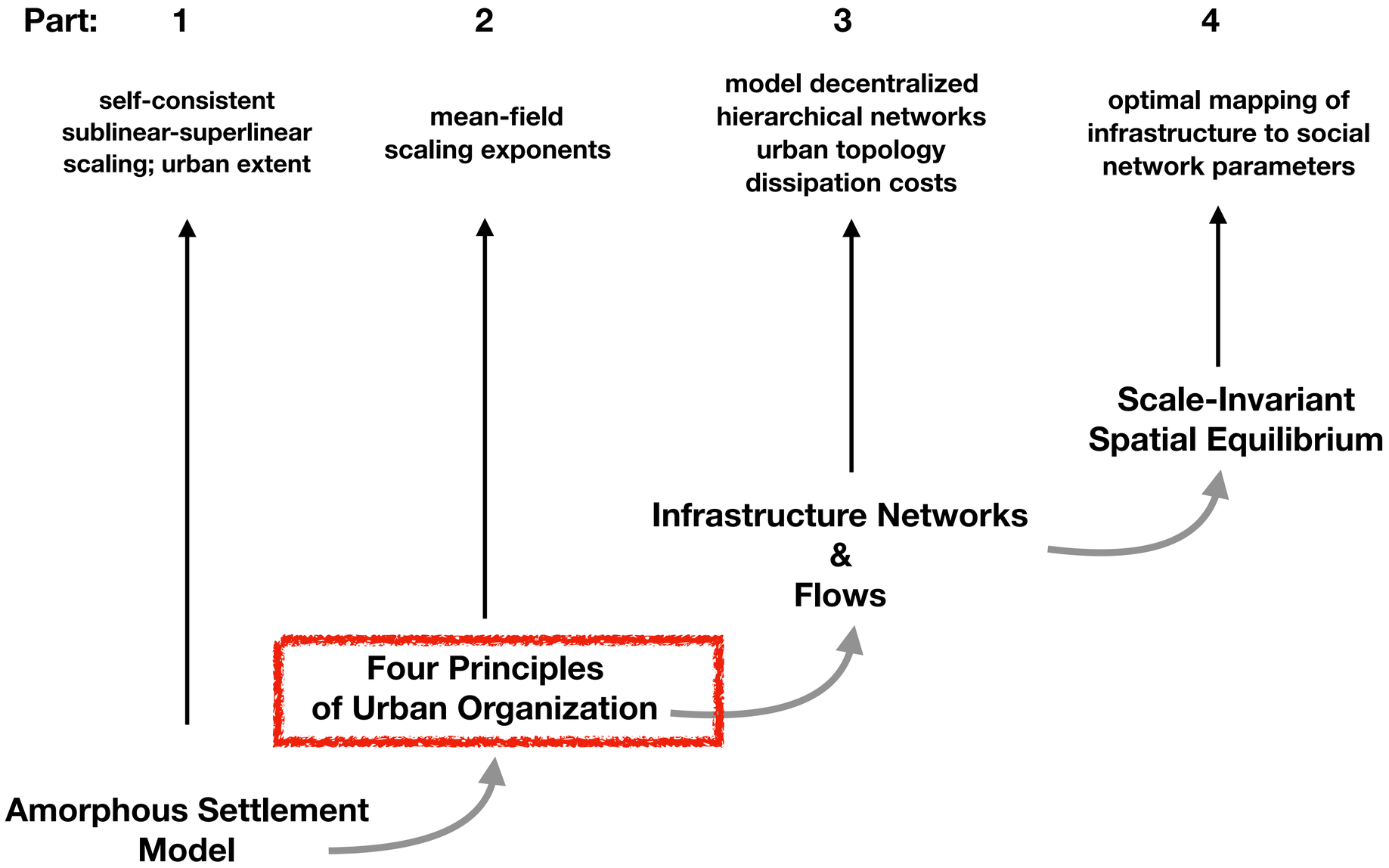
Lecture 7

Network Models of Cities

7.1 Scaling of Infrastructure Networks and Urban Built Spaces

IUS 3.2.2

Urban Scaling Theory



IUS Figure 3.5

Four Principles of Urban Organization

1) Cities are mixing populations (networks) over built space and time — Jacobs, Wirth, Burgess

