Urban body network configurations

Attica

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The methodology presented here is grounded on the reconstruction of the urban body as a network configuration consisting of material and non-material components (Bateson, 1972). It is based on the assumption that if one can describe the rules that define the nodes and the connections of the network construction/urban body, as well as their attributes, then the differentiation on the relationships between elements, or even a shift from one value to another, would result in different network constructions, that would produce a time-based sequence of the self-adaptational and self-organizational reconfigurations occurring during the mutational procedure. The urban body is defined as the part of the urban tissue which distinguishes itself from the whole of the urban landscape, either because of constructed boundaries, or because of the strengthening of a specific attribute, which would result in a kind of an immaterial boundary, or, in other words the formation of an identity.

Keywords: *Mutation, urban body, visualization techniques, network, data manipulation*

INTRODUCTION

The partitions (Blondel et al. 2008) and centrality studies (Newman 2010) made possible through the network configuration reveal attributes of the elements which emerge from the position of each element (node) in relation to other elements of the network and not from the Cartesian topology. Through the application of certain algorithms measuring the different types of centrality (betweenness centrality, degree centrality, closeness centrality) the self-adaptation of the urban body is revealed, on the basis of the alteration of the nodes' connections or the differentiation of the attributes and identity of the nodes themselves.

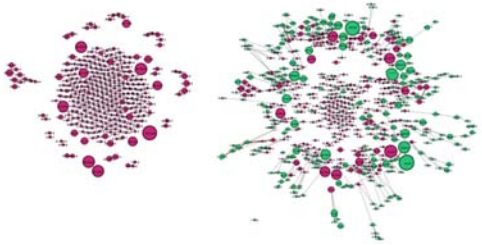


Figure 1
Attributes are assigned at the elements of the network. The nodes' colors correspond to a certain type of identity or attribute assigned on them. The network configuration is readapted as a counter-body of the network is introduced

What is more, being able to represent material and non-material elements as nodes (Hillier, 2007), counter-bodies of mixed proprieties emerge, including physical presence and their attributes. In contrast to the hierarchical constructions, network con-

structions allow for multiple connections between elements (Alexander, 1965), therefore being closer to the complexity of the associative forces found in the structure of the urban body.

METHOD

In the case of Attica, inscribed at the Attic peninsula in Greece, spatial, supra-local nodes are selected and attributes describing their specific qualities are assigned (Figure 1). A methodology concerning urban cohesion, focusing on spatial, social and economic attributes of the urban body was followed. The importance of certain nodes, whether well-connected nodes or nodes though which other nodes or groups of nodes interconnected was evaluated.This study is part of the research programme titled "Strategies for the Networking of Urban Interventions in Athens Metropolitan Centre" at the National Technical University of Athens and it is directed by Giorgos Parmenidis which deals with the detection of nodes that would act as binding elements and the evaluation of a proposed set of actions that would result in self-adaptation of the urban body in a way that would re-evaluate its processes towards a structure of a coherent whole. This research programme was generated by the region of Attica in Greece (Figure2).

In order to construct the network configuration of points of interest, rules describing the criteria of inclusion of nodes and the relationships between them are assigned. The urban body is therefore reconstructed in mathematical terms and the mutational procedure was visualized, based on dissolution of elements and binding forces between them and subsequent reconfiguration of the urban body.

NETWORK CONSTRUCTION FOR SPATIAL NODES AND THEIR ASSIGNED ATTRIBUTES

The network configuration presented here consists of elements whose identity depends on their assigned attributes. The characteristics of supra-local nodes is written on the element's identity, being an adjective describing a spatial node, as a numerical value, or as a boolean attribute answering an hypothesis affirmatively or negatively. The same rule is applied on the connections between elements, being connections of commerce or civilization (in this case this is written as an adjective), connections with a degree of accessibility to pedestrians, bicycles etc (numerical value) or as connections that satisfy hypotheses such as safety, environmental comfort etc.

