# A Constraint Based System to Populate Procedurally Modeled Cities with Buildings




Johannes Scharl

Supervisor: Daniel Scherzer

Institute of Computer Graphics and Algorithms

**Vienna University of Technology**

# Motivation

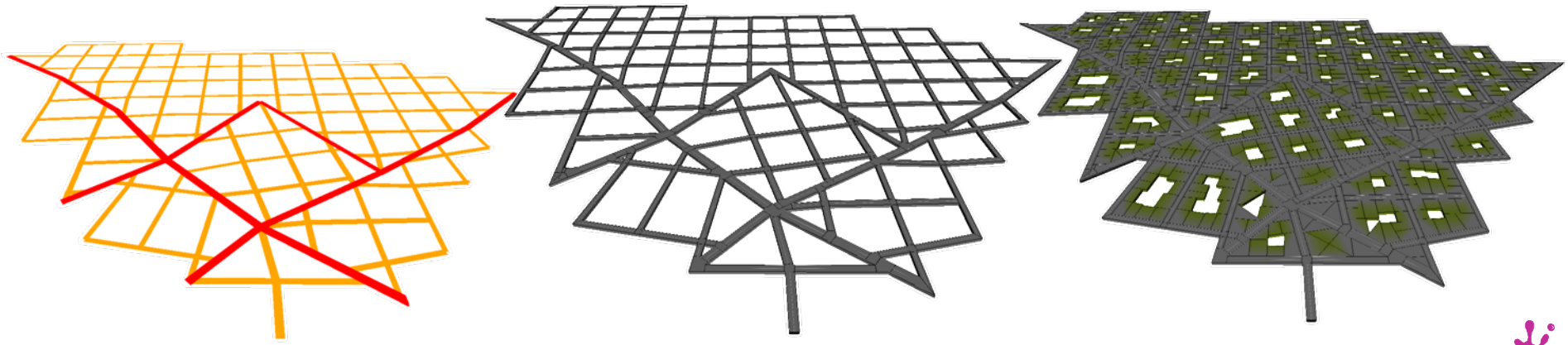
- Results of my ongoing master thesis
- A tool/framework that helps artists and designers to plan and create urban environments and cities for interactive applications

# Motivation

- Modern games: highly detailed environments
- Typically modeled in 3DS Max, Maya
- Very time-consuming task
- Many revisions and changes

# Basic Ideas

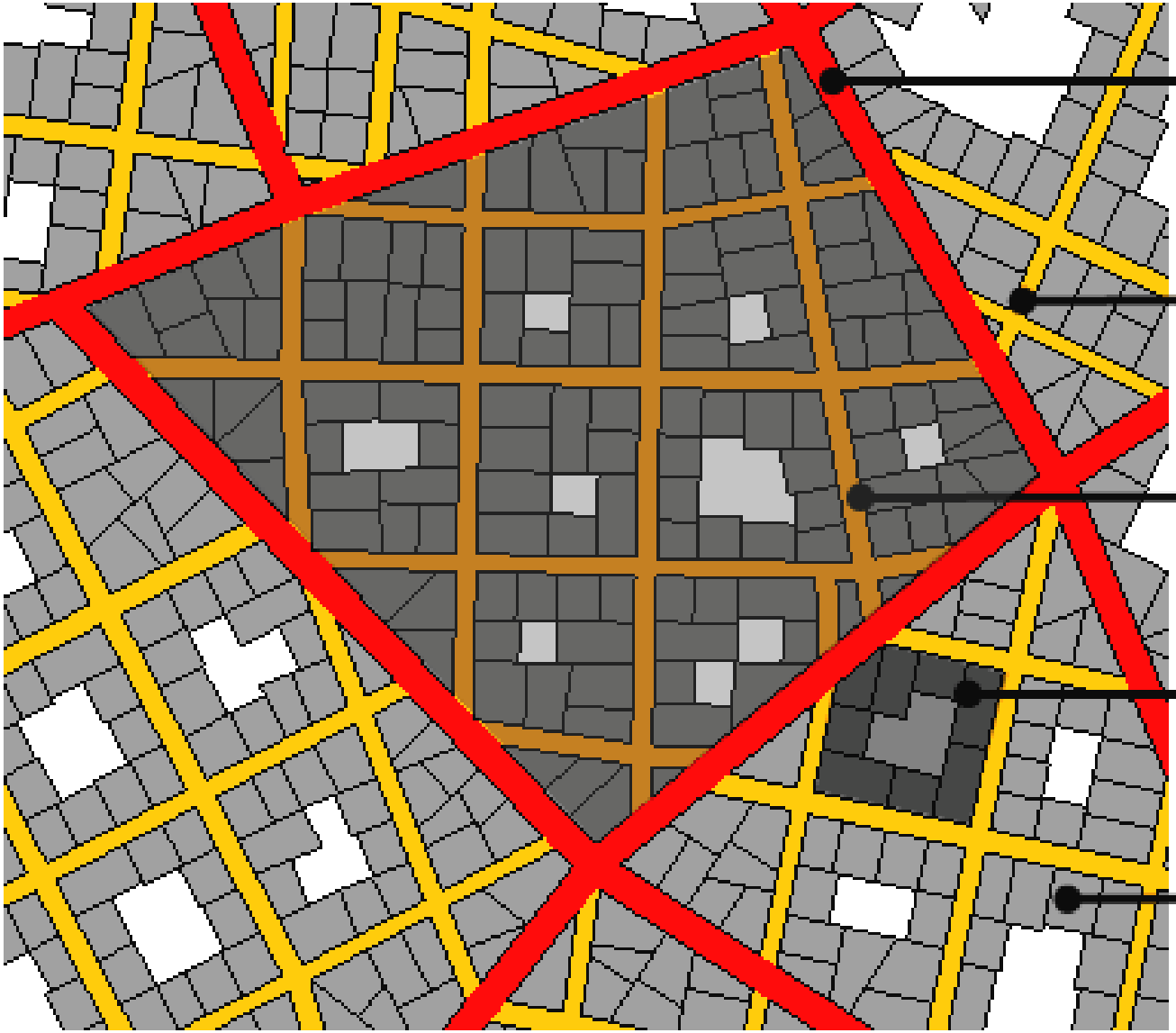
- => Create and edit parts of the environment procedurally to simplify development!
- Create street network using L-Systems
- Tessellate network to create street geometry
- Subdivide blocks to get building parcels



