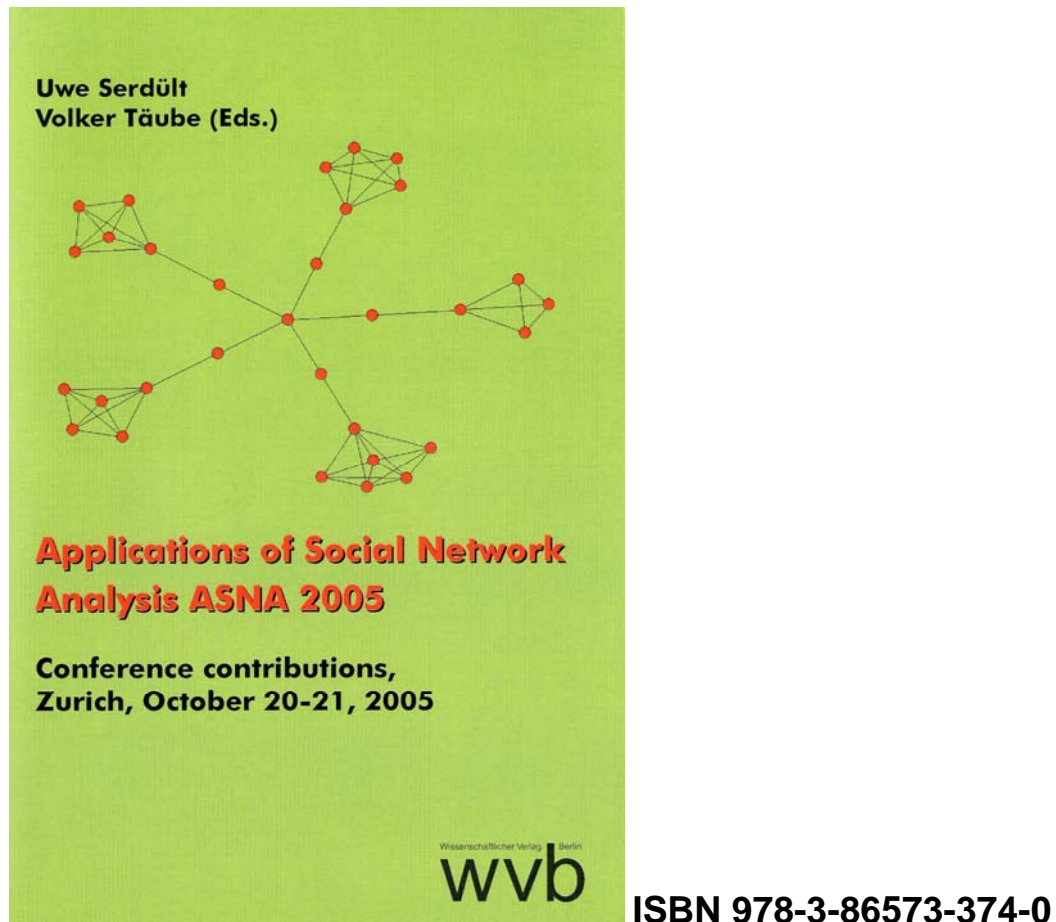


Friemel, Thomas N. (2008): Hierarchical Structures in Digraphs – Measurement and Interpretation. In: Serdült, Uwe/Täube, Volker G. (Eds.): Applications of Social Network Analysis ASNA 2005. Berlin: Wissenschaftlicher Verlag, p. 341-356.



# Hierarchical Structures in Digraphs – Measurement and Interpretation

*Friemel, Thomas, University of Zurich*

## 1 Introduction and theoretical Background

The hypothesis of a multi-step flow of communication, in which the recipients are not only influenced directly by the mass media, but rather by the interpersonal communication, presented 60 years ago an essential paradigm change in communication science. The hypothesis formulated by Lazarsfeld, Berelson and Gaudet of the two-step flow of communication (1968 [1944]) and the subsequent hypothesis of the multi-step flow of communication (Rogers/Shoemakers 1971: 209) were intensively examined in the following years and therefore Weimann refers to several hundred empirical studies, which emerged during the 1960's, „the golden age of opinion leaders“ (Weimann 1994: 29). Designating for this research area is that the focus is not lying on the entire structure of the interpersonal communication but rather on the identification of single roles, all ahead the opinion leaders. Therefore the field is often labelled Opinion Leader research. The identification of opinion leaders and their persuasion should simplify, according to wishful thinking, the persuasion of the broad public. Parallel to the development of the social network analysis, the method to identify communication roles was permanently improved and developing from the self-attribution, as it was used in the early Columbia studies (Lazarsfeld et al. 1968), to the nomination and verification through the interaction partners (Merton 1949; Katz/Lazarsfeld 1962; 1965) to an actual network analyses in the medical innovation study (Coleman/ Katz/ Menzel 1966). In spite of these methodical developments and corresponding theoretical insights<sup>1</sup>, a structural analysis of the examined communication networks stayed extensively away. This astonishes even more because implicitly a hierarchical structure of the interpersonal communication networks is expected in the multi-step flow of communication. Those references, regarding the network position of opinion leaders, either refer to a ‘strategic’ (Homans 1950: 183, Katz/Lazarsfeld 1962: 41, 128; Berelson/Lazarsfeld/McPhee 1963: 110) or central position (Müllers 1970: 157;

---

<sup>1</sup> „[...] one might properly speak less of leaders than of a complex web of opinion-leading relationships“ (Berelson/Lazarsfeld/McPhee 1963: 109).

