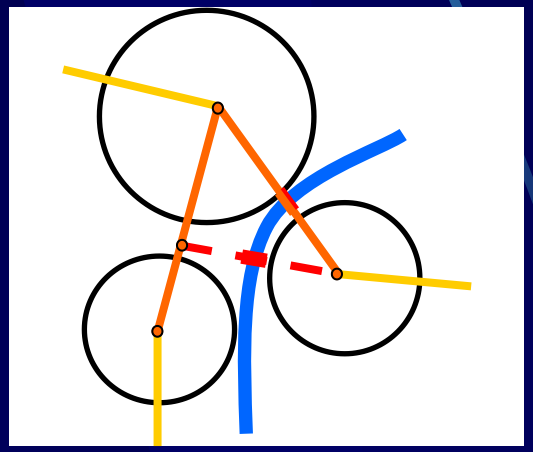
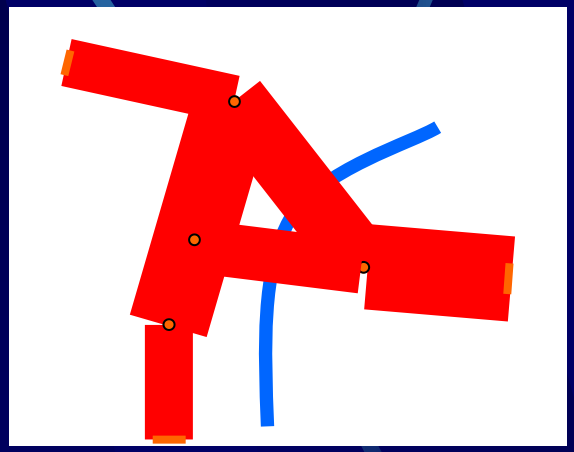
Traffic planning of a road network applying the four-stages method





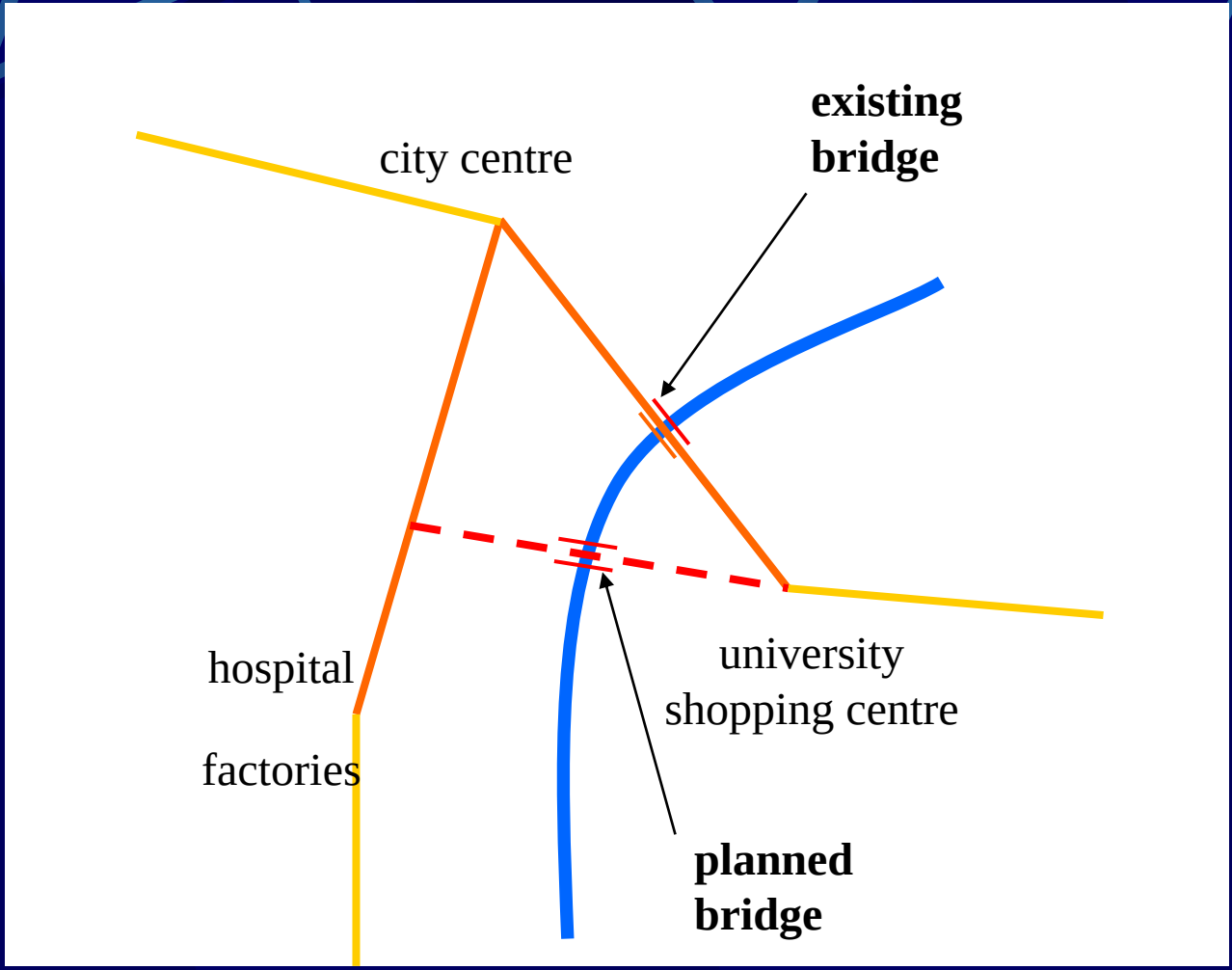
Transport networks practice 3-6.
András Gulyás PhD habil
associate professor

Contents of the practice

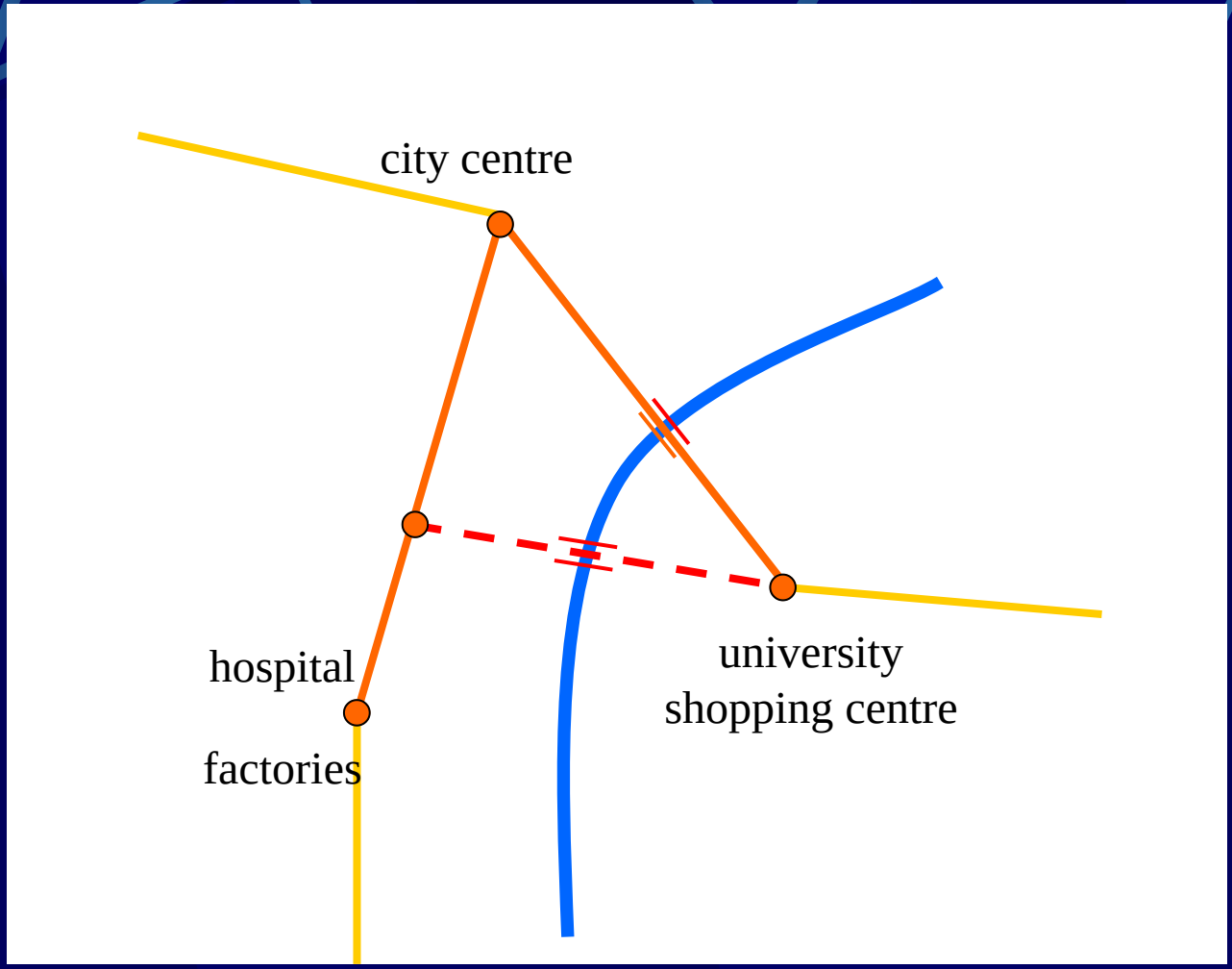
Task: determine the future traffic of a planned bridge

0. **Zones, traffic matrix**
1. **Trip generation (per spatial zones)**
2. **Trip distribution (between zones, matrix)**
3. **Modal split (cars, public transport, freight)**
4. **Assignment (current and future network)**

