Georgia Tech Physical Internet Center
Stewart School of Industrial & Systems Engineering

Potential Access Hub Network Design Optimization in Hyperconnected Urban Logistics

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1. Physical Internet Center
2. Supply Chain & Logistics Institute
3. Coco-Cola Chair in Material Handling & Distribution
4. H. Milton Stewart School of Industrial & Systems Engineering

Georgia Institute of Technology, Atlanta, USA

Corresponding author: pmuthukr3@gatech.edu

Introduction

❑ Impact of Lockdown Effect During COVID-19 Pandemic

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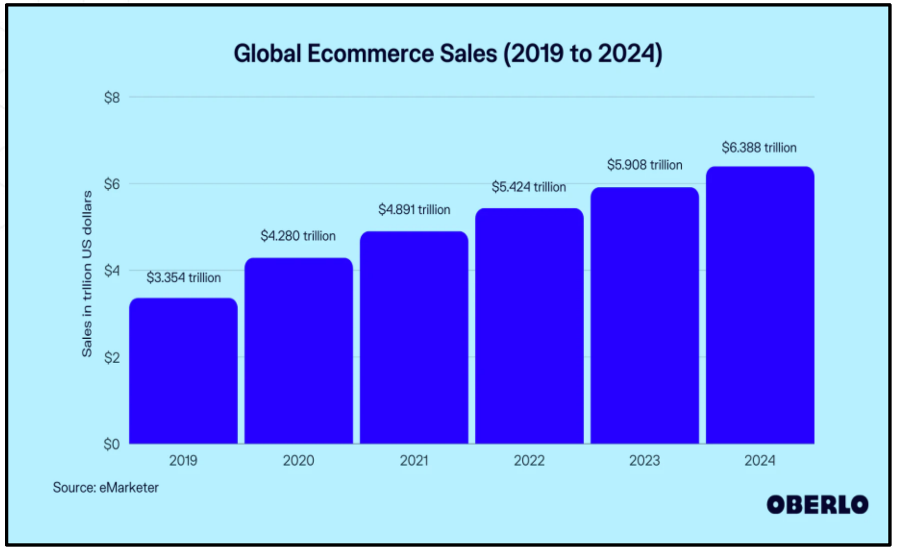
Retail store closures from 2017 to 2020 in US



