

Socio-Technical Systems Engineering and Design: A Meso-Level Network-Based Approach

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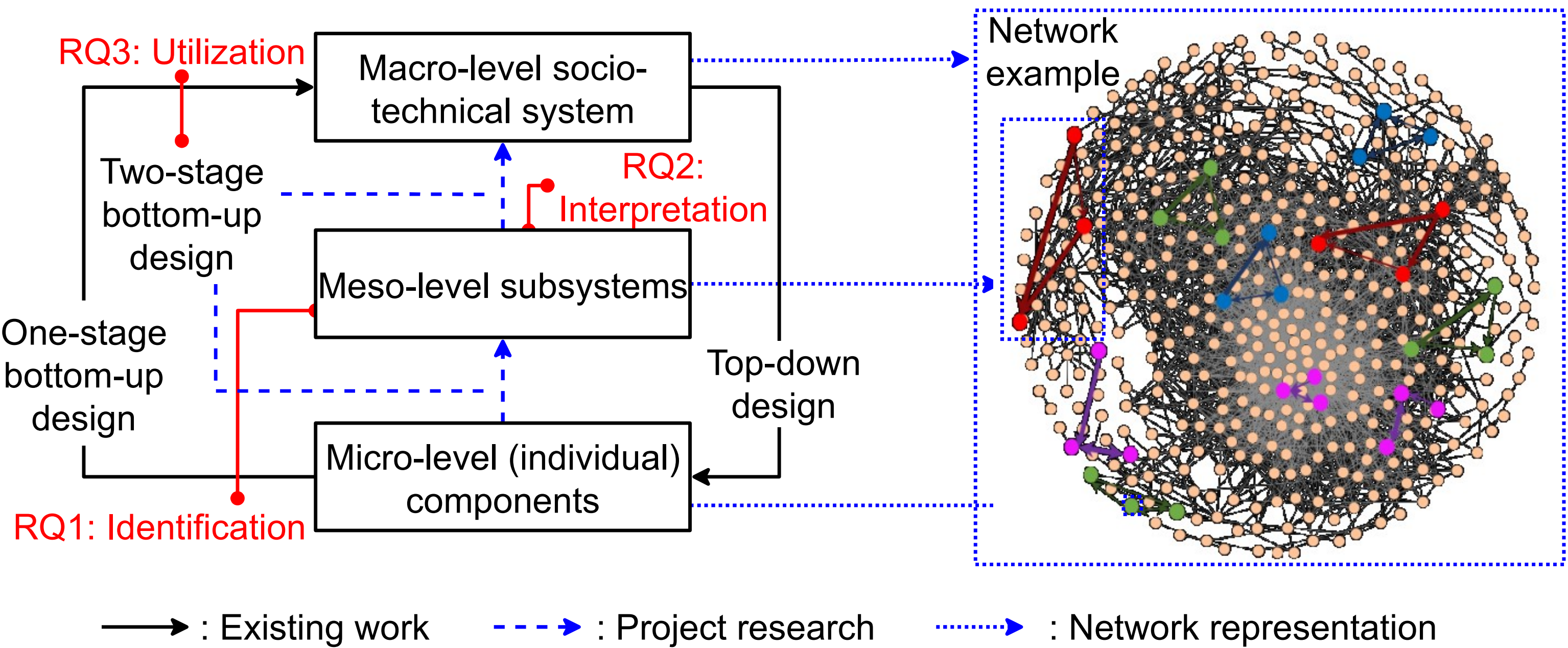



