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## Accessibility of Slovak towns

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**ERSA98**

## **ACCESSIBILITY OF SLOVAK TOWNS**

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**Abstract:** Accessibility is a fundamental concept in analysing spatial organisation of human society. This paper is concerned first with the theoretical basis of accessibility by discussing different accessibility measures and second with applying these measures to analyse accessibility of Slovak towns connected with different kinds of transportation networks.

### 1 Introduction

In every field of geography mathematical methods have been widely used in recent decades. They play a leading role in the studies devoted to complex structures - where men and nature are bond together in very complex way. Spatial analysis is one of the branches where geography is using mathematical tools, and there include measures of accessibility. The theoretical basis of these measures is in the axiomatic theory of General Distance Spaces. Graph theory supports this theory, and even introduces some practical ways of utilizing accessibility measures. It is only necessary to invent and apply algorithms in any kind of research in connection with accessibility.

In geography especially in regional geography networks can be interpreted as graphs, with vertices in cross-roads and paths (roads) connecting these vertices. The next step in such a model situation is using measures of accessibility to make conclusions and after applying modification prognoses of the future development of the regions.

## 2 Graphs and accessibility measures

In this paper simple topological and metrical measures are used to assess accessibility of all Slovak towns. In order to use them the set of towns (136 altogether) and their transport connections (bus, train) are to be conceptualized as a graphs.

Towns represent vertices of graphs. Paths are defined as follows:

Graph B is cumulated from graphs

BD - direct connection (without any bus stop between two towns) in international or national greenline (long-distance) bus network,

BID -connection between two towns (including connections with bus stops out of the given set of towns, e. c. stops in other settlements) in international or national greenline bus network,

BKM - shortest direct (neglecting stops out of the set of selected towns) connection between two towns in KM in international or national greenline bus network,

BMIN - shortest direct (neglecting stops out of the set of selected towns) connection between two towns in min in international or national greenline bus network.

Graph T is cumulated from graphs

TD - direct connection (without any train stop between two towns) in railroad network (international or national),

TID -connection between two towns (including connections with train stops out of the given set of towns, e. c. stops in other settlements) in international or national railroad network,

TKM - shortest direct train connection (neglecting stops out of the set of selected towns) between two towns in KM in international or national railroad network,

TMIN - shortest direct (neglecting stops out of the set of selected towns) connection between two towns in min in international or national railroad network.

The used accessibility measures are defined then as follows:

(1) The topological direct accessibility on graphs B, T on set M is given by matrix  $A$  where  $A_{ij}$ , denoting connection of graph vertices  $i$  and  $j$ , equals 1 when vertices  $i$  and  $j$  are directly connected by path and 0, when there is no direct path. The value of a single vertex  $A_i$  is then given by

$$A_i = \sum A_{ij}, j = 1, \dots, n \quad (1)$$

(2) The topological indirect accessibility on graphs B, T on set M is given by matrix B, where  $B_{ij}$  equals the lowest number of paths connecting vertices i and j. The value of single vertex  $B_i$  is then given by

$$B_i = \sum B_{ij}, j = 1, \dots, n \quad (2)$$

(3) The metric accessibility on graph G on set M is given by matrix C, where  $C_{ij}$  is the shortest path between vertices i and j (measured in KM, miles, time etc.). The value of vertex  $C_i$  is then given by

$$C_i = \sum C_{ij}, j = 1, \dots, n \quad (3)$$

### 3 Accessibility of Slovak towns

Application of the above mentioned three accessibility measures (in metric accessibility were used both KM and min.) to the set of Slovak towns, conceptualised as graphs consisting of 136 vertices connected either by international or national greenline (long-distance) buses (graph B) or by railroads (graph T) yields interesting results. They are put in framework with the latest administrative division of Slovakia and compared with economic strength of Slovakia's regions.

#### 3.1 Accessibility in graph B (bus network)

International and long-distance buses cover the set of Slovak towns quite densely. Just 7 towns do not have access to the graph B. Most of them are the in eastern part of Slovakia. Paradoxically three of them (Gelnica, Medzilaborce and Poltár) are centres of counties.

##### 3.1.1 Topological direct accessibility

The results of topological direct accessibility (Tab. 1) rank to the highest places the most important (economically and administratively) towns. All eight centres of Slovak districts are according to relation (1) placed among 11 most accessible vertices. The best results yields the city of Bratislava (capital of Slovakia). It is necessary to mention that Bratislava (due to position on borders) lost more than 15 connections to the abroad situated destinations. It is surprising, to some extent, that

Košice (the second largest city of Slovakia - metropolis of eastern Slovakia) placed just 11th. The possible reason is a sort of isolation out of other important towns, even after including abroad connections of Košice, it improves its accessibility just for four places.

Correlation between hierarchy according to topological direct accessibility on graph B and hierarchy according to number of inhabitants of Slovak towns is the second highest among all kinds of accessibilities used in this study.

### 3.1.2 Topological indirect accessibility

The results of topological indirect accessibility (Tab. 2) show just a slight shift of the best accessible towns towards the geometrical (measured in Euclidean geometry) middle of Slovakia.

The best accessible town remains Bratislava on the geometrical periphery of the country. Košice placed higher by four places. This kind of accessibility emphasises even stronger the leading role of district centres (all of them are place among ten best accessible towns). The correlation between ranking according population and accessibility is the highest. It is to some extent distorted by neighbourhood position of some satellite towns to district centres e. g. Sliach to Banská Bystrica, Sered' to Trnava and Bratislava.