Schenk 1993: 256) without defining these more precisely. The references of Weimann as well as of Schenk proposing that at least two strategic communication roles are to be distinguished, lets divine that simple centrality measures don't meet the complexity of the object (Weimann 1982: 768; 1994: 81; Schenk 1989: 413; 1983: 333). While 'marginals' (peripheral network position) are responsible for the connection between different groups and its information is primarily forwarded to the 'centrals' (central position), these subsequently provide the connection for the internal group communication. Finally according to the reference of Burt on the significance of structural holes (1992), the development of the structural equivalence (Lorrain/White 1971) and the investigation of brokerage roles (Marsden 1982; Gould/Fernandez 1989; Täube 2004), this differentiation does not seem to be sufficient anymore. The considerations of these additional structural features in the mass media research (e.g. Friemel 2003 for the use of Brokerage-roles) however form the exception.

Even though the mentioned analysis of the various communication roles provided important insights into the media effects mediated by interpersonal communication, it seems like the view for the whole picture got lost by focusing on the different communication roles.

## 2 Research Questions

The multi-step flow of communication hypothesis implicitly assumes a hierarchical structure of interpersonal communication where the information flows in a first step from mass media to the top level of the interpersonal communication hierarchy (the opinion leaders) and in the next steps runs down this structure. But instead of analyzing the structure of the interpersonal communication, the majority of research conducted around this research topic focused on the identification of different communication roles. The actual research interest changed to the question which attributes are typical for the opinion leaders and how they can be identified, reached and persuaded in the most effective way. Even though a network analytic definition of communication roles include by definition basic structural aspects (i.e. indegree) the analysis of the implicitly assumed hierarchization remained locally bounded. The view for the big picture (the hierarchization) got lost by focusing on the communication roles. Therefore it is the goal of this contribution to (a) assess in a first step how and to what extent hierarchical structures can be ascertained for the interpersonal communication and (b) discuss the classic hypothesis in a second step by testing whether distinct individual attributes are detectable for the different hierarchy layers (especially regarding the media use).

### 3 Method and Research Setting

In order to analyse the above-mentioned questions, data of interpersonal communication in school classes was collected by a rooster study. School classes were chosen because they enable the analysis of a complete network with reasonable effort. Beside the fact of an ideal group size (15-25 persons) they represent an important part of the social life of every student (30-40 hours of interaction every week and stability over several years) and are homogeneous considering various (possibly intervening) aspects like age and education. In the four examined school classes of a Swiss grammar school (N=86, average ages 16) the possession and use of mass media as well as the flow of information (interpersonal communication) were examined regarding the subject of 'music'. This subject proved to be, according to a prior study, the central conversation subject for youth in this age. Since no longitudinal data were recorded, this research is not a classical diffusion study, but rather an investigation of a general but nevertheless directed communication structure (digraph) of the school classes under study. The direction and strength of the information flow were measured with a rooster question where every student had to indicate on a five point scale, how often they get and give information to the other class mates. Therefore, every dyad is described by four values (the information flow from A to B, perceived by A and B and the information flow from B to A, perceived by both persons). The four (valued) values were reduced to an asymmetric binary dataset by calculating the average of the two corresponding values in a first step (mean of the value indicated by the two persons for the information flow in one direction) and applying a threshold in a second step. The further analysis therefore refers only to the strong ties and every dyad is either connected by a mutual, an asymmetric or a null (absent) relation.

### 4 Empirical Testing

Since there are hardly any prior studies conducted on this topic, it seems to be appropriate to use a combination of different indices and methods to approach the research questions. To investigate the first research question, how and whether hierarchical structures in the existing networks are detectable, four methods are applied: the graph centrality according to Freeman (1979), the hierarchy indexes according to Krackhardt (1994) and the triadic census according to Davis and Leinhardt (1972). These methods are supplemented through the concept of the symmetric-acyclic decomposition (de Nooy/Mrvar/Batagelj 2005), for whose interpretation two indices are proposed. The different hierarchical layers, which are assessed by means of the symmetric-acyclic decomposition, serve in the end as the unit of analysis for the second research question,

namely whether distinct characteristics can be assessed for individuals on different hierarchical layers of an interpersonal communication structure (b).

#### 4.1 Identification of hierarchical structures in digraphs (a)

The methods discussed in this section represent four distinct approaches even though analogies can be found between some of them. While this chapter primarily describes the methods in an isolated manner, the differences between them are discussed in chapter 5.

