東京大学
THE UNIVERSITY OF TOKYO

CSIS 共同利用・共同研究拠点 Joint Usage / Research Center
東京大学 The University of Tokyo
空間情報科学研究センター
Center for Spatial Information Science

EpiMob: Interactive Visual Analytics of Citywide Human Mobility Restrictions for Epidemic Control

Chuang Yang

2022.09.15

Content

I. Introduction

➢ Research Context

- Various countermeasures[1], such as *Self-Quarantine, Travel Restrictions, Mask Wearing, and Contact Tracing,* have been implemented to contain the rapid spread of the pandemic.

- It's important for policy makers to *Evaluate the effect of countermeasures* quickly, so as to make rational and scientific measures.

- One of the main routes is *Simulation* --- **Simulating the effectiveness of intervention policies**.
  - E.g., *COVID-19 AI and Simulation Project* lauched by Cabinet Office of Japan [2]

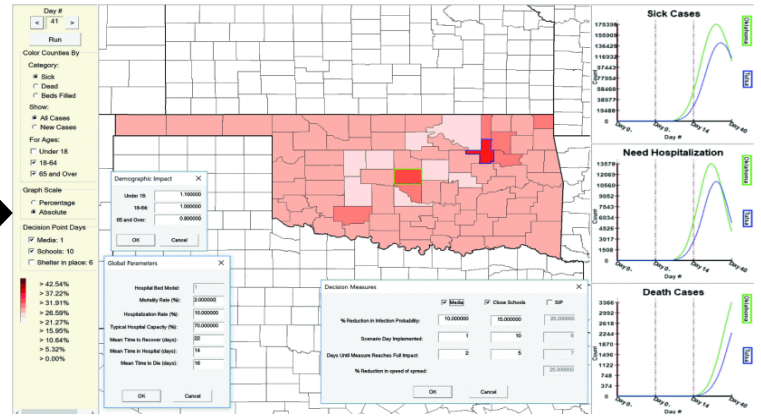
However, the policy searching process is *Tedious and Inefficient*.
- Requiring *substantial programming effort*, for *Modelling and Results Analysis*.
- Facing a *large state space* when exploring *"Where and where for what policies"*.

[1] Hale, Thomas, et al. "A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker)." *Nature Human Behaviour* 5.4 (2021): 529-538.
[2] COVID-19 AI and Simulation Project, CAO, Japan, https://www.covid19-ai.jp/en-us/

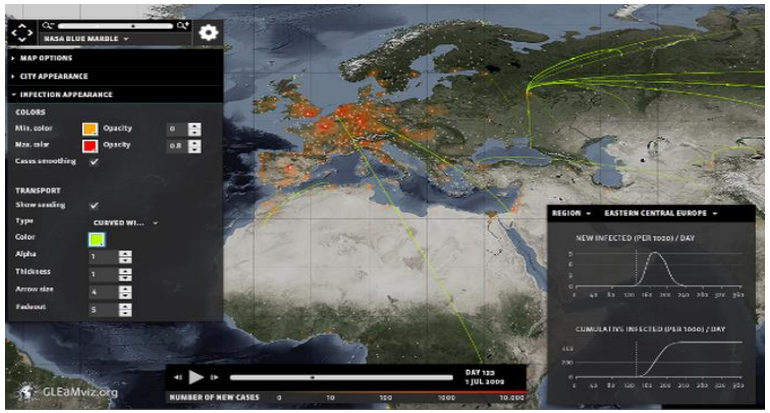
I. Introduction

➢ Research Context

- Some tools/simulators[1,2] for *Interactive simulation and analysis of intervention policies* has been proposed.



[1]



[2]

- Good visualization and interaction design.
- Enhancing the efficiency of policy exploration.
- Being accessible by a boarder set of users.

Simulating at county and higher spatial scales, simplifying citywide scenarios, treating the city as a minimum implementation unit.

Simulators towards citywide fine-grained simulation are still blank.

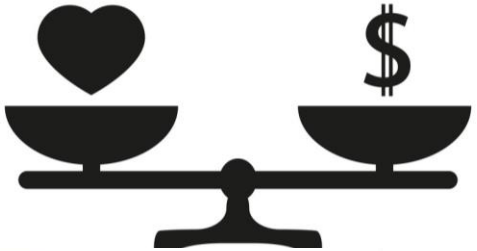
[1] Afzal, Shehzad, et al. "A visual analytics based decision making environment for covid-19 modeling and visualization." 2020 IEEE Visualization Conference (VIS). IEEE, 2020.
[2] Van den Broeck, Wouter, et al. "The GLEaMviz computational tool, a publicly available software to explore realistic epidemic spreading scenarios at the global scale." BMC infectious diseases 11.1 (2011): 1-14.

I. Introduction

➢ Research Context

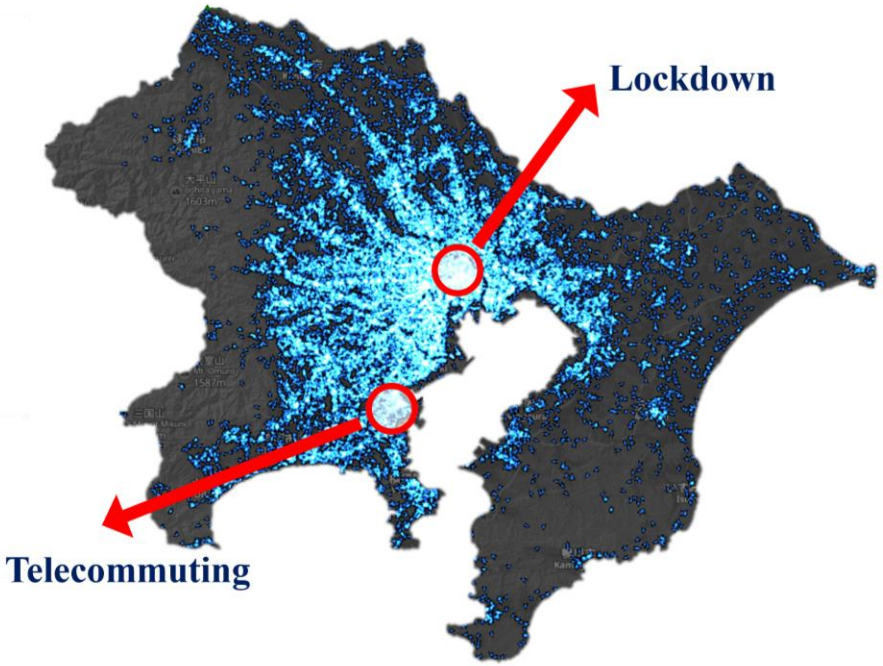
Simulators towards citywide fine-grained simulation are still blank.

- Citywide fine-grained epidemic control and prevention[1] could be a more appropriate route for restraining the spread while maintaining normal livelihood.
  - Identify and lockdown the high-risk areas.



[Coarse-grained]
One Policy on the Whole Area

[Fine-grained]
Specific Policies on the Specific Regions



I. Introduction

➢ Research Target

Designing a simulator *for citywide fine-grained epidemic control scenarios*, aiming to *simplify the policy search process* in city scale.

➢ Requirements

[R1] Policy Configuration

- Explore, set and simulate various countermeasures interactively and intuitively.

[R2] Policy Evaluation

- Measure, compare and analysis the effectiveness of policies interactively and intuitively.

[R3] Extensible

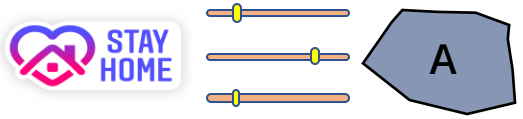
- Control policies/Epidemic models/Visualization views could be customized by users themselves.

*Due to the time and data limit, EpiMob merely considered *mobility related policies* at this moment.

II. Challenges & Solutions

- When and where for what policies in citywide.
  - Local control policies, no clear administrative boundaries.
  - Complex intracity features, no existing solutions.

Interactive Module



Policy Setting & Parameter Setting

Recent visualization methods/views.
Easy-to-use interaction logic.