Some of the worst accessible towns are situated almost to the geometrical centre of Slovakia (e. g. Banská Štiavnica, Bojnice) but in graph B are quite isolated.

### 3.1.3 Metric accessibility

Metric accessibility (Tab. 3, Tab. 4) reflects much more strongly the geometrical position of towns the topological accessibility. It is evident from the obtained results that in case of accessibility measured in KM stronger then in case of accessibility measured in time. It is necessary to mention that generally the graph B on set of Slovak towns would not differ from the existing one in case of including international connections leading out of Slovakia, but it would essentially differ in case of including other (abroad) towns.

The best accessible towns according to the relation(3) measured in KM occupy the central (geometrically) part of Slovakia. They are but shifted to the Southwest where is located the highest number of Slovak towns. Interesting feature of the metric accessibility in KM is the pattern of grouping of the best accessible towns. The first

bunch of them is nesting around the central Slovak traffic corridor leading through the valley of Hron, second along the Northwest traffic corridor leading in Vah valley, third in the area of Podunajská nížina Danubian lowland) and forth in Košická kotlina (Basin of Košice).

Bratislava ranked 96th with the average distance to any Slovak town - 233 KM. In case of best accessible town - Žiar nad Hronom it is 150 KM.

Worst accessible towns are situated in the eastern part of Slovakia. They occupy all 18 lowest ranked positions. The reason why, is not only in distance from the centre of Slovakia (it is approximately the same as from the western part of Slovakia), but also in lack of connections between towns. It reflects the economic potential of the region.

Metric accessibility according to the relation (3) measured in min. shows some differences compared to the metric accessibility in KM:

A) Stronger shift of better accessible towns to the west. It can be explained by reasoning that this quantitative result reflects the quality of different paths of bus network, accumulation of towns to corridors and the highest concentration of towns in Southwest.

B) Largest towns of Slovakia improve their positions in ranking. It is the most evident in case of Košice. These large towns are connected faster in comparison to the rest of Slovak towns than. This is simply not the case of distance measured in KM.

The centres of districts are in both metric accessibility's among the highest ranked towns from their districts. The only exception is Bratislava, due to its eccentric geometrical position. It is, to some extent, overtoped by its economic importance.

### 3.2 Accessibility in graph T (railroad network)

Railroad network is not that dense as the bus network. Sixteen towns do not have access to graph T (no train connection), four of them (Námestovo, Veľký Krtíš, Svidník, Stropkov) are county centres.

Graph T shows the historically developed irregularities between train and bus transportation. Places (villages) on railroad crossings would play important roles in case of incorporating them to the graph T.

The differences between accessibility on graph T and B are essential. They emphasise the existence and role of economic corridors - north and central.

### 3.2.1 Topological direct accessibility

Topological direct accessibility (Tab. 5) uncovers the importance of northern corridor. The best accessible town according to relation (1) is Žilina, followed by Bratislava and Zvolen. Nitra is from the point of view of direct train accessibility very weak. Other district centres are among 30 best accessible towns. Very high (46) is the number of towns with just indirect access to railroad network.

### 3.2.2 Topological indirect accessibility

Topological indirect accessibility (Tab. 6) on graph T according to relation (2) shows even clearer the importance of the north-western region of Slovakia with Žilina, Vrútky, Liptovský Mikuláš. It is followed by south-western towns (Bratislava etc.). Paradoxically some of the worst accessible towns are again from the geometrical centre of Slovakia (Tisovec, Hnúšť'a). It reflects their economic strength and importance.

### 3.2.3 Metrical accessibility

Metrical accessibility (Tab. 6, Tab. 7) according to relation (3) is much less influenced by geometrical position of towns. Due to strict isolation of separate corridors and lines it leads to very interesting situation. The best accessible town measured in KM or min. is Vrútky (small town on cross-roads between Žilina, Martin and Liptovský Mikuláš). From this point of view the interaction of towns on Earth's surface differs considerably from the ideal geometrical situation.

On graph T are evident, similarly to the accessibility on graph B, some concentrations of the best accessible towns. The leading position remains in Northwest in Váh valley, followed by Hron valley corridor.

Bratislava is ranked higher then in graph B. Especially measured in time. It is caused probably by high speed connections to the capitol. It improved the accessibility of every town on the main railroad direction leading from Bratislava through Trenčín, Žilina, Poprad to Košice and Prešov. It is noticeable that the average accessibility from Bratislava to any other Slovak town is ( 17 min) shorter by train then by bus.

The easternmost Slovak towns remained the worst accessible towns in the country.

#### 4 Conclusions

All of applied accessibility measures are useful in uncovering regularities and not geometrical interactions between geographical locations. They can in very simple way express the potential of a location to interact with all other locations included in the given set.

The results are even more interesting when compared in time. In the similar study done 15 years ago the accessibility of towns were much more determined by geometrical position then today. The most considerable change is the shift of importance towards west and Southwest of Slovakia. The second is the growing importance of the accessibility of district centres. From some aspect is contradictory the bad position of some county centres, e. g. Poltár, Medzilaborce, Námestovo, Banská Štiavnica. It can be explained not by incorrectness of used accessibility measures, but on contrary that these county centres were probably in administrative change chosen not properly.

