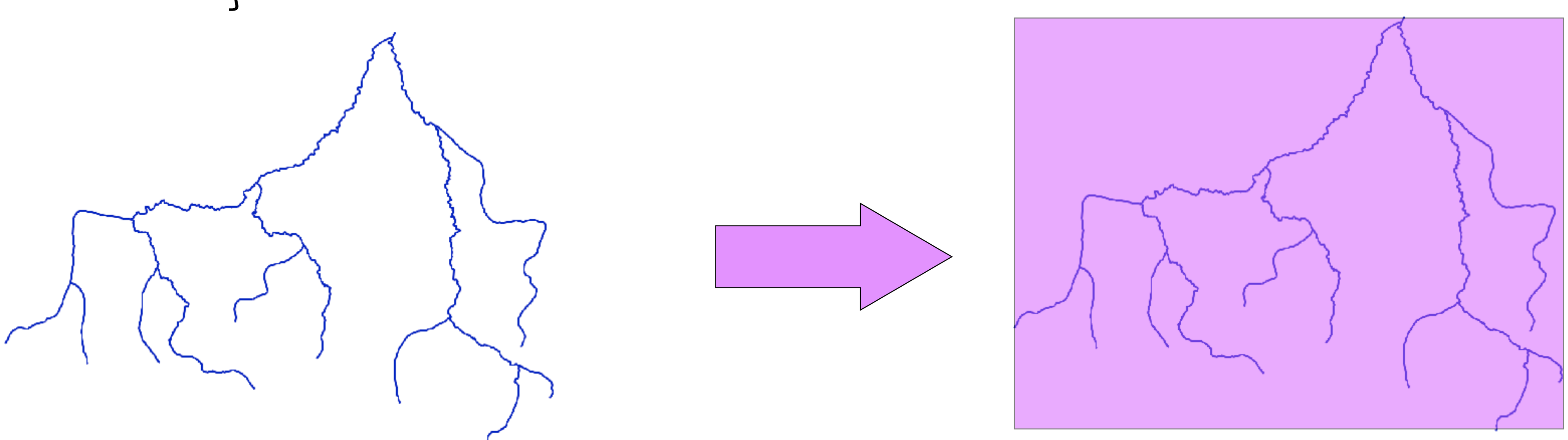
The shape of the “world” agent represents the global environment of a model

By default, a model global environment is a 2D square space of 100m x 100m



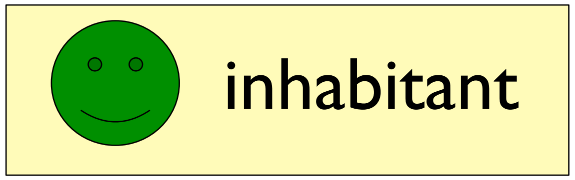
It is also possible to redefine the global environment using a shapefile or asc file.

```
global{
    file river_shapefile <- file("../includes/river.shp");
    geometry shape <- envelope(river_shapefile);
}
```



