Network decomposition and path aggregation for efficient traffic assignment with variable demand

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TRANSW symposium
3 December 2019

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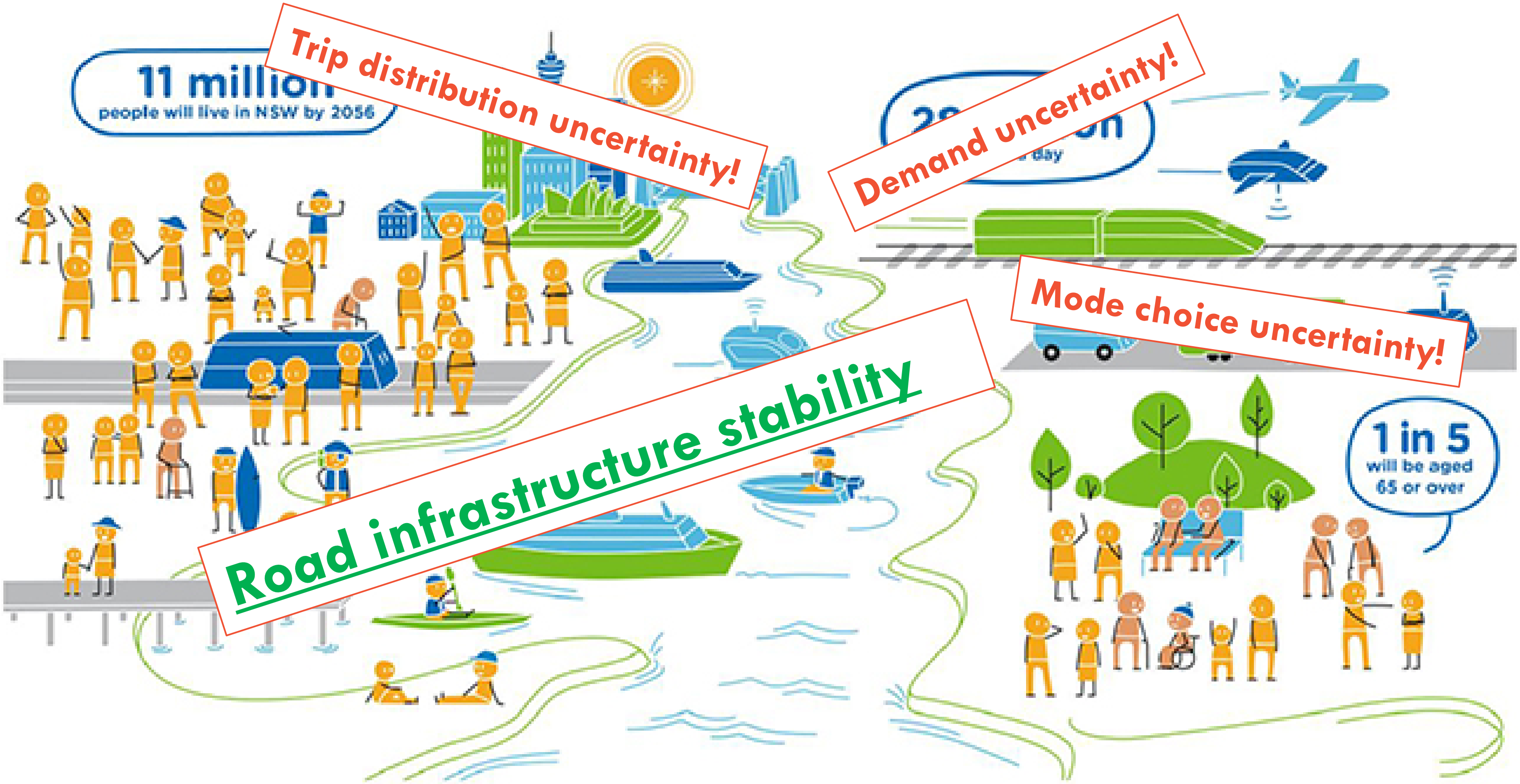
BACKGROUND



src: future transport 2056 report

BACKGROUND

Time budget

Scenario 1	Scenario 2	Scenario 3		Scenario N
- Travel demand 1 - Transport network	- Travel demand 2 - Transport network	- Travel demand 3 - Transport network	....	- Travel demand N - Transport network
Result 1	Result 2	Result 3		

BACKGROUND

Scenario 1
- Travel demand 1
- Transport network

Scenario 2
- Travel demand 2
- Transport network

Scenario 3
- Travel demand 3
- Transport network

....