# Basic Ideas

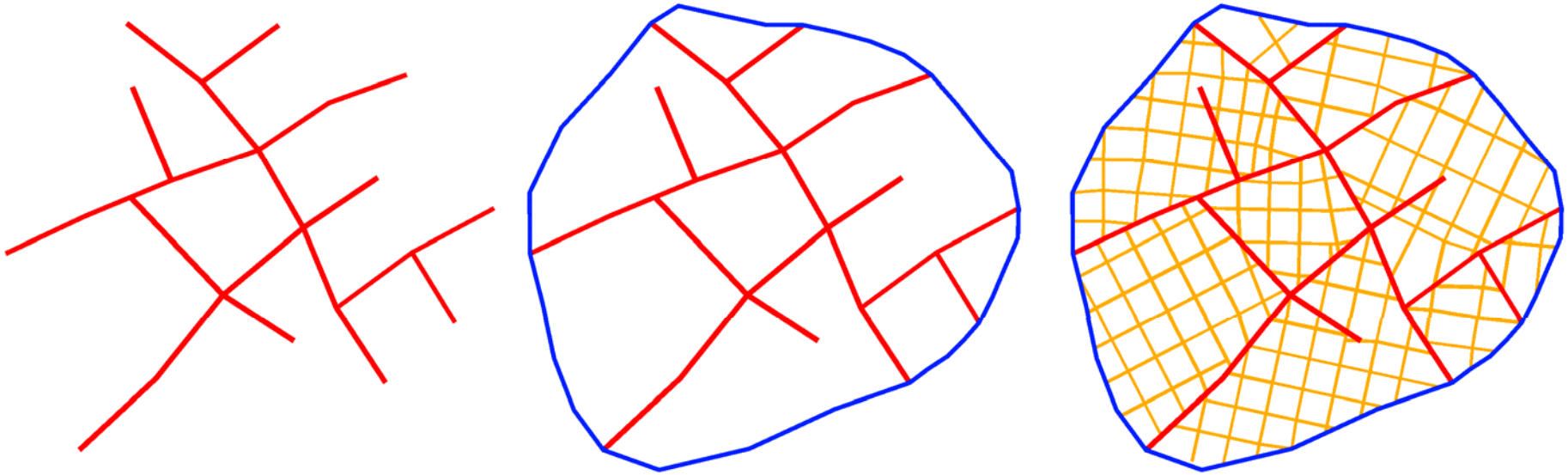
- Assign buildings to parcels

# City Hierarchy



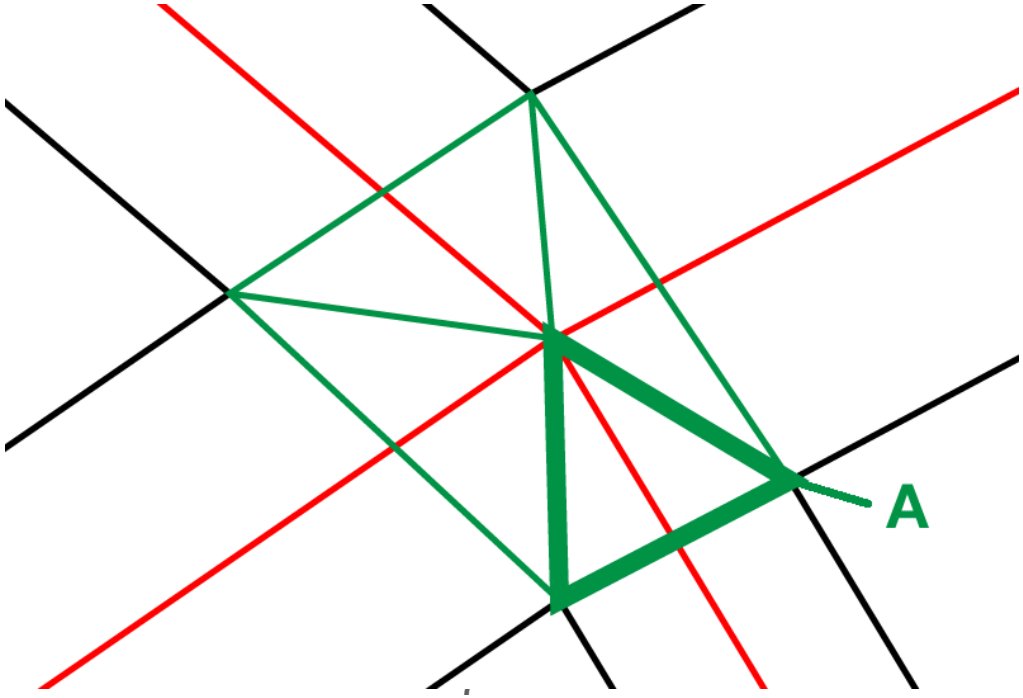
# Creating the Street Network

- Extended L-Systems [Parish et. al.]
- Control maps and parameters: (Terrain, obstacles, population density, street patterns…)
- Major roads created first
- Convex, widened hull to create city shape
- Minor streets created inside quarters