2) Personal effort is limited — Park, Milgram, Zahavi, Simon

3) City infrastructure as decentralized but hierarchical networks — Alexander ←

4) Socioeconomic products of cities are the result of interactions, — Jacobs ←

subject to spatial costs — Alonso ←

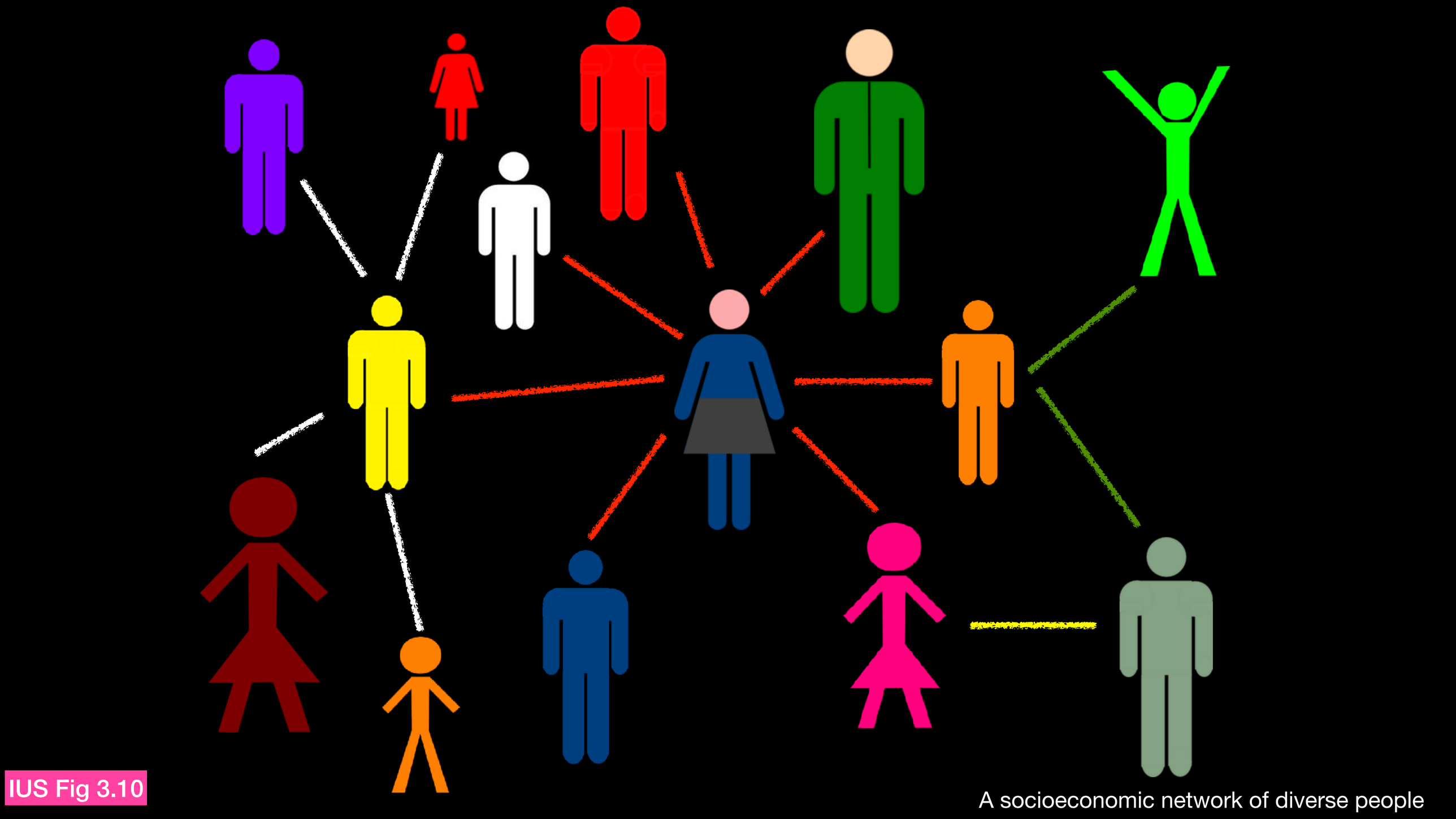
already in the amorphous model, but more to come…

Let’s make a network theory of all this …

People interacting over the built environment:
fast (people, ~days) and slow (infrastructure, ~decade) time scales

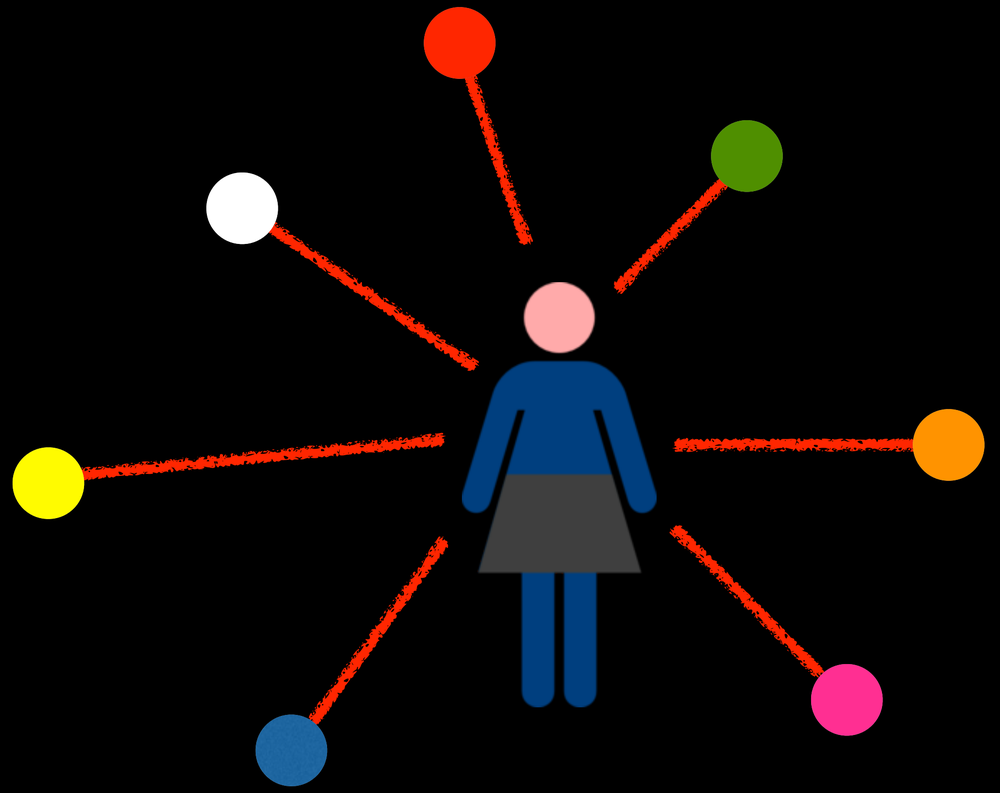
Mumbai Train Station
credit: Randy Olson

