NETWORK EPIDEMIC MODELLING of COVID-19 in HUNGARY

HU-MATHS-IN
Hungarian Service Network for Mathematics in Industry and Innovations

CHALLENGES: network epidemic modelling

Productive sector: healthcare

The Industrial Problem

Creating a network epidemic model that balances between complexity and reality. Determine its parameters from data. Study the predicting power of the model.

GOVERNMENTAL DECISION MAKERS, HEALTH CARE INSTITUTIONS

Research group

Eötvös Loránd University
Institute of Mathematics

Eötvös Loránd University
Faculty of Science

Research profile: Mathematical modelling of real word phenomena in sciences, business and industry.

Company

Ministry of Innovation and Technology

MINISTRY OF
INNOVATION AND TECHNOLOGY

Epidemic modelling research group

SZÉCHENYI 2020
MAGYARORSZÁG KORMÁNYA
Európai Unió
Európai Strukturális és Beruházási Alapok
BEFEKTETÉS A JÖVŐBE

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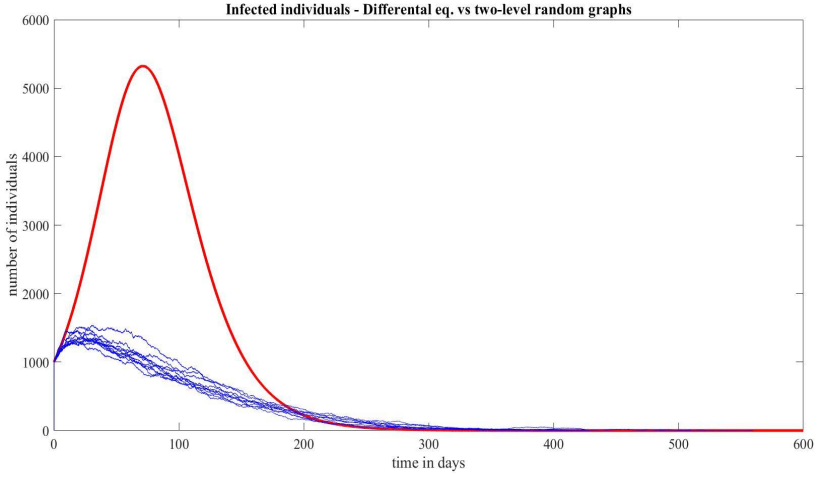
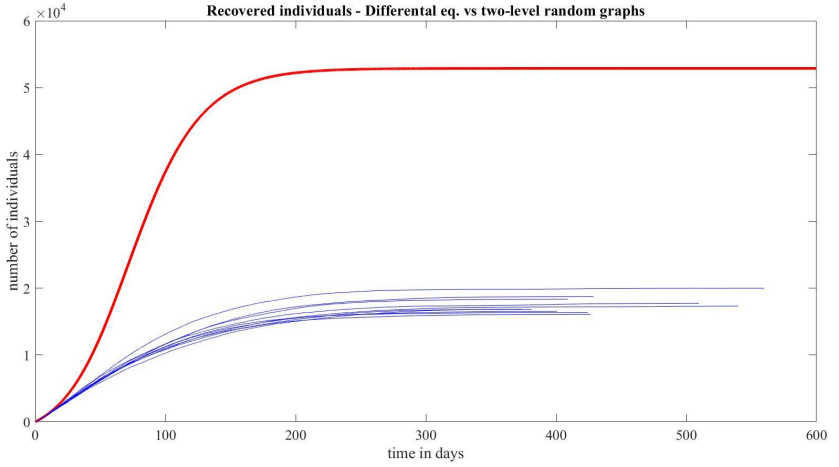
Challenges & Goals

Government, healthcare

Network epidemic modelling

- Different mathematical models of disease propagation.
- **Forecasting** the course of the epidemic.
- **Network epidemic models** have several parameters and complex structure.
- Create a model that can be fit to data.
- Develop a mathematical method to **estimate parameters**.





