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Assignment and route choice: Similarities and differences

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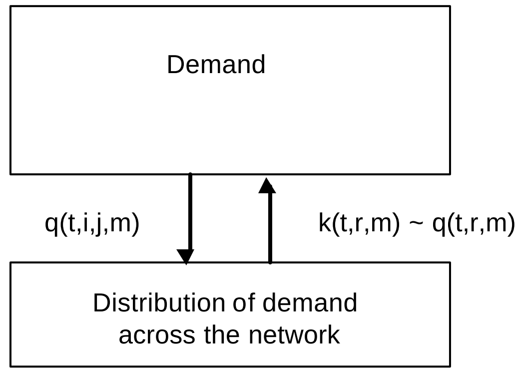
What do we do today ?



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What is the task at hand ?

Distribution of demand between two locations onto the possible and sensible routes:

- Identification of all sensible routes
- Calculation of generalised costs as a function of route demands
- Selection of the approach used to allocate demand between routes

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What are the differences ?

User equilibrium is normative, i.e. the solution of a mathematical programme :

User equilibrium:

- $k'_{ijm} = k'_{rijm}(q'_{rijm})$, for all routes r between i and j with $q'_{rijm} > 0$; for all i, j

System optimum:

- $k'_{rm} = k'_{rijm}(q'_{rijm}) + q'_{rijm} * [\partial k'_{rijm}(q'_{rijm}) / \partial q'_{rijm}]$, for all r between all i,j with $q'_{rijm} > 0$

Route choice is descriptive, i.e. models real behaviour

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Structure of equilibrium algorithms

1) Find the current cheapest paths
2) Distribute demand among all paths found so far according to the criteria chosen

3) Are there any substantial differences to the previous solution ?

   3a) No, equilibrium reached
   3b) Yes, update set of paths found, recalculate link costs [$k'(s) = f(q'(s))$] and go to 1)

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Please note:

- The set of routes is empty at the start of the calculations
- All valid routes have been found at the end

- We have a solution for which we can say

  - No user can unilaterally improve his situations

  or

  - Average costs are minimal

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Example: IVT - Switzerland 1999

Size:

- 3066 zones
- 7949 nodes and 20620 links

Basis:

- Network data of ARE and SBB
- OD matrices of ARE and SBB

1999 version not fully calibrated

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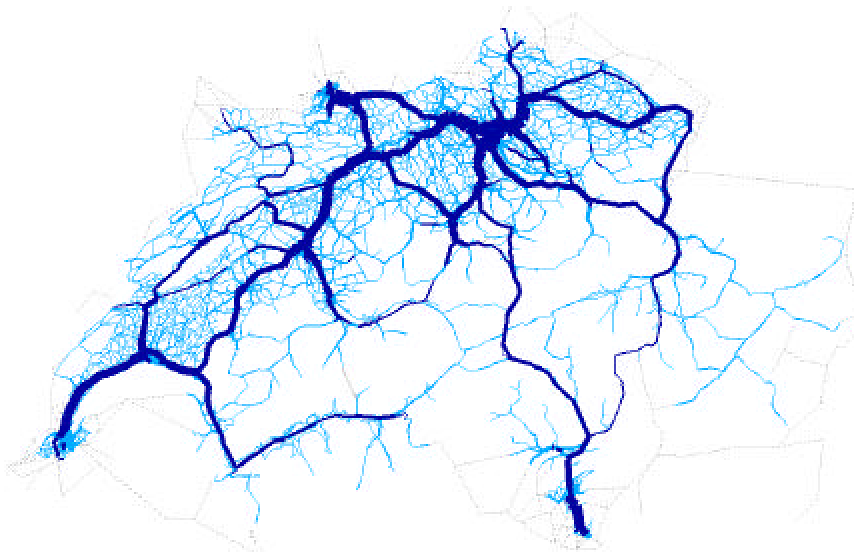
Example: UE IVT – Switzerland



