

AequilibraE

A Transportation
modeling plugin for
QGIS

Pedro Camargo





Outline

- Transportation Modeling in a nutshell
- Software alternatives
- Motivation
- Implementation issues
- Features
- AequilibraE in action

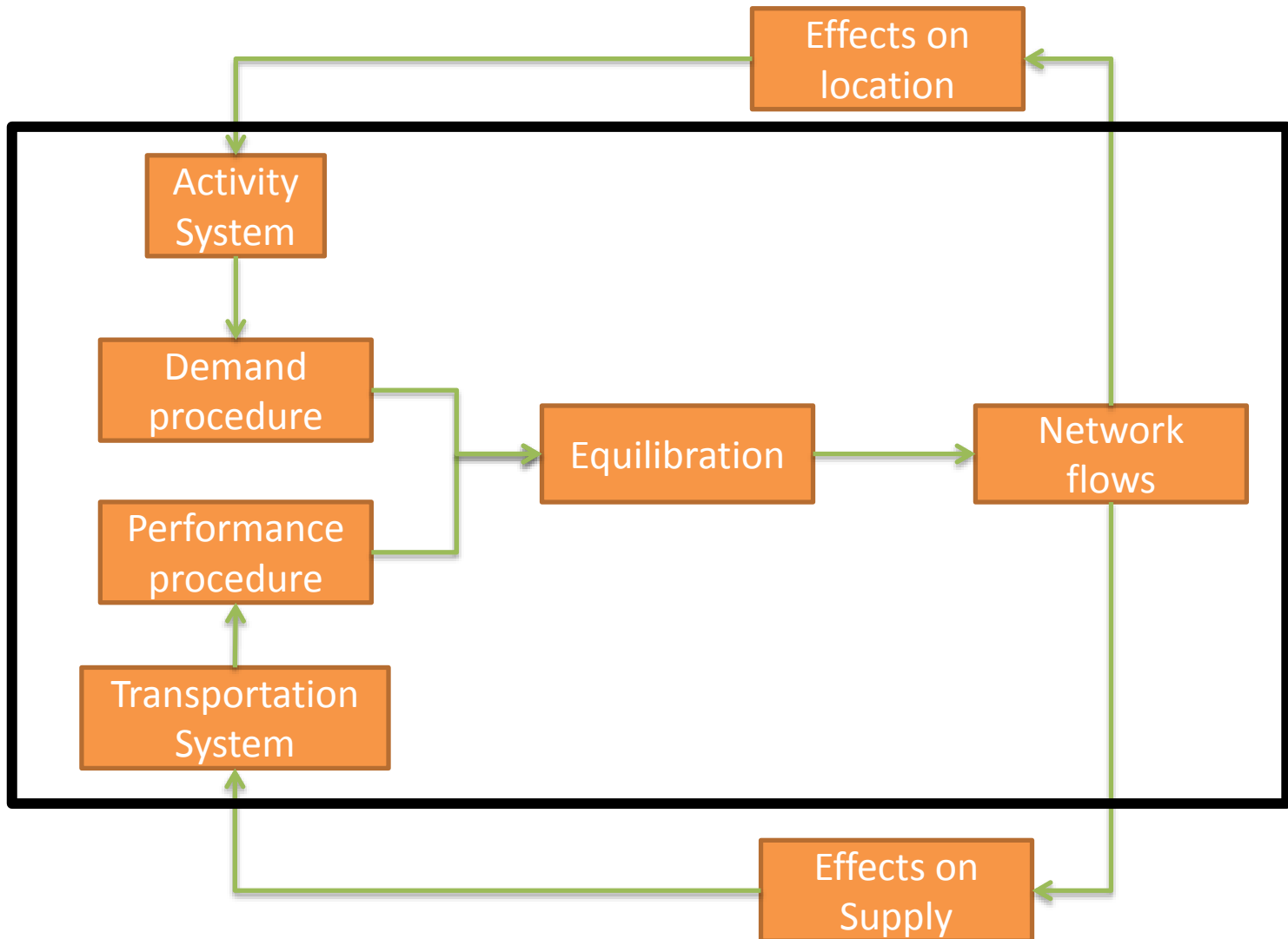


Transportation planning

- Urban or regional scale
- Urban network (infrastructure) represents supply
- People (and goods) moving from point to point represent demand for transportation



Manheim/Florian Transportation Systems Analysis Framework





4-Step model

- Most traditional transportation modeling framework
 - Trip Generation
 - Trip Distribution
 - Mode split/choice
 - Traffic assignment