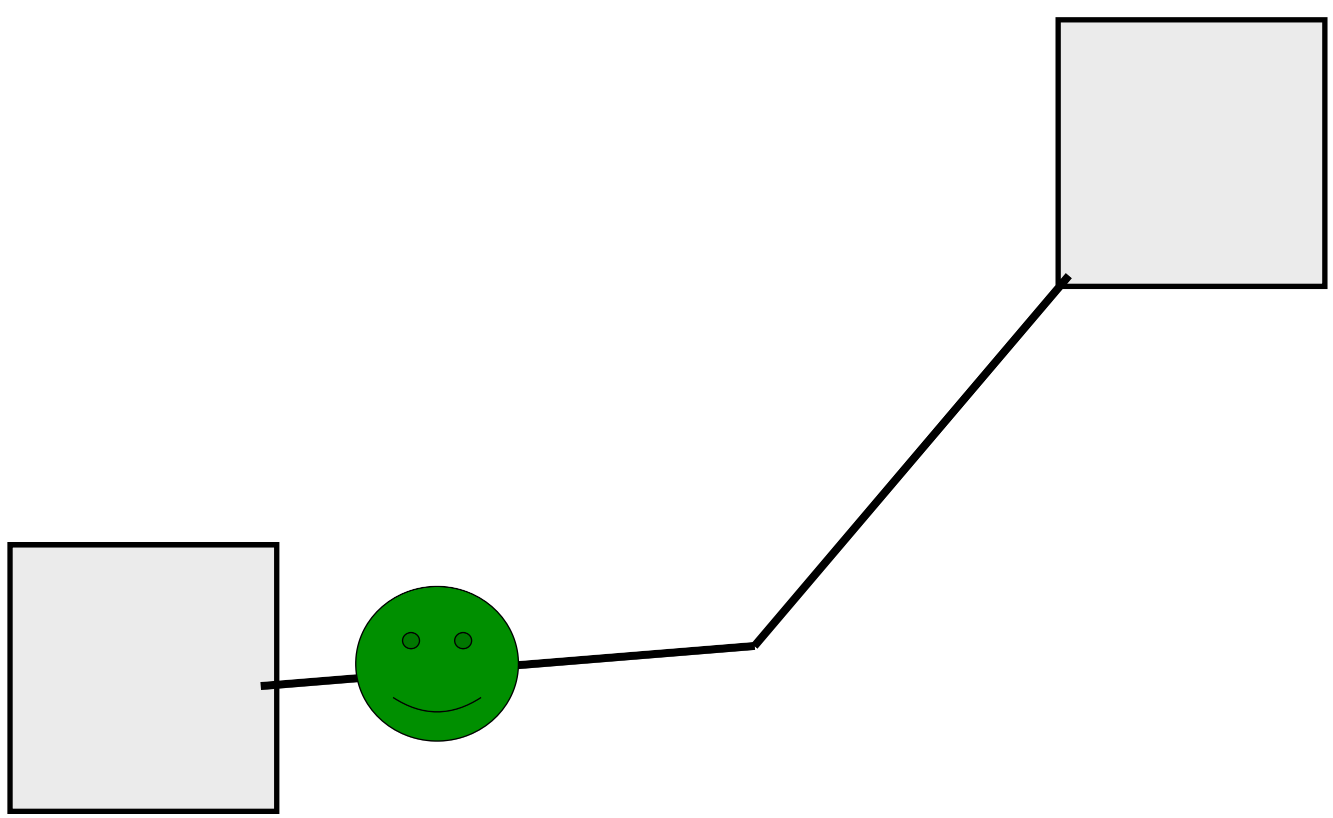
Environment

Introduction to a simple traffic simulation

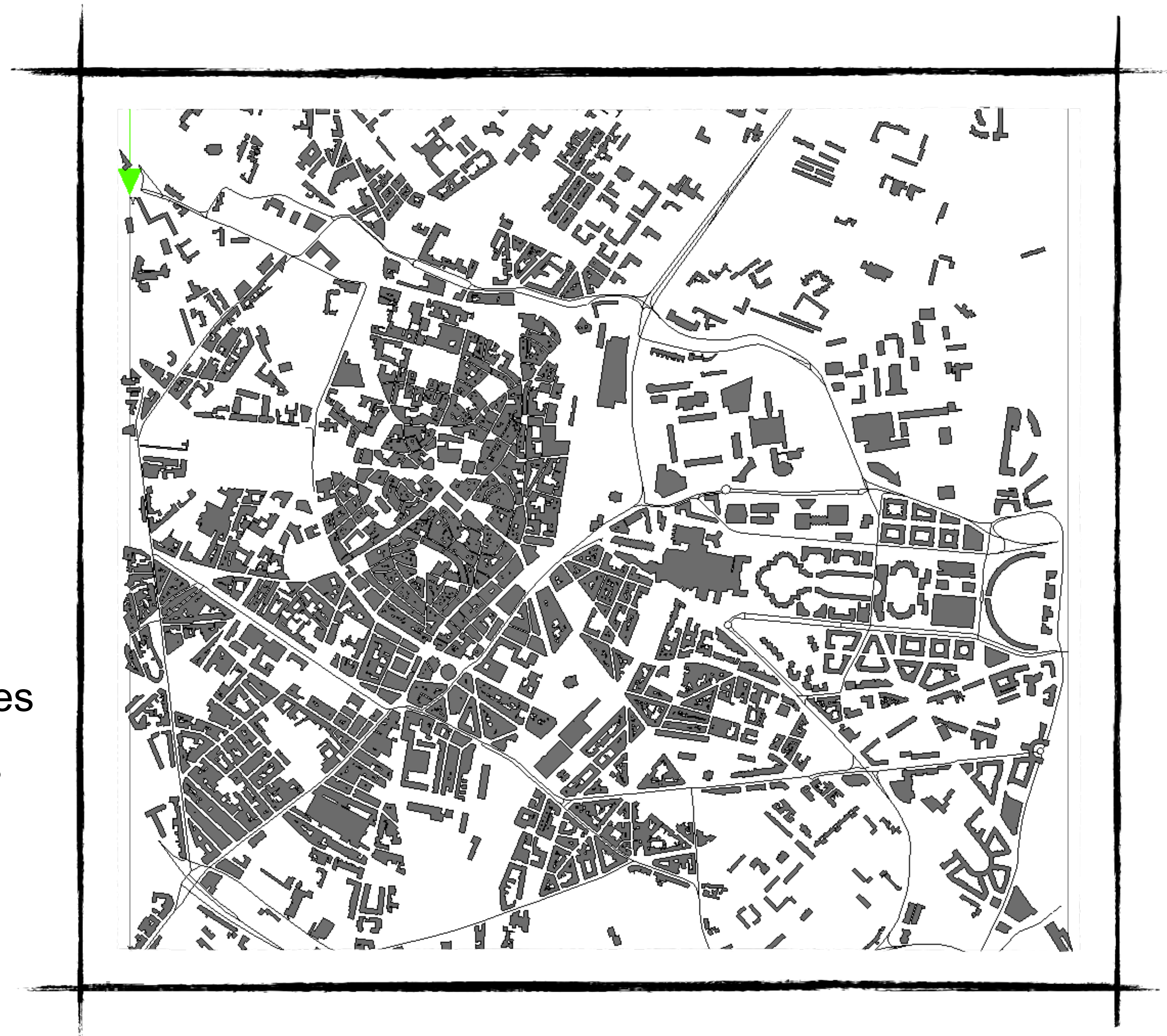


Inhabitants move from one building to another one on a road network.

