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Summary of dissertation

*Modelling the strength of the relations
between telecommunication social network
identities*

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The main objective of this work is to develop and present method, the aim of which is to determine the strength of relation between two identities of telecommunication social network based on the Call Detail Records. Conducted, empirical studies show, that thanks to the developed method, it is possible to determine links between pairs of identities and reflect the relations that occur between them using the strength of relations.

The social network is a social structure that consists of identities, which are connected with each other by the various types of links (relations), and between which the information is exchanged on the basis of common norms and believes [Krupski2003]. The social network can be represented in form of a graph using IT tools. In telecommunications, social network results from the connections between individuals, that use telecommunication services to create and manage relations. These connections describe interpersonal relations that can have various nature. Sample nature of relations defined in psychology are: friendship, love, marriage, propinquity, colleagues and neighbours [Argyle2002]. The subject of presented work are social relations resulting from interactions between individuals or group of people (communities), taking place in accordance with generally accepted standards and practices. There are two types of social relations: social interaction and social conflict [Znaniński2011].

The history of social networks goes back to the 90s of nineteenth century, when the process of the analysis of communities formation began, based on various types of relations that occurred between individuals. It has been shown that communities derive both from personal, informal relations and from formal ones [Tönnies1887]. Further work included the impact of different social and psychological characteristics on the creation of interpersonal relations: gender [Moreno1943], the theory of exchange describing social network as a system of goods exchange between individuals and communities [Blau1964], the characteristics assigned to a specific position in the organization [White1943, Magee2008], and stereotypes of individuals [McPherson2001].

Research related to the analysis of social networks show that the quality of models used for modelling social network is higher, when the nature of relations is taken into account [Liben-Nowell2003]. Many work on social networks describe the link between individuals in a binary form, thus the nature of a social relation between them fades or is shown in a rudimentary way. When treating all relations binary, the analysis of existing social networks is severely limited [Xiang2010], thus it makes difficult to highlight pairs of users that form

strong relations (e.g. family or friends) and weak ones (e.g. acquaintances). The introduction of the strength of relations, involving the valuation of links in social networks, allowed for a better representation of the relations between individuals and initiated research on the importance and role of relations strength in the structure of the social networks. It has been shown that not only the strong ties between individuals are important, but also weak relations can be crucial, especially in the case of links between communities [Granovetter1973]. Current research on the social network analysis focus on determining the strength of relations between individuals, taking into account the social nature of these relations. Based on the analysis of social media such as Facebook¹ and Twitter², predictive variables are determined, that may affect the nature of relations: intensity variables (wall words exchanged, inbox messages exchanged, friend's photo comments), intimacy variables (individual's number of friends, wall intimacy words, appearances together in photo, friend's relationship status), duration variable (days since first communication), reciprocal services variables (links exchanges by wall post, applications in common), structural variables (number of mutual friends, groups in common), emotional support variables (wall and inbox positive and negative emotion words) and social distance variables (age difference, educational difference and political difference) [Gilbert2009].

The proposed method allows to determine the strength of ties between individuals based on the qualitative attributes of relations, resulting from the parameters of interpersonal communication. Presented method is associated with a number of research challenges, because its development have to be preceded by a detailed literature analysis. The results of performed analysis are covered in the first part of dissertation.

Taking into account the research directly related to the proposed concept, it is necessary to draw attention to the specific issues of this method: the creation of social networks and their analysis, the modelling of relations between individuals, as well as the representation of social networks with the use of information systems.

The creation of social networks is associated with the need to identify elements that affect the form of this network, and with the possibilities of social network usage. The research conducted over social networks concerned sample

1 <https://www.facebook.com/>

2 <https://twitter.com/>

usage of these networks in biology, medicine [Barabási2011], computer studies [Easley2010] and telecommunication [Filipowska2015]. Each type of network has a specific structure with attributes used to present this structure, concerning both individuals and relations, and values that these attributes can take. Social network analysis is, however, an approach aimed at exploring social structures, focusing on the social context of an individual and the relations between individuals, and not on the properties of individuals [Wasserman1994]. Therefore, in the presented work, the methods used in social network analysis were examined, based on which the attributes used to describe elements of social networks and methods for calculating the values of these attributes were identified.