##### *Graph Centrality*

The notion of “prestige” refers to a ranked order as we expect it in a hierarchical network. For this reason it makes sense to have a closer look at the various centrality and prestige measures (Wasserman/Faus 1994: 169-219). Most of the time these measures are calculated for single actors (actor centrality). To describe the structure of the whole network, all actor centralities in one network can be aggregated to a single graph centrality. The concept of graph centrality expresses how homogeneous the centrality values are distributed in a network. For this, the difference between the highest centrality value and all remaining centralities is calculated and set up for the purpose of normalization into the relation to the theoretically highest deviation (Freeman 1979). The well-known centrality measures, which are defined mostly for single participants (e.g. degree-, betweenness-, closeness-, eigenvector centrality) are the base for the calculation. In the following, the degree-, betweenness- and the eigenvector centrality are calculated because the closeness-centrality is not defined for networks with isolated vertices and therefore it would be only applicable for one of the examined digraphs.

All measures have in common that for a star-shaped (radial) network they take on the maximal value 1 and for circles and complete graphs the minimal value 0.

*Tab 1: Graph Centralities according to Freeman (1979)*

<b>Centrality measure</b>	<b>School class</b>			
	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
Degree	0.11	0.13	0.12	0.10
Betweenness	0.06	0.23	0.13	0.05
Eigenvector	0.47	0.26	0.36	0.42

Tab. 1 refers to a relatively little centrality of the observed networks and their divergence is an effect of their different conception. Because the degree and betweenness centrality are solely defined for symmetric data, only the results for the eigenvector centrality are considered. It shows that class B with a value of

0.26 falls clearly away from the remaining classes which have values between 0.36 and 0.47. This is an indicator that class B might be less hierarchical than the other classes.

*Hierarchy indices according to Krackhardt*

Krackhardt builds up his considerations for hierarchy indices by starting with a perfectly hierarchical structure, the so-called outtree. The four conditions, which are necessary and sufficient for an outtree are then used to calculate how close a structure match this ideal structure. These four conditions are: „1. The digraph is connected. 2. The digraph is graph hierarchic. 3. The digraph is graph efficient. 4. Every pair of points in the digraph has a least upper bound” (Krackhardt 1994: 95). The deviation of these four indices from the idealized structure is expressed by values between 0.0 (criteria is not accomplished) and 1.0 (equals the outtree).

Tab 2: Hierarchy according to Krackhardt (1994)

Condition	School class			
	A	B	C	D
Connectedness	0.65	1.00	0.91	0.89
Hierarchy	0.76	0.55	0.66	0.80
Efficiency	0.98	0.91	0.90	0.92
LUB	0.54	0.74	0.91	0.78
<b>Sum</b>	<b>2.9</b>	<b>3.2</b>	<b>3.4</b>	<b>3.4</b>

Tab. 2 shows that the numbers of dyads, which mutually cannot reach each other, are the highest in class A and therefore contains a low value for the *connectedness*. The requirement of *hierarchy* expresses how many dyads have mutual choices, which represents an injury of the graphs hierarchy. In the examined networks, an injury of this condition is especially recognizable for class B. The *efficiency* as a third feature tests whether the networks do not contain any surplus connections, whereby the smallest necessary amount of connections (N-1) is serving as the test value. All four networks show a quite high efficiency (values over 0.90) whereas; there are bigger differences between classes for the condition of the *least upper boundedness*. This condition is especially injured if a vertex has a higher indegree than 1 and therefore is standing in parallel „dependence“ of multiple information sources. Although Krackhardt doesn't propose that, here an addition of the four values to one sum is applied. This is a reduction of the complexity to a single index. It shows that especially class A falls away from the other networks (2.9 vs. 3.2 – 3.4). This indicates that class A

serves the criteria the least, followed by class B and at the top end are classes C and D with equal index values.

### *Triad Census (Ranked Clusterability)*

The *triad census* as a third analysis method is based on the assumption that for the structural analysis of a network it is sufficient to analyse smaller sub-networks (de Nooy/Mrvar/Batagelj 2005: 207; Wasserman/Faus 1994: 602)<sup>2</sup>. Which out of these 16 different triads are typical for a hierarchical network is based on theoretical considerations. One of the very few analyses on this topic was conducted by Davis and Leinhardt, whose study builds on the propositions of George Homans about the structure of social groups (Davis/Leinhardt 1972; Homans 1950). According to Homans assumptions, “small groups inevitably generate a social structure which combines subgroups (cliques) and a ranking system” (Davis/Leinhardt 1972: 218). This ranking system of various levels of individuals and subgroups correspond to what this paper calls a hierarchical structure. While the triads of the Types 003, 102, 021D, 021U, 030T, 120D, 120U and 300 are “permissible” in a hierarchical structure (marked with green circles in Fig. 1), the following triads are not: 012, 021C, 111D, 111U, 030C, 201, 120C, 210 (marked with red squares in Fig. 1). To assess whether the school classes possess a hierarchical structure, the frequency of the different triads are compared to the expected frequency of a random graph<sup>3</sup> (Davis/Leinhardt 1972: 226).

The difference between observed and expected triads is divided by the number of expected triads to an “index of the degree of discrepancy” (David/Leinhardt 1972: 245). This index is calculated both, for the “permissible” and the “not permissible” triads of a clustered and ranked social network.