Scenario N
- Travel demand N
- Transport network

Result 1

Result 2

Result 3

Part I:
Delay Network extraction through travel time decomposition

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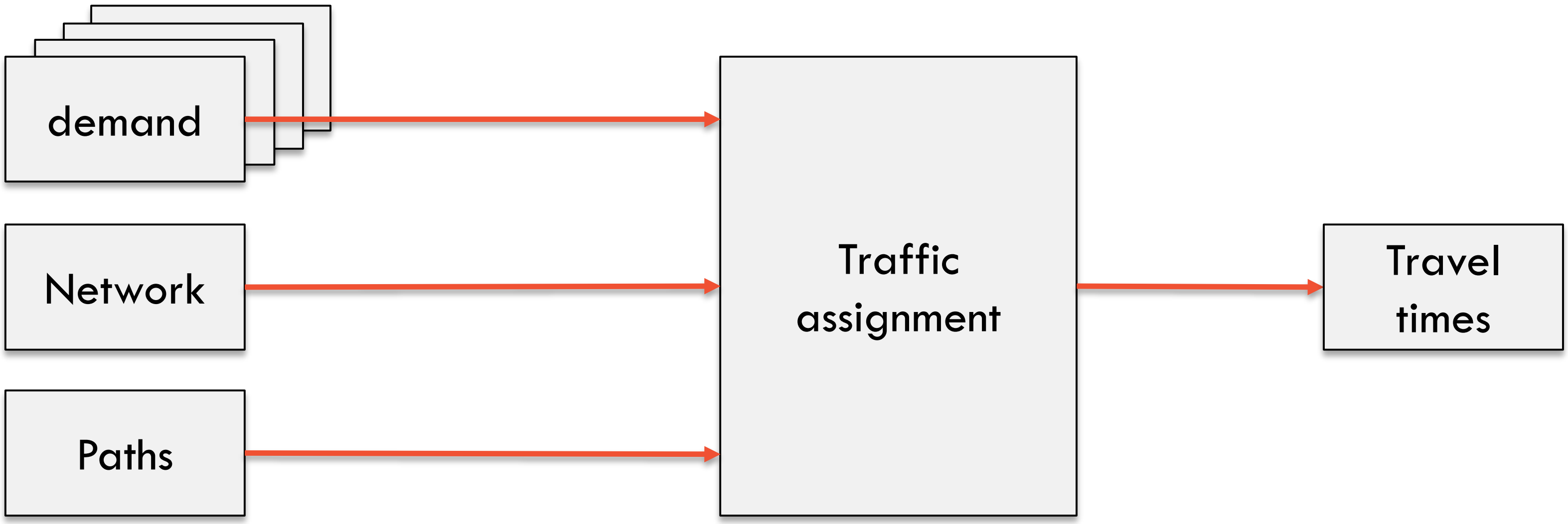
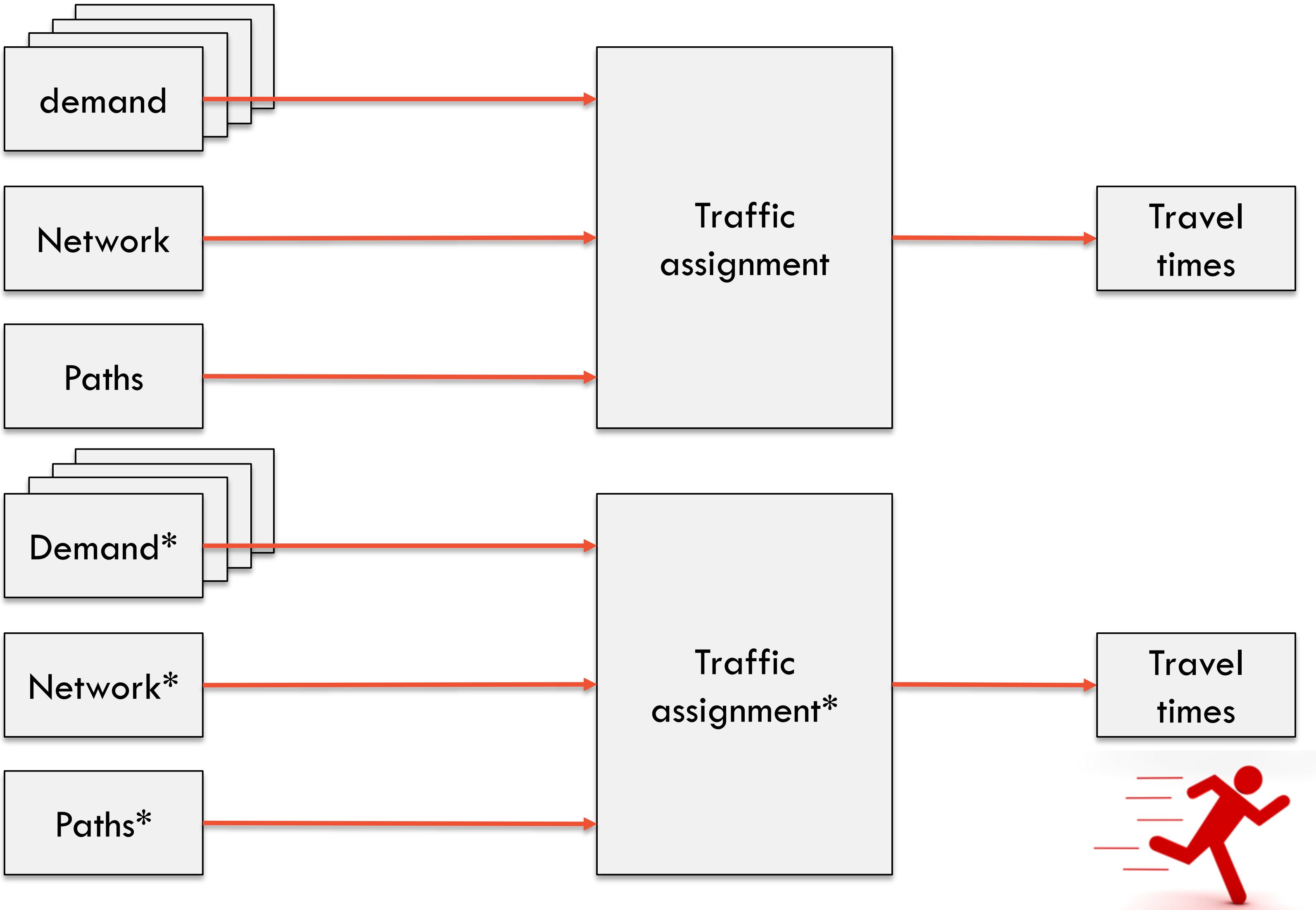
METHODOLOGY