Background and Motivation

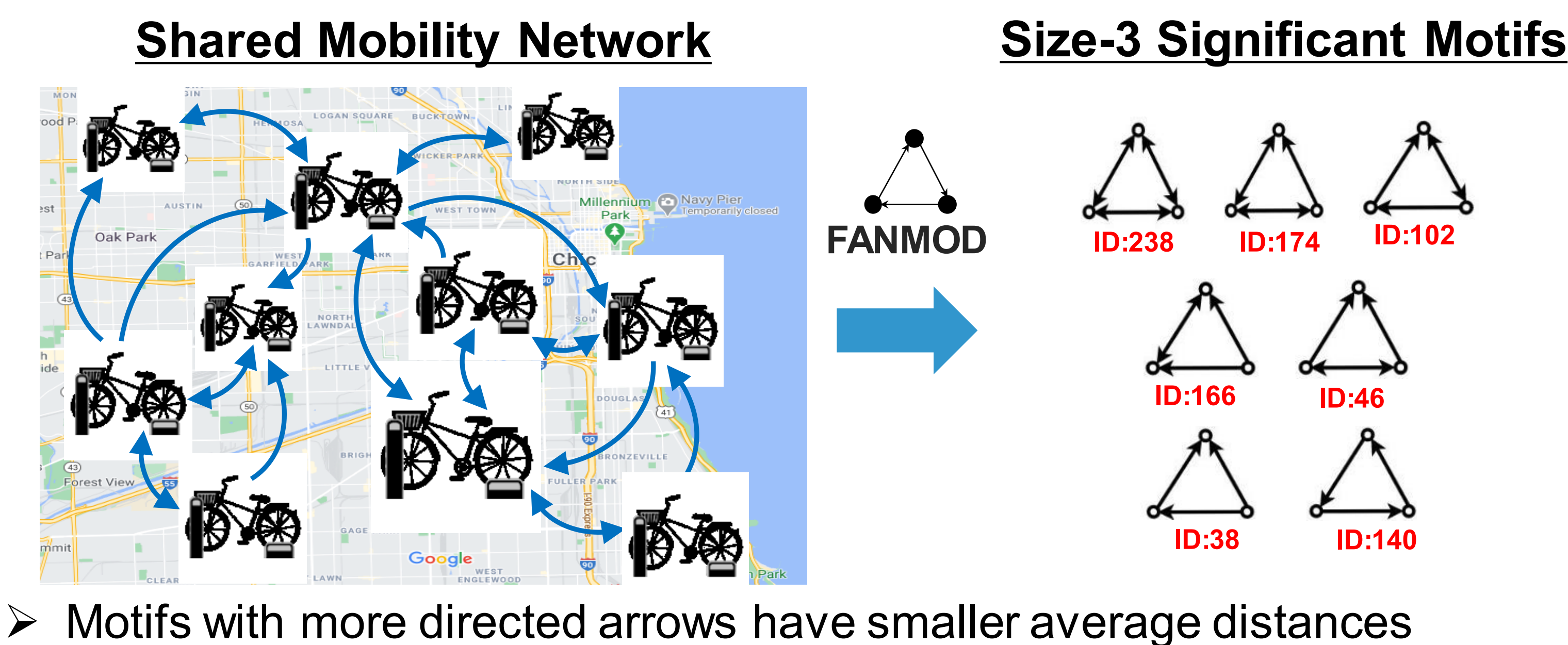
- The design of socio-technical systems (STS), emerging from the interplay between social and technological factors from the bottom-up, cast new challenges in the systems engineering lifecycle.
- The meso-level structures (i.e., small subgroups and clusters) could serve as critical links in influencing STS structures and behaviors.
- A fundamental knowledge gap exists in understanding how critical meso-level information in STSs can be extracted and utilized to guide the design of such systems.

Research Objective and Questions

- **Research Objective:** To develop a meso-level network-based design framework for complex socio-technical systems.
- **Research Questions:**
 - 1) How can the significant meso-level system structures be identified?
 - 2) What are the quantitative influences of those significant meso-level subsystems on the system performance at the macro-level?
 - 3) how can the meso-level structural information be used to design an STS to achieve desired macro-level structure and performance?