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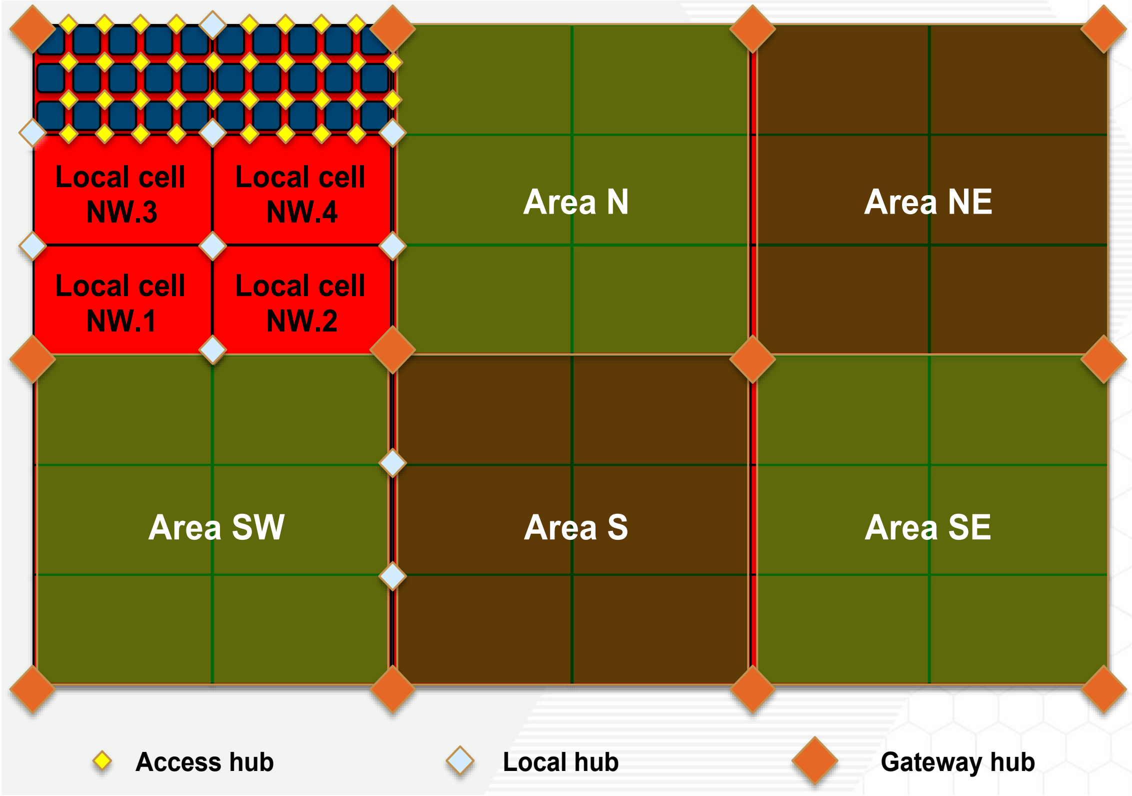
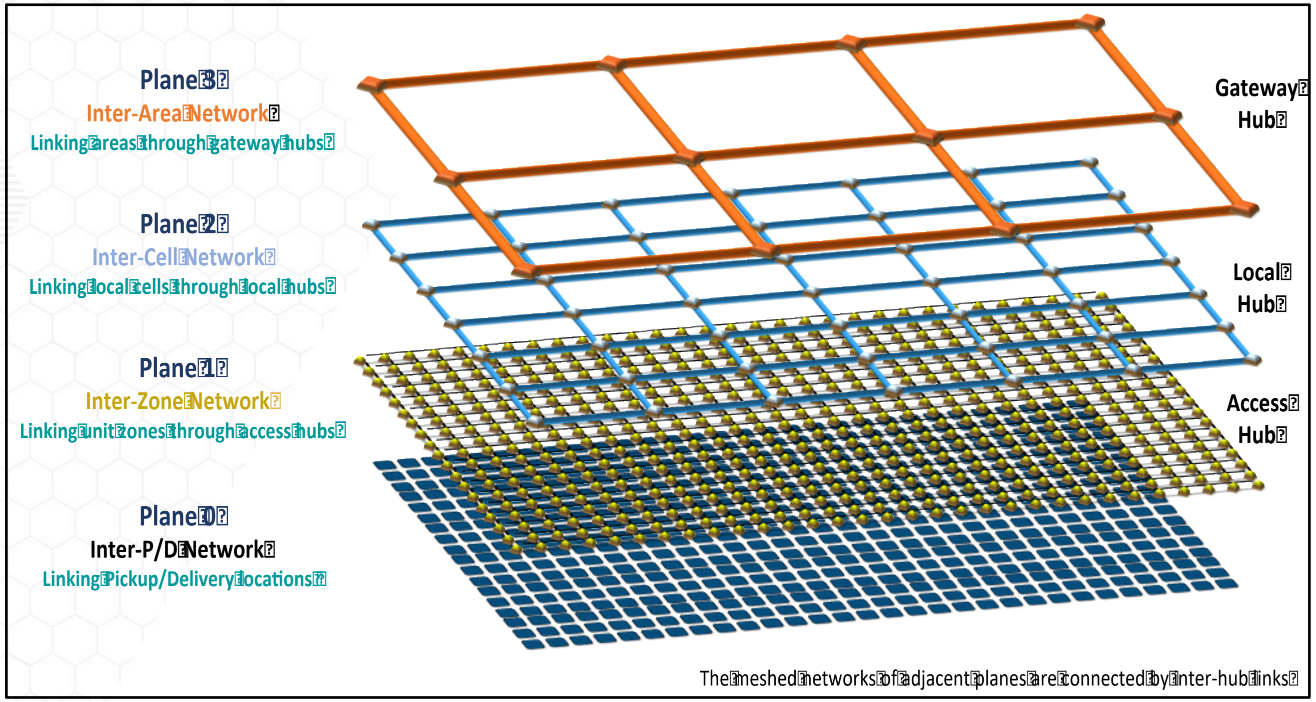
Hyperconnected Logistic web : The Next-Gen

Cbtfe!po!Nvmj.Ujfs!Ijfsbsdijdbm!Tqbdf!Tusvduvsjoh!boe!bo!Joufsdpoofdufe!Nvmuj.qmbof!Mphjtujdt!Nfti!Ofuxpsl t

"Future of retail might be transformation of stores into mini- or micro-Distribution Centers located near customer locations to meet increased e-commerce demands and fulfillment timelines"