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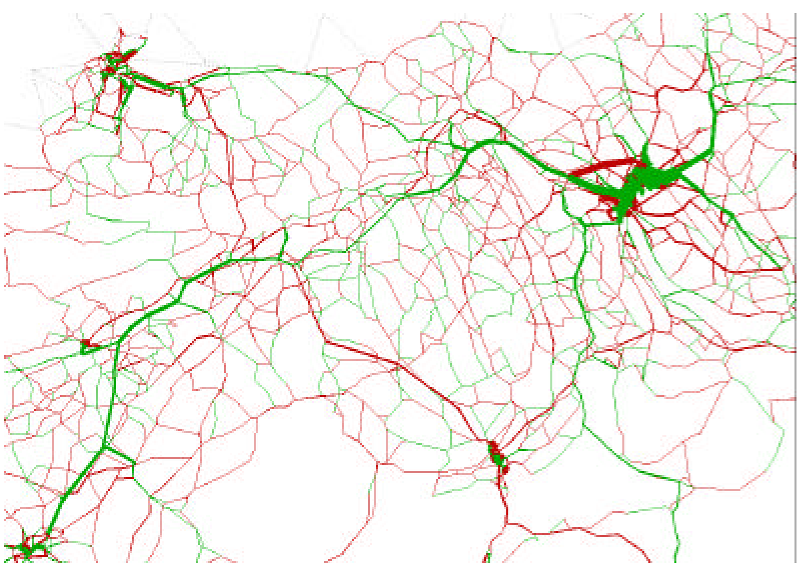
Example: Difference All-or-nothing and UE



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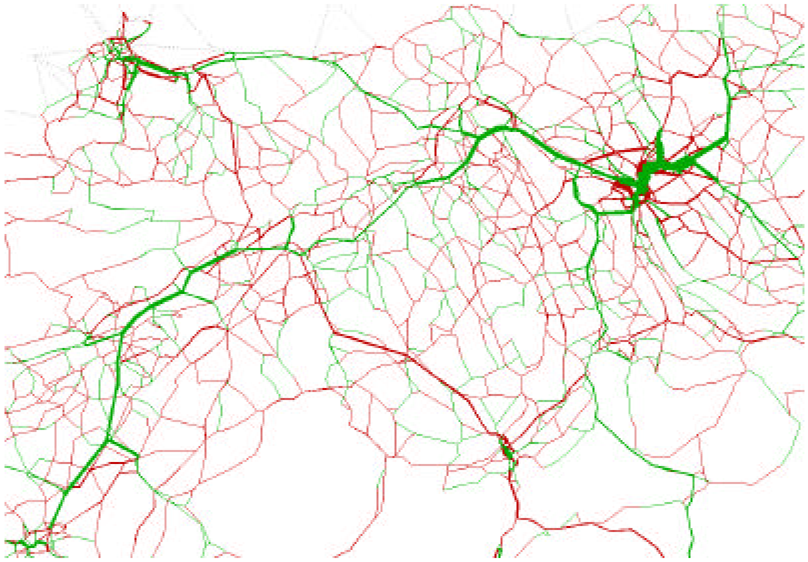
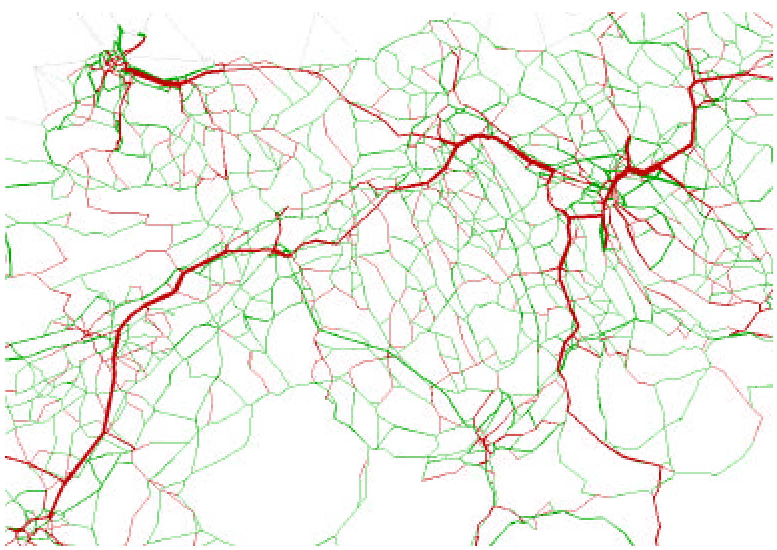
Example: Difference Iterative and UE



Example: Difference SO and UE



Why route choice ?

