18th ACM International Conference on Modeling, Analysis and Simulation of Wireless and Mobile Systems, 05 November, 2015, Cancun, Mexico

Modelling the Bandwidth Allocation Problem in Mobile Service-Oriented Networks

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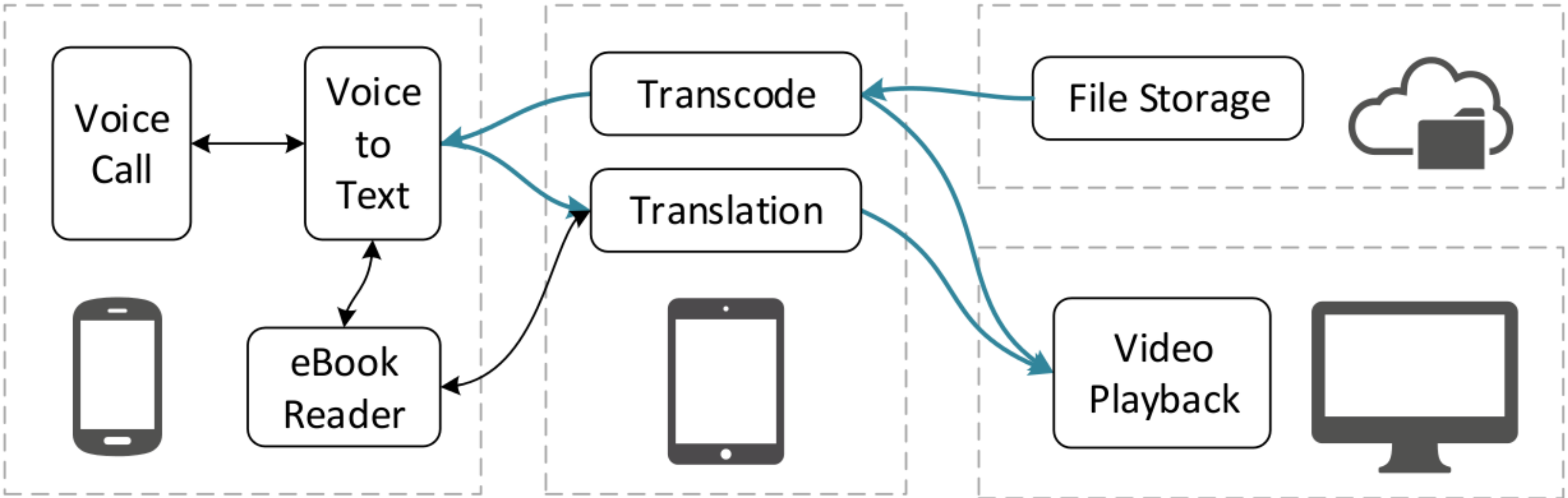
THE UNIVERSITY OF WARWICK