Trip Generation

- **How many trips is a person or a group of people doing for a particular purpose?**
- Based (mostly) on statistical procedures
 - Linear regression
 - Category Analysis
 - Decision trees (e.g. CHAID)



Trip Distribution

- **Where are people going?**
- Gravity models are the most widely used
 - Idea is to find the parameters for a trip impedance function that would result in the appropriate Trip Length distribution when applied

$$T_{ij} = \frac{\alpha O_i D_j}{C_{ij}^2} \longrightarrow T_{ij} = \alpha O_i D_j f(C_{ij}) \begin{cases} \longrightarrow f(C_{ij}) = e^{-\beta C_{ij}} \\ \longrightarrow f(C_{ij}) = C_{ij}^{-\gamma} \end{cases}$$

- Iterative proportional fitting is often used
- Destination choice models are somewhat used



Mode split/choice

- **Which mode will each person use?**
- Usually based on discrete choice models
 - Multinomial logit
 - Nested logit



Traffic Assignment

- **Which route will each person use?**
- Several procedures have been used
 - All-or-Nothing (Shortest path with no congestion effects)
 - Route choice
 - **Equilibrium assignment**
- Wardrop's 1st principle
 - *“The journey times in all routes actually used are equal and less than those which would be experienced by a single vehicle on any unused route”*



Comercial software

- TransCAD, Caliper corporation, ~US\$12,000
- Cube, Citilabs, ~US\$20,000+
- Visum, PTV, Germany, ~US\$ 20,000+
- Emme, Inro, Canada, ~US\$ 20,000+
- Aimsun, Aimsun, Spain, ~US\$ 30,000+



Other open source software

- **Tranus**
 - Programmed in Fortran (latest commit: Nov/2012)
 - Author promises QGIS plugin for mid 2015
- **Matsim**
 - Micro-simulator
- **Transims**
 - US DOT project
 - Stopped development in 2011



Motivation

- Why developing AequilibraE
 - There are no good open source alternatives
 - Commercial software are black boxes
 - Good way of honing programming skills
 - Consolidating all the code I had written
- Why QGIS
 - Best GIS platform available
 - Simple plugin interface
 - Python/Cython



Main issues

- Network representation/editing
- No efficient matrix format currently available in QGIS
- Core algorithms are often VERY specific and not freely available
- Performance
 - is a key factor that will make its adoption possible/likely



The network issue

- GIS networks
 - Lines/links
- Transportation networks
 - Lines/links;
 - Intersections (nodes);
 - Turn prohibitions;
 - Node-related delays (e.g. Traffic lights)
- We need a good network editor (that edits the nodes as you edit the lines and vice versa)



AequilibraE

- Transportation modeling tools
 - Focused on the 4-step model
 - Trip distribution
 - Network preparation
 - Traffic assignment
- GIS tools
 - Customization of traditional GIS tools/operations to fit Transportation modeling needs



Some other characteristics

- Fully threaded
 - No interface freezing
 - Progress bars
- Core algorithms written in Cython
 - No GIL required
 - Parallel processing with true multi-threading



Transportation modeling tools

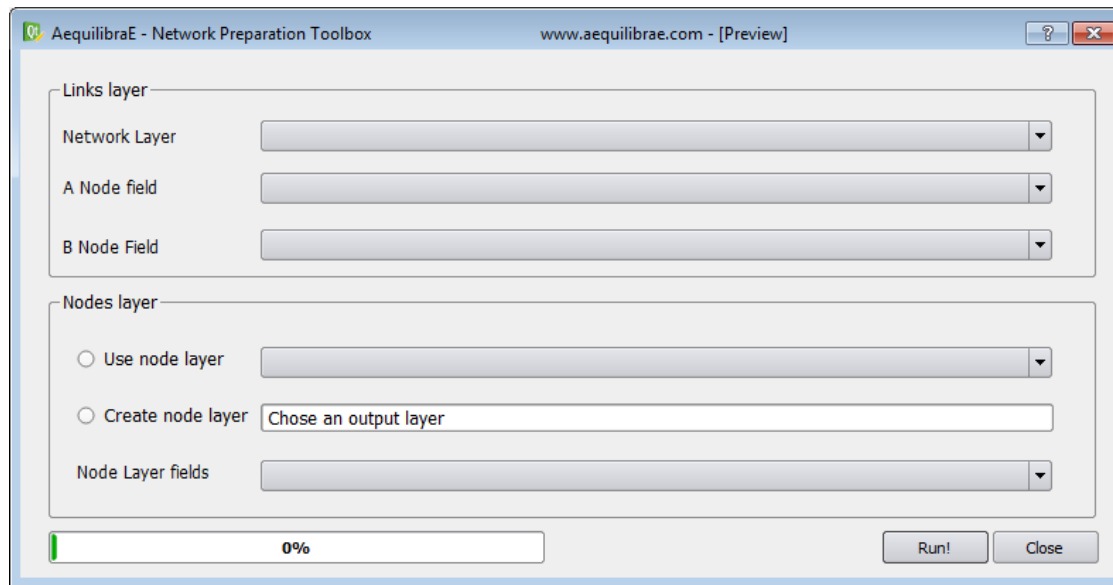
- Trip distribution
 - Gravity models
 - Iterative-proportional fitting

