
M. M. Felber

Mag.

Vienna University of Economics and Business Administration

J. A. Mazanec

Dr. Prof.

Vienna University of Economics and Business Administration

J. Wöckl

DI Dr.

Vienna University of Economics and Business Administration

Visualizing the Accessibility by Air (AbA): Examples for Urban Destinations in Europe

A major competitive advantage of a destination is its accessibility by air. Cities and airports are advised to carefully monitor the airlines' flight schedules that will be reflected in the passengers' perceptions of reachability. An AbA Index is constructed for 219 European destinations and 15 departure airports. The Index is based on the travelers' combined flight and waiting time. The information hidden in the 219-by-15 matrix is subjected to data compression and visualization. Self-Organizing Maps are used for condensing the accessibility information into a two-dimensional array that portrays the density of flight connections offered by a particular airport.

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By

Markus F. Felber

Mag.

Vienna University of Economics and Business Administration

Augasse 2-6; 1090 Vienna; Austria

+43 1 31336 4583

+43 1 3171205

Markus.Felber@wu-wien.ac.at

Josef A. Mazanec

Dr. Prof.

Vienna University of Economics and Business Administration

Augasse 2-6; 1090 Vienna; Austria

+43 1 31336 4584

+43 1 3171205

Josef.Mazanec@wu-wien.ac.at

Jürgen Wöckl

DI Dr.

Vienna University of Economics and Business Administration

Augasse 2-6; 1090 Vienna; Austria

+43 1 31336 4587

+43 1 3171205

Jürgen.Wöckl@wu-wien.ac.at

Markus M. Felber, doctoral candidate in business administration at the Institute for Tourism and Leisure Studies (tourism.wu-wien.ac.at), Vienna University of Economics and Business Administration (WU Wien); studies of Mathematical Computer Science at the Vienna University of Technology (TU Wien). Research interests: measuring customer satisfaction, market segmentation, cluster analysis, leisure and tourism.

Josef A. Mazanec, full professor of business administration; head of the Institute for Tourism and Leisure Studies (tourism.wu-wien.ac.at) of the Vienna University of Economics and Business Administration (WU Wien) since 1981. Visiting scholar, Alfred P. Sloan School of Management, MIT, 1992. Vice-Rector for Research of the WU Wien 1997-2002; Speaker of the Joint Research Program on *Adaptive Information Systems and Modeling in Economics and Management Science* 1997-2001. Research interests: consumer behavior, strategic marketing, decision-support systems, management science applications in hospitality, leisure and tourism.

Jürgen Wöckl, post-doctoral researcher; member of staff in the research program for adaptive modeling and computer simulation at the Vienna University of Economics and Business Administration (WU Wien) since 2001. Doctoral degree in Applied Mathematics from the Vienna University of Technology (TU Wien), 2003; graduate (Master) from a joint study program of physics and economics of the TU Wien, 2000. Research interests: adaptive modeling and simulation, artificial consumer market models, multidimensional data analysis and statistical learning, inferred causation and MCMC methods.

Operationalizing the Index of Accessibility by Air

The index for measuring the Accessibility by Air was developed by the Institute for Transport and Logistics of the Vienna University of Economics and Business Administration. Other examples of indices measuring accessibility were introduced by Bökemann and Kramer (1999), Allen et al. (1993), Gutiérrez (2001), Brilon and Reichardt (1994), Rietveld and Bruinsma (1998), Lutter et al. (1993) and Gosling (1999). The underlying project (see Kummer and Medenbach, 2004) aimed at determining the economic importance of air transport for the Greater Vienna region. The index is defined by

$$A_i = \frac{1}{T_{ij}}$$

where the total duration of a trip from departure airport *i* to the destination *j*

$$T_{ij} = TT + CT + WTD$$

with

TT : Travel Time, i.e. the actual flight duration according to the schedule. An expected amount of delay time based on the average of all flights is included. The *WTC* = Waiting Time on Connecting Flights is incorporated into the *TT*.

CT : Check-In/Check-Out Time, i.e. the time consumed before take-off and after disembarking including all security controls.

WTD : Waiting Time on Departure, depends on the number of flights within a time period (7 a.m. – 7 p.m.) according to

$$WTD = \frac{720 \text{ Minutes}}{\text{Number of flights} + 1}$$

At first glance the index seems to reflect the intuitive concept one may bear in mind when judging the reachability of a city from the air passenger's point of view. But there are caveats. A flight offered in addition to what is already considered in the index may deteriorate the index value. This happens if the increase in the average Travel Time excels the decrease of the Waiting Time on Departure. Therefore, it is recommended to restrict the choice of connections to direct flights.

So far, the type of aircraft is not considered. The seating capacity might be incorporated by applying a weighting factor. Finally, the time span for the calculation of the Waiting Time on Departure was deliberately fixed at 7:00 a.m. to 7:00 p.m.; the flights offered during night time do not enter the comparison.

Visualizing the Accessibility by Air from a particular origin

The Accessibility Index shown in this example covers 219 destinations and 15 departure airports. The bulk of information hidden in a table of 219 rows and 15 columns needs an efficient tool for data compression. Self-Organizing Maps (Kohonen 1982, 1989, 2001; Kohonen et al. 2000) are used for condensing the accessibility information into a two-dimensional format. The maps are not a geographical representation. Rather they mimic the topological structure of the destinations in the 15-dimensional accessibility space in just two

dimensions.¹ In a first step the destinations are classified into ‘prototypes’ i.e. airports with a similar profile of accessibility values for the 15 departure airports selected earlier. In this example the ‘accessibility map’ consists of an array of six-by-six cells. Each cell or map position contains the destinations of similar accessibility (cf. Exhibit 1 and Table A1 in the Appendix). The data reduction, therefore, replaces the 219 destinations by 36 accessibility ‘classes’. According to the topology-preserving property of the map the neighborhood structure of the destinations also conveys meaningful information: Destination prototypes lying adjacent to each other are more similar in terms of their accessibility profile than destination cells farther apart.