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## Topological direct accessibility in graph B (No=ranking)

Tab. 1

No	town	Acc
1	Bratislava	16
2	Nitra	15
3	Žilina	11
4	Zvolen	10
5	Prešov	9
5	Trenčín	9
5	Poprad	9
8	Banská Bystrica	8
8	Trnava	8
8	Piešťany	8
11	Košice	7
11	Levice	7
11	Žarnovica	7
14	Michalovce	6
14	Sereď	6
14	Rimavská Sobota	6
17	Žiar nad Hronom	5
17	Bánovce nad Bebravou	5
17	Ružomberok	5
17	Považská Bystrica	5
21	Vranov nad Topľou	4
21	Senec	4
21	Galanta	4
21	Sládkovičovo	4
21	Nové Zámky	4
21	Senica	4
21	Topoľčany	4
21	Hlohovec	4
21	Liptovský Mikuláš	4
21	Lučenec	4
21	Martin	4
21	Turčianske Teplice	4
21	Dubnica nad Váhom	4

No	town	Acc
38	Kežmarok	3
38	Sabinov	3
38	Rožňava	3
38	Spišské Podhradie	3
38	Podolíne	3
38	Svidník	3
57	Spišské Vlachy	2
57	Malacky	2
57	Pezinok	2
57	Veľký Meder	2
57	Šamorín	2
57	Šaľa	2
57	Hurbanovo	2
57	Želiezovce	2
57	Dudince	2
57	Vráble	2
57	Šurany	2
57	Holíč	2
57	Myjava	2
57	Stará Turá	2
57	Leopoldov	2
57	Vrbové	2
57	Brezno	2
57	Veľký Šariš	2
57	Rajecké Teplice	2
57	Kysucké Nové Mesto	2
57	Púchov	2
57	Handlová	2
57	Hnúšťa	2
57	Tisovec	2
57	Veľký Krtíš	2
57	Sliač	2
57	Kremnica	2

No	town	Acc
91	Turzovka	1
91	Trstená	1
91	Tvrdošín	1
91	Liptovský Hrádok	1
91	Bojnice	1
91	Tornaľa	1
91	Modrý Kameň	1
91	Hriňová	1
91	Krupina	1
91	Rajec	1
91	Bardejov	1
91	Sobrance	1
91	Starý Smokovec	1
91	Svit	1
91	Lipany	1
91	Jelšava	1
91	Revúca	1
91	Stará Ľubovňa	1
91	Stropkov	1

Svätý Jur

0

21	Ilava	4	57	Bytča	2	Kolárovo	0
21	Nová Dubnica	4	57	Giraltovce	2	Gbely	0
21	Prievidza	4	57	Humenné	2	Nemšová	0
21	Levoča	4	57	Moldava nad Bodvou	2	Gelnica	0
38	Sečovce	3	57	Spišská Belá	2	Námestovo	0
38	Dunajská Streda	3	57	Spišská Nová Ves	2	Fiľakovo	0
38	Komárno	3	57	Hanušovce nad Topľou	2	Poltár	0
38	Zlaté Moravce	3	91	Trebišov	1	Medzev	0
38	Partizánske	3	91	Modra	1	Medzilaborce	0
38	Nové Mesto nad Váhom	3	91	Stupava	1	Banská Štiavnica	0
38	Trenčianske Teplice	3	91	Šahy	1	Spišská Stará Ves	0
38	Čadca	3	91	Timače	1	Snina	0
38	Vrútky	3	91	Štúrovo	1	Kráľovský Chlmec	0
38	Nováky	3	91	Brezová pod Bradlom	1	Čierna nad Tisou	0
38	Detva	3	91	Skalica	1	Dobšiná	0
38	Nová Baňa	3	91	Kropachy	1	Veľké Kapušany	0
38	Strážske	3	91	Dolný Kubín	1		

## Topological indirect accessibility in graph B (No=ranking)

Tab. 2

No	town	Acc	No	town	Acc	No	town	Acc
1	Bratislava	433	52	Sečovce	581	103	Bardejov	735
2	Zvolen	437	53	Považská Bystrica	583	104	Svidník	737
3	Trenčín	456	54	Bytča	587	104	Spišská Belá	737
4	Banská Bystrica	458	55	Rajecké Teplice	591	106	Brezová pod Bradlom	742
4	Nitra	458	56	Moldava nad Bodvou	592	107	Lipany	743
6	Žilina	464	57	Čadca	593	108	Spišské Vlachy	745
7	Košice	466	58	Kysucké Nové Mesto	594	109	Bojnice	759
8	Trnava	485	59	Senica	599	110	Šahy	768
9	Poprad	495	60	Kremnica	605	111	Štúrovo	787
10	Prešov	499	61	Leopoldov	610	112	Modrý Kameň	794
11	Piešťany	500	62	Vranov nad Topľou	611	113	Fiľakovo	800
12	Žarnovica	501	63	Kežmarok	614	114	Trstená	806
13	Rimavská Sobota	511	64	Partizánske	616	115	Jelšava	825
14	Žiar nad Hronom	513	65	Spišská Nová Ves	618	116	Stará Ľubovňa	846
15	Martin	516	66	Giraltovce	619	117	Skalica	851
16	Ružomberok	517	67	Hanušovce nad Topľou	620	118	Stropkov	862
17	Turčianske Teplice	528	67	Spišské Podhradie	620	119	Revúca	872
18	Sereď	530	69	Sabinov	621	120	Kropachy	893
19	Hlohovec	535	69	Svit	621	121	Tvrdošín	926
19	Topoľčany	535	71	Starý Smokovec	622	122	Dobšiná	1003
21	Sliač	544	72	Vrbové	624	123	Banská Štiavnica	1170
21	Liptovský Mikuláš	544	73	Handlová	627	124	Spišská Stará Ves	1227
23	Levice	545	73	Veľký Šariš	627	125	Námestovo	1250
24	Nová Baňa	548	75	Dolný Kubín	629	126	Snina	1336
24	Malacky	548	76	Hnúšťa	630	127	Kolárovo	1339
24	Lučenec	548	77	Prievidza	632	128	Veľké Kapušany	1974
27	Senec	550	78	Tornaľa	636	129	Kráľovský Chlmec	2101
28	Bánovce nad Bebravou	551	79	Ilava	650			