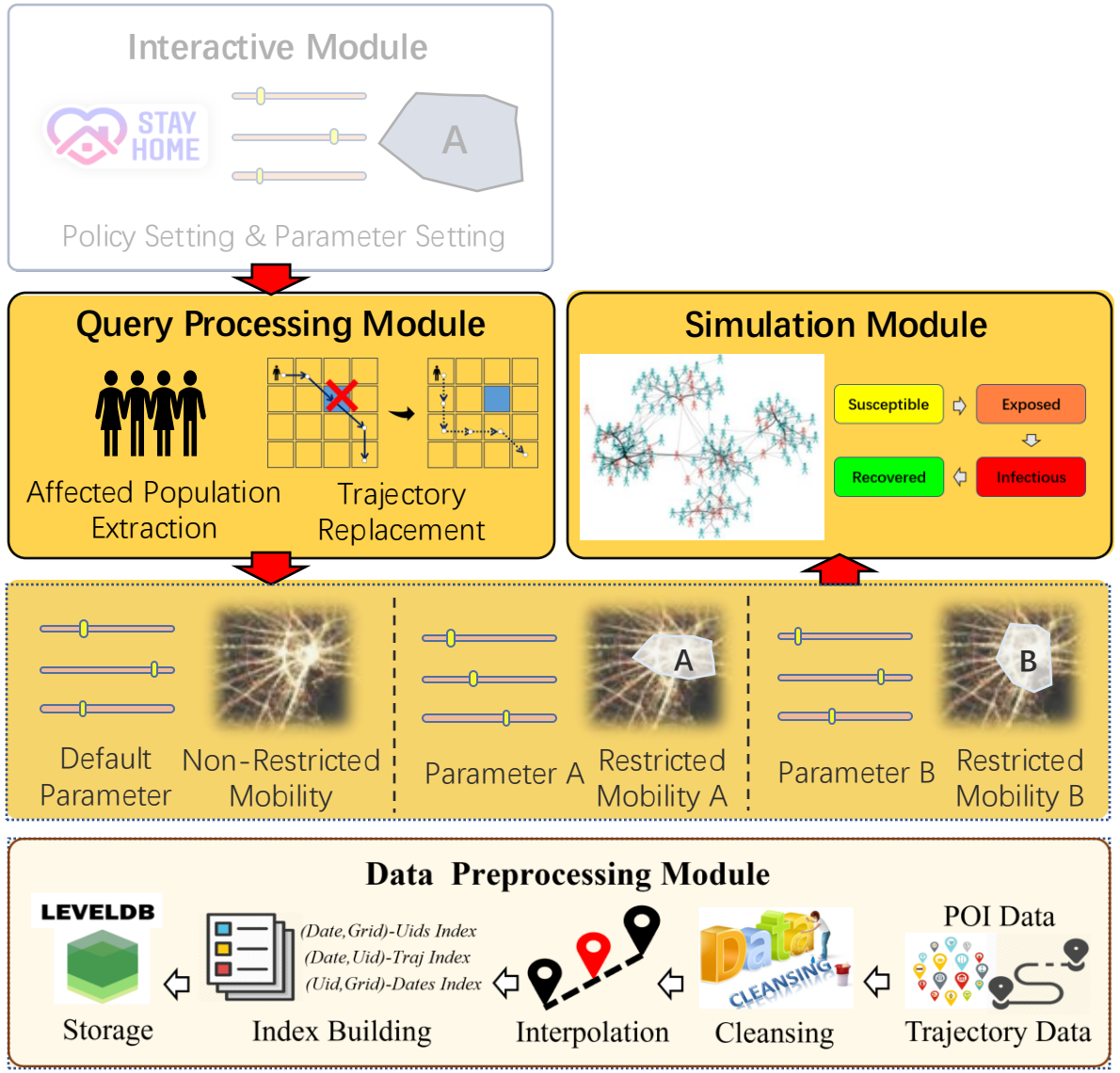
➡

Interactive policy exploration and setting

II. Challenges & Solutions

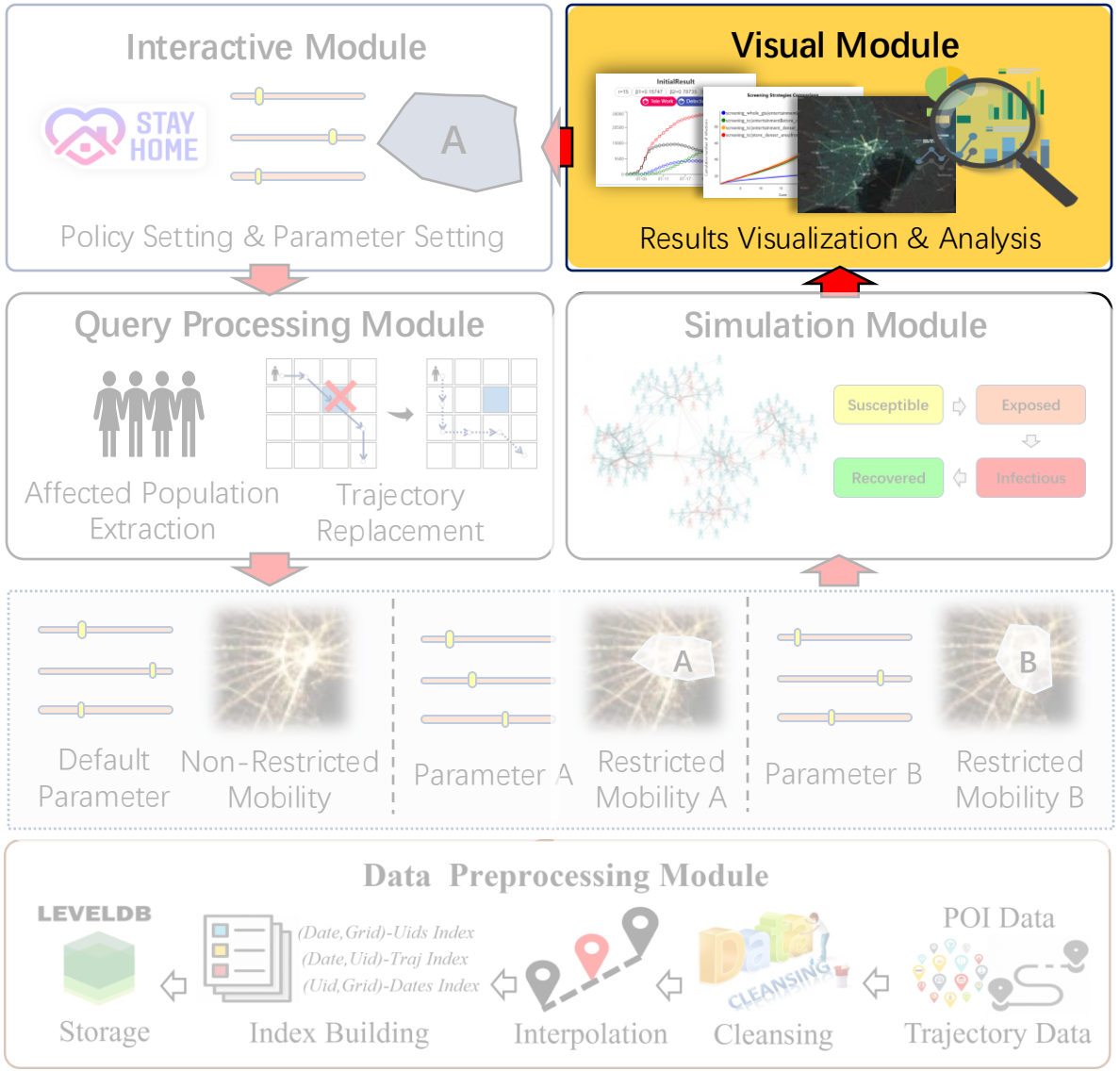
- When and where for what policies in citywide.
  - Local control policies, no clear administrative boundaries.
  - Complex intracity features, no existing solutions.

- **Designing a simulation paradigm to accommodate different mobility policy settings.**
  - **Different types, intensities, and spatiotemporal scope of restrictions.**
  - **Performing multiple types of policies simultaneously.**