From the airport or airline management point of view the major question addresses the performance of a departure airport in serving the 219 European destinations. To improve the quality of visualization the ‘coverage’ of each departure airport/city is indicated by shaded colors. A darker shade of grey denotes a higher index of accessibility and the destinations collected in this map position are more easily accessible from the departure airport under study. Table A2 in the Appendix describes the degree of accessibility of 36 classes of destinations from each departure airport represented by a column (‘outbound reachability’). The map conveys an instantaneous impression of an important facet of the relative competitive strength of a departure airport viz. its coverage of destination. More cells of darker shading point to stronger competitiveness. In the visualization actually two elements of the structure of competition among the airports become apparent: the width and the intensity of the coverage of the destinations, and the overlap or exclusiveness of the destinations served in comparison with the competitors.

The sample maps in the Exhibits 2 to 5 for Vienna, Frankfurt, Paris and Salzburg also demonstrate well-known phenomena such as

¹ For a more rigorous explanation of the Kohonen Map with an empirical application to measuring and comparing the company images of luxury hotels see Mazanec (1995).

- the competitive advantage in the home markets
- the amount of specialization
- the dense coverage of East and South-East European destinations ex Vienna
- destinations with a frequent or a rare accessibility profile
- the difference in magnitude between the global and the regional players in this market.

It is worth noting that the results are always relative to the departure airports chosen. The managers may decide on the selection of airports with respect to competitive threat. A more refined visualization may also portray the importance in terms of passenger turnaround by the size of each cell. The visualization procedure may also incorporate a dynamic aspect and contribute to the benchmarking and monitoring toolkit of the airlines and airports.

Example of a visualization applet: For live illustration of a different format of the accessibility visualization a Java-based tool is provided. The program is based on a platform independent Java applet which allows for interactive usage on the internet (try http://tourism.wu-wien.ac.at/e_index/VisSom_jar.html). Java applets are a client-side technology where an appropriate Java installation on the user's computer for internet access is needed and the Java support of the browser has to be enabled. The applet was tested under Sun's J2SE 1.4.2 and J2SE 5.0.

The visualization is subdivided into two layers to provide a complete description of the destination nodes in the SOM. The nodes are represented by bubbles (see the screenshot in Exhibit 6). On the first layer (node layer) of the map only the name of one popular destination among the cities represented by each node is printed next to the bubble. (See Table A1 in the Appendix for the full list of destinations and their respective SOM positions.) The area of a bubble is proportional to the mean accessibility value of the destinations collected in this node given a particular departure airport. With the airport selector on the node layer the user chooses one of the 15 departure airports i.e. one of the columns in the Table A2 of the Appendix (cf.

Paris in Exhibit 6). All bubbles are click-able to retrieve the destination names. The mouse click opens the second layer and a list of the destinations assigned to the selected node is displayed showing their names and their accessibility index values (Exhibit 7). On this second layer (list layer) the airports may be marked and added to a text field for copying and subsequent processing. Placing the mouse pointer on the node layer inside a bubble makes a tool tip window pop up showing a preview of the airports assigned to this bubble (see Bologna etc. in Exhibit 6). The setup menu provides functions such as altering the text size, the bubble and text overlapping, or the factor of proportionality between the accessibility values of the nodes and the bubble size.

In this visualization the destination coverage – a major component of the competitive strength of a departure airport -- is expressed by the number of large-sized bubbles.

Exhibit 1: European destinations according to the similarity of their accessibility profiles for 15 departure airports

1-6	Frankfurt	Dortmund Münster Paderborn	Linz Salzburg	Kos LasPalmas Riga Tallinn Thira Vilnius	Biarritz Clermont-F Limoges Liverpool Montpellier Nantes Rennes Southampton Strasbourg	Brest Pau	Aberdeen Belfast Cork Eindhoven GlasgowIA Leeds Newcastle Rotterdam Teesside
7-12	BerlinTgl Cologne Düsseldorf Munich	BerlinSch BerlinTmp	Antalya Dresden Heraklion Ibiza Palma Rhodes Thessaloniki	Faro Fuerteventura Izmir Kerkyra MoscowD Tenerife	Funchal GothenburgSA Olbia Reus Rijeka RomC Santiago Sevilla Shannon		Bern Bordeaux Bristol Cardiff FlorencePA Genoa Nottingham Valencia
13-20	Vienna	Amsterdam Brussels Copenhagen Hamburg MilanM Prague Stuttgart Zurich	MilanO	Bourgas Bournemouth Constanta Forli Gdansk Gerona GlasgowPA Hof Kattowice Kerry Kiel Krasnodar Malmö Nizhniy-Novg OsloTA Paphos Pescara Rostov StCruz Simferopol StockholmS	Almeria Bodrum Brindisi Dalaman Jerez Lamezia Menorca Mikonos Mytilene Rimini		Ancona Brno Cagliari Calvi Elba Erfurt Karpathos Rostok Saarbrücken Samos Sibiu Trieste Uralsk Westerland Wroclav Zakinthos
19-24	LondonCA LondonG LondonH LondonL LondonSt ParisCDG	Dublin Edinburgh Manchester MilanL	Bilbao Larnaka OsloA Porto Reykjavik Stavanger	Klagenfurt	Ankara Catania Lanzarote Preveza Timisoara		Karlsruhe Lourdes
25-30	Basel Geneva Hannover Lyon RomF	Barcelona Helsinki Lisbon Luxembourg Madrid Nice StockholmA	Bologna Bucharest Sofia StPetersburg Verona Zagreb	Altenrhein Chisinau Cluj Dnepropetrovsk Donetsk Cavalla Kharkov Kosice Krakow Lviv Minsk MönchenG Odessa Ohrid Poznan Pristina Siena Tbilisi Zadar	Belgrade Podgorica Sarajevo Skopje Split Tirana		Friedrichshafen
31-36	Birmingham Budapest Nuremberg Venice Warsaw	Billund Bremen FlorenceAV GothenburgL Leipzig Marseille Toulouse Turin	Alicante Athens Dubrovnik Istanbul Kiev Malaga Malta MoscowSh	Ljubljana	Bolzano		Graz Innsbruck