29	Galanta	552
30	Sládkovičovo	553
31	Komárno	554
32	Vrútky	555
32	Dunajská Streda	555
32	Zlaté Moravce	555
35	Detva	556
35	Pezinok	556
35	Šamorín	556
38	Stupava	558
39	Krupina	559
40	Levoča	570
41	Nové Zámky	571
42	Dubnica nad Váhom	572
42	Nové Mesto nad Váhom	572
42	Trenčianske Teplice	572
45	Nová Dubnica	573
46	Brezno	574
47	Vráble	575
48	Rožňava	579
48	Šaľa	579
50	Michalovce	580
50	Šurany	580

80	Hurbanovo	651
81	Nováky	655
82	Dudince	656
83	Tisovec	660
84	Strážske	661
85	Želiezovce	662
85	Tlmače	662
87	Veľký Krtíš	667
88	Liptovský Hrádok	668
89	Modra	677
90	Veľký Meder	679
91	Hriňová	683
92	Stará Turá	688
93	Rajec	696
94	Trebišov	704
94	Humenné	704
96	Sobrance	705
97	Púchov	707
98	Nemšová	709
99	Turzovka	717
100	Myjava	721
101	Holíč	724
102	Podolíneč	731

Svätý Jur	0
Gbely	0
Gelnica	0
Poltár	0
Medzev	0
Medzilaborce	0
Čierna nad Tisou	0

## Metric accessibility (KM) in graph B (No=ranking)

Tab. 3

No	town	Acc
1	Žiar nad Hronom	19442
2	Zvolen	19718
3	Sliač	19906
4	Banská Bystrica	19919
5	Žarnovica	20115
6	Handlová	20805
7	Prievidza	20836
8	Nová Baňa	20850
9	Detva	20890
10	Turčianske Teplice	20963
11	Nováky	21132
12	Kremnica	21204
13	Brezno	21311
14	Hriňová	21387
15	Partizánske	21433
16	Bojnice	21590
17	Zlaté Moravce	21649
18	Tlmače	21945
19	Krupina	22080
20	Lučenec	22152
21	Martin	22275
22	Topoľčany	22494
23	Bánovce nad Bebravou	22506

No	town	Acc
51	Šurany	25119
52	Kysucké Nové Mesto	25242
53	Bytča	25284
54	Revúca	25627
55	Fíľakovo	25648
56	Sereď	25650
57	Púchov	25691
58	Vrbové	25865
59	Považská Bystrica	25882
60	Šaľa	26007
61	Poprad	26028
62	Nové Mesto nad Váhom	26089
63	Želiezovce	26127
64	Nové Zámky	26227
65	Trnava	26380
66	Dobšiná	26410
67	Nemšová	26502
68	Jelšava	26822
69	Sládkovičovo	27002
70	Tornaľa	27003
71	Galanta	27122
72	Kežmarok	27449
73	Stará Turá	27706

No	town	Acc
100	Spišská Stará Ves	31474
101	Stupava	32821
102	Veľký Meder	32863
103	Holíč	33186
104	Šamorín	33291
105	Prešov	33390
106	Dunajská Streda	33521
107	Lipany	33560
108	Starý Smokovec	33626
109	Veľký Šariš	34046
110	Malacky	34072
111	Skalica	34082
112	Sabinov	34475
113	Hanušovce nad Topľou	36082
114	Košice	36084
115	Bardejov	36290
116	Giraltovce	37035
117	Vranov nad Topľou	38760
118	Moldava nad Bodvou	39179
119	Stropkov	39710
120	Svidník	40240
121	Sečovce	40258
122	Strážske	40890

24	Levice	22529
25	Banská Štiavnica	22626
26	Vrútky	22968
27	Dudince	22993
28	Nitra	23088
29	Tisovec	23189
30	Hnúšťa	23442
31	Ružomberok	23834
32	Vráble	23915
33	Veľký Krtíš	24000
34	Šahy	24026
35	Žilina	24090
36	Modrý Kameň	24283
37	Rajecké Teplice	24376
38	Hlohovec	24577
39	Ilava	24603
40	Trenčianske Teplice	24613
41	Dolný Kubín	24660
42	Trenčín	24729
43	Rimavská Sobota	24751
44	Rajec	24772
45	Liptovský Mikuláš	24779
46	Piešťany	24809
47	Liptovský Hrádok	24838
48	Nová Dubnica	24842
49	Dubnica nad Váhom	24915
50	Leopoldov	25107