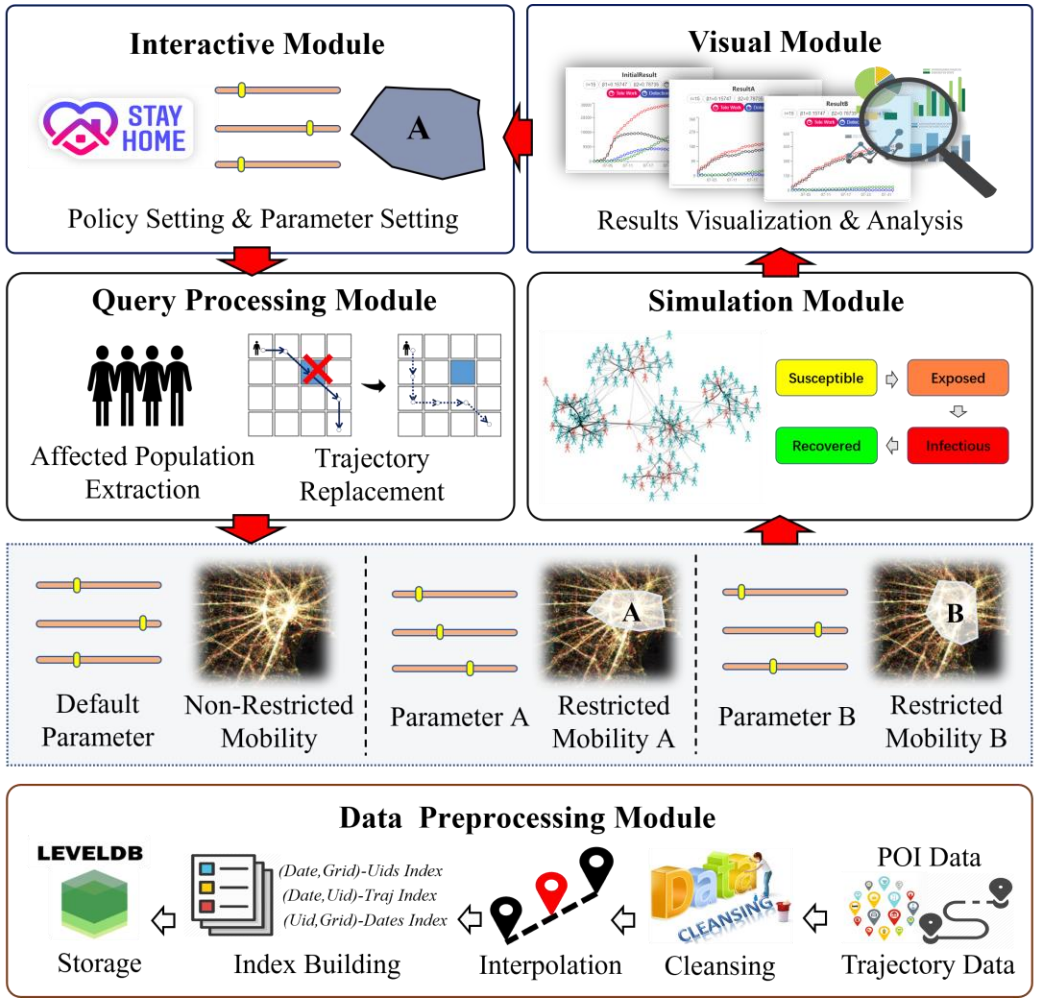
II. Challenges & Solutions

- When and where for what policies in citywide.
  - Local control policies, no clear administrative boundaries.
  - Complex intracity features, no existing solutions.
- Designing a simulation paradigm to accommodate different policy settings.
  - Different types, intensities, and spatiotemporal scope of restrictions.
  - Performing multiple types of policies simultaneously.
- **Deeper understanding of simulation results.**
  - **Not just an infection curve.**
  - **Understanding the fine-grained secondary effects.**
  - **e.g., the new infection hotspots, the hub nodes.**



II. Challenges & Solutions

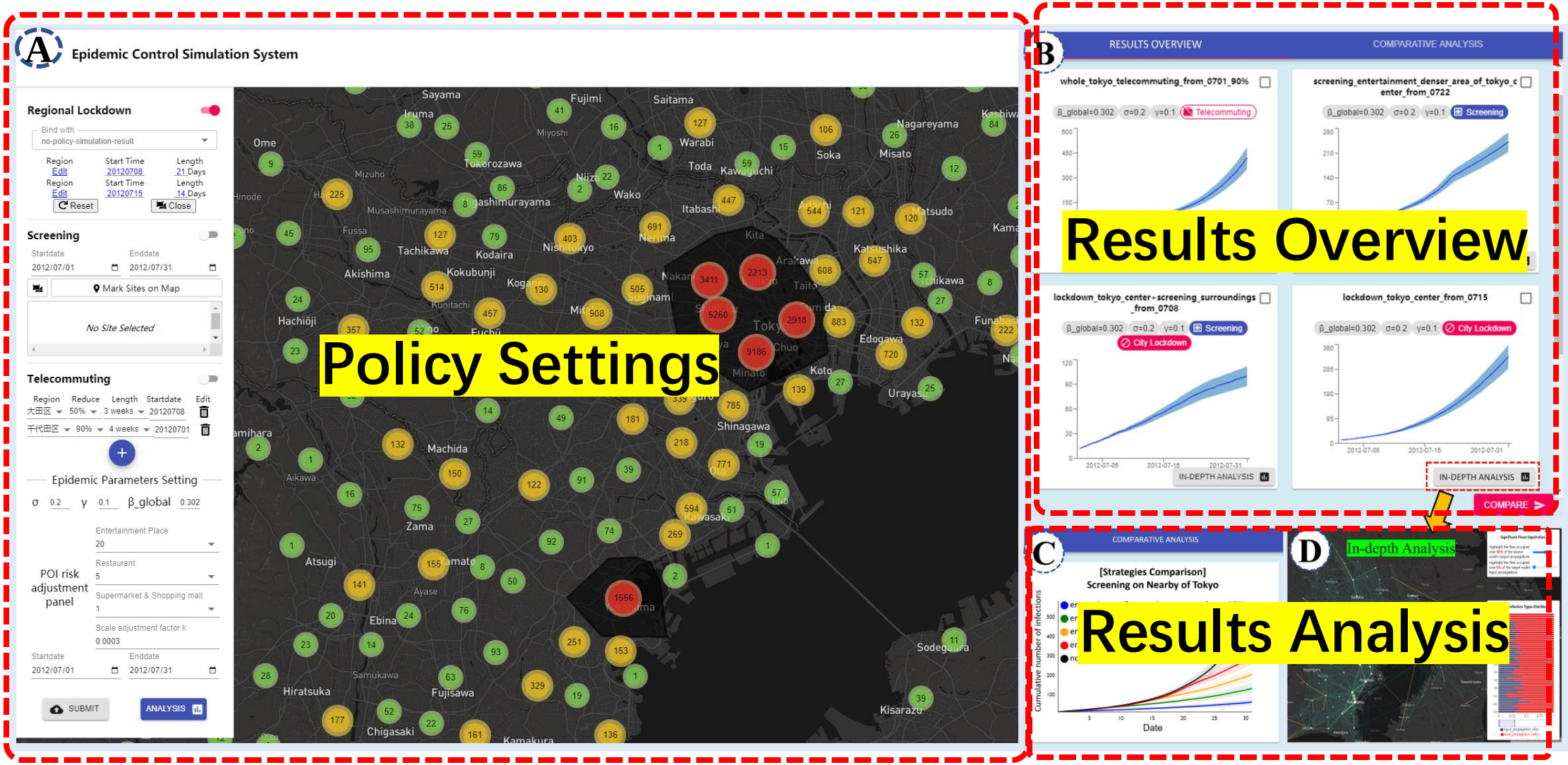
- When and where for what policies in citywide.
  - Local control policies, no clear administrative boundaries.
  - Complex intracity features, no existing solutions.
- Designing a simulation paradigm to accommodate different policy settings.
  - Different types, intensities, and spatiotemporal scope of restrictions.
  - Performing multiple types of policies simultaneously.
- Deeper understanding of simulation results.
  - Not just an infection curve.
  - Understanding the fine-grained secondary effects.
  - e.g., the new infection hotspots, the hub nodes.



[R1] Policy Configuration >>> ***explore, set and simulate*** various countermeasures.
[R2] Policy Evaluation >>> ***measure, compare and analysis*** the effectiveness of policies.
[R3] Extensible >>> ***control policies/epidemic models/visualization view.***

