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AN ANALYSIS ON THE CONNECTIONS OF FACTORS IN A PUBLIC TRANSPORT SYSTEM BY AHP-ISM

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Abstract. In order to gain an overall view on all relevant connections of the elements in a public transportation system, a systematic approach is advisable to follow, which applies well-proven methodology. In case a structure contains both hierarchical and non-hierarchical connections, the formerly recommended methodologies are: ISM-AHP, ISM-ANP, ANP. This paper however proposes a different approach: AHP-ISM, which aims to keep the AHP hierarchy, but simultaneously to amend that with the non-hierarchical types of linkages within the structure. By that, those connections that were verified in the AHP procedure can be considered dominant, but also weaker linkages might provide important additional information about the whole structure. The additional ISM procedure is suitable for two purposes: the most influential elements of the AHP structure can be selected, moreover also direct and indirect impacts of element improvement might be followed in the structure by considering both types of connections within the system, using the directed graph of ISM. The introduced AHP-ISM model is applicable for analyzing public transportation systems – as shown in the paper – but also generally applicable for any AHP applications, which are not strictly but dominantly hierarchically structured.

Keywords: interaction, transport, system elements, AHP, ISM.

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Introduction

Elements of public transportation systems have been analysed thoroughly in the transport scientific literature (e.g. Chien, Yang 2000; Asakura, Kashiwadani 1991; Bokor 2009; Dailydka, Lingaitis 2012; Stoyanov, Gagova 2012; Havlena *et al.* 2013). Many of the recent publications however put emphasys on the dependencies among these elements and aim to determine some linkages between two or more different issues. Van Nes and Bovy (2000) highlighted the possible connections within a transportation system in terms of the objectives of different strategies. Ceder (1984) discovered linkage among bus frequency and other system elements. Ibeas *et al.* (2010) examined optimal bus spacing in urban areas from other issues point of view within the structure. Hensher (2007) determined a service quality index including many transport issues and their interactions. Ongkittikul and Geerlings (2006) focused on public transport system innovation and the transitive impact on the whole structure. Guo (2011) shed light on the role of perspicuity of information before travel in passengers' route selection. Yang *et al.* (2011) conducted a research on how reliability – as the probability of delay time – affects other transport system elements. Molander *et al.* (2012) claimed that mainly physical improvements have been suggested for public transportation and mental issues and their relations have not been evaluated enough in scientific research.

Sivilevičius (2011) gave an overall perspective on the interactions of transport system elements. 6 interaction levels were distinguished: autointeractions, element interactions, elements interactions with external environment, interactions of transport modes, elements interactions with the country's economy and the connection of transportation and Gross Added Value (GAV). The author divided the transport system into 3 groups: transport material elements (such as passengers, vehicles, road), transportation process (preparation, embarkation, carriege, disembarkation) and regulation (e.g. legal, taxation, economic). Many different interactions

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were pointed out by Sivilevicius: e.g. traffic participant – traffic participants interaction, vehicle – vehicle, transport road – transport road, traffic participants – vehicle, and so on. These connections were evaluated from the aspect of roadway transport safety by the Analytic Hierarchy Process (AHP). For AHP references, see Saaty (1977, 2004), Dyer (1990), Pérez (1995).

Duleba *et al.* (2012) evaluated the transport system elements by AHP for public bus transport and Sivilevičius and Maskeliūanaitė (2010) for rail constructed hierarchical structures. Although these structures included hierarchical dependencies of system elements, non-hierarchical connections also could be detected and had to be ignored because of the strict conditions of the AHP procedure. Moreover, the hierarchy was set up by the researchers themselves (obviously based on scientific literature review and expertise), and not by a systematic and methodologically proved consensus of the decision makers.

This paper aims to provide a clear view on the interactions of transport system elements and to create the overall linkages within the structure by Interpretive Structural Modelling (ISM) with keeping the dominant hierarchical connections (which were verified by the evaluators and by the consistency of results) of the former AHP procedure.

ISM is considered as an effective method to determine relationship among the elements of a complex problem and to select driving issues, which have significant impact on other issues in the system. It has been used since its introduction (Malone 1975; Warfield 1974) e.g. for creating a dependency graph for knowledge management criteria (Tabrizi *et al.* 2010), for understanding the inhibitors of a telecommunication supply chain (Pramod, Banwet 2010), to evaluate renewable energy adoption for sustainable development (Eswarlal *et al.* 2011), for vendor selection (Mandal, Deshmukh 1994) and for evaluation of buyer-supplier relationships (Thakkar *et al.* 2008). Pfohl *et al.* (2011) stated in their paper that the process of ISM proved to be more reliable – having applied their model for 2 case studies – than an assessment based on paper questionnaires.