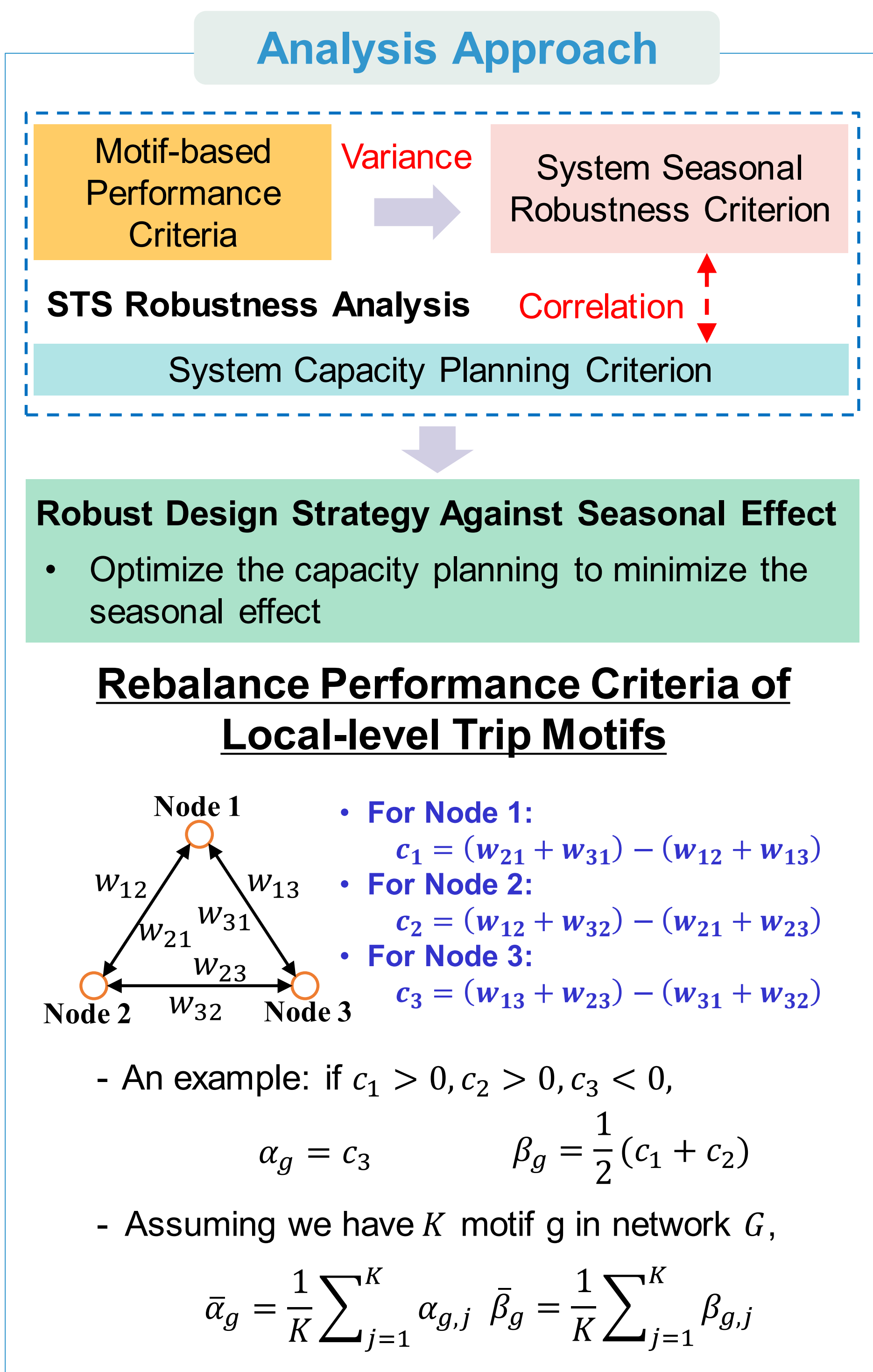


Study One: Significant Network Motif (Sub-Network) Identification and Feature Extraction^[1]



[1] Y. Xiao, Z. Sha, "Towards Engineering Complex Sociotechnical Systems Using Network Motifs: A Case Study on Bike-Sharing Systems", ASME 2020 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference, St. Louis, MO, Aug. 16-19, 2020.