III. Visualization Design of the Prototype System

➢ UI Overview



III. Visualization Design of the Prototype System

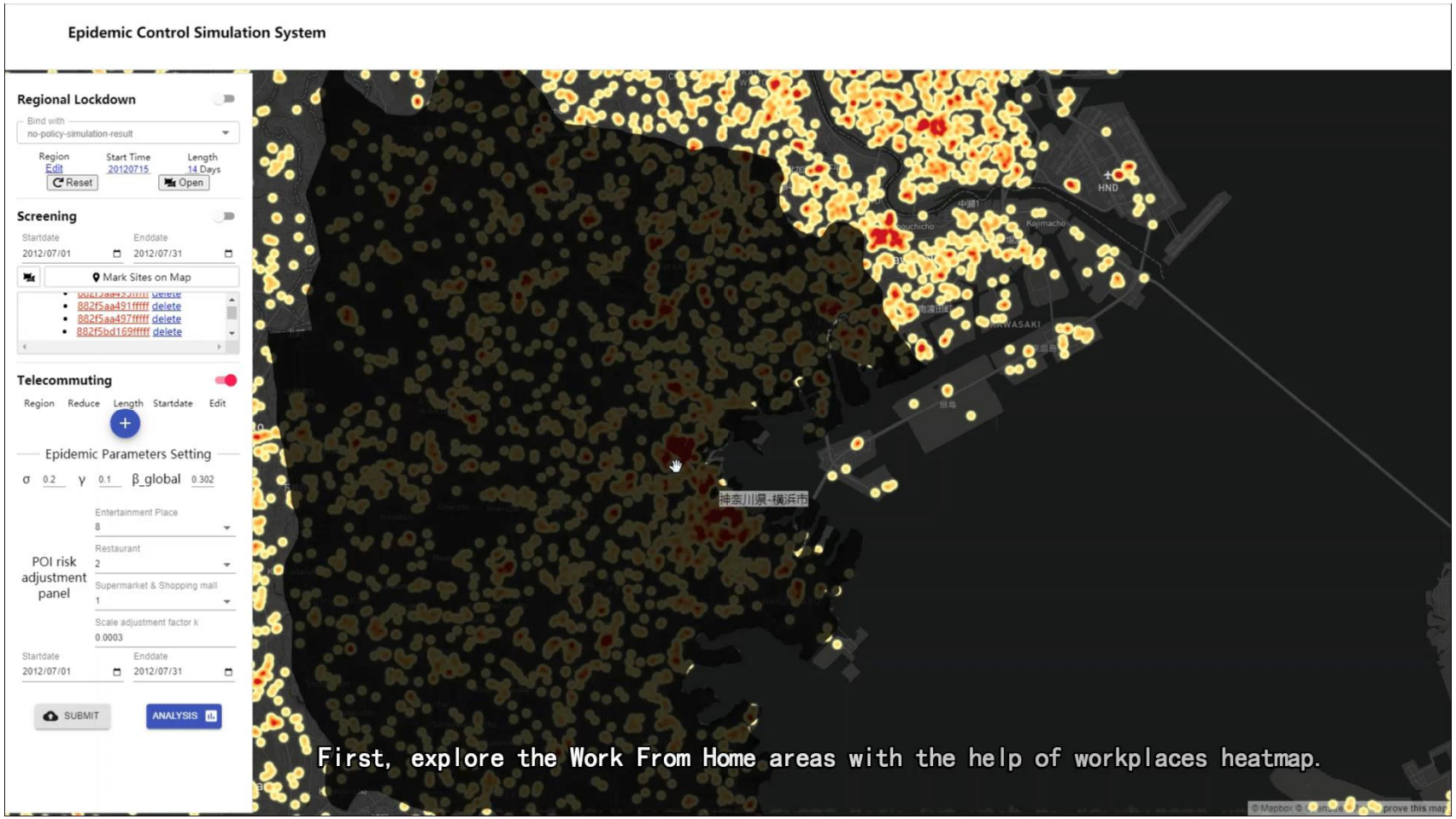
➢ Restriction Policy Settings --- Regional Lockdown View

Motivation => Lockdown could be performed on the regions of high infection risks.

III. Visualization Design of the Prototype System

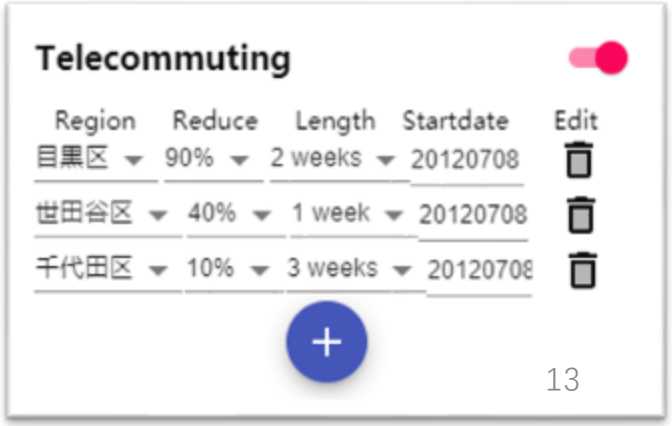
➢ Restriction Policy Settings--- Telecommuting View

Motivation => *Identifying workplaces with high-frequency visitation* to assisting users in deciding where to enforce remote working.



◆ An heatmap view to visual the workplaces of individuals.

- ✓ When hovering the mouse over a region, the name of its administrative district is displayed.
- ✓ User can ***specify the telecommuting districts; set the corresponding reduction rate; start time and duration***.
- ✓ During simulation, the ***people satisfies the rules will work from home***.

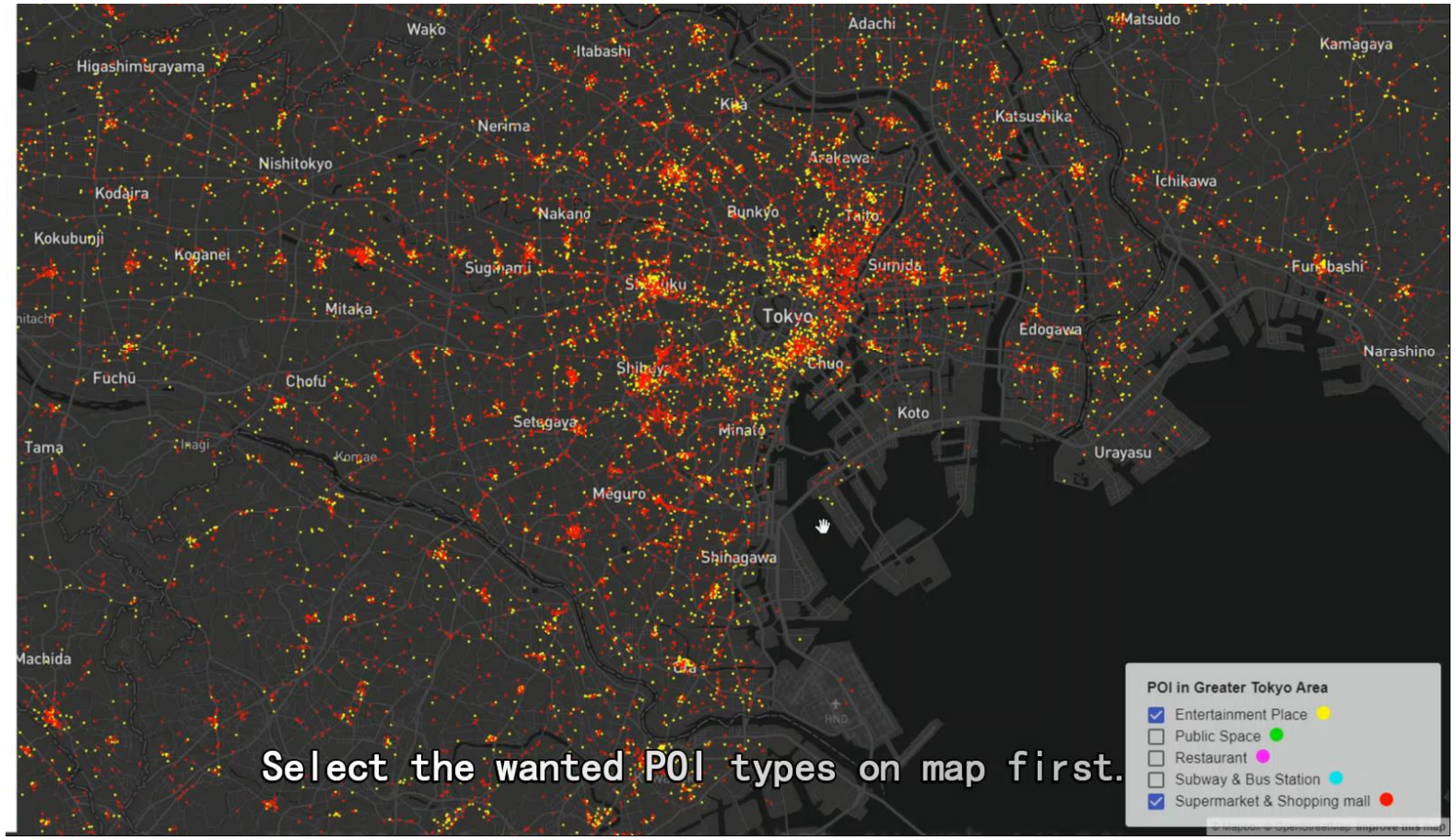


III. Visualization Design of the Prototype System

➢ Restriction Policy Settings--- Screening View

Motivation

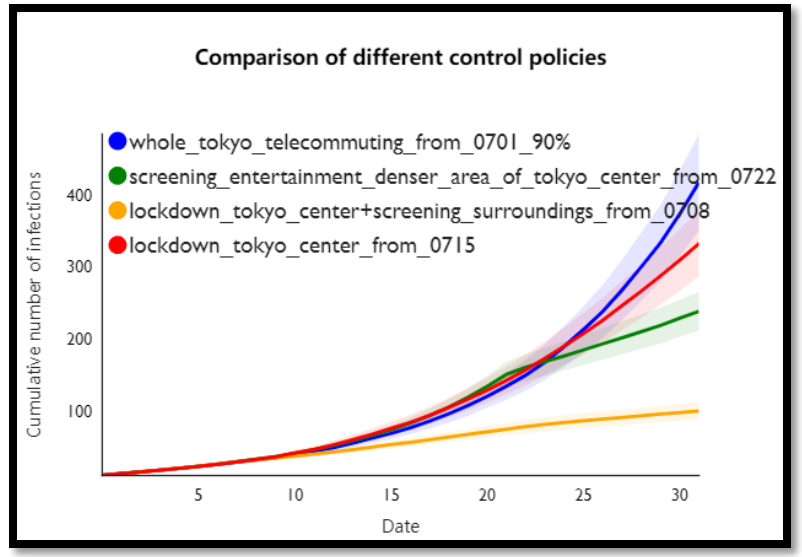
- ◆ The government often needs to set up screening points in certain areas.
- ◆ Select the locations where some kinds of POIs are denser than others to set detection points.