			Naples	
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Exhibit 2: Map of the Accessibility by Air ex VIENNA

1-6	Frankfurt	Dortmund Münster Paderborn	Linz Salzburg	Kos LasPalmas Riga Tallinn Thira Vilnius	Biarritz Clermont-F Limoges Liverpool Montpellier Nantes Rennes Southampton Strasbourg	Brest Pau Aberdeen Belfast Cork Eindhoven GlasgowIA Leeds Newcastle Rotterdam Teesside
7-12	BerlinTgl Cologne Düsseldorf Munich	BerlinSch BerlinTmp	Antalya Dresden Heraklion Ibiza Palma Rhodes Thessaloniki	Faro Fuerteventura Izmir Kerkyra MoscowD Tenerife	Funchal GothenburgSA Olbia Reus Rijeka RomC Santiago Sevilla Shannon	Bern Bordeaux Bristol Cardiff FlorencePA Genoa Nottingham Valencia
13-20	Vienna*)	Amsterdam Brussels Copenhagen Hamburg MilanM Prague Stuttgart Zurich	MilanO	Bourgas Bournemouth Constanta Forli Gdansk Gerona GlasgowPA Hof Kattowice Kerry Kiel Krasnodar Malmö Nizhny-Novg OsloTA Paphos Pescara Rostov StCruz Simferopol StockholmS	Almeria Bodrum Brindisi Dalaman Jerez Lamezia Menorca Mikonos Mytilene Rimini	Ancona Brno Cagliari Calvi Elba Erfurt Karpathos Rostok Saarbrücken Samos Sibiu Trieste Uralsk Westerland Wroclav Zakinthos
19-24	LondonCA LondonG LondonH LondonL LondonSt ParisCDG	Dublin Edinburgh Manchester MilanL	Bilbao Larnaka OsloA Porto Reykjavik Stavanger	Klagenfurt	Ankara Catania Lanzarote Preveza Timisoara	Karlsruhe Lourdes
25-30	Basel Geneva Hannover Lyon RomF	Barcelona Helsinki Lisbon Luxembourg Madrid Nice StockholmA	Bologna Bucharest Sofia StPetersburg Verona Zagreb	Altenrhein Chisinau Cluj Dnepropetrovsk Donetsk Cavalla Kharkov Kosice Krakow Lviv Minsk MönchenG Odessa Ohrid Poznan Pristina Siena Tbilisi Zadar	Belgrade Podgorica Sarajevo Skopje Split Tirana	Friedrichshafen
31-36	Birmingham Budapest Nuremberg Venice Warsaw	Billund Bremen FlorenceAV GothenburgL Leipzig Marseille Toulouse Turin	Alicante Athens Dubrovnik Istanbul Kiev Malaga Malta MoscowSh Naples	Ljubljana	Bolzano	Graz Innsbruck

white: 0.0-0.09	10% grey: 0.10-0.19	25% grey: 0.20-0.29	37.5% grey: 0.30-0.39
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*) Index = 1.0. Vienna builds a class of its own and coloring in black would not make sense.