In a building, they will stay for some time: at each simulation step, they have a probability to leave (`proba_leave`)



Step 1: definition of building and road agents



Objectives:

- Definition of building and road species
- Creation of building and road agents
- Display agents

Definition of the *building* species

```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

TO DO: define the *building* species, with an aspect called “geom” drawing the shape of the agent with a grey color.

Answer:

```
species building {
   aspect geom {
      draw shape color: #gray;
   }
}
```

The agent geometry is accessible get through the ***shape*** attribute.

Definition of the *road* species

```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

TO DO: define the *road* species, with an aspect called "geom" drawing the shape of the agent with a black color.

Answer:

```
species road {
   aspect geom {
      draw shape color: #black;
   }
}
```

We have defined the building and road species.
Next step: creation of the *building* and *road* agents !

Definition of the shape files

```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

TODO: define 2 new global variables (with the file type) getting as value the shape file of buildings (resp. roads). Use the last on to redefine the environment size.

Answer:

```
global {
    file shapefile_buildings <- file("../includes/buildings.shp");
    file shapefile_roads <- file("../includes/roads.shp");
    geometry shape <- envelope(shapefile_roads);
    ...
}
```

Environnement

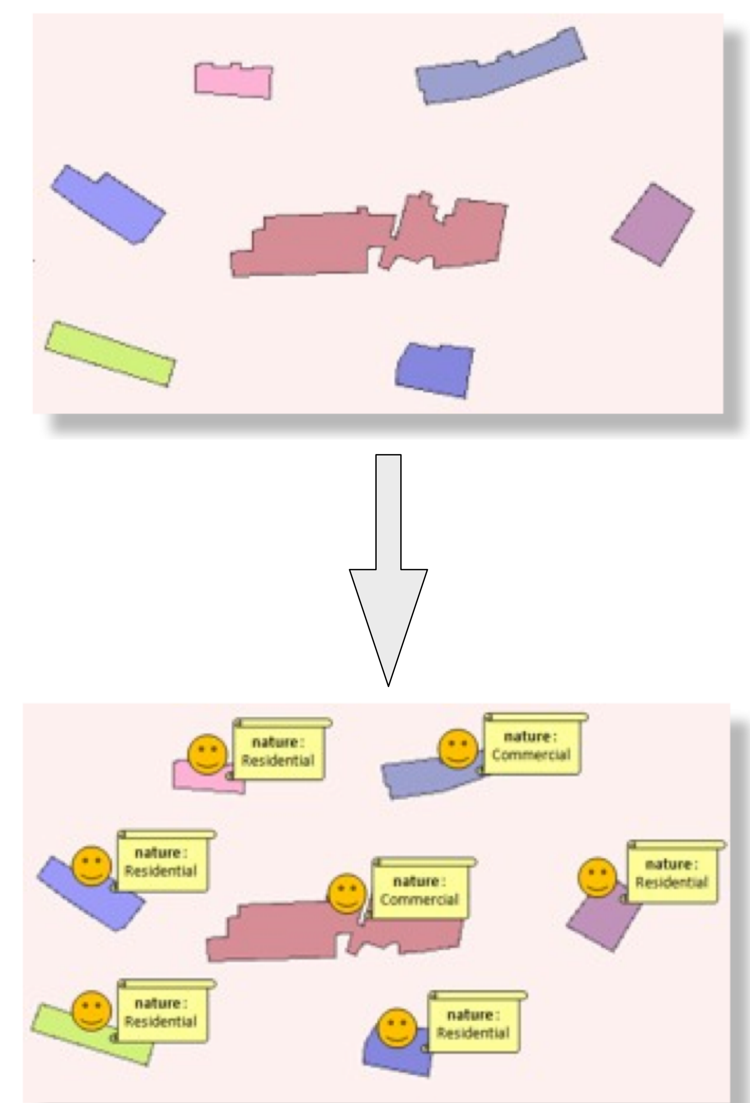
Creation of building and road agents

```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

TODO: define an *init* section (in the global) to create building and road agents from the 2 shapefiles.

Answer:

```
global {
   //variables
   init {
      create building from: shapefile_buildings;
      create road from: shapefile_roads;
   }
   ...
}
```



We have created building and road agents.
Next step: display them !