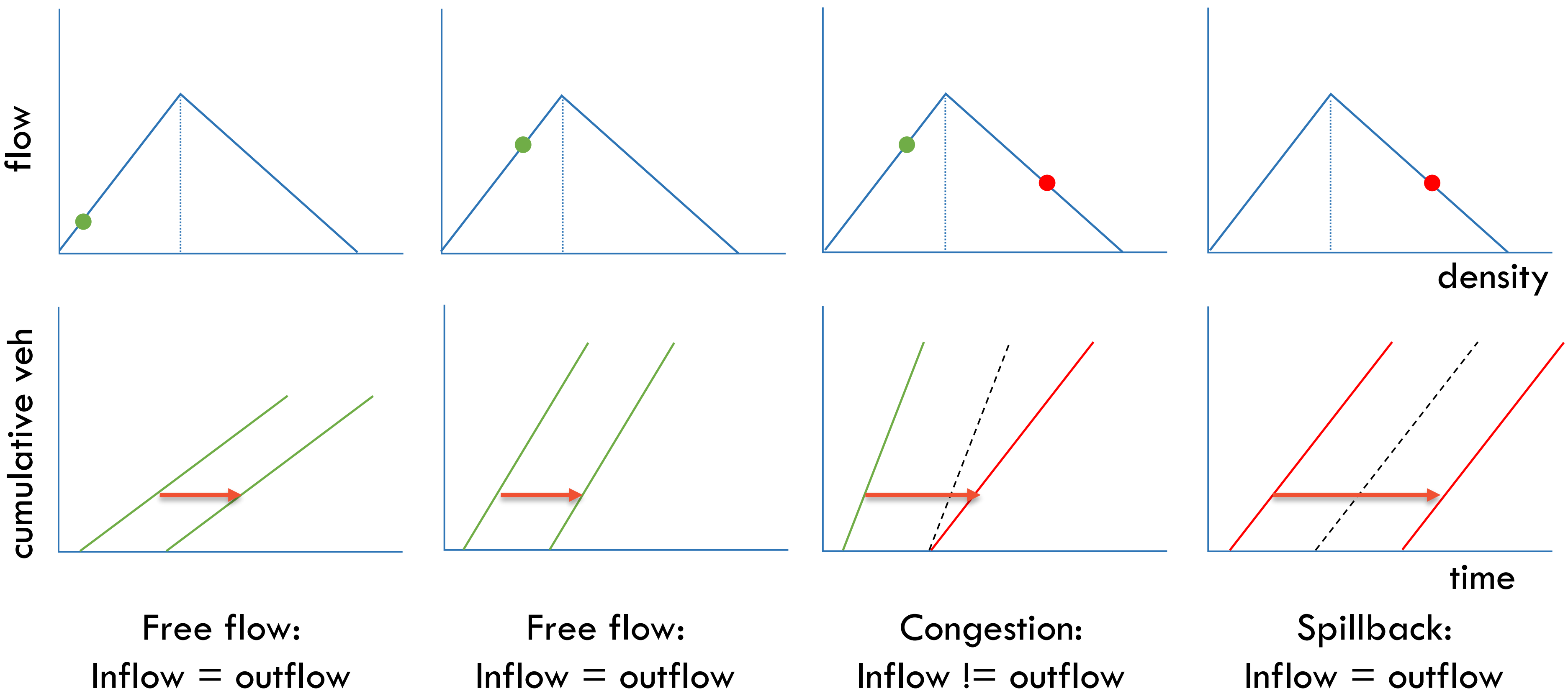


METHODOLOGY



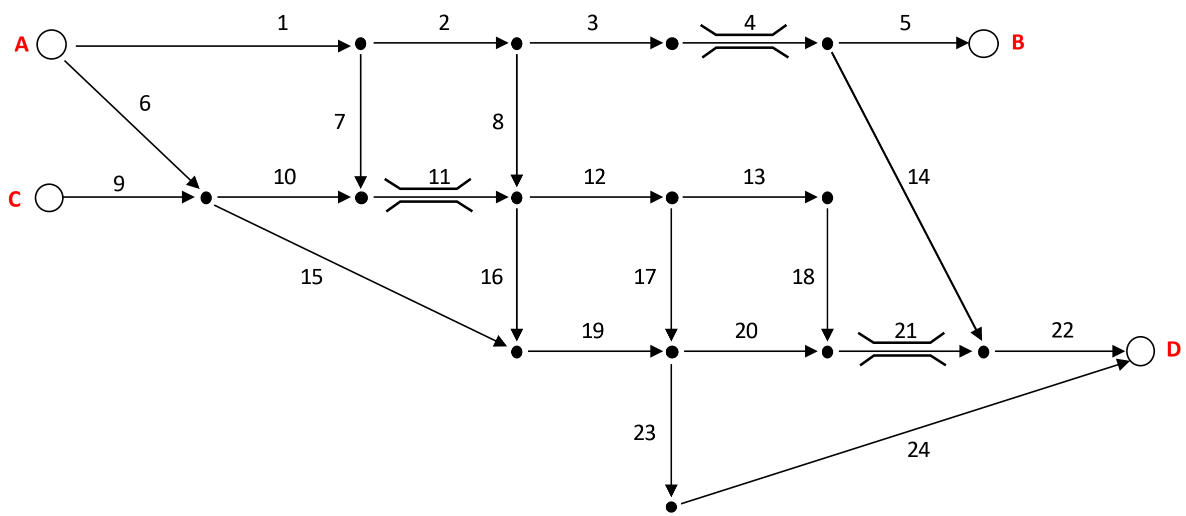
METHODOLOGY

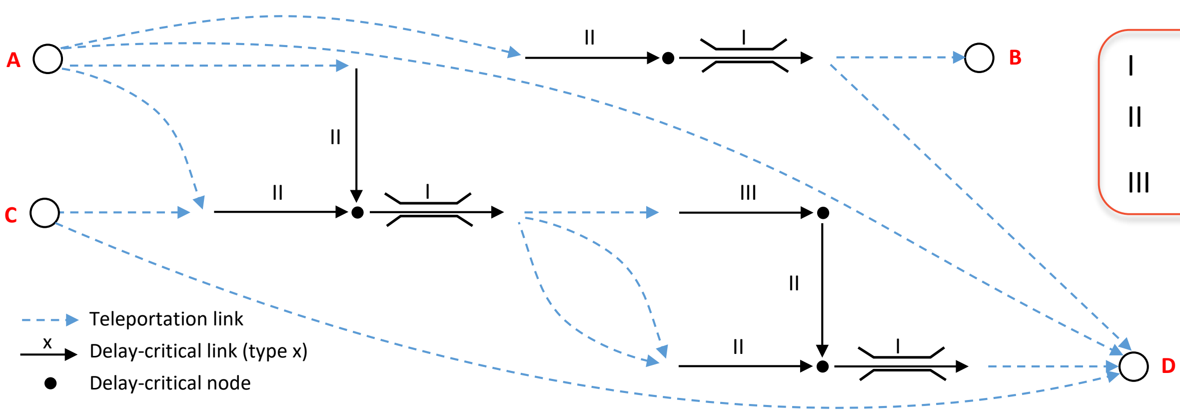
Travel time based decomposition



METHODOLOGY

Travel time based decomposition

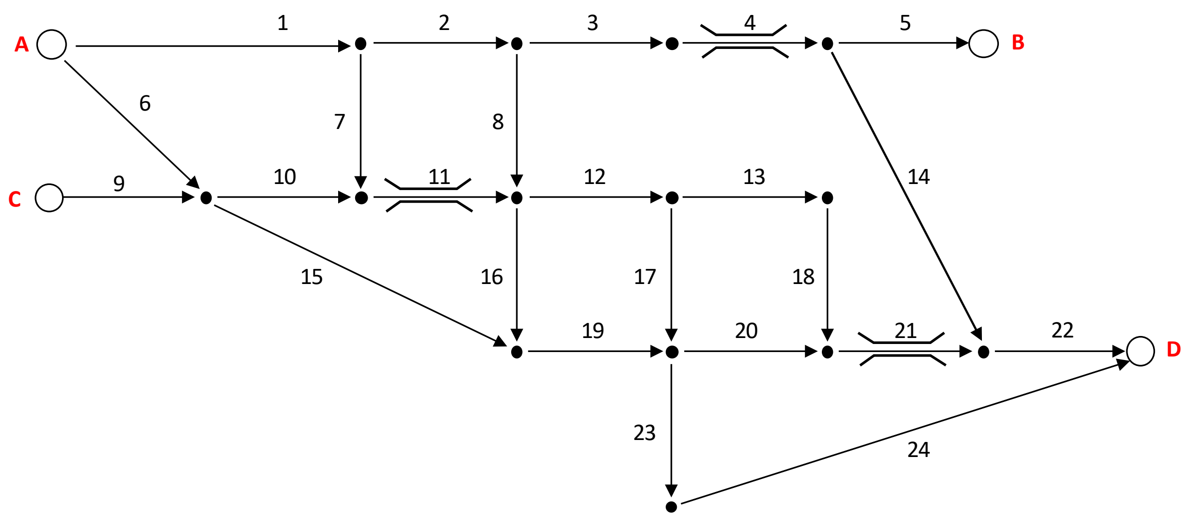


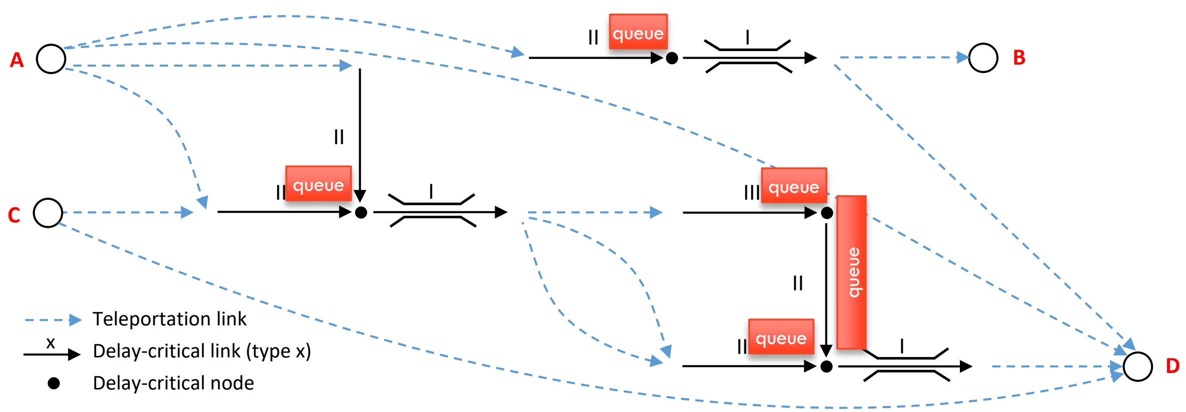


- I (potential) bottleneck link
- II (potential) primary queuing delay link
- III (potential) secondary queuing delay link