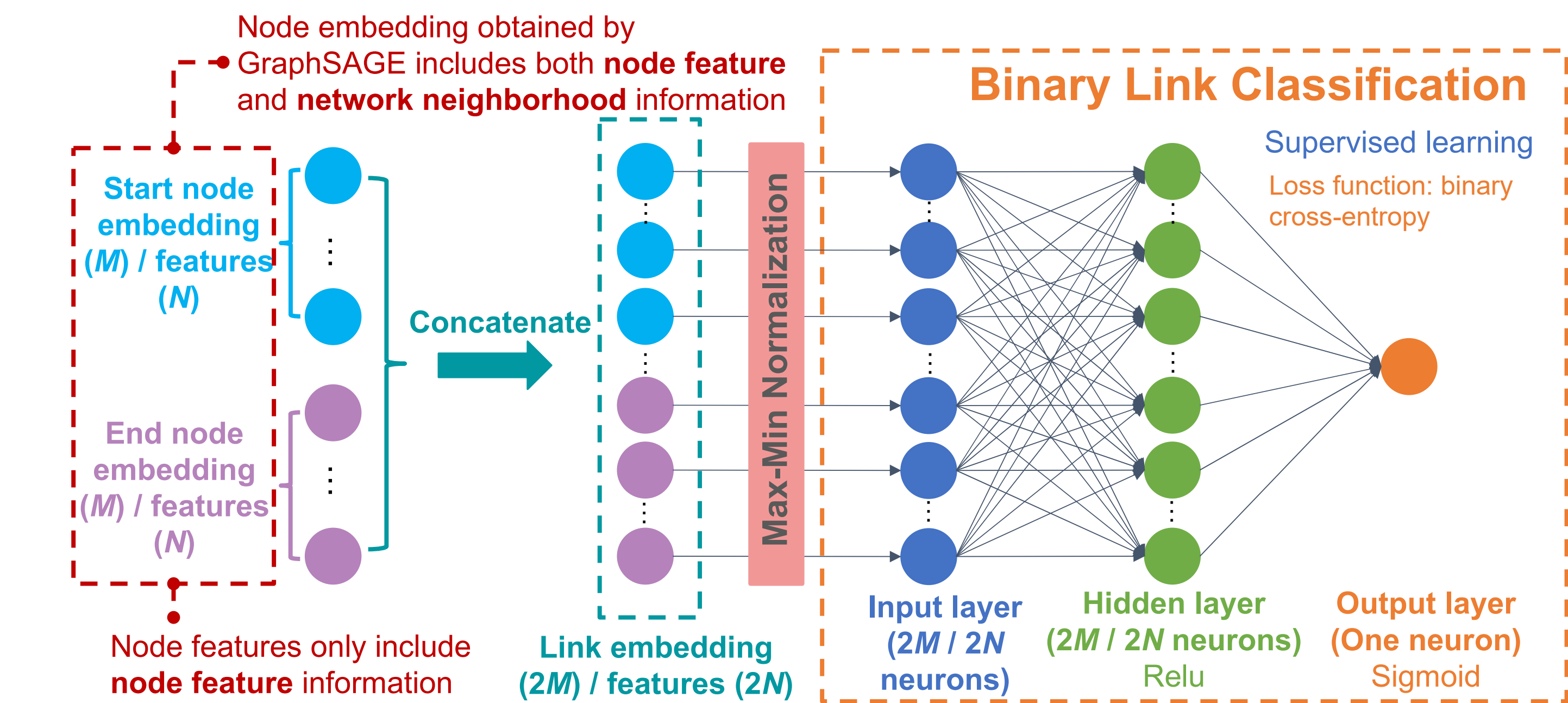
Study Two: Network Motif-Based Robust Design of STS Against Seasonal Effects^[2]



[2] Y. Xiao, Z. Sha, "Robust Design of Complex Socio-Technical Systems against Seasonal Effects: A Network Motif-Based Approach", Design Science, 8, E2.