Exhibit 3: Map of the Accessibility by Air ex FRANKFURT

1-6	Frankfurt*)	Dortmund Münster Paderborn	Linz Salzburg	Kos LasPalmas Riga Tallinn Thira Vilnius	Biarritz Clermont-F Limoges Liverpool Montpellier Nantes Rennes Southampton Strasbourg	Brest Pau Aberdeen Belfast Cork Eindhoven GlasgowIA Leeds Newcastle Rotterdam Teesside
7-12	BerlinTgl Cologne Düsseldorf Munich	BerlinSch BerlinTmp	Antalya Dresden Heraklion Ibiza Palma Rhodes Thessaloniki	Faro Fuerteventura Izmir Kerkyra MoscowD Tenerife	Funchal GothenburgSA Olbia Reus Rijeka RomC Santiago Sevilla Shannon	Bern Bordeaux Bristol Cardiff FlorencePA Genoa Nottingham Valencia
13-20	Vienna	Amsterdam Brussels Copenhagen Hamburg MilanM Prague Stuttgart Zurich	MilanO	Bourgas Bournemouth Constanta Forli Gdansk Gerona GlasgowPA Hof Kattowice Kerry Kiel Krasnodar Malmö Nizhniy-Novg OsloTA Paphos Pescara Rostov StCruz Simferopol StockholmS	Almeria Bodrum Brindisi Dalaman Jerez Lamezia Menorca Mikonos Mytilene Rimini	Ancona Brno Cagliari Calvi Elba Erfurt Karpathos Rostok Saarbrücken Samos Sibiu Trieste Uralsk Westerland Wroclav Zakinthos
19-24	LondonCA LondonG LondonH LondonL LondonSt ParisCDG	Dublin Edinburgh Manchester MilanL	Bilbao Larnaka OsloA Porto Reykjavik Stavanger	Klagenfurt	Ankara Catania Lanzarote Preveza Timisoara	Karlsruhe Lourdes
25-30	Basel Geneva Hannover Lyon RomF	Barcelona Helsinki Lisbon Luxembourg Madrid Nice StockholmA	Bologna Bucharest Sofia StPetersburg Verona Zagreb	Altenrhein Chisinau Cluj Dnepropetrovsk Donetsk Cavalla Kharkov Kosice Krakow Lviv Minsk MünchenG Odessa Ohrid Poznan Pristina Siena Tbilisi Zadar	Belgrade Podgorica Sarajevo Skopje Split Tirana	Friedrichshafen
31-36	Birmingham Budapest Nuremberg Venice Warsaw	Billund Bremen FlorenceAV GothenburgL Leipzig Marseille Toulouse Turin	Alicante Athens Dubrovnik Istanbul Kiev Malaga Malta MoscowSh Naples	Ljubljana	Bolzano	Graz Innsbruck
	white:	10% grey:	25% grey:	37.5% grey:	50% grey:	

0.0-0.09	0.10-0.19	0.20-0.29	0.30-0.39
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would not make sense.

*) Index = 1.0. Frankfurt builds a class of its own and coloring in black

Exhibit 4: Map of the Accessibility by Air ex PARIS/CDG

1-6	Frankfurt	Dortmund Münster Paderborn	Linz Salzburg	Kos LasPalmas Riga Tallinn Thira Vilnius	Biarritz Clermont-F Limoges Liverpool Montpellier Nantes Rennes Southampton Strasbourg	Brest Pau	Aberdeen Belfast Cork Eindhoven GlasgowIA Leeds Newcastle Rotterdam Teesside
7-12	BerlinTgl Cologne Düsseldorf Munich	BerlinSch BerlinTmp	Antalya Dresden Heraklion Ibiza Palma Rhodes Thessaloniki	Faro Fuerteventura Izmir Kerkyra MoscowD Tenerife	Funchal GothenburgSA Olbia Reus Rijeka RomC Santiago Sevilla Shannon		Bern Bordeaux Bristol Cardiff FlorencePA Genoa Nottingham Valencia
13-20	Vienna	Amsterdam Brussels Copenhagen Hamburg MilanM Prague Stuttgart Zurich	MilanO	Bourgas Bournemouth Constanta Forli Gdansk Gerona GlasgowPA Hof Kattowice Kerry Kiel Krasnodar Malmö Nizhny-Novg OsloTA Paphos Pescara Rostov StCruz Simferopol StockholmS	Almeria Bodrum Brindisi Dalaman Jerez Lamezia Menorca Mikonos Mytilene Rimini		Ancona Brno Cagliari Calvi Elba Erfurt Karpathos Rostok Saarbrücken Samos Sibiu Trieste Uralsk Westerland Wroclav Zakinthos
19-24	LondonCA LondonG LondonH LondonL LondonSt ParisCDG*)	Dublin Edinburgh Manchester MilanL	Bilbao Larnaka OsloA Porto Reykjavik Stavanger	Klagenfurt	Ankara Catania Lanzarote Preveza Timisoara		Karlsruhe Lourdes
25-30	Basel Geneva Hannover Lyon RomF	Barcelona Helsinki Lisbon Luxembourg Madrid Nice StockholmA	Bologna Bucharest Sofia StPetersburg Verona Zagreb	Altenrhein Chisinau Cluj Dnepropetrovsk Donetsk Cavalla Kharkov Kosice Krakow Lviv Minsk MünchenG Odessa Ohrid Poznan Pristina Siena Tbilisi Zadar	Belgrade Podgorica Sarajevo Skopje Split Tirana		Friedrichshafen
31-36	Birmingham Budapest Nuremberg Venice Warsaw	Billund Bremen FlorenceAV GothenburgL Leipzig Marseille Toulouse Turin	Alicante Athens Dubrovnik Istanbul Kiev Malaga Malta MoscowSh Naples	Ljubljana	Bolzano		Graz Innsbruck
	white:	10% grey:	25% grey:		50% grey:		85% grey:

0.0-0.09	0.10-0.19	0.20-0.29	...
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makes sense.