Display building and road agents

```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

TODO: add *building* and *road* agents in a display (named "map") with their aspect.

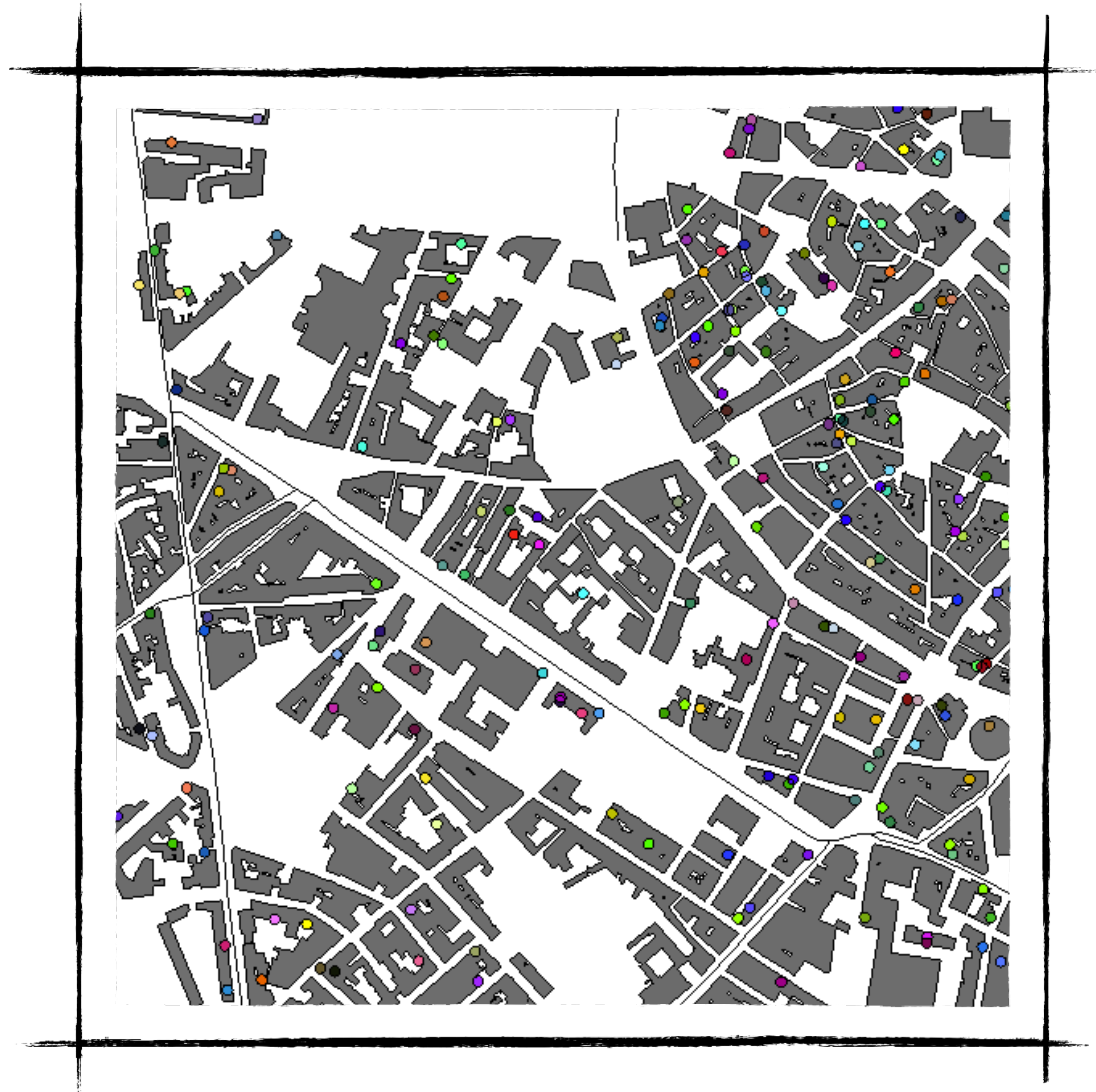
Answer:

```
experiment traffic type: gui {
    output {
        display map {
            species building aspect: geom refresh: false;
            species road aspect: geom;
        }
    }
}
```

End of step 1

We will define now the *inhabitant* species.

Step 2: definition of inhabitant agents



Objectives:

- Definition of the *inhabitant* species
- Creation of *inhabitant* agents
- Display agents

Definition of the inhabitant species

```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

TODO: define an *inhabitant* species with the moving skill and 3 attributes:

- *target* (type = point)
- *proba_leave* (type = float, init value= 0.05)
- *speed* (type = float, init value = 5 km/h)
- *color* (type = rgb, init value = random color)

Its aspect will be a circle (radius = 5m) with the color *color*.

Answer:

```
species inhabitant skills: [moving]{
    point target;
    rgb color <- rnd_color(255);
    float proba_leave <- 0.05;
    float speed <- 5 #km/#h;

    aspect circle {
        draw circle(5) color: color;
    }
}
```

A *skilll* is a plugin (written in Java) giving new variables and actions to agents.

With the *moving* skill, agents get new attributes (*speed*, *heading*, *destination*) and actions (*follow*, *goto*, *move*, *wander*) supplémentaires

the operator **rnd_color**(255) returns a random color

Creation of inhabitant agents

```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

TODO: create 1000 inhabitant agents and locate them in a building.

Answer:

```
global {
   //variables
   init {
      //creation of buildings and roads

      create inhabitant number: 1000{
         location <- any_location_in(one_of(building));
      }
   }
   ...
}
```

the operator **any_location_in(a_geometry)** returns a random location inside a geometry

Display of inhabitant agents

```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

TODO: add inhabitants to the map display with their circle display.