The novel contribution of this paper is on one hand amending a former AHP structure by ISM with the consideration of non-hierarchical connections of the elements, on the other hand to highlight the most influential factors of the transport structure, which might modify the AHP ranking of importance. Some authors applied ISM together with AHP (e.g. Gorvett, Liu 2007), however in their approach ISM evaluations were made without any former knowledge about the structure of the elements, however in our case, losing a formerly verified structure would cause loss of information. Another possible way might be applying ISM and ANP together (Huang *et al.* 2005), however with this application the hierarchy could not be kept as well. Finally, Saaty (2004) proposed Analytic Network Process (ANP) for all cases, which contain both hierarchical and non-hierarchical element interactions but with that methodology the proved hierarchy would have been lost again. In our transport system case it is essential to define the elements group-wisely (in order to provide a clear image and proper definition of elements for decision makers) and then by adding non-group-wise connections a new graph of influence can be created. The ISM method is also applicable for the scope of selecting system elements by their driving power, which means that most influential transport elements can be clustered, so an effective tool for strategy decision makers might be provided. Moreover, because of having 3 different evaluator groups: passengers, company managers and government officers (Duleba *et al.* 2012), the decisions on importance of elements are made by all 3 groups, however the group with most information on the system (public bus company managers) is judging the structural influence of elements by ISM. With this condition, a more proper final decision might be gained by considering the more expertise of the different decision maker groups. The elaborated and currently introduced procedure might also be applied for other Multi-Criteria Decision Making (MCDM) problems.

In the following sections, the theoretical background of ISM, afterwards the created model and research results are introduced.

1. Aspects of Interpretive Structural Modeling

This session is based on Warfield (1974) and Huang *et al.* (2005). ISM is capable to determine all connections among elements and also driving powers and dependencies in a structure. It has to be stressed however that this method is not capable to deal with the strength of these connections, only the existence and direction of linkages might be gained.

For that objective, firstly the relation matrix has to be constructed. This is a binary and quadratic matrix (the number of rows and columns equals the number of structure elements), with the following principle:

a_{ij} = 1, if element i affects element j;

a_{ij} = 0, otherwise.

The general structure of a relation matrix (D):

	e_1	e_2	...	e_n
e_1	0	a_{12}	...	a_{1n}
e_2	a_{21}	0	...	a_{2n}
...	...	...	0	...
e_n	a_{n1}	a_{n2}	...	0

,

where: e_i is the i-th element of the system; a_{ij} denotes the relation between i-th and j-th element.

Then two following steps are to be taken:

$$RM = D + I, \tag{1}$$

so unity matrix I is added, which makes the main diagonal consist all 1-s. By that RM, reachability matrix is gained:

$$RM^* = RM^k = RM^{k+1},\ k > 1, \tag{2}$$

where: k denotes powers, and RM^* is the final reachability matrix.

Creating the final reachability matrix from reachability matrix is a very essential step. This provides the transitivity criterion of ISM matrices:

if $a_{ij} = 1$ and $a_{jk} = 1$, then $a_{ik} = 1$.

Therefore, giving powers to the reachability matrix assures the transitivity among structure elements, which might not be considered in the creation of relation matrix *D* or reachability matrix *RM*.

Note that the final reachability matrix RM^* is under the operators of Boolean multiplication and addition (i.e. $1 \cdot 1 = 1$ and $1 + 1 = 1$). This is necessary in order to keep the final reachability matrix binary as well. Through this process, additional 1 elements are gained, which reflect the transitive connections among the system elements that were not considered by the relation matrix evaluators. By that more information can be gained about the linkages of the system.

Next reachability set ($R(ti)$, which indicates that the element *i* affects which other elements) and antecedent set ($A(ti)$, which indicates that element *i* is affected by which other elements) is calculated by:

$$R(ti) = \left\{ e_i \mid m^*_{ji} = 1 \right\}; \tag{3}$$

$$A(ti) = \left\{ e_i \mid m^*_{ij} = 1 \right\}, \tag{4}$$

where: m^*_{ij} denotes the value of the *i*-th row and *j*-th coloumn.