*) ParisCDG is combined with London; hence the coloring in black

Exhibit 5: Map of the Accessibility by Air ex SALZBURG

1-6	Frankfurt	Dortmund Münster Paderborn	Linz Salzburg*)	Kos LasPalmas Riga Tallinn Thira Vilnius	Biarritz Clermont-F Limoges Liverpool Montpellier Nantes Rennes Southampton Strasbourg	Brest Pau Aberdeen Belfast Cork Eindhoven GlasgowIA Leeds Newcastle Rotterdam Teesside
7-12	BerlinTgl Cologne Düsseldorf Munich	BerlinSch BerlinTmp	Antalya Dresden Heraklion Ibiza Palma Rhodes Thessaloniki	Faro Fuerteventura Izmir Kerkyra MoscowD Tenerife	Funchal GothenburgSA Olbia Reus Rijeka RomC Santiago Sevilla Shannon	Bern Bordeaux Bristol Cardiff FlorencePA Genoa Nottingham Valencia
13-20	Vienna	Amsterdam Brussels Copenhagen Hamburg MilanM Prague Stuttgart Zurich	MilanO	Bourgas Bournemouth Constanta Forli Gdansk Gerona GlasgowPA Hof Kattowice Kerry Kiel Krasnodar Malmö Nizhny-Novg OsloTA Paphos Pescara Rostov StCruz Simferopol StockholmS	Almeria Bodrum Brindisi Dalaman Jerez Lamezia Menorca Mikonos Mytilene Rimini	Ancona Brno Cagliari Calvi Elba Erfurt Karpathos Rostok Saarbrücken Samos Sibiu Trieste Uralsk Westerland Wroclav Zakinthos
19-24	LondonCA LondonG LondonH LondonL LondonSt ParisCDG	Dublin Edinburgh Manchester MilanL	Bilbao Larnaka OsloA Porto Reykjavik Stavanger	Klagenfurt	Ankara Catania Lanzarote Preveza Timisoara	Karlsruhe Lourdes
25-30	Basel Geneva Hannover Lyon RomF	Barcelona Helsinki Lisbon Luxembourg Madrid Nice StockholmA	Bologna Bucharest Sofia StPetersburg Verona Zagreb	Altenrhein Chisinau Cluj Dnepropetrovsk Donetsk Cavalla Kharkov Kosice Krakow Lviv Minsk MünchenG Odessa Ohrid Poznan Pristina Siena Tbilisi Zadar	Belgrade Podgorica Sarajevo Skopje Split Tirana	Friedrichshafen
31-36	Birmingham Budapest Nuremberg Venice Warsaw	Billund Bremen FlorenceAV GothenburgL Leipzig Marseille Toulouse Turin	Alicante Athens Dubrovnik Istanbul Kiev Malaga Malta MoscowSh Naples	Ljubljana	Bolzano	Graz Innsbruck
	white:	10% grey:	25% grey:	...	50% grey:	

0.0-0.09	0.10-0.19	0.20-0.29	
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sense.