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Problem Definition

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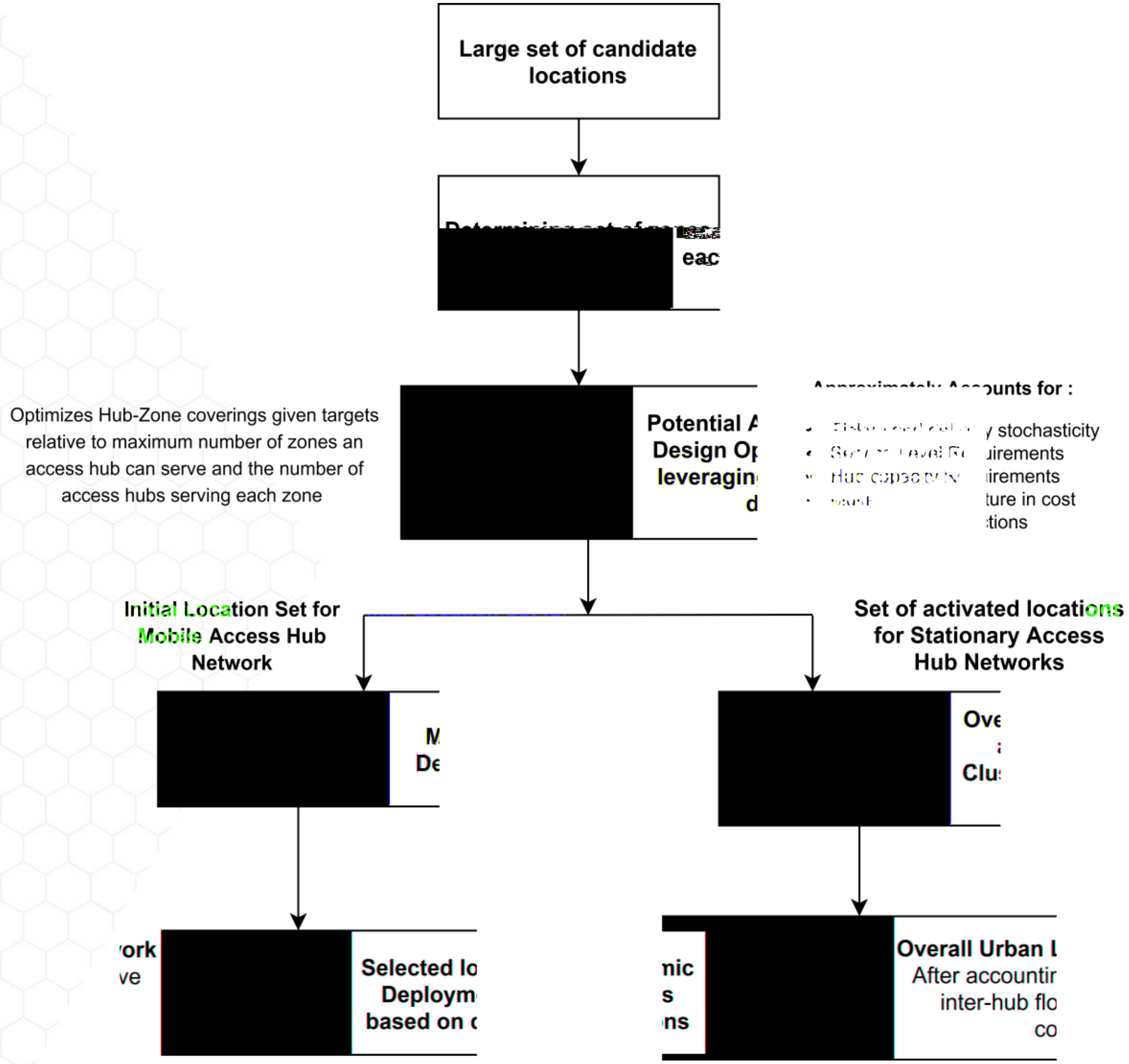

Assumptions used in the Proposed Optimization Model

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Allocation of locations to unit zones