- Types of traffic without strong volume - travel time feedbacks (cycling, (partially) public transport)
- Modelling differences in user preferences (tolls, elements of the total travel times, safety)
- Integration with other choices (departure time, mode choice)

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How do we achieve consistent solutions ?

- The share of each route r between zones i and j is proportional to the probability that is optimal for the users with regards to the total utility of the route, i.e. including non measureable elements of the utility:

  $q'_{rijm} = q'_{ijm} * P(r)$, for all r, i and j

- $P(r) = f(k'_{rijm}(q_{rijm}))$ is calculated with a suitable model
- Travel times of routes between the same i and j need not be the same

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Example of an allocation rule

Multinomial logit - model:

$$P(i) = \exp[\beta V(i)] / \sum_{\forall r} \exp[\beta V(r)]$$

with:

$\beta = 1$

$V(r) = \sum_{\forall i} \alpha_i X_{ir}$

X_{ir} : Value of attribute i of route r

α_i : Parameter of attribute i

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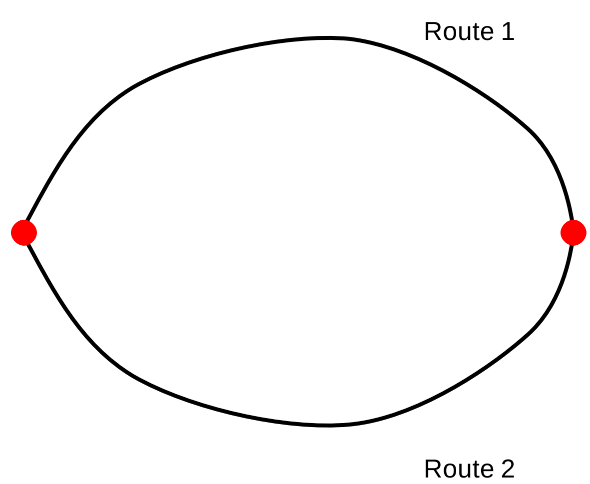
Example



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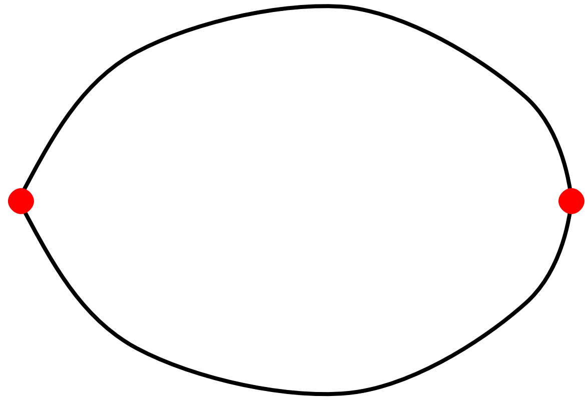
Example



	Exp.	Logit
R1	50%	
R2	50%	

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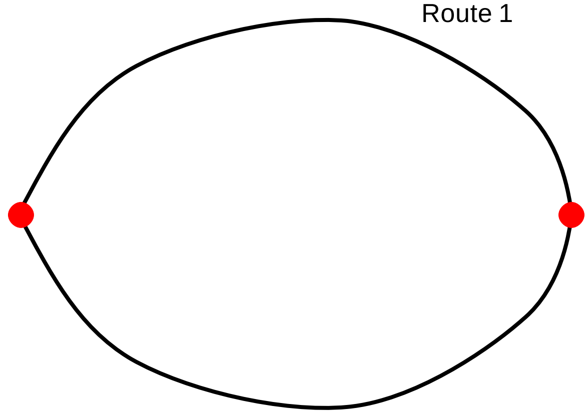
Example