*) Salzburg is combined with Linz; hence the coloring in black makes

Exhibit 6: Screenshot of Java applet layer 1

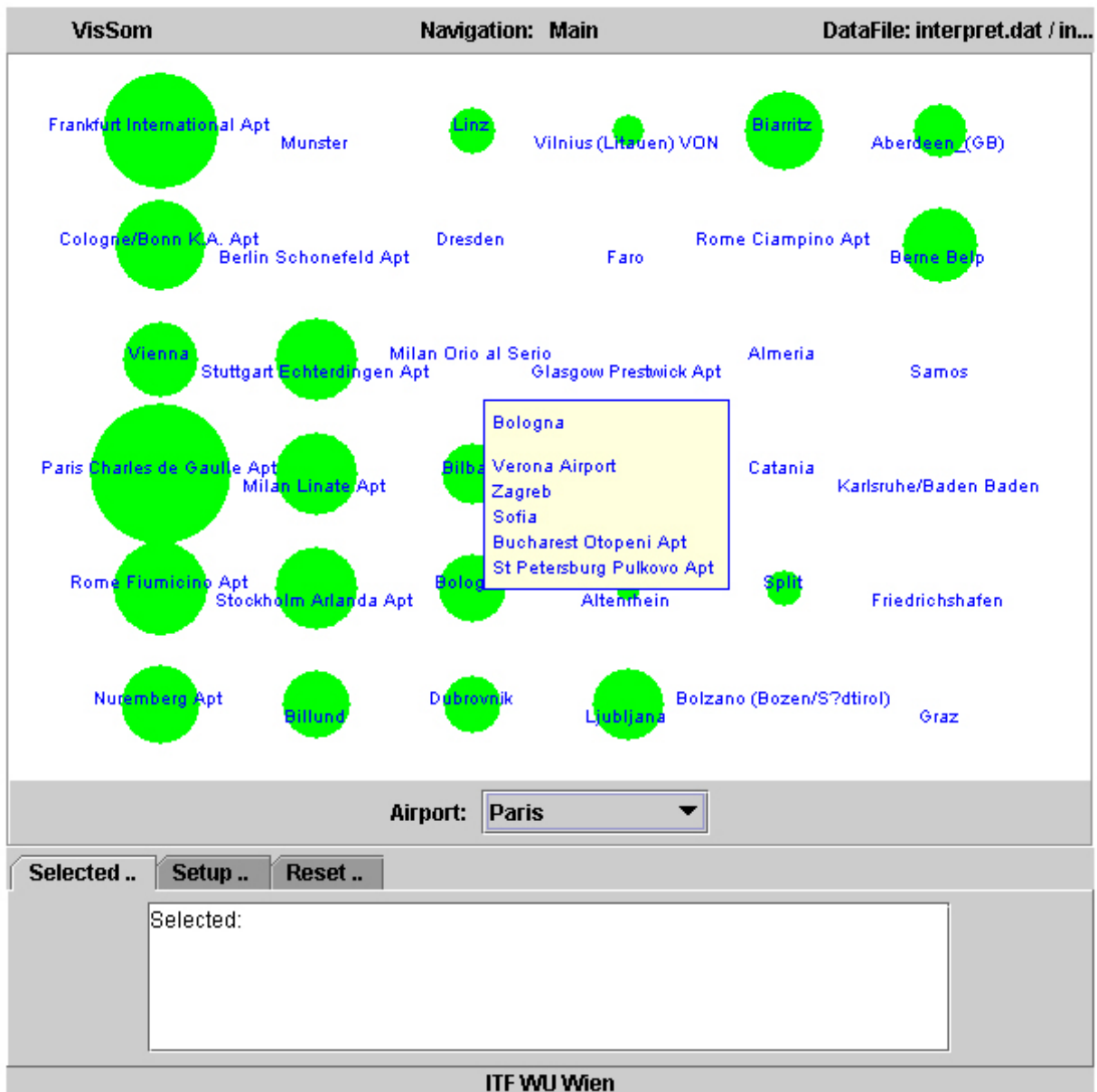
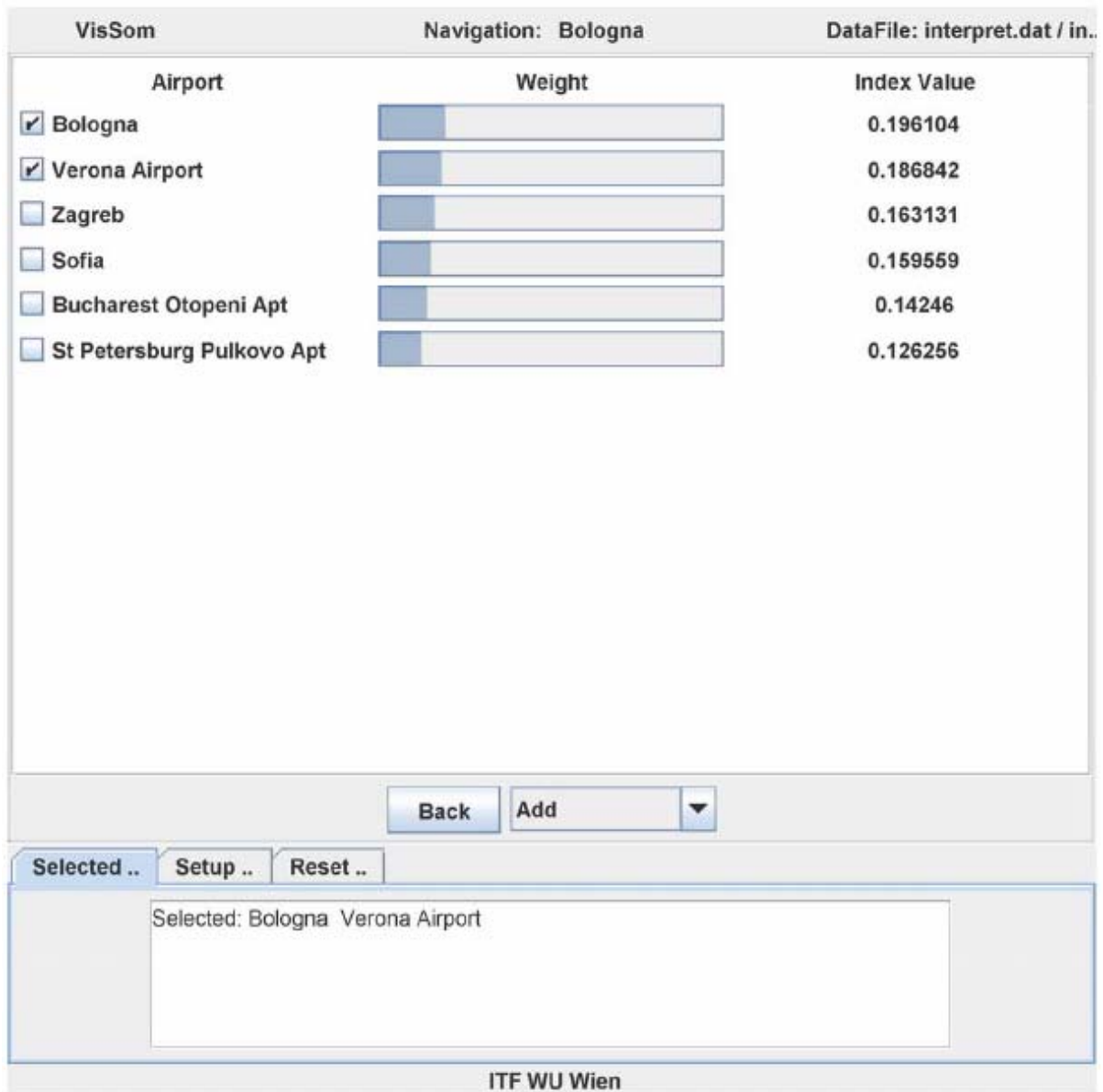