note now that spaces are structured, not amorphous: we need to understand the nature of their networks



IUS Fig 3.10

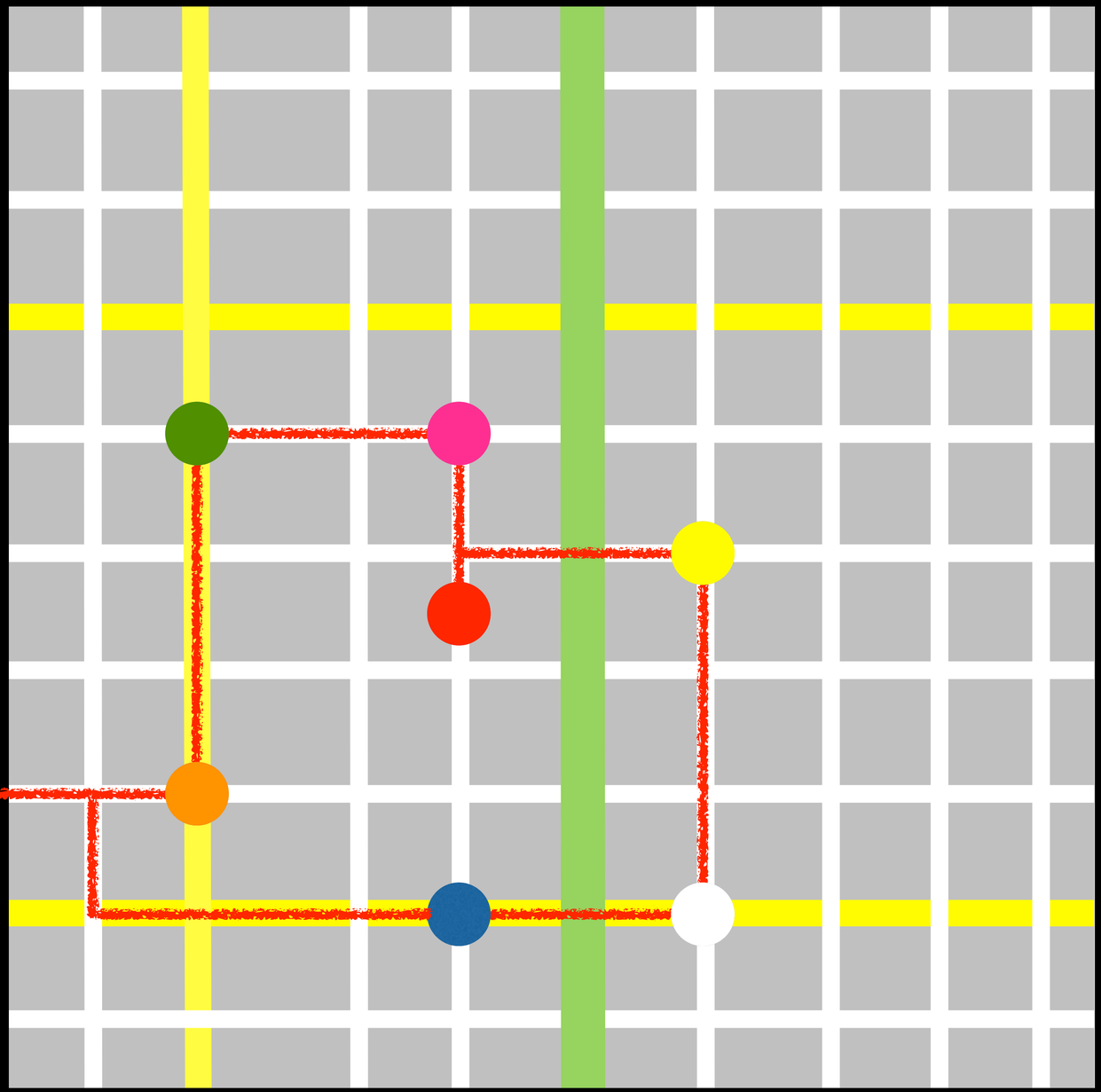
A socioeconomic network of diverse people

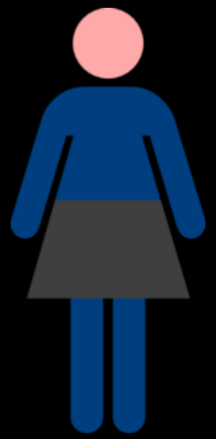


IUS Fig 3.10

…can be abstracted in terms of an “ego-network”

Health
Love
Money
Education
Fun
Food
Services
. . .