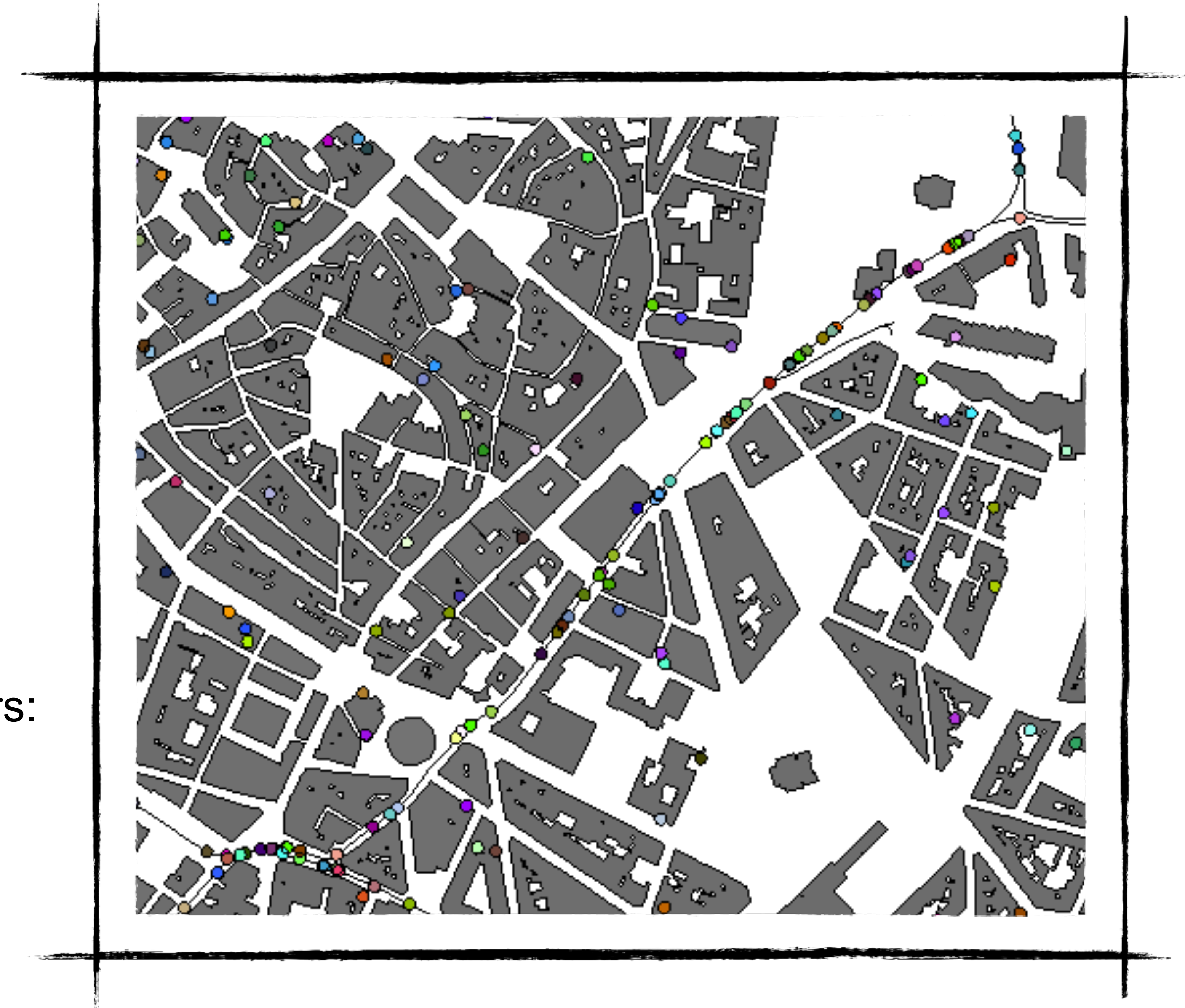
Answer:

```
experiment traffic type: gui {
    output {
        display map type: opengl{
            species building aspect: geom refresh: false;
            species road aspect: geom refresh: false;
            species inhabitant aspect: circle;
        }
    }
}
```

End of step 2

Now we will define inhabitant agents' behaviour.

Step 3: definition of inhabitant agents' behaviour



Objectives:

- Creation of the road network
- Creation of *inhabitant* agents' behaviours:
  - leave buildings
  - move on the graph

Definition of the road network

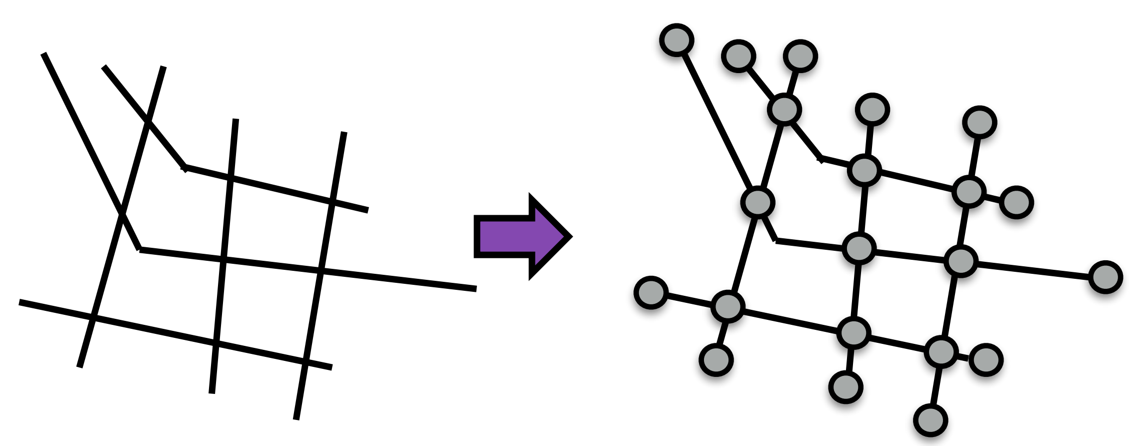
```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

TODO: define a new global variable road_network and initialise it in the global init block (with a graph created from the road agents).

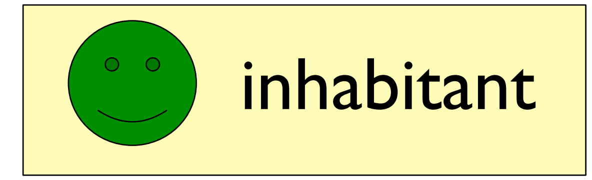
Answer:

```
global {
   // other variables
   graph road_network;

   init {
      create building from: shapefile_batiments;
      create road from: shapefile_routes;
      create inhabitant number: 1000{
         location <- any_location_in(one_of(building));
      }
      road_network <- as_edge_graph(road);
   }
}
```

The operator **as_edge_graph(***list of polylines***)** builds a graph from a list of polylines.



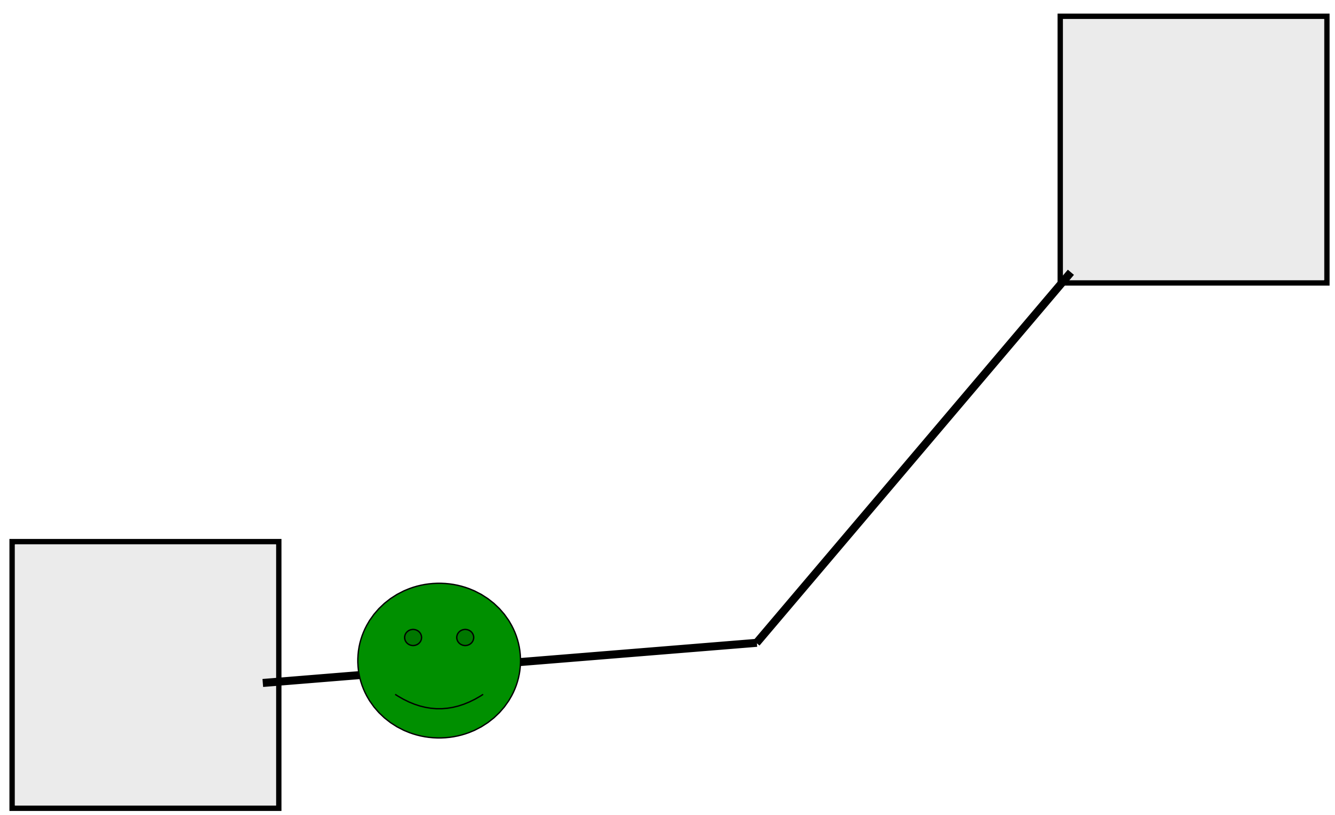
Inhabitant agents’ behaviour



Inhabitants move from one building to another one on a road network.

They move if and only if they have a target.

In a building, they will stay for some time: at each simulation step, they have a probability to leave (`proba_leave`)



inhabitant species: *leave* reflex

```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

TODO: define a new reflex (named leave) for inhabitant species:

- it is activated whether the agent does not have a target and given a probability *proba_leave*
- the agent chooses as new target a random location in a random building

Answer:

```
species inhabitant skills: [moving]{
    //definition of variables

    reflex leave when: (target = nil) and (flip(proba_leave)) {
        target <- any_location_in(one_of(building));
    }

    //aspect
}
```

inhabitant species: *move* reflex

```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

TODO: define a new reflex (named *move*) for the *inhabitant* species:

- activated when the agent has a target
- the agent moves on the network toward its target
- when it reaches its target, it drops its target.

Answer:

```
species inhabitant skills: [moving]{
    //definition of variables and reflex

    reflex move when: target != nil {
        do goto target: target on: road_network;
        if (location = target) {
            target <- nil;
        }
    }
    //aspect
}
```

The **goto** action can only be used by inhabitant agents because they have the moving skill.

The **goto** action takes into account the ***speed*** built-in inhabitant variable and the ***step*** global variable.

Modification of the simulation step duration

Remark: agents move very slowly (more precisely, in 1 simulation step, they move on a short distance)

TODO: set the duration of 1 simulation step to 10 seconds.

Answer:

```
global {
   //definition of global variables
   float step <- 1#mn;
   ...
}
```

```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

The symbol # can also be used for units (e.g. **#min**, **#m**, **#h** …)

step is a global built-in variable that represents the duration of 1 simulation step (default value = 1 s)

Similarly **cycle** is a global built-in variable that contains the number steps for the simulation beginning.