Exhibit 7: Screenshot of Java applet layer 2



Appendix

Table A1: Destinations in the 36 nodes of the accessibility maps

Destination	serial nr,	node (map position)
Aberdeen (GB)	1	6
Alicante	2	33
Almeria	3	17
Altenrhein	4	28
Amsterdam	5	14
Ancona	6	18
Ankara Esenboga Apt	7	23
Antalya	8	9
Athens Eleftherios Venizelos Intl Apt	9	33
Barcelona Apt	10	26
Belfast City Apt	11	6
Belgrade	12	29
Berlin Schonefeld Apt	13	8
Berlin Tegel Apt	14	7
Berlin Tempelhof Apt	15	8
Berne Belp	16	12
Biarritz	17	5
Bilbao	18	21
Billund	19	32
Birmingham International Airport	20	31
Bodrum Milas Airport	21	17
Bologna	22	27
Bolzano (Bozen/Südtirol)	23	35
Bordeaux Airport	24	12
Bourgas	25	16
Bournemouth	26	16
Bremen	27	32
Brest (FR)	28	5
Brindisi	29	17
Bristol	30	12
Brno Turany Apt	31	18
Brussels National Airport	32	14
Bucharest Otopeni Apt	33	27
Budapest	34	31
Cagliari	35	18
Calvi	36	18
Cardiff	37	12
Catania	38	23
Chisinau	39	28
Clermont-Ferrand	40	5
Cluj	41	28
Cologne/Bonn K.A. Apt	42	7
Constanta	43	16
Copenhagen Apt	44	14
Cork	45	6
Dalaman	46	17
Dnepropetrovsk	47	28
Donetsk	48	28
Dortmund	49	2
Dresden	50	9
Dublin	51	20
Dubrovnik	52	33
Dusseldorf Rhein Ruhr Airport	53	7
Edinburgh	54	20
Eindhoven Airport	55	6
Elba Island	56	18
Erfurt	57	18
Euroairport Basel	58	25
Faro	59	10
Florence Amerigo Vespucci	60	32

Florence Pisa Airport	61	12
Forli	62	16
Frankfurt International Apt	63	1
Friedrichshafen	64	30
Fuerteventura	65	10
Funchal	66	11
Gdansk	67	16
Geneva	68	25
Genoa	69	12
Gerona	70	16
Glasgow International Airport	71	6
Glasgow Prestwick Apt	72	16
Gothenburg Landvetter Apt	73	32
Gothenburg Saeve Apt (Ryanair !!!)	74	11
Graz	75	36
Hamburg Fuhlsbuettel Airport	76	14
Hannover	77	25
Helsinki	78	26
Heraklion	79	9
Hof	80	16
Ibiza	81	9
Innsbruck	82	36
Istanbul	83	33
Izmir Adnan Menderes Apt	84	10
Jerez de la Frontera	85	17
Karlsruhe/Baden Baden	86	24
Karpathos	87	18
Katowice	88	16
Kavala	89	28
Kerkyra	90	10
Kerry County	91	16
Kharkov (Ukraine) HRK	92	28
Kiel	93	16
Kiev Borispol Apt	94	33
Klagenfurt	95	22
Kos	96	4
Kosice	97	28
Krakow	98	28
Krasnodar (Russland) KRR	99	16
Lamezia Terme	100	17
Lanzarote	101	23
Larnaca	102	21
Las Palmas	103	4
Leeds Bradford	104	6
Leipzig/Halle	105	32
Limoges	106	5
Linz	107	3
Lisbon	108	26
Liverpool	109	5
Ljubljana	110	34
London City Apt	111	19
London Gatwick Apt	112	19
London Heathrow Apt	113	19
London Luton Apt	114	19
London Stansted Apt	115	19
Lourdes/Tarbes	116	24
Luxembourg	117	26
Lviv (Ukraine) LWO	118	28
Lyon Saint Exupery Apt	119	25
Madrid Barajas Apt	120	26
Malaga	121	33
Malmo Sturup Apt	122	16
Malta	123	33
Manchester International Apt	124	20
Marseille Provence Apt	125	32
Menorca	126	17
Mikonos	127	17
Milan Linate Apt	128	20
Milan Malpensa Apt	129	14
Milan Orio al Serio	130	15
Minsk International Apt 2	131	28

Moenchengladbach	132	28
Montpellier Mediterranee Apt	133	5
Moscow Domodedovo Apt	134	10
Moscow Sheremetyevo Apt	135	33
Munich International Airport	136	7
Munster	137	2
Mytilene (Griechenland) MJT	138	17
Nantes Atlantique Airport	139	5
Naples Capodichino Apt	140	33
Newcastle	141	6
Nice	142	26
Nizhniy Novgorod	143	16
Nottingham East Midlands Airport	144	12
Nuremberg Apt	145	31
Odessa Ukraine) ODS	146	28
Ohrid (Mazedonien) OHD	147	28
Olbia (Italien/Sardinien)	148	11
Oslo Airport	149	21
Oslo Torp Airport	150	16
Paderborn	151	2
Palma Mallorca	152	9
Paphos	153	16
Paris Charles de Gaulle Apt	154	19
Pau	155	5
Pescara	156	16
Podgorica (Montenegro) TGD	157	29
Porto	158	21
Poznan (Polen) POZ	159	28
Prague	160	14
Preveza/Lefkas (Griechenland) PVK	161	23
Pristina (Kosovo) PRN	162	28
Rennes St Jacques Airport	163	5
Reus	164	11
Reykjavik Keflavik Apt	165	21
Rhodes	166	9
Riga	167	4
Rijeka	168	11
Rimini	169	17
Rome Ciampino Apt	170	11
Rome Fiumicino Apt	171	25
Rostock-Laage	172	18
Rostov	173	16
Rotterdam Apt	174	6
Saarbrücken Ensheim Airport	175	18
Salzburg	176	3
Samos	177	18
Santa Cruz de la Palma	178	16
Santiago de Compostela	179	11
Sarajevo	180	29
Seville	181	11
Shannon	182	11
Sibiu	183	18
Siena	184	28
Simferopol	185	16
Skopje (Mazedonien) SKP	186	29
Sofia	187	27
Southampton	188	5
Split	189	29
St Petersburg Pulkovo Apt	190	27
Stavanger	191	21
Stockholm Arlanda Apt	192	26
Stockholm Skavsta Airport	193	16
Strasbourg Entzheim Airport	194	5
Stuttgart Echterdingen Apt	195	14
Tallinn	196	4
Tbilisi (Georgien) TBS	197	28
Teesside	198	6
Tenerife Sur Reina Sofia Apt	199	10
Thessaloniki	200	9
Thira (Griechenland) JTR	201	4
Timisoara (Rumänien) TSR	202	23