	Exp.	Logit
R1	50%	50%
R2	50%	50%

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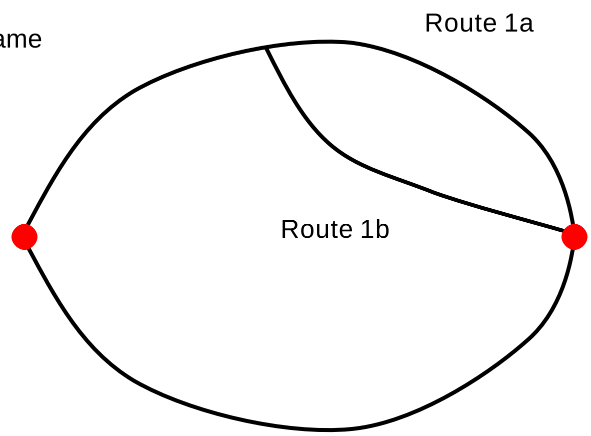
Example

All routes have the same generalised costs !



	Exp.	Logit
R1a	28%	
R1b	28%	
R2	44%	

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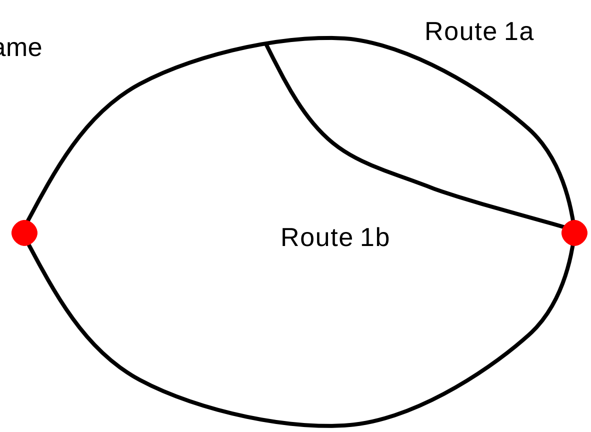
Example

All routes have the same generalised costs !



	Exp.	Logit
R1a	28%	33%
R1b	28%	33%
R2	44%	33%

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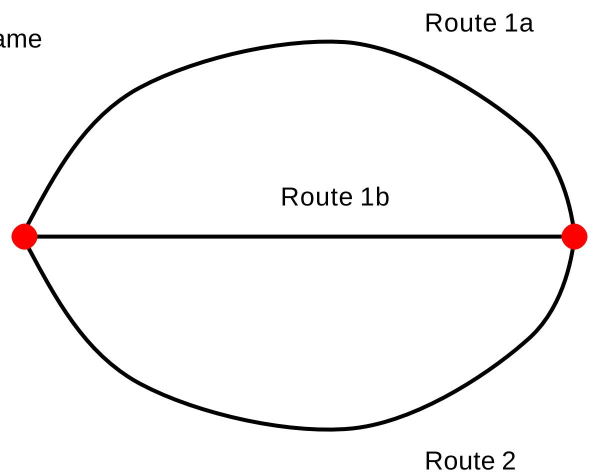
Example

All routes have the same generalised costs !



	Exp.	Logit
R1a	33%	33%
R1b	33%	33%
R2	33%	33%

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Why the error ?

Independence of Irrelevant Alternatives:

P(i)/P(j) = exp(V(i))/exp(V(j)) = constant !

P(1)/P(2) = 1 -> P(1) = P(2)= 50%

Introducing the new route

P(1a)/P(1b) = 1 -> P(1a) = P(1b) = P(2) = 33%

The simple model ignores the similarities of the routes !

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What can we do ?

Correction of the MNL:

- C-Logit (Cascetta)
- Path-Size - Logit (Bierlaire and Ben-Akiva)

- Correction of temporal overlap (Friedrich and Wekeck)

More general logit-type models:

- Cross-nested logit
- Probit

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What attributes should we account for ?

	PT	mIV
Access and egrees times	✓	✓
In-vehicle time	✓	
With congestion		✓
Without congestion		✓
Number of transfers	✓	
Transfer time	✓	
Headway	✓	
Reliability	✓	✓
Comfort (Vehicle type, ride quality)	✓	✓
Variable costs	✓	✓
Tolls, supplements	✓	✓

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How to find the routes ?