74	Senec	27734
75	Čadca	27760
76	Rožňava	27815
77	Brezová pod Bradlom	27869
78	Štúrovo	27982
79	Hurbanovo	27999
80	Spišská Belá	28140
81	Levoča	28220
82	Spišská Nová Ves	28310
83	Modra	28463
84	Námestovo	28893
85	Podolíne	29056
86	Tvrdošín	29183
87	Pezinok	29245
88	Svit	29278
89	Spišské Podhradie	29532
90	Komárno	29549
91	Myjava	29574
92	Turzovka	29808
93	Trstená	29901
94	Spišské Vlachy	30090
95	Bratislava	30267
96	Senica	30338
97	Stará Ľubovňa	30411
98	Kolárovo	30710
99	Krompachy	30986

123	Trebišov	41690
124	Humenné	42192
125	Michalovce	42553
126	Snina	44656
127	Sobrance	45013
128	Veľké Kapušany	47834
129	Kráľovský Chlmec	48986

Svätý Jur	0
Gbely	0
Gelnica	0
Medzev	0
Medzilaborce	0
Čierna nad Tisou	0
Poltár	0

## Metric accessibility (min) in graph B (No=ranking)

Tab. 4

No	town	Acc
1	Žarnovica	17955
2	Žiar nad Hronom	18048
3	Zvolen	18161
4	Sliač	18452
5	Banská Bystrica	18460
6	Nová Baňa	18827
7	Zlaté Moravce	18830
8	Ružomberok	18913
9	Prievidza	19045
10	Turčianske Teplice	19254
11	Martin	19278
12	Kremnica	19283
13	Nováky	19358
14	Vrútky	19436
15	Handlová	19512
16	Detva	19825
17	Nitra	19856
18	Bojnice	19934
19	Žilina	20091

No	town	Acc
51	Tisovec	22433
52	Šurany	22463
53	Svit	22487
54	Dudince	22564
55	Púchov	22630
56	Hnúšťa	22801
57	Filakovo	22918
58	Banská Štiavnica	22970
59	Leopoldov	22981
60	Trnava	23006
61	Nemšová	23149
62	Kežmarok	23168
63	Šaľa	23312
64	Starý Smokovec	23388
65	Nové Zámky	23526
66	Vrbové	23542
67	Želiezovce	23668
68	Galanta	23719
69	Sládkovičovo	23763

No	town	Acc
101	Moldava nad Bodvou	27477
102	Krompachy	27651
103	Veľký Šariš	27672
104	Kolárovo	28586
105	Hanušovce nad Topľou	28605
106	Sabinov	28943
107	Šamorín	29129
108	Spišská Stará Ves	29285
109	Holíč	29511
110	Giraltovce	29672
111	Malacky	30083
112	Stupava	30201
113	Lipany	30278
114	Veľký Meder	30611
115	Skalica	30781
116	Vranov nad Topľou	31110
117	Sečovce	31772
118	Dunajská Streda	31773
119	Stropkov	31889

19	Levice	20091
21	Partizánske	20141
22	Timače	20352
23	Bánovce nad Bebravou	20451
24	Brezno	20590
25	Liptovský Mikuláš	20677
26	Trenčín	20716
27	Ilava	20760
28	Lučenec	20780
29	Dubnica nad Váhom	20795
30	Bytča	20890
31	Vráble	21002
32	Považská Bystrica	21039
33	Hriňová	21062
34	Topoľčany	21088
35	Liptovský Hrádok	21209
36	Nová Dubnica	21276
37	Dolný Kubín	21482
38	Poprad	21483
39	Šahy	21609
40	Rimavská Sobota	21697
41	Rajec	21969
42	Trenčianske Teplice	21979
43	Veľký Krtíš	22003
44	Hlohovec	22137
45	Kysucké Nové Mesto	22168
45	Sereď	22168
47	Nové Mesto nad Váhom	22247
48	Rajecké Teplice	22275
49	Piešťany	22278
50	Modrý Kameň	22365

70	Levoča	23898
71	Stará Turá	23981
72	Tornaľa	24005
73	Čadca	24235
74	Spišská Belá	24333
75	Krupina	24574
76	Revúca	24705
77	Rožňava	24749
78	Spišská Nová Ves	24807
79	Senec	24988
80	Spišské Podhradie	25208
81	Hurbanovo	25247
82	Tvrdošín	25305
83	Trstená	25461
84	Podolíneec	25467
85	Brezová pod Bradlom	25625
86	Jelšava	25696
87	Modra	25884
88	Myjava	25985
89	Prešov	26001
90	Spišské Vlachy	26094
91	Turzovka	26127
92	Námestovo	26287
93	Štúrovo	26494
94	Senica	26506
95	Bratislava	26510
96	Dobšiná	26748
97	Stará Ľubovňa	26792
98	Košice	26897
99	Pezinok	26984
100	Komárno	27338

120	Bardejov	32003
121	Strážske	33348
122	Trebišov	33557
123	Svidník	33674
124	Michalovce	34096
125	Humenné	34719
126	Sobrance	37216
127	Snina	38367
128	Veľké Kapušany	39653
129	Kráľovský Chlmec	44225

Svätý Jur	0
Gbely	0
Gelnica	0
Poltár	0
Medzev	0
Medzilaborce	0
Čierna nad Tisou	0

