Introduction to transportation planning

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Lecture 2
Transport system as a complex system

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Transport system

=

Demand

+

Supply

Transport demand

Travelers **demand** to travel (change location)

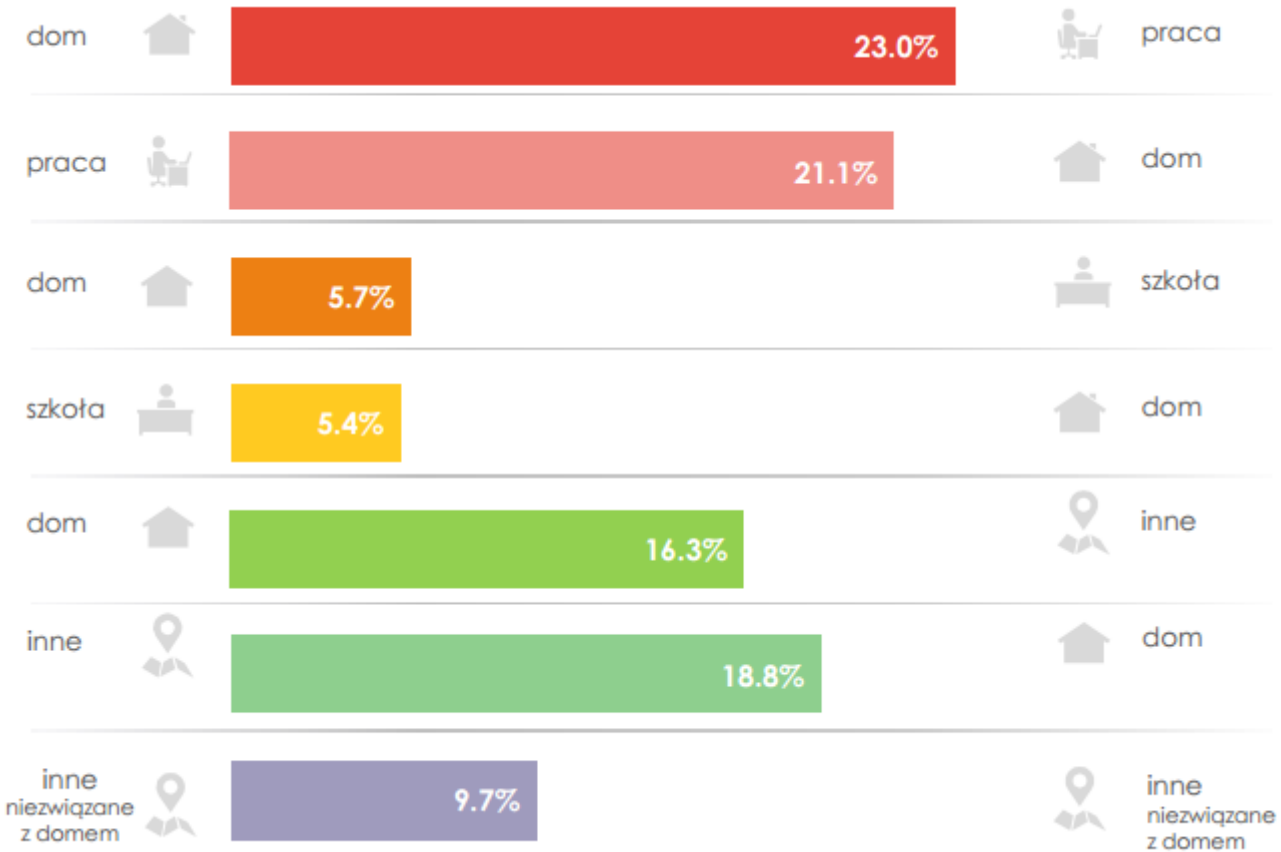
They are in place *o* and want to be get to place *d* at lowest cost *c* (shortest time *t*)

i.e.

in the morning people depart from homes to get to workplaces.

Transport demand

Warsaw 2015



Transport demand

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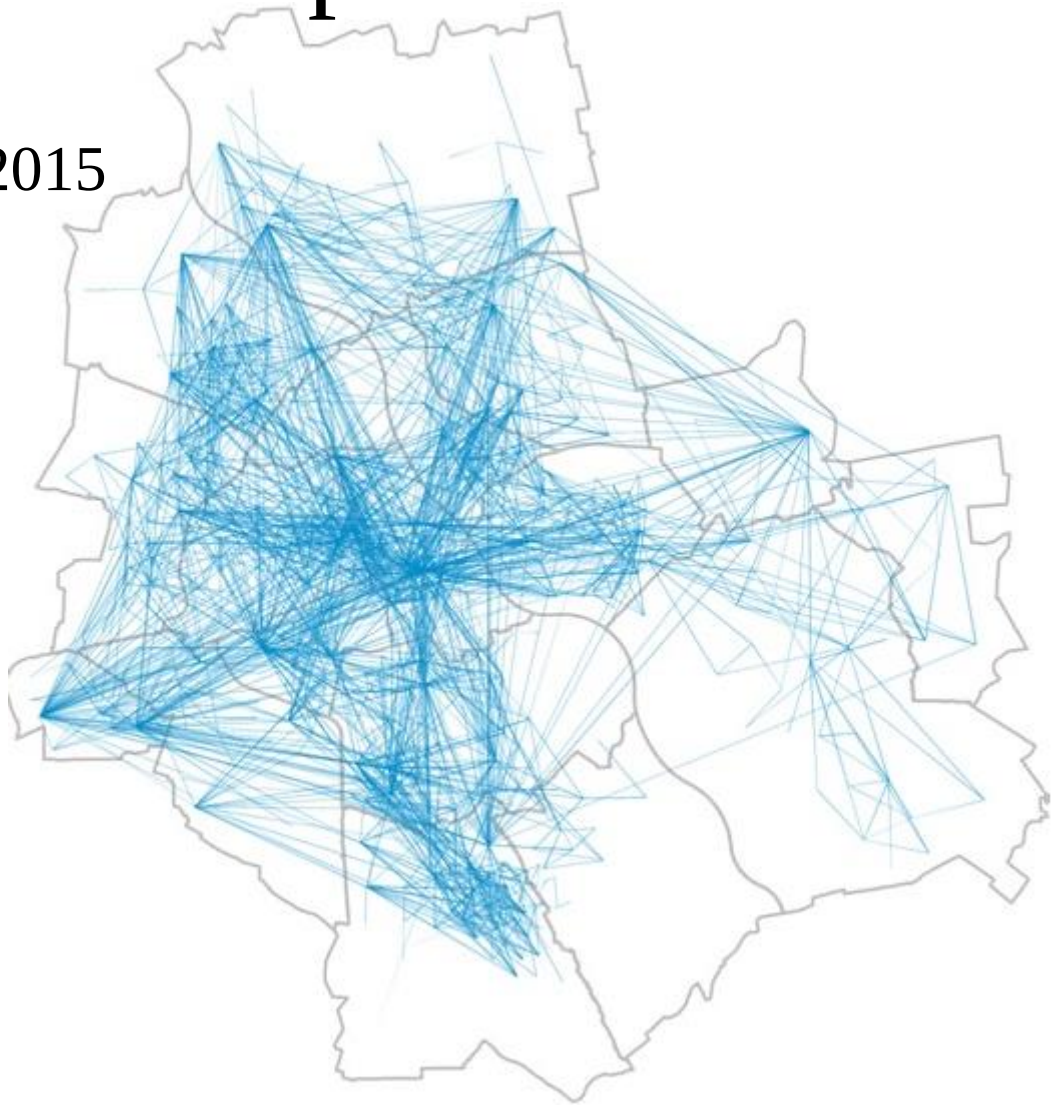