METHODOLOGY

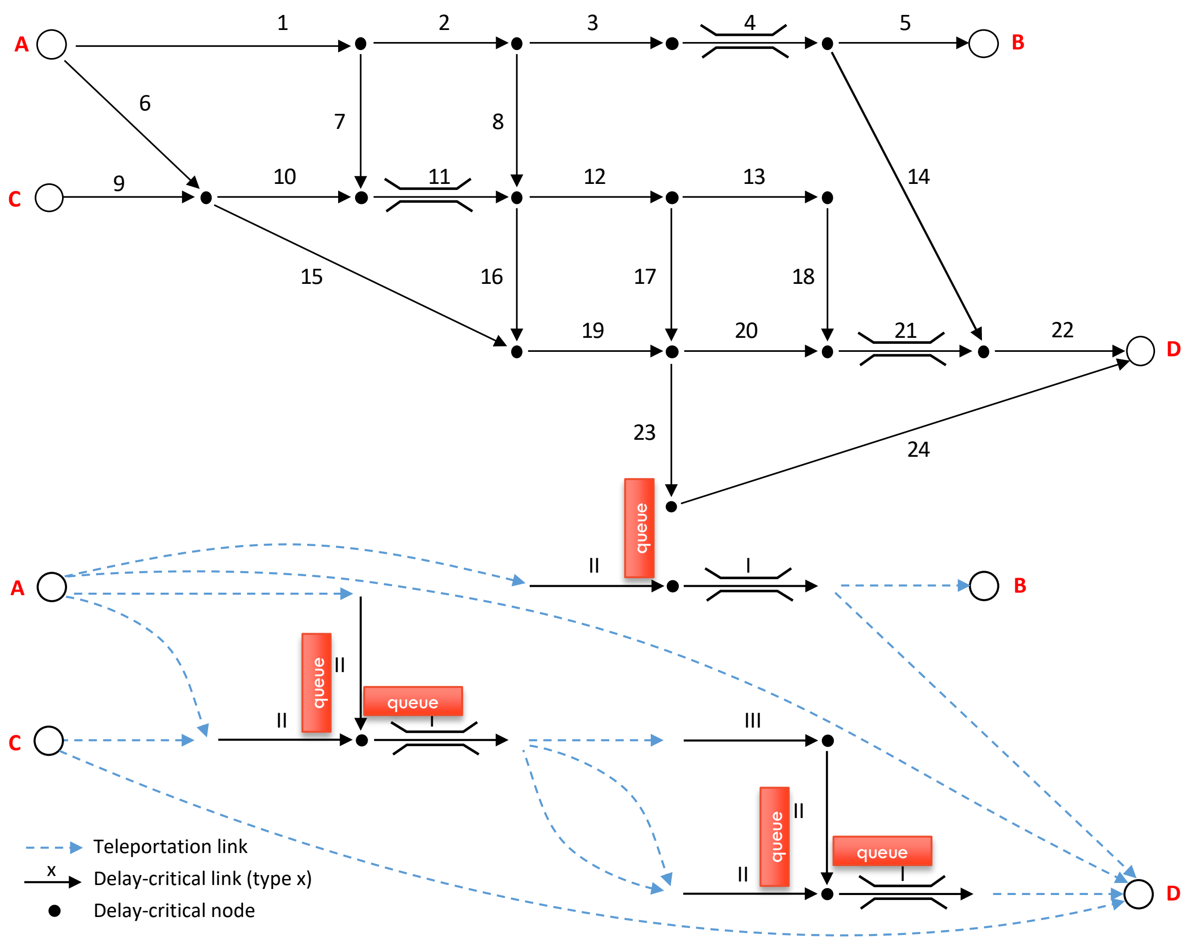
Travel time based decomposition – Spatial queue





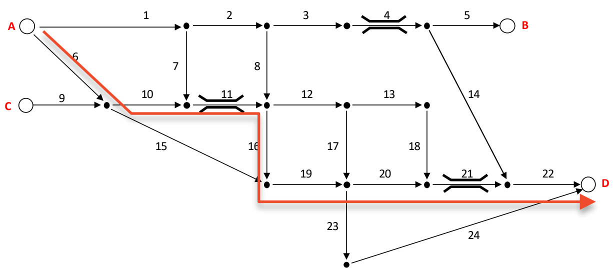
METHODOLOGY

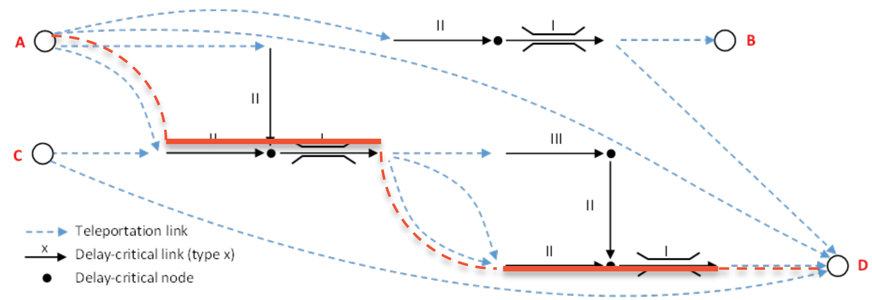
Travel time based decomposition – Point queue