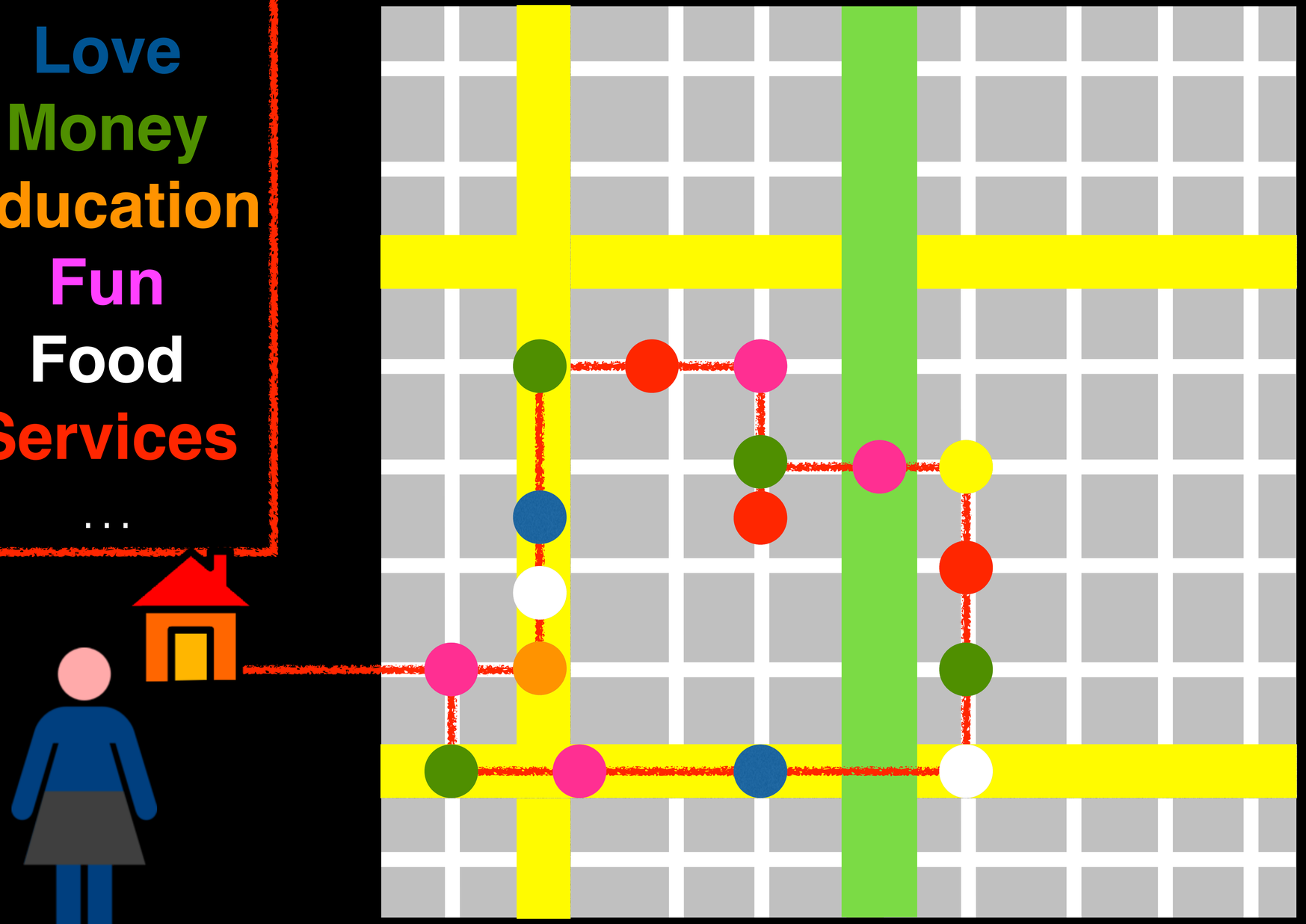




…which is embedded in spacetime via life paths (time geography)

IUS Fig 3.10

Health
Love
Money
Education
Fun
Food
Services
. . .