- ◆ <u>A visual display to help specify the potential screening point.</u>
- ✓ User could select and display multiple kinds of POIs at the same time on the map.
- ✓ Then *mark the locations with denser POIs as screening points (indicated by the red markers)*.
- ✓ During the policy implements, all people passing the marker covering regions will accept a screening (e.g., PCR, temperature). If detected, they will be isolated on the subsequent simulation.

III. Visualization Design of the Prototype System

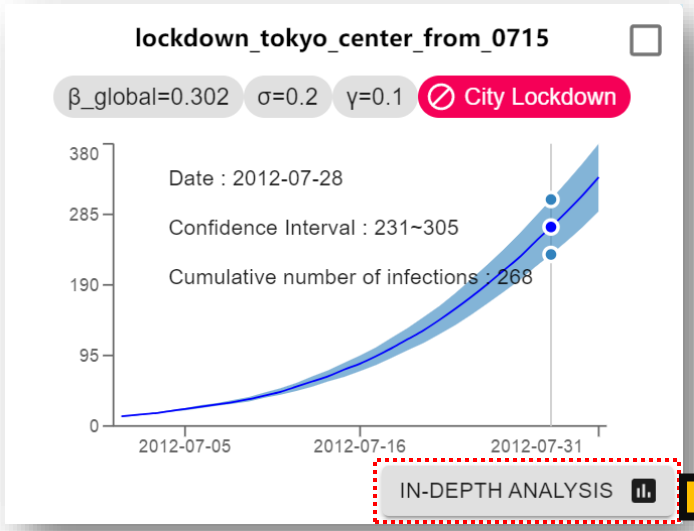
➢ Result Evaluation --- Curve View

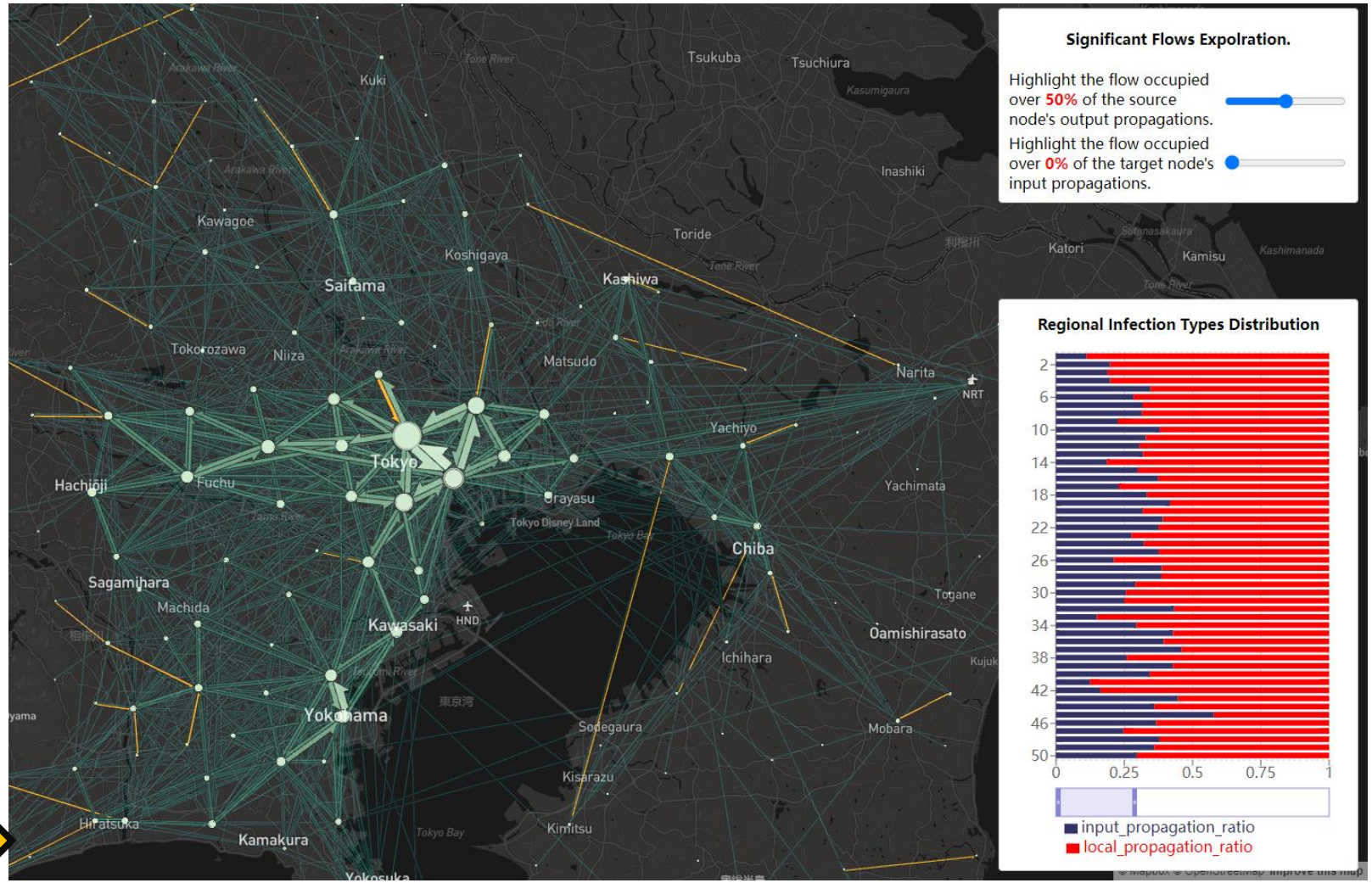


III. Visualization Design of the Prototype System

➢ Result Evaluation --- In depth Analysis View

Designed to analyze the [policies' secondary effects] from the perspective of spatial propagation based on Flowmap.blue[1]