Transport demand

Warsaw 2015

Tabela krzyżowa motywacja początku podróży * motywacja końca podróży

Liczebność

		home	work	school	Uni	services in mall	services not mall	other	
		motywacja końca podróży							
		do domu	do pracy	do szkoły	uczelnię	w WOH	poza WOH	inne	Ogółem
motywacja początku podróży	dom	13	7865	1511	638	711	1342	3004	15084
	praca	7244	334	7	20	241	338	568	8752
	szkoła	1472	1	5	0	5	12	44	1539
	wyższa uczelnia	560	20	0	13	15	22	49	679
	WOH	988	16	2	0	24	17	47	1094
	poza WOH	1691	49	2	2	23	112	95	1974
	inne	3211	326	15	15	78	142	465	4252
Ogółem		15179	8611	1542	688	1097	1985	4272	33374

Transport demand

Travelers **demand** to travel (change location)

They are in place *o* and want to be get to place *d* at lowest cost *c* (shortest time *t*)

i.e.

in the morning people depart from homes to get to workplaces.

Transport demand

notation:

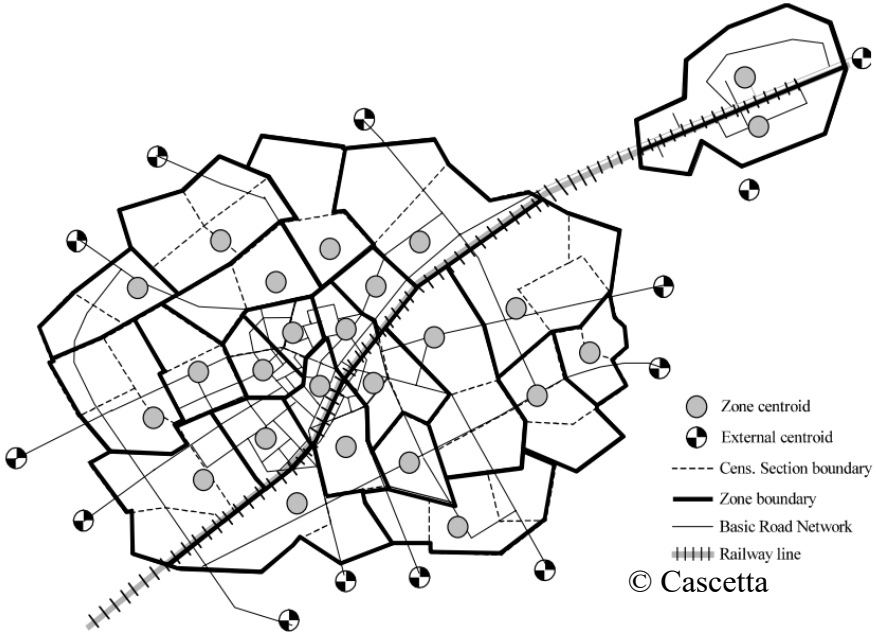
$d_{od}(\tau)$ demand from origin *o* to destination *d* in time period τ

number of passengers/vehicles

Transport demand

$d_{od}(\tau)$ from given place (where I am) to given place (where I want to be).

we need to discretize (space) and aggregate (people)



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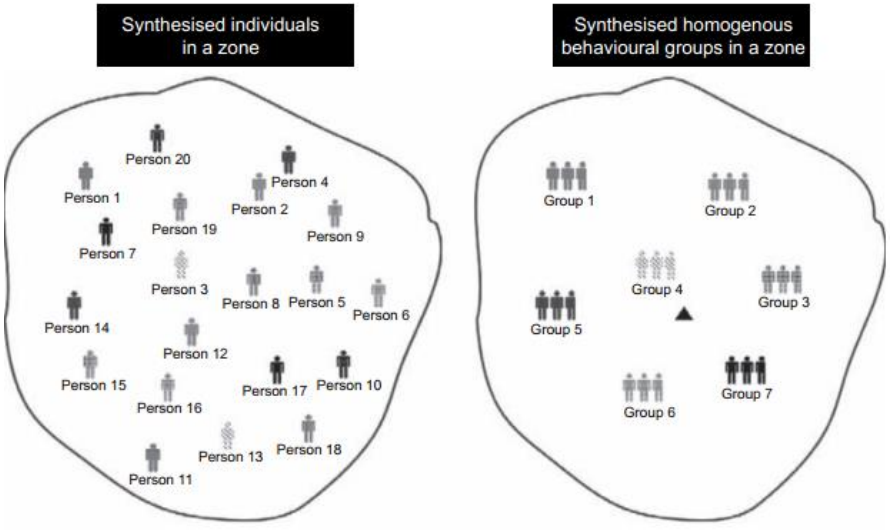

Figure 14.3 Individuals and homogenous behavioural groups in a zone

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Transport supply

The transportation network (system) allows to satisfy (supply) the demand.

