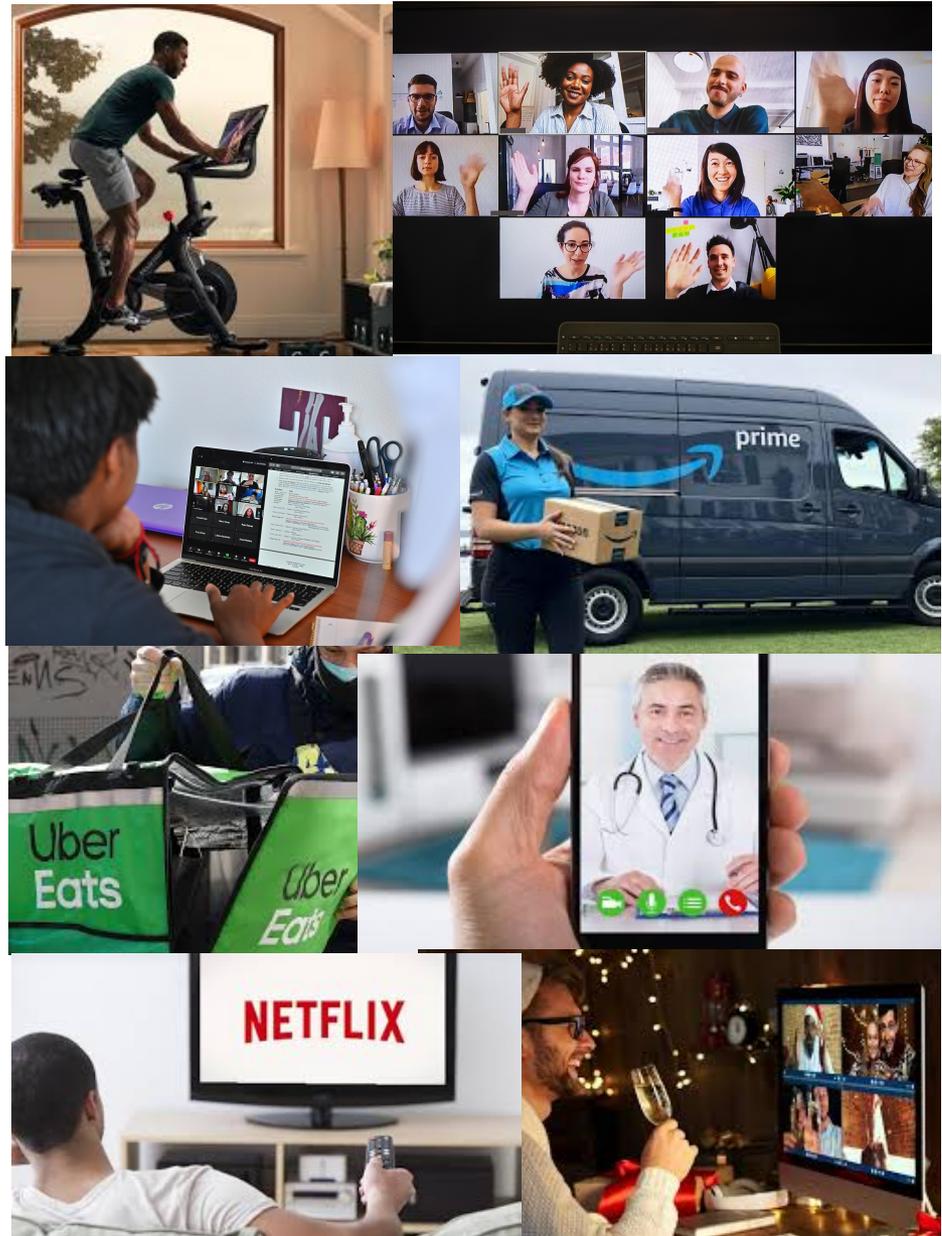


The Coming Age of a Transportation- Light Future

Saif Benjaafar

Distinguished McKnight University Professor
Director of the Initiative on the Sharing Economy
University of Minnesota

A day in the pandemic years of 2020-2021



Analytics (models, algorithms, analysis) and technology to enable digital products services and innovative business models

Optimization

Food Diet example

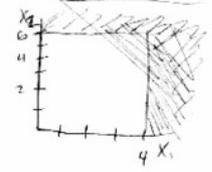
Minimize $cost = 2x_1 + 3x_2 + 8x_3 + 150x_4 + 11x_5 + x_6$
 s.t. $4x_1 + 8x_2 + 7x_3 + 13x_4 + 8x_5 + 9.2x_6 \geq 46$ protein
 $1x_1 + 5x_2 + 9x_3 + 0.1x_4 + 7x_5 + 1x_6 \geq 65$ fat
 $15x_1 + 11.7x_2 + 0.4x_3 + 22.0x_4 + 0x_5 + 17x_6 \geq 250$ carbs
 $x_1, x_2, x_3, x_4, x_5, x_6 \geq 0$ physical constraint

Example 2: The product mix problem

aluminum frame window
 wooden frame window
 plant 1 aluminum frames
 plant 2 wood frames
 plant 3 produces glass and assembles all windows