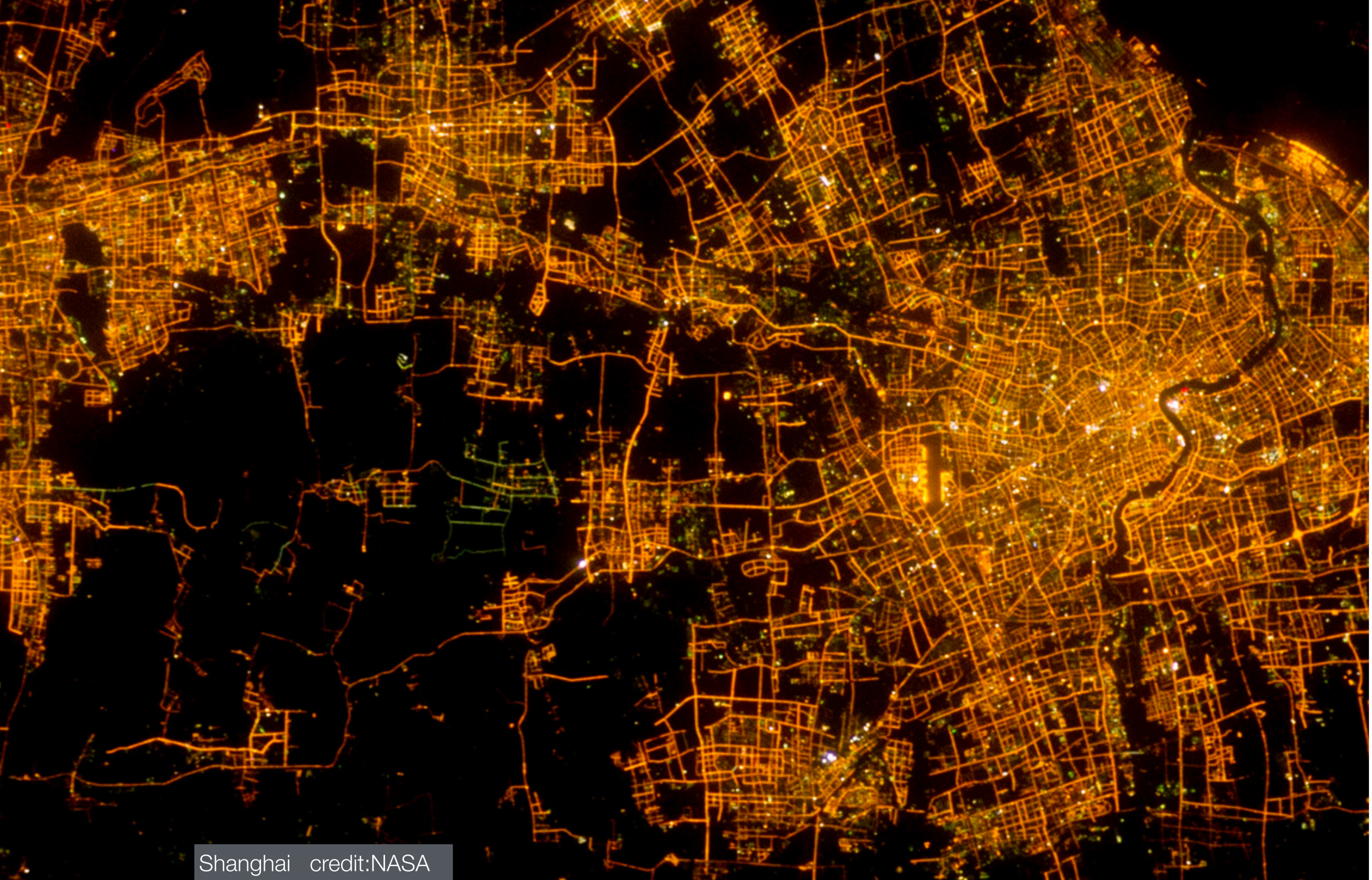
IUS Fig 3.10

…which is embedded in spacetime via life paths, which meet more events in larger, denser, more heterogeneous cities

The Structure of Built Spaces in Cities

Streets and City Blocks also form networks

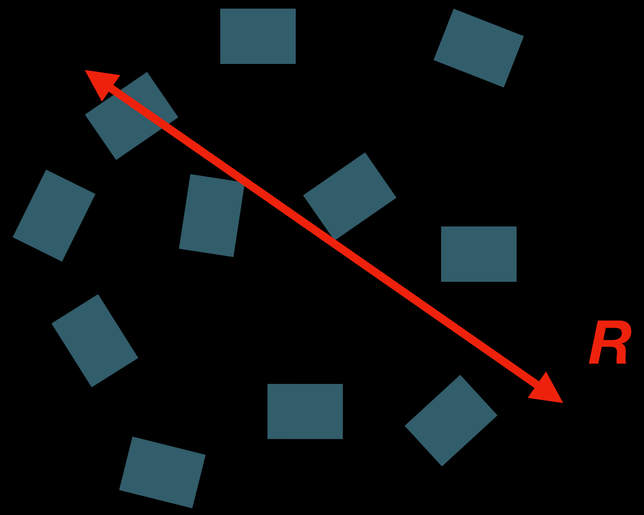

OLISSIPPO quæ nunc Lisboa, ciuitas amplissima Lusitaniæ, ad Tagum. totiq
Orientis, et multarum Insularum Aphricæque et Americæ emporium nobilissimum.
121 Sacellum D.N. consolationis
super portam ferri. 122 Templum
sancti Anthonii de Padua.
123 Templum Misericordiæ.
124 Sacellum sancti Spiritꝰ de alfama.
125 Templum sancti Martini. 126
Templum sancti Blasij et sanctæ Luciæ.
127 Templum sancti Ludouici.
128 Templum sancti Spiritꝰ da pedreira.
129 Ermita D.N. do monte.
Septentrio
Occasus
Oriens
Meridies
Nonnulla alia.
130 Moles lapidum vulgo Cais da pedra.
131 Carcer priuat. Ciuitatis vulgo tingo.
132 Domꝰ monetæ. 133 Palatium
Ducis de Aueiroa. 134 Pala-
Ducis de Graganca. 135 Palatium
Marchionis de Vila real. 136 Pala-
tium Comitis de Porcalegre. 137 Pala-
tium Comitis de Rodendo. 138 Pa-
latium Comitis de Linsare. 139 Praca
dos Canos. 140 Sacellum D.N. da
Palma. Putei publici.
Campus S. Claræ
Tagus
credit:Braun & Hogenberg / Ozgur Tufekci