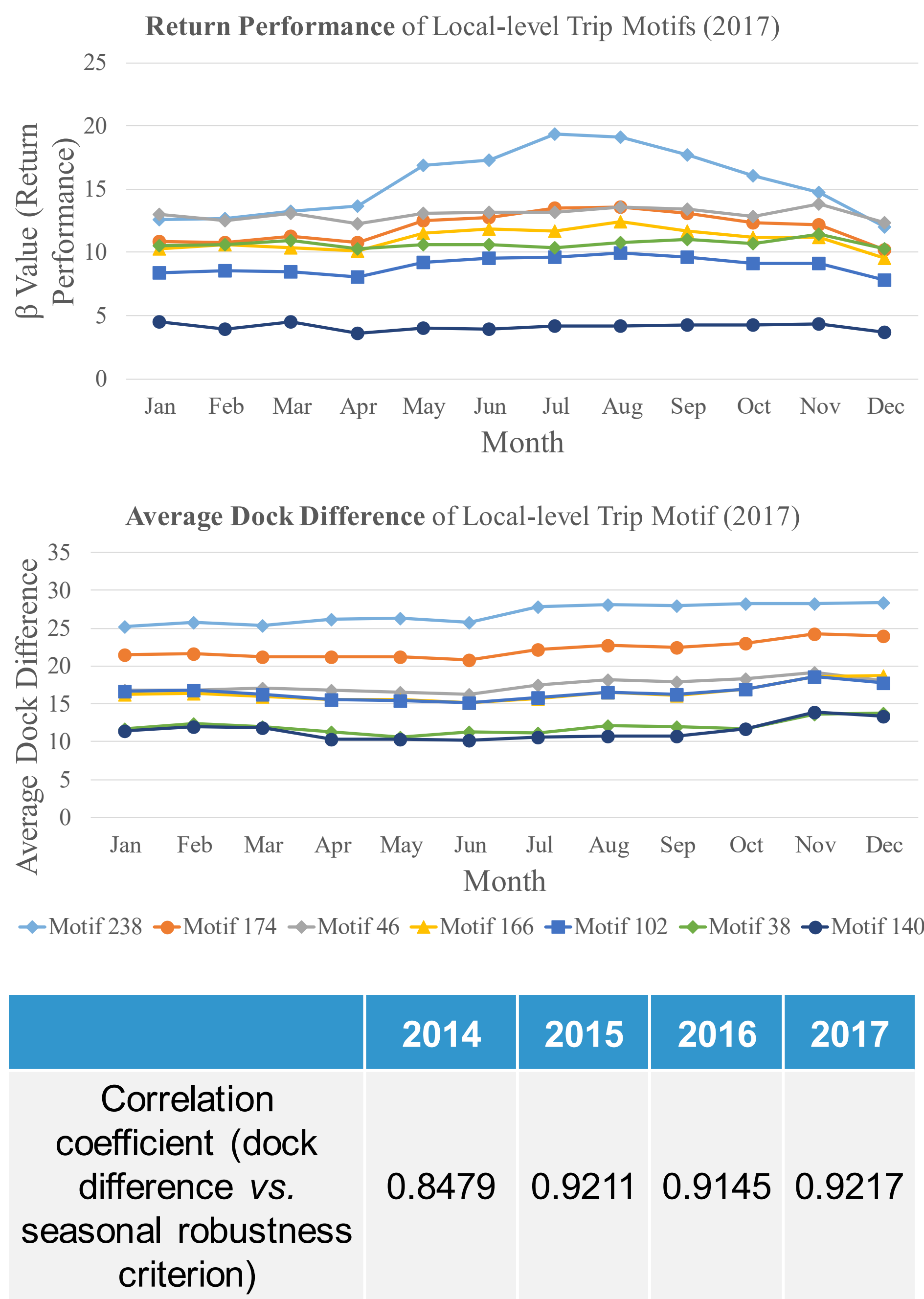
Study Three: Using Local Network Information for Link Prediction^[3]

- Year One local network information and node attributes are applied to predict Year Two linkage.
- Higher PR AUC of GraphSAGE implies that **local network information** can enhance the predictive power of the **minority class (positive links)** at an aggregated level.