## Topological direct accessibility in graph T (No=ranking)

Tab. 5

No	town	Acc
1	Žilina	10
2	Zvolen	8
2	Bratislava	8
4	Nové Zámky	6
4	Galanta	6
6	Košice	5
7	Poprad	4
7	Šurany	4
7	Trenčín	4
7	Leopoldov	4
7	Banská Bystrica	4
7	Liptovský Mikuláš	4
7	Martin	4
7	Žiar nad Hronom	4
15	Sabinov	3

No	town	Acc
47	Komárno	1
47	Nitra	1
47	Štúrovo	1
47	Holíč	1
47	Myjava	1
47	Skalica	1
47	Topoľčany	1
47	Hlohovec	1
47	Krompachy	1
47	Trstená	1
47	Tvrdošín	1
47	Liptovský Hrádok	1
47	Filákov	1
47	Medzilaborce	1
47	Dubnica nad Váhom	1

Námestovo	0
Poltár	0
Medzev	0
Nová Dubnica	0
Bojnice	0
Rimavská Sobota	0
Hnúšťa	0
Tornaľa	0
Tisovec	0
Veľký Krtíš	0
Modrý Kameň	0
Hriňová	0
Krupina	0
Banská Štiavnica	0
Kremnica	0

15	Pezinok	3
15	Šaľa	3
15	Levice	3
15	Nové Mesto nad Váhom	3
15	Trnava	3
15	Piešťany	3
15	Ružomberok	3
15	Lučenec	3
15	Vrútky	3
15	Turčianske Teplice	3
15	Považská Bystrica	3
15	Humenné	3
15	Michalovce	3
15	Strážske	3
30	Trebišov	2
30	Senec	2
30	Sládkovičovo	2
30	Stará Turá	2
30	Veľký Šariš	2
30	Čadca	2
30	Kysucké Nové Mesto	2
30	Púchov	2
30	Prievidza	2
30	Detva	2
30	Sliač	2
30	Nová Baňa	2
30	Žarnovica	2
30	Bytča	2
30	Moldava nad Bodvou	2
30	Prešov	2
30	Spišská Nová Ves	2
47	Spišské Vlachy	1
47	Svätý Jur	1
47	Malacky	1
47	Dunajská Streda	1
47	Veľký Meder	1

47	Ilava	1
47	Handlová	1
47	Nováky	1
47	Svit	1
47	Lipany	1
47	Rožňava	1
47	Vranov nad Topľou	1
47	Čierna nad Tisou	1

			Rajec	0
			Bardejov	0
			Giraltovce	0
			Sobrance	0
			Kežmarok	0
			Spišská Belá	0
			Starý Smokovec	0
			Spišská Stará Ves	0
			Jelšava	0
			Snina	0
			Revúca	0
			Levoča	0
			Spišské Podhradie	0
			Stará Ľubovňa	0
			Podolíne	0
			Svidník	0
			Stropkov	0
			Sečovce	0
			Hanušovce nad Topľou	0
			Kráľovský Chlmec	0
			Dobšiná	0
			Veľké Kapušany	0
	Modra	0		
	Stupava	0		
	Šamorín	0		
	Sereď	0		
	Hurbanovo	0		
	Kolárovo	0		
	Šahy	0		
	Timače	0		
	Želiezovce	0		
	Dudince	0		
	Vráble	0		
	Zlaté Moravce	0		
	Senica	0		
	Brezová pod Bradlom	0		
	Gbely	0		
	Bánovce nad Bebravou	0		
	Partizánske	0		
	Nemšová	0		
	Trenčianske Teplice	0		
	Vrbové	0		
	Brezno	0		
	Gelnica	0		
	Rajecké Teplice	0		
	Dolný Kubín	0		
	Turzovka	0		

## Topological indirect accessibility in graph T (No=ranking)

Tab. 6

No	town	Acc
1	Žilina	742
2	Liptovský Mikuláš	787
3	Vrútky	792
4	Ružomberok	793
5	Bratislava	802
6	Trenčín	813
7	Poprad	820
8	Nové Zámky	829
9	Galanta	830
10	Martin	842

No	town	Acc
52	Tornaľa	1047
53	Sereď	1057
54	Nová Baňa	1059
55	Žarnovica	1062
56	Prešov	1083
57	Michalovce	1088
58	Veľký Meder	1101
59	Gbely	1114
60	Dolný Kubín	1119
61	Kremnica	1139

No	town	Acc
103	Želiezovce	1708
104	Rajec	1794
105	Tvrdošín	1795
106	Vráble	1883
107	Kolárovo	1884
108	Veľké Kapušany	1914
109	Senica	1926
110	Podolíne	2072
111	Revúca	2213
112	Dudince	2392

11	Považská Bystrica	858
12	Bytča	859
12	Púchov	859
14	Kysucké Nové Mesto	869
15	Zvolen	870
16	Čadca	872
17	Šurany	874
18	Košice	875
19	Trnava	885
20	Pezinok	892
21	Malacky	894
22	Piešťany	895
23	Liptovský Hrádok	899
24	Senec	900
25	Spišská Nová Ves	907
26	Turčianske Teplice	908
27	Šaľa	909
28	Leopoldov	915
28	Nové Mesto nad Váhom	915
30	Levice	918
31	Banská Bystrica	924
32	Svit	938
33	Komárno	942
34	Sládkovičovo	943
35	Štúrovo	945
36	Žiar nad Hronom	948
37	Moldava nad Bodvou	954
38	Lučenec	969
39	Detva	975
40	Trebišov	977
41	Sliač	986
42	Čierna nad Tisou	993
43	Rožňava	1006
43	Fišakovo	1006
45	Svätý Jur	1010
46	Dunajská Streda	1013
47	Hlohovec	1022
48	Stará Turá	1028
49	Ilava	1029
50	Dubnica nad Váhom	1034
51	Nemšová	1043