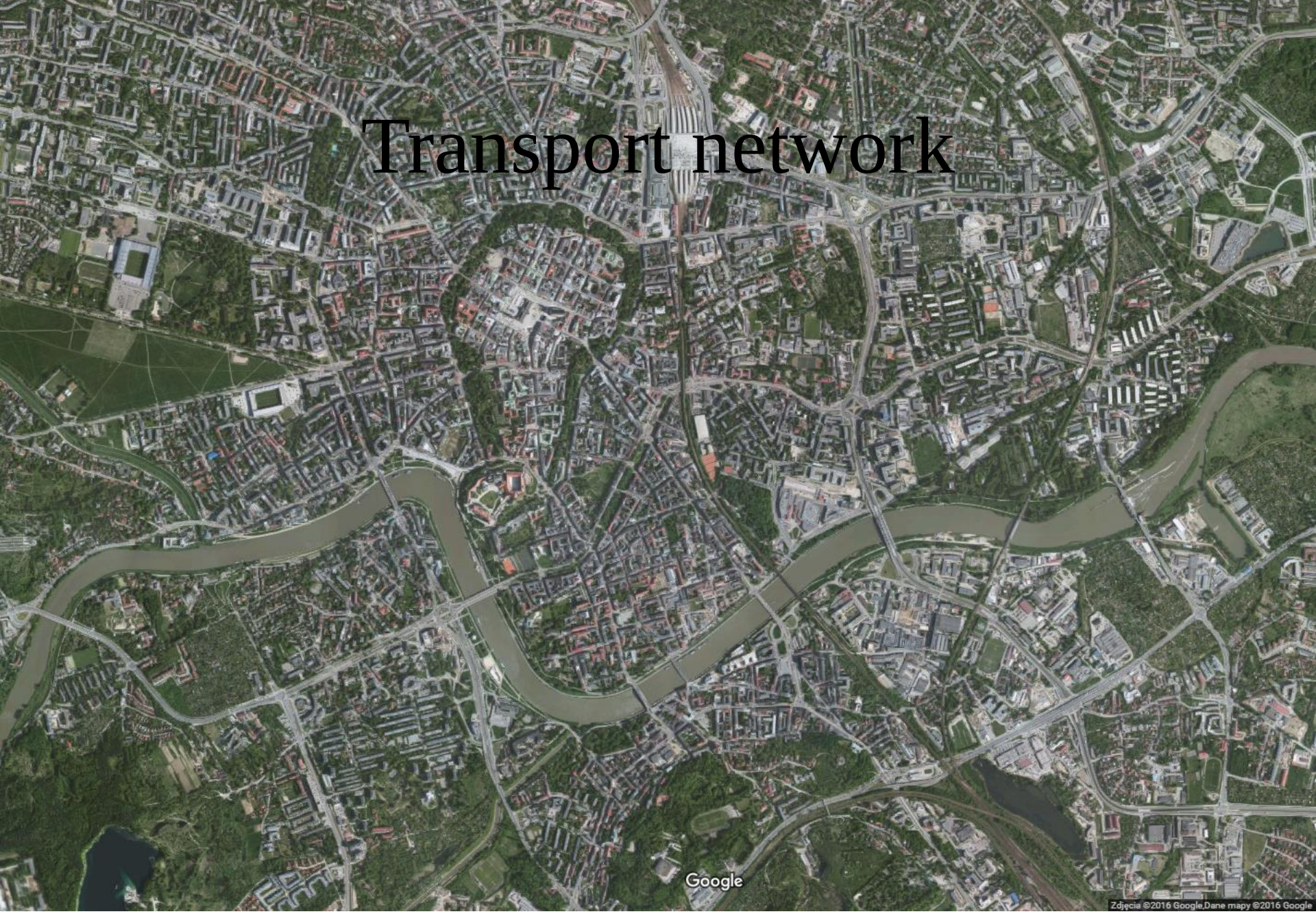
The need to travel (demand) is satisfied by travelling through the transport network (supply).

Transport supply

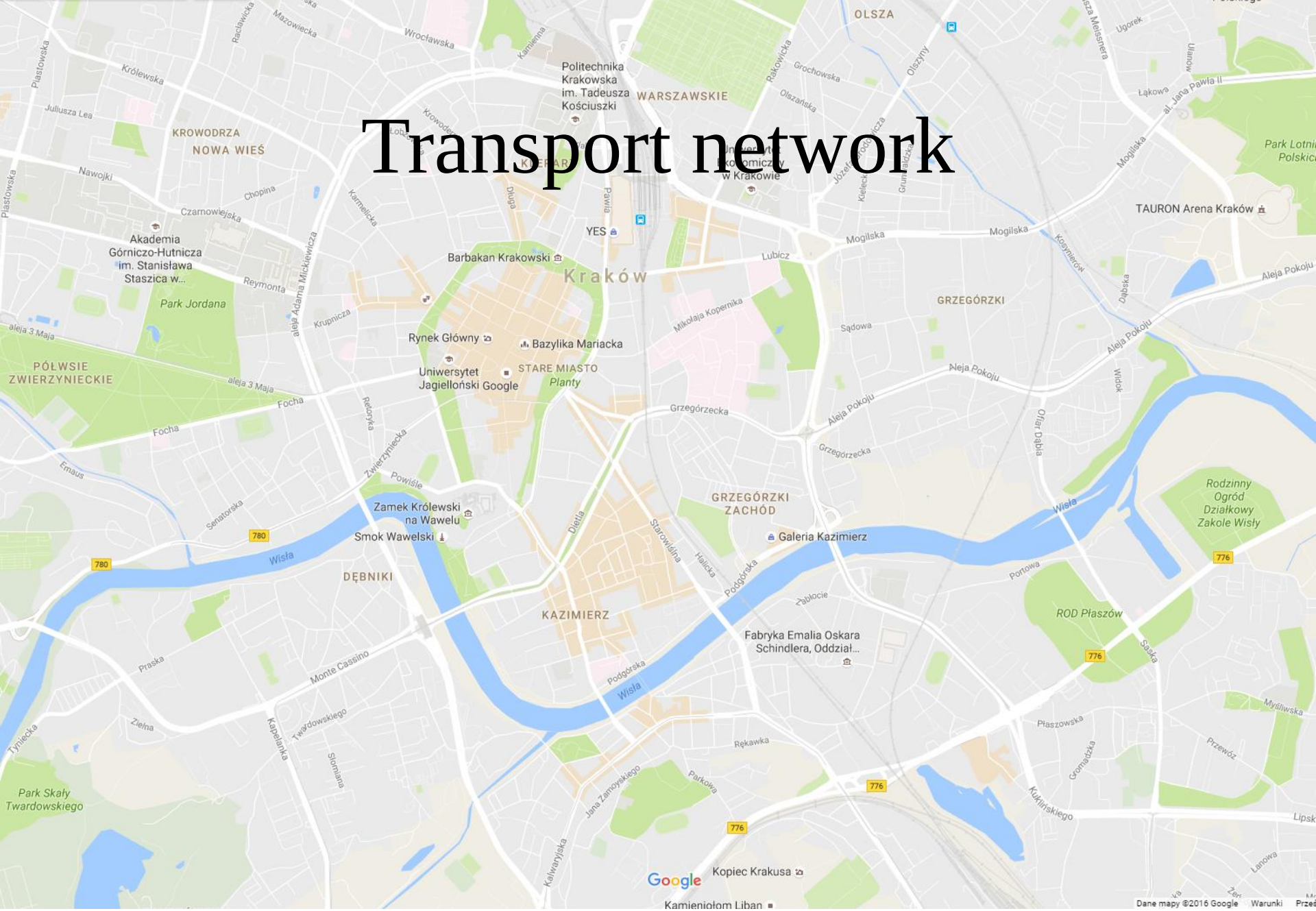
How can we allow people to travel?