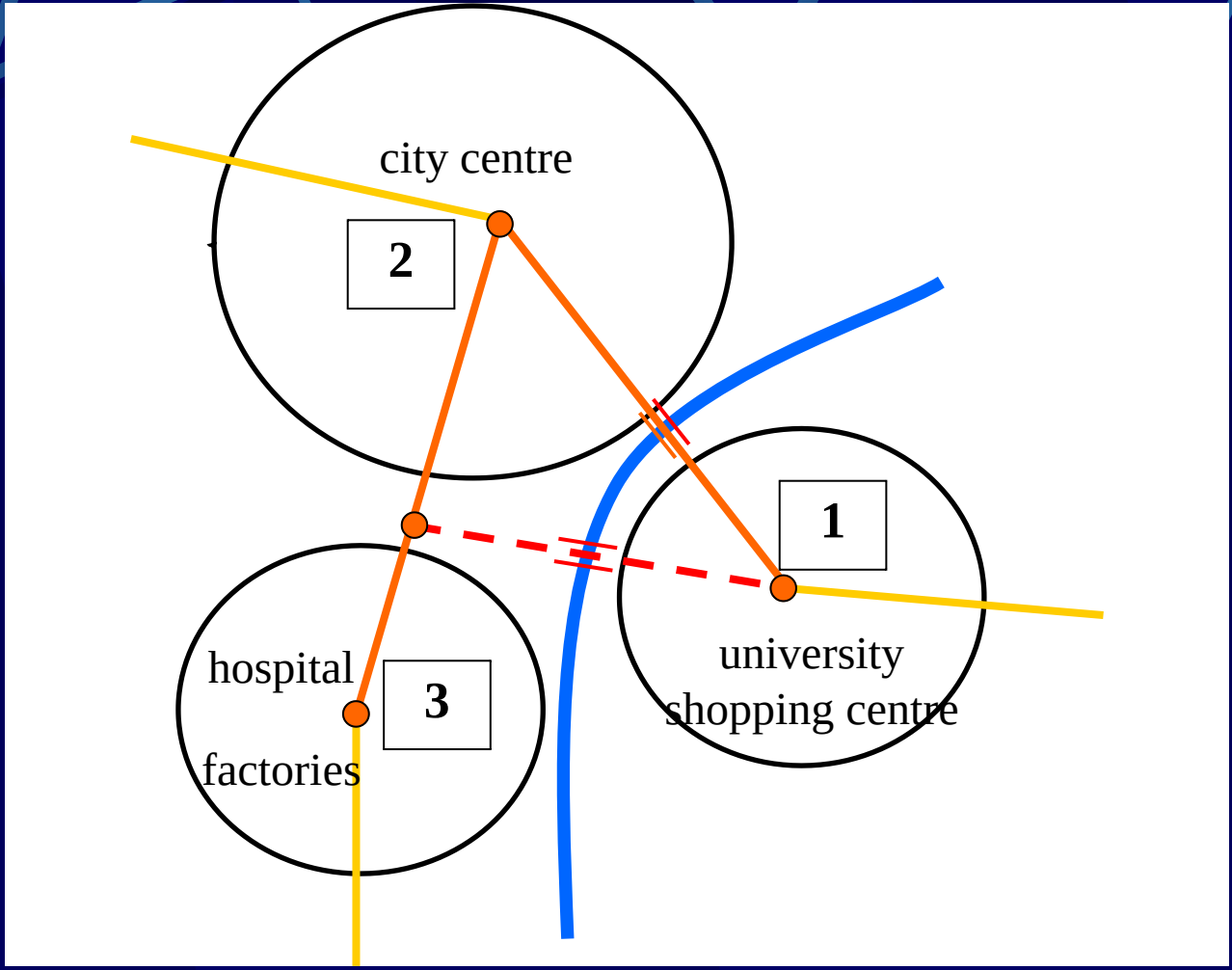
Zones – land-use, project task



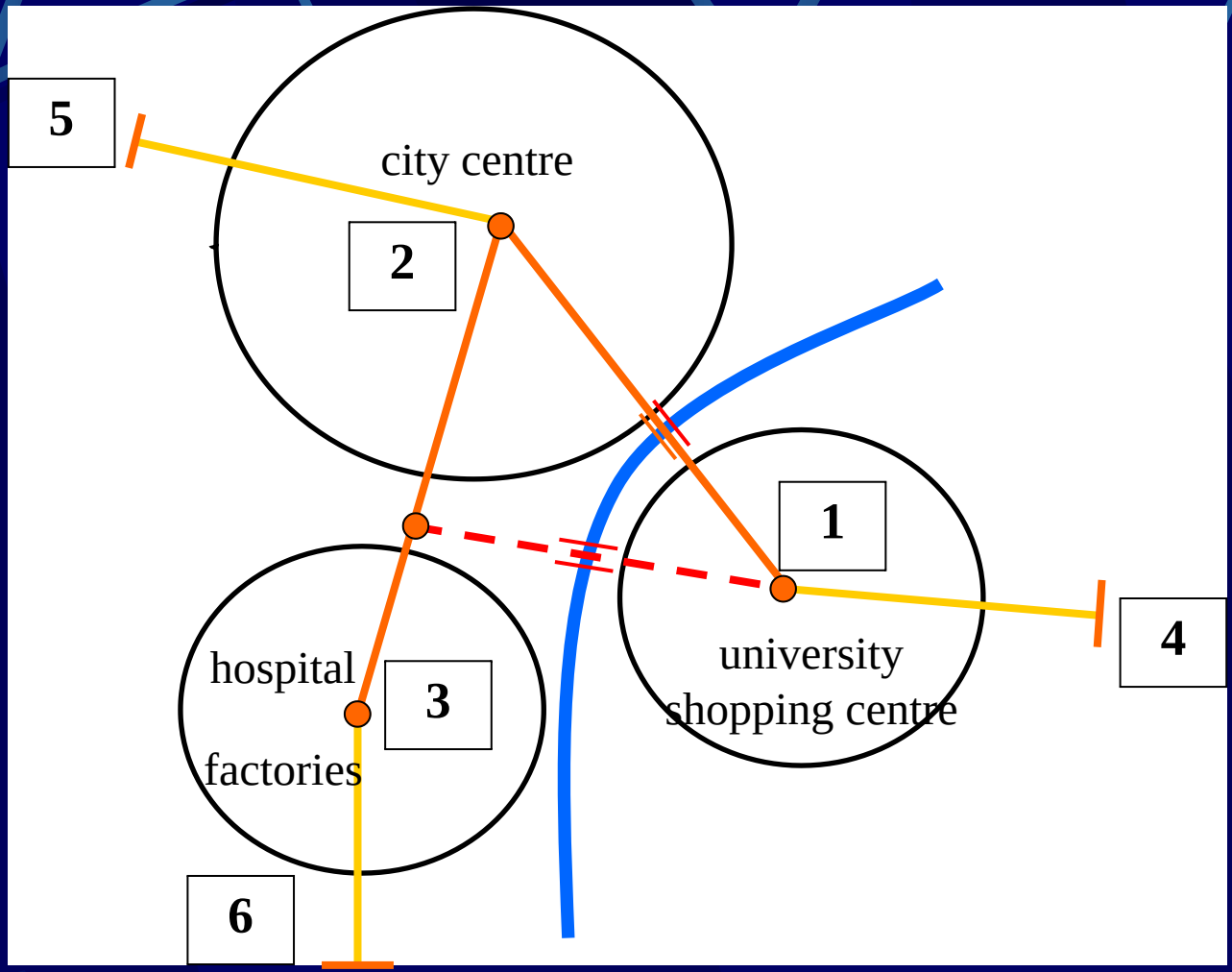
Zones – road network



Zones – inner zones



Zones – cordons



Traffic matrix – parts

Traffic matrix	1 - 3	4 - 6	össz.
1 – 3	inner traffic	origin	generation
4 - 6	destination	through traffic	generation
sum	attraction	attraction	total traffic

Trip generation – land-use variables

Zones Land-use variables	1	2	3
Inhabitants I (person)	-	10 000	5 000
Workplaces W (employee)	1000	5 000	5 000
Services S (m^2)	24 000	15 000	5 000

Trip generation – regression

Calculation of trip generation from land-use variables applying a regression function:

$$F = 0.01\ I + 0.01\ W + 0.01\ S$$

$$F_1 = 10 + 240 = 250$$

$$F_2 = 100 + 50 + 150 = 300$$

$$F_3 = 50 + 50 + 50 = 150$$

dimension of traffic values: personal car units / hour

Trip generation – present inner traffic

PRESENT	1	2	3	Sum
1				250
2				300
3				150
Sum	250	300	150	700

Trip distribution – „A” method

Trip distribution by proportions of attractions:

$$f_{i,j} = P_i \frac{A_j}{\sum A_j}$$

Trip distribution – „A” initial step present traffic

$F_{1,2} = 250 * 300 / (300 + 150) = 167$

$F_{1,3} = 250 * 150 / (300 + 150) = 83$

$F_{2,1} = 300 * 250 / (250 + 150) = 188$

$F_{2,3} = 300 * 150 / (250 + 150) = 112$

$F_{3,1} = 150 * 250 / (250 + 300) = 68$

$F_{3,2} = 150 * 300 / (250 + 300) = 82$

Trip distribution – „A” initial step present traffic

PRESENT	1	2	3	Sum
1	-	167	83	250
2	188	-	112	300
3	68	82	-	150
Sum	256	249	195	700

Trip distribution – „B” method

Trip distribution applying the generalised gravity model

$$f_{i,j} = \alpha \frac{P_i \cdot A_j}{r_{i,j}}$$

resistance function ($r_{i,j}$) is proportional to the user cost of travel between zones

simplification: all sections have the same unit cost (10)

Trip distribution – „B” distances present situation

PRESENT	1	2	3
1	-	10	30
2	10	-	20
3	30	20	-

Trip distribution – „B” initial step present traffic

$F_{1,2}$ = 0.0286 * (250 * 300) / 10 = 214

$F_{1,3}$ = 0.0286 * (250 * 150) / 30 = 36 250

$F_{2,1}$ = 0.0308 * (300 * 250) / 10 = 231

$F_{2,3}$ = 0.0308 * (300 * 150) / 20 = 69 300

$F_{3,1}$ = 0.0428 * (150 * 250) / 30 = 54

$F_{3,2}$ = 0.0428 * (150 * 300) / 20 = 96 150

alfa values were chosen to get back zonal trip generations

Trip distribution – „B” initial step present traffic

PRESENT	1	2	3	Sum
1	-	214	36	250
2	231	-	69	300
3	54	96	-	150
Sum	285	310	105	700

Trip distribution – iterative step 1 average of „A” and „B” – present

PRESENT	1	2	3	Sum
1	-	190	60	250
2	210	-	90	300
3	61	89	-	150
Sum	271	279	150	700

Trip distribution – iterative step 2 average of symmetrical elements

PRESENT	1	2	3	Sum
1	-	200	60	260
2	200	-	90	290
3	60	90	-	150
Sum	260	290	150	700

Trip distribution – iterative step 3 adjustment to trip generations

PRESENT	1	2	3	Sum
1	-	200	50	250
2	200	-	100	300
3	50	100	-	150
Sum	250	300	150	700

Trip generation – forecast

Forecast applying growth factors:

- development in zone 1. +20%
- development in zone 2. 0 (saturated)
- development in zone 3. +20%

$F_{1T} = 250 * 1.2 = 300$

$F_{2T} = 300$

$F_{3T} = 150 * 1.2 = 180$

Trip generation – future inner traffic

FUTURE	1	2	3	Sum
1				300
2				300
3				180
Sum	300	300	180	780

Trip distribution – „A” initial step future traffic

$F_{1,2} = 300 * 300 / (300 + 180) = 188$

$F_{1,3} = 300 * 180 / (300 + 180) = 112$

$F_{2,1} = 300 * 300 / (300 + 180) = 188$

$F_{2,3} = 300 * 180 / (300 + 180) = 112$

$F_{3,1} = 180 * 300 / (300 + 300) = 90$

$F_{3,2} = 180 * 300 / (300 + 300) = 90$

Trip distribution – „A” initial step future traffic

FUTURE	1	2	3	Sum
1	-	188	112	300
2	188	-	112	300
3	90	90	-	180
Sum	278	278	224	780

Trip distribution – „B” distances future situation

FUTURE	1	2	3
1	-	10	20
2	10	-	20
3	20	20	-

Trip distribution – „B” initial step future traffic

$F_{1,2} = 0.026 * (300 * 300) / 10 = 230$

$F_{1,3} = 0.026 * (300 * 180) / 20 = 70$

$F_{2,1} = 0.026 * (300 * 300) / 10 = 230$

$F_{2,3} = 0.026 * (300 * 180) / 20 = 70$

$F_{3,1} = 0.033 * (180 * 300) / 20 = 90$

$F_{3,2} = 0.033 * (180 * 300) / 20 = 90$

Trip distribution – „B” initial step future traffic

FUTURE	1	2	3	Sum
1	-	230	70	300
2	230	-	70	300
3	90	90	-	180
Sum	320	320	140	780

Trip distribution – iterative step 1 average of „A” and „B” - future traffic

FUTURE	1	2	3	Sum
1	-	209	91	300
2	209	-	91	300
3	90	90	-	180
Sum	299	299	182	780

Trip distribution – iterative step 2, 3 adjustment to trip generations

FUTURE	1	2	3	Sum
1	-	210	90	300
2	210	-	90	300
3	90	90	-	180
Sum	300	300	180	780

Trip generation – origin-destination traffic

PRESENT = FUTURE	1	2	3	Sum
4				700
5				350
6				350
Sum				1400

Trip distribution – origin-destination traffic

- Values of the origin-destination traffic and the through traffic are known from traffic survey performed at cordon points.
- Simplification: no future traffic development within the region.
- Distribution of the origin-destination traffic is based on the proportions of inner traffic attractions.

$$f_{k,j} = P_k \frac{A_{j,\ inner}}{\sum A_{j,\ inner}}$$

Trip distribution – origin-destination traffic – present traffic

$F_{4,1} = 700 * 250 / (250 + 300 + 150) = 250$

$F_{4,2} = 700 * 300 / (250 + 300 + 150) = 300$

$F_{4,3} = 700 * 150 / (250 + 300 + 150) = 150$

$F_{5,1} = 350 * 250 / (250 + 300 + 150) = 125$

$F_{5,2} = 350 * 300 / (250 + 300 + 150) = 150$

$F_{5,3} = 350 * 150 / (250 + 300 + 150) = 75$

Trip distribution – origin-destination traffic – present traffic

PRESENT	1	2	3	Sum
4	250	300	150	700
5	125	150	75	350
6	125	150	75	350
Sum	500	600	300	1400

Trip distribution – origin-destination traffic – present and future traffic

$F_{4,1} = 700 * 300 / (300 + 300 + 180) = 270$

$F_{4,2} = 700 * 300 / (300 + 300 + 180) = 270$

$F_{4,3} = 700 * 180 / (300 + 300 + 180) = 160$

$F_{5,1} = 350 * 300 / (300 + 300 + 180) = 135$

$F_{5,2} = 350 * 300 / (300 + 300 + 180) = 135$

$F_{5,3} = 350 * 180 / (300 + 300 + 180) = 80$

Trip distribution – origin-destination traffic – future traffic

FUTURE	1	2	3	Sum
4	270	270	160	700
5	135	135	80	350
6	135	135	80	350
Sum	540	540	320	1400

Trip distribution – through traffic

PRESENT = FUTURE	4	5	6	Sum
4	-	50	50	100
5	50	-	50	100
6	50	50	-	100
Sum	100	100	100	300

Total traffic matrix – present traffic

PRESENT	1	2	3	4	5	6	Sum
1	-	200	50	250	125	125	750
2	200	-	100	300	150	150	900
3	50	100	-	150	75	75	450
4	250	300	150	-	50	50	800
5	125	150	75	50	-	50	450
6	125	150	75	50	50	-	450
Sum	750	900	450	800	450	450	3800

Total traffic matrix – future traffic

FUTURE	1	2	3	4	5	6	Sum
1	-	210	90	270	135	135	840
2	210	-	90	270	135	135	840
3	90	90	-	160	80	80	500
4	270	270	160	-	50	50	800
5	135	135	80	50	-	50	450
6	135	135	80	50	50	-	450
Sum	840	840	500	800	450	450	3880