Maximize $D = 3000x_1 + 5000x_2$

$x_1 = \text{batches of 1}$
 $x_2 = \text{batches of 2}$



Distribution of interarrival times
 $f(t)$: density function for the time interval between arrivals
 $f(t) = \lambda e^{-\lambda t}, t \geq 0$

$$E(t) = \int_0^{\infty} t f(t) dt = \int_0^{\infty} t \lambda e^{-\lambda t} dt = \frac{1}{\lambda}$$

$$Pr(t > T) = \int_T^{\infty} f(t) dt = \int_T^{\infty} \lambda e^{-\lambda t} dt = e^{-\lambda T}$$

M/M/1

(service times $\sim \text{Exp}(\mu)$)

interarrival times $\sim \text{Exp}(\lambda)$

$$E(t) = \frac{1}{\lambda}$$

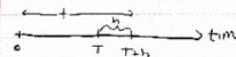
The memoryless property

Conditional probability

$$P(A|B) = \frac{P(A \cap B)}{P(B)}$$

we consider all possibilities: the structure of the problem runs but that may not

$$P(t > T+h | t > T)$$



$$P(t > T+h | t > T) = \frac{P(t > T+h)}{P(t > T)} = \frac{e^{-\lambda(T+h)}}{e^{-\lambda T}} = e^{-\lambda h} = P(t > h)$$

example -

$$\mu = 20/h1 \quad \mu = 20/h1$$



service times $\sim \text{Exp}(\mu=20)$

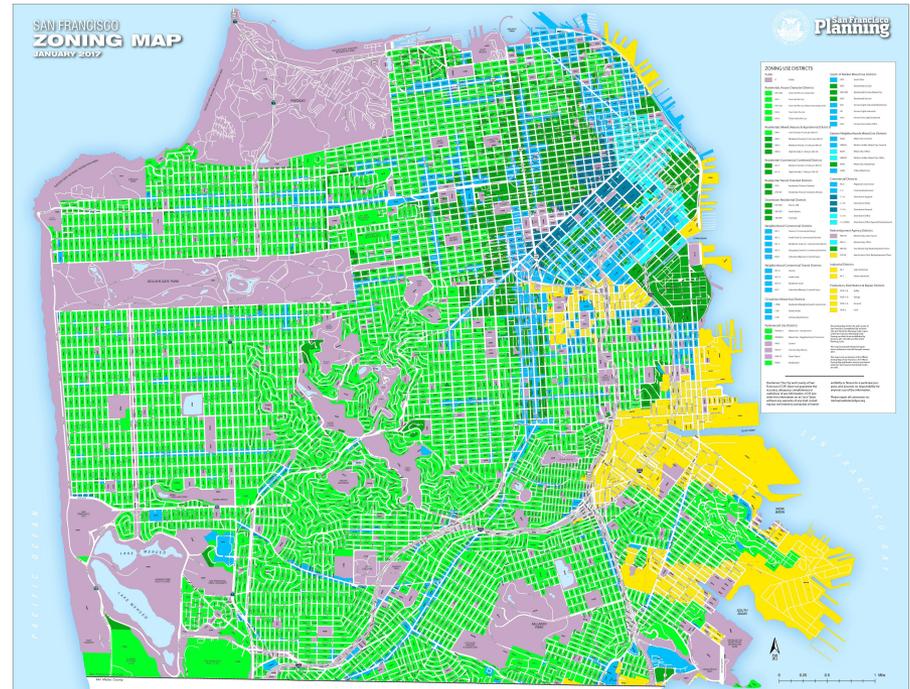
Post office

what is the prob that Jim is the last to leave PO

Four emerging **forces** that will shape the transportation landscape

- The **digitization** of products, services, and work
- The emergence of **transportation-enabled** services
- The **de-scaling** of the economy and its impact on **cities**
- The growth of products and services **on demand**

Transportation is a solution to the **spatial mismatch** between where people are and where the products and services they seek are



This friction is increasingly being addressed by

- The digitization of products, services and work (or the tele-economy: tele-work, tele-health, tele-fitness, online learning)
- Transportation-enabled services – the shift from the transporting of people to the transporting of products and services (online shopping, home deliveries, mobile clinics, mobile grocery stores)

Although the transport of “things” is likely to significantly increase, the reduction in the transport of people is likely to more than offset it



Cities are attractive because of the **proximity** to work, schools, hospitals, retail, and entertainment and the **efficiency** with which they can deliver the associated products and services



- Because of forces 1 and 2, both **geographic proximity** and **density** would increasingly matter less
- Over time, the net effect may be diminished importance of cities as hubs for the delivery of products and services, resulting in **new patterns of land use** and of **travel**

The emergence of business models that provide on-demand access to products and services as needed (**when, where needed** and in the **amount needed**) is obviating the need for **ownership**



Mobility on-demand
(which, while reducing the
number of vehicles owned,
may or may not reduce
total miles traveled)



Automated vehicles could accelerate the shift to mobility on-demand and further reduce the need for car ownership



Automated vehicles could also amplify the magnitude of the other forces at play (particularly enabling more transportation-enabled services and the diminished role of cities as hubs for the efficient delivery of products and services)



The pandemic has given us a glimpse of a perhaps a not too-distant future of a **transportation-light** economy, that will be increasingly technology-driven, on-demand, and automated

Over the next decade, this may call for a rethinking of government spending on transportation **infrastructure, public transit,** and how transportation is **regulated**

Thank you!



Questions, Comments, Suggestions?

saif@umn.edu

<https://cse.umn.edu/isye/saif-benjaafar>

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