1. By building the roads (road network)
2. By providing them services (trains, buses, trams, bike-sharing, car-sharing, …)

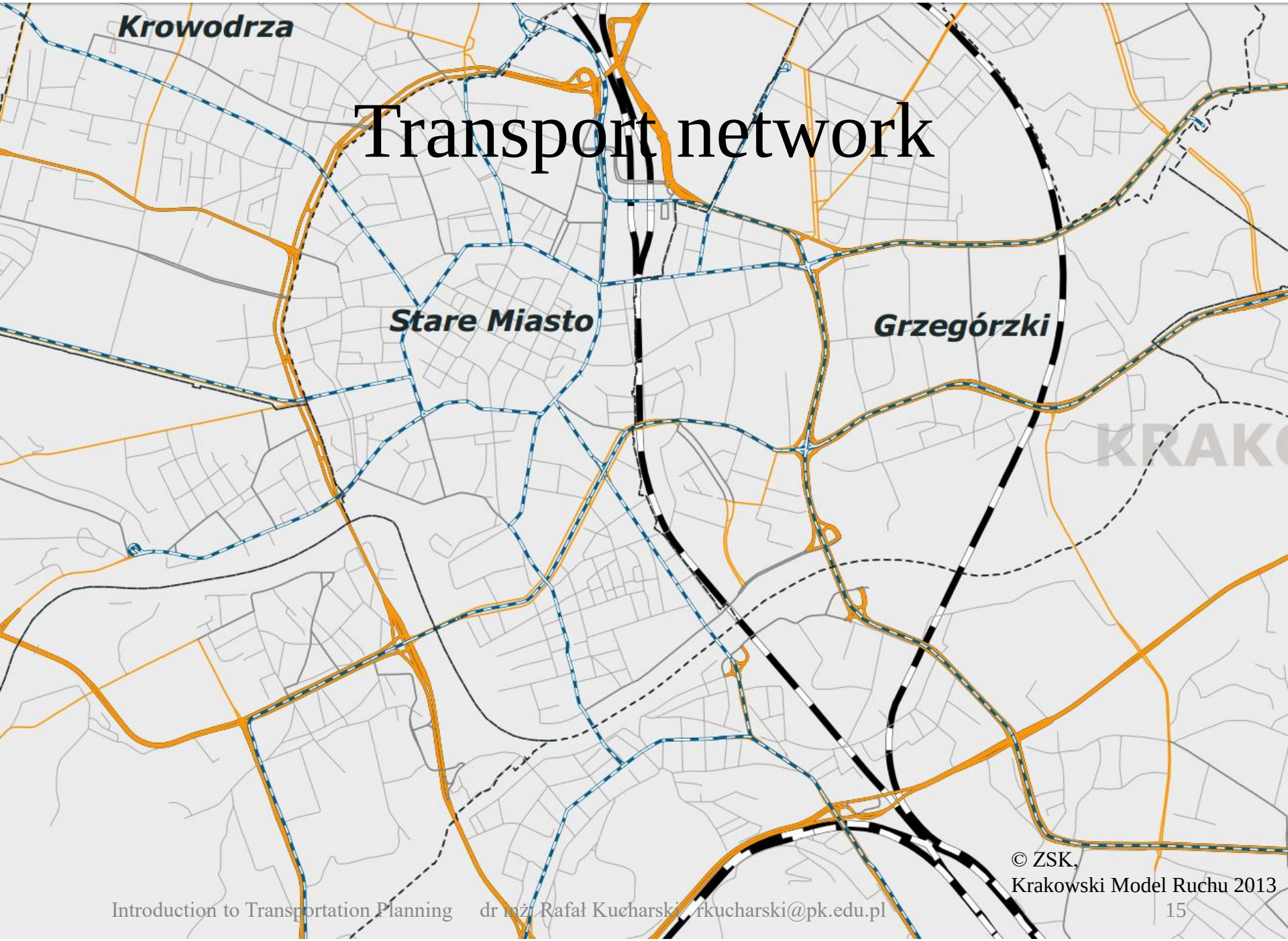
Transport network



Transport network



Transport network



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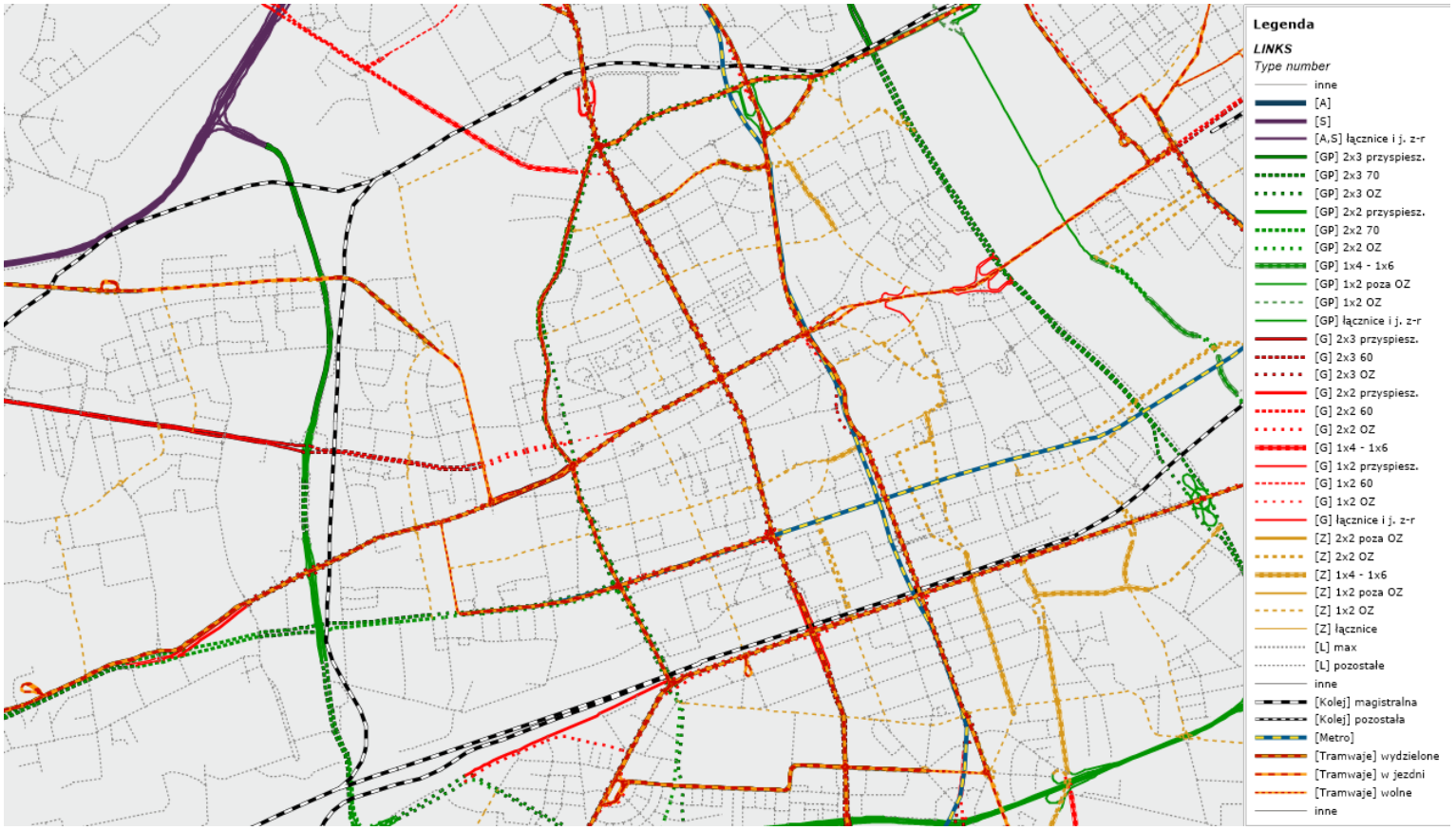
Transport network