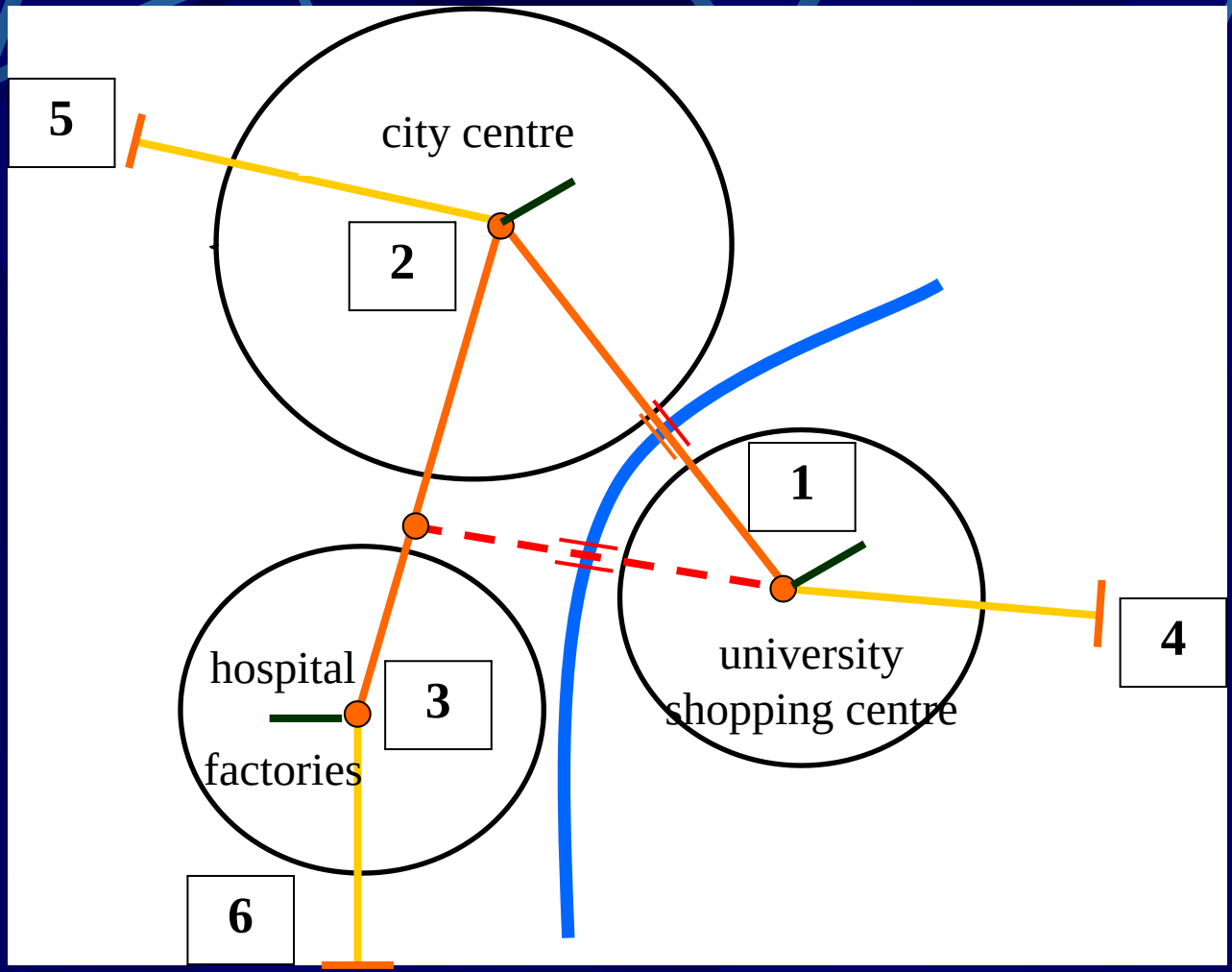
Modal split

- Proportion of individual and public transport
- Layers in the traffic matrix
- The practice example does not deal with this.

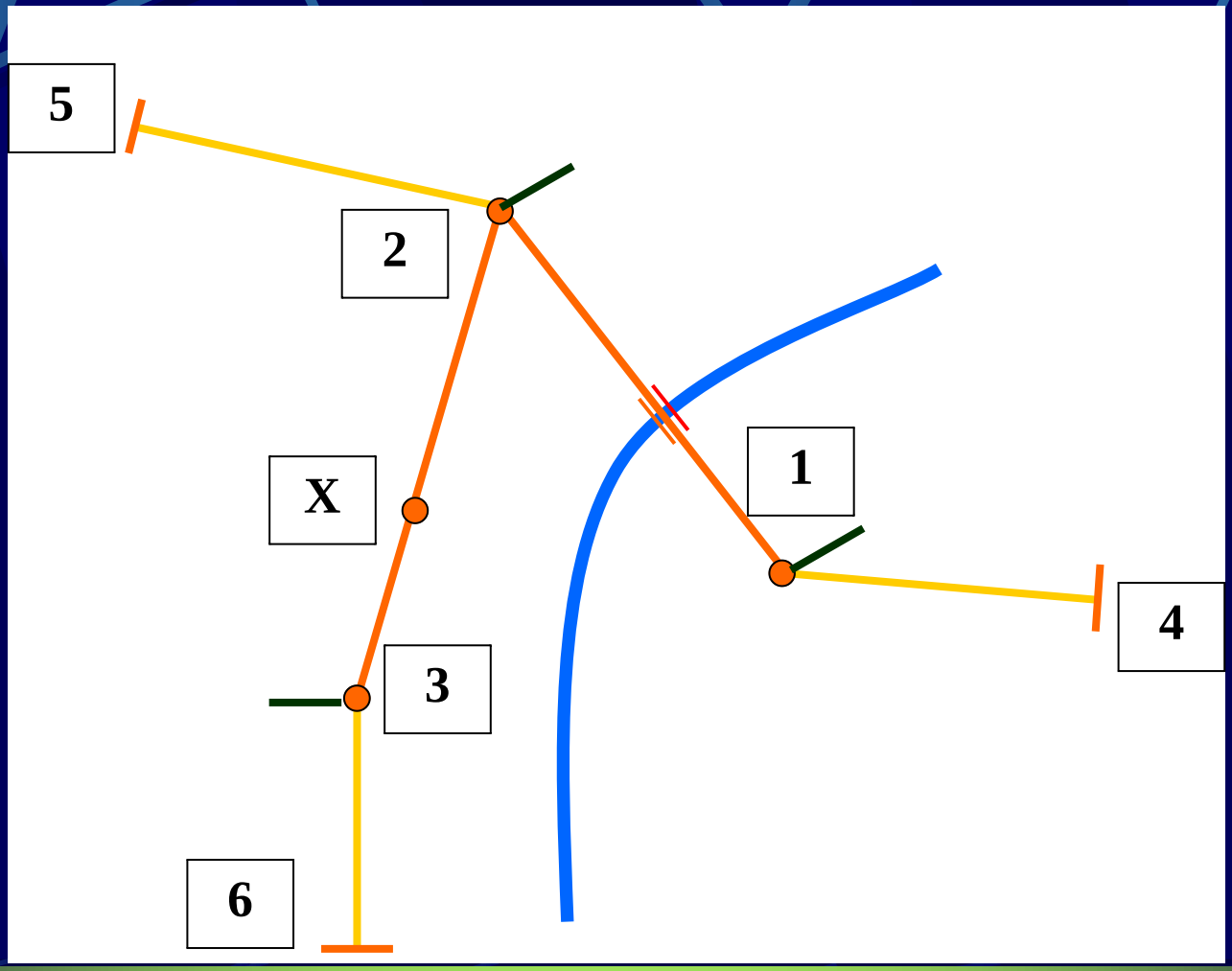
public	1 - 3	4 - 6	sum
1 – 3	inner	origin	generation
4 - 6	destination	through	keltés
sum	attraction	attraction	total traffic

public	1 - 3	4 - 6	sum
1 – 3	inner	origin	generation
4 - 6	destination	through	keltés
sum	attraction	attraction	total traffic

Traffic assignment– zone connections



Traffic assignment – present network



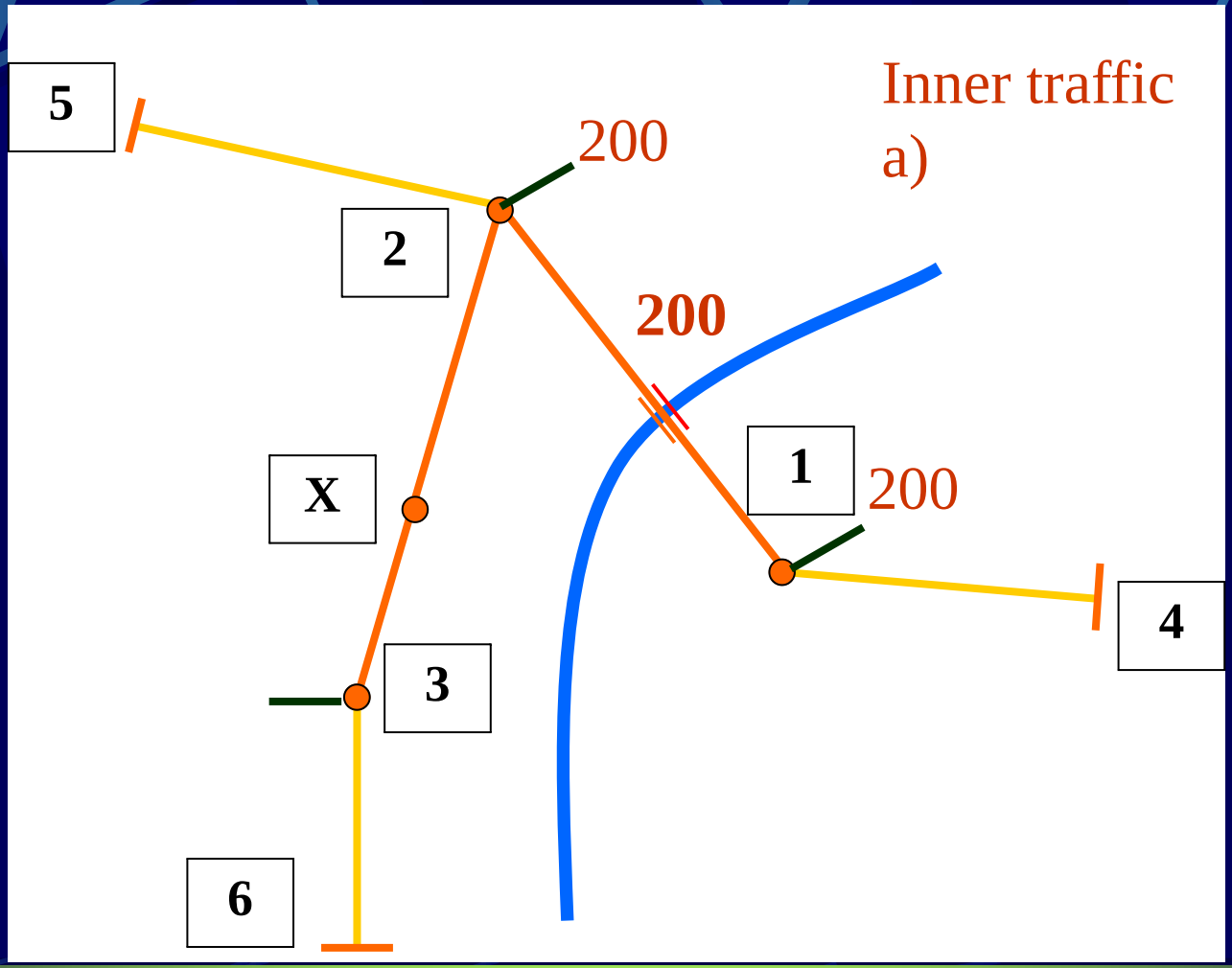
Total traffic matrix – present traffic

PRESENT	1	2	3	4	5	6	Sum
1	-	200	50	250	125	125	750
2	200	-	100	300	150	150	900
3	50	100	-	150	75	75	450
4	250	300	150	-	50	50	800
5	125	150	75	50	-	50	450
6	125	150	75	50	50	-	450
Sum	750	900	450	800	450	450	3800

Total traffic matrix – present traffic

PRESENT	1	2	3	4	5	6	Sum
1	-	200	50	250	125	125	750
2	200	-	100	300	150	150	900
3	50	100	-	150	75	75	450
4	250	300	150	-	50	50	800
5	125	150	75	50	-	50	450
6	125	150	75	50	50	-	450
Sum	750	900	450	800	450	450	3800

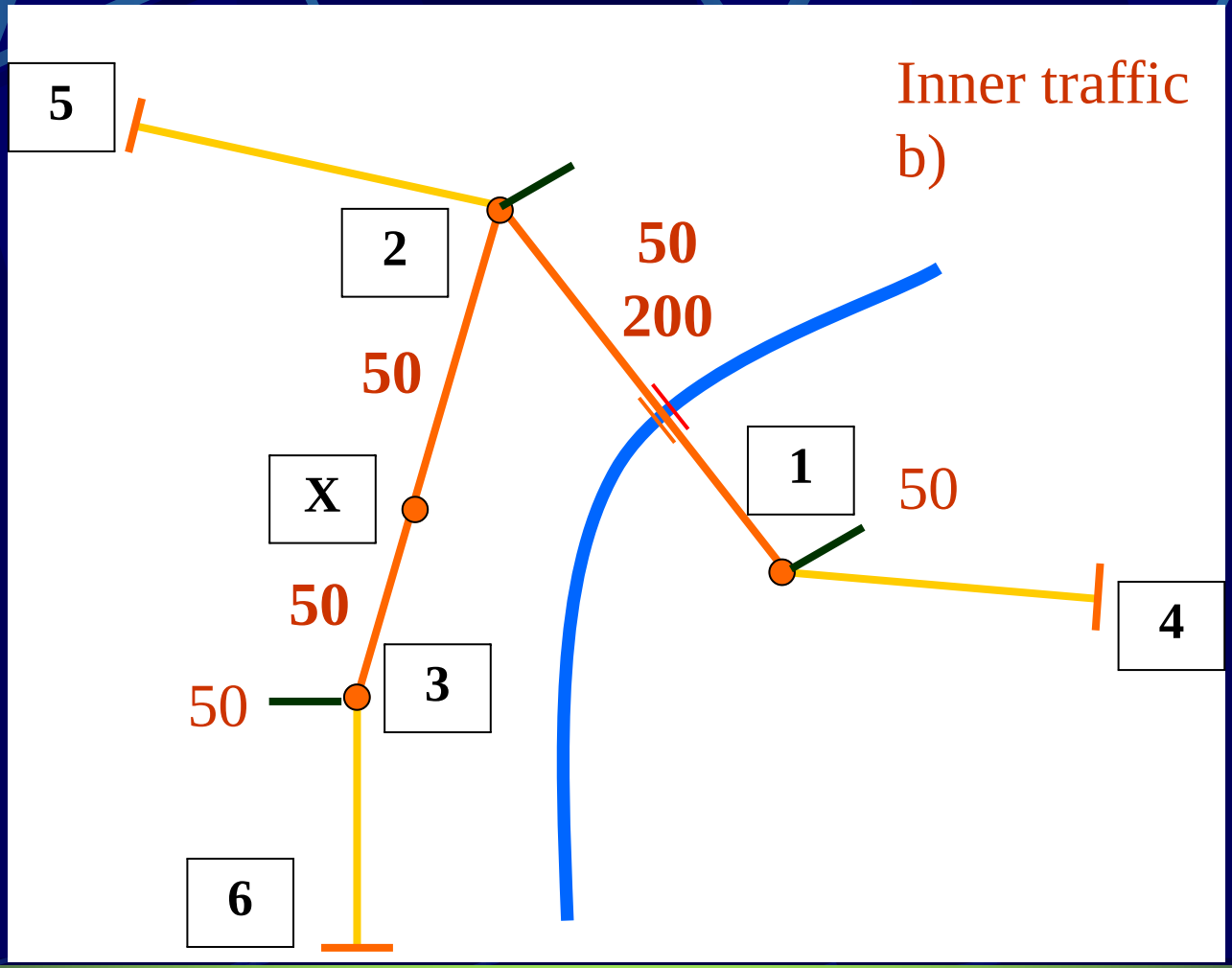
Traffic assignment – present network



Total traffic matrix – present traffic

PRESENT	1	2	3	4	5	6	Sum
1	-	200	50	250	125	125	750
2	200	-	100	300	150	150	900
3	50	100	-	150	75	75	450
4	250	300	150	-	50	50	800
5	125	150	75	50	-	50	450
6	125	150	75	50	50	-	450
Sum	750	900	450	800	450	450	3800