- Incremental heuristics, e.g. set of all cheapest paths across all iterations
- A priori using rules:
  - k-cheapest paths (with and without overlaps)
  - set of path matching various cost criteria (distance, travel time, number of nodes, shares of certain types of roads, scenery etc.)
  - Selection based on random travel times

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Problems with route sets: Share of used routes found by

Approach	Required overlap/match	
	100%	80%
Shortest path by distance	20%	28%
Time shortest path	34%	45%
16 multicriteria searches	72%	85%
K-cheapest paths	57%	80%
48 „random“ shortest paths	50%	79%
All of the above	84%	94%

Ben-Akiva (2002)

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Structure of the route-choice approaches

All/the relevant routes should be known at the start

At convergence:

- Route shares are consistent with user perceptions
- The set of routes has been checked and, if required, been expanded
- A Stochastic User Equilibrium (SUE) has been achieved

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Summary

Perception of costs	Criterion	Consistent solution
Without error (Objective)	User costs	User equilibrium (UE)
	Social costs	System optimum (SO)
With error (Subjective)	User costs	Stochastic user equilibrium (SUE) for given set of routes and choice rule

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What next ?

- Hypernetwork of public transport and private transport
- Hypernetwork with departure time choice
- Improvement of „corrected“ logit approaches
- Development of models for the selection of the route choice set
- Improvement estimation of the choice model parameters (better accounting for similarities between choices)

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Literature

Ben-Akiva, M.E. (2002) Methodology for dynamic traffic management systems, Vortrag an der ETH Lausanne, Mai 2002

Ben-Akiva, M.E. and M. Bierlaire (1999) Discrete choice models and their applications to short term decisions, in R.W. Hall (ed.) *Handbook of Transportation Science*, 5-33, Kluwer, Dordrecht.

Cascetta, E., A. Nuzzola, F. Russo and A. Vitetta (1996) A modified logit route choice model overcoming path overlapping problems: Specification and some calibration results for interurban networks, in J.B. Lesort (ed.) *Proceedings of the International Symposium on Transportation and Traffic Theory*, 697-711, Lyon.

Vrtic M. and K.W. Axhausen (2002) The impact of tilting trains in Switzerland: a route choice model of regional- and long distance public transport trips, *Arbeitsberichte Verkehrs- und Raumplanung*, **128** Institut für Verkehrsplanung und Transportsysteme, ETH Zürich, Zürich.

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Appendix

C - Logit

Utility of route r: $U(r) = \beta\ CF(r) + \sum_{\forall i} \alpha_i X_{ir}$

The „commonality factor (CF)" is defined as:

$$CF(r) = \sum_{\forall j} (l(rj)/[(l(r)\ l(j))^{1/2}])^{\mu}$$

with

- l(rj) Joint length of routes r and j
- l(j) Length of route j
- β, μ Parameters

Pathsize - Logit

Utility of route r: $U(r) = \ln(S(r)) + \sum_{\forall i} \alpha_i X_{ir}$

The „path size factor (PSF)" is defined as:

$PSF = \sum_{\forall a \varepsilon S(r)} g(a) * l(a)/l(r)$

$1/g(a) = \sum_{\forall j \varepsilon R} \delta(aj)\ l^* / l(j)$

with

- s(a) Length of link a
- S(r) Set of the links of route r
- R Set of routes
- l(j) Length of route j
- l^* Length of the cheapest route in R
- $\delta(aj)$ = 1, if link a is part of route j; otherwise = 0

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Valuation of the generalised cost attributes

	Com-muters	Shopping	Leisure /vacation	Business
VOT in-vehicle time [CHF/h]	11.9	20.1	15.8	52.4
VOT headway [CHF/h]	3.5	4.1	3.6	1.0
VOT transfer time [CHF/h]	7.7	25.0	6.5	43.9
Transfer [CHF/transfer]	1.5	2.0	5.9	4.5
IR-doubledecker [CHF]*	1.2	4.1	3.6	2.7
IC/EC [CHF]*	1.2	2.9	4.2	7.9
ICN [CHF]*	1.9	3.9	4.6	2.8
Number of transfer / in-vehicle time [min. in-vehicle time / transfer]	7.7	5.9	22.6	5.2
Transfer time / in-vehicle time	0.7	1.2	0.4	0.8
Headway / in-vehicle time	0.3	0.2	0.2	0.02

Vrtic and Axhausen (2002)

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