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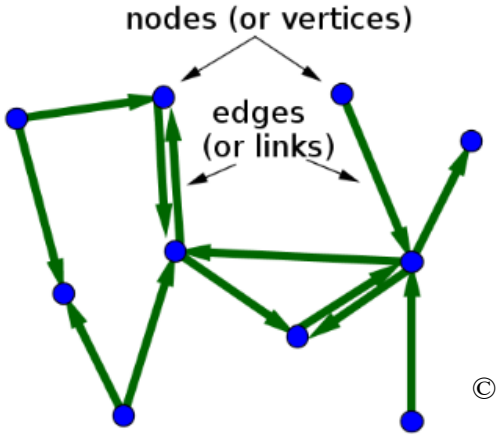
Transport network

G(N,A) oriented, connected, directed **graph**

graph in math is another word for a network, i.e., a set of objects (called nodes) that are connected together.

The connections between the vertices are called edges or links.



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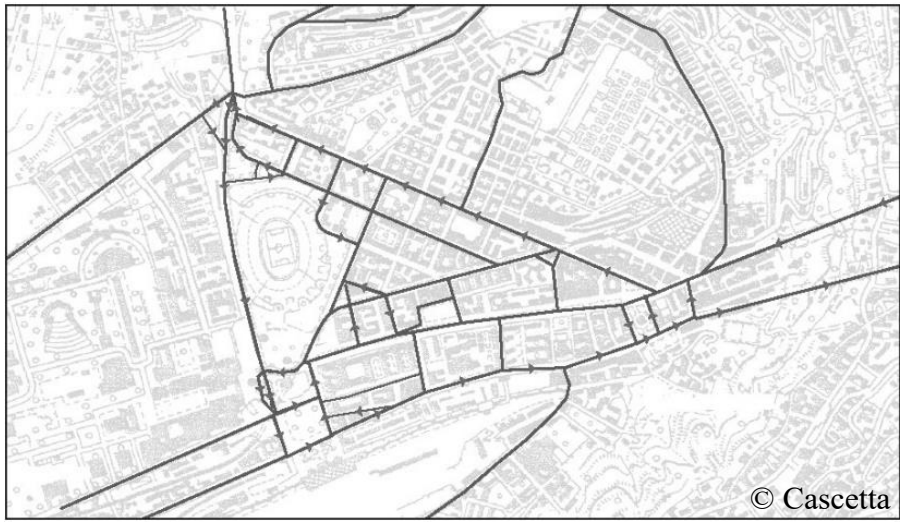
Transport network

$n \in N$

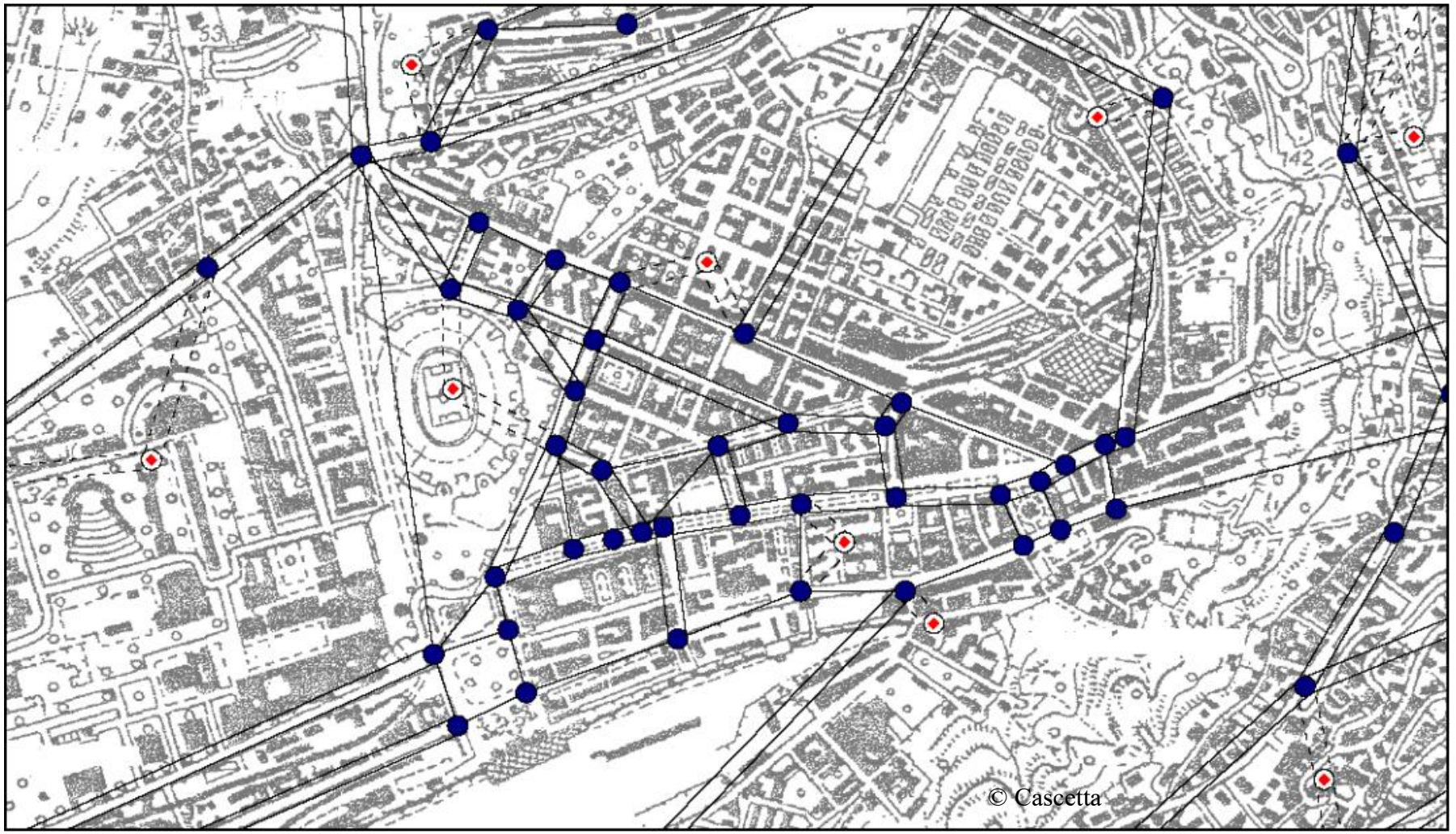
node – crossing, junction, bus stop

$a \in A$

arc, link – road (line) segment connecting two nodes



Transport network



Transport network

Two basic things we want to know about the **demand** and **supply** in the network