62	Krompachy	1144
63	Myjava	1152
64	Hurbanovo	1176
65	Strážske	1197
66	Sabinov	1198
67	Humenné	1209
68	Handlová	1224
69	Veľký Šariš	1228
70	Spišské Vlachy	1232
71	Gelnica	1242
72	Tlmače	1253
73	Levoča	1261
74	Hanušovce nad Topľou	1299
74	Vranov nad Topľou	1299
76	Lipany	1316
77	Sečovce	1331
77	Prievidza	1331
79	Rajecké Teplice	1337
80	Nitra	1338
81	Medzilaborce	1341
82	Holíč	1346
83	Brezno	1375
84	Kežmarok	1380
85	Trenčianske Teplice	1397
86	Zlaté Moravce	1406
87	Starý Smokovec	1410
88	Nováky	1438
89	Topoľčany	1443
90	Skalica	1464
91	Rimavská Sobota	1526
92	Krupina	1554
93	Medzev	1555
94	Turzovka	1570
95	Banská Štiavnica	1578
96	Partizánske	1595
97	Spišská Belá	1608
98	Jelšava	1623
99	Poltár	1639
100	Trstená	1678
101	Bánovce nad Bebravou	1695
102	Spišské Podhradie	1704

113	Dobšiná	2422
114	Stará Ľubovňa	2426
115	Snina	2491
116	Brezová pod Bradlom	2507
117	Hnúšťa	2562
118	Bardejov	2623
119	Šahy	2637
120	Tisovec	3034

Modra	0
Stupava	0
Šamorín	0
Vrbové	0
Námestovo	0
Nová Dubnica	0
Bojnice	0
Veľký Krtíš	0
Modrý Kameň	0
Hriňová	0
Giraltovce	0
Sobrance	0
Spišská Stará Ves	0
Svidník	0
Stropkov	0
Kráľovský Chlmec	0

## Metric accessibility (KM) in graph T (No=ranking)

Tab. 7

No	town	Acc
1	Vrútky	19699
2	Martin	20020
3	Turčianske Teplice	20074

No	town	Acc
51	Poprad	24866
52	Vráble	25147
53	Tisovec	25165

No	town	Acc
101	Sabinov	31666
102	Dunajská Streda	31890
103	Hanušovce nad Topľou	31937

4	Banská Bystrica	20254
5	Sliač	20527
6	Zvolen	20533
7	Handlová	20545
8	Žilina	20591
9	Kremnica	20604
10	Bytča	21278
11	Prievidza	21361
12	Ružomberok	21623
13	Nováky	21641
14	Považská Bystrica	21644
15	Kysucké Nové Mesto	21719
16	Partizánske	21847
17	Žiar nad Hronom	21949
18	Banská Štiavnica	22135
19	Detva	22187
20	Brezno	22246
21	Púchov	22278
22	Rajecké Teplice	22319
23	Dolný Kubín	22443
24	Topoľčany	22491
25	Žarnovica	22611
26	Liptovský Mikuláš	22631
27	Trenčín	22738
28	Ilava	22776
29	Levice	22920
30	Dubnica nad Váhom	23012
31	Nová Baňa	23013
32	Rajec	23039
33	Liptovský Hrádok	23044
34	Tlmače	23176
35	Bánovce nad Bebravou	23185
36	Šurany	23881
37	Zlaté Moravce	23963
38	Nitra	23973
39	Lučenec	24099
40	Trenčianske Teplice	24154
41	Čadca	24155
42	Krupina	24181
43	Nemšová	24390
44	Želiezovce	24416
45	Leopoldov	24470
46	Piešťany	24533
47	Hlohovec	24600
48	Svit	24611
49	Fiľakovo	24689
50	Nové Zámky	24845

54	Šaľa	25301
55	Sereď	25352
56	Poltár	25364
57	Galanta	25442
58	Nové Mesto nad Váhom	25474
59	Turzovka	25771
60	Dolný Kubín	25807
61	Hnúšťa	26074
62	Sládkovičovo	26136
63	Rimavská Sobota	26228
64	Štúrovo	26312
65	Tvrdošín	26387
66	Starý Smokovec	26400
67	Kežmarok	26546
68	Hurbanovo	26617
69	Spišská Nová Ves	26895
70	Trstená	26977
71	Tornaľa	27244
72	Gelnica	27280
73	Spišská Belá	27344
74	Dudince	27398
75	Spišské Vlachy	27685
76	Krompachy	27715
77	Stará Turá	27794
78	Senec	27842
79	Rožňava	28360
80	Podolíne	28388
81	Komárno	28399
82	Levoča	28429
83	Pezinok	28688
84	Spišské Podhradie	28747
85	Košice	29043
86	Svätý Jur	29276
87	Šahy	29298
88	Prešov	29362
89	Moldava nad Bodvou	29409
90	Veľký Meder	29602
91	Bratislava	29686
92	Stará Ľubovňa	30040
93	Jelšava	30134
94	Veľký Šariš	30274
95	Myjava	30523
96	Senica	30562
97	Kolárovo	31337
98	Dobšiná	31428
99	Medzev	31495
100	Revúca	31550