Illustrating the difference of differential equation (red) and network model (blue) on 100000 vertices

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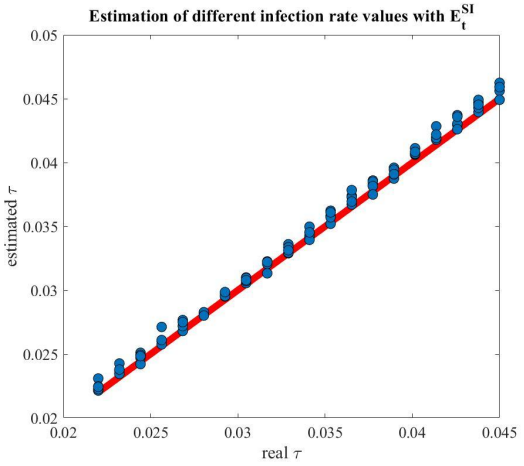
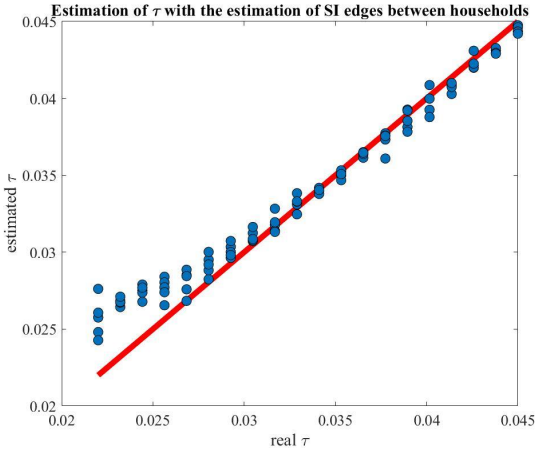
Mathematical and computational methods and techniques applied

- Model: **SIR process on household model** with small complete graphs with an added Erdős-Rényi or preferential attachment graph with smaller weight.
- Infection rate and recovery rate were estimated with the methods adapted from the deterministic case, **if the number of SI edges is known exactly**.
- We examined **various approaches to estimate the number of SI edges** within and between households separately.
- Numerical simulations: **Gillespie and fast SIR algorithms** were impemented in Matlab, on a graph of 10000 vertices, to check whether the estimations match the orinigal values.



Estimation of the infection rate if we know the number of SI edges



The same with estimated number of SI edges between households

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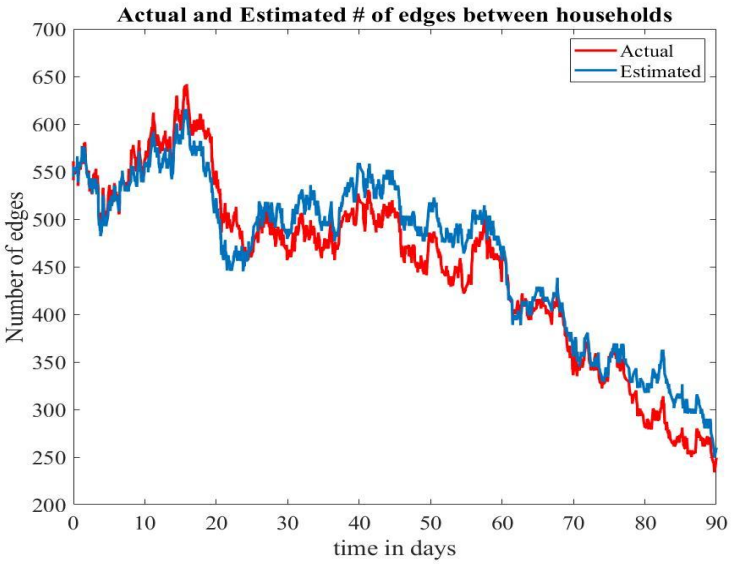
Results & Benefits to the company

- Results
  - The number of S, I, R individuals;
  - **number of households with a given SIR configuration** (e.g. one S, two I, one R);
  - proportion of people infected at home provide sufficient data for estimation.
- Benefits

  We obtained a more detailed picture on **parameter estimation in epidemic spread on a two-level random network**, and identified the statistics that are important for forecasting and making decisions.



Real and estimated number of SI edges

Detailed information about the infection phase of households enables us to accurately estimate paramaters.