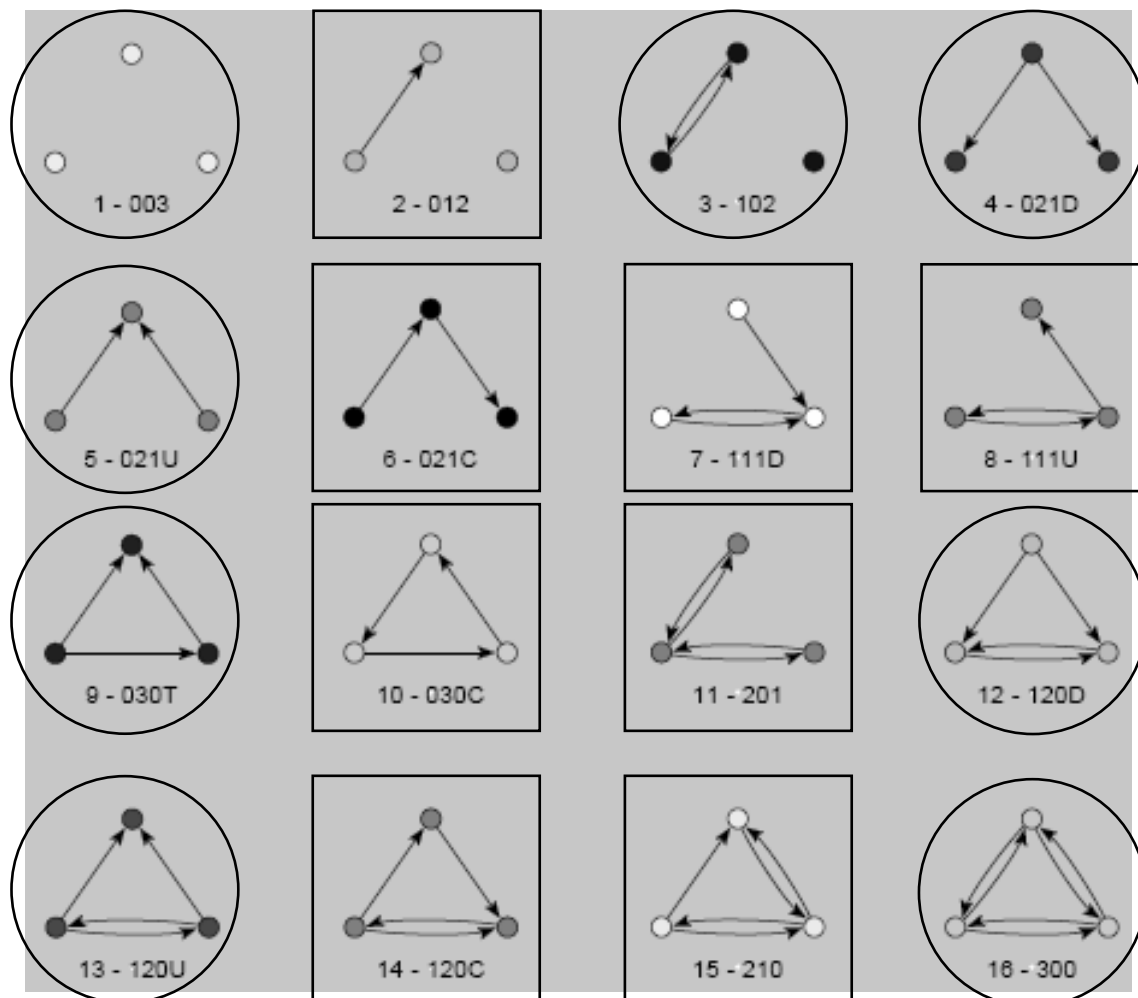
To take account of the presence of “permissible” and the absence of “not permissible” triads, the index of the “not permissible” is subtracted from the index of the “permissible” triads. The results in Tab. 3 show that by means of the measured ratio all network possess the characteristics of a hierarchical network to certain extent. In Network B for example there are 60% more “permissible” triads than expected and 38% fewer “not permissible” triads than expected. This sums to an overall index value of 0.98 for class B which is the highest com-

<sup>2</sup> Analog also as in p\*-Modells (Wassermann/Pattison 1996).

<sup>3</sup> The exact formula states:  $(\text{assessed frequency} - \text{expected frequency}) / (\text{expected frequency})$ . Here the restriction must be noticed that the expected (random) distribution of the triads is not sufficient according to the classical requirements of the statistical tests due to the fact that the different triads are not independent of one another (Wasserman/Faust 1994: 568).

pared to the other three classes. Class A, C and D serve the criteria for a ranked clustered network not to the same extends (values of 0.75 to 0.79).