Then the levels and relationships between the elements (as well as dependence and driving power) can be determined and the structure of elements relationships by graph, using:

$$R(ti) \cap A(ti) = R(ti). \tag{5}$$

So the first level is gained by selecting those elements from the system, which have exactly the same intersection set $R(ti) \cap A(ti)$ and reachability set $R(ti)$. After having selected the first level elements, they are deleted from the system, and the procedure is the same for the remained elements. The calculation goes on until all factors of the system are clustered into levels.

2. The Original AHP Hierarchical Structure

Based on relevant literature review and researcher expertise, an AHP hierarchical model was created for elements of an arbitrary public bus transport system (Duleba *et al.* 2012). This structure is demonstrated on Fig. 1.

In the AHP process, two criteria must be fulfilled to verify the created structure: evaluators must confirm that no element is misclustered or missing or can be omitted, and the consistency of evaluations must keep the Consistency Ratio criterion of $CR < 0.1$ (Saaty 1977). The conducted survey verified both criteria (Duleba *et al.* 2012).

Although the hierarchical structure can be considered as a sufficient approach, experts of transportation systems might discover some non-hierarchical connections among the elements. E.g. frequency of lines has got an impact on the awaiting time of the passengers (obviously the more frequently buses are coming the shorter awaiting time can be reached) or information provided during the journey might increase mental comfort, etc. These non-hierarchical connections should also be considered in the final decision – by this valuable additional information can be added – with the precondition of regarding them weaker than hierarchical connections.

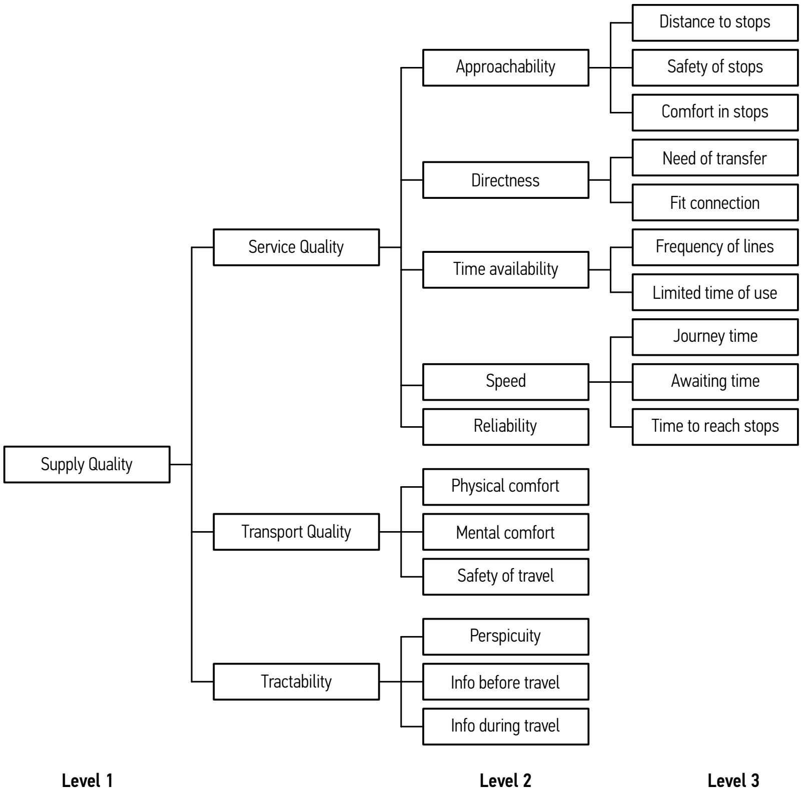

Fig. 1. The hierarchical model of public bus transportation supply quality

The final objective of the AHP application was to determine the importance of the transport system elements in terms of their necessity of improvement. By the hierarchical structure, scores could be determined and ranking could be set up. However, the non-hierarchical connections of the system might modify this ranking and scores. If an element of the transport system is improved and it has got non-hierarchical positive impacts on other elements, then the final effect of improvement will be larger (in case the impact is negative then smaller). Therefore, the influential elements of the structure must be determined. Also important that the direct connections (both hierarchical and non-hierarchical) of the elements should be followed, because the effect of improving a certain element can be indicated that way.

For these two objectives, ISM has been selected as an efficient method. As introduced in the former session, this method is not capable to deal with the strength of the connections but in this case strength can be ignored. It is assumed – based on the verification of the hierarchical structure – that the hierarchical connections are stronger and dominant in comparison with the non-hierarchical ones. Only the existences of connections are highlighted and for that ISM is a proven and widely applied method.