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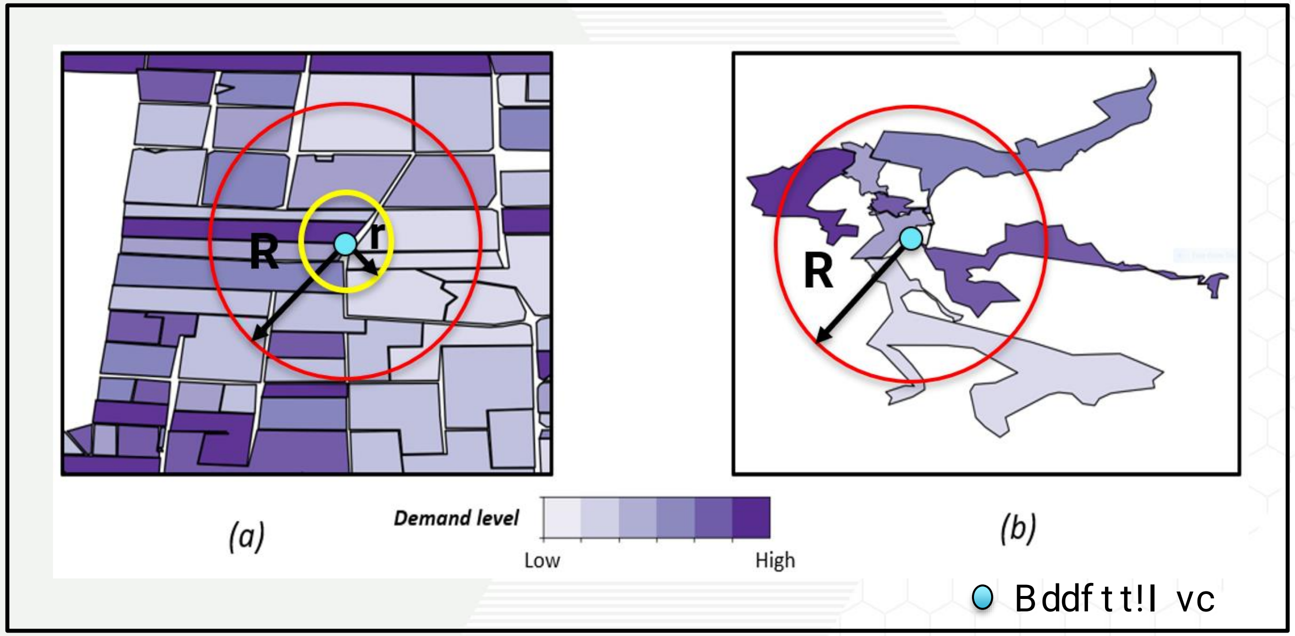
- Gjy b uisftipme ejtubodf gspn fbdi mpdbujpo boe bttjho juup cf dbqbcmf pg tfswjoh voju{poft gbmmjoh voefs uif jn bhjobsz djsdmf xjui uisftipme ejtubodf bt sbejvt



(a) Dense collection of unit zones smaller in area

(b) Sparse collection of unit zones larger in area

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HFP.T FDJGJD!UI SFTIPME!

Accounting for distribution of unit zones across the megacity

Optimization Model - Decision Variables and Parameters

Mathematical Sets:

U set of unit zones

A set of candidate locations

P set of {zone, location} pairs where $(u, h) \in$ P implies o pof $u \in U$ can be served from location $h \in A$.

Parameters:

s_u total pickup and delivery demand of unit zone $u \in U$

m_u minimum number of activated locations required near unit zone $u \in U$

t_h maximum number of unit zones that can be served from location $h \in A$

C_m fixed cost of adding a module

$C_u(s_u, h)$ operation cost estimates of courier (s) serving $u \in U$ from hub at location $h \in A$

$C_d(h)$ fixed cost of deploying a hub at location $h \in A$ - can be interpreted as land-reservation cost

Q_u maximum of inbound or outbound parcels at unit zone $u \in U$ during rider replenishment cycle

α capacity of a module

g_u known % imbalance in demand assigned to hubs capable of serving unit zone $u \in U$ and $g_u = 0$ if $m_u = 1$

Decision Variables:

X_h 0-1 variable indicating if hub is deployed at location $h \in A$

Y_{uh} 0-1 variable indicating if hub at location $h \in A$ is chosen to serve $u \in U, \forall (u, h) \in P$

Z_h number of modules added at location $h \in A$

Integer Programming Formulation

$$\min \quad \Big(\sum_{(u,h)\in P} C_u(s_u,h) * Y_{uh} + \sum_{h\in A} C_d(h) * X_h + \sum_{h\in A} C_m * Z_h \Big) \qquad (1)$$

N jojn j{f t!dpvsjf s!pqf sbujpot!boe!ef qmpzn f ou dptut

Subjected to:

$$\sum_{u\in U} Y_{uh} \quad \leq \quad t_h * X_h \quad \forall h \in A \qquad (2)$$

Limits #zones an activated location can serve

$$\sum_{h\in A} Y_{uh} \quad \geq \quad m_u \quad \forall u \in U \qquad (3)$$

Ensures min #activated locations near each zone

$$\sum_{u:(u,h)\in P} (\frac{1}{m_u} + g_u) Q_u * Y_{uh} \quad \leq \quad \alpha * Z_h \quad \forall h \in A \qquad (4)$$

