

A photograph of a busy street in Helsinki, Finland. The street is paved with cobblestones and has tram tracks running down the center. A tram is visible in the background, and many pedestrians are walking across the street. The scene is captured in a high-contrast, slightly grainy style, emphasizing the urban environment.

accessibility instruments in planning practice

Spatial Network Analysis for Multi-Modal Transport Systems (SNAMUTS): Helsinki

Prof Carey Curtis, Dr Jan Scheurer,
Curtin University, Perth - RMIT University, Melbourne/Barcelona

POLICY CONTEXT

Cities worldwide - interest in a more coordinated approach to growth management → sustainable urban form → sustainable transport outcomes.

A popular planning strategy → public transport oriented development (PTOD), more commonly referred to as transit oriented development (TOD)

- need to consider both land use planning and transport planning in an integrated way,

- city planning framed around public transport

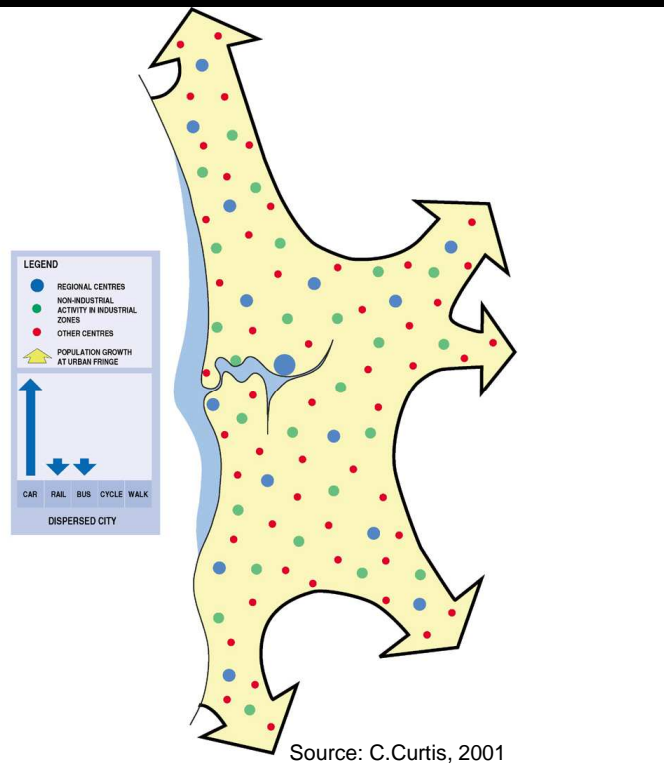
 - address both the form and structure of the city, and

 - quality of the public transport network

to ensure each are mutually supportive and provide for improved accessibility.

Curtis C (2015) Public Transport Orientated Development and Network Effects, in *An International Handbook on Transport and Development*, Edward Elgar, Co-Editors: Hickman, R., Bonilla, D., Givoni M., Banister D.

Context - Land use transport integration in Australian cities



- clear policy intentions in Metropolitan Plans for LUTI
- but selective implementation resulted in low density and dispersed form
- not only are cities spread out but land use activity is scattered.. a myriad of centres
- possibility of supplying a high frequency public transport system to serve these centres a challenge.

SEPTEMBER 2004

FOR PUBLIC COMMENT

Network city framework

Managing growth
by sharing responsibility
between
industry, communities
and government

- Plan with communities
- Nurture the environment
- Make fuller use of urban land
- Encourage public over private transport
- Strengthen local sense of place
- Develop strategies which deliver local jobs
- Provide affordable housing

Activity centres bring people together

- Activity centres on activity corridors (diagrammatic)
- Other activity centres

Networks connect people and places

- Passenger rail
- Activity corridors with excellent public transport
- Transport corridors for cars, trucks and express buses
- Other transport corridors

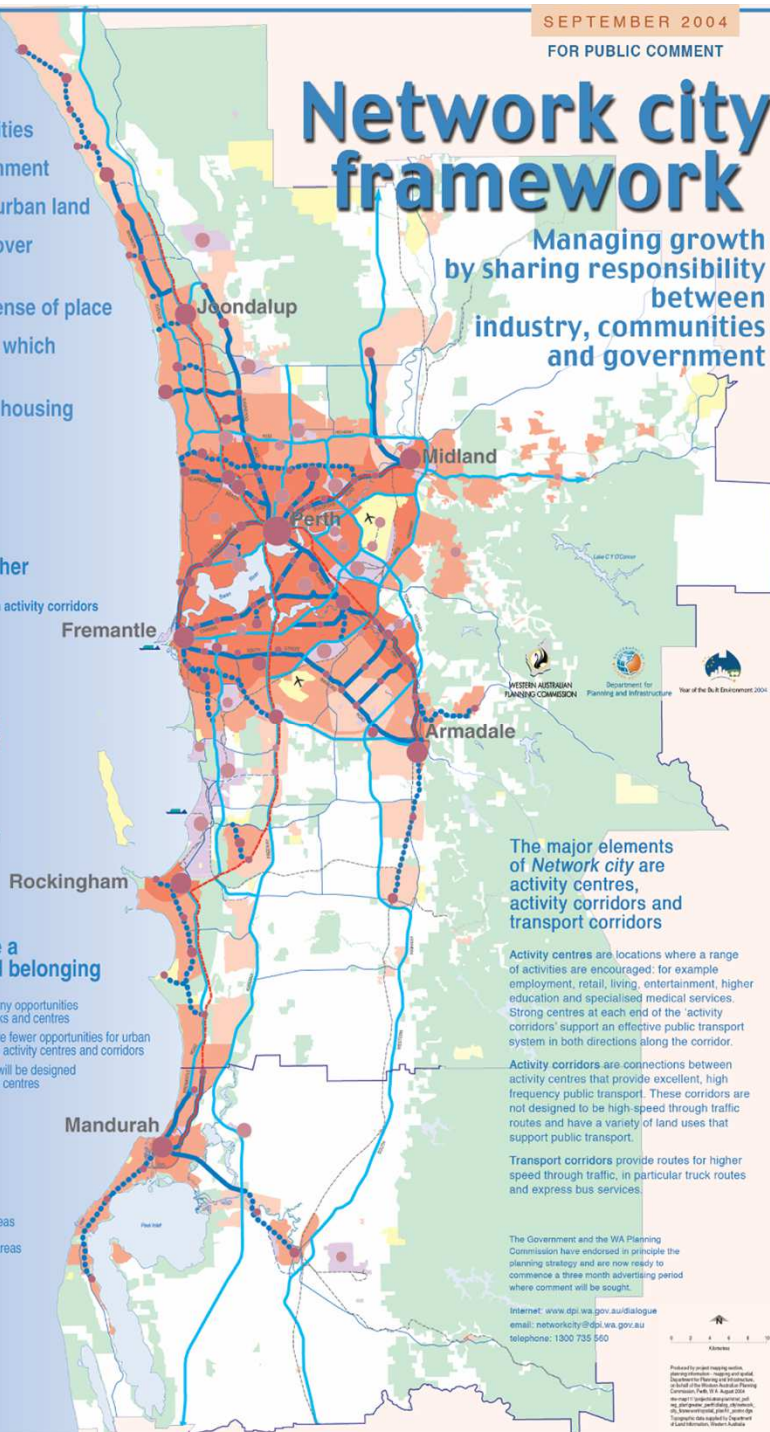
Communities have a sense of place and belonging

- Older areas have many opportunities to strengthen networks and centres
- Areas where there are fewer opportunities for urban consolidation outside activity centres and corridors
- Future communities will be designed around networks and centres

The environment sustains the city

- Non-development areas
- Rural and resource areas including natural vegetation

- Urban
- Public domain
- Private



The major elements of Network city are activity centres, activity corridors and transport corridors

Activity centres are locations where a range of activities are encouraged: for example employment, retail, living, entertainment, higher education and specialised medical services. Strong centres at each end of the 'activity corridors' support an effective public transport system in both directions along the corridor.

Activity corridors are connections between activity centres that provide excellent, high frequency public transport. These corridors are not designed to be high speed through traffic routes and have a variety of land uses that support public transport.

Transport corridors provide routes for higher speed through traffic, in particular truck routes and express bus services.

The Government and the WA Planning Commission have endorsed in principle the planning strategy and are now ready to commence a three month advertising period where comment will be sought.

Internet: www.dpi.wa.gov.au/dialogue
email: networkcity@dpi.wa.gov.au
telephone: 1800 735 560



Produced by project mapping services
Map information: map data and design
provided by the Western Australian Planning
Commission (WA) for 2004
Map information: map data and design
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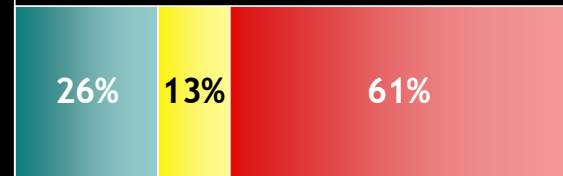
mid 1990's new approach
emerging

Mode Share Target by trips
(1995):

Perth
2000



Perth
2029



- Non-motorised modes
- Public transport
- Private vehicle

...targets imply that public
transport patronage needed to
grow four-fold between
2000 and 2030...

Network City spatial framework

did not determine which centres should perform which role within the goal of sustainable accessibility



These new policy goals demanded a multi-dimensional perspective...

- Which Activity Centres and Corridors can best be intensified?
- Which Centres should perform a regional role and which a local roles?
- Where should public transport investment (infrastructure, service improvement) go?
- What effect would changes to transport accessibility by car have (through fuel price increases, parking strategies etc)?
- Centres must not be considered in isolation from each other... the way in which they are networked forms an important component shifting from a case by case perspective to a strategic perspective

Answers to these questions provide a robust basis for decisions about the future metropolitan structure.

Evolution of our accessibility work...

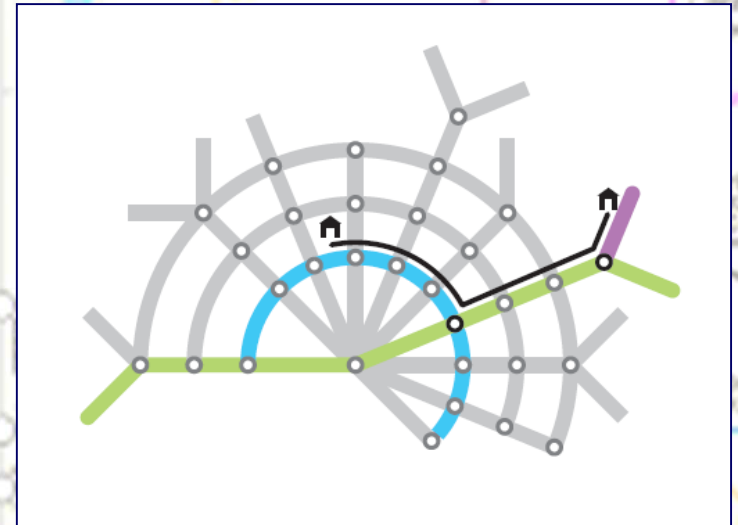
1. ARC Project on TOD examined how accessibility changed following opening of a new 72km railway
2. Research Consultancy – Australian State Governments:
 - a) Metropolitan growth choices
 - b) Public transport investment
3. ARC 3 year project - Continue the development of the interactive accessibility tool by examining 25 Cities in Australia, Europe, N. America & Asia:
 - SNAMUTS as a benchmarking tool
 - SNAMUTS methodology and robustness in a range of city types
1. EU COST Action TU1002: Accessibility Tools in Planning Practice:
 - 22 European Countries & Australia
 - Local (National) Workshops – USE & USEABILITY

spatial network analysis for multimodal urban transport systems (SNAMUTS)

Purpose: To assess and quantify how transport networks, in terms of geographical configuration and service levels, perform in their urban context (distribution of land use activities).