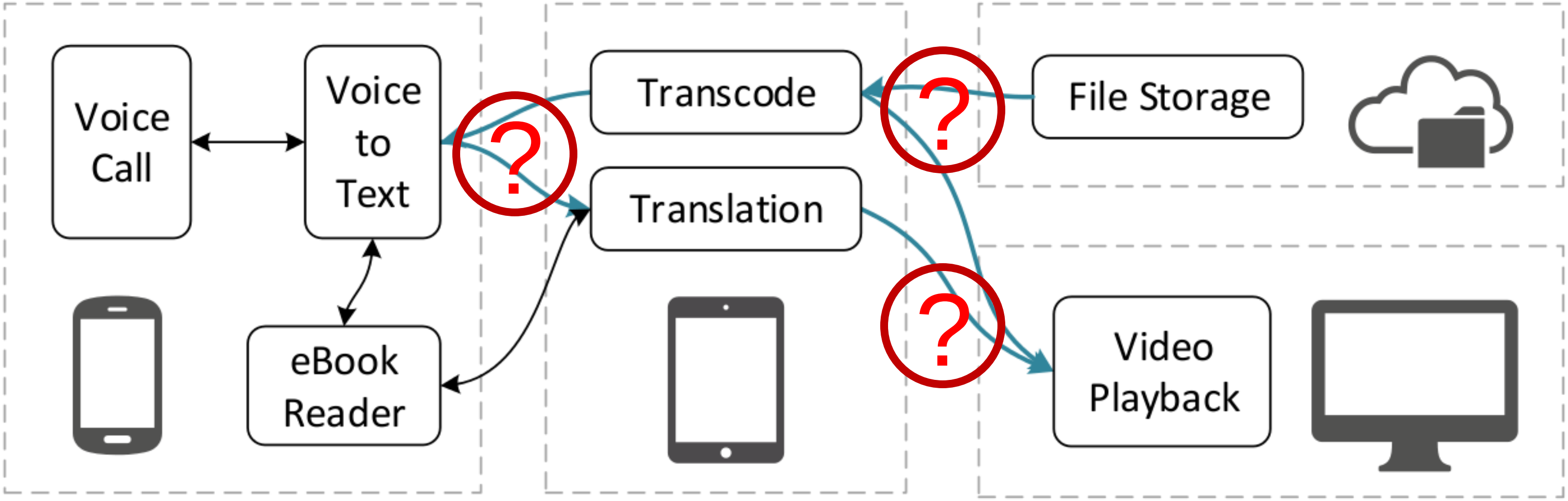
Outline

- The problem
  - Mobile Service-Oriented Networks (MSONs)
  - Service Bandwidth Dependency and Allocation
- Solution
  - Leontief Input-Output Model (Economics)
  - Network I-O Model (MSONs)
- Results

Mobile Service-Oriented Networks

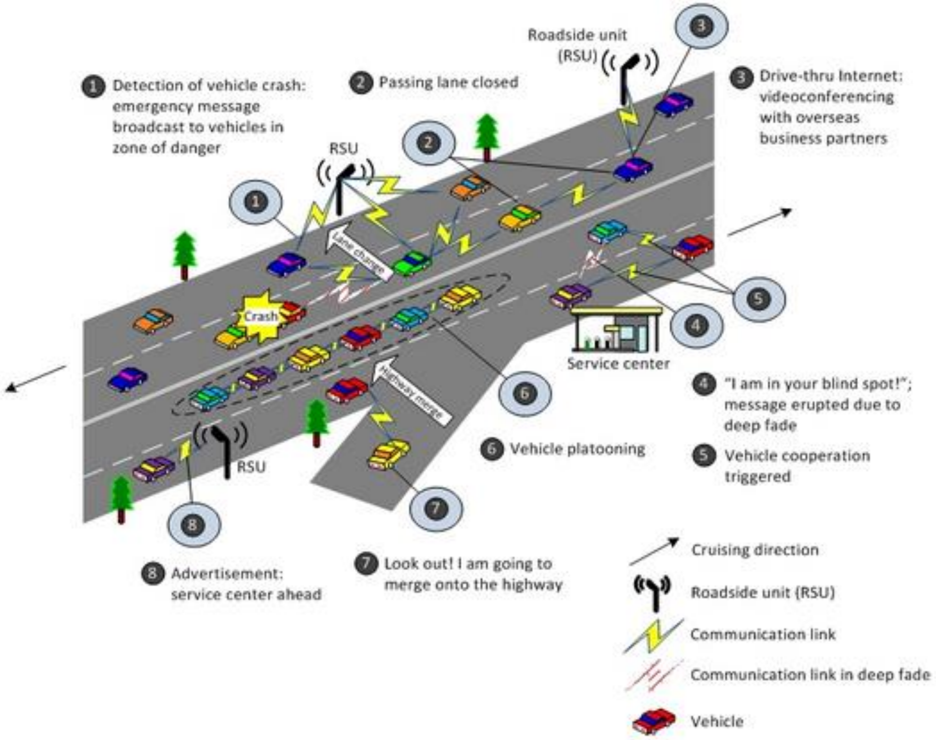


Mobile Service-Oriented Networks



Bandwidth Dependency? Allocation?