3. Results of the ISM Application for the Transport System

In order to pursue the ISM procedure, the hierarchy must be temporally unbounded and all 24 factors must be equally assessed. Table 1 shows the notation of elements.

The ISM evaluations were made by 3 experts' consensus. Getting to the second step of the previously introduced general procedure (1), the following *RM* (reachability matrix) was gained by the experts' evaluation (Table 2).

As can be seen, all hierarchical connections were kept on the left side of the main diagonal, block wisely; however *RM* contains 1-s – which indicate the existence of linkage between two elements – in other rubrics as well. To assure transitivity, *FRM* (final reachability matrix) were computed by raising the *RM* to the 4-th power, from that power the matrix is stable, so no additional changes can be reached by raising more powers with reflect to Boolean algebra multiplication and addition rules (2).

Table 3 also demonstrates the following step, made by (3) and (4). Driving power aggregates all 1-s for the certain elements row wisely, so the higher the number is, the more impact of the element on other elements can be detected. Dependence aggregates all 1-s columns wisely, so the higher the number is, the more dependencies from other elements can be detected. By that we can state that for this specific case, the factor of 'need of transfer *r*18' possesses the highest driving power in the structure with the value of 9, and the factor of 'service quality *r*1' is the most dependent from other factors with the value of 18.

Table 1. The notation of system elements

Sevice Quality	*r*1
Transport Quality	*r*2
Tractability	*r*3
Approachability	*r*4
Directness	*r*5
Time availability	*r*6
Speed	*r*7
Reliability	*r*8
Physical Comfort	*r*9
Mental Comfort	*r*10
Safety of Travel	*r*11
Perspicuity	*r*12
Info Before Travel	*r*13
Info During Travel	*r*14
Distance To Stops	*r*15
Safety of Stops	*r*16
Comfort in Stops	*r*17
Need of Transfer	*r*18
Fit Connection	*r*19
Frequency of Lines	*r*20
Limited Time of Usage	*r*21
Journey Time	*r*22
Awaiting Time	*r*23
Time to Reach Stops	*r*24

Based on the *FRM*, a direct graph for all factors of the system can be drawn (Fig. 2). This graph does not contain the transitive linkages among system elements, only the direct connections are exhibited.

Important conclusions could be drawn by Fig. 3. 3 factors *r*5, *r*8, *r*19 are integrated, because they have exactly the same dependent and driving factors. That indicates close connection. Service quality *r*1 is only affected directly by two elements: approachability *r*4 and speed *r*7, while the other 3 (hierarchically) affecting factors are put behind (Fig. 1.). Note that the hierarchical connections are still kept, just some of them became indirect. There are some elements *r*12, *r*14, *r*18, *r*20, *r*21, *r*22 which affect more than one general factor *r*1, *r*2, *r*3, so their development will cause additional improvement in the overall factors as well. With the application of Fig. 2, it can be forecasted that an improvement of an arbitrary factor of the system will affect which other factors directly or indirectly. The indirect cases can be determined by following the arrows on the graph.

For obtaining more sophisticated results, iterations were done by the procedure of (5). 6 levels were determined as shown in Table 4.

Iteration phase is not applied for determining new hierarchical structure, but determining influential levels within the system structure. Level 1 contains the most dependent elements which have no driving powers on others. Level 6 contains the only factor (*r*18, so the need of transfer) which is not depending on any other factors but has many impacts on other elements of the structure. This is exhibited on Fig. 3.

Table 2. The reachability matrix of system elements

	*r*1	*r*2	*r*3	*r*4	*r*5	*r*6	*r*7	*r*8	*r*9	*r*10	*r*11	*r*12	*r*13	*r*14	*r*15	*r*16	*r*17	*r*18	*r*19	*r*20	*r*21	*r*22	*r*23	*r*24
*r*1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*r*2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*r*3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*r*4	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*r*5	1	0	0	0	1	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
*r*6	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*r*7	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*r*8	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
*r*9	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*r*10	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*r*11	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
*r*12	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
*r*13	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
*r*14	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
*r*15	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
*r*16	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
*r*17	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
*r*18	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
*r*19	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
*r*20	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
*r*21	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
*r*22	1	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0
*r*23	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
*r*24	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Table 3. The final reachability matrix