SNAMUTS is a **supply-side tool**: it does not provide predictions about usage or capacity levels. Rather it asks: **What is the role of the public transport system in facilitating movement and activity across a city region?**

network connectivity



Create a 'network effect' by local optimisation to routes, good interchange facilities, high and standardised service frequencies, timetable coordination and the presence of orbital/cross-suburban routes to maximise market penetration for public transport.

Map Sources: www.railpage.com.au, www.hitrans.org



public transport from a user perspective

How can we measure distance (or travel impediment) **in ways that come close to user perceptions and motivations?**

Public transport users are only marginally interested in geographical distance: **the main factors of travel disutility** are travel time, and the **ubiquity of travel opportunities** (service frequency)

compiling a base network

Spatial separation or impediment measure: Travel time divided by service frequency ($d=4t/\sqrt{f}$)

Minimum service standard (SNAMUTS 23): 20 min frequency during the weekday interpeak, 30 min on Sat/Sun (buses, trams), 30 min weekdays and 7 day service (rail)

Identifying activity nodes: SNAMUTS matrix of activity nodes derived from activity centre hierarchy in strategic planning documents and from field observation. Helsinki has 102 activity nodes with an average catchment of approximately 14,000 residents and jobs.



8 key snamuts indicators

**Service
Intensity**
*Operational
input*

**Closeness
Centrality**
*Ease of
movement*

**Degree
Centrality**
*Transfer
intensity*

**Network
Coverage**
*Who gets
access?*

**30-minute
Contour
Catchments**

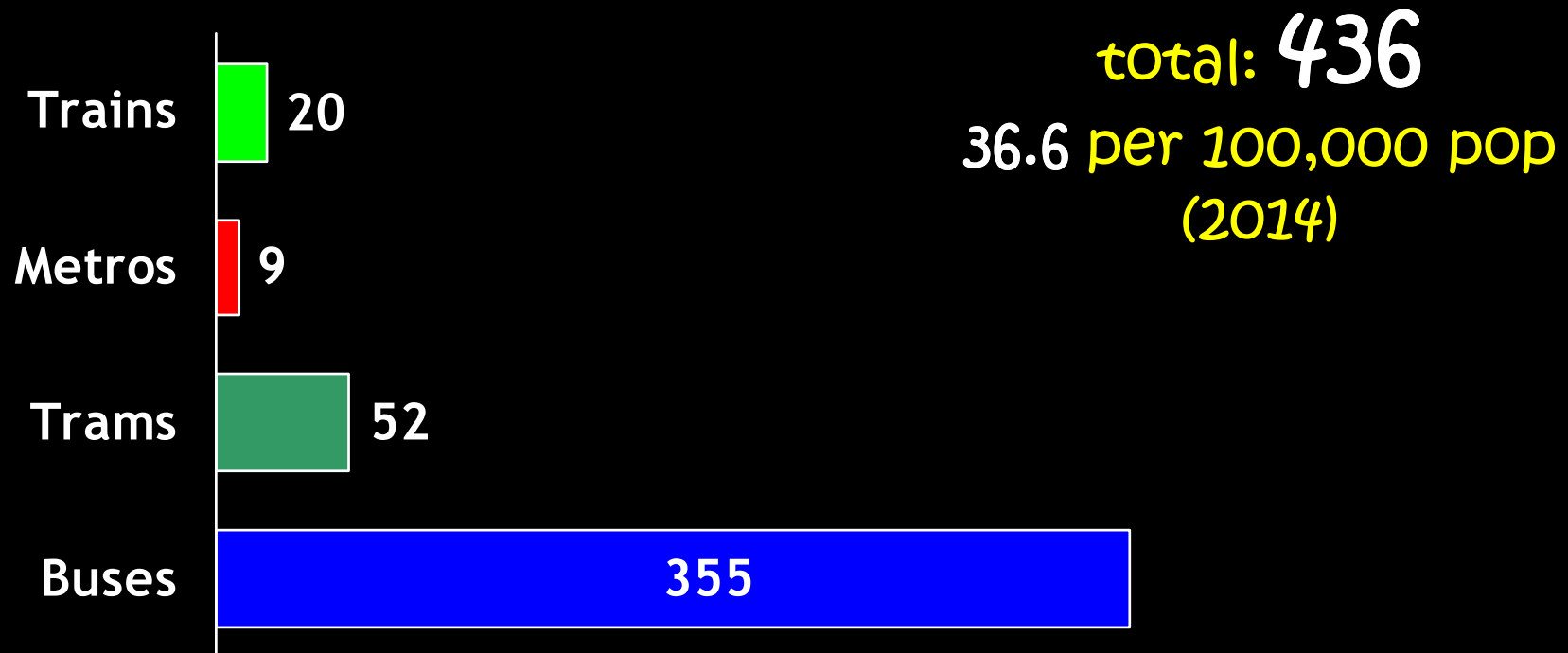
**Betweenness
Centrality**
*Presence and
distribution of
PT travel
opportunities*

**Network
Resilience**
*How future-proof
is the public
transport system?*

**Nodal
Connectivity**
*Flexibility of
movement in
urban space*

helsinki: service intensity

Number of vehicles/train sets required in simultaneous operation for the minimum standard network
(20 min weekdays, 30 min weekends for trams and buses,
30 minutes weekdays for trains)



service intensity: what does and what doesn't this index tell us?

Operational efficiency: Networks dominated by slow modes (especially buses) tend to require greater operational input (in number of vehicles/drivers) than networks dominated by fast modes (especially light or heavy rail).

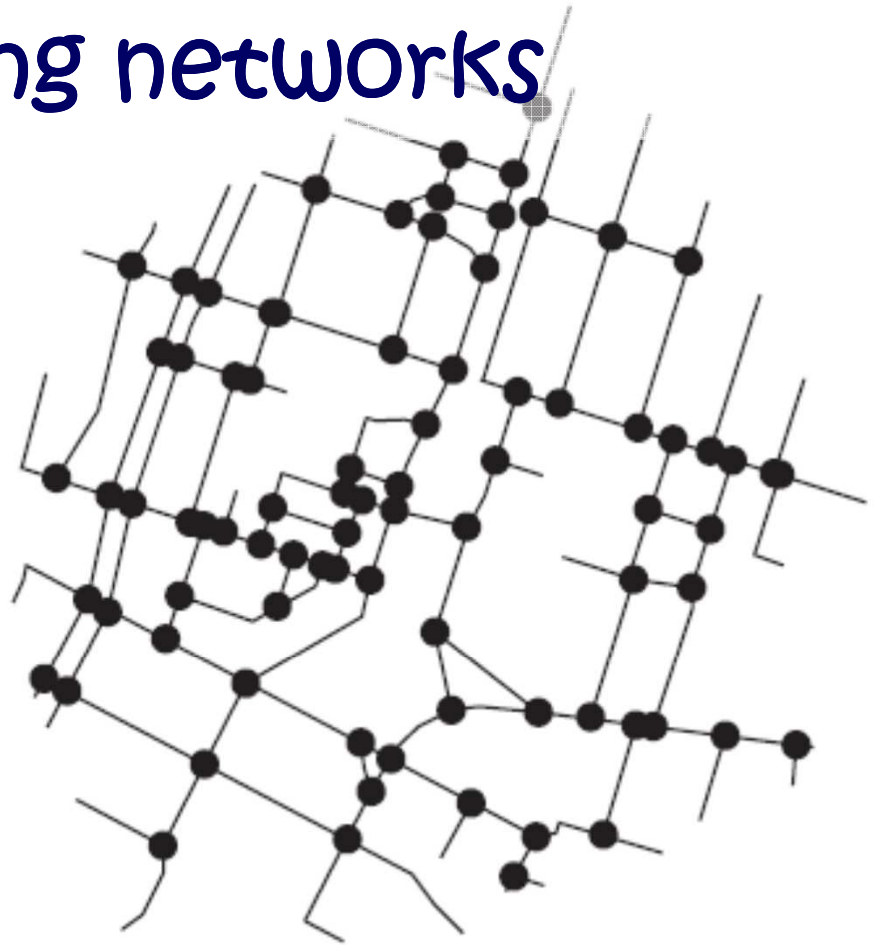
Performance expectation: Does a higher outlay of operational resources consistently result in better public transport accessibility and network performance?

Comparison of service intensity vehicles per 100,000 population



Singapore	48.9
Hong Kong	41.9
Edinburgh	38.2
Helsinki	36.6
Göteborg	32.3
Amsterdam	28.7
Zürich	25.9
Wien	25.5
Oporto	24.9
København	24.8
Oslo	23.5
Barcelona	21.9
Vancouver	19.3
Adelaide	18.1
Hamburg	17.2
Zuid Holland	16.8
Utrecht	16.2
Sydney	14.9
München	13.9
Melbourne	13.4
Perth	12.6
Brisbane	11.6
Montreal	10.4
Portland Seattle	10.2
Auckland	9.2

understanding networks






Networks have **topological properties** (how many degrees of separation from A to B) and **metric properties** (how many units of distance/impediment from A to B)