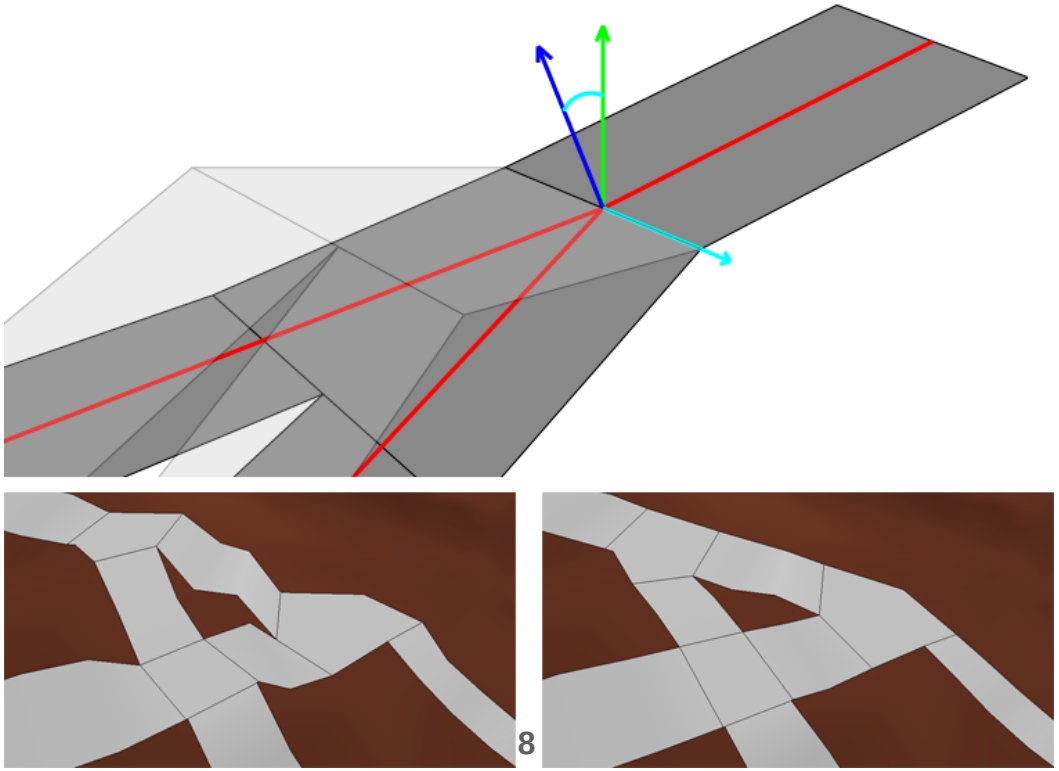
# Tesselating the Street Geometry

- Junctions may connect 2, 3, 4, ..., n street segments
- Offsetting from street centerline
- Junctions assembled by street heads→

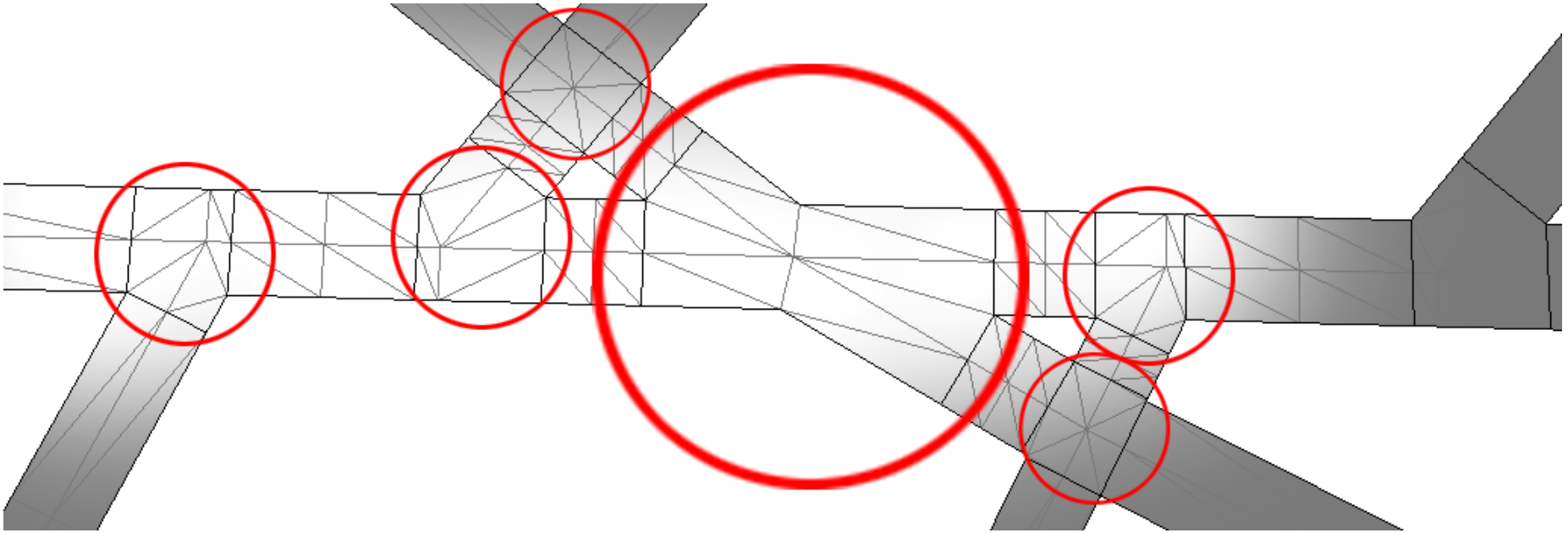


# Geometry Displacement for 3D Streets

- Problem: Junction geometry must be in a single plane
  - If flat: unrealistic steps and extreme slopes
  - Rotate junction into tangent plane of terrain