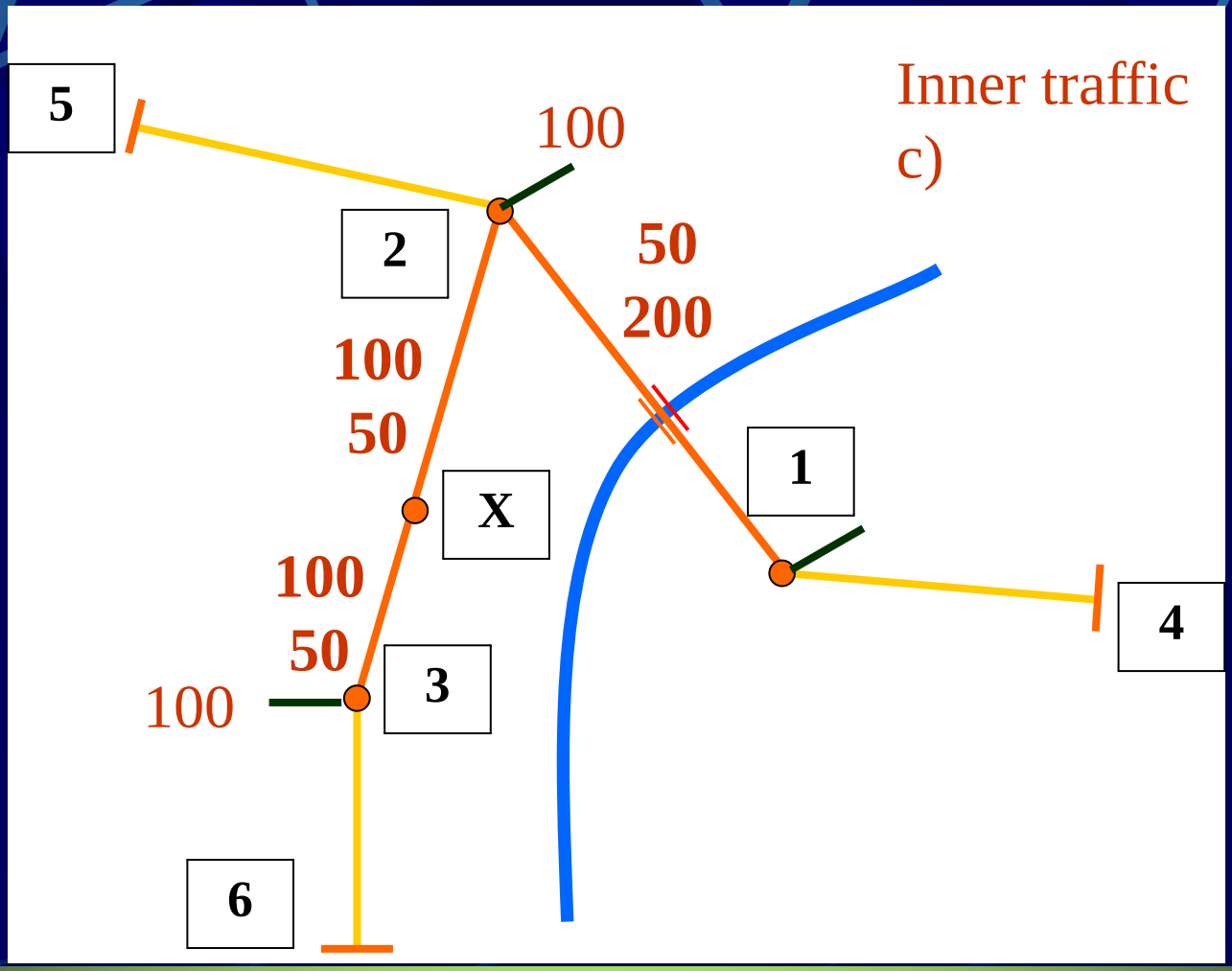
Traffic assignment – present network



Total traffic matrix – present traffic

PRESENT	1	2	3	4	5	6	Sum
1	-	200	50	250	125	125	750
2	200	-	100	300	150	150	900
3	50	100	-	150	75	75	450
4	250	300	150	-	50	50	800
5	125	150	75	50	-	50	450
6	125	150	75	50	50	-	450
Sum	750	900	450	800	450	450	3800

Traffic assignment – present network



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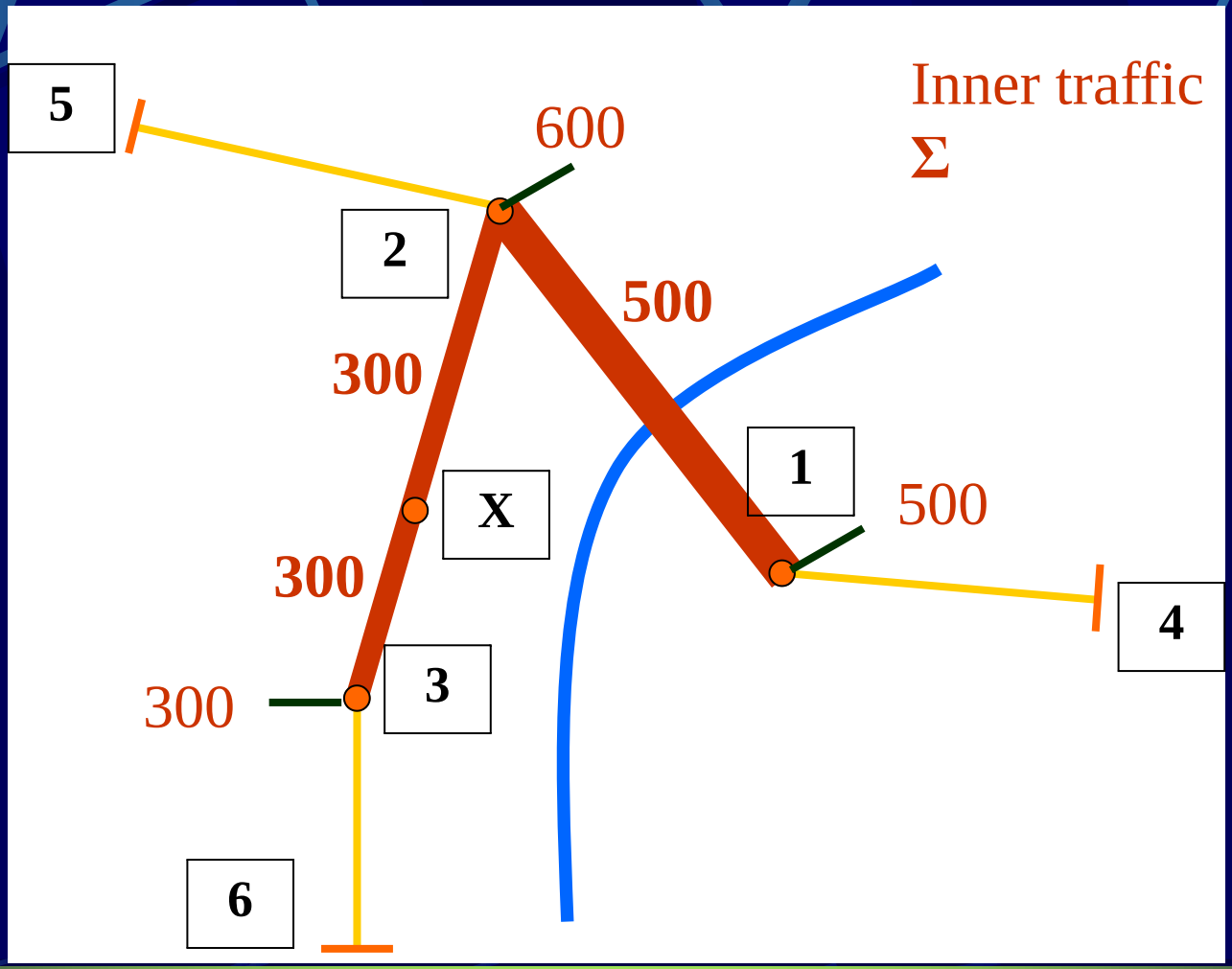
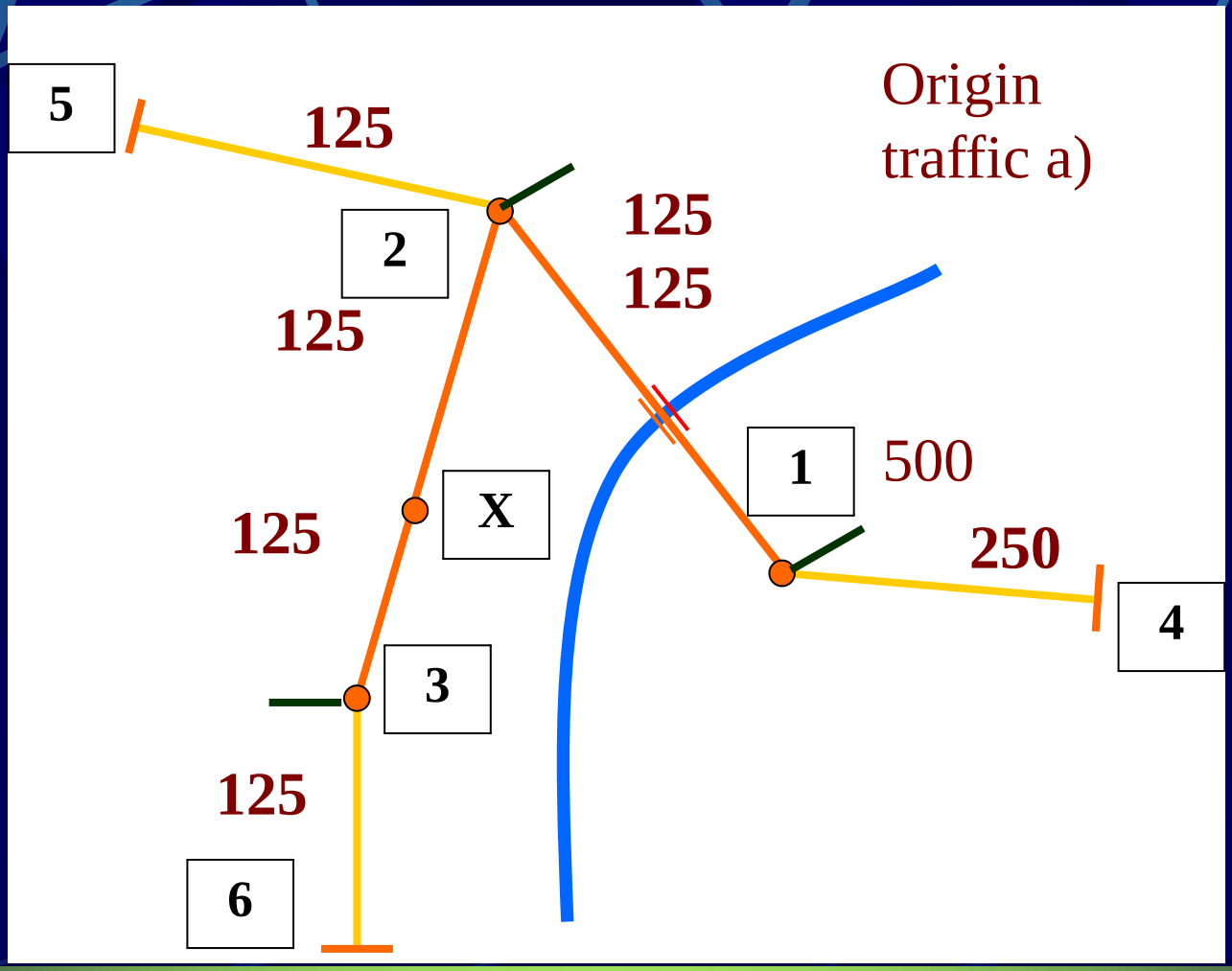


Total traffic matrix – present traffic

PRESENT	1	2	3	4	5	6	Sum
1	-	200	50	250	125	125	750
2	200	-	100	300	150	150	900
3	50	100	-	150	75	75	450
4	250	300	150	-	50	50	800
5	125	150	75	50	-	50	450
6	125	150	75	50	50	-	450
Sum	750	900	450	800	450	450	3800