Fig.1: Triad types and their M-A-N number



Tab 3: Index of the observed frequency compared to the expected number of triads

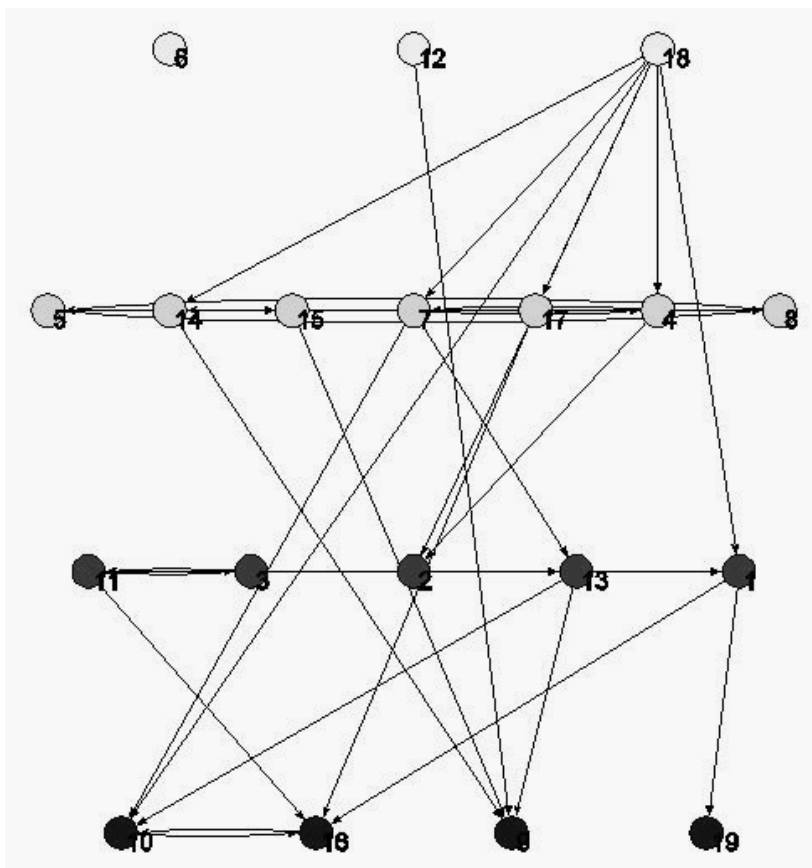
Triadic Types	Index of the degree of discrepancy			
	A	B	C	D
Permissible	0.52	0.60	0.49	0.49
Not permissible	-0.26	-0.38	-0.26	-0.26
<b>Exp – Unexp.</b>	<b>0.79</b>	<b>0.98</b>	<b>0.75</b>	<b>0.75</b>

*Symmetric-acyclic decomposition*

The three methods described above are supplemented by the symmetric-acyclic decomposition as described by de Nooy, Mrvar and Batagelj (2005: 214). In

contrast to the analysis of acyclic networks, which would be also suitable for the investigation of hierarchical structures, a stricter criterion is used for the decomposition. In a symmetric-acyclic network all individuals possessing symmetrical connections (directly or indirectly<sup>4</sup>) are assigned to the same hierarchical layer. In other words: the decomposition into different layers (groups) is made along symmetric and cyclic structure which leaves acyclic connections between the layers. In a graphic representation of a symmetric-acyclic decomposed network all connections between the different layers are aligned in one direction (e.g. top-down direction). Fig. 2 shows this exemplarily for class D.

*Fig. 2: Symmetric-acyclic decomposition of Class D (with Pajek)*



Two indices are proposed here in order to review the hierarchical characteristics of the symmetric-acyclic decomposed network and to enable a comparison of different networks. These two indices are the „direct layer dependency“ (1) and the „verticality“ (2).

The direct layer dependency (DLD) expresses the relation to what extent the layers are connected only with its direct neighbours and not to other layer (by arcs reaching across more than one layer). The DLD is therefore calculated by

<sup>4</sup> Indirect symmetric connections are given if a cyclic structure exist.

the number of arcs which connect direct neighbours, minus the arcs across more than one layer, divided by the total number of arcs between layers.

$$(1) \text{ Direct layer dependency} = \frac{(\# \text{arcs between neighbours}) - (\# \text{arcs across } > 1 \text{ layer})}{(\text{arcs between layers})}$$

If there are solely direct connections, the index reaches the maximal value 1. The minimal value of the index approaches -1 and amounts to exactly 0, if both arc-types are in balance. This index expresses how ordered the flow of information trickles down the hierarchy and how distinct the difference of the various layers is.

Tab 4: Direct layer dependency of the symmetric-acyclic decomposed networks

	School classes			
	A	B	C	D
Arcs between neighbours	10	8	9	10
Arcs across > 1 layer	1	5	6	5
Total arcs between layers	11	13	15	15
<b>Direct layer dependency (DLD)</b>	<b>0.82</b>	<b>0.23</b>	<b>0.20</b>	<b>0.33</b>

The results in 0 show, that the direct layer dependency of class A ( $DLD_A = 0.82$ ) outreaches the other classes clearly (DLD between 0.20 and 0.33) and is pointing toward a hierarchical structure of the network of class A.

The second Index is proposed to get an idea how deep and wide a hierarchical structure is. The *verticality* (2) therefore expresses a ratio of the arcs between the layers to the arcs within the layers. The value area lies between 0 (no verticality) and  $\infty$  (high verticality).

$$(2) \text{ Verticality} = \frac{\# \text{arcs between layers}}{\# \text{arcs within layers}}$$

Tab 5: Verticality of the symmetric-acyclic decomposed networks

	School classes			
	A	B	C	D
Total arcs between layers	11	13	15	15
Arcs within layers	24	28	29	24
<b>Verticality (V)</b>	<b>0.46</b>	<b>0.46</b>	<b>0.52</b>	<b>0.62</b>

4.1.4 shows a more even distribution of the verticality between the school classes than the results of the direct layer dependency. The values range from 0.46 for class A and B to 0.62 for class D.