METHODOLOGY

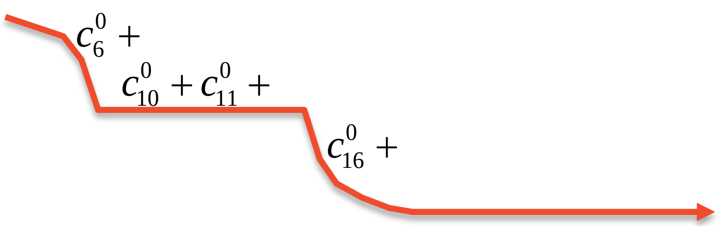
Travel time based decomposition





Free flow path travel time

All scenarios



$c_6^0 +$

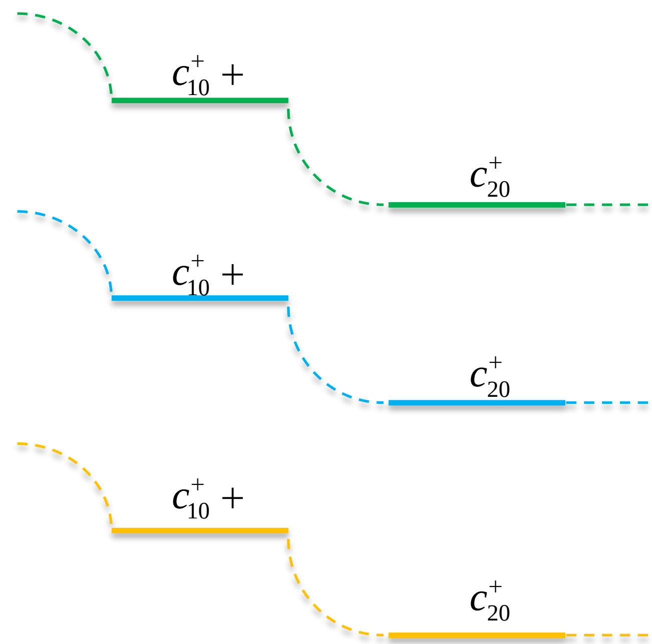
$c_{10}^0 + c_{11}^0 +$

$c_{16}^0 +$

$c_{19}^0 + c_{20}^0 + c_{21}^0 + c_{22}^0$

$+$

Path travel time delay



Scenario 1

$c_{10}^+ +$

c_{20}^+

Scenario 2

$c_{10}^+ +$

c_{20}^+

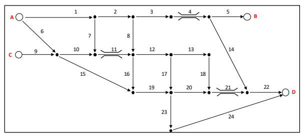
Scenario Z

$c_{10}^+ +$

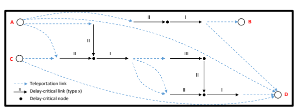
c_{20}^+

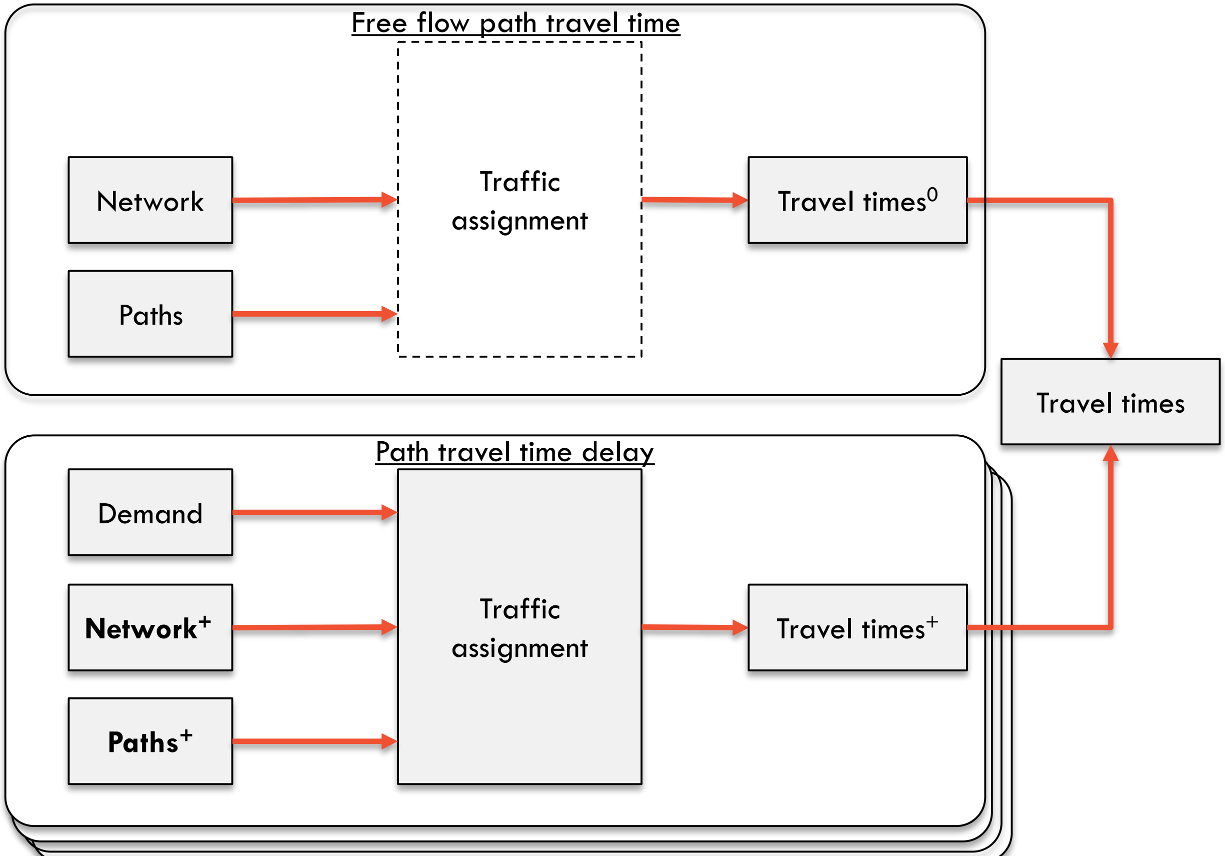
METHODOLOGY

Once



For each scenario Z





Network$^+$ $\leq$ Network

Paths$^+$ $\leq$ Paths

Part II: Path consolidation

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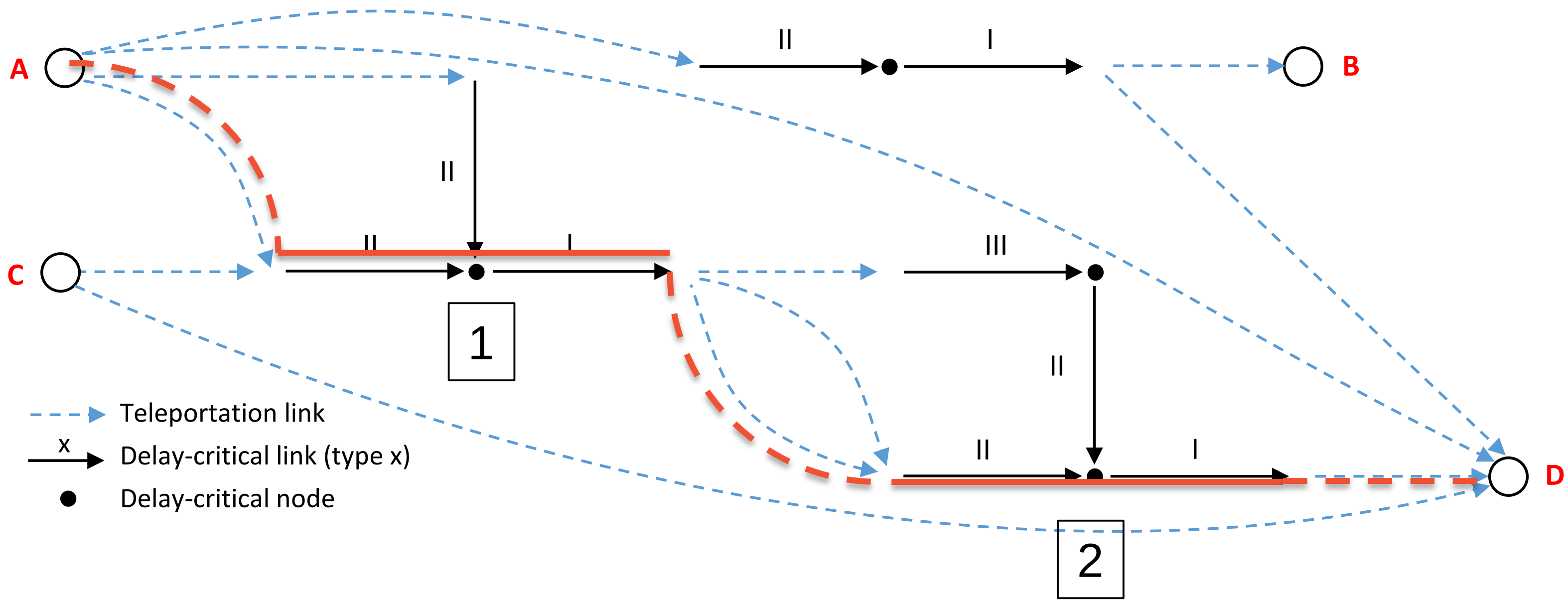
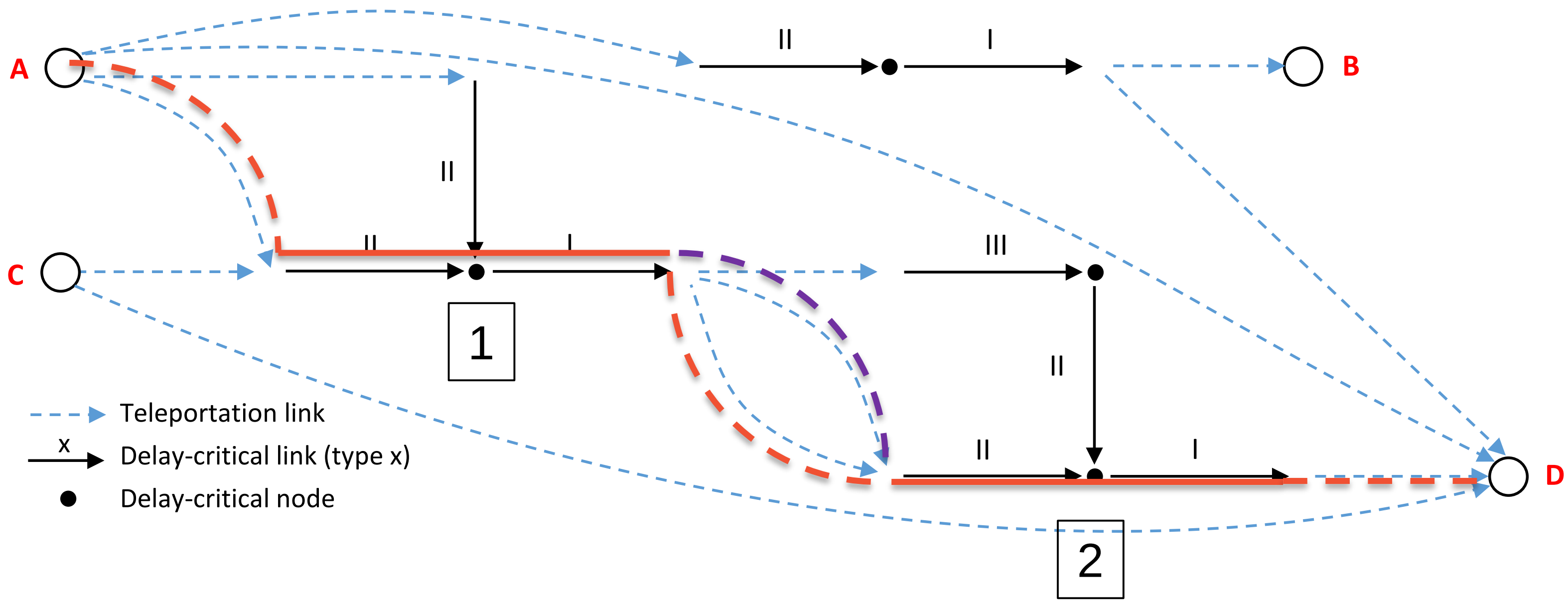
METHODOLOGY