$q_a(\tau)$ number of vehicles/pax on arc a at time τ
demand

$t_a(\tau)$ travel time of arc a at time τ
supply

Transport network

$q_a(\tau)$ number of vehicles/pax on arc a at time τ

demand

free-flow

congestion

jam

Transport network

$t_a(\tau)$ travel time of arc a at time τ

supply

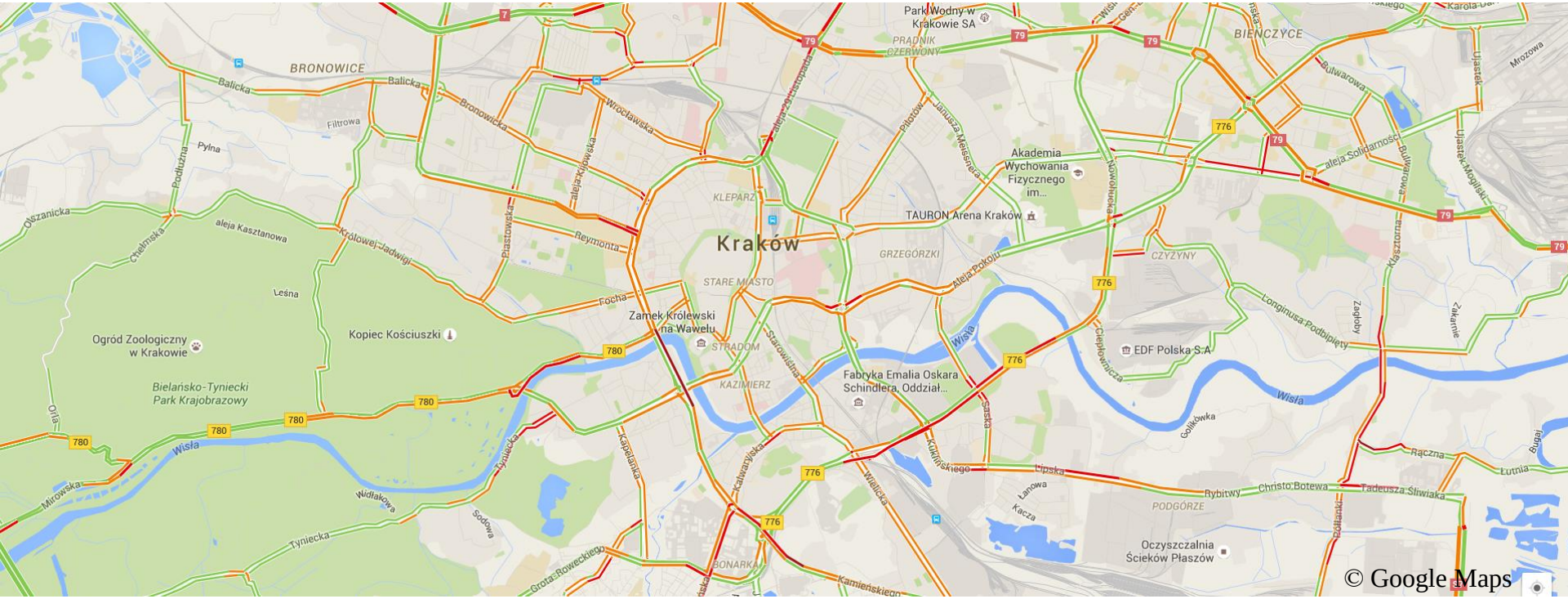
free-flow

delayed

stop-and-go

Transport network

$t_a(\tau)$ travel time of arc a at time τ



Supply - Demand

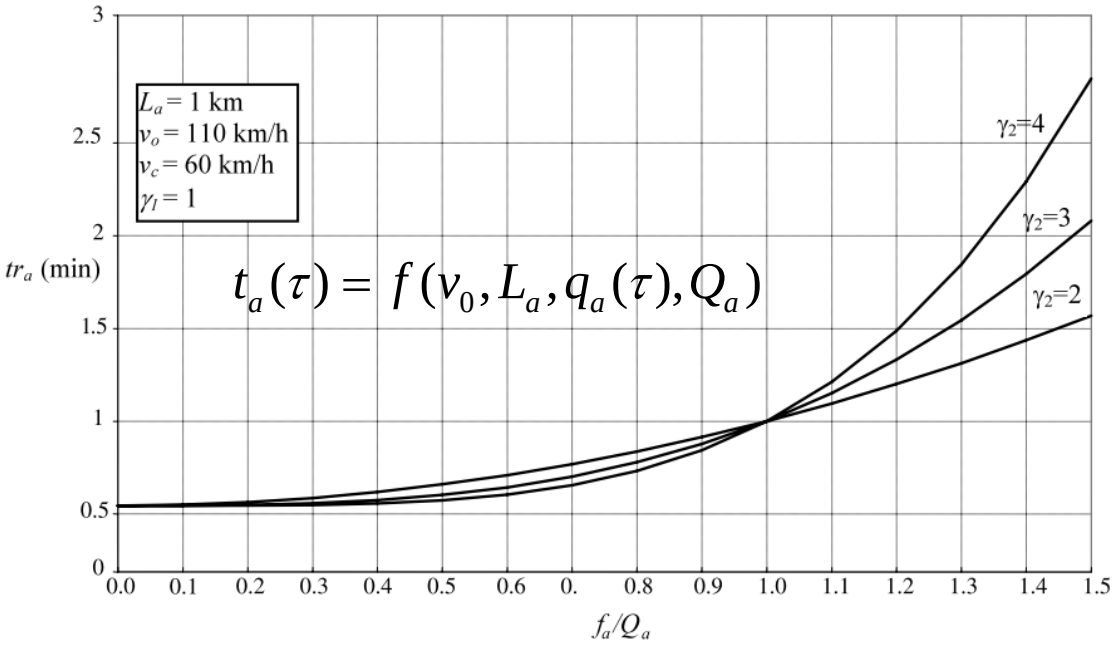
$t_a(\tau)$ travel time of arc a at time τ depends on:

- $\boldsymbol{Q_a}$ link capacity, the average maximum number of vehicles that can travel along the road section in a time unit
- $\boldsymbol{q_a(\tau)}$ number of vehicles (demand)
- v_0 free-flow speed
- L length

$$t_a(\tau) = f(v_0, L_a, q_a(\tau), Q_a)$$

Supply - Demand

$t_a(\tau)$ travel time of arc a at time τ



Demand → network flows

$q_a(\tau)$ number of vehicles/pax on arc a at time τ

results from number of passengers that want to travel via this arc

total demand for trips $d_{od}(\tau)$

$\times$

share that wants to use this arc

(because arc is convenient/efficient)