A deficiency of both formulas is that the extreme case of zero verticality is not defined for the DLD-formula and a pure verticality is not defined for the verticality. If every layer consists only of one node and all nodes are connected in one vertical line (pure verticality) a division by 0 (zero) would occur for the verticality formula, because there are any arcs within the layers. Since both extreme cases can be detected quite easily, this remains a more theoretical than a practical problem.

Combining the two measures for each class, no clear picture is detectable. The calculated indices for class A show a strong DLD but a comparable low verticality value ( $DLD_A = 0.82$ ;  $V_A = 0.46$ ). Class D shows moderate values for both indices ( $DLD_D = 0.33$ ;  $V_D = 0.62$ ) and the classes B and C show moderate to low values ( $DLD_B = 0.23$ ;  $V_B = 0.46$ ;  $DLD_C = 0.20$ ;  $V_C = 0.52$ ). Because of the different value ranges of the two indices it wouldn't make sense to combine them to a single index. One solution to combine the two indices to a single index would be by summing up the ranks of the classes for the two measures.

*Tab 6: Hierarchization of the symmetric-acyclic decomposed networks*

			<b>Rank of the school classes</b>			
			<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
<b>Direct</b>	<b>layer</b>	<b>dependency</b>	1	3	4	2
<b>(DLD)</b>						
<b>Verticality (V)</b>			3.5	3.5	2	1
<b>Hierarchization of the sym-ac.</b>			<b>4.5</b>	<b>6.5</b>	<b>6</b>	<b>3</b>
<b>NW</b>						

This way of reducing the data to a single index is a truly rough way but since there are any reference values available by now, it seems to be the only available solution. The hierarchization index for the symmetric-acyclic decomposed networks indicate that class A and D possess a more hierarchical structure than class B and C (0).

## 4.2 Attributes of individuals on different hierarchical layers (b)

The different measures described earlier were selected in order to test how hierarchical a network is. The last of the four methods, the symmetric-acyclic decomposition, additionally can be used to approach the second research question: "are distinct attributes detectable for the different layers?". The symmetric-acyclic decomposition divides the network in ranked subgroups of nodes for

which mean values for each layer or correlations between every node and its layer-rank can be calculated. This paper focuses on the analysis of the possession and use of mass media devices.

Since the numbers of individuals per layers are partially very low (1-4 nodes) some layers were merged, so that in each network only three (top, medium and bottom) or two layers (top and bottom) were distinguished. Moreover, class B was excluded from the analysis because of a lack of hierarchical structure (see 0). Out of 86 students, 27 of them belong to the top-layer, 16 to the middle and 14 to the lower hierarchical layer (23 persons were in class B and 6 persons were isolated and therefore did not belong to any layer). A mean value comparison showed some significant differences between the layers which are summarised in 0.

*Tab. 7: Differences in the Media use of the different hierarchical layers (Klassen A, C und D)*

Layer	Layer		
	Top	Medium	Bottom
<b>Top</b>	-	Number of Mini-Discs* Frequency music TV**	Number of Mini-Discs**
<b>Medium</b>	-	-	Number of MP3-files* Duration of listening to recorded music*
<b>Bottom</b>	-	-	-

The table has to be interpreted in the way that the rows show a significant (\*) respectively highly significant (\*\*) higher value than the columns. The representatives of the top-layer possess therefore significantly more Mini-Discs than the medium-layer and high significantly more Mini-Discs than the Bottom layer. Individuals from the top-layer additionally watch music TV significantly more frequently than these in the medium-layer. In addition the differences between the medium and the bottom layer include a higher number of mp3-files and a longer duration of music listening by the medium layer.

## 5 Discussion

Because of lacking reference values, the findings of this explorative analysis will be compared not only to its theoretical value range but also against each other. The summary of the different test results (0) is based therefore on a situ-

ational comparison of the empirical results and does not orient itself to objective limits.

Tab 8: Summarised Interpretation of the different Test results

Test method	Clues to hierarchical structures?			
	A	B	C	D
Graph centrality (eigenvector)	Yes	No	Yes	Yes
Hierarchy indexes (Krackhardt 1994)	No	Partially	Yes	Yes
Triadic census	Yes	Yes	Yes	Yes
Symmetric-acyclic decomposition	Yes	No	No	Yes

The summary clarifies that with the methods in use, one arrives at divergent results. If one regards the four variants as equivalent and as supplementary references to a hierarchical structure, then this could point, especially for network D, to be hierarchical. Evidence of classes A and C points toward a hierarchical structure too, while network B does not fulfil the applied criteria at all. This class was therefore excluded from the analysis regarding the media use.