Source: Porta, Crucitti and Latora 2006

Closeness Centrality

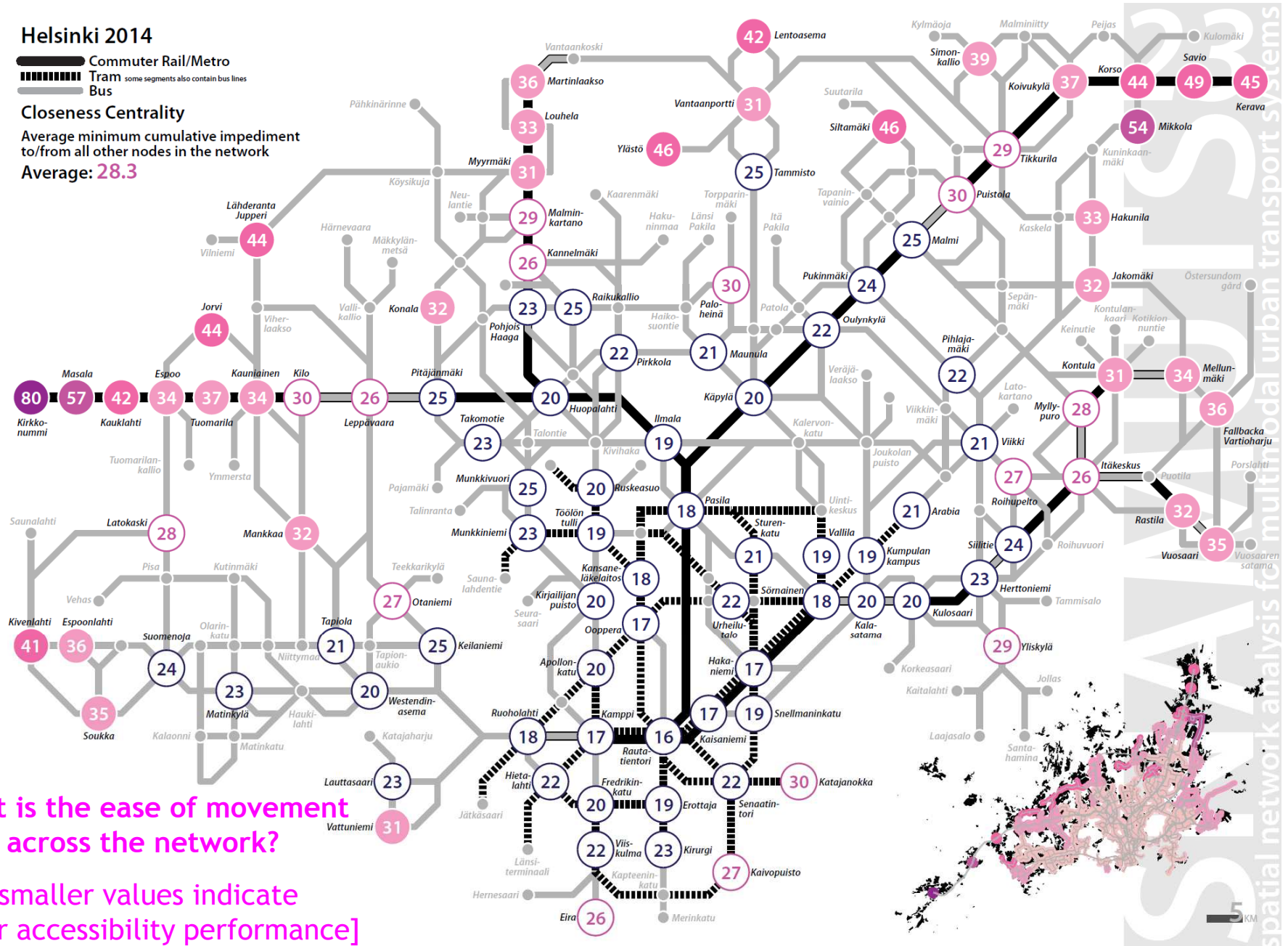
Helsinki 2014

 Commuter Rail/Metro
 Tram some segments also contain bus lines
 Bus

Closeness Centrality

Average minimum cumulative impediment to/from all other nodes in the network

Average: 28.3



What is the ease of movement across the network?

[smaller values indicate better accessibility performance]

Closeness Centrality: what does and what doesn't this index tell us?

Ease of movement: Closeness scores are a spatial separation measure for the activity centre network. They are inflated by

- (1) dispersed settlement patterns,
- (2) detours forced by geographical barriers or missing links,
- (3) slow travel speeds,
- (4) low service frequencies,

or a combination of several of the above.

Network size: Larger networks with a greater number of activity centres will generally produce higher (poorer) average closeness centrality scores than smaller ones.

comparison of closeness centrality average per network



Helsinki 28.3




Wien 38.8
Göteborg 39.6
Vancouver 42.1
Oslo 43.1
Barcelona 44.8
Oporto 46.4
Montreal 47.1
Zürich 47.4
København 47.9
München 48.4
Amsterdam 48.8
Utrecht 49.2
Hamburg 51.4
Singapore 51.6
Hong Kong 53.7
Portland 57.4
Auckland 59.0
Perth 59.3
Adelaide 61.1
Melbourne 62.3
Zuid Holland 62.9
Brisbane 64.1
Seattle 64.3

Edinburgh 72.1

Sydney 81.5

degree centrality

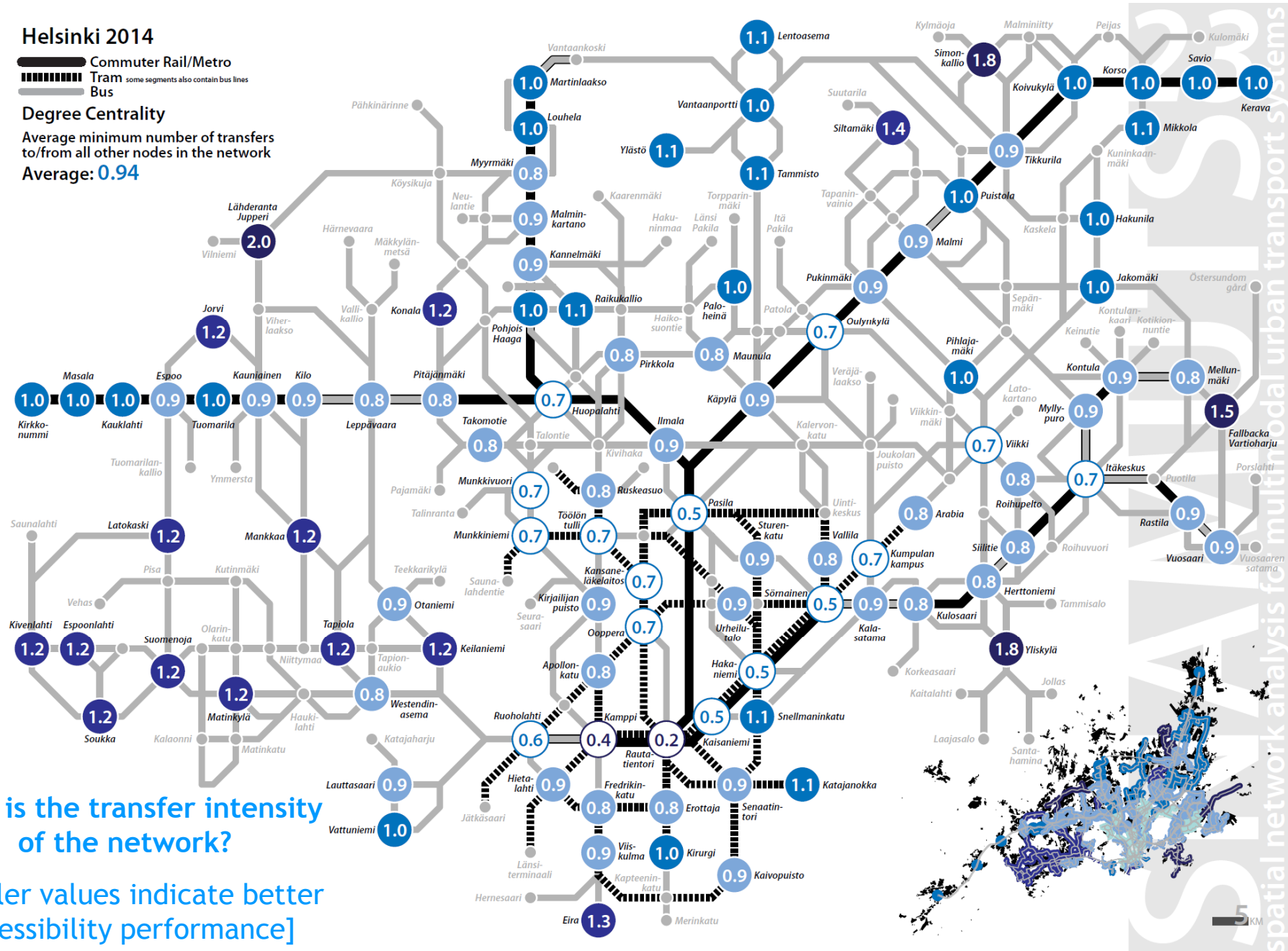
Helsinki 2014

 Commuter Rail/Metro
 Tram some segments also contain bus lines
 Bus

Degree Centrality

Average minimum number of transfers to/from all other nodes in the network

Average: **0.94**



degree centrality: what does and what doesn't this index tell us?

Network organisation:

Is the public transport network organised around a modal hierarchy with lower-capacity modes acting as feeders and distributors to higher-capacity nodes (greater transfer intensity)?

Or do the networks of modes with different performance coexist (compete?) in spatial terms (lower transfer intensity)?



comparison of degree centrality average per network



Singapore	0.74
Portland	0.79
Göteborg	0.83
Oslo	0.84
Edinburgh München	0.89
Melbourne Brisbane Oporto	0.91
København	0.93
Helsinki	0.94
Auckland	0.95
Hong Kong	0.96
Perth	1.03
Sydney	1.04
Seattle	1.07
Amsterdam	1.08
Adelaide	1.09
Barcelona	1.11
Hamburg	1.12
Vancouver	1.13
Utrecht	1.17
Wien	1.20
Zürich	1.22
Montreal	1.38
Zuid Holland	1.60