Mobile Service-Oriented Networks

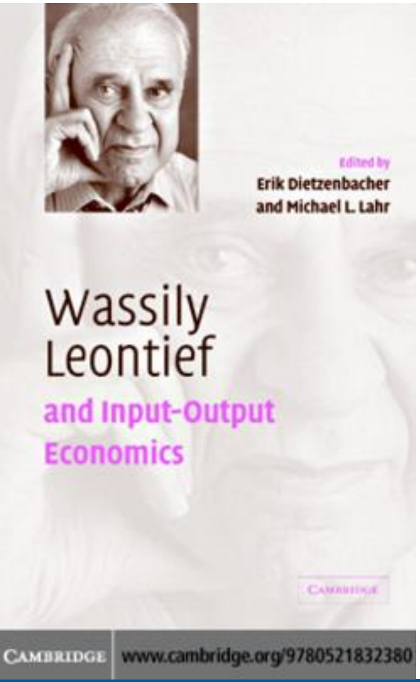


- H. T. Cheng, H. Shan, and W. Zhuang, "Infotainment and road safety service support in vehicular networking: from a communication perspective," *Journal of Mechanical Systems and Signal Processing (MSSP, Elsevier)*, in revision.

Leontief Input-Output Model

Exchange of Goods and Services in the U.S. for 1947 (in billions of 1947 dollars)

	Agriculture	Manufacturing	Services	Open Sector
Agriculture	34.69	4.92	5.62	39.24
Manufacturing	5.28	61.82	22.99	60.02
Services	10.45	25.95	42.03	130.65
Total Gross Output	84.56	163.43	219.03	



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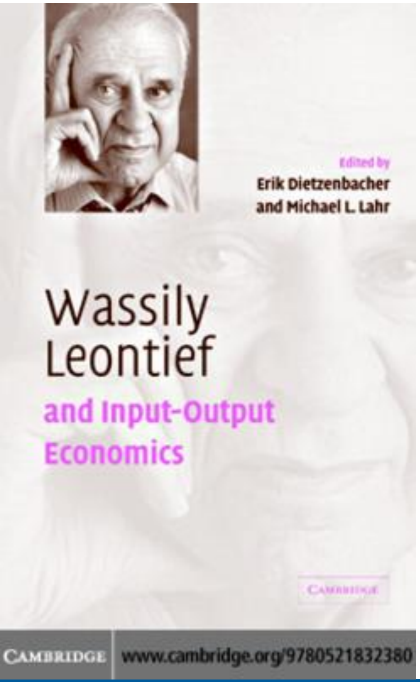

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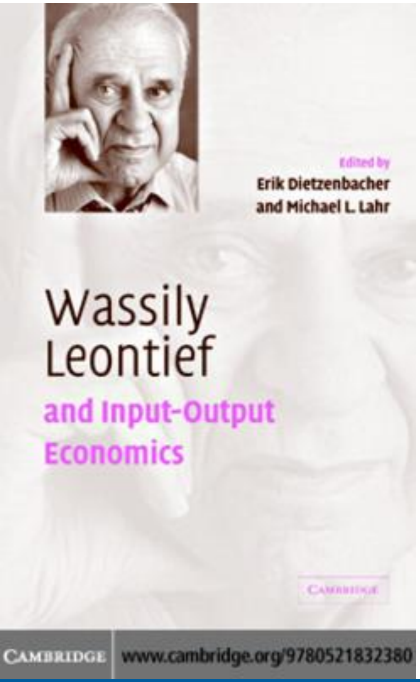
consumption matrix

demand vector

$$C = \begin{bmatrix} .4102 & .0301 & .0257 \\ .0624 & .3783 & .1050 \\ .1236 & .1588 & .1919 \end{bmatrix} \quad \mathbf{d} = \begin{bmatrix} 39.24 \\ 60.02 \\ 130.65 \end{bmatrix}$$