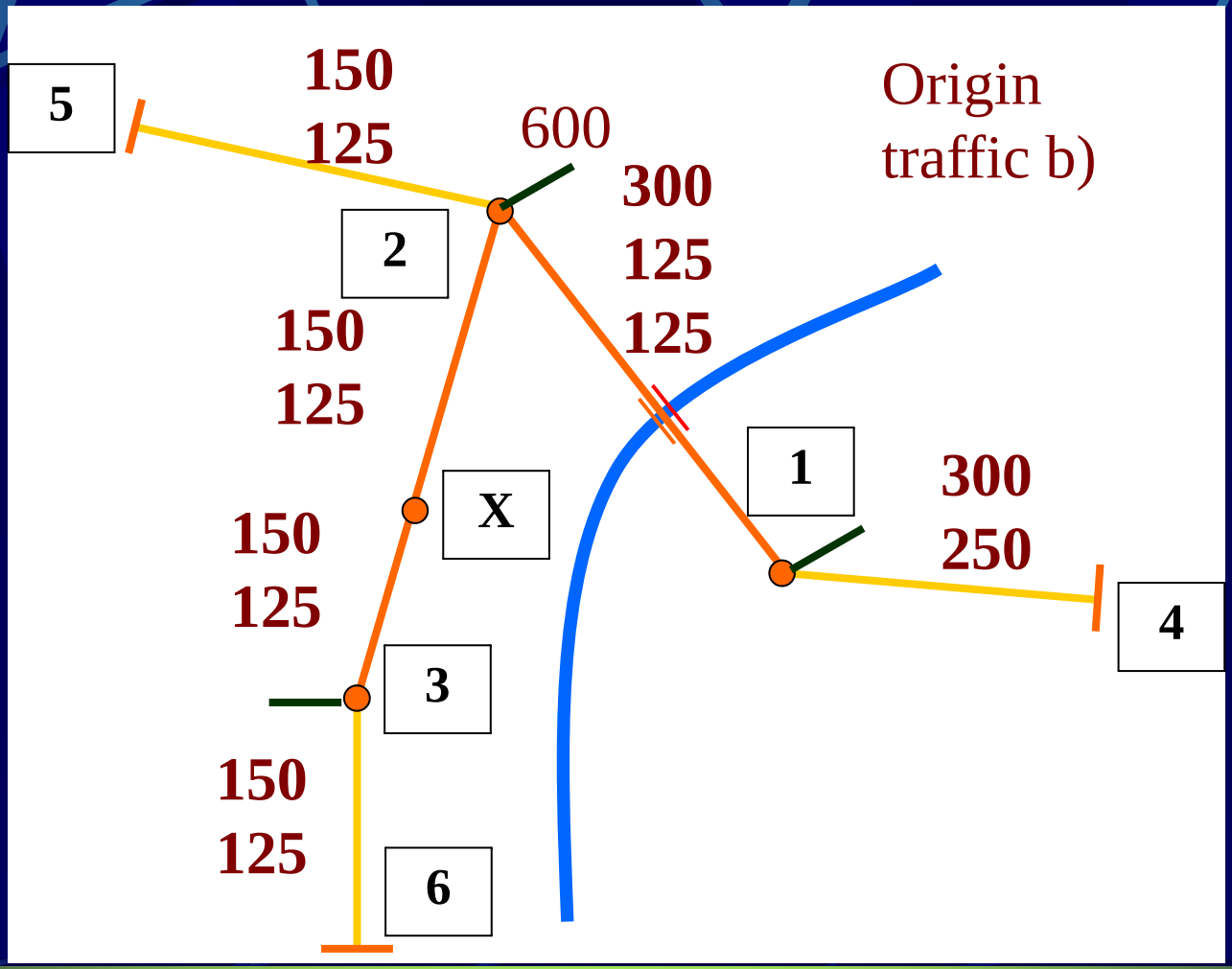
Traffic assignment – present network



Total traffic matrix – present traffic

PRESENT	1	2	3	4	5	6	Sum
1	-	200	50	250	125	125	750
2	200	-	100	300	150	150	900
3	50	100	-	150	75	75	450
4	250	300	150	-	50	50	800
5	125	150	75	50	-	50	450
6	125	150	75	50	50	-	450
Sum	750	900	450	800	450	450	3800

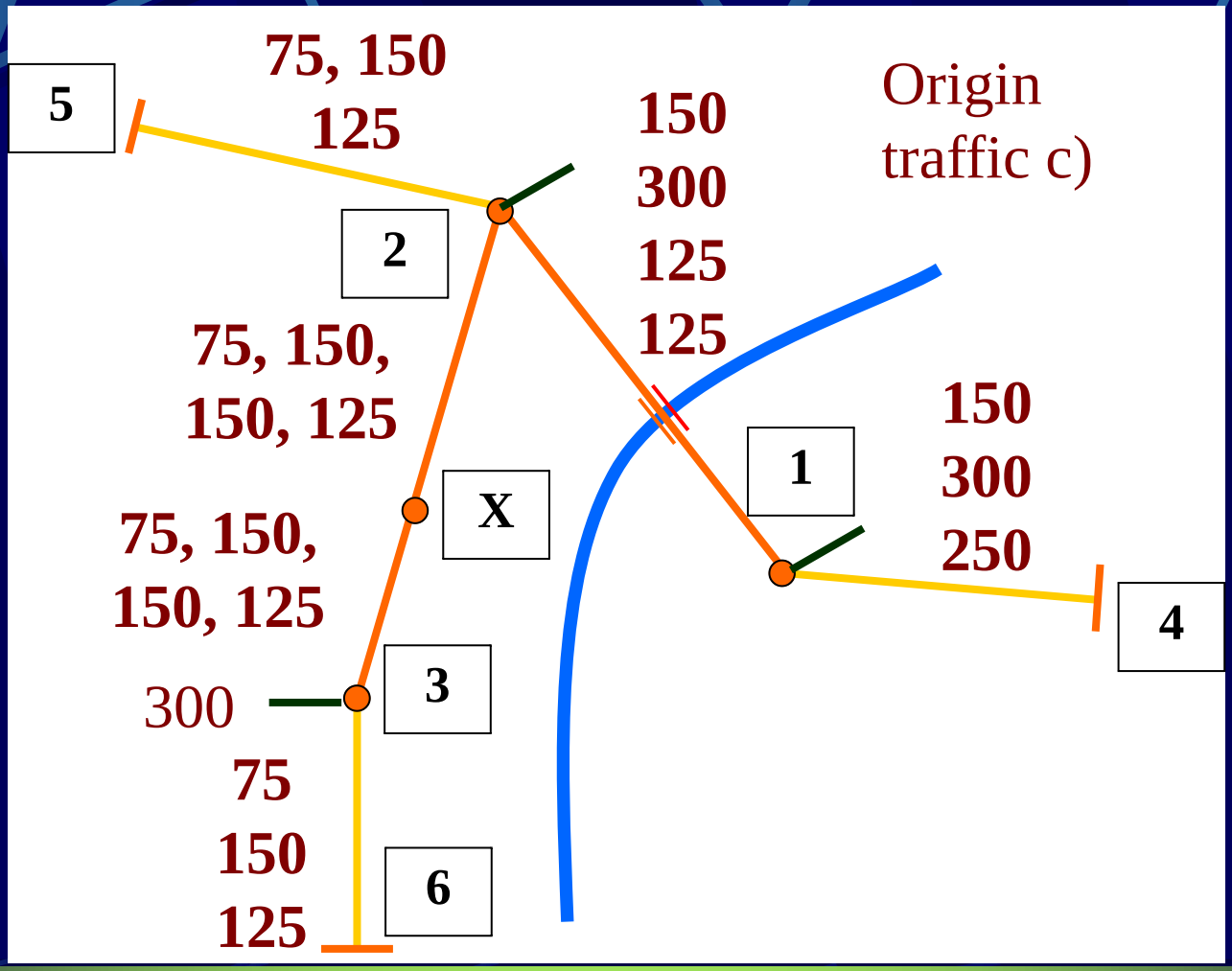
Traffic assignment – present network



Total traffic matrix – present traffic

PRESENT	1	2	3	4	5	6	Sum
1	-	200	50	250	125	125	750
2	200	-	100	300	150	150	900
3	50	100	-	150	75	75	450
4	250	300	150	-	50	50	800
5	125	150	75	50	-	50	450
6	125	150	75	50	50	-	450
Sum	750	900	450	800	450	450	3800

Traffic assignment – present network



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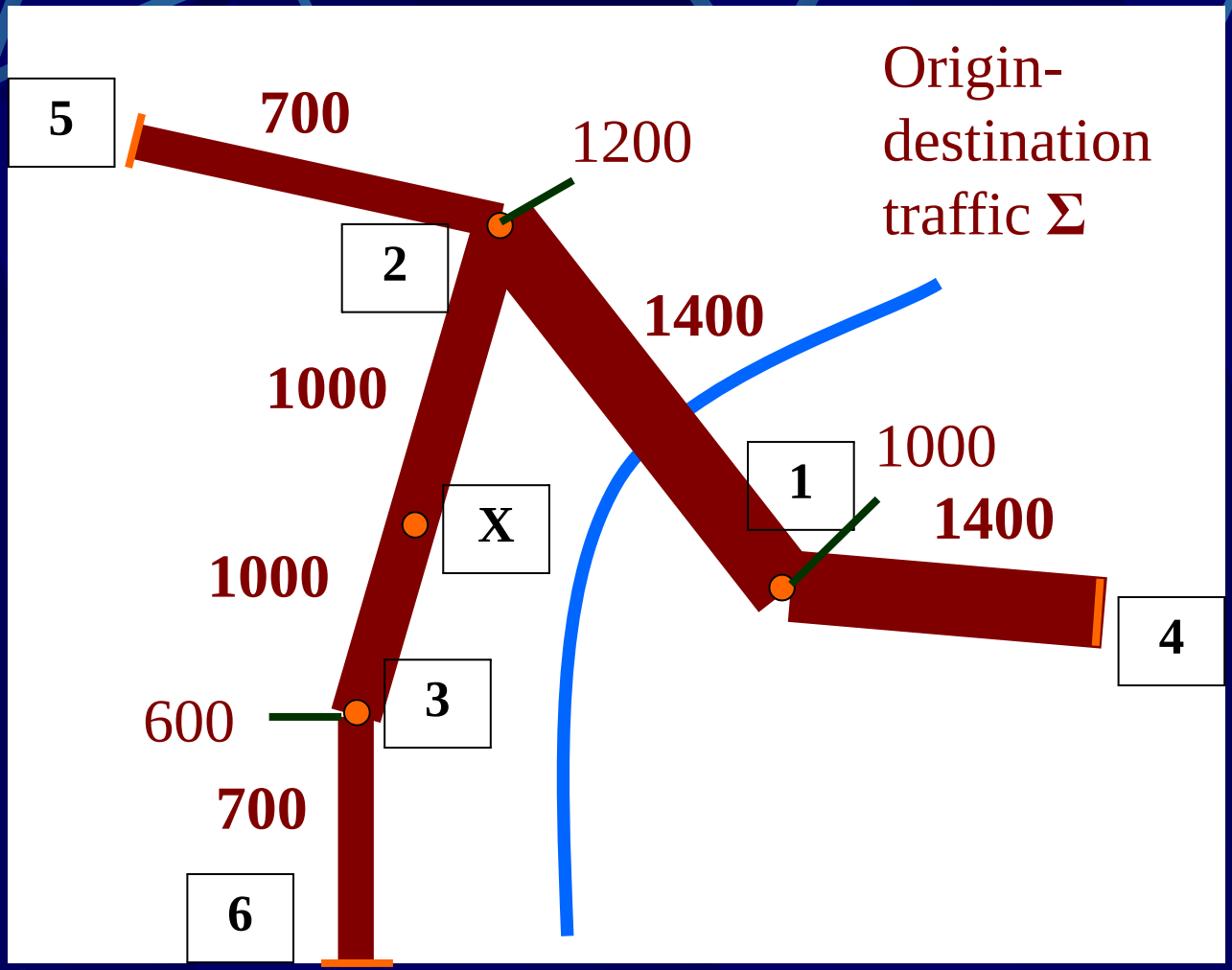