Ensures enough capacity deployed at each location

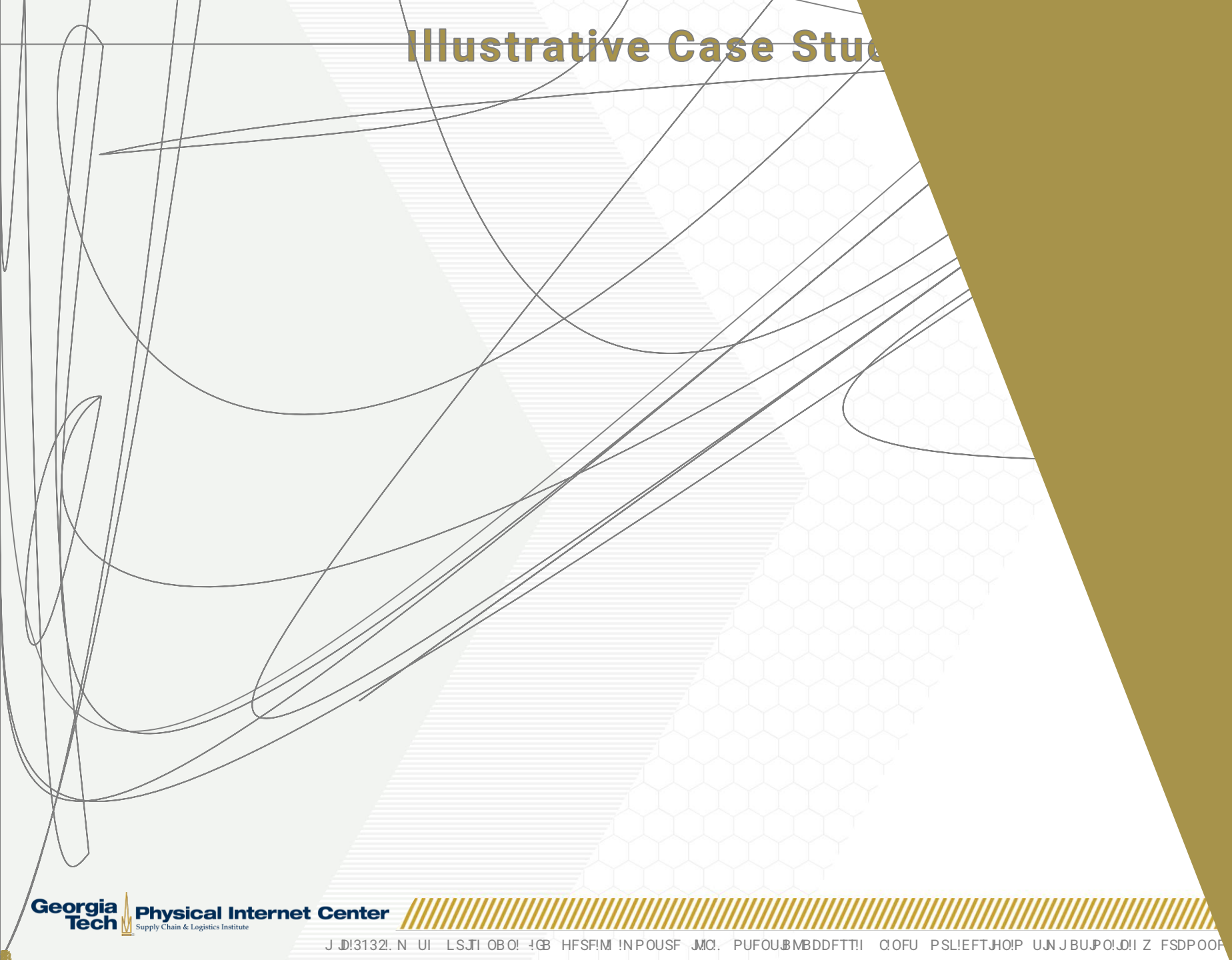
$$Z_h \quad \leq \quad M * X_h \quad \forall h \in A \qquad (5)$$