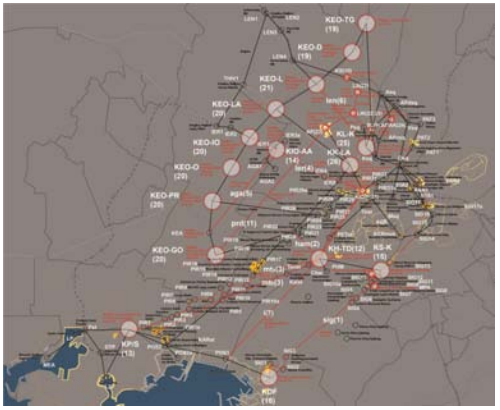


Figure 2
The network configuration describing supralocal nodes and their connections.

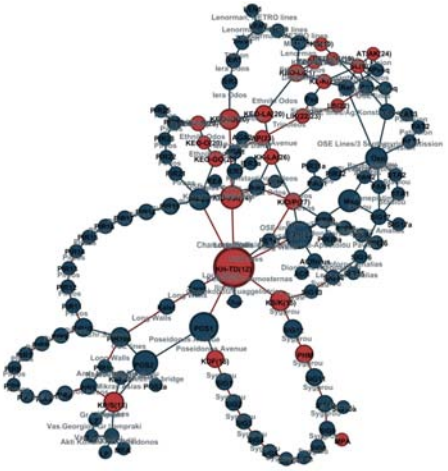


Figure 3
The network configuration of the map shown in figure 2. The elements of the network are distinguished on the basis of being "problematic" nodes or connections where interventions should be made. The size of the node depicts the value of the betweenness centrality algorithm.

STRATEGIES FOR COHESION OF THE NETWORK CONFIGURATION FOR THE URBAN BODY

The methodology adopted here involves the evaluation of the network's nodes in respects to their relative position in the network construction and according to the measurements of betweenness centrality and degree centrality (Newman, 2010), aiming at a selection of nodes to be rehabilitated, in a successive order of phases. It is therefore assumed that nodes with a greater importance in what concerns their relative position at the network, would be rehabilitated in an earlier stage, as opposed to those nodes that don't contribute much to the cohesion of the urban body. The term cohesion is used here to describe the different types of a network construction, depending on whether they consist of one, connected network or if they consist of two or more separate network configurations (sub-networks). It is assumed that while sub-networks interconnect to form one, connected network, the network configuration is regarded to "move" from a state of non-coherent form, to the acquisition of a coherent form of network construction.

It is assumed that betweenness centrality measure has a greater significance in the re-acquisition of the coherence of the network construction, due to the fact that nodes with a greater degree of betweenness centrality are capable of connecting nodes that form groups of interconnected nodes and need to pass their connections through these specific nodes in order to get connected with the rest of the network construction.

It is therefore possible to evaluate certain nodes of the network as being more important, not only because of the possibility of state interventions, but also in what concerns their relative position and their significance for being a kind of umbilical cord for the network configuration.

Figure 4
The network configuration after the application of the algorithm measuring Degree Centrality