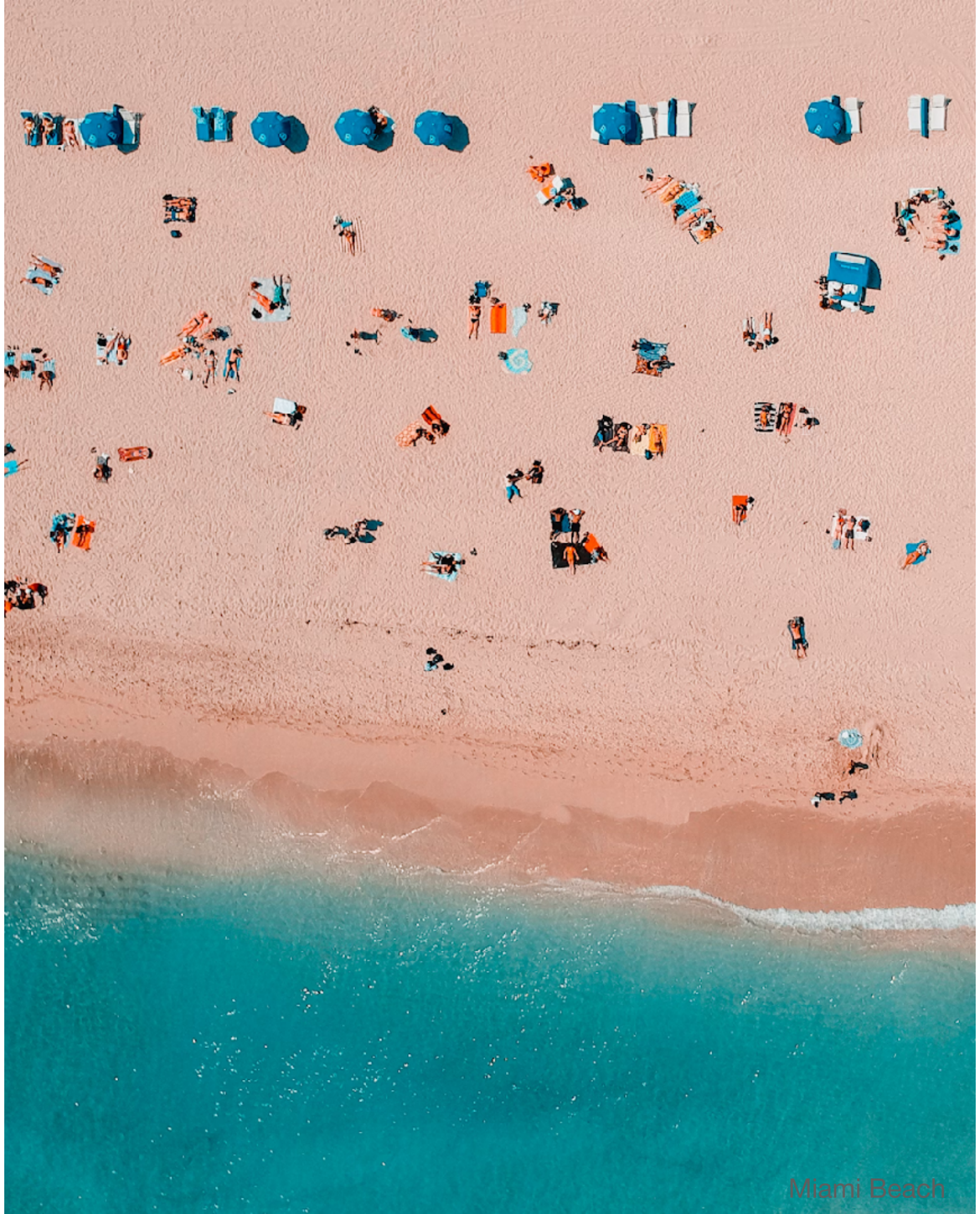
Shanghai credit:NASA

How does this work?