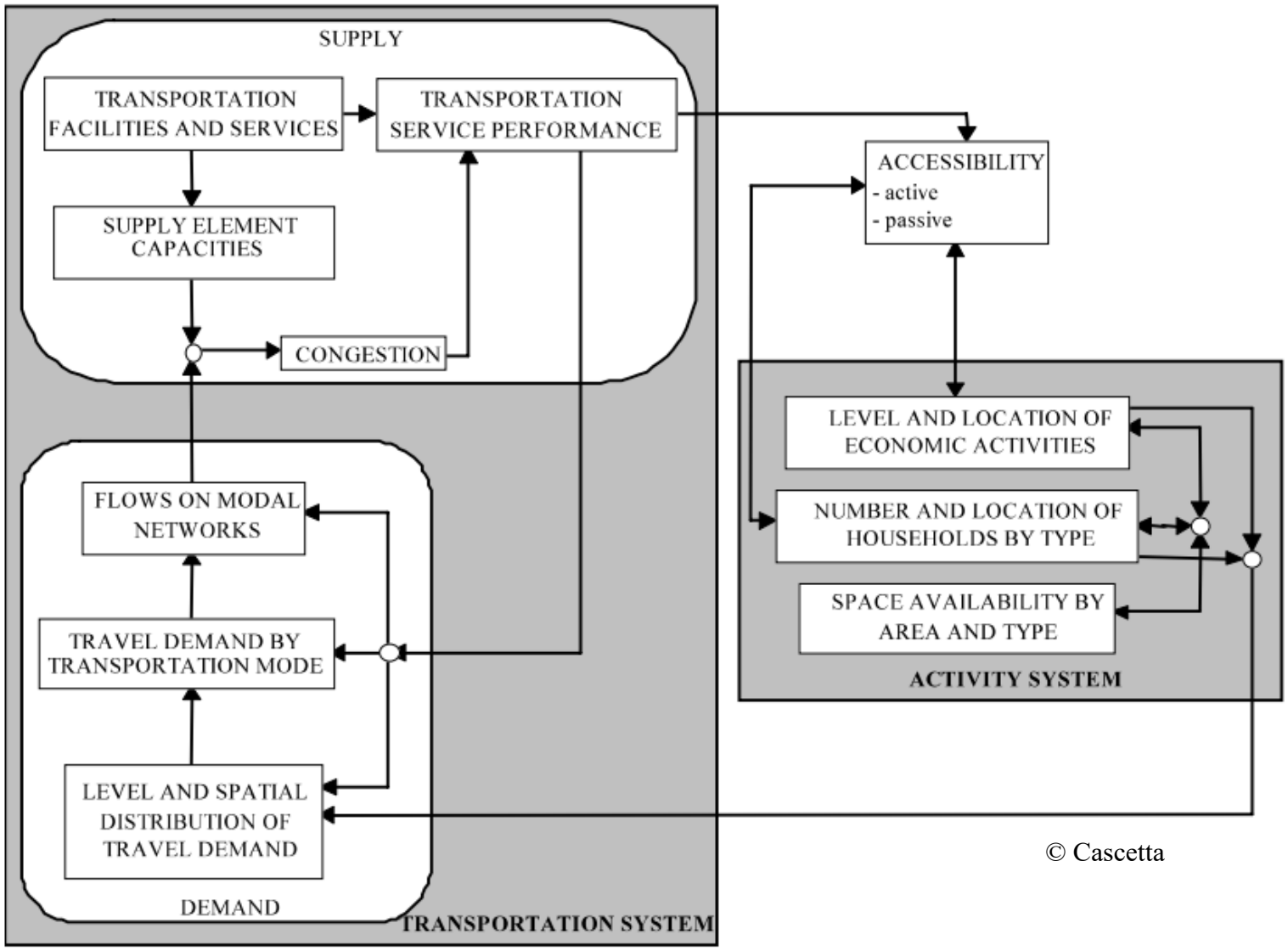
Variability

How the system changes?
Why the system changes?

Will the demand *d* change?
Will the flows *q* change?
Will the travel times *t* change?

$$\frac{dq_a(\tau)}{dx} \qquad \frac{dt}{dq}$$

Transport system



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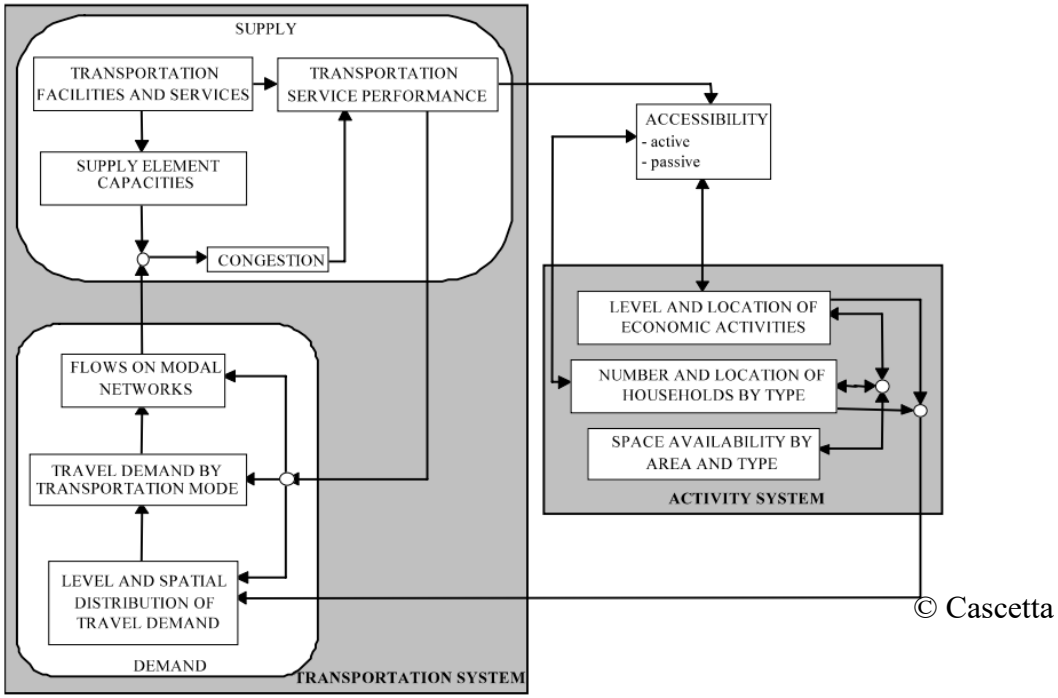
Transport system