Modelling ties between individuals require a detailed analysis of the available methods used for describing relations. The identification of mechanisms, by which social networks are evolving is a challenging research for the understanding of situations, in which the connections between individuals are created, and that consequently alter the structure of the network in time [Liben-Nowell2003]. As a part of prepared dissertation, the analysis of the homophily of identities and its impact on relations was performed [McPherson2001], as well as the identification of factors influencing the description of relations, such as the complexity and methods used for measuring the relations [Ansari2011]. The concept of the strength of relations was derived, that involves the valuation of links in social network, which allows a better representation of the relations between individuals. Using the examples of research related to the analysis of ties between users of social networking sites like Facebook [Kumar2012] or Flickr [Zhuang2011], the quantitative attributes were identified, used to measure the strength of relations. These research were the basis for further experiments in the domain of social network, especially related with the identification of qualitative attributes [Gilbert2009]. In addition, due to the focus on telecommunication social network in presented dissertation, the analysis of available methods was performed, that were designated to calculate the strength of relations between individuals based on Call Detail Records, and the limitations imposed by the quantitative attributes of relations were described [Kazienko2009].

The analysis of telecommunication data needs a relevant class of tools. The challenge is to choose such tools, which will enable the modelling and efficient processing of the graph data structures used in telecommunication

social networks. Experiments carried out in presented research enabled the selection of tools adapted to the graph structure of the network and allowed for the implementation of the data model, that reflects the connections in telecommunication networks, while providing a high efficiency of data processing.

The research conducted on the development of method for measuring the relations strength resulted in additional contribution to the science. Through the literature analysis, the importance of proper representation of the nature of relations between individuals using their strength has been indicated. Moreover, a new research domain of the qualitative attributes of ties for relations occurring in social network has been identified. The research problem associated with the qualitative attributes in telecommunications has not yet been formulated, and consequently there are no reports of attempts to create similar method. A separate contribution is a part of dissertation that focuses on the analysis of tools for data storage and management, which allows a comparison of available solutions, that could have not been made solely based on the analysis of literature.

The process of testing method for measuring the strength of relations between telecommunication social network individuals requires the preparation of an appropriate test data set. Further part of dissertation presents the data and procedures that were used to create the test data set. It describes the structure of the source files containing Call Detail Records and presents statistics for the entire set of events, taking into account both network parameters of the nodes, like number of callers and receivers, as well as related to the edges, which include the number of events, relations and the parameters of those relations. In addition, a data model used in graph database was proposed an the import of data was carried out for the relevant tools, in order to conduct further research in case of measuring the strength of relations.

The description of the method is presented in the third part of the dissertation. The first stage was the identification of qualitative attributes of relations in telecommunication social networks. Based on the examples of research conducted for other networks, along with the literature analysis from sociological [Morreale2007, Granovetter 1973] and psychological [Argyle2002] domains, three qualitative attributes of relations in telecommunications were listed, that were included in the proposed method: reciprocity, intimacy and closeness. For each of these attributes, the parameters of telecommunication

events were identified, that may affect them. Among identified parameters, following can be listed: the type of service, number of events, the duration of an event, the time of the day and the activity time of an individual. Moreover, it described the questionnaire research, which was used to test hypotheses related to the impact of the parameters of individual events on the interpersonal relations. Based on the results of conducted questionnaire and the statistics of test data set, mathematical representations of attributes were prepared. These were used to derive the model of the method used to calculate the strength of relations between individuals.

The last step was to verify and validate the developed method using two separate experiments, through conducting the comparison of results of proposed method with results of a basic, commonly used method. The first experiment included the calculation of the strength of relations for test data set. As a result, it was possible to compare and analyse, how the proposed, qualitative attributes affect the formation of the strength of relations between individuals. A significant difference between the values of both methods was indicated, stressing the importance of the impact of each attribute on the strength of relations. This experiment proved the thesis about the possibility of modelling the strength of relations based on the qualitative attributes of relations. For the purpose of the second experiment, a mobile application was prepared, that enabled the validation of the proposed method. The aim of the experiment was to confirm a better representation of relation between telecommunication users with the proposed method, than with the basic one and the indication of the potential usage of this method in practice. The achieved results showed that the method of measuring the social strength of ties reflects the telecommunication relations more effectively than basic strength. In 240 cases the social strength was better, and only in 12 cases the basic strength provided better results. Furthermore, the responses indicated the importance of proper representation of relation strength and the possibility to apply the proposed method in practice.

Several fields of applications of the elaborated method can be pointed, and the most promising are:

- the creation and analysis of social networks,
- the analysis and evaluation of the relations between individuals, created and managed using various communication methods,
- social media marketing,
- churn analysis in telecommunication.