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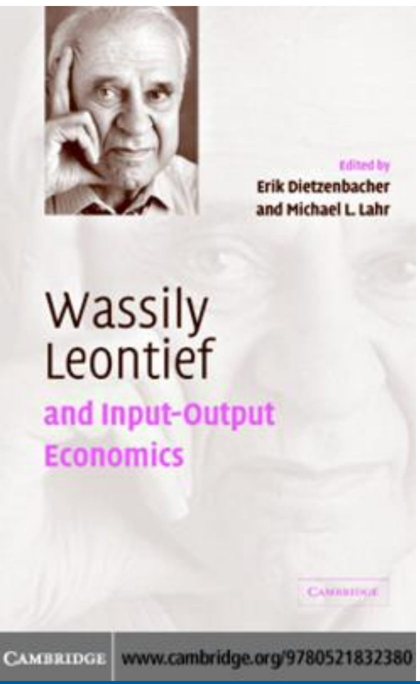
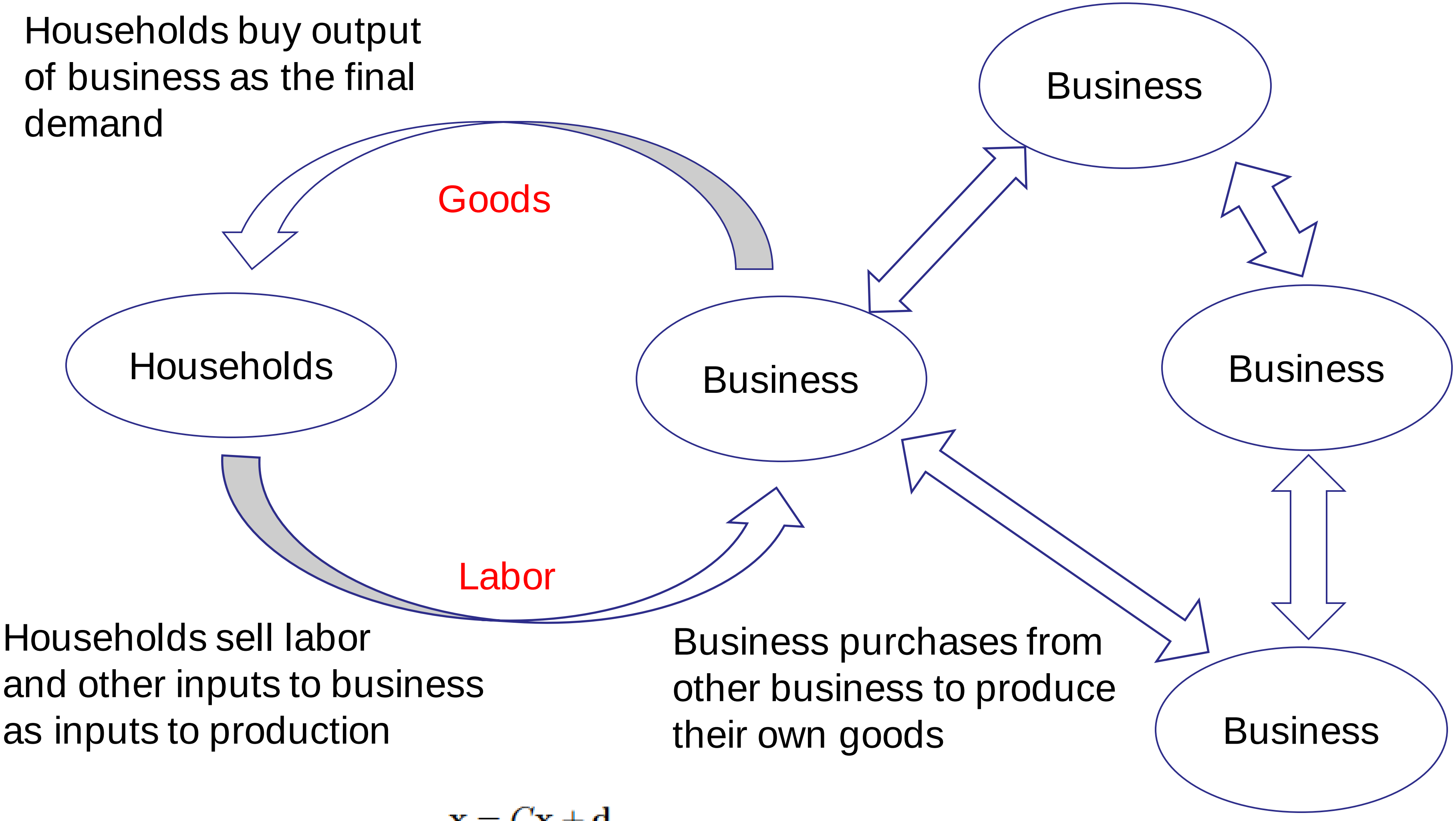