Tirana (Albanien) TIA	203	29
Toulouse Blagnac Apt	204	32
Trieste	205	18
Turin Citta Di Torino Airport	206	32
Uralsk	207	18
Valencia (ES)	208	12
Venice Marco Polo Apt	209	31
Verona Airport	210	27
Vienna	211	13
Vilnius (Litauen) VON	212	4
Warsaw	213	31
Westerland	214	18
Wroclaw	215	18
Zadar (Kroatien) ZAD	216	28
Zagreb	217	27
Zakinthos	218	18
Zurich Airport	219	14

Table A2: Mean indices of accessibility for the 36 nodes of the map

	Berl	Dortm	FrkfH	Frkft	Fried	Graz	Innsb	Klgft	Laib	Linz	Lond	Münch	Paris	Slzbg	Wien
1	0.455	0.000	0.000	0.000	0.284	0.284	0.169	0.156	0.189	0.215	0.343	0.439	0.442	0.217	0.264
2	0.075	0.544	0.000	0.261	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.190	0.000	0.000	0.060
3	0.000	0.000	0.000	0.220	0.000	0.000	0.000	0.000	0.000	0.492	0.000	0.147	0.072	0.494	0.293
4	0.121	0.029	0.000	0.110	0.013	0.000	0.000	0.000	0.000	0.000	0.017	0.038	0.035	0.050	0.104
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.207	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.258	0.000	0.096	0.014	0.000
7	0.533	0.202	0.000	0.453	0.118	0.040	0.000	0.038	0.059	0.122	0.236	0.498	0.258	0.072	0.243
8	1.000	0.221	0.000	0.000	0.079	0.000	0.000	0.000	0.000	0.084	0.000	0.000	0.000	0.084	0.142
9	0.176	0.120	0.000	0.209	0.052	0.000	0.000	0.057	0.000	0.089	0.031	0.206	0.000	0.100	0.081
10	0.108	0.029	0.000	0.136	0.013	0.000	0.000	0.000	0.016	0.036	0.031	0.132	0.000	0.043	0.000
11	0.035	0.000	0.015	0.000	0.000	0.014	0.000	0.000	0.000	0.000	0.070	0.021	0.000	0.000	0.008
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.159	0.191	0.000	0.016
13	0.279	0.158	0.000	0.289	0.000	0.213	0.267	0.300	0.286	0.310	0.216	0.302	0.180	0.257	0.000
14	0.254	0.083	0.000	0.355	0.018	0.049	0.018	0.000	0.107	0.023	0.298	0.299	0.234	0.043	0.238
15	0.243	0.176	0.360	0.360	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.009	0.000	0.000	0.134	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.004
17	0.000	0.000	0.000	0.116	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.124	0.000	0.000	0.000
18	0.006	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.155	0.000	0.000	0.000
19	0.067	0.032	0.087	0.312	0.024	0.020	0.000	0.020	0.050	0.000	0.519	0.213	0.780	0.047	0.071
20	0.091	0.000	0.000	0.271	0.000	0.000	0.000	0.000	0.057	0.000	0.411	0.067	0.220	0.029	0.063
21	0.000	0.000	0.000	0.163	0.000	0.000	0.000	0.000	0.000	0.000	0.158	0.024	0.124	0.000	0.020
22	0.000	0.000	0.000	0.163	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.303
23	0.024	0.016	0.000	0.064	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.129	0.000	0.000	0.129
24	0.000	0.000	0.000	0.000	0.239	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.000	0.000	0.000
25	0.023	0.000	0.000	0.325	0.000	0.027	0.000	0.033	0.000	0.000	0.213	0.224	0.284	0.000	0.180
26	0.071	0.000	0.000	0.219	0.000	0.000	0.000	0.000	0.000	0.000	0.229	0.135	0.233	0.000	0.140
27	0.000	0.000	0.000	0.209	0.000	0.000	0.000	0.000	0.000	0.000	0.076	0.172	0.162	0.000	0.177
28	0.000	0.000	0.000	0.045	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.022	0.000	0.151
29	0.022	0.000	0.000	0.118	0.000	0.000	0.000	0.000	0.203	0.000	0.043	0.052	0.045	0.000	0.172
30	0.000	0.000	0.000	0.284	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.294	0.000	0.000	0.000
31	0.187	0.000	0.000	0.278	0.000	0.000	0.000	0.000	0.000	0.000	0.094	0.223	0.209	0.000	0.211
32	0.000	0.028	0.000	0.236	0.000	0.000	0.000	0.000	0.000	0.000	0.035	0.189	0.161	0.000	0.000
33	0.115	0.012	0.000	0.180	0.000	0.000	0.015	0.000	0.011	0.011	0.091	0.150	0.111	0.000	0.142
34	0.000	0.000	0.000	0.192	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.272	0.168	0.000	0.280
35	0.000	0.000	0.000	0.000	0.000	0.000	0.377	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
36	0.000	0.000	0.000	0.231	0.000	0.281	0.308	0.000	0.000	0.101	0.000	0.088	0.000	0.000	0.306

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