Total traffic matrix – present traffic

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1	-	200	50	250	125	125	750
2	200	-	100	300	150	150	900
3	50	100	-	150	75	75	450
4	250	300	150	-	50	50	800
5	125	150	75	50	-	50	450
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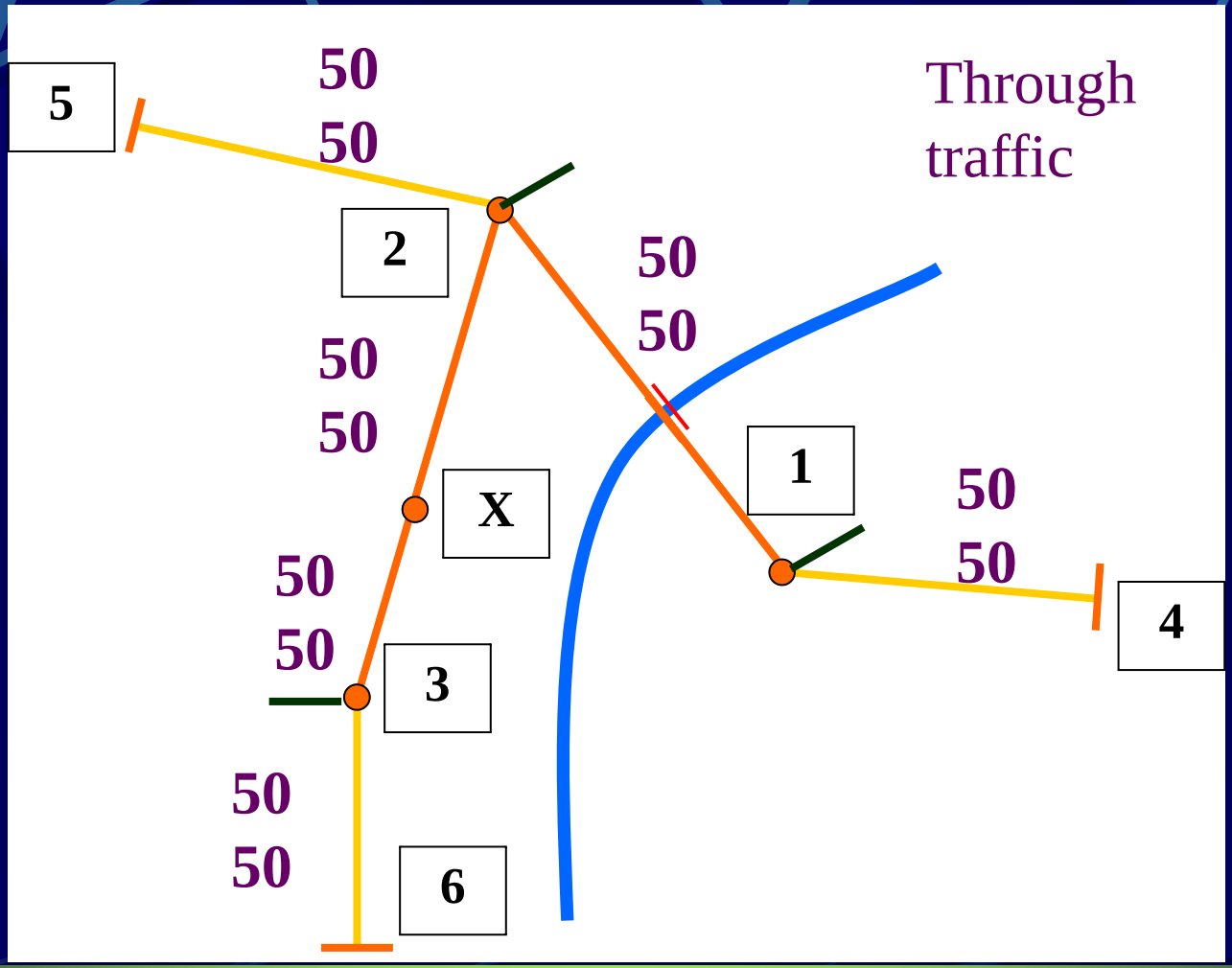
Traffic assignment – present network



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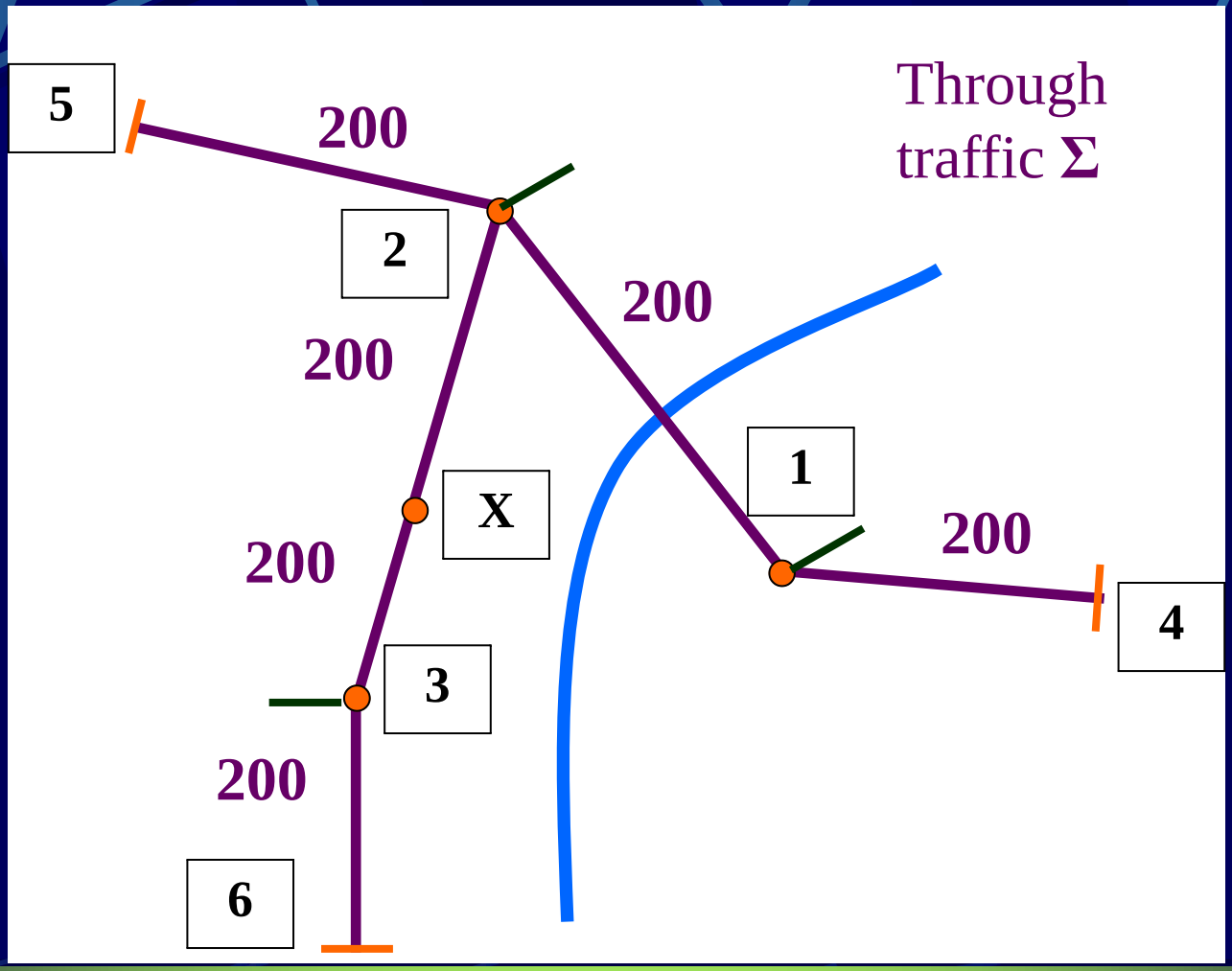
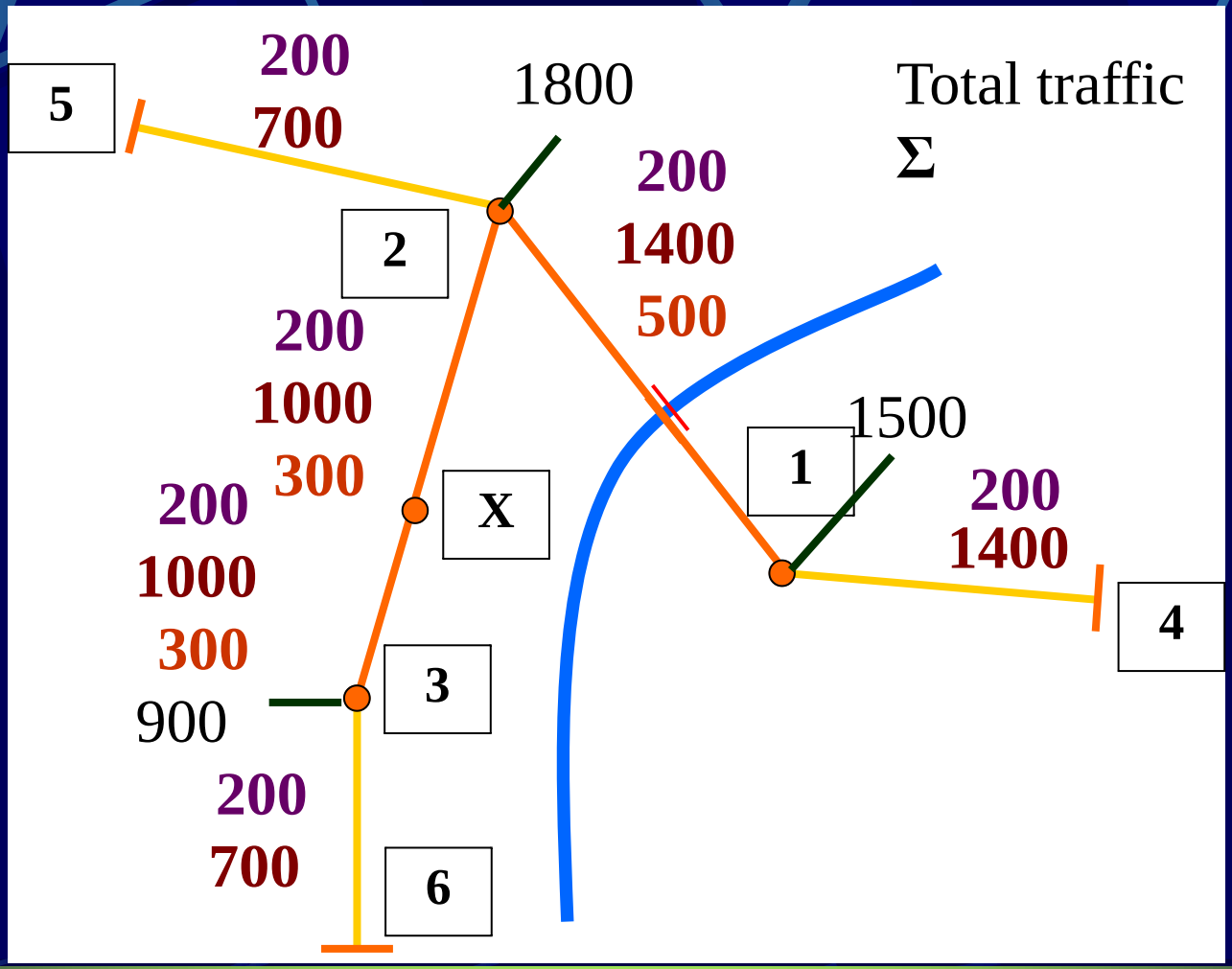
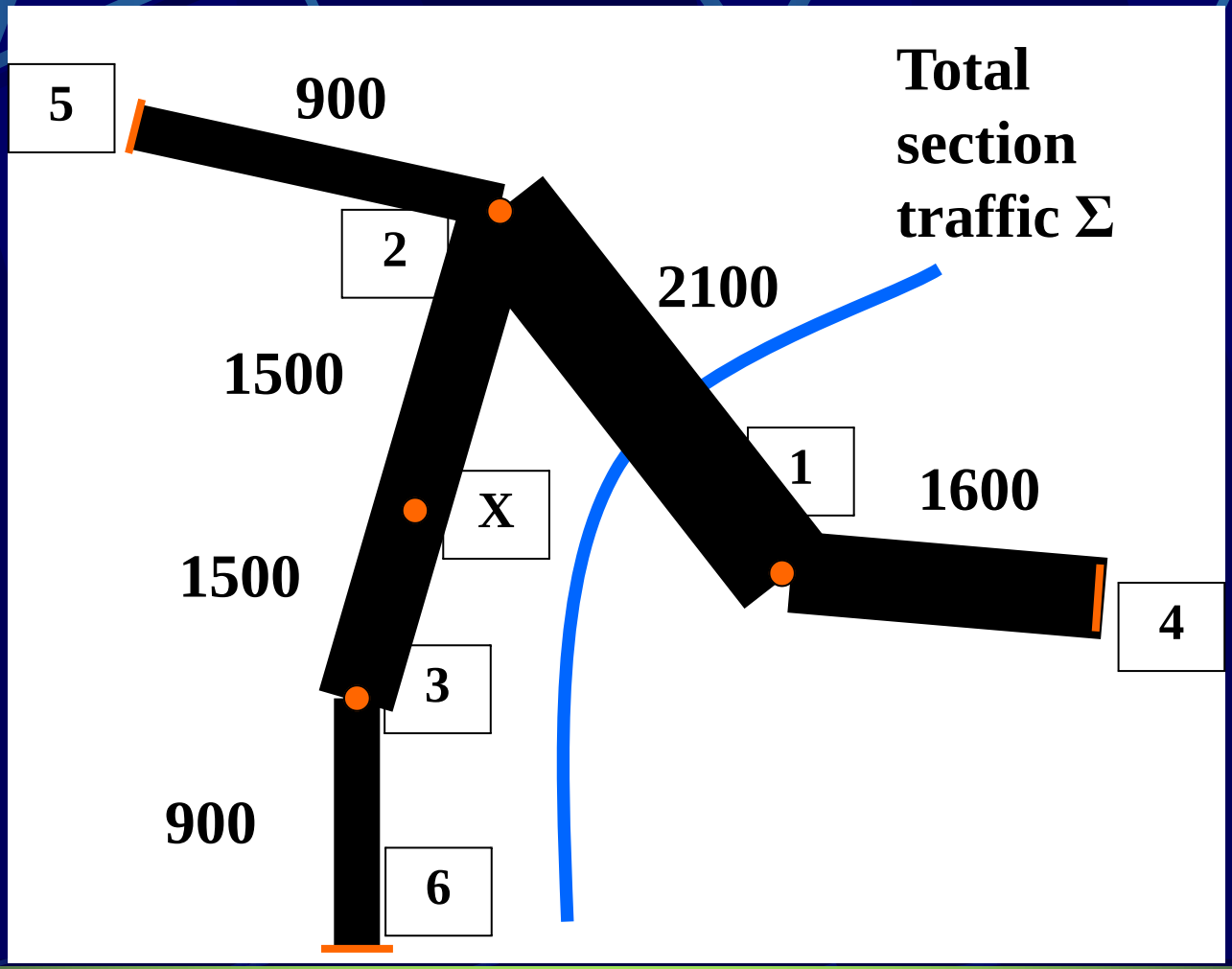