x - Equilibrium Production Level $\mathbf{x} = C\mathbf{x} + \mathbf{d}$

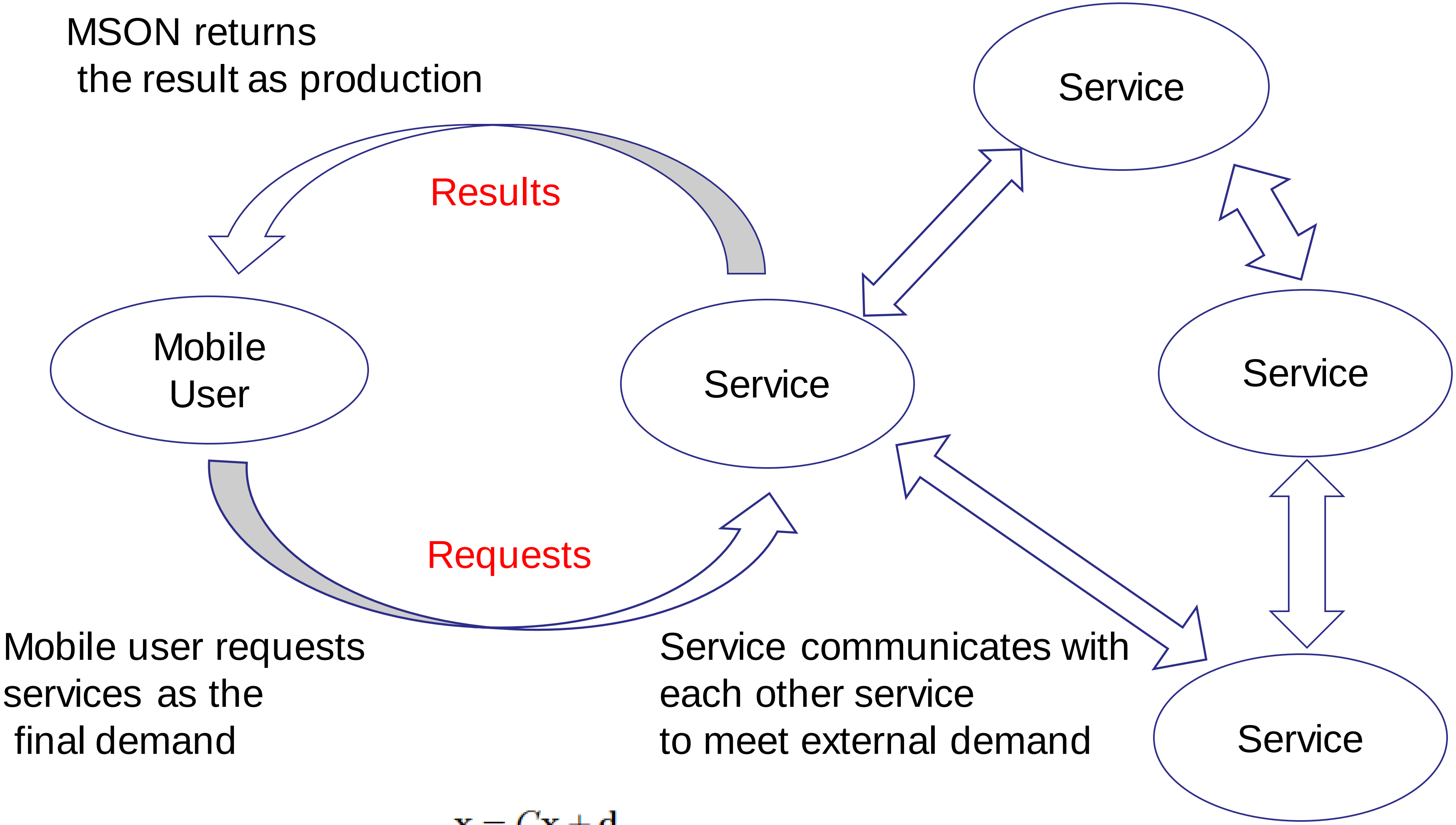
$$\mathbf{x} = (I - C)^{-1}\mathbf{d} = \begin{bmatrix} 82.40 \\ 138.85 \\ 201.57 \end{bmatrix}$$