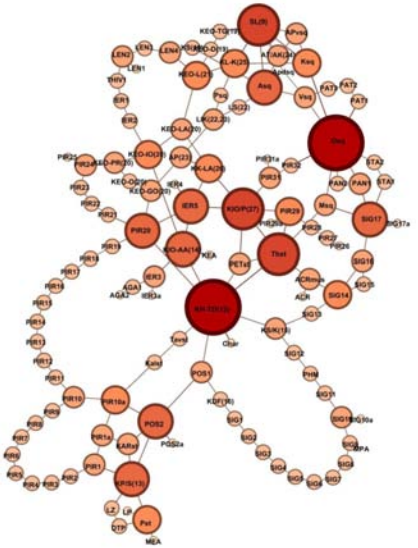
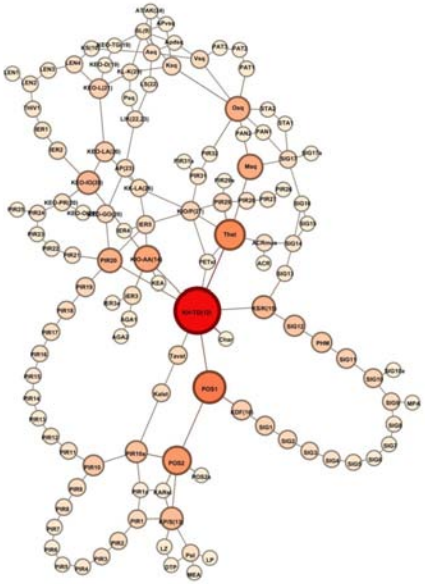
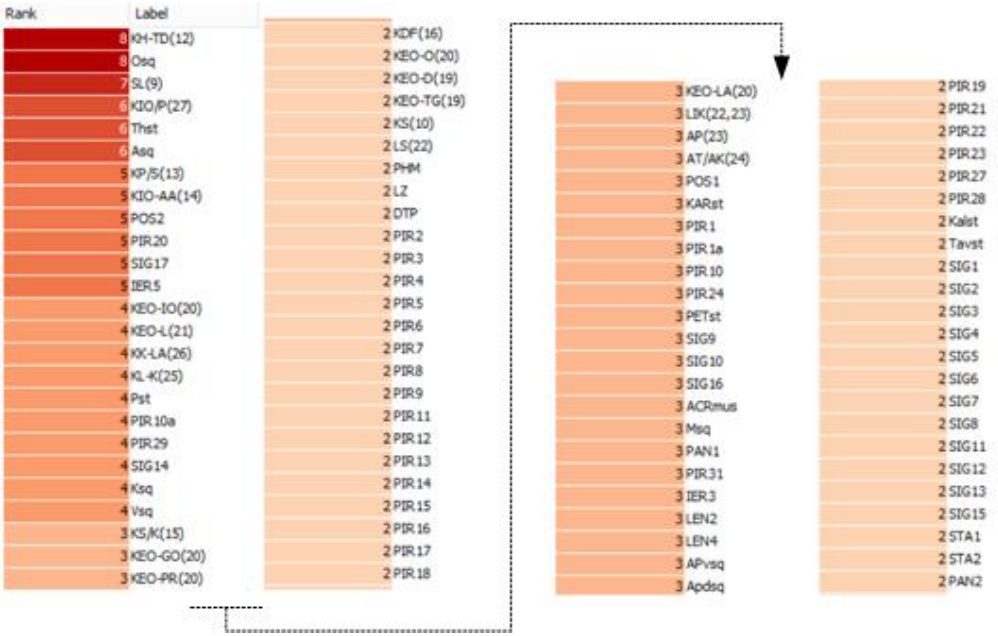


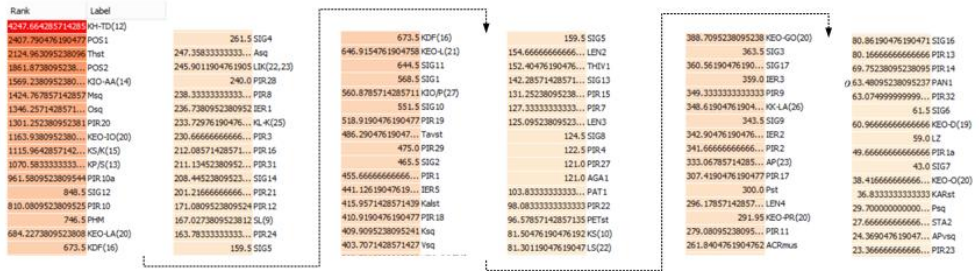
Figure 5
The network configuration after the application of the algorithm measuring Degree Centrality