Modules are added only when location is activated

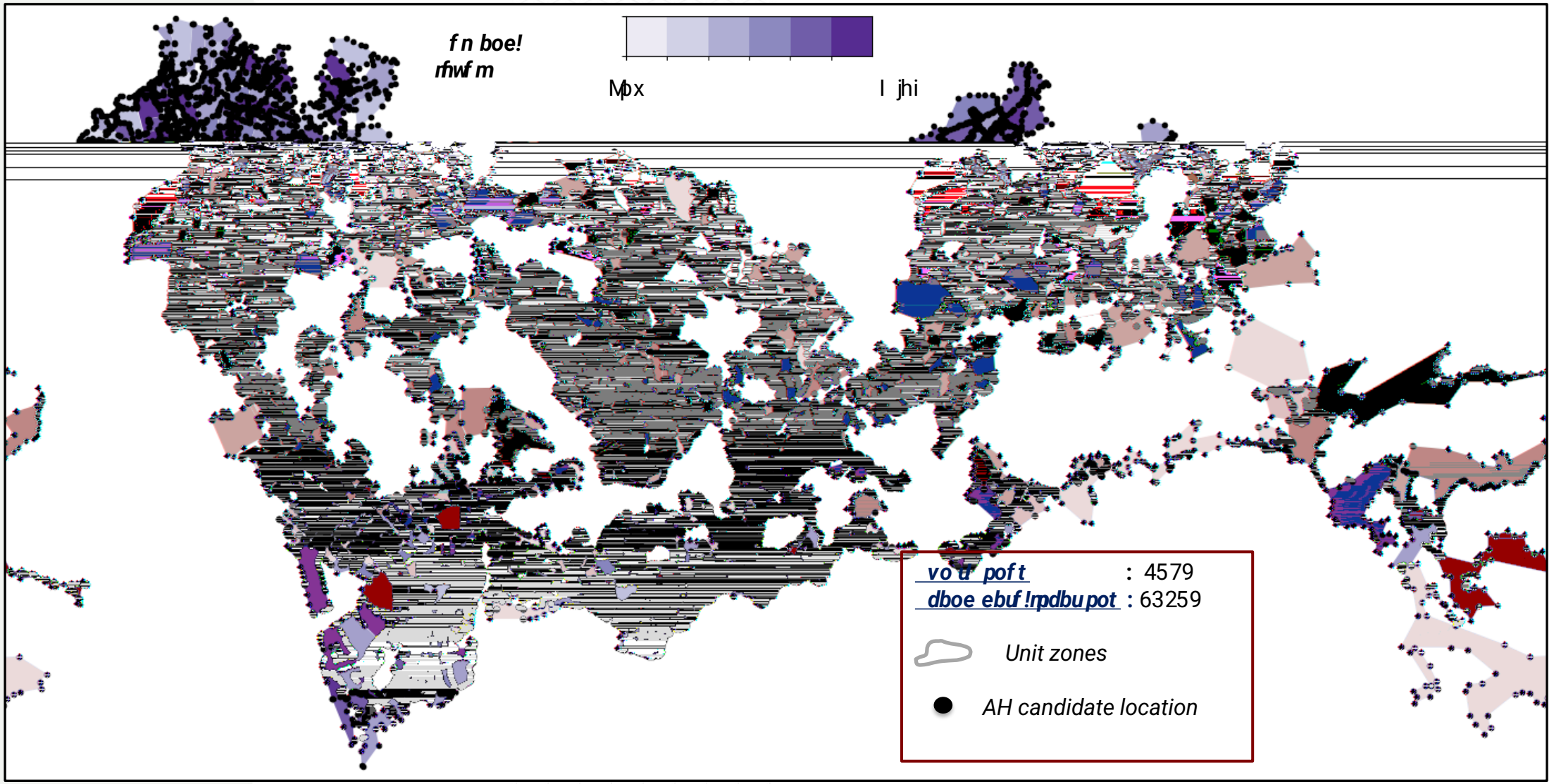
$$0 \leq X_h, Y_{uh} \leq 1, Z_h \geq 0 \quad \forall h \in A, (u,h) \in P \qquad (6)$$

$$X_h, Y_{u,h}, Z_h \text{ Integers, M is a sufficiently large positive number} \qquad (7)$$