Modern industry ecosystem



$$\mathbf{x} = C\mathbf{x} + \mathbf{d}$$

MSON



$$\mathbf{x} = C\mathbf{x} + \mathbf{d}$$

I-O Models in

Economics	**(M)SONs**
Similarities	
Sectors	Services
Consumers	Users
Commodity	Data
Currency	Bandwidth
Differences	
Do receiving cost	Downlink and Uplink Costs
Sectors are all independent	Co-Located Services

I-O Models in

Economics	**(M)SONs**
Differences	
Do receiving cost	Downlink and Uplink Costs
Sectors are all independent	Co-Located Services

$$\underbrace{\boldsymbol{x}}_{\text{production}} = \underbrace{A\boldsymbol{x}}_{\text{intermediate demand}} + \underbrace{\boldsymbol{d}}_{\text{external demand}}$$

$$\underbrace{\boldsymbol{x}^{\uparrow}}_{\textit{uplink cost}} = \underbrace{A^{\uparrow}\boldsymbol{x}^{\uparrow}}_{\textit{relayed uplink demand}} + \underbrace{\boldsymbol{c}^{\uparrow}}_{\textit{self-initiated demand}}$$

$$\underbrace{\boldsymbol{x}^{\downarrow}}_{\textit{downlink cost}} = \underbrace{A^{\downarrow}\boldsymbol{x}^{\uparrow}}_{\textit{relayed downlink demand}}$$

$$\omega_{ij} = \begin{cases} 0 & \text{if } \Theta(s_i) = \Theta(s_j), \\ 1 & \text{otherwise.} \end{cases}$$

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Application of Network I-O Model

I-O Based Adaptive Model

$$\min_{\check{\boldsymbol{\lambda}}} \quad \|\boldsymbol{\lambda} - \check{\boldsymbol{\lambda}}\|_2$$

$$\begin{aligned}
\text{s.t.} \quad & (A^{\uparrow} - I)\check{\boldsymbol{x}}^{\uparrow} + \check{\boldsymbol{\lambda}} \circ \boldsymbol{\beta} \circ \boldsymbol{\rho} = \mathbf{0} \\
& A^{\downarrow}\check{\boldsymbol{x}}^{\uparrow} - \check{\boldsymbol{x}}^{\downarrow} = \mathbf{0} \\
& \check{b}_m = \textstyle\sum_i \check{x}_i^{\uparrow} + \sum_i \check{x}_i^{\downarrow}, \quad \Theta(s_i) = m \\
& \check{b}_m \le b_m, \quad m \in \{\mathbb{M} - \mu\} \\
& \check{b}_\mu \le \check{B}_\mu
\end{aligned}$$

$$\begin{aligned}
\text{s.t.} \quad & (A^{\uparrow} - I)\check{\boldsymbol{x}}^{\uparrow} + \check{\boldsymbol{\lambda}}' \circ \boldsymbol{\beta} \circ \boldsymbol{\rho} = \mathbf{0} \\
& \check{\lambda}_i' = \lambda_i, \quad \Theta(s_i) = \mu
\end{aligned}$$

$$\begin{aligned}
\text{s.t.} \quad & (A^{\uparrow} - I)\check{\boldsymbol{x}}^{\uparrow} + \check{\boldsymbol{\lambda}}'' \circ \boldsymbol{\beta} \circ \boldsymbol{\rho} = \mathbf{0} \\
& \check{\lambda}_i'' = \lambda_i, \quad \Theta(s_i) \ne \mu
\end{aligned}$$