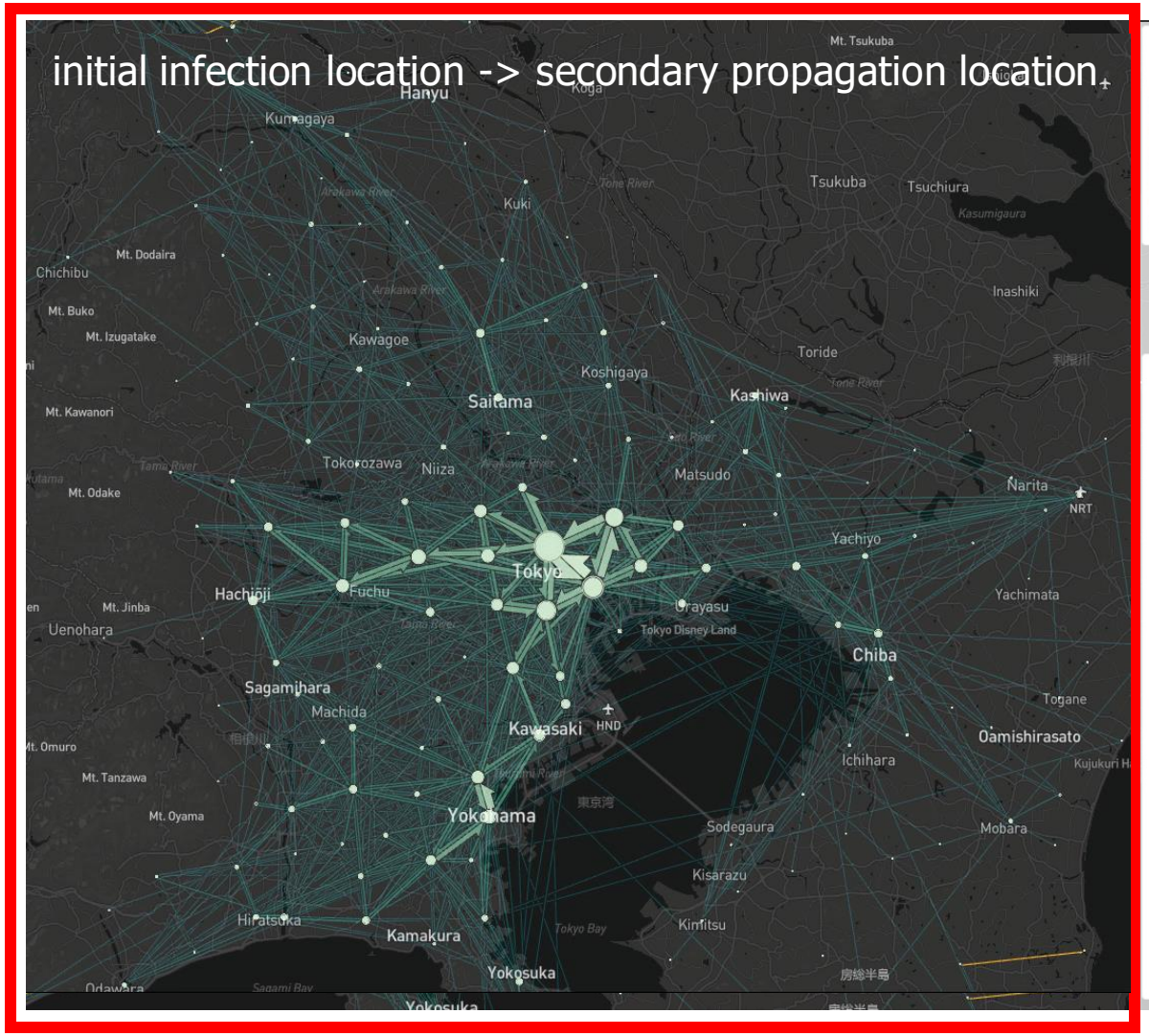




[1] https://flowmap.blue/

III. Visualization Design of the Prototype System

➢ Result Evaluation --- In depth Analysis View

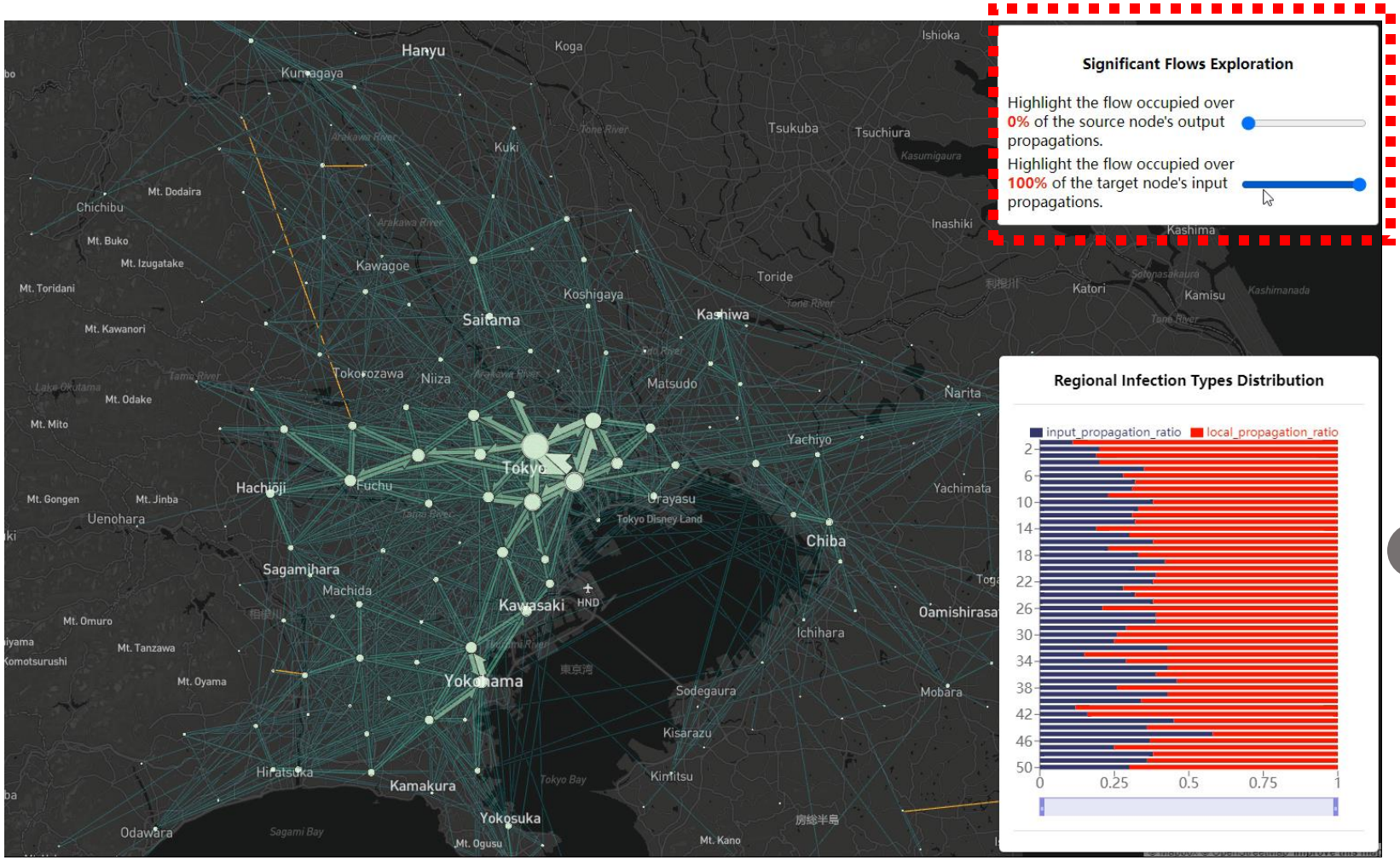


A map component to display the spatial transmission network.

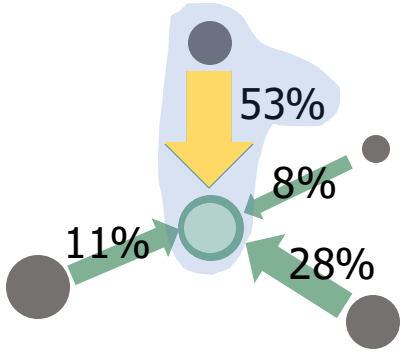
- ✓ The bi-direction of the edges encodes the direction of spatial diffusion of the disease.
- ✓ Both the width and transparency of the edges map the intensity of the transition.

III. Visualization Design of the Prototype System

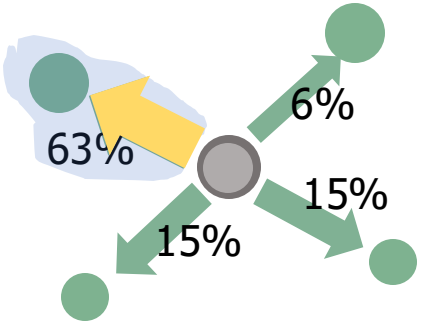
➢ Result Evaluation --- In depth Analysis View



A filter component to explore the **significant cross-region propagation patterns**.



