Revisiting Social Media Tie Strength in the Era of Data Access Restrictions

Jayesh Prakash Gupta[1][a], Hannu Kärkkäinen[1][b], Osku Torro[1][c] and Raghava Rao Mukkamala[2,3][d]
[1]*Unit of Information and Knowledge Management, Tampere University, Tampere, Finland*
[2]*Department of Digitalization, Copenhagen Business School, Copenhagen, Denmark*
[3]*Department of Technology, Kristiania University College, Oslo, Norway*

Keywords: Data Access Policy, API, Tie Strength, Social Media, Tie Strength Models, Weak Ties, Strong Ties.

Abstract: The strength of social ties has an impact on how information is transferred and processed in a social network. Many studies have used social media data to evaluate tie strength. However, many of these studies were done at a time when social media data could be accessed legally without using the social media platform API. In the past few years, there have been significant changes in the data access policies of these platforms, which has led to a considerable reduction in the possibilities of using social media data for tie strength evaluation. The paper aims to study the impact of the data access policy changes of major social media platforms on the existing social media based tie strength models. The findings of this study show that the existing social media based tie strength models can no longer be utilized in their current form. Our study suggests that there is either a need to modify the existing social media based tie strength models or to develop new social media based tie strength models that reflect the recent changes in the data access policies.

1 INTRODUCTION

The concept of strong and weak ties was introduced by Granovetter in his seminal study *The Strength of Weak Ties* (Granovetter, 1973). Personal social ties and networks have been demonstrated as quintessential in the effective information and knowledge transfer. Strong and weak social ties have been studied in many contexts, including knowledge and information management, as well as organization science In more detail, weak ties have been found to be of great importance in encouraging information exchange and avoiding redundancy, while strong ties have been found more likely to facilitate to tacit knowledge transfer. (Gupta et al., 2016) In addition, knowledge workers across different work domains have been found to utilize weak ties to improve their work efficiency in different manners such as locating new useful knowledge (Zhang et al., 2017).

Various models and algorithms to evaluate the tie strength has been developed during the years to detect weak and strong ties from a variety of data sources. Over the decades, the concept of tie strength has been used to study various social phenomena, such as innovation and creativity, knowledge transfer, information diffusion, and content sharing (Gupta et al., 2016). At the same time, the tie strength measurement has been extended from its original use at an interpersonal level to a group-level, organizational level, and inter-organizational level, as well (see (Zhang et al., 2017)).

In the recent decade, the maturation of various social media platforms has provided new avenues for information and knowledge transfer. New models and approaches for detecting social ties and for the evaluation of tie strength has been created, which make use of various types of social media data. In such studies, social media has been found as very prominent in tie detection, and tie strength evaluation and many tie strength evaluation models have been coined for the tie strength(e.g., Gilbert and Karahalios (2009); Jones et al. (2013)). During the last few years, there have been significant changes in the data access policies of major social media platforms, such as Twitter and Facebook (Hogan, 2018). These changes are due to various reasons, including changes in platform companies' business models, changes in data regulations such as the EU-originated GDPR, as well as the

[a] https://orcid.org/0000-0003-4043-4818
[b] https://orcid.org/0000-0003-4753-4416
[c] https://orcid.org/0000-0003-0706-5010
[d] https://orcid.org/0000-0001-9814-3883

Gupta, J., Kärkkäinen, H., Torro, O. and Mukkamala, R.
Revisiting Social Media Tie Strength in the Era of Data Access Restrictions.
DOI: 10.5220/0008067501870194
In *Proceedings of the 11th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (IC3K 2019)*, pages 187-194
ISBN: 978-989-758-382-7

public exposure of unethical conduct related to the use of social media users' data. The aforementioned has undoubtedly impacted the usefulness of social media data in the evaluation of tie strength. Most of the previous studies and the predictors related to social media datamade use of private data, which is no longer legally accessible from major social media platforms (Gupta et al., 2016).

Moreover, while many of the most cited social media-based tie strength models were created before many significant data access changes had taken place, this has presumably affected the usefulness and accuracy of the models, the models' tie strength dimensions, as well as the usefulness of individual tie strength predictors. There is no study that explored the impact of data access changes on the tie strength evaluation, and this paper aims to shed light on the impact of data access changes on the tie strength evaluation. The following is our research question.

RQ: "How the data access changes of major social media platforms impacted the utility of existing social media tie strength evaluation models?"

This study is not only relevant for the overall purposes of tie strength but also for the development of better social recommendation systems based on strong and weak ties (see Huhtamäki and Olsson (2018)). The structure of the paper is as follows. In sections 2 and 3, we first introduce the concept of tie strength, then social media based tie strength models. Then in section 4, we explain the methodology of the paper and section 5 will present our findings. Finally, in section 6, we will discuss the conclusions and future work.

2 CONCEPT OF TIE STRENGTH

The concept of tie strength was originally introduced by Mark Granovetter (1973) in his seminal study "The Strength of Weak Ties". According to him tie strength can be defined as *"a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie"* (Granovetter, 1973). In the original definition provided by Granovetter, the tie strength evaluation was used to understand the different interpersonal relationships. In other words, the concept of tie strength provided the degree of closeness between two individuals (Gupta et al., 2016). However, Granovetter left the more precise definition of tie strength to future work.