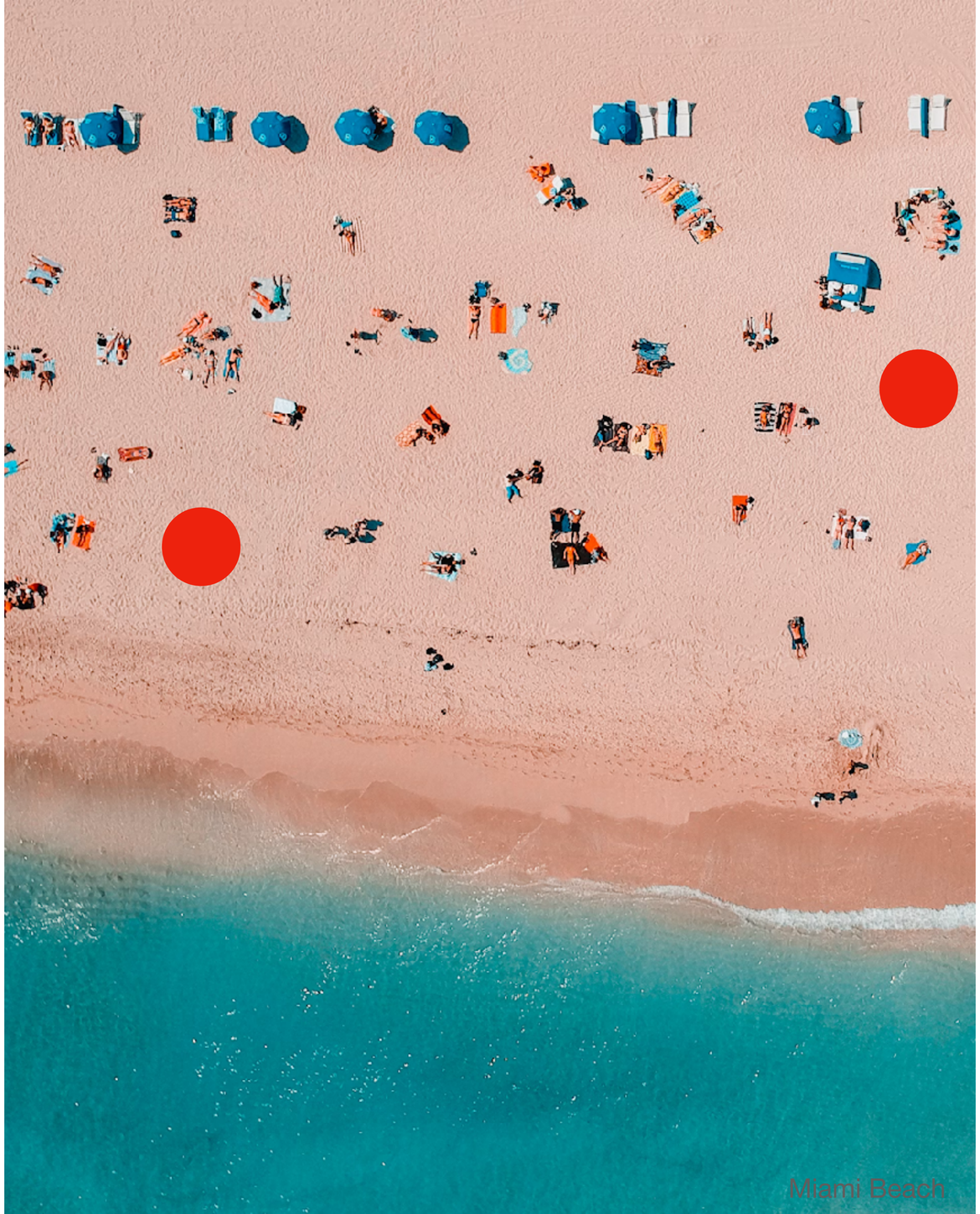
Amorphous Settlement



Where will you go?



Where will you go?