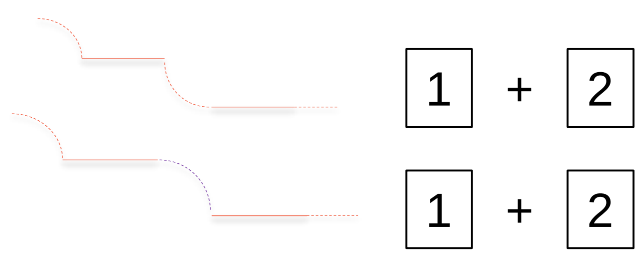
Path consolidation



METHODOLOGY

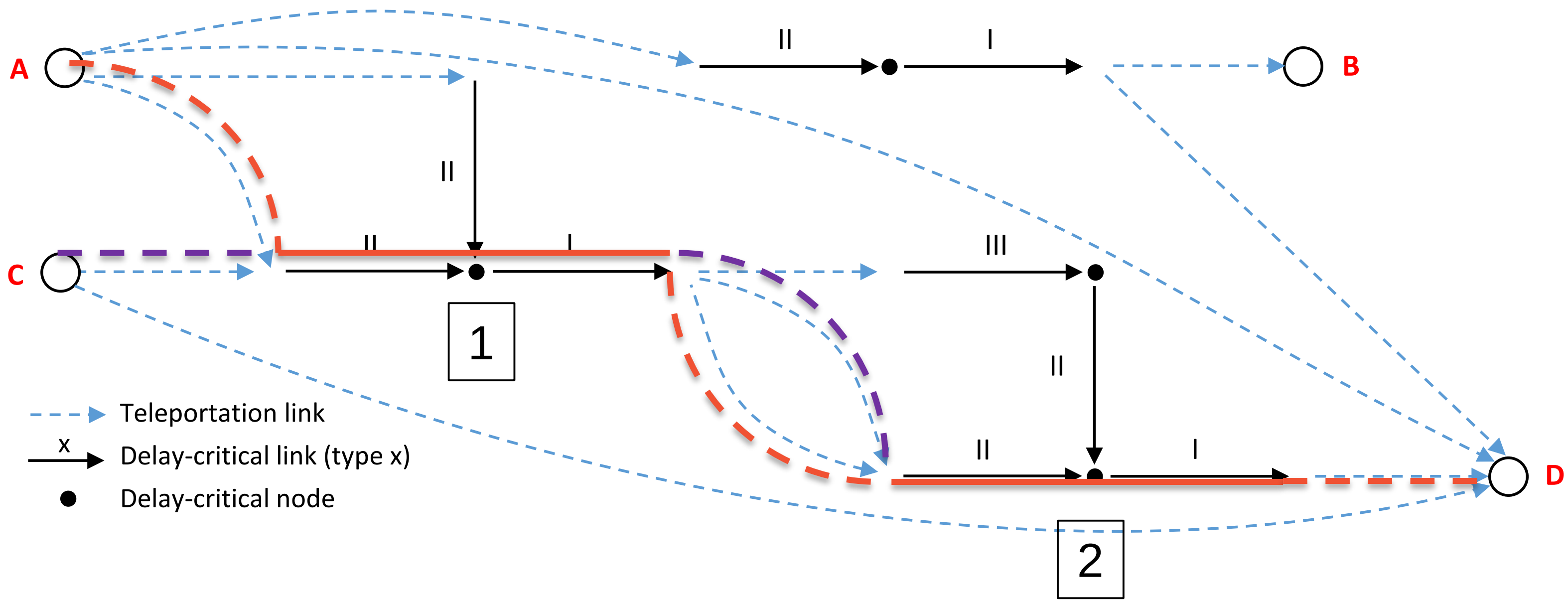
Path consolidation

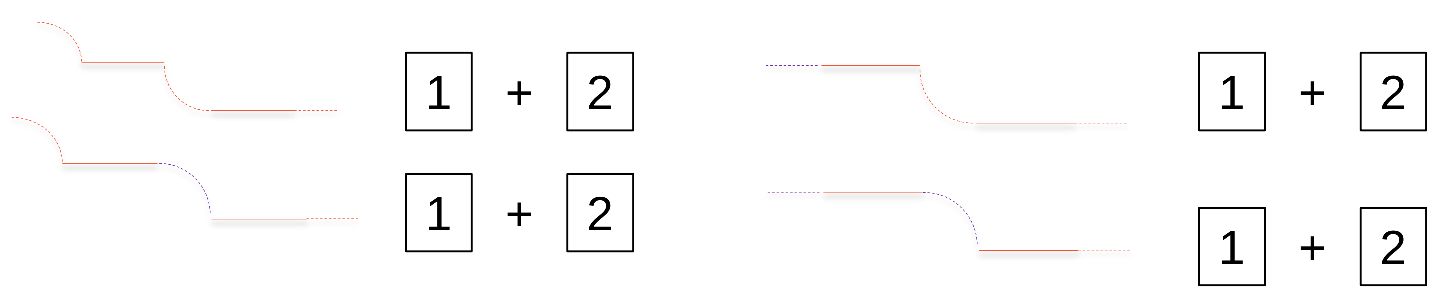




METHODOLOGY

Path consolidation



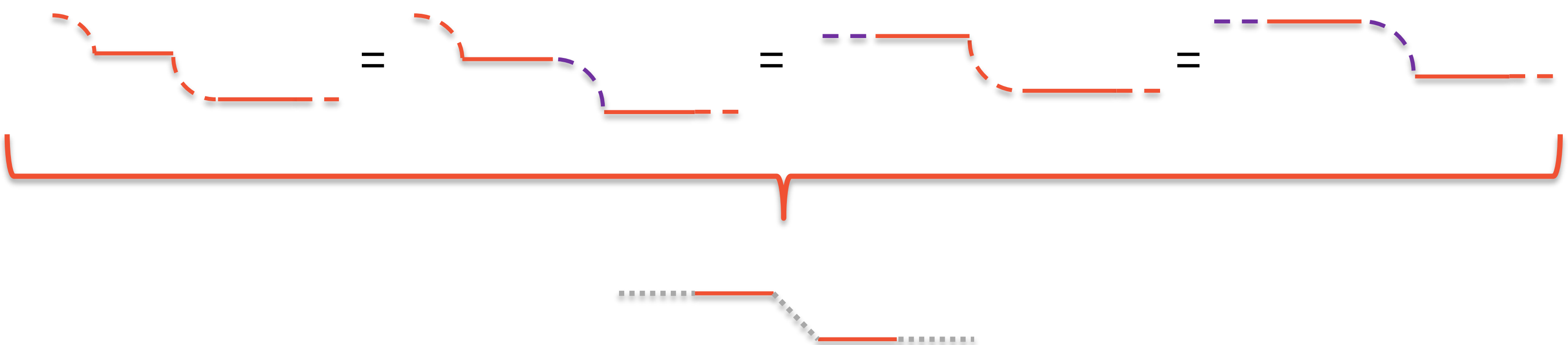


METHODOLOGY

Path consolidation

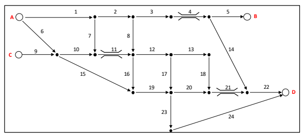
- All paths with identical critical-delay links (Type I and Type II) can be consolidated
  - Why? Because having different free flow links (zero cost in delay network) do not amount to a change in delay

- Consolidated paths do not even need to have the same origin and destination!

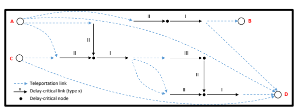


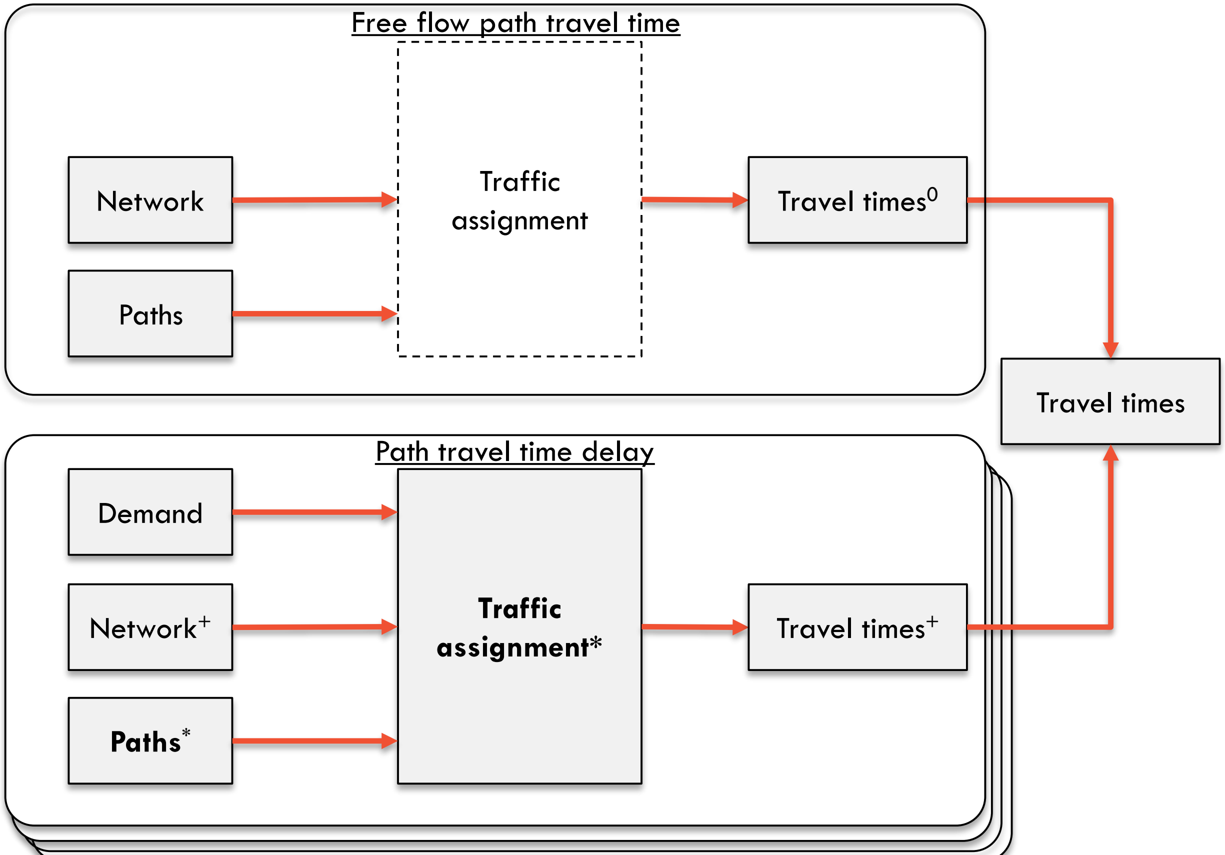