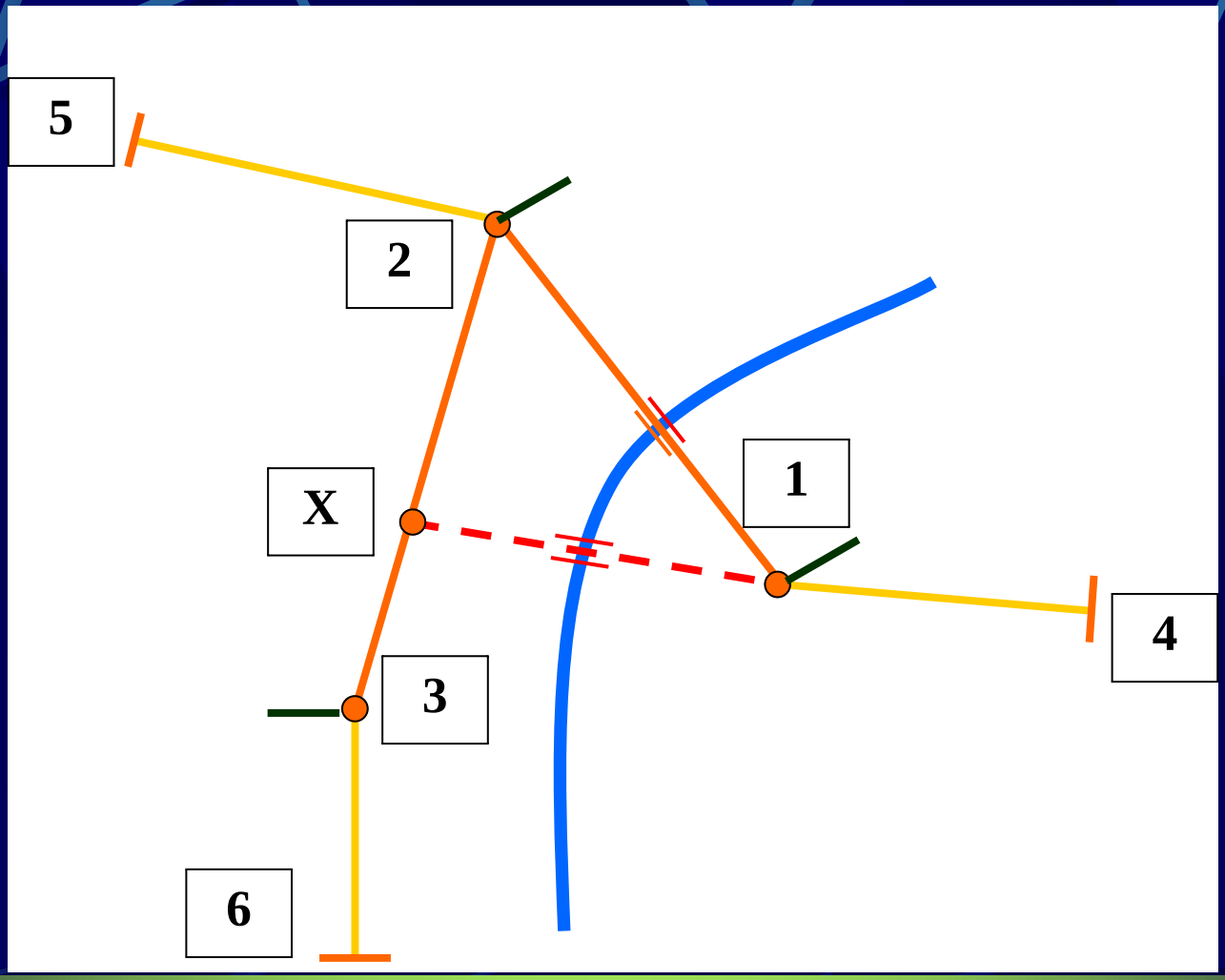
Traffic assignment – present network



Traffic assignment – present network



Traffic assignment – future network



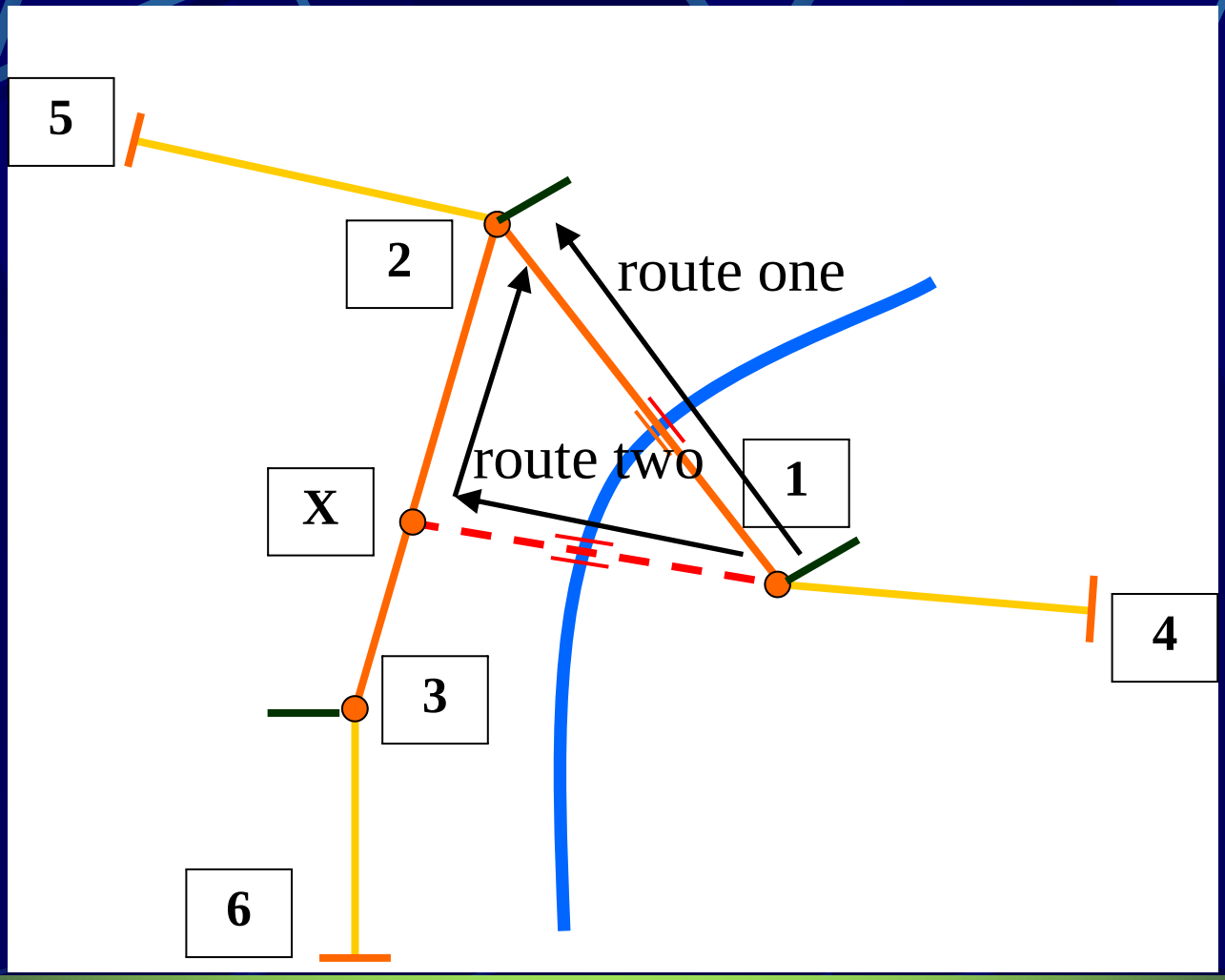
Total traffic matrix – future traffic

FUTURE	1	2	3	4	5	6	Sum
1	-	210	90	270	135	135	840
2	210	-	90	270	135	135	840
3	90	90	-	160	80	80	500
4	270	270	160	-	50	50	800
5	135	135	80	50	-	50	450
6	135	135	80	50	50	-	450
Sum	840	840	500	800	450	450	3880

Total traffic matrix – future traffic

FUTURE	1	2	3	4	5	6	Sum
1	-	210	90	270	135	135	840
2	210	-	90	270	135	135	840
3	90	90	-	160	80	80	500
4	270	270	160	-	50	50	800
5	135	135	80	50	-	50	450
6	135	135	80	50	50	-	450
Sum	840	840	500	800	450	450	3880

Traffic assignment – future network



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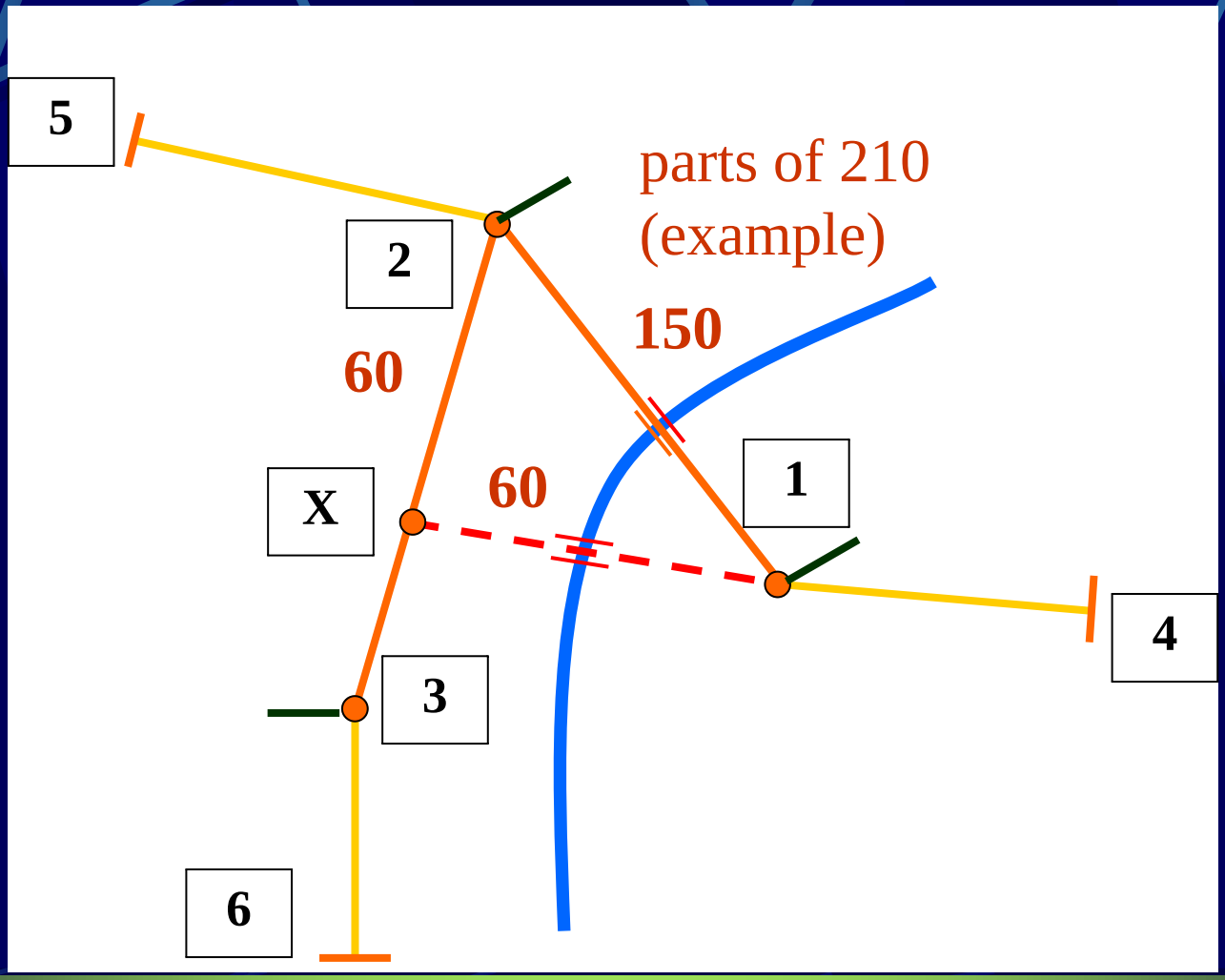