# Street Geometry Results



# Parcel Generation

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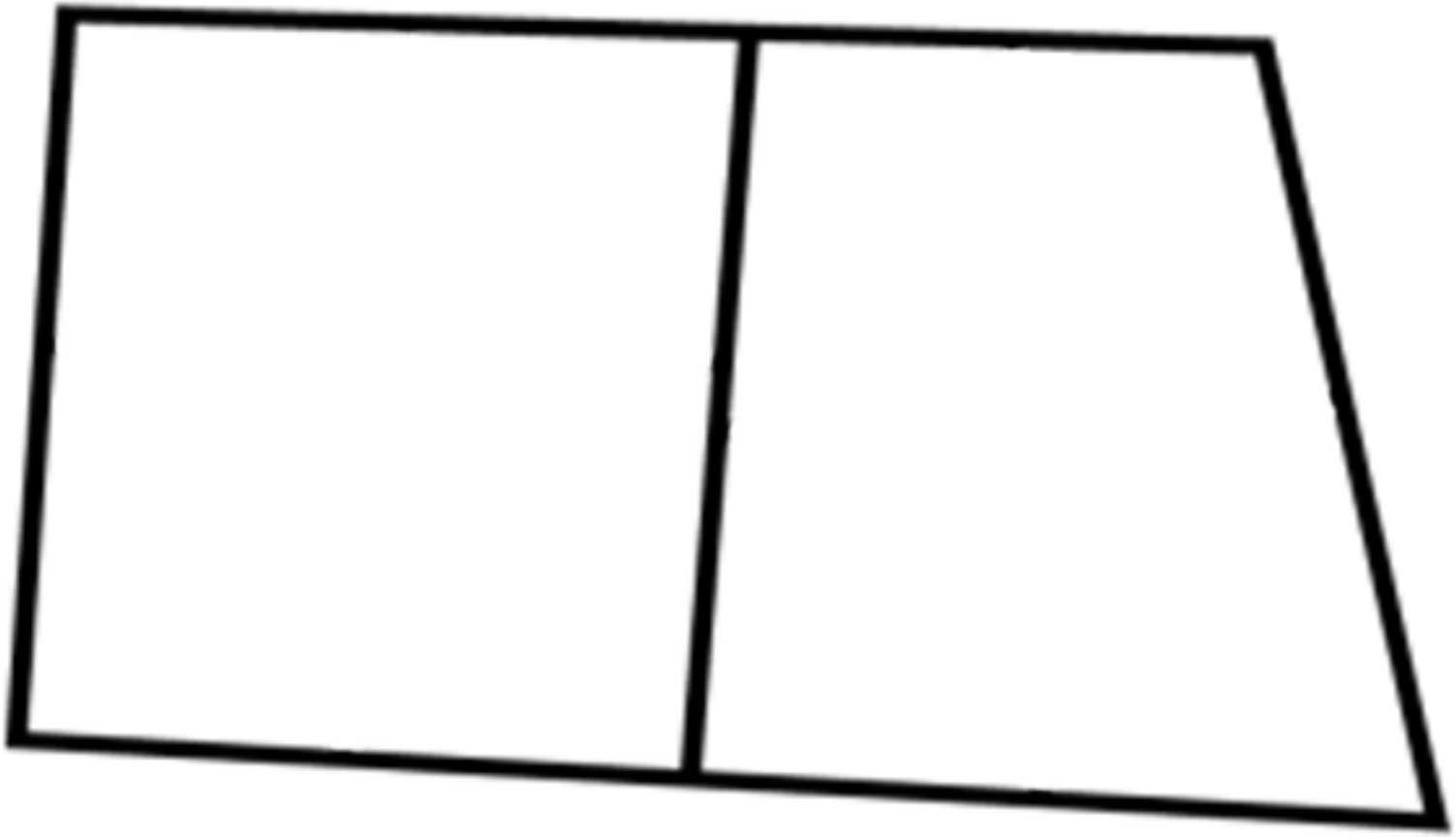

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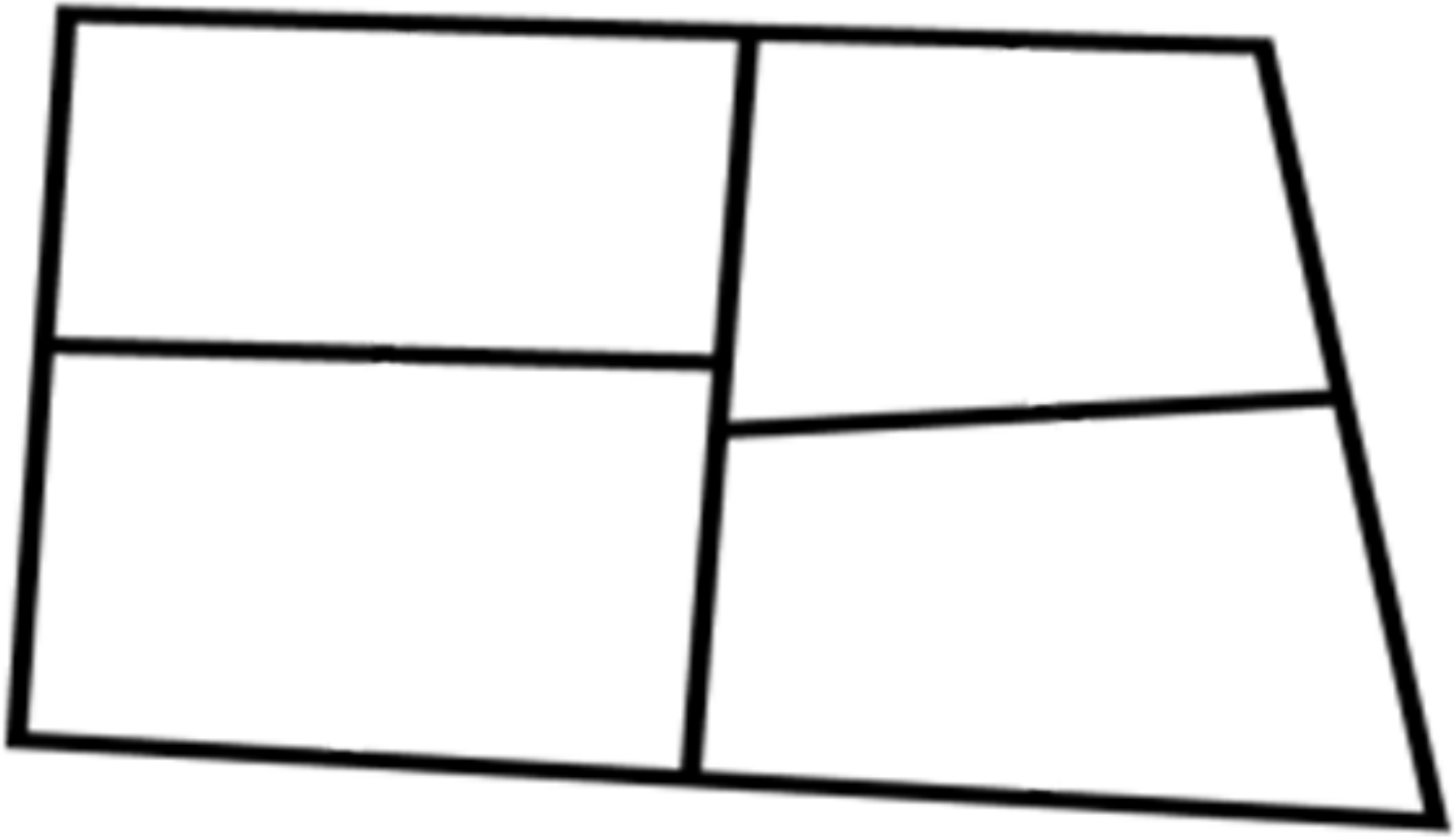