METHODOLOGY

Once



For each scenario Z





$\text{Network}^{+} \leq \text{Network}$

$\textbf{Paths}^{*} \leq \text{Paths}^{+} \leq \text{Paths}$

Part III: Results

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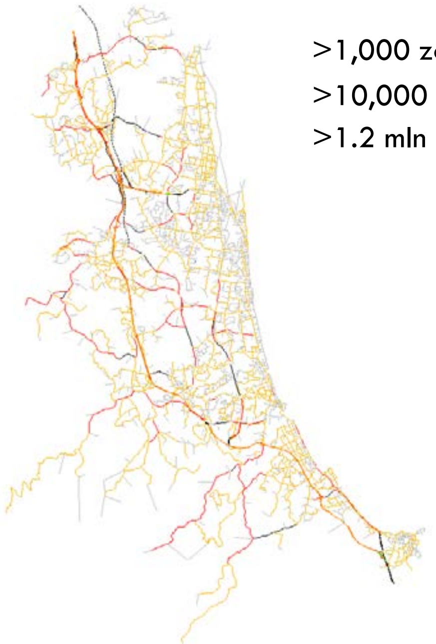
RESULTS

Case study: Gold Coast

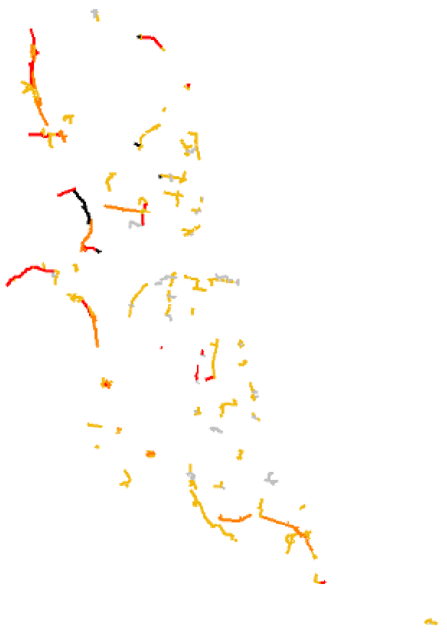
- Objective:
    - **Identify the potential performance gain**
- Procedure:
    - Equilibrate original demand matrix
        - Collect computation time + path travel times
    - Construct delay subnetwork
        - Super-scenario = original demand matrix
    - Equilibrate delay subnetwork
        - Collect time spent + path travel times
    - Compare results…