Contour Catchments

Helsinki 2014

 Commuter Rail/Metro
 Tram some segments also contain bus lines
 Bus

30-minute Contour Catchments

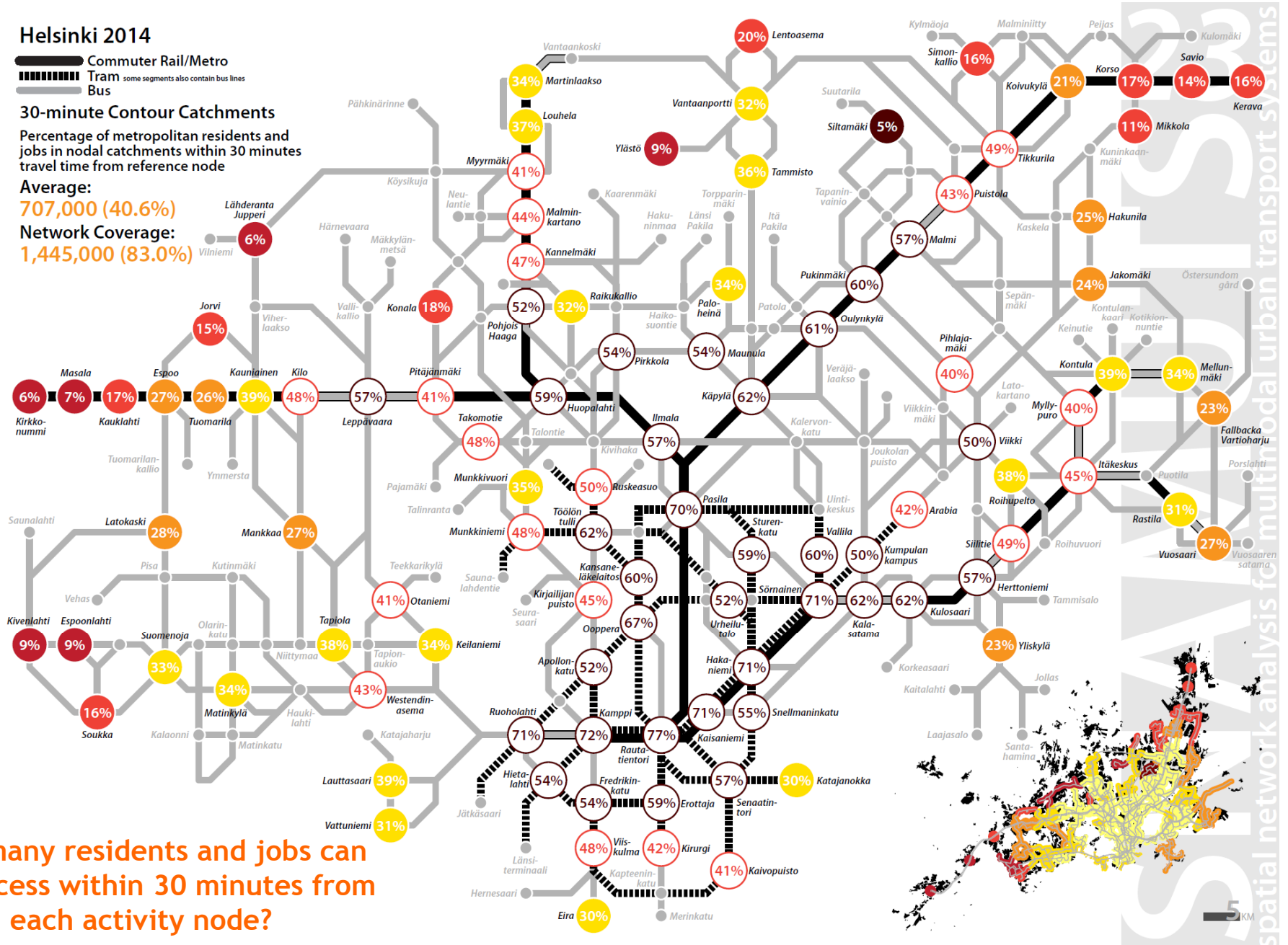
Percentage of metropolitan residents and jobs in nodal catchments within 30 minutes travel time from reference node

Average:

707,000 (40.6%)

Network Coverage:

1,445,000 (83.0%)



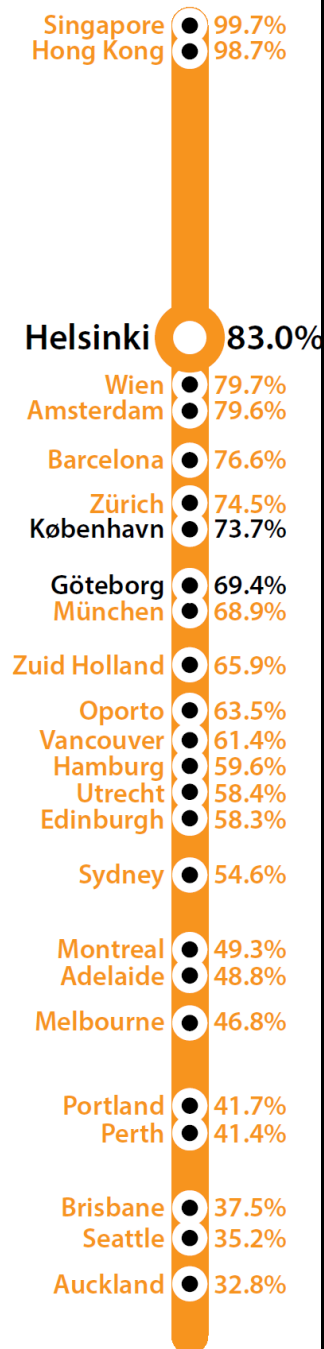
How many residents and jobs can you access within 30 minutes from each activity node?

network coverage and contour catchments: what do and what don't these indexes tell us?

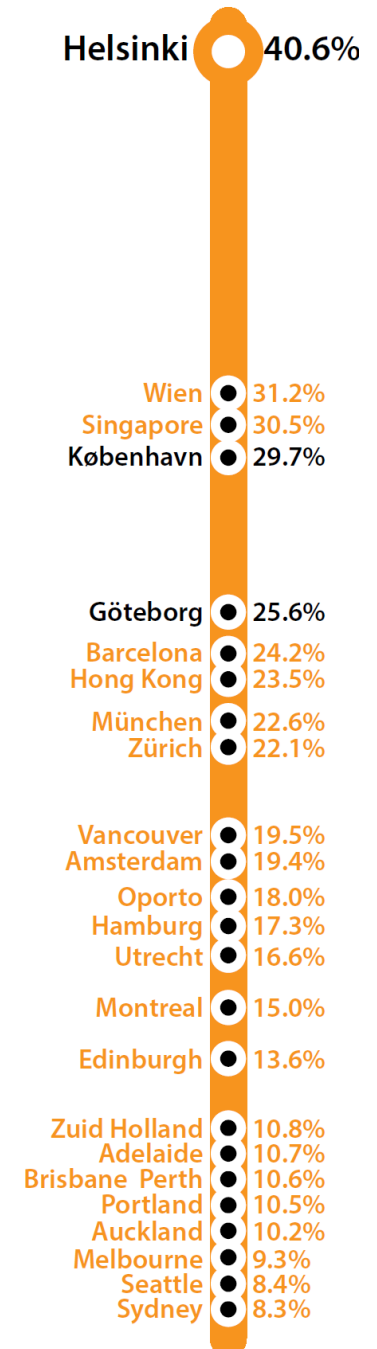
Network coverage describes the quantity of people with access to public transport, while the **contour catchment measure** expands this with a qualitative message (how many people can you access within 30 minutes?)

The **contour catchment** assesses how successfully public transport endowment translates into the practical penetration of the settlement area with useful public transport journey paths.

Ideally, a city should achieve 100% network coverage and an average contour catchment of 50%.






Comparison of network coverage (left) and average contour catchments (right) percentage of metropolitan residents and jobs



betweenness centrality

Helsinki 2014

 Commuter Rail/Metro
 Tram some segments also contain bus lines
 Bus

Nodal Betweenness

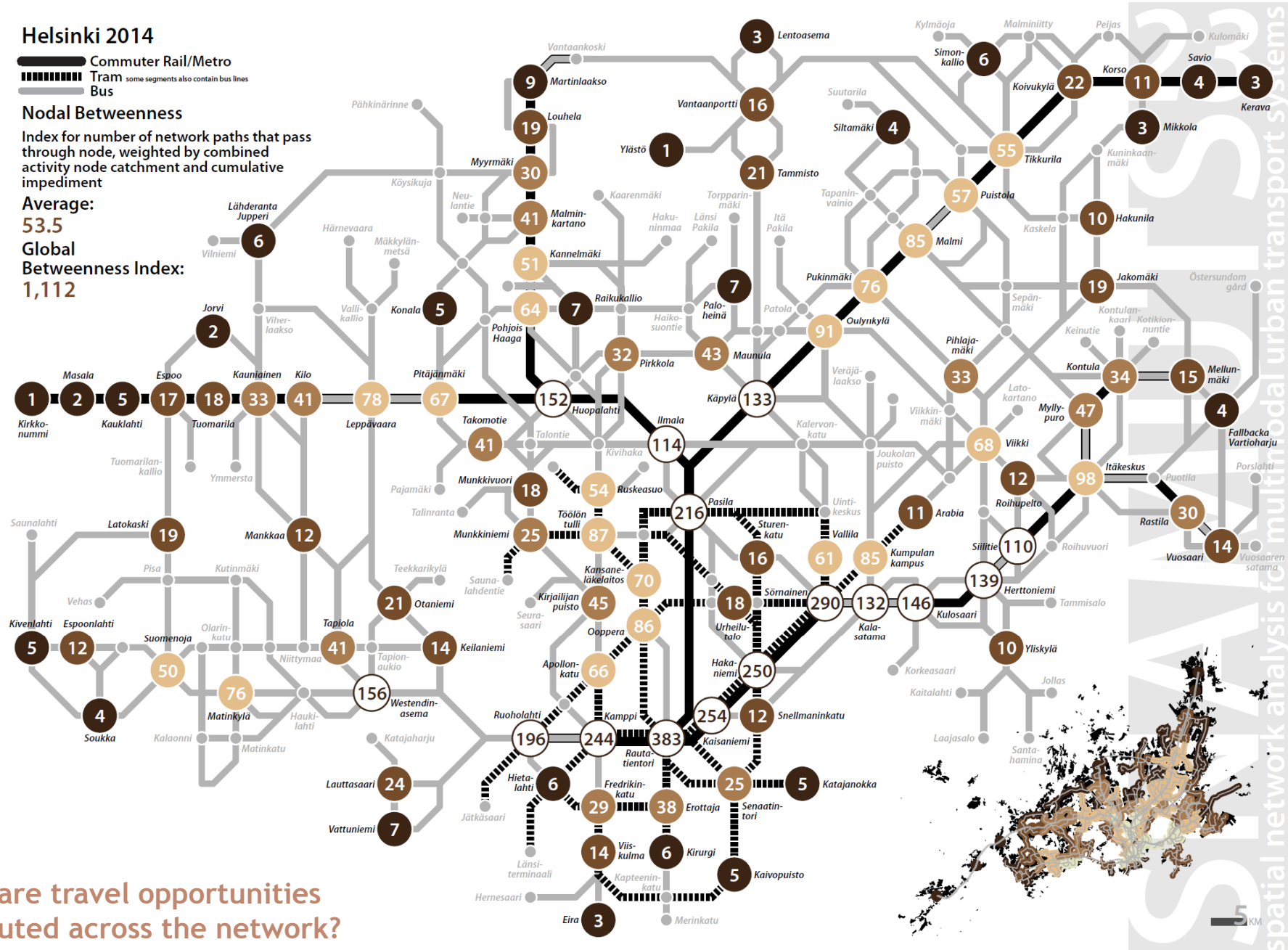
Index for number of network paths that pass through node, weighted by combined activity node catchment and cumulative impediment

Average:

53.5

Global
Betweenness Index:

1,112



How are travel opportunities distributed across the network?