The final results represent a very strong simplification and depending on the application this might be a step to far. It is important to note that the different approaches take into account different aspects of hierarchical structure and depend on the research question not all aspects might be meaningful. In summary, the following aspects are specific for the four approaches:

The concept of *graph centrality* expresses how homogeneous the centrality values are distributed in a network. This might be a first hint for uneven distributed prestige values of the actors but says little about the structure. Of course the results depend strongly on the centrality value which is chosen. This paper promotes the incorporation of the overall structure of a network to analyse the hierarchization. One could argue that eigencentality fulfils this demand sufficiently. By applying eigencentality, the values of the actors can be used to arrange them on a vertical axis (Brandes/Raab/Wagner 2001). Similar to the symmetric-acyclic decomposition this leads to a hierarchical structured picture of the network. The disadvantage of this approach is that injuries of the ideal structure are not restrained (arcs may point against “the general direction”). To take this into account and reduce the complexity to a single hierarchization index, one could calculate, in analogy to the proposed measures for the symmetric-acyclic decomposition, a measure which puts the number of “wrong” oriented arcs into relation to the other (“right oriented”) arcs.

The *hierarchization indices* according to Krackhardt compare the network under study with an outtree, an ideal type of a hierarchical network. Applying four defining characteristics, the deviation to an outtree is expressed on a value range between 0.0 and 1.0.

The *triadic census* and similar approaches which put observed micro structures in relation to probabilistic estimated structures of the same kind, provide the statistical basis to test theories which connect micro and macro structures. These approaches depend on a strong theoretical basis. But since useful micro theories like the balance theory of Newcomb are rare, the assumptions about “permissible” and “non-permissible” might get somehow arbitrary.

The hypothesis of the multi-step flow of communication assumes that ‘opinion leaders’ are more influenced and informed by the media. Actually corresponding references can be found in this investigation. The representatives of the top-layer possess and use significantly more music TV than the medium and the lowest layer. The middle layer is also able to delimit itself from the lowest layer based on the possession of MP3-files and according to the duration of listening to recorded music. In order to track down the classical terminology of the opinion-leading research, one could designate the individuals on the three layers (top, medium, and bottom) also as leaders, exchangers and followers. Simultaneously it has to be referred to that a reinforced media use by the upper layer represents solely a necessary, however, not a sufficient condition for the confirmation of the multi-step flow hypothesis. For a more exact analysis of the hypothesis, a panel-design and on the other hand a very much more specific detection of the media use as well as interpersonal communication would be necessary. The fact that only for four out of altogether 18 media use variables significant differences could be assessed can be explained by the fact of a co-orientation within the four classes (Friemel 2005). Therefore the characteristics regarding the media use in the different classes are mutually equalized.

Comparing the findings of this study with the results of other analysis of the same data, some final conclusions can be drawn. By operationalizing the communication roles by their in and out degrees, which is a much more simpler way than the symmetric-acyclic decomposition, similar findings for the TV use are made. Friemel and Schnell (2005) found that for the degree-based opinion leaders the source for new information is mainly the television (hit parade and music program) while the followers use primarily the radio hit parade. Independent of the operationalization of communication roles (degree-based or structural-analytical-based) television proves to be a medium of the leaders respectively for the ruling layers.

## 6 Limitations

Besides the explorative characteristics of the research setting, which limits generalization statements, there must be some restrictions disclosed for the methods in use. Therefore, the subdivision of the triadic types allows broad interpretation latitude for the expected and not expected elements. This is especially the case,

when no well-defined theory basis is applied such as the balance theory by Newcomb (1954)<sup>5</sup>. This applies to the method of the symmetric-acyclic decomposition, where also broad interpretation latitude is available. Individuals, who are bound solely by means of a single connection into a network, can be incorporated, onto each layer, which (depending on the arcs direction) lies above or beneath the layer it is connected to. Exemplary you can see this by the person no. 12 in Fig. 1. In the existing case, the vertex was adjusted into the uppermost layer; however, it could also be put onto one of the two middle layers.

The biggest deficiency from methodical point of view lies therein, that no purely objective but instead situational-dependent interpretations were selected for the related indices. In comparison with a formal organization structure, the examined networks would have to be classified as not hierarchical. The more so as this is an explorative analysis with strongly diverging network structures and no reference values existed at all, yet the selected procedure appears to be justifiably.

## 7 Contribution

This paper tried to show which methodical possibilities are available for the analysis with respect to hierarchical structures. Even without a systematic variation of the network features, as they are known from simulation studies, it could be assessed that the related indices lead to diverging results. Especially for the application without a strong theoretical background it is recommended to apply a method combination. In comparison with findings, which were made at other places, it could be shown moreover, that the structural operationalization of communication roles show an additional explanation potential for the integral analysis of mass communication and interpersonal communication.

## 8 References

- Berelson, Bernhard R./ Lazarsfeld, Paul F./ McPhee, William N. (1963): *Voting. A Study of Opinion Formation in a Presidential Campaign* (4<sup>th</sup> Ed., Original 1954). Chicago/ London.
- Burt, Ronald S. (1992): *Structural Holes: The Social Structure of Competition*. Cambridge, MA.
- Brandes, Ulrik/Raab, Jörg/Wagner, Dorothea (2001): *Exploratory Network Visualization: Simultaneous Display of Actor Status and Connections*. In: *Journal of Social Structure* 2/4.