Rank	Label
8	KH-TD(12)
8	Osq
7	SL(9)
6	KIO/P(27)
6	Thst
6	Asq
5	KP/S(13)
5	KIO-AA(14)
5	POS2
5	PIR20
5	SIG17
5	IER5
4	KEO-IO(20)
4	KEO-L(21)
4	KK-LA(26)
4	KL-K(25)
4	Pst
4	PIR10a
4	PIR29
4	SIG14
4	Ksq
4	Vsq
3	KS/K(15)
3	KEO-GO(20)
3	KEO-PR(20)
2	KDF(16)
2	KEO-O(20)
2	KEO-D(19)
2	KEO-TG(19)
2	KS(10)
2	LS(22)
2	PHM
2	LZ
2	DTP
2	PIR2
2	PIR3
2	PIR4
2	PIR5
2	PIR6
2	PIR7
2	PIR8
2	PIR9
2	PIR11
2	PIR12
2	PIR13
2	PIR14
2	PIR15
2	PIR16
2	PIR17
2	PIR18
3	KEO-LA(20)
3	LIK(22,23)
3	AP(23)
3	AT/AK(24)
3	POS1
3	KARst
3	PIR1
3	PIR1a
3	PIR10
3	PIR24
3	PETst
3	SIG9
3	SIG10
3	SIG16
3	ACRmus
3	Msq
3	PAN1
3	PIR31
3	IER3
3	LEN2
3	LEN4
3	APvsq
3	Apdsq
2	PIR19
2	PIR21
2	PIR22
2	PIR23
2	PIR27
2	PIR28
2	Kalst
2	Tavst
2	SIG1
2	SIG2
2	SIG3
2	SIG4
2	SIG5
2	SIG6
2	SIG7
2	SIG8
2	SIG11
2	SIG12
2	SIG13
2	SIG15
2	STA1
2	STA2
2	PAN2

Table 1
Degree Centrality
Rank Table



Rank	Label
4247.664285714285	KH-TD(12)
2407.790476190477	POS1
2124.963095238096	Thst
1861.873809523...	POS2
1569.238095238...	KIO-AA(14)
1424.767857142857	Msq
1346.257142857...	Osq
1301.252380952381	PIR20
1163.938095238...	KEO-IO(20)
1115.964285714...	KS/K(15)
1070.583333333...	KP/S(13)
961.5809523809544	PIR10a
848.5	SIG12
810.0809523809525	PIR10
746.5	PHM
684.2273809523808	KEO-LA(20)
673.5	KDF(16)
261.5	SIG4
247.3583333333...	Asq
245.9011904761905	LIK(22,23)
240.0	PIR28
238.3333333333...	PIR8
236.7380952380952	IER1
233.7297619047619...	KL-K(25)
230.6666666666...	PIR3
212.0857142857...	PIR16
211.1345238095238...	PIR31
208.4452380952381...	SIG14
201.2166666666...	PIR21
171.0809523809524	PIR12
167.0273809523812	SL(9)
163.7833333333...	PIR24
159.5	SIG5
673.5	KDF(16)
646.9154761904758	KEO-L(21)
644.5	SIG11
568.5	SIG1
560.8785714285711	KIO/P(27)
551.5	SIG10
518.9190476190477	PIR19
486.2904761904762...	Tavst
475.0	PIR29
465.5	SIG2
455.6666666666...	PIR1
441.1261904761904...	IER5
415.9571428571429	Kalst
410.9190476190477	PIR18
409.9095238095241	Ksq
403.7071428571427	Vsq
159.5	SIG5
154.6666666666666...	LEN2
152.4047619047619...	THIV1
142.2857142857142...	SIG13
131.2523809523809...	PIR15
127.3333333333333...	PIR7
125.0952380952381...	LEN3
124.5	SIG8
122.5	PIR4
121.0	PIR27
121.0	AGA1
103.8333333333333...	PAT1
98.08333333333333	PIR22
96.57857142857135	PETst
81.50476190476192	KS(10)
81.30119047619047	LS(22)
388.7095238095238	KEO-GO(20)
363.5	SIG3
360.5619047619047...	SIG17
359.0	IER3
349.3333333333333	PIR9
348.6190476190476...	KK-LA(26)
343.5	SIG9
342.9047619047619...	IER2
341.6666666666666...	PIR2
333.0678571428571...	AP(23)
307.4190476190477	PIR17
300.0	Pst
296.1785714285714...	LEN4
291.95	KEO-PR(20)
279.0809523809524...	PIR11
261.8404761904762	ACRmus
80.86190476190471	SIG16
80.16666666666666	PIR13
69.75238095238095	PIR14
63.48095238095237	PAN1
63.07499999999999...	PIR32
61.5	SIG6
60.96666666666666	KEO-D(19)
59.0	LZ
49.66666666666666	PIR1a
43.0	SIG7
38.41666666666666...	KEO-O(20)
36.83333333333333	KARst
29.70000000000...	Psq
27.66666666666666...	STA2
24.36904761904762...	APvsq
23.36666666666666...	PIR23

Table 2
Betweeness
Centrality Rank
Table

Table 3
The resulting values after the application of the different algorithms at the network configuration.