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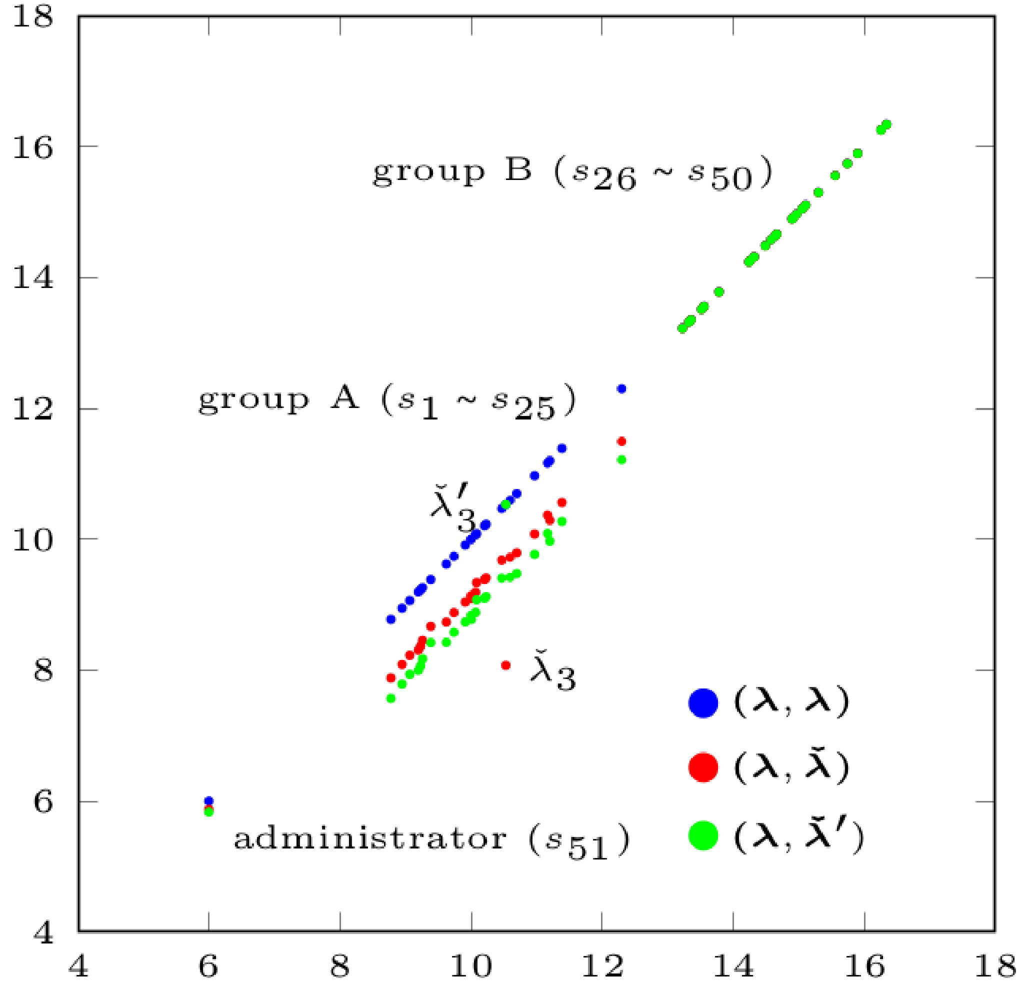
Application of Network I-O Model



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Summary

- Mobile Service-Oriented Networks
- Extend Leontief's I-O Model in Economics to a Network I-O Model
- Application of Network I-O Model

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Thank you

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