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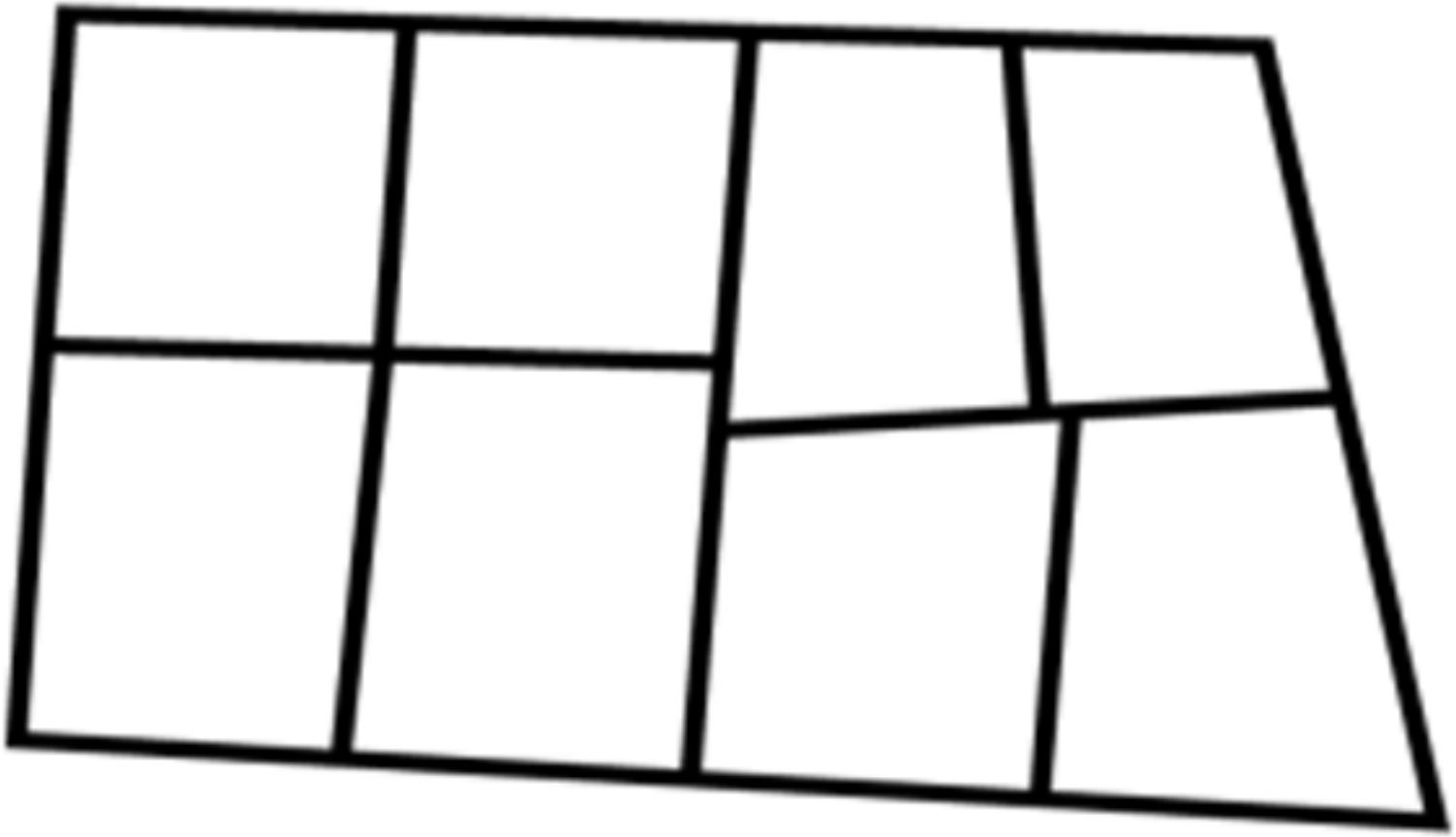
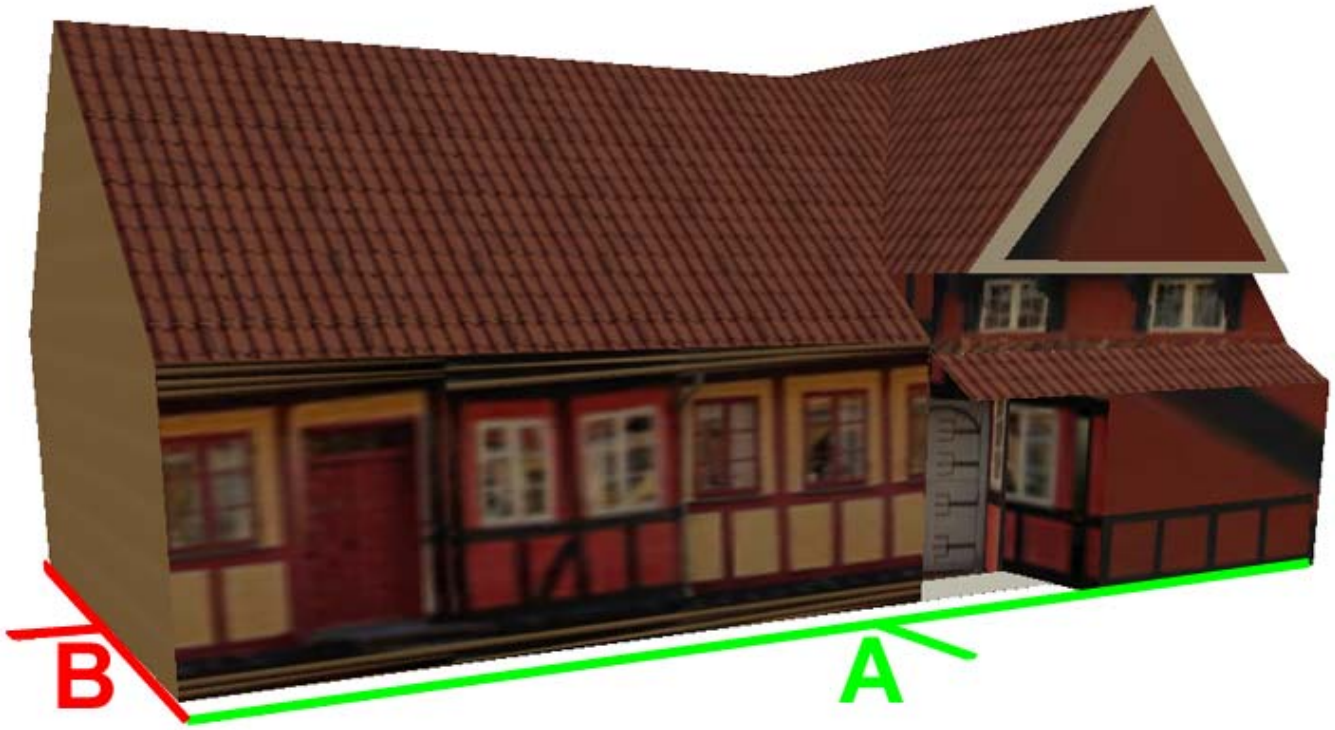