nodal and segmental betweenness

Helsinki 2014

- Commuter Rail
- Metro
- Tram some segments also contain bus lines
- Bus

Segmental Betweenness

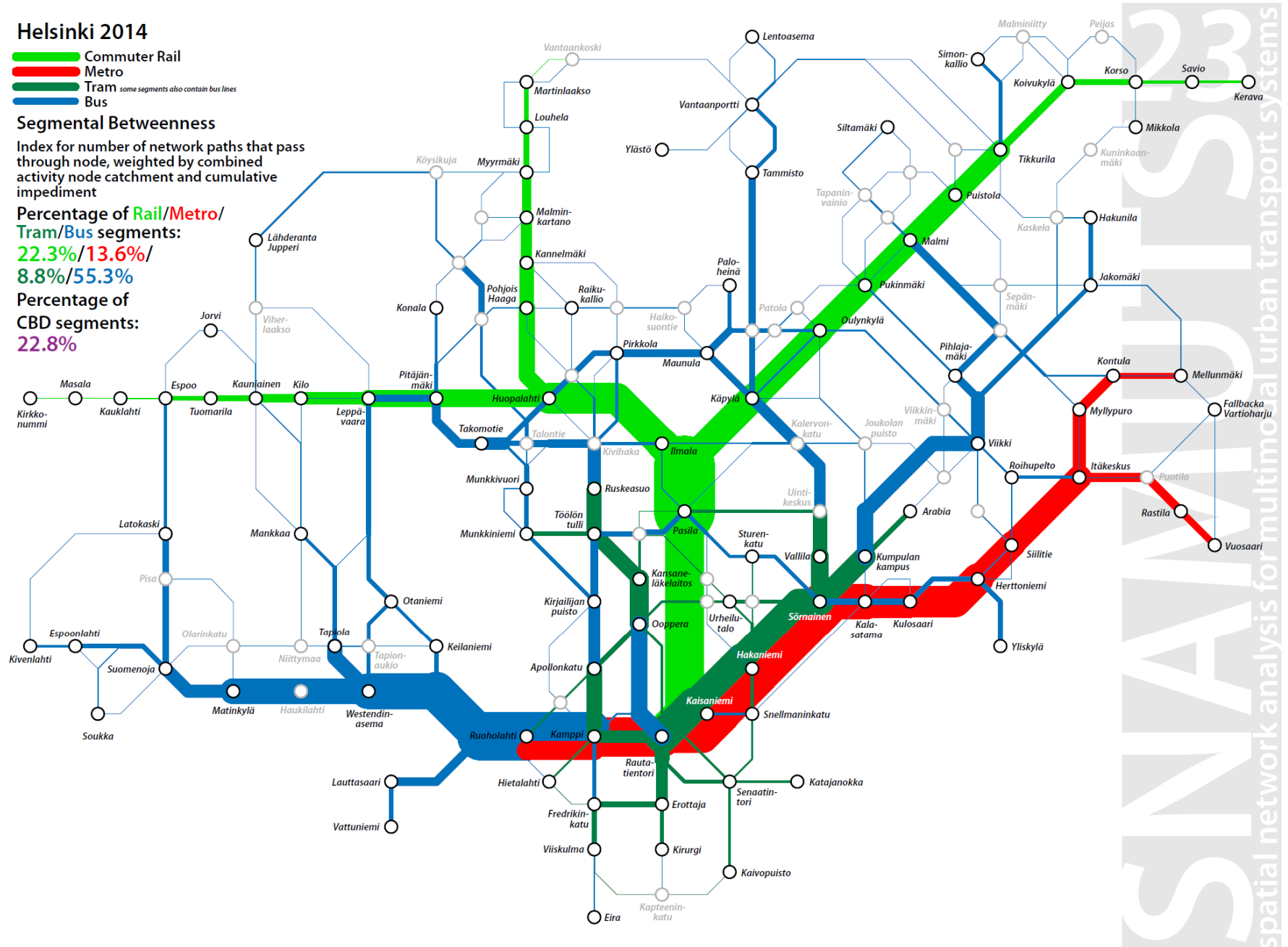
Index for number of network paths that pass through node, weighted by combined activity node catchment and cumulative impediment

Percentage of Rail/Metro/
Tram/Bus segments:

22.3%/13.6%/
8.8%/55.3%

Percentage of
CBD segments:

22.8%



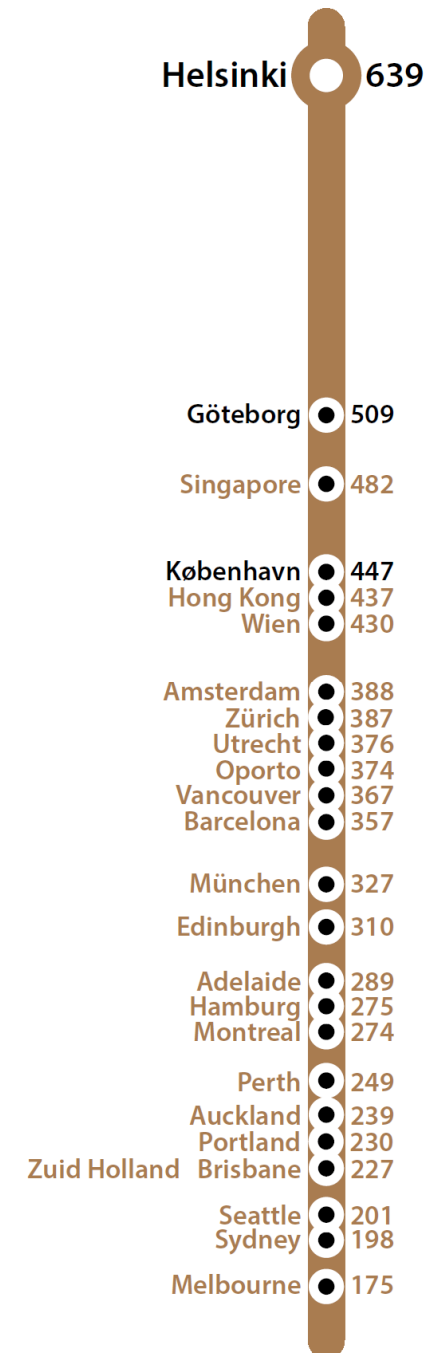
betweenness centrality: what does and what doesn't this index tell us?

Public transport 'movement energy': Betweenness centrality attempts to quantify the presence of public transport opportunities in each centre, and across the metropolitan area, as well as visualise how this presence flows across the network.

Balanced and unbalanced nodes/places, stressed locations and routes: Betweenness can help identify pressures on network elements originating from either their land use or their transport function (or both in conjunction).

Betweenness scores are not necessarily proportional to usage levels, but **correlations with usage can point to under- or over-utilised potential** for public transport movement.

Comparison of global betweenness total per network per million residents and jobs



segmental betweenness and resilience

Helsinki 2014

- Commuter Rail
- Metro
- Tram some segments also contain bus lines
- Bus

Segmental Betweenness

Index for number of network paths that pass through node, weighted by combined activity node catchment and cumulative impediment

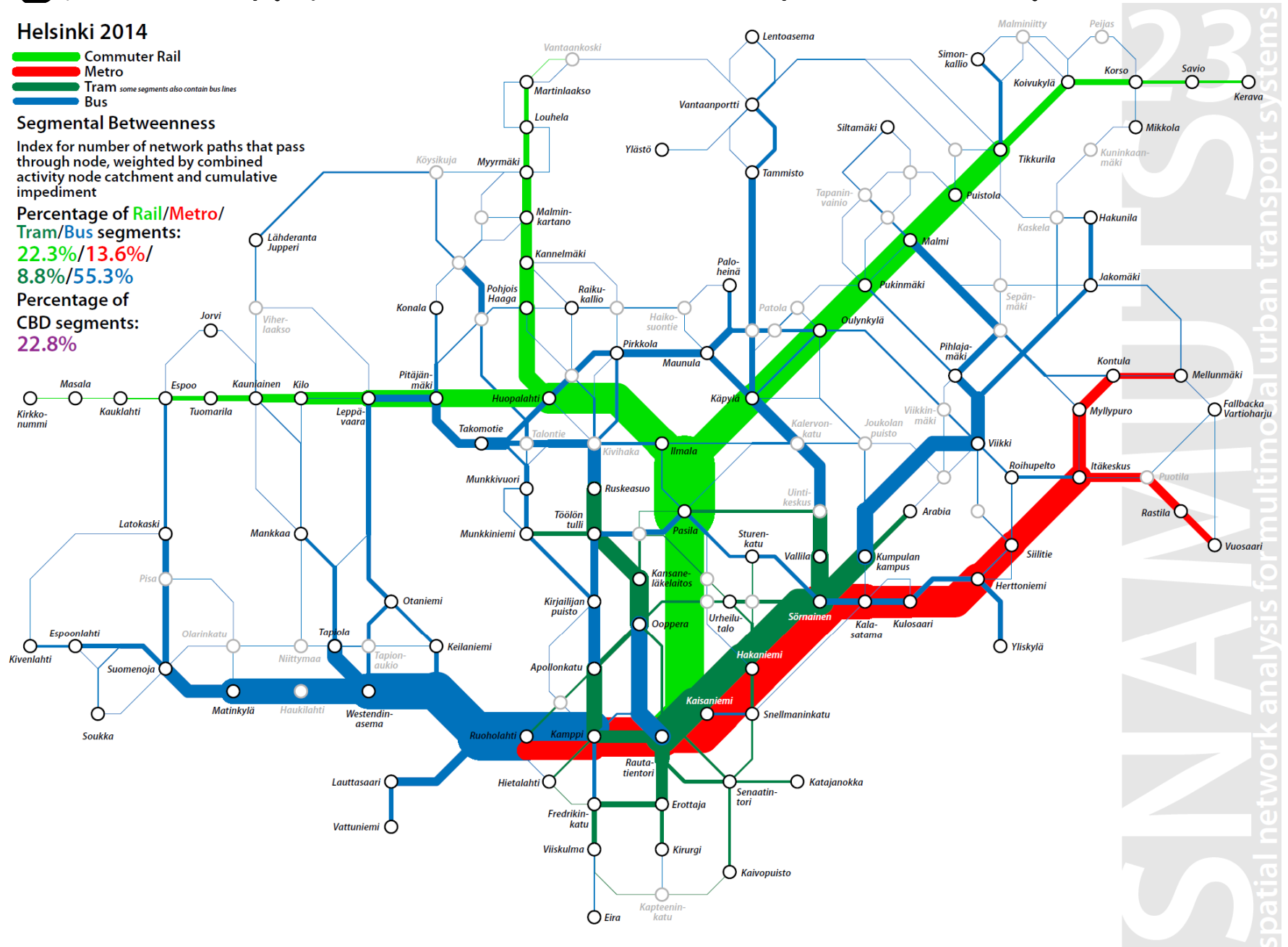
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
22.3%/13.6%/

8.8%/55.3%

Percentage of
CBD segments:

22.8%



 Commuter Rail/Metro
 Tram *some segments also contain bus lines*
 Bus

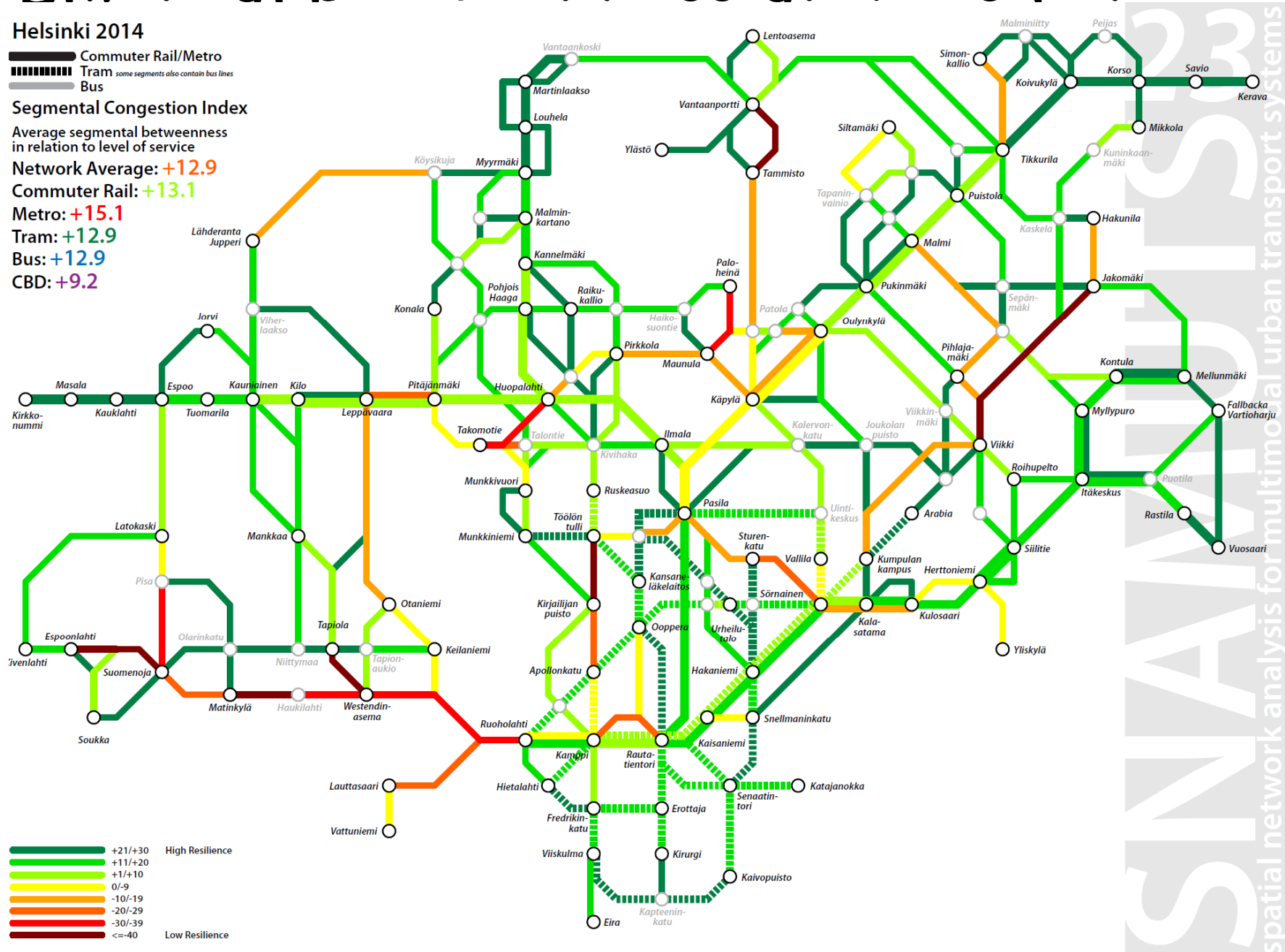
Average segmental betweenness in relation to level of service

Commuter Rail: +13.1

Tram: +12.9

Bus: +12.9

CBD: +9.2



network resilience: what does and what doesn't this index tell us?

A 'troubleshooting' tool to pinpoint mismatches in public transport supply and (potential) demand (ie. demand as derived from urban form and network configuration)

Includes a feedback loop, as isolated measures to improve service levels to relieve stress (ie. frequency upgrades) will also add to network stress through greater ease of movement.

Responds most vigorously to more comprehensive solutions, such as network reconfigurations and mode upgrades.




Comparison of network resilience average per network



Zürich	●	+19.4
Wien	●	+18.5
Göteborg	●	+17.0
Edinburgh	●	+16.4
København	●	+14.9
München	●	+14.8
Amsterdam	●	+13.1
Helsinki	●	+12.9
Barcelona	●	+12.2
Perth	●	+11.4
Utrecht	●	+11.0
Singapore	●	+9.7
Adelaide	●	+9.1
Hamburg	●	+8.7
Melbourne	●	+7.6
Oporto	●	+7.5
Zuid Holland	●	+6.3
Auckland	●	+6.2
Brisbane	●	+5.6
Portland	●	+5.6
Vancouver	●	+4.1
Sydney	●	+2.4
Seattle	●	+2.1
Montreal	●	-0.9
Hong Kong	●	-1.5

nodal connectivity

Helsinki 2014

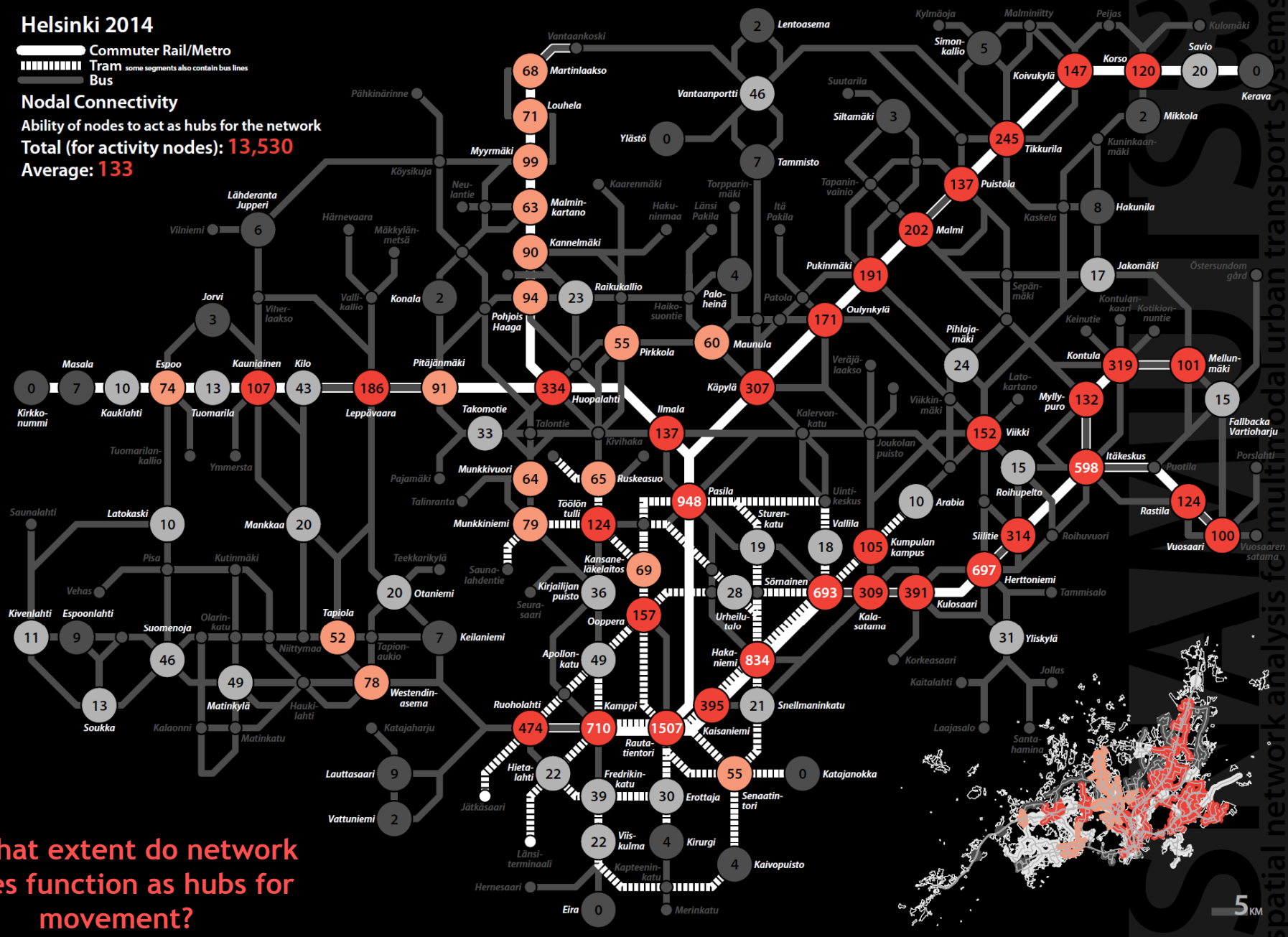
 Commuter Rail/Metro
 Tram some segments also contain bus lines
 Bus

Nodal Connectivity

Ability of nodes to act as hubs for the network

Total (for activity nodes): **13,530**

Average: **133**



To what extent do network nodes function as hubs for movement?

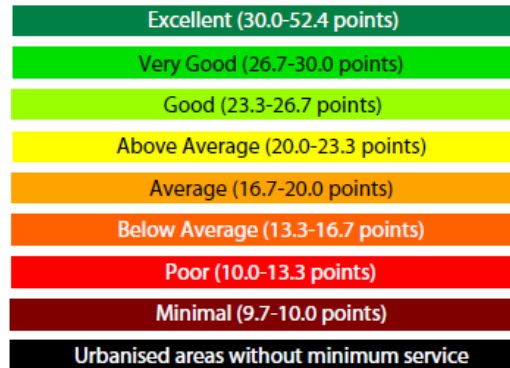
Comparison of nodal connectivity average per network



Hong Kong	868
Singapore	751
Barcelona	305
Wien	193
München	176
Hamburg	166
Helsinki	133
Amsterdam	123
København	88
Vancouver	87
Zuid Holland	86
Zürich	83
Melbourne	82
Sydney	77
Göteborg	71
Utrecht	60
Montreal	52
Oporto	47
Brisbane	42
Edinburgh	31
Seattle Portland	26
Perth	19
Auckland	13
Adelaide	12