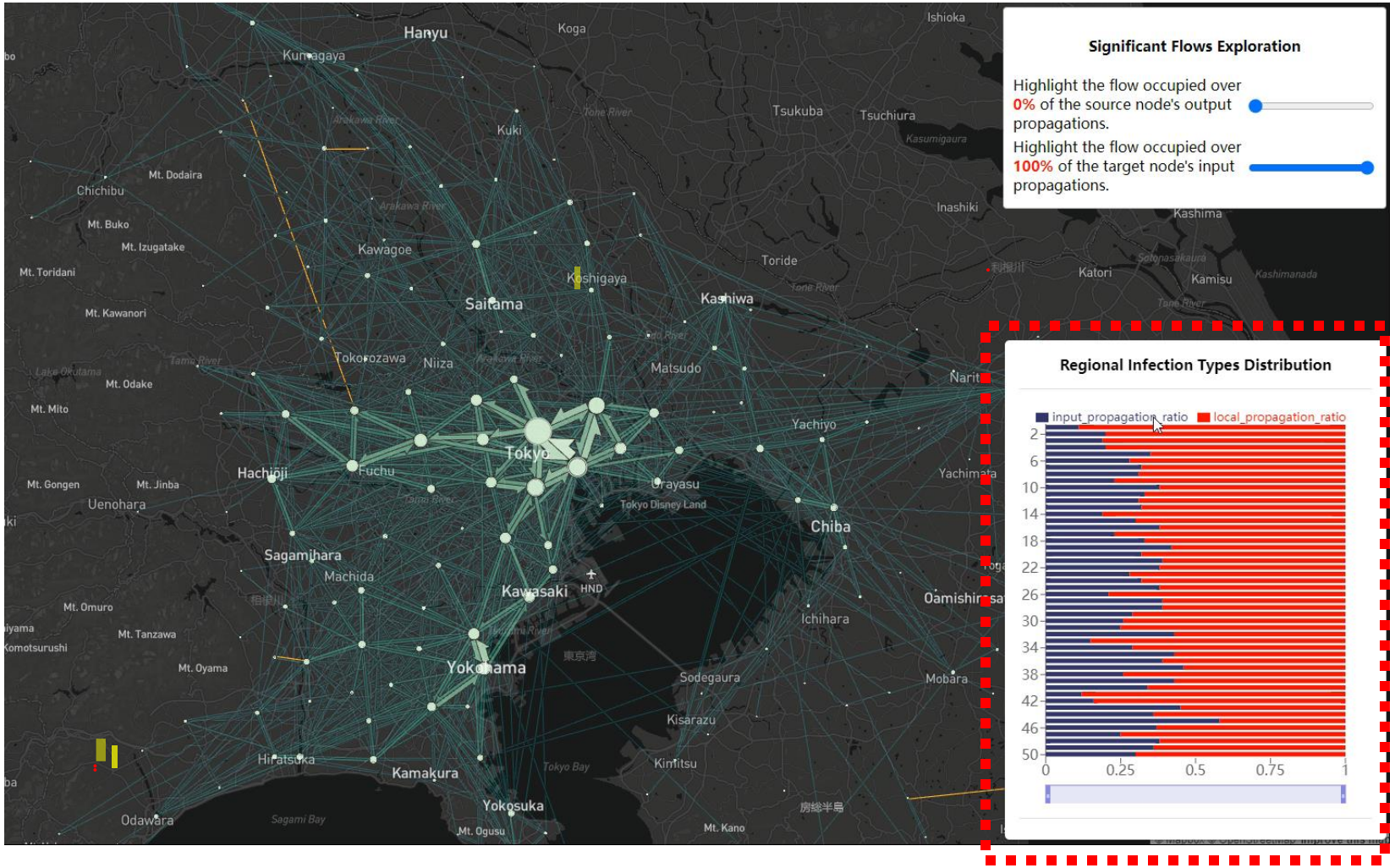
Find significant input node/region



Find significant output node/region

III. Visualization Design of the Prototype System

➢ Result Evaluation --- In depth Analysis View



A tracing panel to explore the local infection patterns.

- Each bar represents a region.
- The blue and red bar encode the proportion of the two infection types.
- When the clicks on the bar of interest, its in-out flow, and spatial coverage are highlighted on the map.

Content

IV. Case Study & Findings

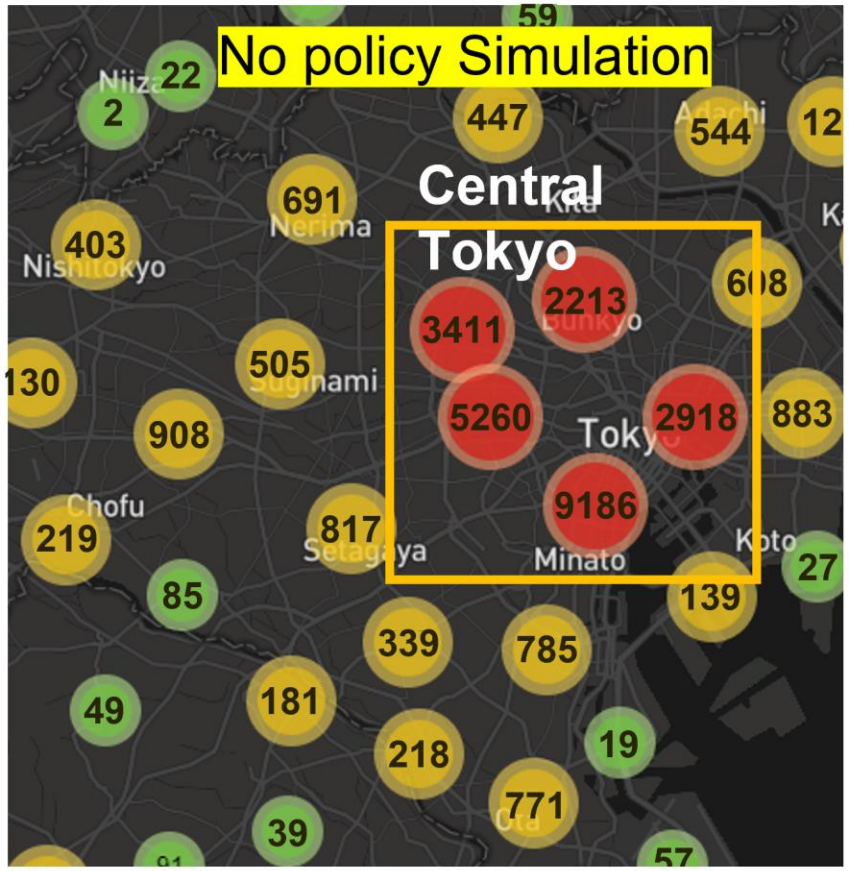
➢ Settings

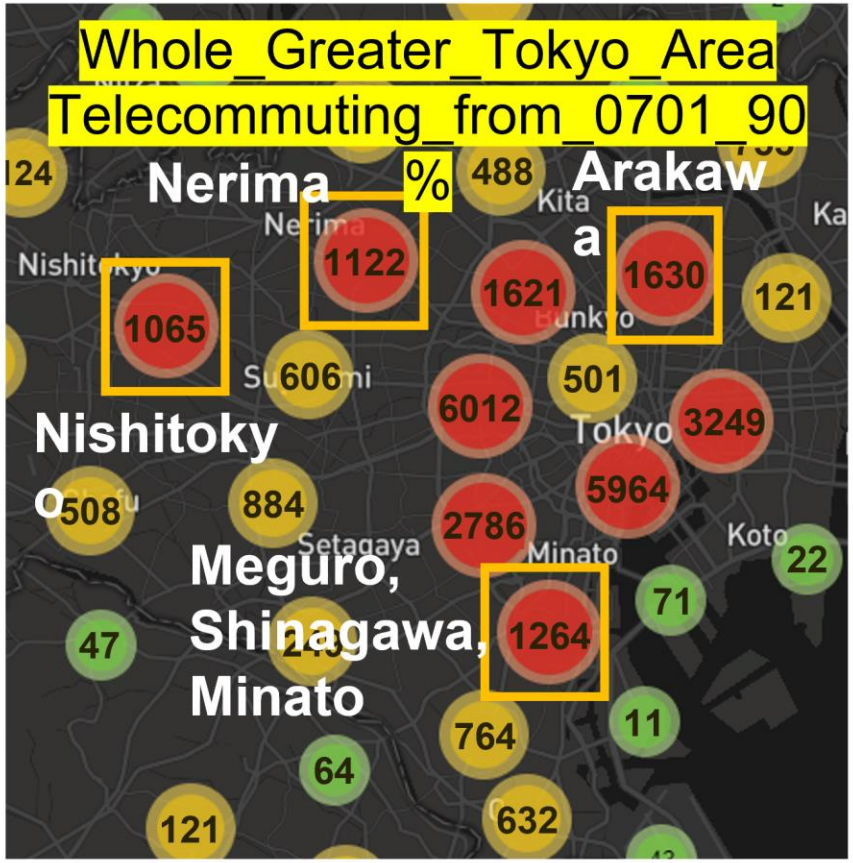
- Simulation Time Range: 2012-07-01 to 2012-07-31 -> 1 months
- Simulation Spatial Range: Greater Tokyo Area
- Simulation Individuals Number: 30000
- Initial Infection Number: 10
- Epidemic model: Trajectory-based SEIR model
- Simulated Infectious Disease.
  - COVID-19
  - Epidemiological parameters are set with reference to medical papers and the real infection data of first wave in the Greater Tokyo Area [1,2,3]

[1] Linton, Natalie M., et al. "Incubation period and other epidemiological characteristics of 2019 novel coronavirus infections with right truncation: a statistical analysis of publicly available case data." Journal of clinical medicine 9.2 (2020): 538.
[2] S. Chang, E. Pierson, P.W. Koh, J. Gerardin, B. Redbird, D. Grusky, and J. Leskovec, “Mobility network models of covid-19 explain inequities and inform reopening,” Nature, pp. 1–6, 2020.
[3] T. Kuniya, “Prediction of the epidemic peak of coronavirus disease in japan, 2020,” Journal of clinical medicine, vol. 9, no. 3, p. 789, 2020.

V. Case Study & Findings

➢ Case-1 Exploring the Effect of telecommuting policies.