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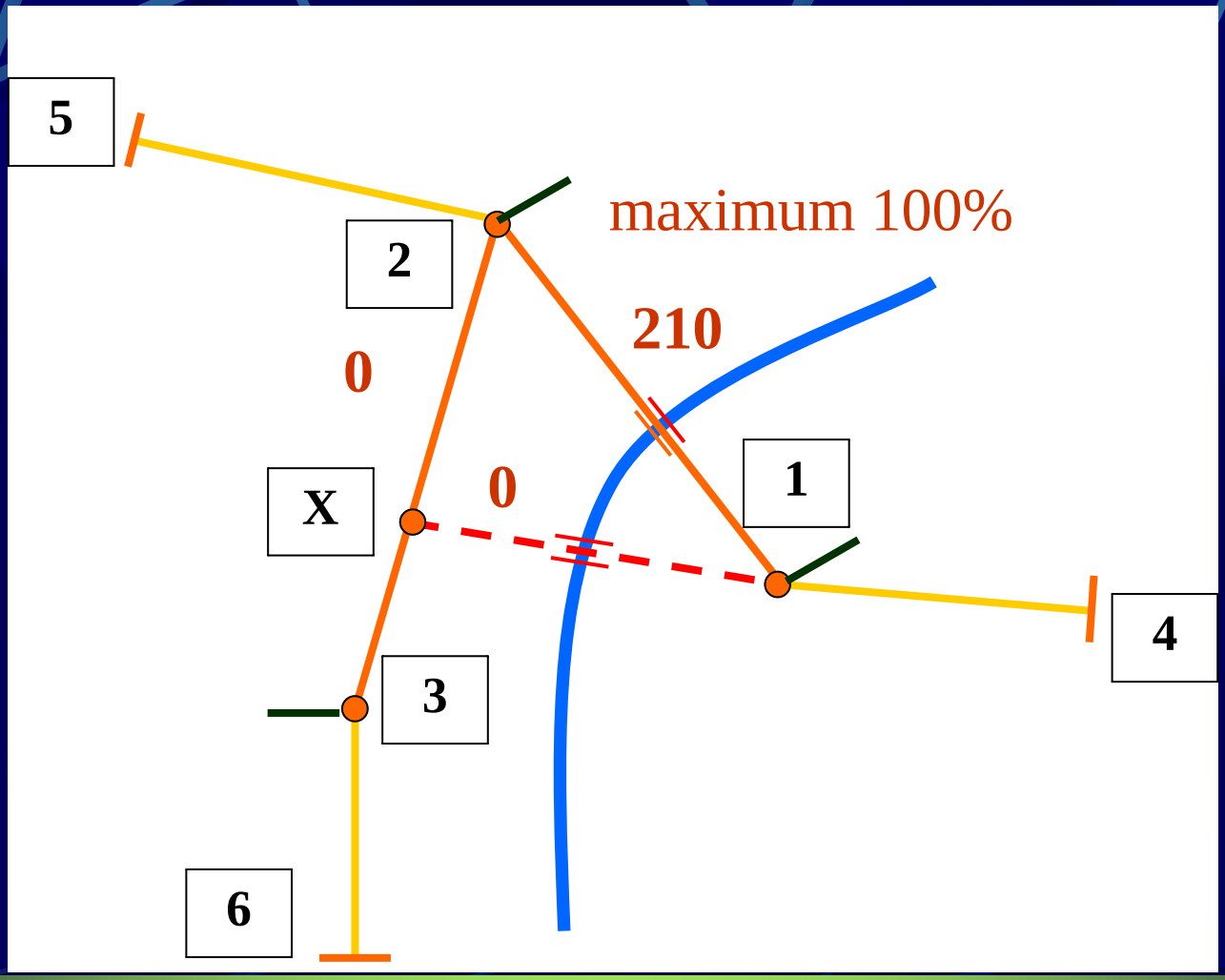
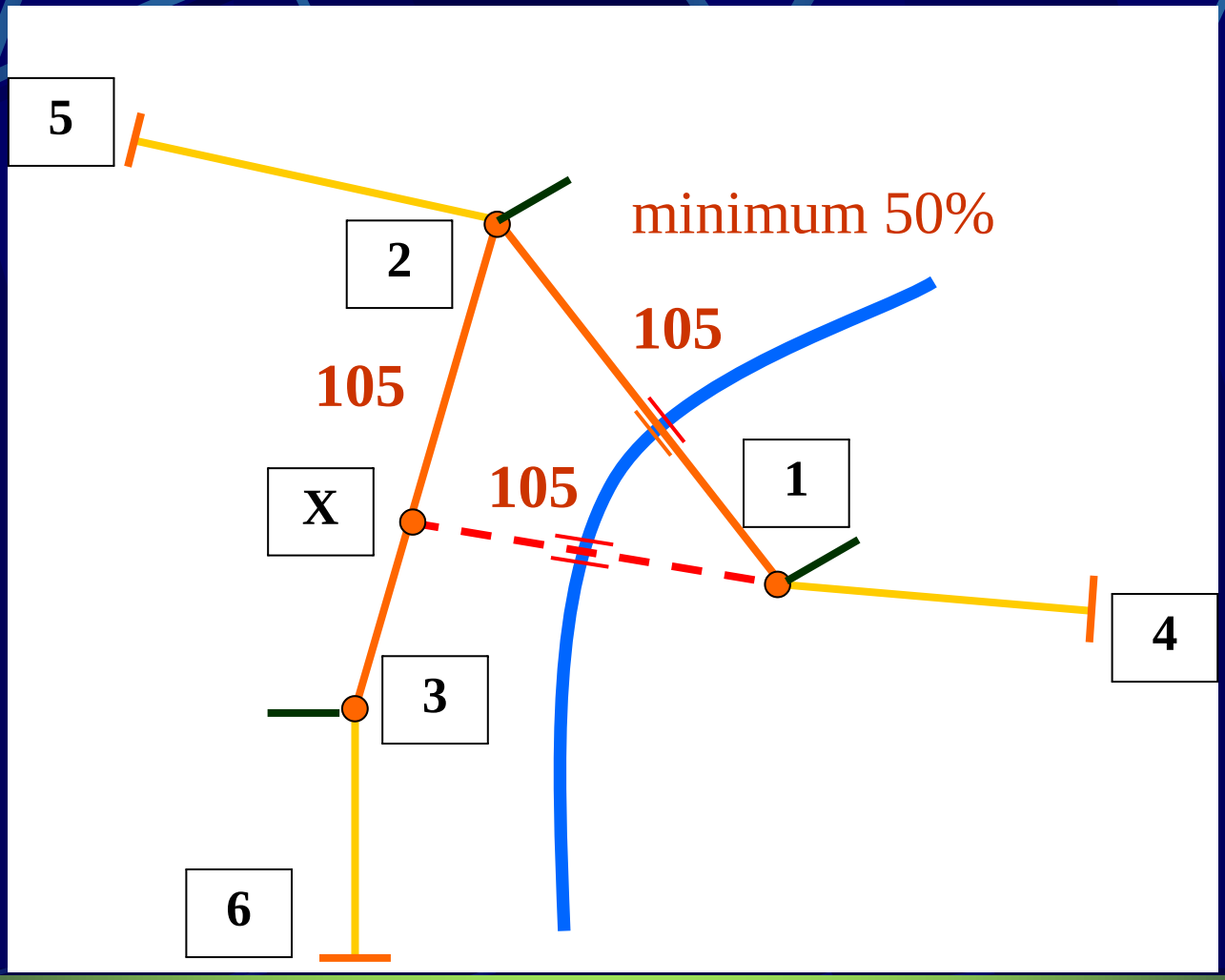
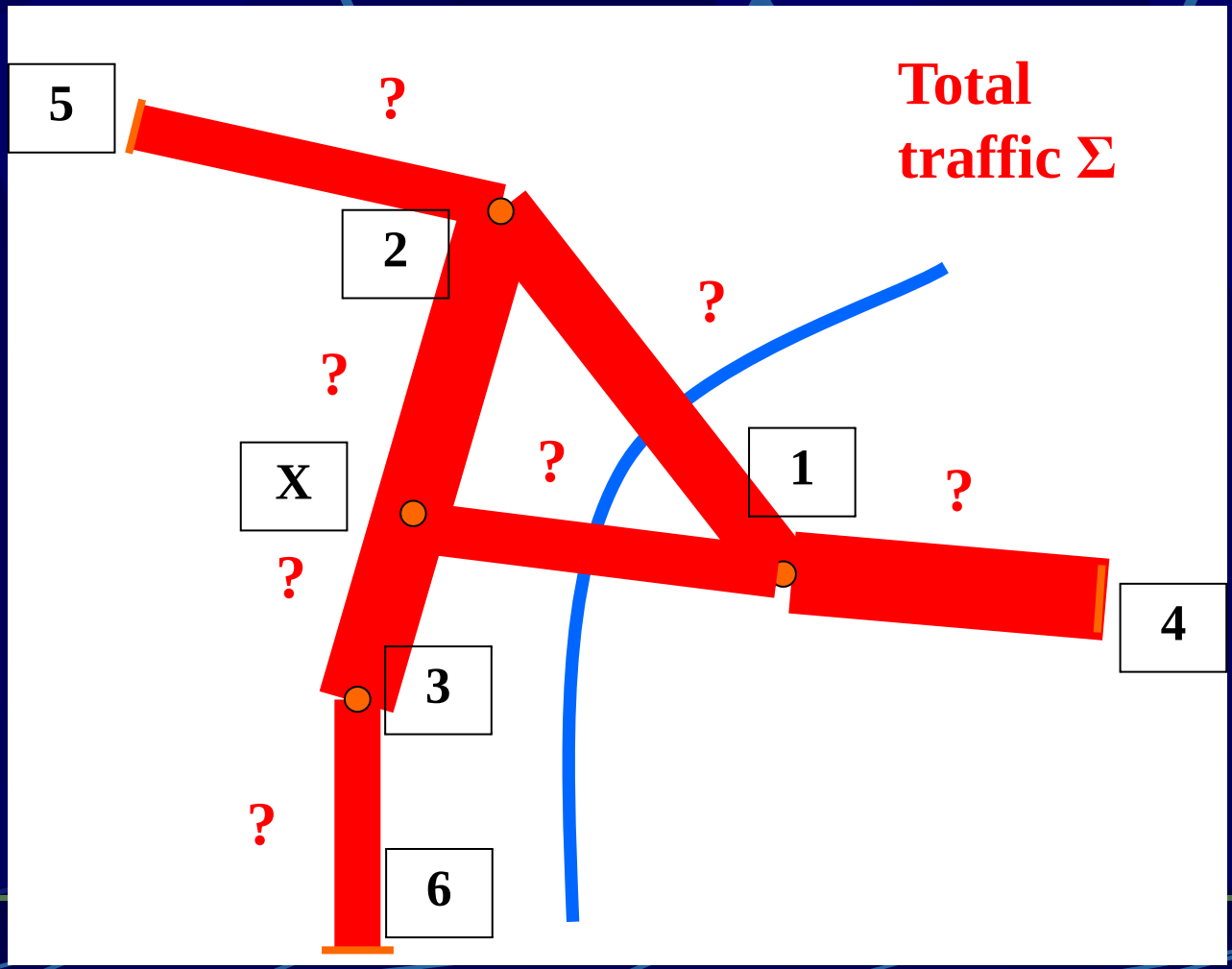


Traffic assignment – future network



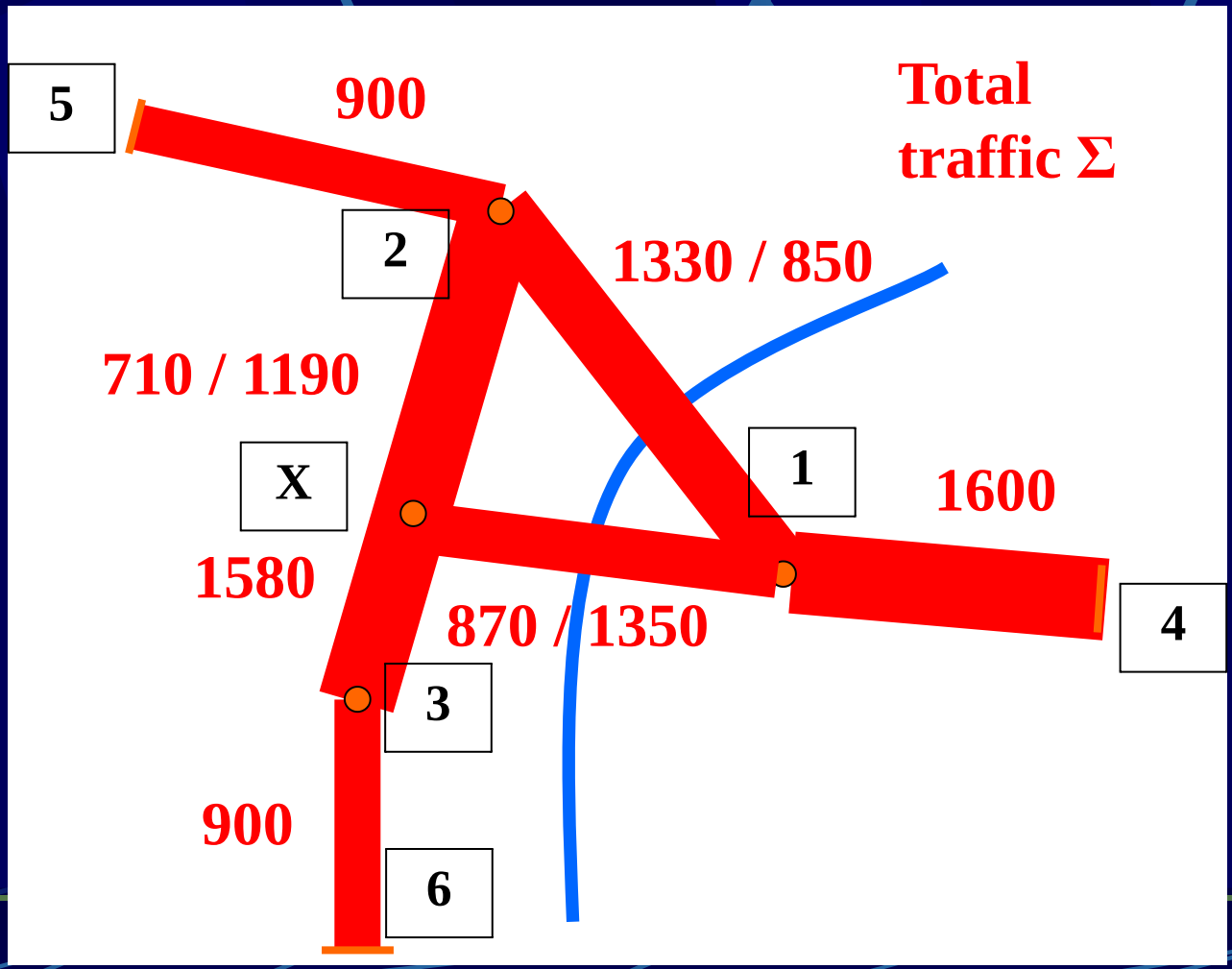
Traffic assignment – future network

Teamwork – future traffic assignment



Traffic assignment – future network

Possible values of the resulted traffic on sections



Summary

- The initial step of traffic planning is to establish zones.
- Parts of the traffic matrix: inner traffic, origin-destination traffic, through traffic.
- The calculation of the inner traffic is based on land-use characteristics.
- Origin-destination and through traffic can be acquainted by cordon surveys.
- In the trip distribution usually iterative steps provide a balanced traffic matrix calculation.

Summary

- Modal split means the layering of the traffic matrix by travel modes.
- Traffic assignment seeks the first (and second etc.) best route of minimum cost or travel time.
- Traffic assignment in steps may take into account capacity constraints.
- Very important is the reasonable presentation of results, understandable by decision makers.

Thank you for your attention!

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