Label	Description	Phase of Completion	Priority	Degree	Modularity Class	Closeness Centrality	Betweeness Centrality
KP/S(13)	Peiraios / Skilitsi Node (The Gate of Piraeus) (c. 13)	B,C	A	5	1	5.901639344	1070.583333
KDF(16)	Delta Falirou Node (c. 16)	A,B	B	2	4	5.393442623	673.5
KS/K(15)	Siggrou-Kallirois Node (c. 15)	B	A	3	0	4.827868852	1115.964286
KH-TD(12)	Chamosternas-Tavros Node (c. 12)	B	A	8	6	4.057377049	4247.664286
KEO-GO(20)	Ethniki Odos/OSE lines Node (c. 20)	B,C	C	3	3	5.229508197	388.7095238
KEO-O(20)	Ethniki Odos/Orfeos Node (c. 20)	B,C	C	2	3	5.959016393	38.41666667
KEO-PR(20)	Ethniki Odos/Petrou Ralli Node (c. 20)	B,C	C	3	3	5.87704918	291.95
KEO-IO(20)	Ethniki Odos/Iera Odos Node (c. 20)	B,C	B	4	7	5.073770492	1163.938095
KEO-LA(20)	Ethniki Odos/Leoforos Athinon Node (c. 20)	B,C	C	3	6	5.295081967	684.227381
KEO-L(21)	Ethniki Odos/Lenorman Node (c. 21)		C	4	8	5.827868852	646.9154762
KEO-D(19)	Ethniki Odos/Dirrachiou Node (c. 19)		C	2	8	6.737704918	60.96666667
KEO-TG(19)	Three Bridges Node (c. 19)		B	2	8	7.286885246	15.15
KK-LA(26)	Konstantinoupoleos/Leof.Athinon Node (c. 26)		B	4	6	5.180327869	348.6190476
KIO-AA(14)	Iera Odos/Agias Annis Node (c. 14)	A,B,C	A	5	7	4.540983607	1569.238095
KL-K(25)	Lenorman/Konstantinoupoleos Node (c. 25)		B	4	8	6.352459016	233.7297619
KIO/P(27)	Iera Odos/Pireos Node (Keramikos) (c. 27)	B,C	A	6	6	4.795081967	560.8785714
SL(9)	Larissis Station Node (c. 9)	B	A	7	8	6.590163934	167.027381
KS(10)	Sepolia/OSE Lines Node (c. 10)	B	B	2	8	7.18852459	81.5047619
LS(22)	Skouze Hill Node (c. 22)	A,B,C	A	2	8	6.631147541	81.30119048
LIK(22,23)	Ippios Kolonos Node (c. 22,23)	A,B,C	A	3	8	6.090163934	245.9011905
AP(23)	Akadimia Platonos Node (c. 23)	A,B,C	C	3	3	5.467213115	333.0678571
AT/AK(24)	Urban Pockets-Empty shells (c. 24)	A,B,C	C	3	8	7.37704918	4.166666667

According to the results of the algorithms applied, the nodes KH-TD(12), KP/S(13), POS1, POS2, Thst, KIO-AA(14), KIO/P(27), PIR20, Osq, KEO-IO(20), KL-K(25), Asq, Ksq seem important for the network cohesion, due to the high values of degree and betweeness centrality. Among the nodes proposed for interventions, the nodes KH-TD(12) described as Chamosternas/Tavros Node (c. 12), KP/S(13) described as Piraeus/Skilitsi Node (The Gate of Piraeus) (c. 13), KS/K(15) decribed as Siggrou/ Kallirois Node (c. 15), KIO/P(27) described as Iera Odos/ Pireos Node (Keramikos) (c. 27), KIO-AA(14) described as Iera Odos/Agias Annis Node (c. 14), SL(9) described as Larissis Station (c. 9), KEO-IO(20) described as Ethniki Odos / Iera Odos Node (c. 20),KEO-L(21), described as Ethniki Odos/ Lenorman Node (c. 21), KL-K(25) described as Lenorman/Konstantinoupoleos Node (c. 25) seem to contribute greatly to the cohesion of the network configuration.