104	Lipany	32964
105	Brezová pod Bradlom	33025
106	Gbely	33753
107	Malacky	33790
108	Vranov nad Topľou	33937
109	Trebišov	34350
110	Bardejov	34752
111	Holíč	35029
112	Sečovce	35357
113	Strážske	35535
114	Skalica	35855
115	Michalovce	36543
116	Humenné	36824
117	Veľké Kapušany	38590
118	Snina	39163
119	Čierna nad Tisou	39531
120	Medzilaborce	42023

Modra	0
Stupava	0
Šamorín	0
Vrbové	0
Námestovo	0
Nová Dubnica	0
Bojnice	0
Veľký Krtíš	0
Modrý Kameň	0
Hriňová	0
Giraltovce	0
Sobrance	0
Spišská Stará Ves	0
Svidník	0
Stropkov	0
Kráľovský Chlmec	0

## Metric accessibility (min) in graph T

(No=ranking)

Tab. 8



No	town	Acc
1		
2	Vrútky	17531
2	Žilina	17916
4	Martin	17916
5	Ružomberok	18734
6	Turčianske Teplice	18812
7	Zvolen	18859
8	Bytča	18933
9	Kysucké Nové Mesto	19048
10	Považská Bystrica	19280
11	Púchov	19400
12	Sliač	19443
13	Banská Bystrica	19559
14	Žiar nad Hronom	19615
15	Trenčín	19677
16	Liptovský Mikuláš	19769
17	Detva	19878
18	Dubnica nad Váhom	19890
19	Liptovský Hrádok	20030
20	Ilava	20199
21	Nové Mesto nad Váhom	20376
22	Kremnica	20466
23	Žarnovica	20511
24	Piešťany	20560
25	Leopoldov	20700
26	Nová Baňa	20780
27	Čadca	20960
28	Nemšová	21009
29	Levice	21084
30	Rajecké Teplice	21180
31	Galanta	21242
32	Poprad	21258
33	Šurany	21340
34	Lučenec	21381
35	Nové Zámky	21438
36	Hlohovec	21458
37	Dolný Kubín	21517
38	Sereď	21530
39	Fiľakovo	21562
40	Trnava	21586
41	Šaľa	21665
42	Tlmače	21711
43	Svit	21966
44	Handlová	22027
45	Rajec	22582
46	Bratislava	22602
47	Banská Štiavnica	22632
48	Spišská Nová Ves	22715
49	Hurbanovo	22930
50	Želiezovce	23165

No	town	Acc
50	Pezinok	23267
51	Prievidza	23441
52	Trenčianske Teplice	23487
53	Kežmarok	23498
54	Krupina	23647
55	Nitra	23702
56	Zlaté Moravce	23738
57	Nováky	23816
58	Štúrovo	23850
59	Stará Turá	23855
60	Tornaľa	23917
61	Svätý Jur	23965
62	Košice	24070
63	Bánovce nad Bebravou	24112
64	Komárno	24167
65	Turzovka	24226
66	Poltár	24323
67	Spišská Belá	24524
68	Starý Smokovec	24562
69	Brezno	24729
70	Rimavská Sobota	24754
71	Rožňava	24806
72	Moldava nad Bodvou	24914
73	Spišské Vlachy	24937
74	Partizánske	24942
75	Levoča	25193
76	Vráble	25290
77	Topoľčany	25313
78	Myjava	25416
79	Krompachy	25513
80	Malacky	25673
81	Gelnica	26062
82	Senec	26314
83	Podolíne	26380
84	Prešov	26616
85	Dunajská Streda	26779
86	Spišské Podhradie	26825
87	Veľký Meder	27161
88	Senica	27562
89	Sládkovičovo	27848
90	Jelšava	27899
91	Trebišov	28491
92	Medzev	28500
93	Gbely	28533
94	Sabinov	28568
95	Dudince	28585
96	Brezová pod Bradlom	28708
97	Stará Ľubovňa	28740
98	Veľký Šariš	28934

No	town	Acc
99	Hnúšťa	28979
100	Kolárovo	29429
101	Tvrdošín	29471
102	Hanušovce nad Topľou	29541
103	Trstená	29599
104	Lipany	29748
105	Holíč	29925
106	Sečovce	30274
107	Šahy	30526
108	Michalovce	30730
109	Revúca	30731
110	Dobšiná	30824
111	Skalica	30987
112	Tisovec	31103
113	Vranov nad Topľou	31547
114	Strážske	32048
115	Čierna nad Tisou	33084
116	Humenné	33297
117	Bardejov	35370
118	Veľké Kapušany	35959
119	Snina	37829
120	Medzilaborce	39107

Modra	0
Stupava	0
Šamorín	0
Vrbové	0
Námestovo	0
Nová Dubnica	0
Bojnice	0
Veľký Krtíš	0
Modrý Kameň	0
Hriňová	0
Giraltovce	0
Sobrance	0
Spišská Stará Ves	0
Svidník	0
Stropkov	0
Kráľovský Chlmec	0