End of step 3

Now let take congestion into account!

Step 4: introduction of congestion

Objectives:

- Make the roads “aware” of the state in terms of congestion

- Addition of a new reflex to update speed on roads

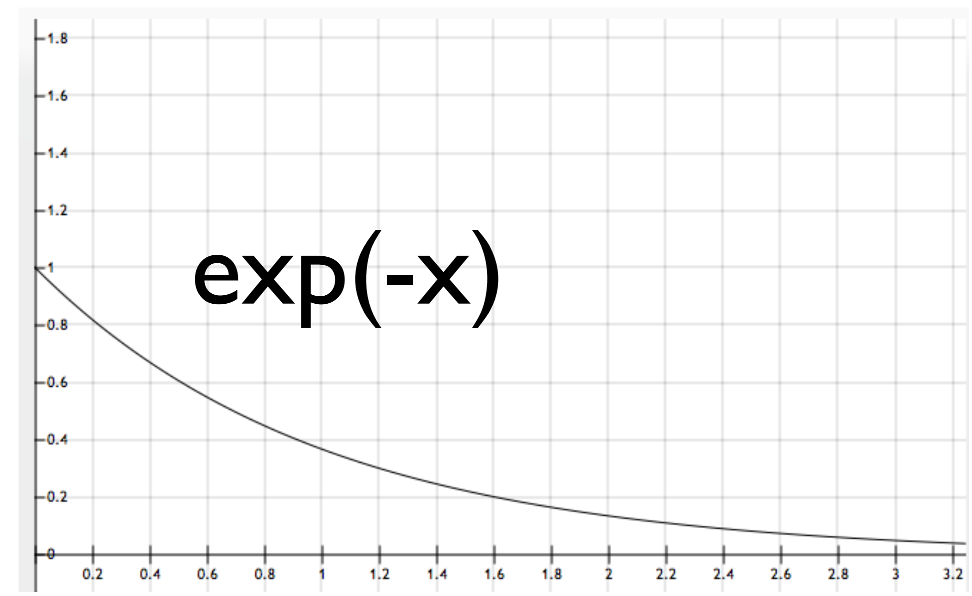
road species: new dynamic variables

```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

TODO: define 3 new dynamic variables for road agents

- capacity (type = float, init value = 1 + road perimeter/30.0)
- nb_drivers (type = int, update = number of inhabitants at a distance of 1 #m)
- speed_rate (type = float, update = exp(-nb_drivers/ capacity)

Modify the geom aspect in order to add a buffer of size 3* speed_rate around the geometry and change its color in red.



Answer:

```
species road {
    float capacity <- 1 + shape.perimeter/30;
    int nb_drivers <- 0 update: length(inhabitant at_distance 1);
    float speed_rate <- 1.0 update:  exp(-nb_drivers/capacity);
    aspect geom {
        draw (shape + 3 * speed_rate) color: #red;
    }
}
```

global block: definition of the *update_speed* reflex

```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

TODO: define a new global reflex (update_speed) that associates to each road a weight (function of the speed_rate) in a map data structure. It then updates the weight of the graph edge with this map.

Answer:

```
global {
    //variables and init
    reflex update_speed {
        map<road,float> new_weights <- road as_map (each::each.shape.perimeter * each.speed_rate);
        road_network <- road_network with_weights new_weights;
    }
}
```