NETWORK CONFIGURATION VISUALIZATION

In order to visualize the network configuration in accordance to the priority given at the proposed interventions (interventions of a, b and c priority), the following rules were applied:

- initially the problematic nodes are removed from the network
- at the following stages the nodes are introduced gradually, depending on the priority given on them. (Figures 6,7,8,9).

More specifically, initially (Figure 6) the network consists of the existing nodes (82.11%) and not those proposed for interventions.

At the second time-lapse (Figure 7) the nodes belonging to category "priority a" are introduced (6.5%; see table 4). The resulting configurations of the urban body are based upon the hypothesis that even though the nodes proposed for interventions exist spatially, they exhibit a dysfunctional behavior in what concerns their contribution at the coherence of

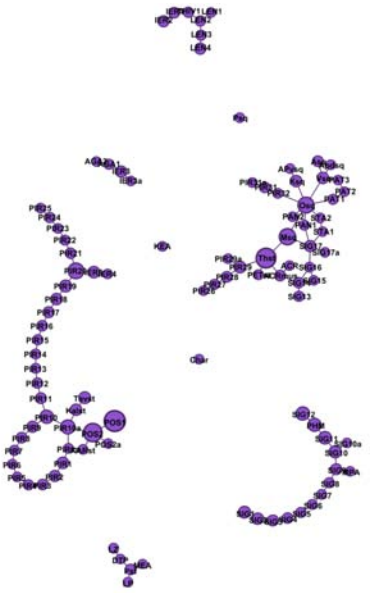


Figure 6
Time lapses of the self-adaptations of the network construction, in accordance to the priority given at the proposed interventions. The nodes' colour corresponds at the priority given, while the size of the node depicts the value of the betweenness centrality algorithm. The nodes of the category "proposed for interventions" are missing.

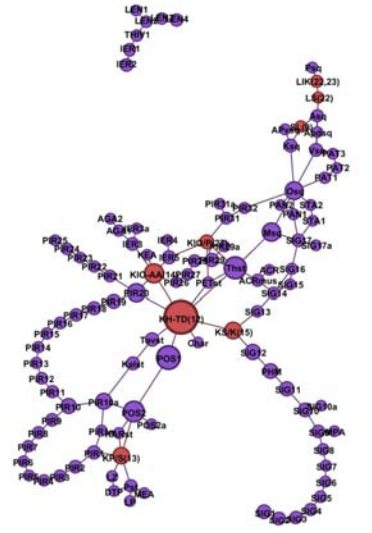


Figure 7
The nodes of the category "Priority a" are introduced.

the whole. At the network configuration presented here, it is assumed that if a node doesn't contribute at the coherence of the network, due to the discontinuity, it creates at a spatial basis and/or at an attribute basis, it is removed from the network and the resulting sub-network is re-adapted and re-organized.

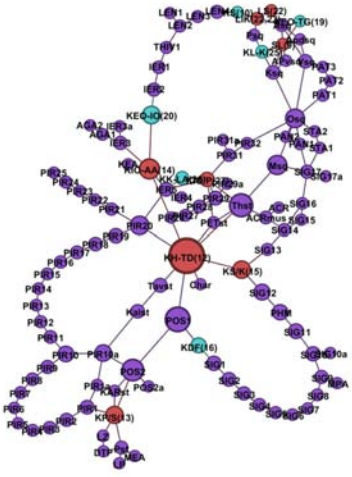


Figure 8
The nodes of the category "Priority b" are introduced.

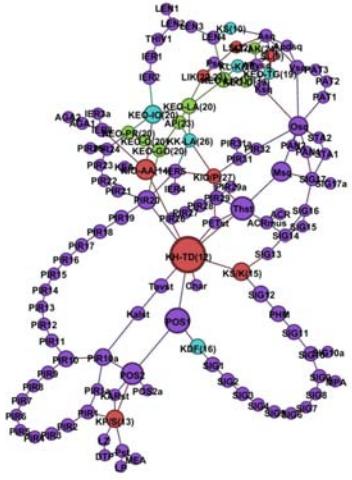


Figure 9
The nodes of the category "Priority c" are introduced.