>1,000 zones
>10,000 link
>1.2 mln paths

RESULTS

Case study: Gold Coast



>1,000 zones
>10,000 link
>1.2 mln paths

Network	Links	Paths	Total path links	Network loading time (s)
Original	5,076	1,221,446	55,852,786	2,178
Delay subnetwork only	836	1,221,446	12,919,862	902 (**-59%**)
Delay subnetwork + path consolidation	836	99,528	1,142,338	89 (**-96%**)

Conclusions

Case study: Gold Coast

- Potentially lossless decomposition and aggregation procedure to reduce the cost of traffic assignment

- Best results are obtained in combination with static point-queue models but method is also suitable for
  - Traditional static assignment (lossy)
  - Dynamic Traffic Assignment (DTA) (lossy)

- Potential gains are a 25-fold reduction in computation time (conditioned on Gold Coast case study)

- Applications:
  - Consider more potential scenarios in quick scan applications
  - Improve od-matrix calibration (speed-up or fit)
  - Improve insight in demand uncertainty by running more scenarios

Questions

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Part III: Super-scenario identification

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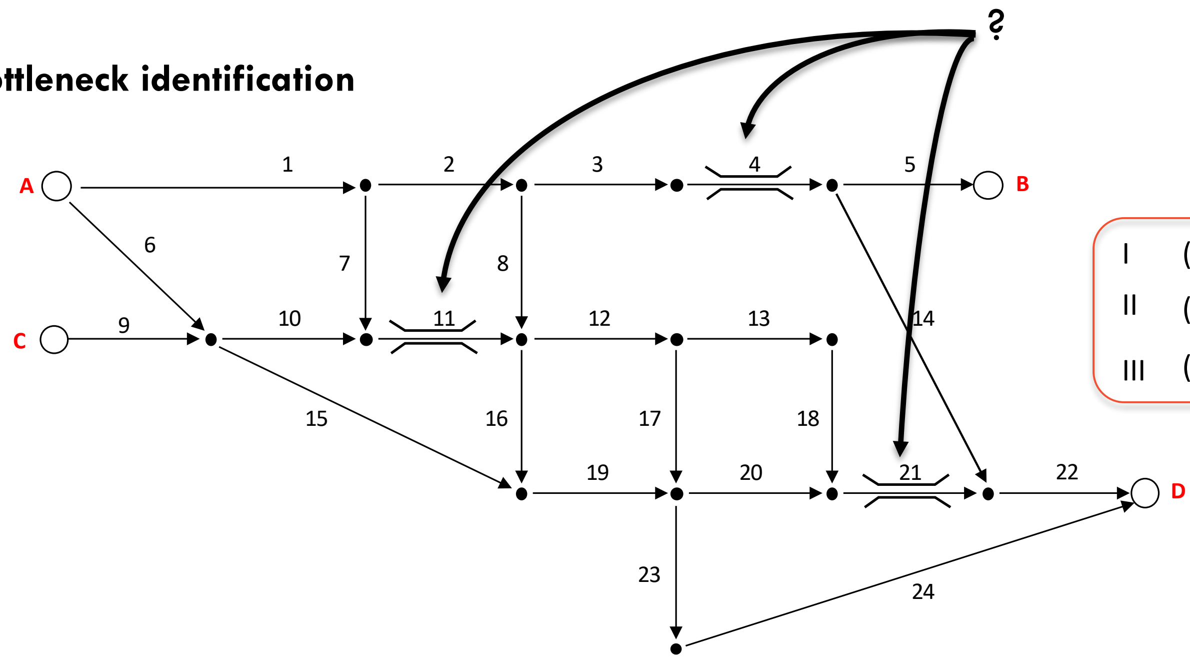
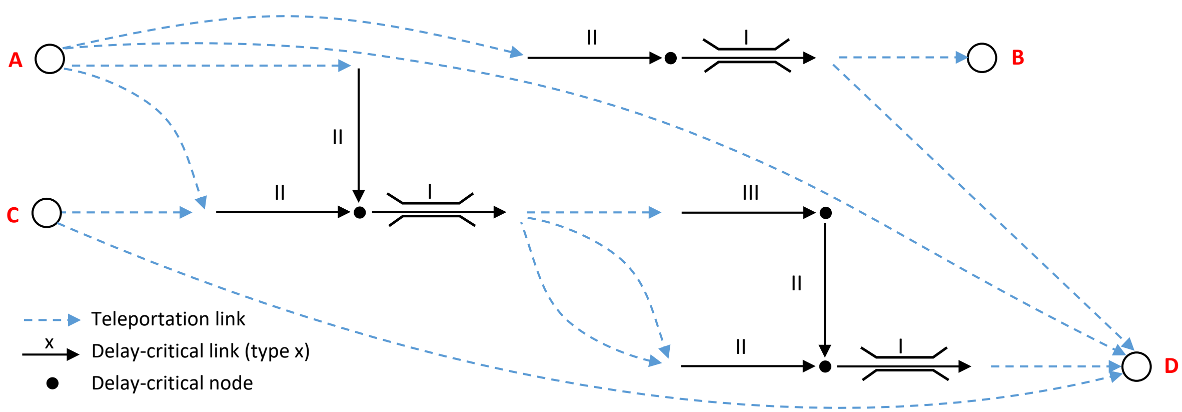
METHODOLOGY

Bottleneck identification



I	(potential) bottleneck link
II	(potential) primary queuing delay link
III	(potential) secondary queuing delay link



METHODOLOGY

Super-scenario I

- Objective:
  - **Identify ALL potential bottlenecks across ALL demand scenarios**

- Information loss:
  - When we miss even a single bottleneck we cannot guarantee lossless result

- Problem:
  - To guarantee lossless result, we must equilibrate ALL demand scenarios
  - Equilibrating all demand scenarios negates any computational gains of our method

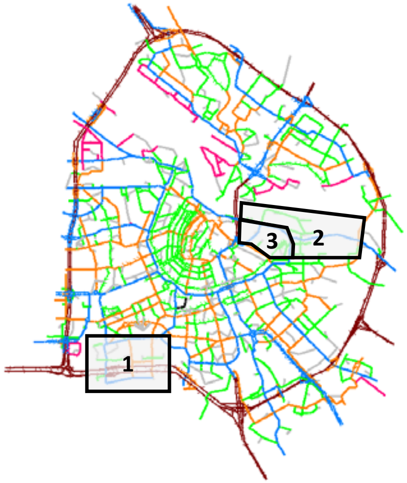
- Solution approach:
  - Identify as many potential bottlenecks across ALL demand scenarios without equilibrating all demand scenarios
  - Equilibrate a single demand scenario: super-scenario

METHODOLOGY

Super scenario II

- Tested two approaches:
  - Maximum od demand across all scenarios
  - Average od demand across all scenarios

- Tested under various demand scenarios perturbations:
  - Uniform demand scenarios, i.e., od's experience the same change across the network
  - Non-uniform demand scenarios, i.e., od's do not experience the same change (area specific, combinations of area specific changes etc.)



METHODOLOGY

Super scenario II