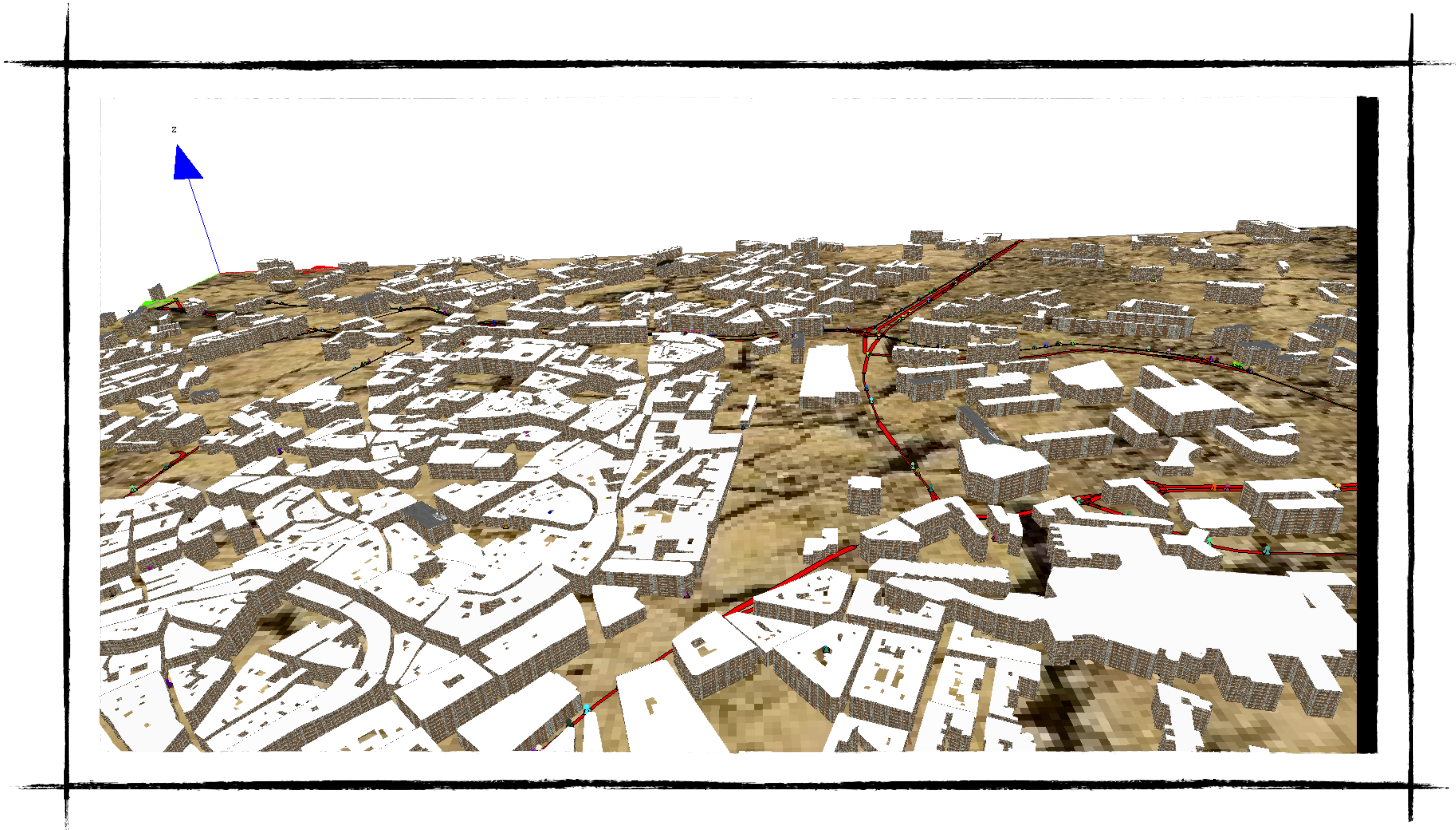
End of step 4

Now, let's have a nice visualisation.

Step 5: definition of a 3D display

Objectives:

- Definition of 3D aspects for building and inhabitant agents

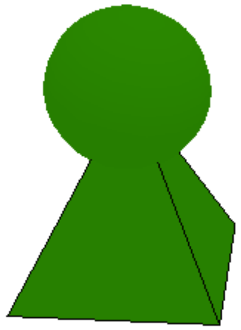


inhabitant species: aspect threeD

```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

TODO: define a new threeD aspect that:

- draw a pyramid with a height of 5m and a color color
- draw a sphere (with a radius of 2m) at a height of 5m and with a color color.



Answer:

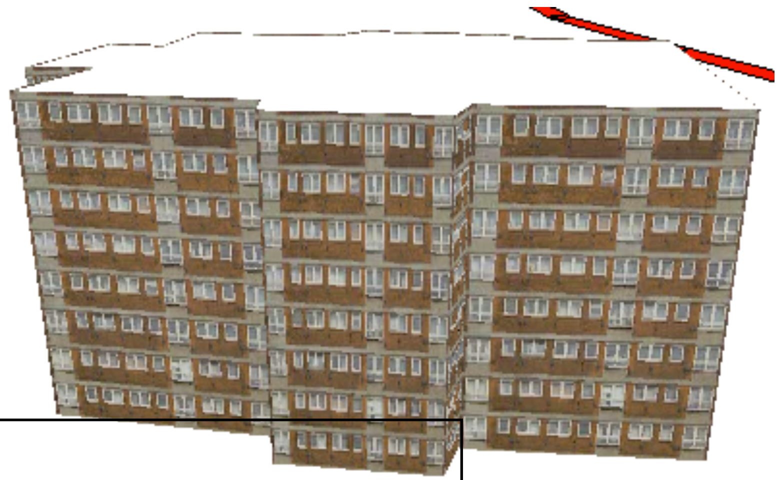
```
species inhabitant skills: [moving]{
    //definition of the variables, reflex and aspect

    aspect threeD{
        draw pyramid(5) color: color;
        draw sphere(2) at: location + {0,0,5} color: color;
    }
}
```

building species: improve the display

```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

TODO:

- add a height variable (type = int) to the building species, with a value read from the shapefile.
- add a new aspect (threeD) drawing the shape of the building with a height (height) and a texture.



Answer:

```
global {
    init {
        create building from: shapefile_buildings with:[height::int(read("height"))];
```

read attribute value and store it into an attribute.

```
species building {
    int height;
    aspect threeD {
        draw shape color: #gray depth: height texture: ["../includes/roof_top.png","../
includes/texture5.jpg"];
    }
}
```

Display of the agents

```
model my_model

global {
}

species my_species {
}

experiment my_model type: gui {
}
```

TODO: Add in the map display a background picture and modify the aspect of building and inhabitants (using threeD).
Use the *opengl* mode for the display.

Answer:

The use of **type: opengl** is mandatory to display 3D in a **display**.
It can also be used for 2D simulation (and often makes the zoom in/out smoother)

```
experiment traffic type: gui {
    output {
        display map type: opengl{
            image "../includes/soil.jpg" refresh: false;
            species building aspect: threeD refresh: false;
            species road aspect: geom ;
            species inhabitant aspect: threeD;
        }
    }
}
```

End of step 5