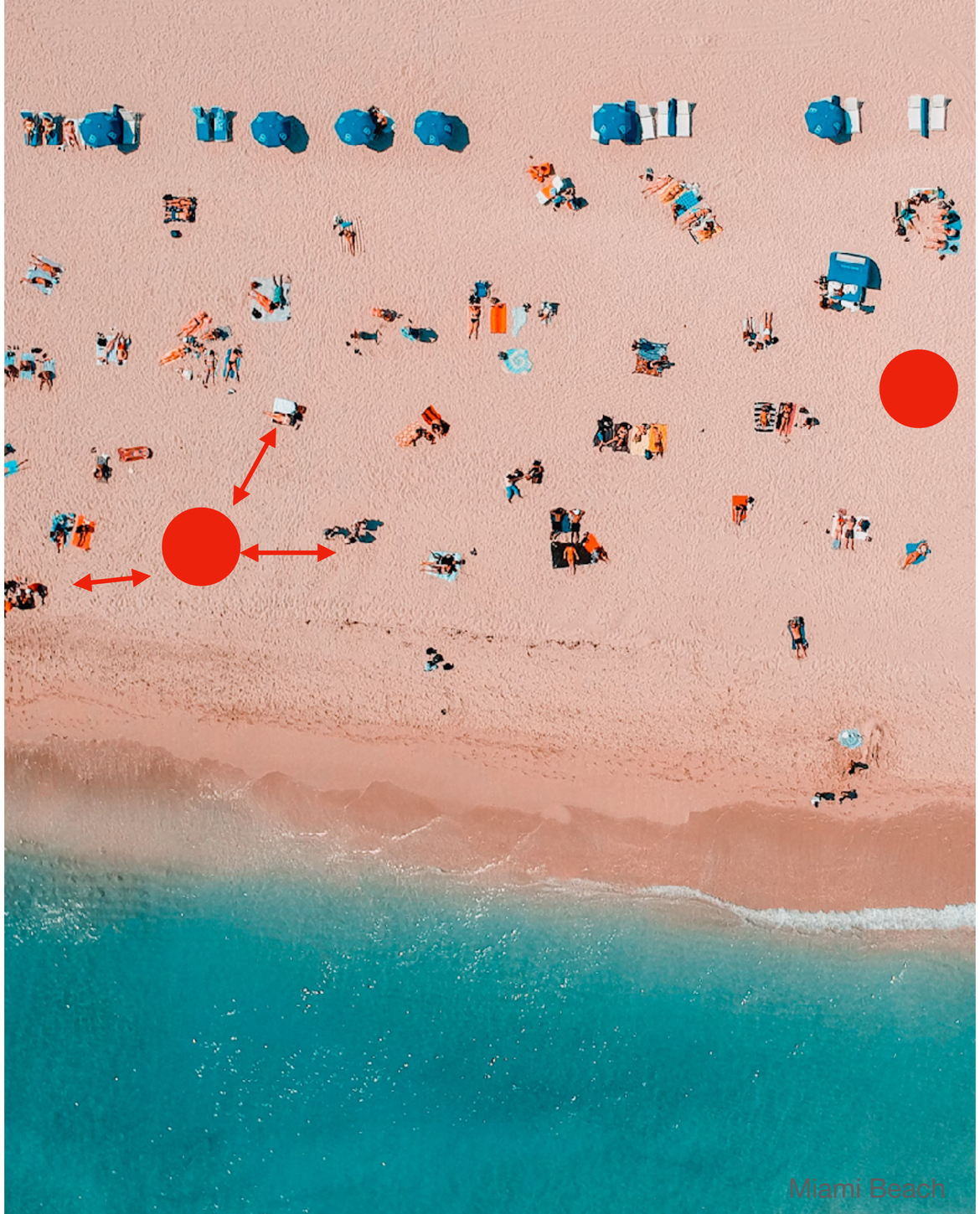


Where will you go?

Average distance is set by density

$$A(N) = aN^{\frac{2}{3}} \rightarrow \frac{A}{N} \sim N^{-\frac{1}{3}}$$

$$d_A = \left(\frac{A}{N}\right)^{1/2} \sim N^{-\frac{1}{6}}$$

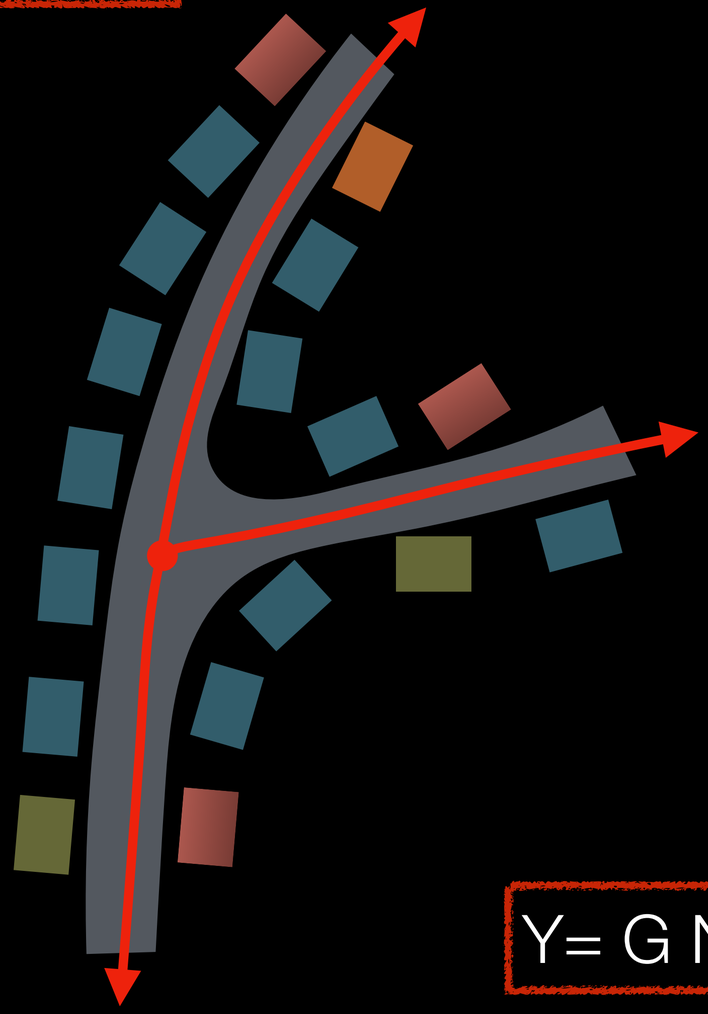


Decentralized Networks

The volume of infrastructure grows faster than land

$A_n \sim d_A \; N \sim N^{5/6} \quad d_A = (A/N)^{1/2}$

$$\delta = \frac{1}{6}$$



Networked Settlement

$Y = G \; N \; N/A_n \sim G \; N^{7/6}$

Social interactions accelerate

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