Illustrative Case Stu



Illustrative Case Study - Map Containing all Unit Zones & Candidate Locations



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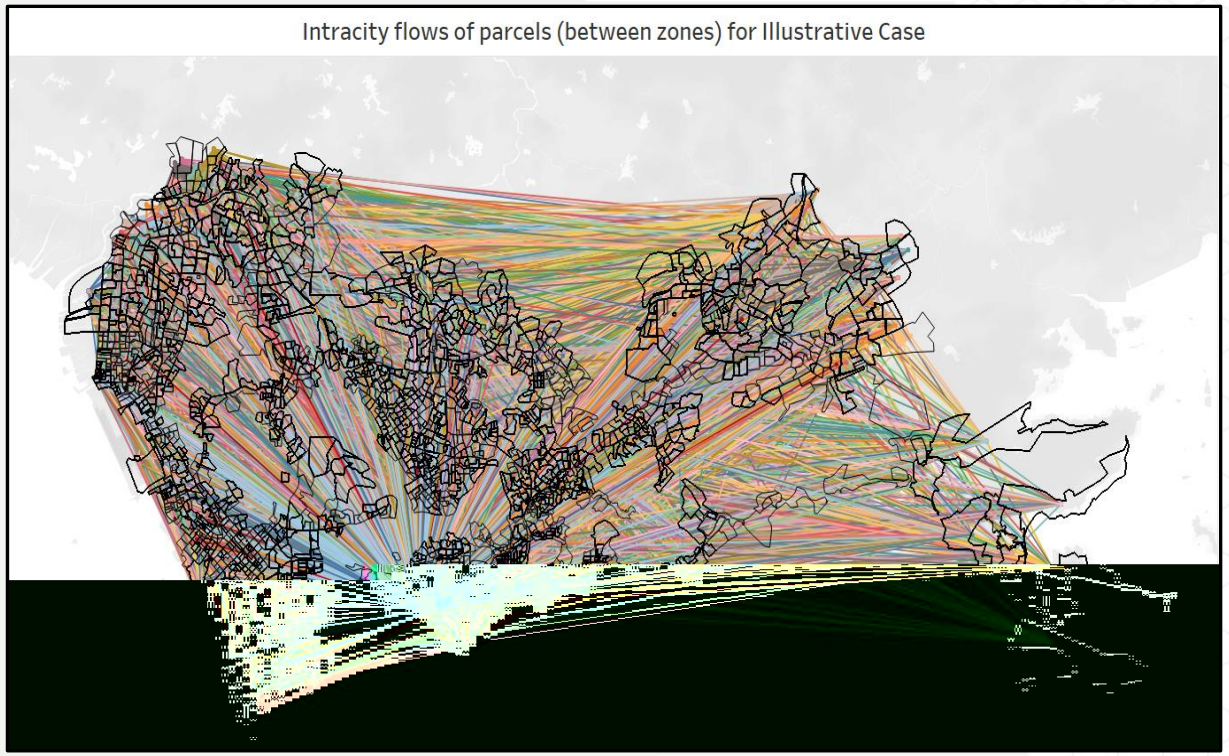
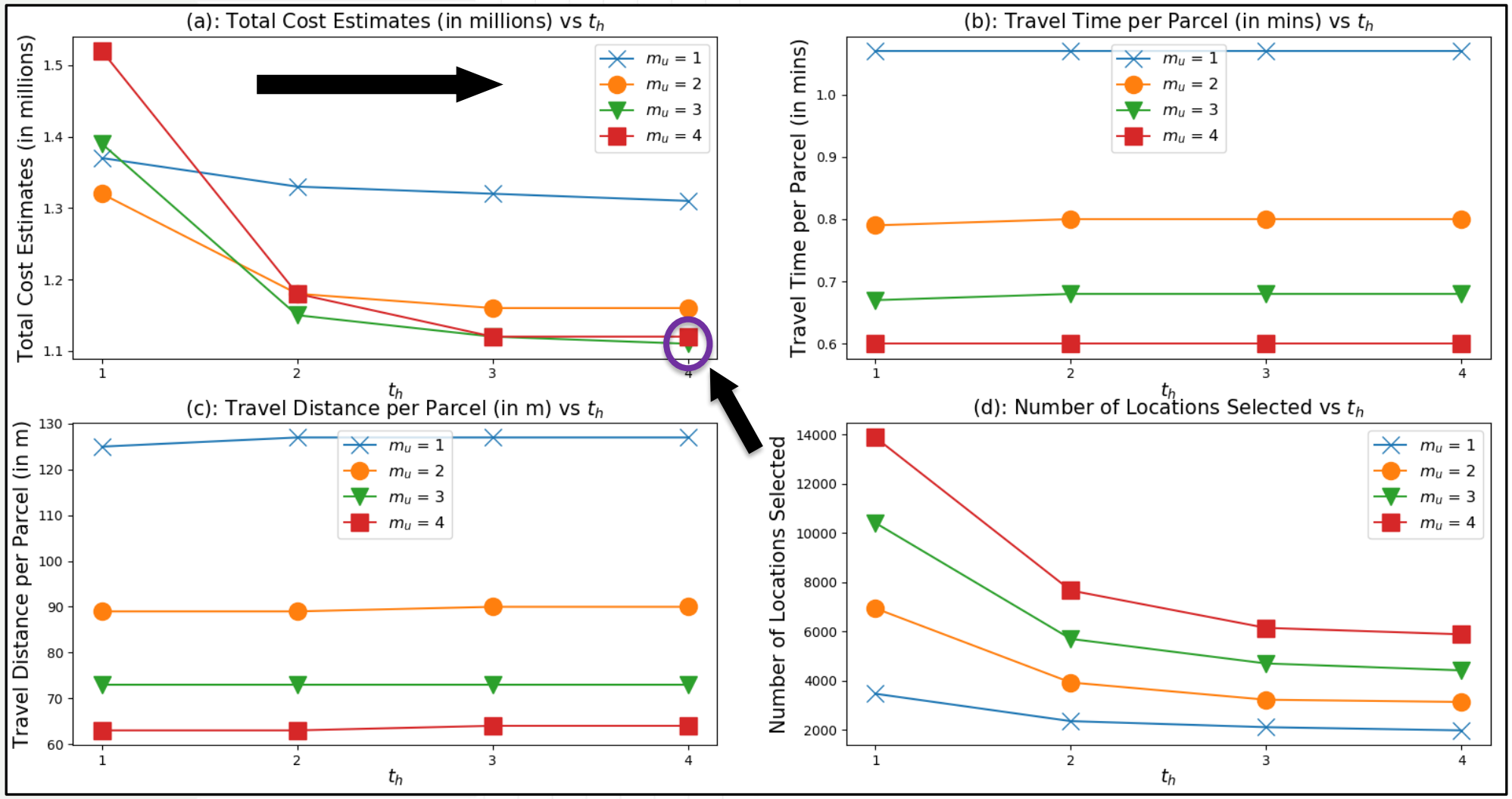
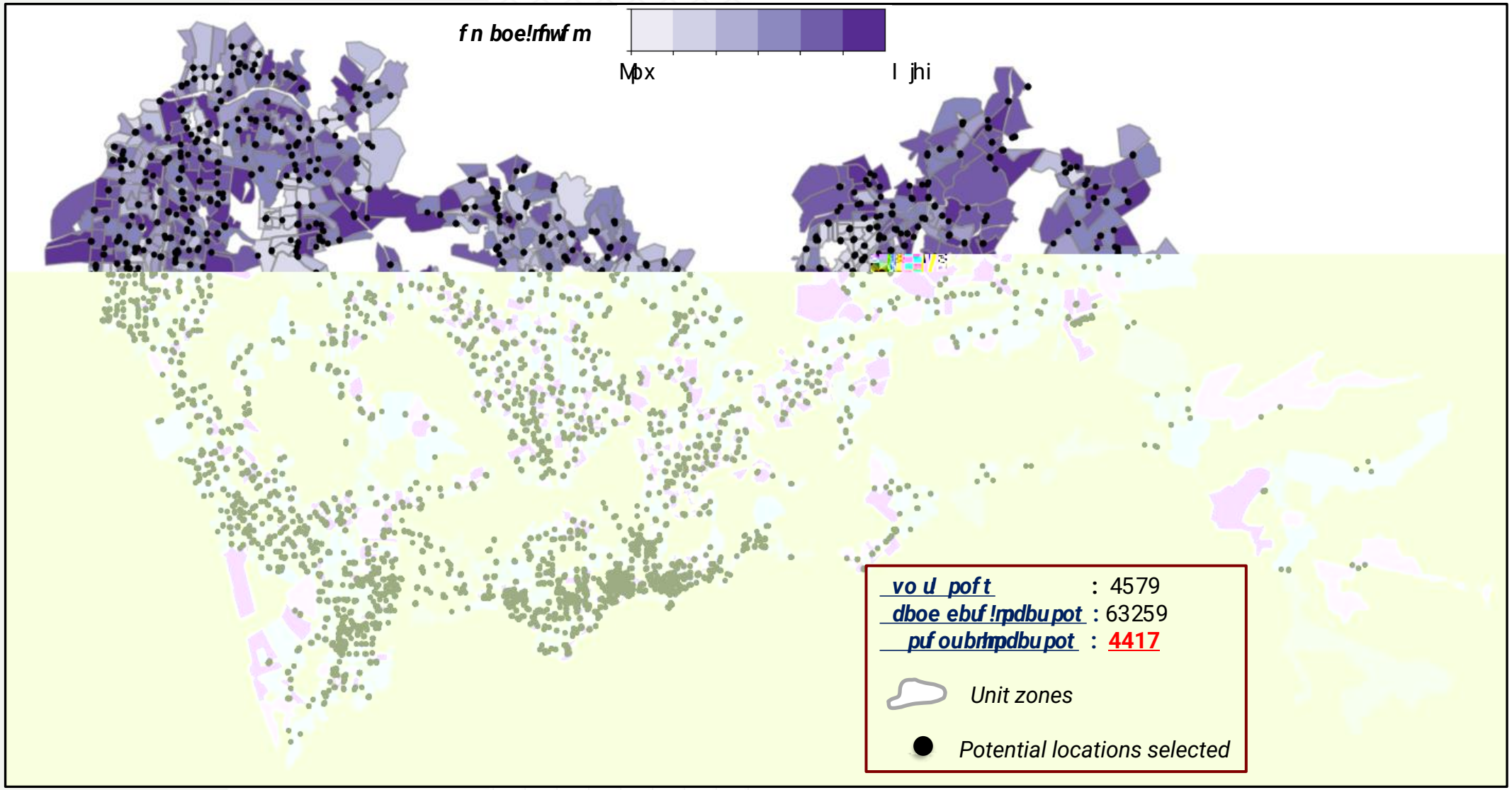

Intracity flows of parcels (between zones) for Illustrative Case

Key Performance Indicators vs t_h



Activated Locations chosen in the case: $m_u = 3$ and $t_h = 4$



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Future Avenues for Research & Innovation

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Questions, comments and ideas are most welcome !

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