---

<sup>5</sup> The statistical problems of this method as well as possible alternatives (p\*) were already mentioned.

- Coleman, James/ Katz, Elihu/ Menzel, Herbert (1966): *Medical Innovation: A Diffusion Study*. Indianapolis.
- Davis, James A./Leinhardt, Samuel (1972): *The Structure of Positive Interpersonal Relations in Small Groups*. In: Berger, Joseph/Zelditch, Morris Jr./Anderson, Bo (Eds.): *Sociological Theories in Progress*, Vol. 2. Boston, p. 218-251.
- de Nooy, Wouter/ Mrvar, Andrej/ Batagelj, Vladimir (2005): *Exploratory Social Network Analysis with Pajek*. Cambridge.
- Freeman, Linton C. (1979): *Centrality in Social Networks. Conceptual Clarification*. In: *Social Networks* 1, p. 215-239.
- Gould, Roger V./ Fernandez, Roberto M. (1989): *Structures of mediation: A formally approach to brokerage in transaction networks*. In: *Sociological Methodology* 19, p. 89-126.
- Homans, George C. (1959): *The Human Group*. New York.
- Katz, Elihu/ Lazarsfeld, Paul F. (1962): *Persönlicher Einfluss und Meinungsbildung*. München.
- Katz, Elihu/ Lazarsfeld, Paul F. (1965): *Personal Influence. The Part Played by People in the Flow of Mass Communication* (2<sup>nd</sup> Ed., Original 1955). New York.
- Krackhardt, David (1994): *Graph Theoretical Dimensions of Informal Organizations*. In: Carley, Kathleen M./ Prietula, Michael J. (Eds.): *Computational Organization Theory*. Hillsdale, p. 89-111.
- Lazarsfeld, Paul F./ Berelson, Bernard/ Gaudet, Hazel (1968): *The People's Choice* (3<sup>rd</sup> Ed., Original 1944). New York/ London.
- Friemel, Thomas N. (2003): *Kommunikationsrollen - An der Schnittstelle von interpersonaler Kommunikation und Massenmedien? Eine Netzwerkanalyse in Schulklassen unter besonderer Berücksichtigung der Multi-Step-Flow of Communication Hypothese*. Lizentiatsarbeit, Universität Zürich.
- Friemel, Thomas N. (2005): *Mediennutzung und interpersonale Kommunikation im Kontext von Schulklassen*. Forschungsreferat an der Tagung der DGPs Fachgruppe Medienpsychologie, 7.-9. September, Erfurt.
- Friemel, Thomas N./Schnell, Kevin (2005): *Überschätzte Meinungsmacher. Auf der Suche nach Opinion Leaders*. In: *Media Trend Journal* 20/1-2, p. 56-58.
- Homans, George C. (1950): *The Human Group*. New York.
- Lorrain, François/ White, Harrison C. (1971): *Structural Equivalence in Social Networks*. *Journal of Mathematical Sociology* 1, p. 49-80.
- Marsden, Peter V. (1982): *Brokerage Behavior in Restricted Exchange networks*. In: Marsden, Peter V./ Lin, Nan (Eds.): *Social Structure and network Analysis*. Beverly Hills, p. 201-18.
- Müller, Peter (1970): *Die soziale Gruppe im Prozess der Massenkommunikation*. Stuttgart.

- Newcomb, Theodore M. (1953): An approach to the study of communicative acts. In: *Psychological Review* 60, p. 393-404.
- Rogers Everett M./ Shoemaker, Floyd F. (1971): *Communication of Innovations* (2<sup>nd</sup> Ed.). New York, London.
- Schenk, Michael (1989): Massenkommunikation und interpersonale Kommunikation. In: *Sonderheft der Kölner Zeitschrift für Soziologie und Sozialpsychologie: Massenkommunikation. Theorien, Methoden, Befunde*. Opladen, p. 406-417.
- Schenk, Michael (1983): Meinungsführer und Netzwerke persönlicher Kommunikation. In: *Rundfunk und Fernsehen* 31/3-4, p. 326-337.
- Schenk, Michael (1993): Die ego-zentrierte Netzwerke von Meinungsführern. In: *Kölner Zeitschrift für Soziologie und Sozialpsychologie* 45/2, p. 254-269.
- Täube, Voker G. (2004): Measuring the Social Capital of Brokerage Roles. In: *Connections* 26/1, p. 29-52.
- Wasserman, Stanley/Faust, Katherine (1994): *Social Network Analysis: Methods and Applications*. Cambridge.
- Wasserman, Stanley/Pattison, Philippa (1996): Logit Model and Logistic Regressions for Social Networks: I. An Introduction to Markov Graphs and p\*. In: *Psychometrika* 61, p. 401-425.
- Weimann, Gabriel (1982): On the Importance of Marginality: One More Step in the Two-Step Flow of Communication. In: *American Sociological Review* 47, p. 764-773.
- Weimann, Gabriel (1994): *The Influentials. People Who Influence People*. New York.