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- [Ansari2011] Ansari, A., Koenigsberg, O. i Stahl, F., 2011, *Modeling Multiple Relationships in Social Networks*, Journal of Marketing Research.
- [Argyle2002] Argyle, M., 2002, *Psychologia stosunków międzyludzkich*, Wydawnictwo Naukowe PWN.
- [Blau1964] Blau, P.M., 1964, *Exchange and Power in Social Life*, Transaction Publishers.
- [Barabási2011] Barabási, A.L., Gulbahce, N. i Loscalzo, J., 2011, *Network medicine: a network-based approach to human disease*, Nature Reviews Genetics, , nr 12, s. 56–68.
- [Easley2010] Easley, D. i Kleinberg, J., 2010, *Networks, Crowds, and Markets: Reasoning about a Highly Connected World*, rozdz. The Structure of the Web, Cambridge University Press.
- [Filipowska2015] Filipowska, A., Mucha, M., Perkowski, B., Szczekocka, E., Gromada, J. i Konarski, A., 2015, *Towards Social Telco Applications based on User Behaviour and Relations*, w: 18th International Conference on Intelligence in Next Generation Networks (ICIN), IEEE, s. 95–102.
- [Gilbert2009] Gilbert, E. i Karahalios, K., 2009, *Predicting Tie Strength with Social Media*, w: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, ACM, New York, NY, USA, s. 211–220.
- [Granovetter1973] Granovetter, M., 1973, *The Strength of Weak Ties*, The American Journal of Sociology, tom 78, nr 6, s. 1360–1380.
- [Kazienko2009] Kazienko, P. i Ruta, D., 2009, *The Impact of Customer Churn on Social Value Dynamics*, International Journal of Virtual Communities and Social Networking, tom 1, nr 3.
- [Krupski2003] R. Krupski, *Zarządzanie strategiczne. Koncepcje. Metody.*, Wrocław: Wydawnictwo Akademii Ekonomicznej we Wrocławiu, 2003.
- [Kumar2012] Kumar, A., Rao, T. i Nagpal, S., 2012, *Contemporary Computing*, tom 306, rozdz. Using Strong, Acquaintance and Weak Tie Strengths for Modeling Relationships in Facebook Network, Springer, s. 188–200.
- [Liben-Nowell2003] Liben-Nowell, D. i Kleinberg, J., 2003, *The Link Prediction Problem for Social Networks*, w: International Conference on Information and Knowledge Management.
- [Magee2008] Magee, J. C. i Galinsky, A. D., 2008, *The Self-Reinforcing Nature of Social Hierarchy: Origins and Consequences of Power and Status*, w: IACM 21st Annual Conference Paper.
- [McPherson2001] McPherson, M., Smith-Lovin, L. i Cook, J.M., 2001, *Birds of a Feather: Homophily in Social Networks*, Annual Review of Sociology.
- [Moreno1943] Moreno, J.L., 1934, *Who Shall Survive?*, Beacon House Inc.
- [Morreale2007] Morreale, S., Spitzberg, B. i J.K., B., 2007, *Komunikacja między ludźmi. Motywacja, wiedza i umiejętności*, Wydawnictwo Naukowe PWN.
- [Tönnies1887] Tönnies, F., 1988, *Wspólnota i stowarzyszenie*.

- [Wasserman1994] Wasserman, S. i Faust, K., 1994, *Social Network Analysis: Methods and Applications*, Cambridge University Press.
- [Wellman1990] Wellman, B. i Wortley, S., 1990, *Different Strokes from Different Folks: Community Ties and Social Support*, The American Journal of Sociology, tom 96, nr 3, s. 558–588.
- [White1943] White, H. C., 1970, *Chains of opportunity: system models of mobility in organizations*, Harvard University Press.
- [Xiang2010] Xiang, R., Neville, J. i Rogati, M., 2010, *Modeling Relationship Strength in Online Social Networks*, w: Proceedings of the 19th International Conference on World Wide Web, ACM, s. 981–990.
- [Zhuang2011] Zhuang, J., Mei, T., Hoi, S.C.H., Hua, X.S. i Li, S., 2011, *Modeling Social Strength in Social Media Community via Kernel-based Learning*, w: ACM Multimedia, ACM Multimedia.
- [Znanięcki2011] Znanięcki, F. i Hałas, E., 2011, *Relacje społeczne i role społeczne: niedokończona socjologia systematyczna*, PWN.