	*r*1	*r*2	*r*3	*r*4	*r*5	*r*6	*r*7	*r*8	*r*9	*r*10	*r*11	*r*12	*r*13	*r*14	*r*15	*r*16	*r*17	*r*18	*r*19	*r*20	*r*21	*r*22	*r*23	*r*24	Driving power
*r*1	1																								1
*r*2		1																							1
*r*3			1																						1
*r*4	1			1																					2
*r*5	1		1		1		1	1					1						1				1		8
*r*6	1					1	1																		3
*r*7	1						1																		2
*r*8	1		1		1		1	1					1						1				1		8
*r*9		1							1																2
*r*10		1								1															2
*r*11		1									1														2
*r*12	1		1				1					1											1		5
*r*13	1		1				1						1										1		5
*r*14		1	1							1				1											4
*r*15	1			1			1								1									1	5
*r*16	1			1												1									3
*r*17	1			1													1								3
*r*18	1		1		1		1	1					1					1	1				1		9
*r*19	1		1		1		1	1					1						1				1		8
*r*20	1	1				1	1		1											1			1		7
*r*21	1		1			1	1						1								1		1		7
*r*22	1	1					1		1	1	1											1			7
*r*23	1						1																1		3
*r*24	1						1																	1	3
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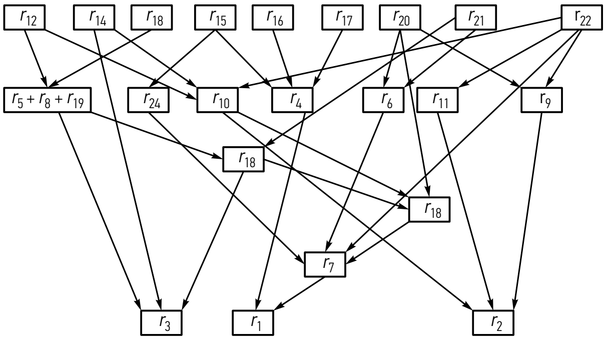

Fig. 2. The connecting graph of transport system elements

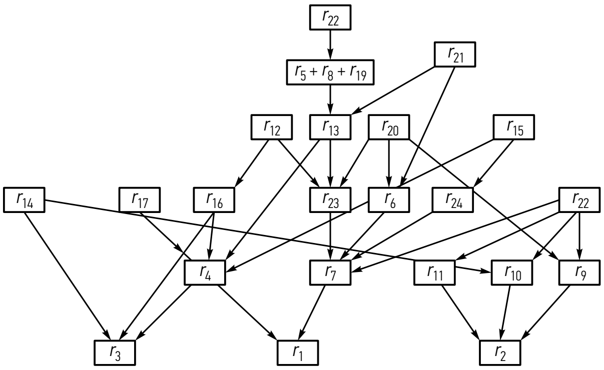

Fig. 3. Level graph of system elements

Table 4. Iterations

	Reachability set	Antecedent set	Intersection set	Level
*r*1	1	1,4,5,6,7,8,12,13,15,16,17,18,19,20,21,22,23,24	1	1
*r*2	2	2,9,10,11,14,20,22	2	1
*r*3	3	3,5,8,12,13,14,18,19,21	3	1
*r*4	1,4	4,15,16,17	4	
*r*5	1,3,5,7,8,13,19,23	5,8,18,19	5,8,19	
*r*6	1,6,7	6,20,21	6	
*r*7	1,7	5,6,7,8,12,13,15,18,19,20,21,22,23,24	7	
*r*8	1,3,5,7,8,13,19,23	5,8,18,19	5,8,19	
*r*9	2,9	9,20,22	9	
*r*10	2,10	10, 14,22	10	
*r*11	2,11	11,22	11	
*r*12	1,3,7,12,23	12	12	
*r*13	1,3,7,13,23	5,8,13,18,19,21	13	
*r*14	2,3,10,14	14	14	
*r*15	1,4,7,15,24	15	15	
*r*16	1,4,16	16	16	
*r*17	1,4,17	17	17	
*r*18	1,3,5,7,8,13,18,19,23	18	18	
*r*19	1,3,5,7,8,13,19,23	5,8,18,19	5,8,19	
*r*20	1,2,6,7,9,20,23	20	20	
*r*21	1,3,6,7,13,21,23	21	21	
*r*22	1,2,7,9,10,11,22	22	22	
*r*23	1,7,23	5,8,12,13,18,19,20,21,23	23	
*r*24	1,7,24	15,24	24	
	Reachability set	Antecedent set	Intersection set	Level
*r*4	4	4,15,16,17	4	2
*r*5	5,7,8,13,19,23	5,8,18,19	5,8,19	
*r*6	6,7	6,20,21	6	
*r*7	7	5,6,7,8,12,13,15,18,19,20,21,22,23,24	7	2
*r*8	5,7,8,13,19,23	5,8,18,19	5,8,19	
*r*9	9	9,20,22	9	2
*r*10	10	10,14,22	10	2
*r*11	11	11,22	11	2
*r*12	7,12,23	12	12	