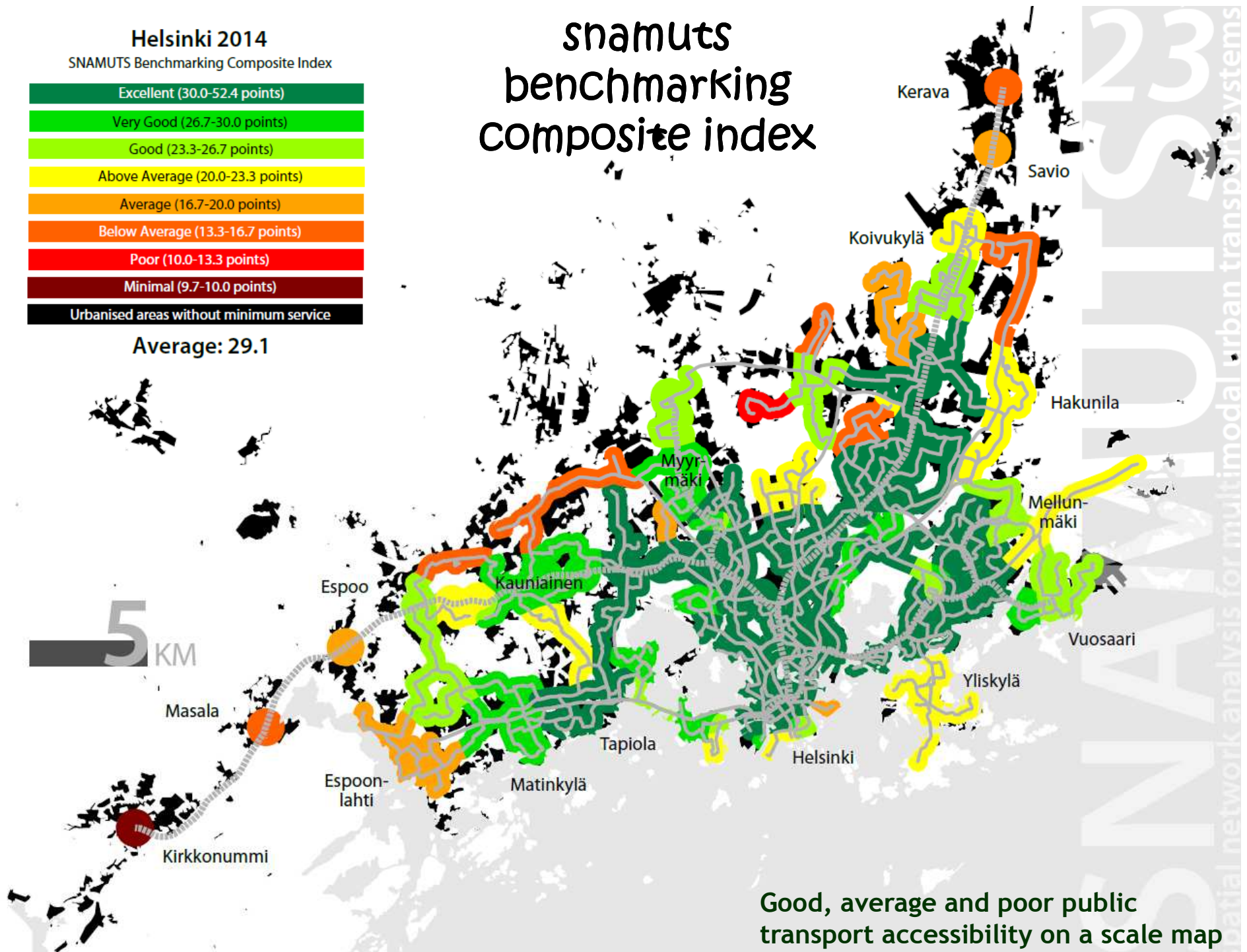
Helsinki 2014

SNAMUTS Benchmarking Composite Index



Average: 29.1

snamuts benchmarking composite index



snamuts helsinki: preliminary findings (i)

Helsinki has the **second highest level of operational input** relative to population among the non-Asian SNAMUTS cities. This largesse translates into the **highest concentration of public transport travel opportunities** in the SNAMUTS sample, and the **highest level of network coverage** outside Asia.

The **average ease of movement** in Helsinki's public transport network is by far the best of all cities in the sample.

[Comparatively small city size supports this outcome.]

Helsinki's network **has mixed modal hierarchies**: developed task-sharing between metro and bus and to some extent between tram and bus, but less so between train and bus.

snamuts helsinki: preliminary findings (ii)

Small size, compact city shape, good travel speeds and a multidirectional network that effectively bridges geographical barriers (water bodies) combine to deliver the **largest average 30-minute contour catchment** relative to population of all 26 SNAMUTS cities.

Helsinki's network **remains relatively bus-reliant** (though this is set to decrease with the opening of Länsimetro) and shows **some weaknesses in resilience** on critical bus links, suggesting unexhausted potential for ridership - perhaps this is due to a generous and highly competitive road system particularly in the middle and outer suburbs?



the effects of ring rail and länsimetro (stage 1)

Service intensity: slight decline from 36.6 to 35.4
vehicles/trains per 100,000 inh

Closeness centrality: average decline from 28.3 to 30.3

Degree centrality: average constant at 0.94

Network coverage and average contour catchments
increase slightly (83.0 to 83.3%/40.6% to 41.1%)




Betweenness centrality: global betweenness declines slightly
from 639 to 630. Heavy rail share (segmental betweenness)
increases from 35.9% to 50.2%. CBD significance declines
slightly from 22.8% to 21.5%

Network resilience: average increase from +12.9 to +16.2

Nodal connectivity: average increase from 133 to 139

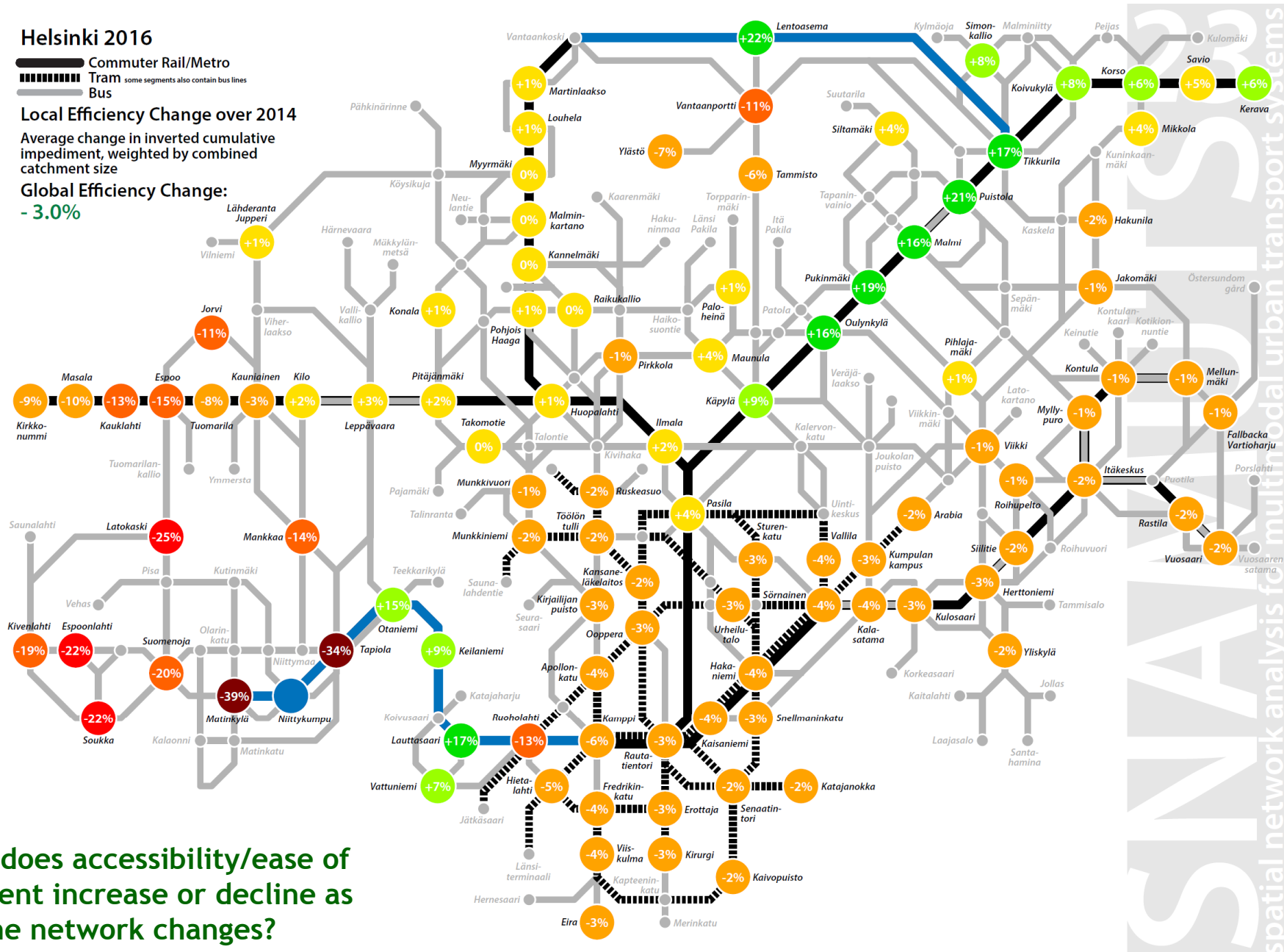
Map of the Helsinki commuter rail network showing percentage changes in passenger volume by station. Stations with green circles indicate an increase, while those with orange circles indicate a decrease.

Station	Change (%)
Savio	+5%
Kerava	+6%
Mikkola	+4%
Kulomäki	0%
Mellunmäki	-1%
Fallbacka Vartiola	-1%
Puotila	-2%
Rastila	-2%
Vuosaari	-2%

 Commuter Rail/Metro
 Tram some segments also contain bus lines
 Bus

Average change in inverted cumulative
impediment, weighted by combined
catchment size

- 3.0%



Where does accessibility/ease of movement increase or decline as the network changes?