# Building Properties

- Footprint: convex hull of all vertices projected on ground plane
- Sides that must face a street (Street Access Sides)
- Sides that must not face a street (Inaccessible Sides)

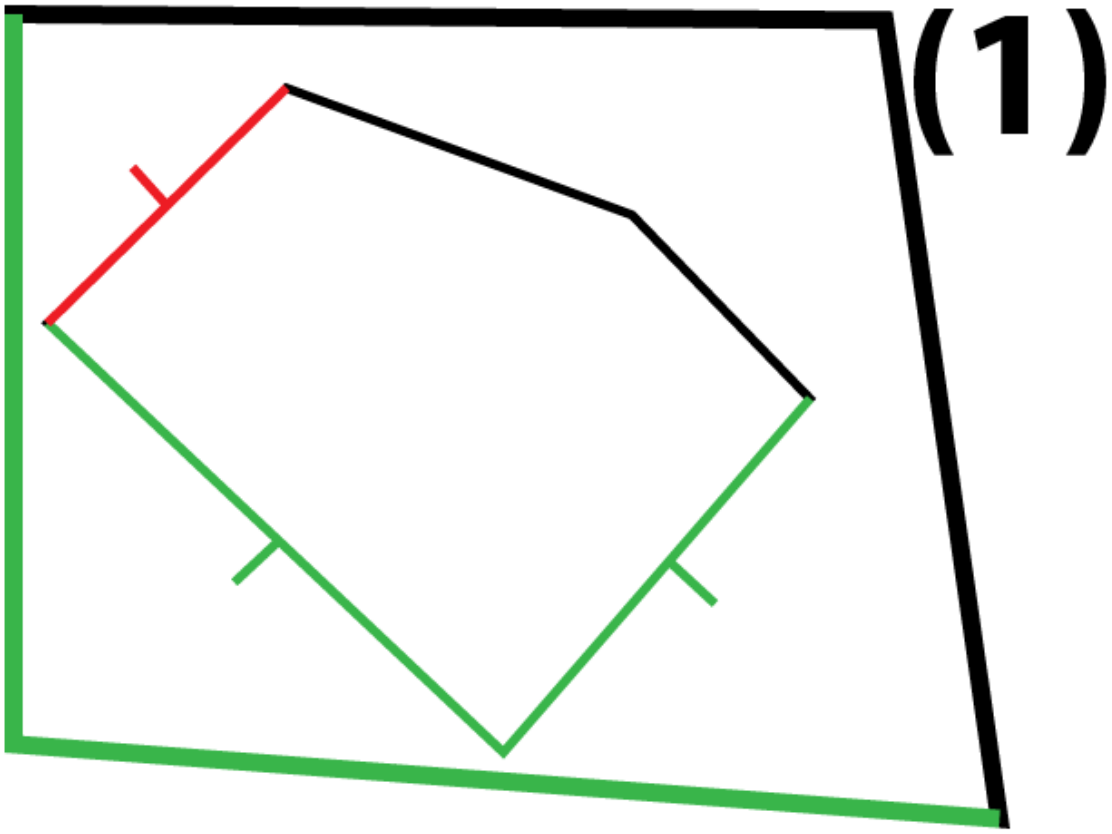


# Selecting a Building

- Constraint based system
- Previously modeled buildings sorted by footprint area size: largest => smallest
- Discard larger buildings
- For every Parcel, starting with largest remaining building:

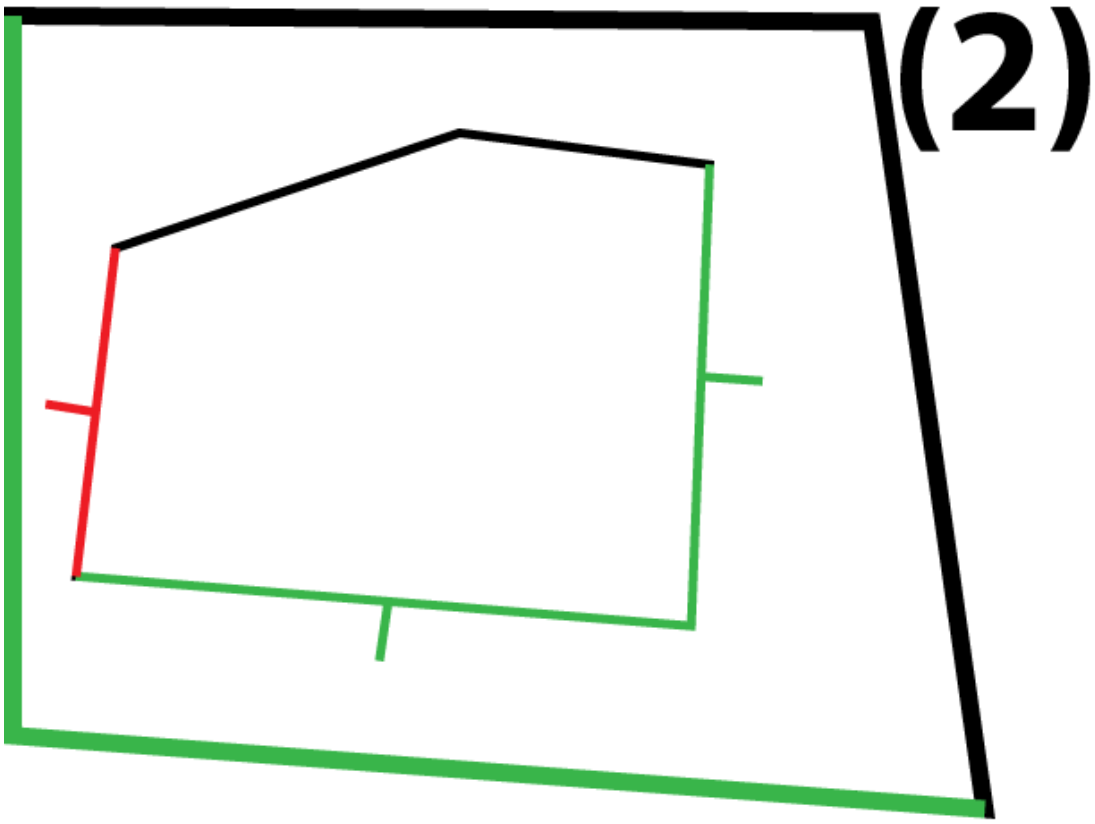
# Selecting a Building

- Move building to center of parcel



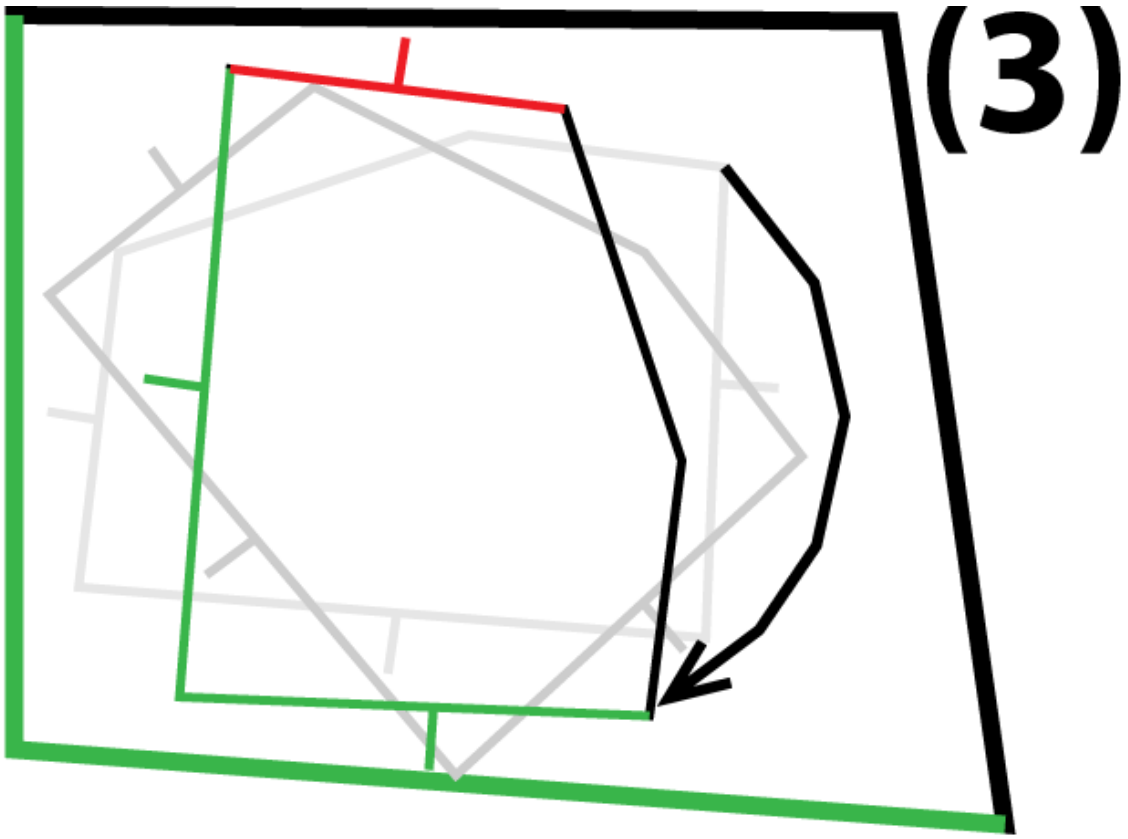
# Selecting a Building

- Align largest Street Access Side to largest street side



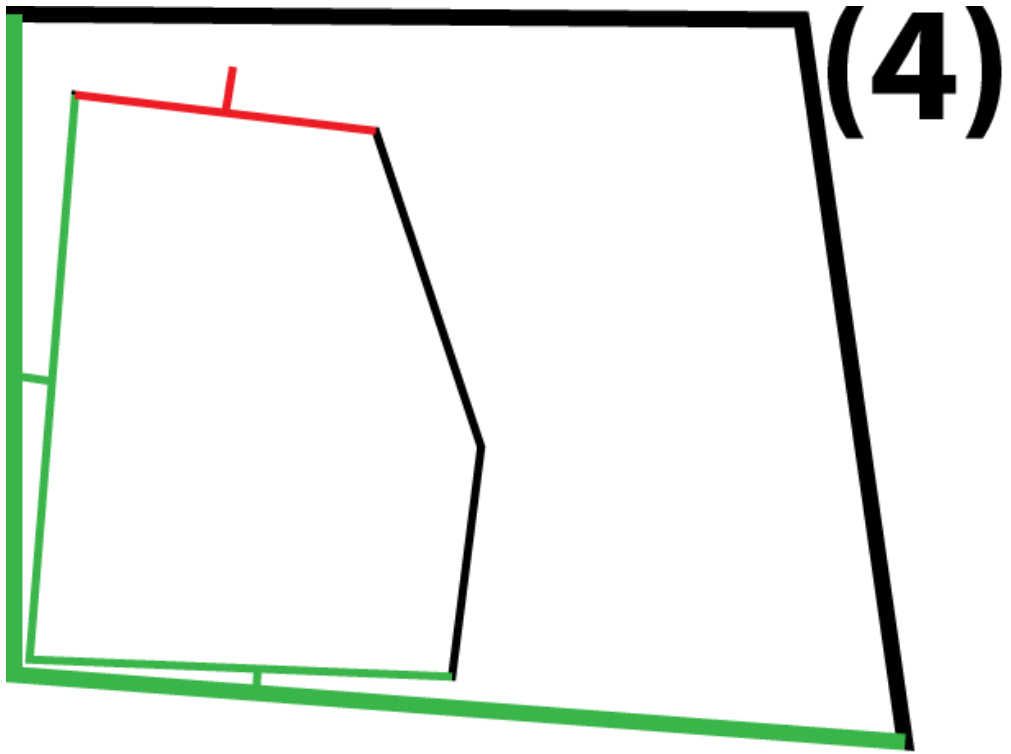
# Selecting a Building

- Rotate until all Street Access Sides and Inaccessible Sides are aligned correctly



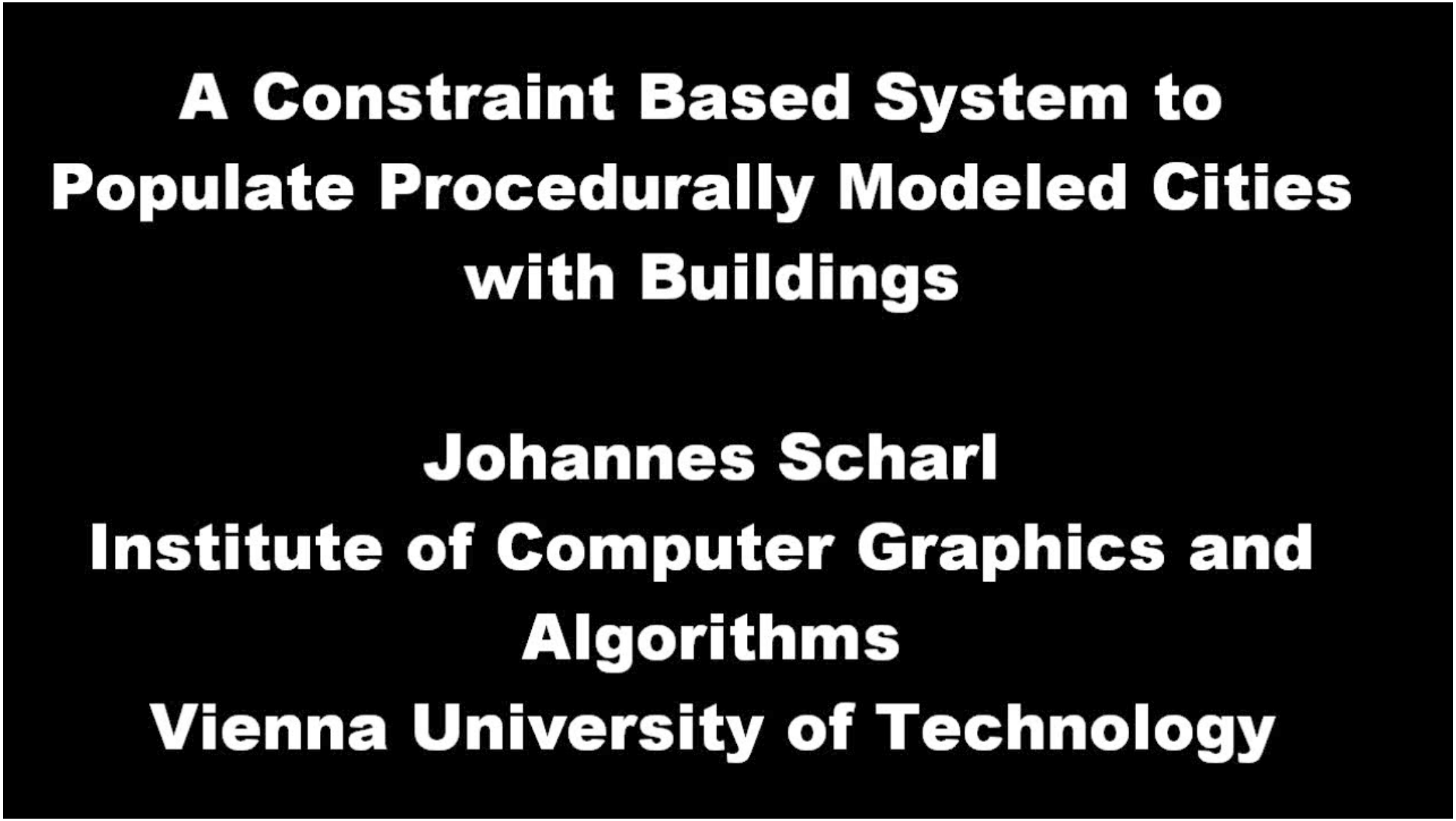
# Selecting a Building

- Move building to streets




- Check if all points are inside the parcel
- If any test failed, repeat with smaller building.

# Video Showcase



# Conclusion and Future Work

- Results:
  - Procedurally created urban environments
  - Constraint based system that choses „best fitting“ building for every parcel
  - Robust method to create 3D street geometry
  - More realistic city shapes
- Future Work:
  - Better control over building assignment process
  - More flexibility to interactively change environment

# The End!

## Thank you for your attention!



## Questions?