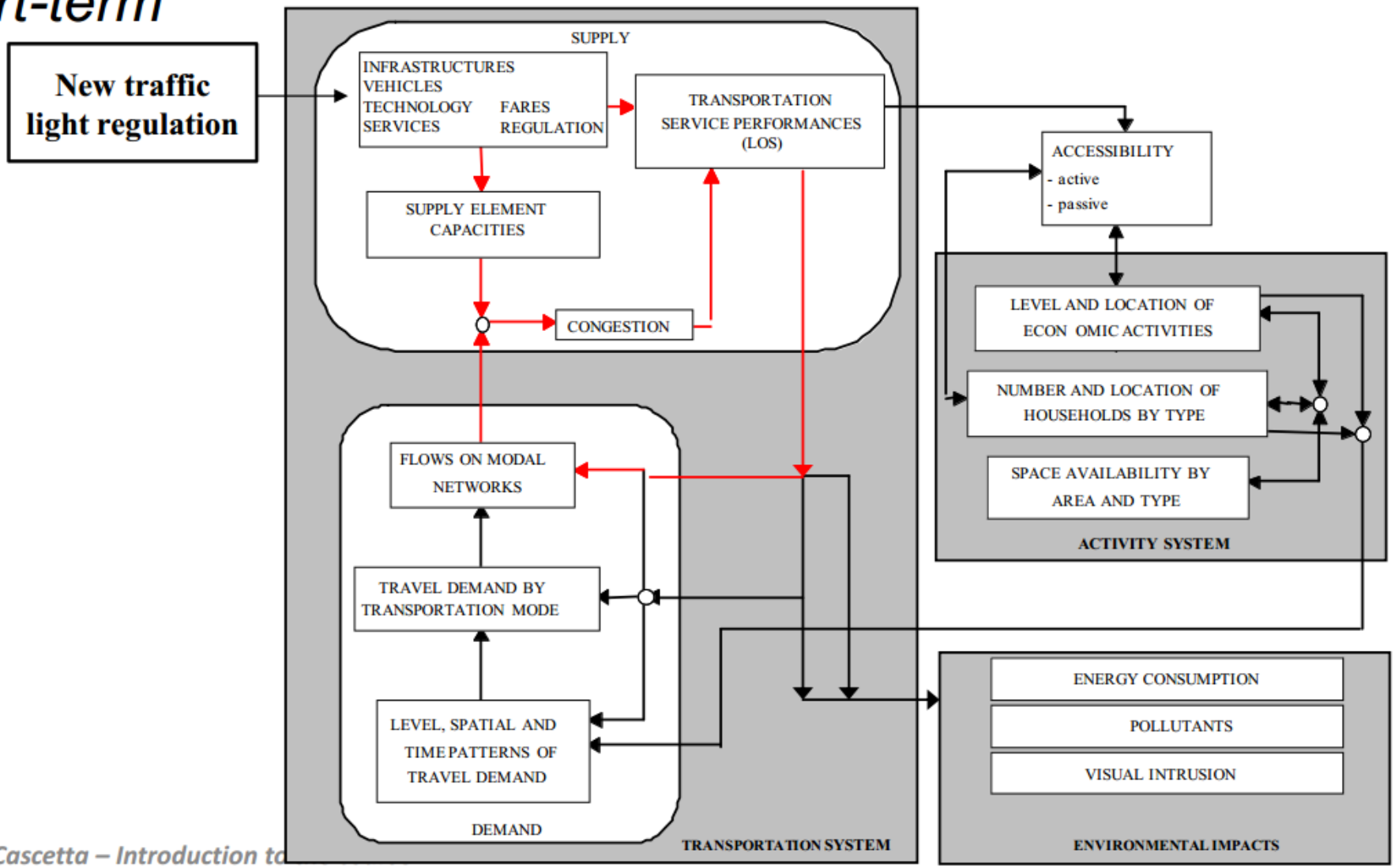
we create (plan) the system to make it optimal

but how the system will change after we change it?



Transport system

Short-term



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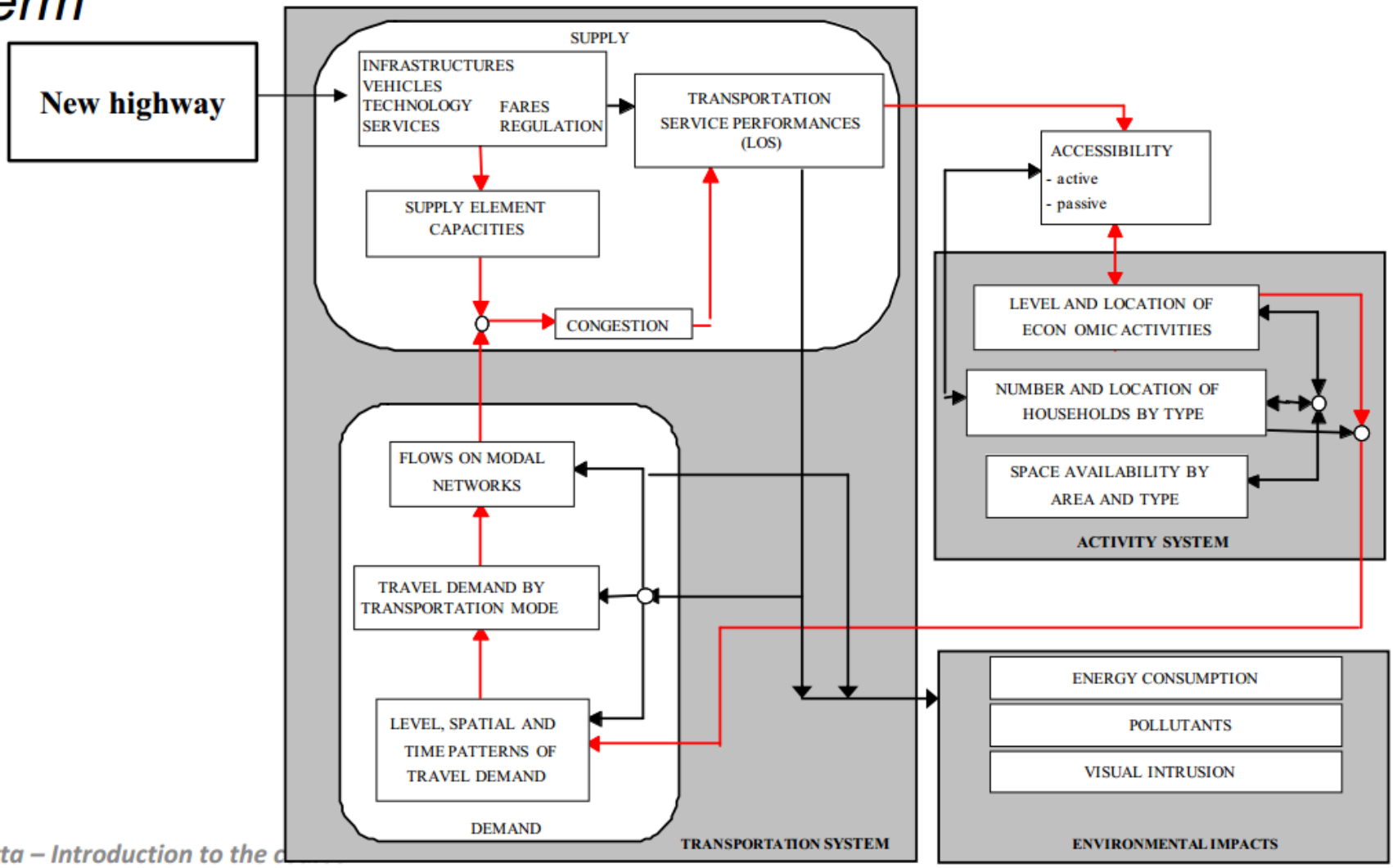
Transport system

Long-term



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Next week

1. Demand models
2. What are the trips?
3. Where do they come from?
4. Why people travel?
5. How to quantify it?
6. Four-stage model
7. Activity chains