segmental betweenness

Helsinki 2014

- Commuter Rail
- Metro
- Tram some segments also contain bus lines
- Bus

Segmental Betweenness

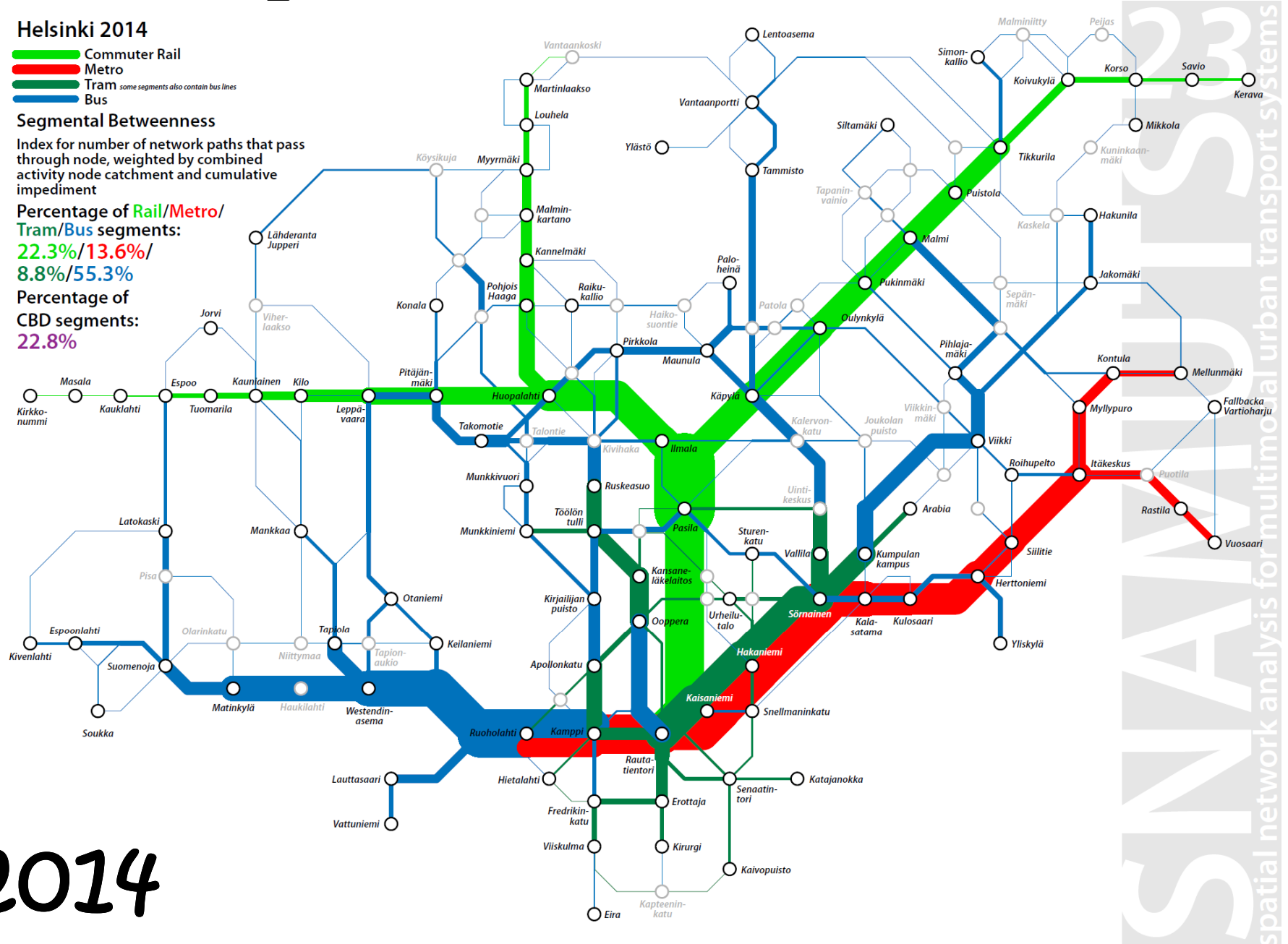
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8.8%/55.3%

Percentage of
CBD segments:

22.8%



2014

segmental betweenness

Helsinki 2016

- Commuter Rail
- Metro
- Tram some segments also contain bus lines
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Segmental Betweenness

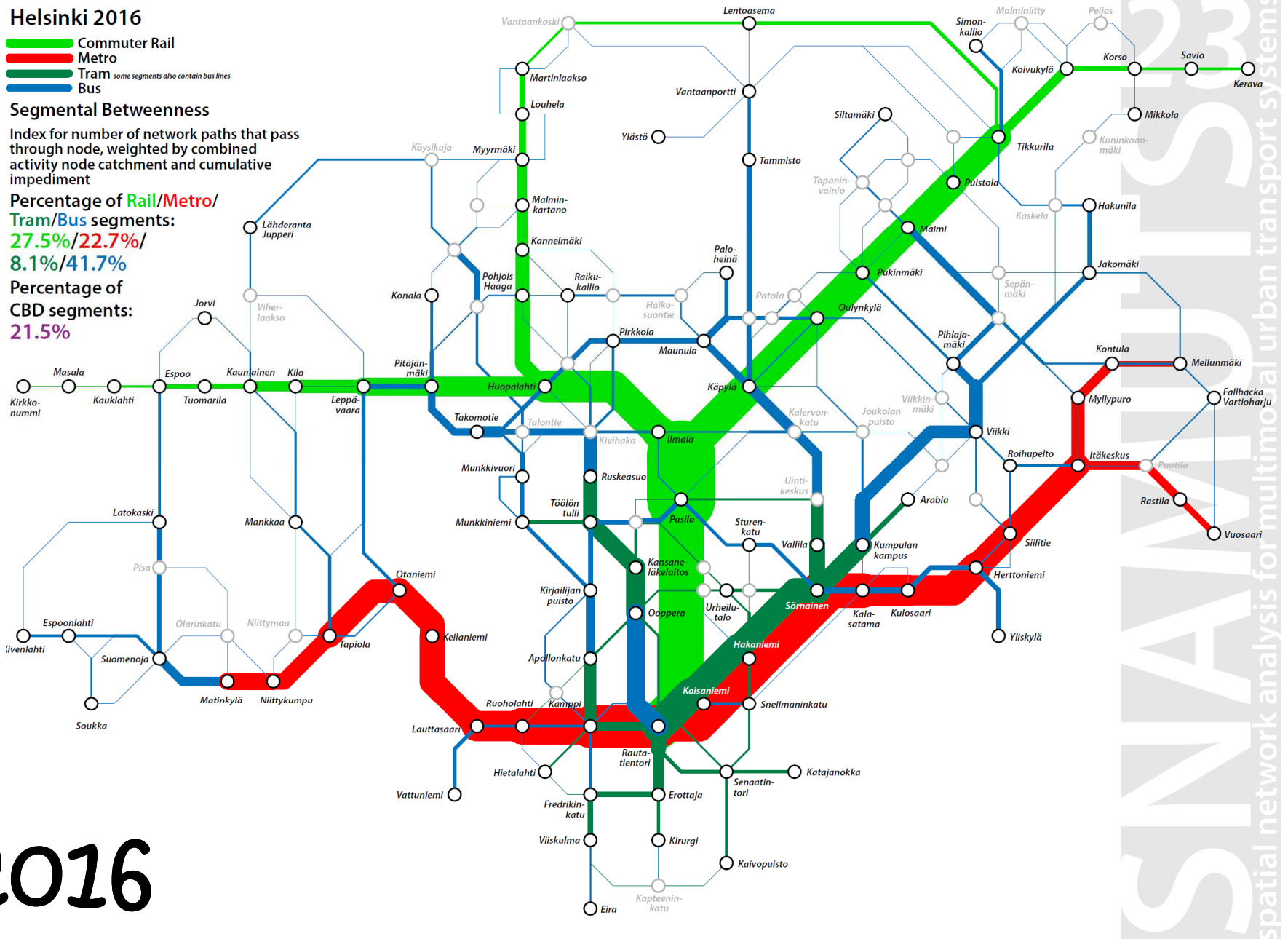
Index for number of network paths that pass through node, weighted by combined activity node catchment and cumulative impediment

Percentage of Rail/Metro/
Tram/Bus segments:

27.5%/22.7%/8.1%/41.7%

Percentage of
CBD segments:




21.5%



2016

network resilience

Helsinki 2014

 Commuter Rail/Metro
 Tram *some segments also contain bus lines*
 Bus

Segmental Congestion Index

Average segmental betweenness in relation to level of service

Network Average: +12.9

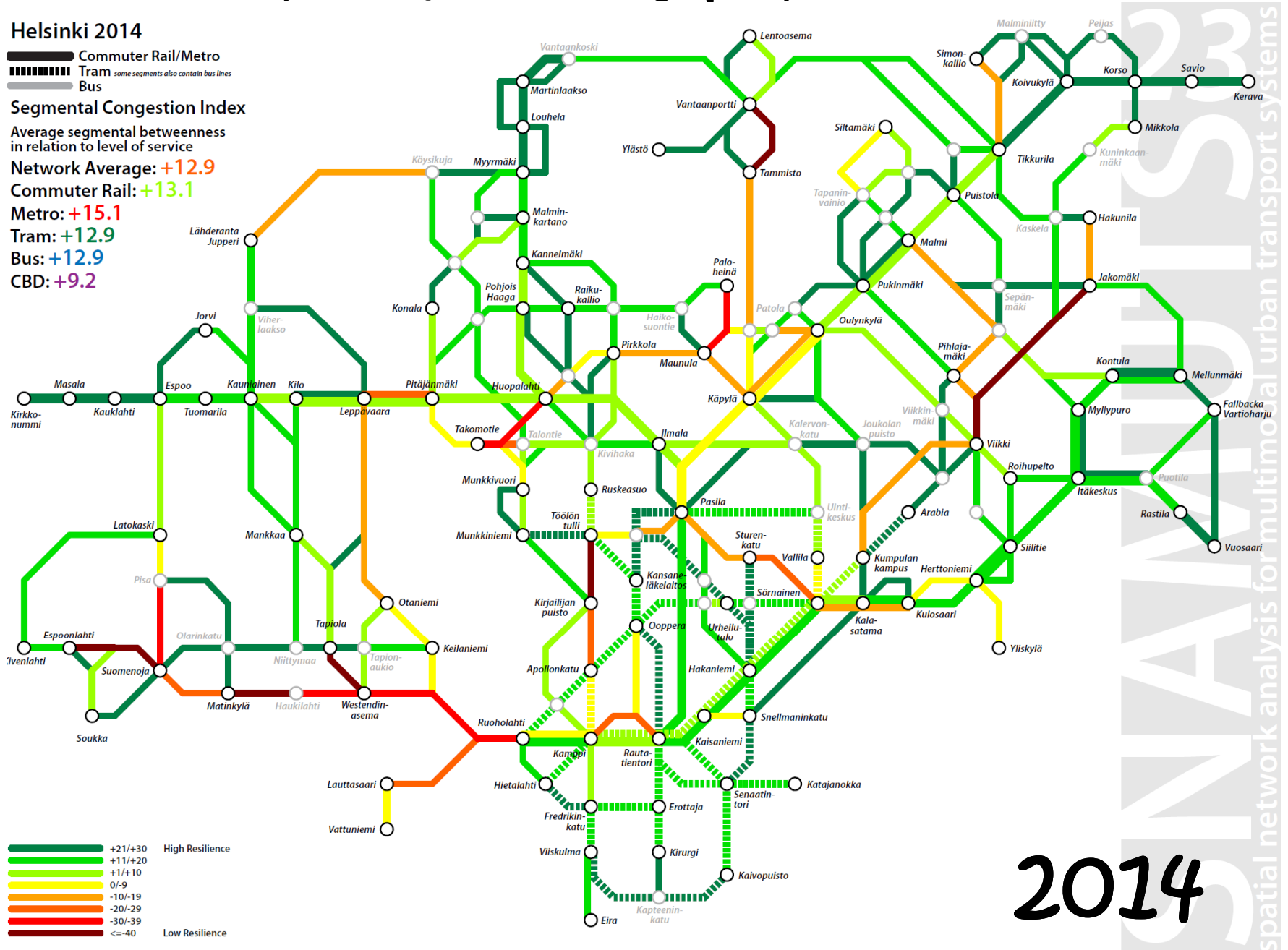
Commuter Rail: +13.1

Metro: +15.1

Tram: +12.9

Bus: +12.9

CBD: +9.2



A photograph of a busy street in Helsinki, Finland, featuring tram tracks and a tram. The street is paved with cobblestones and has tram tracks running along it. A tram is visible in the background, and many pedestrians are walking across the street. The scene is captured in a wide-angle shot, showing the intersection and the flow of traffic and pedestrians.

accessibility instruments in planning practice

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