The screenshot shows the 'AequilibraE - Trip distribution methods - [Preview]' window. It features a tabbed interface with 'Gravity calibration' selected. The 'Model Type' section has radio buttons for 'Friction Factors' and 'Synthetic gravity', with 'Synthetic gravity' selected. The 'Deterrence Function' section has radio buttons for 'Exponential', 'Power', and 'Gamma', with 'Exponential' selected. The 'Input Matrix' section contains dropdown menus for 'Matrix', 'From', 'To', and 'Flow'. The 'Impedance matrix' section contains dropdown menus for 'Matrix', 'From', 'To', and 'Impedance'. Below these sections are a 'Result File' input field, a 'CALIBRATE' button, and a 'CLOSE' button at the bottom.



Network preparation

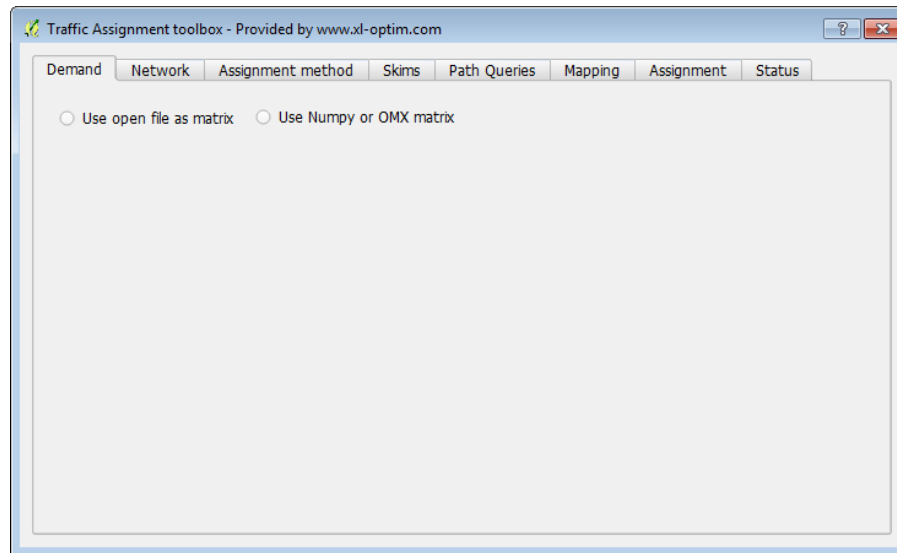
- Spatially matches links and nodes
- or
- Creates nodes for all link extremities





Traffic assignment

- Assigning traffic between zones to a network
 - All-Or-Nothing (Shortest path)
 - Equilibrium (Congestion considerations)*
 - Route choice*





Traffic flow mapping

- Many dimensions to be represented
 - Flows
 - Speeds, travel times, etc.
- Flows in most links are bi-directional
 - Not trivial to do in QGIS
 - Most transportation planners are NOT very proficient in GIS



How big are the problems

- Phoenix Metro model
 - Network: ~47,500+ directed links
 - Zones: 3,000+
- Running time (2x Xeon 6-core): ~8/24h (assignment/total)



Needed improvements

- Network editor
- Parallel interface with hdf5 containers
 - Some large outputs are generated by some procedures (e.g. path files)
- Interface for the standard matrix format
 - Open data format (*.omx)
- Interface with BIOGEME (choice modeling)
- ...



Demonstration



Contacts

- Pedro Camargo
- Email: c@margo.co
- Project website: www.aequilibrae.com
- Blog: www.xl-optim.com
- Repositories: <https://bitbucket.org/pedrocamargo>
- Profile: www.linkedin.com/in/pedrocamargo
- Twitter: @pedrocamargo

AequilibraE

QUESTIONS?