End of Table 4

	Reachability set	Antecedent set	Intersection set	Level
*r*13	7,13,23	5,8,13,18,19,21	13	
*r*14	10,14	14	14	
*r*15	4,7,15,24	15	15	
*r*16	4,16	16	16	
*r*17	4,17	17	17	
*r*18	5,7,8,13,18,19,23	18	18	
*r*19	5,7,8,13,19,23	5,8,18,19	5,8,19	
*r*20	6,7,9,20,23	20	20	
*r*21	6,7,13,21,23	21	21	
*r*22	7,9,10,11,22	22	22	
*r*23	7,23	5,8,12,13,18,19,20,21,23	23	
*r*24	7,24	15,24	24	

	Reachability set	Antecedent set	Intersection set	Level
*r*5	5,8,13,19,23	5,8,18,19	5,8,19	
*r*6	6	6,20,21	6	3
*r*8	5,8,13,19,23	5,8,18,19	5,8,19	
*r*12	12,23	12	12	
*r*13	13,23	5,8,13,18,19,21	13	
*r*14	14	14	14	3
*r*15	15,24	15	15	
*r*16	16	16	16	3
*r*17	17	17	17	3
*r*18	5,8,13,18,19,23	18	18	
*r*19	5,8,13,19,23	5,8,18,19	5,8,19	
*r*20	6,20,23	20	20	
*r*21	6,13,21,23	21	21	
*r*22	22	22	22	3
*r*23	23	5,8,12,13,18,19,20,21,23	23	3
*r*24	24	15,24	24	3

	Reachability set	Antecedent set	Intersection set	Level
*r*5	5,8,13,19	5,8,18,19	5,8,19	
*r*8	5,8,13,19	5,8,18,19	5,8,19	
*r*12	12	12	12	4
*r*13	13	5,8,13,18,19,21	13	4
*r*15	15	15	15	4
*r*18	5,8,13,18,19	18	18	
*r*19	5,8,13,19	5,8,18,19	5,8,19	
*r*20	20	20	20	4
*r*21	13,21	21	21	

	Reachability set	Antecedent set	Intersection set	Level
*r*5	5,8,19	5,8,19	5,8,19	5
*r*8	5,8,19	5,8,19	5,8,19	5
*r*18	5,8,18,19	18	18	
*r*19	5,8,19	5,8,19	5,8,19	5
*r*21	21	21	21	5

	Reachability set	Antecedent set	Intersection set	Level
*r*18	18	18	18	6

Conclusions

1. Elements of a transportation system interact in various ways: hierarchical and non-hierarchical connections also can be detected among them. Due to the complexity of interactions, systematic methodology is needed to determine all linkages. Creating a new model for that purpose is a significant new contribution to the transport field.
2. Provided a hierarchical structure – created by researchers and based on scientific literature review and expertise – has been verified by an AHP procedure (by the evaluators and consistency), hierarchical connections can be regarded as dominant in the structure.
3. Non-hierarchical connections however also exist, for their determination Interpretive Structural Modelling (ISM) is an efficient tool. ISM considers both types of linkages and is capable to select the most influential elements of the system, moreover sheds light on all direct and indirect connections, which might help in following the effects of changing (or developing) an element on other linked system factors. This can lead to efficient policy making in public transport.
4. The formerly elaborated models in the scientific literature (ISM-AHP, ISM-ANP, ANP) are not applicable for this case, because none of them keep the structure of the elements, which is a dominant pre-condition in this systematic approach.
5. By AHP, importance (of improvement) of the transport system elements was gained. These scores should be modified by considering the structural influence of certain elements. For this, the introduced AHP-ISM model is applicable. To elaborate the exact modification process is a topic of further research.
6. For the specific case, the factor of 'need of transfer (*r*18)' must be emphasized and its ranking should be modified in AHP scoring, because of its high influence on other factors in the structure. Decision makers are suggested to achieve that the majority of journeys in the examined public bus transport system might be done without transfer of vehicles for the passengers.

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