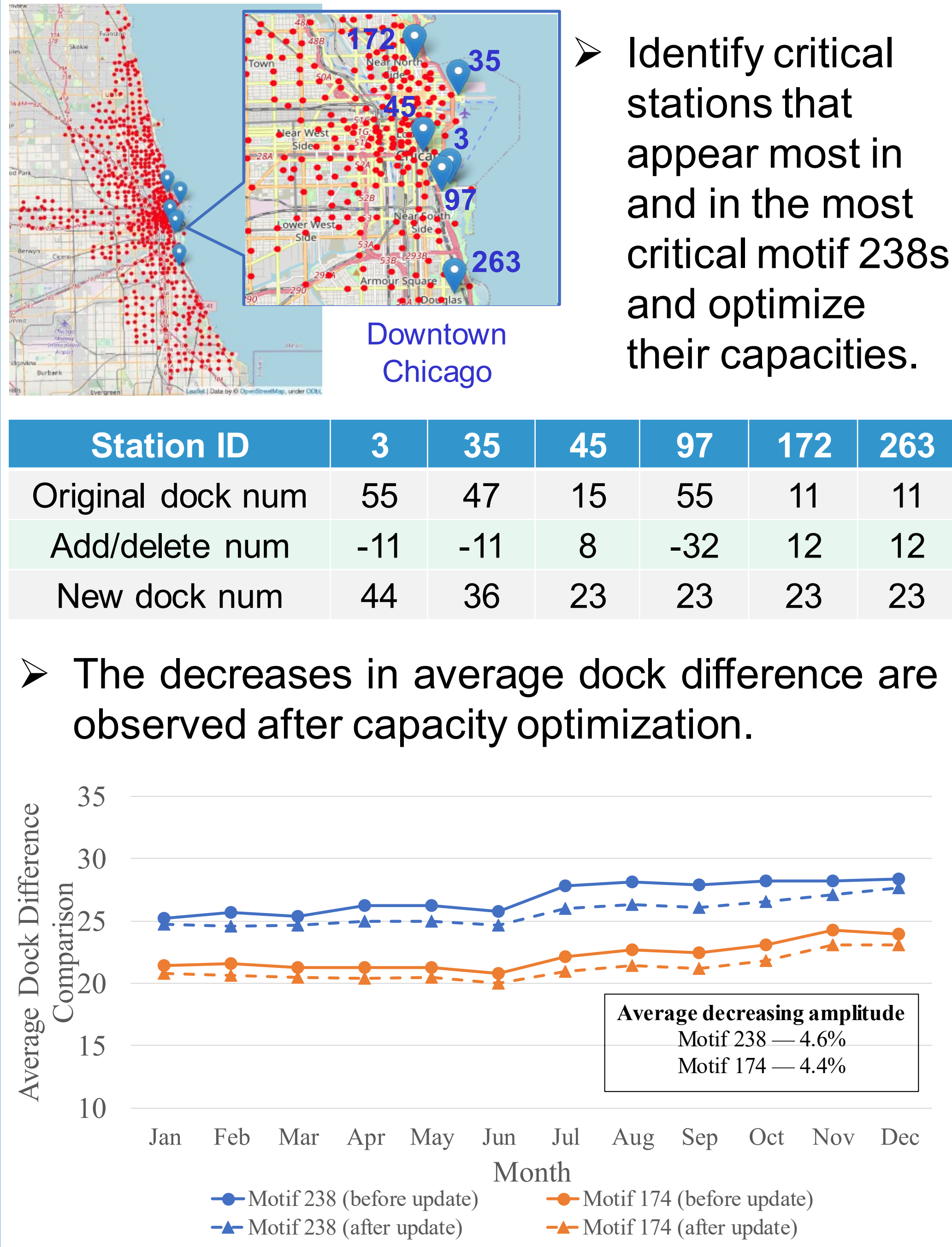


[3] Y. Xiao, Z. Sha, "Socio-Technical Systems Engineering and Design: A Meso-Level Network-Based Approach", DTM Student Poster Competition, ASME 2022 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference, St. Louis, MO, Aug. 14-17, 2022.

STS Robustness Analysis



Robust Design Method



- Identify critical stations that appear most in and in the most critical motif 238s and optimize their capacities.

- The decreases in average dock difference are observed after capacity optimization.

Future Work

- Assess the utility of the local network information-based predictive model in support of design decision evaluation.
- Incorporate meso-level structure information into the process of STS design to achieve desired meso-level and macro-level system performances.
- Develop a meso-level network-based design framework.

For more information, please contact

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