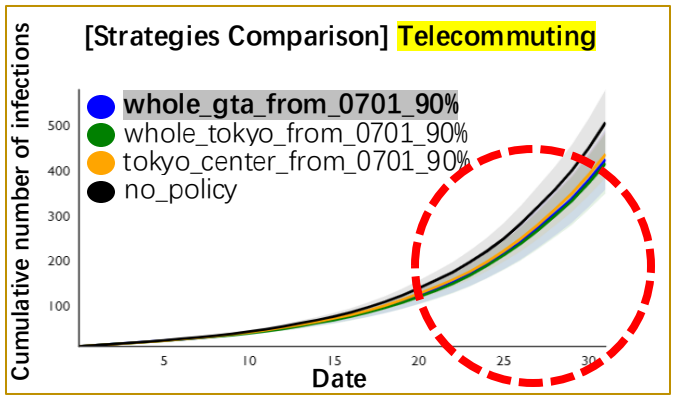


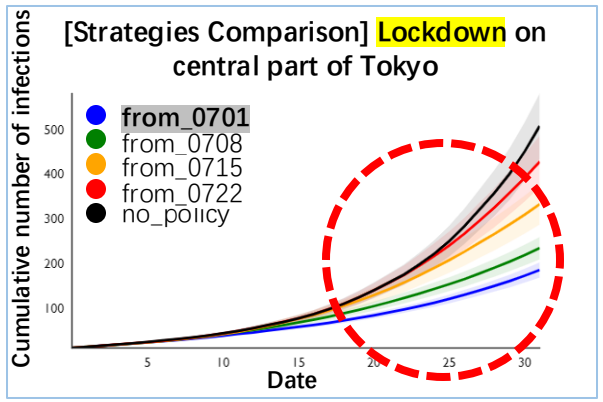
"Household Infections Rise in Urban Areas—Most Common Route of Infection in Tokyo" --- Asahi Shimbun[1]

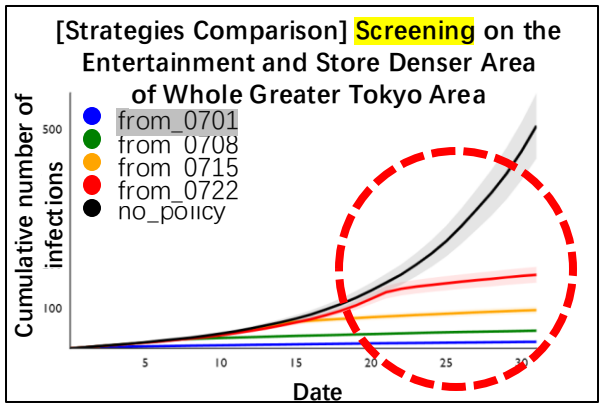
[1] https://www.asahi.com/articles/ASNDS56RPNDPULBJ00T.html

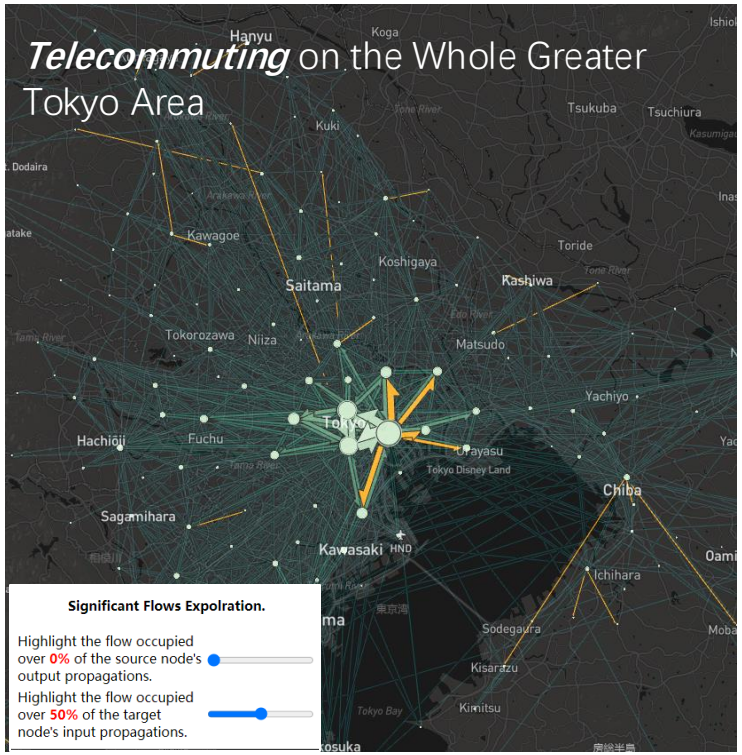
V. Case Study & Findings

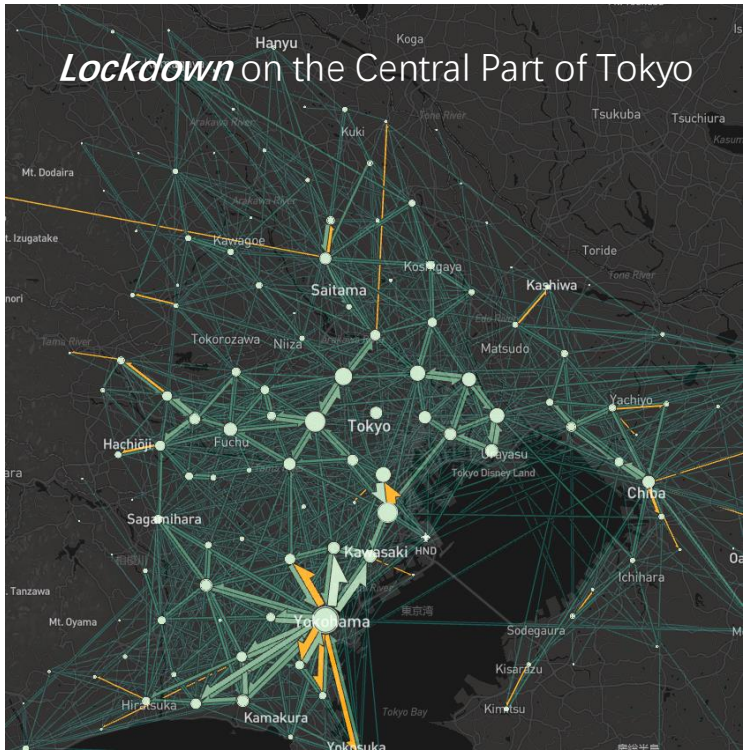
➢ Case-2 Exploring the Effect of screening policies.

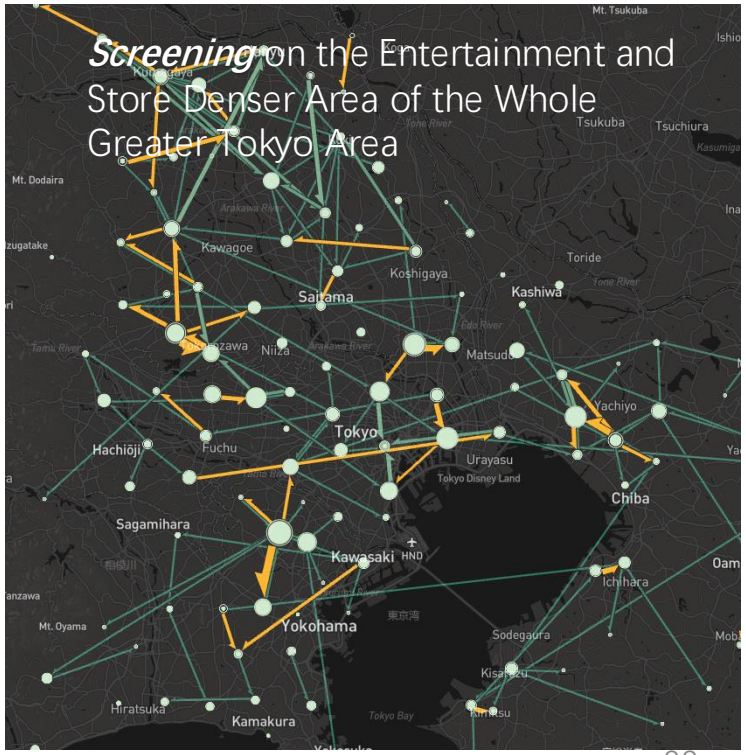












VI. Summary

- A simulator towards citywide epidemic control scenarios
  - Users can interactively and intuitively explore, set, and simulate various mobility restriction policies at the city scale.
  - Measure, compare and analysis the effectiveness of policies.
  - Currently, three policies are supported:
    - regional lockdown
    - Telecommuting
    - Screening
  - User can utilize the control policies/epidemic models/visualization view customized by themselves.
  - More details and case studies are available in our paper.
    - **Yang, Chuang, Zhiwen Zhang, Zipei Fan, Renhe Jiang, Quanjun Chen, Xuan Song, and Ryosuke Shibasaki. "EpiMob: Interactive Visual Analytics of Citywide Human Mobility Restrictions for Epidemic Control."** ***IEEE Transactions on Visualization and Computer Graphics*** **(2023).**

THANK YOU FOR LISTENING!
Q&A