At the third time-lapse (Figure 8) the nodes belonging to "priority b" are introduced (4.88%; see table 5).

Finally, the nodes belonging to "priority c" are introduced (6.5%; see table 6).

The nodes' attributes which refer to their inclusion to categories such as interventions of priority a,b,c, as well as intervention of a, b and c phase of completion refer to attributes such as

- the funding potentiality,
- their capability to trigger the development of compensatory uses,
- their competence with other proposed interventions,
- their capability to provoke multiscale alterations (concerning the Attica Region, via-municipal or inter-municipal),
- the ability to substantiate the proposed intervention in discrete phases which enable a gradual funding accordingly,
- their contribution at the amelioration of the environmental conditions and the residential quality.

CONCLUSIONS

To conclude, the network configuration in the case where attributes are inscribed as characteristics of the nodes they refer to supplies us with information in what concerns the betweenness centrality and degree centrality values, which is an importance measure of

- the nodes' ability to act as umbilical cords to the network configuration we refer to
- the nodes being strongly connected with other nodes in the network

This way, is possible to flourish the criteria of consequent interventions on problematic nodes and therefore form a strategy of interventions in different instances (phase a, phase b, etc) which would mean a

Table 4

KH-TD(12)	Chamosternas/Tavros Node (c. 12)
KIO-AA(14)	Iera Odos/Agias Annis Node (c. 14)
KS/K(15)	Siggrou/Kallirois Node (c. 15)
KP/S(13)	Pireos/Skilitsi Node (The Gate of Piraeus) (c. 13)
KIO/P(27)	Iera Odos/Pireos Node (Keramikos) (c. 27)
LIK(22,23)	Ippios Kolonos Node (c. 22,23)
SL(9)	Larissis Station (c. 9)
LS(22)	Skouze Hill Node (c. 22)

Table 5

KEO-IO(20)	Ethniki Odos/Iera Odos Node (c. 20)
KDF(16)	Delta Falirou Node (c. 16)
KK-LA(26)	Konstantinoupoleos/Leoforos Athinon Node (c. 26)
KL-K(25)	Lenorman/Konstantinoupoleos Node (c. 25)
KS(10)	Sepolia/OSE Lines Node (c. 10)
KEO-TG(19)	Three Bridges Node (c. 19)

Table 6

KEO-LA(20)	Ethniki Odos/Leoforos Athinon Node (cc. 20)
KEO-L(21)	Ethniki Odos/Lenorman Node (c. 21)
KEO-GO(20)	Ethniki Odos OSE Lines Node (c. 20)
AP(23)	Akadimia Platonos Node (c. 23)
KEO-PR(20)	Ethniki Odos/Petrou Ralli Node (c. 20)
KEO-D(19)	Ethniki Odos/ Dirrachiou Node (c. 19)
KEO-O(20)	Ethniki Odos/Orfeos Node (c. 20)
AT/AK(24)	Urban Pockets/Empty Shells (κωδ. 24)

selection of certain nodes to be rehabilitated at an earlier stage, according to their contribution to the acquisition of a coherent form of the network construction.

REFERENCES

Alexander, C 1965, 'A City is not a Tree', *Architectural Form*, 122(1), p. 58–61

Bateson, G 1972, *Steps to an Ecology of Mind*, University of Chicago Press, Chicago

Blondel, VD, Guillaume, JL, Lambiotte, R and Lefebvre, E 2008, 'Fast unfolding of communities in large networks', *Theory and Experiment*, 10

Hillier, B and Vaughan, L 2007, 'The city as one thing', *Progress in Planning*, 67, pp. 205 - 230

Maturana, H 2002, 'Autopoiesis, Structural Coupling and Cognition', *Cybernetics & Human Knowing*, 9, pp. 5-34.

Newman, MEG 2010, *Networks: An Introduction*, Oxford University Press, Oxford New York