In general, strong ties are people whom you trust and whose social circles tightly overlap with your social circle. In the personal context, the strong tie is the people with whom you have a long relationship history, interact regularly and share different life experiences, such as family members. In the professional context, strong ties might be people with whom you work in a project or in the same group, exchange frequent information about work tasks and ask for personal advice. Strong ties provide emotional support and are more stable and easy to rely upon. In the professional context, as well, people rely on their strong ties for protection and comfort in situations of uncertainty. (Granovetter, 1973; Gupta et al., 2016)

On the other hand, weak ties are acquaintances or unfamiliar individuals. Weak ties have been found to provide access to novel information and to help in the diffusion of new ideas, helping to provide also new knowledge for individuals and organizations (Gilbert and Karahalios, 2009; Granovetter, 1973).

Over the past decade, the rise and popularity of social media have given rise to new ways to detect, establish, and manage ties online. The collective process of production, consumption, and diffusion of information on social media are starting to reveal a significant portion of human social life. (Gupta et al., 2016) Thus, the availability and access to social media have led to many new research opportunities in the area of tie strength related research. This has resulted in many studies that use social media data to identify different kinds of online ties by trying to predict the tie strength of these online relationships. In this paper, we refer to tie strength calculated using social media data as **Social Tie Strength**. However, there has been a gradual shift in terms of how these social media platforms share and provide access to their data for different purposes, including research. Hence, there is a need to understand how these data access policy changes of the social media platforms can impact the tie strength models.

3 INFLUENCE OF API ON SOCIAL TIE STRENGTH

3.1 Social Tie Strength Models

In this section, a brief description of the major social tie strength evaluation/calculation is provided. First, we will describe the kind of social media platform, the kind of social media data that was used by the model, and then how the social media data for these studies were collected. These social tie strength models were shortlisted based on the criteria defined in section 4. and based on that criteria, a total of four different social tie strength models are described below.

3.1.1 Model by Gilbert and Karahalios

The first social tie strength model was developed by Gilbert and Karahalios (2009). This was the first model that tried to use social media data to predict tie strength between social media users. According to the definition of tie strength provided by Granovetter, tie strength has different dimensions that can be operationalized using different measures and predictors. In this paper, these different measures and predictors of tie strength were operationalized using the different functionalities/features that were available on the social media platform, especially for Facebook. A total of 74 Facebook variables were used as predictors to measure the social tie strength. The different dimensions of tie strength (written in capital letters) and some of the predictors (written in small letters) used in this model are also shown in Fig. 1. This model used the explicit relationship data of Facebook friends and other explicit Facebook friendship related data of experimental study participants to calculate the tie strength. The social media data for this study was collected by crawling the Facebook page and profile data of the study participant. In this study, the final developed social tie strength model was a linear combination of the predictive variables, the pairwise interaction of the predictive variables and the network structure where the network structure was based on the explicit Facebook friendship data that was crawled from Facebook. This model was later transformed and applied to tie strength calculation using Twitter data. Many of the Facebook predictors, which were used in the previous model, were substituted with similar predictors from Twitter data. However, this Twitter data based tie strength model did not have predictors from all the different tie strength dimensions (Gilbert, 2012).

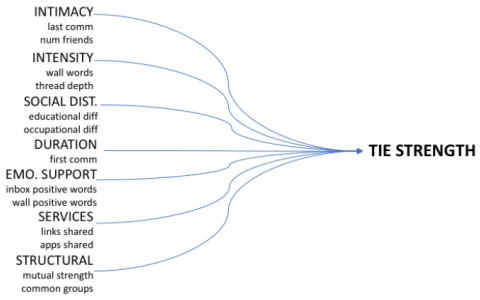

Figure 1: Tie strength dimensions and predictors used in tie strength model by Gilbert and Karahalios (2009).

3.1.2 Model by Kahanda and Neville

Kahanda and Neville (2009) developed a supervised learning model for social tie strength calculation with the goal of detecting strong and weak ties. In practice, this model was able to perform the binary task of predicting whether or not a relationship was strong. The model was based on using Facebook data, which was divided into four different kinds of graphs: friendship graph, wall graph, picture graph, and group graph. From these graphs, a total of 50 different features were constructed and used for classification of the relationship as being strong or not. This model also used explicit relationship data related to Facebook friends. A publicly available social media dataset - Purdue Facebook network was used to carry out this study. However, this data is no longer available due to the change in Facebook terms of service.

3.1.3 Model by Xiang et al.

Xiang et al. (2010) developed an unsupervised learning model for social tie strength to infer relationship strength based on profile similarity and interaction activity. The model was based on the principle of homophily i.e., people tend to form relationships with similar kinds of people. Hence, the model assumed that the stronger the tie, the higher the similarity. The model tried to model the tie strength as the hidden cause of user profile similarities and user interactions. The model used social media data, which was divided into four kinds of graphs: friendship graph, top-friend graph, wall graph, and picture graph. These graphs were used to evaluate the tie strength between the social media users of this study. This model also used the explicit relation data, which was Facebook friends in case of the Facebook dataset and the Linkedin network data in case of the Linkedin dataset. This study used two different social media datasets. The first dataset was a proprietary dataset from Linkedin.com. The second dataset was a public dataset from the Purdue Facebook network. However, this data is no longer available due to the change in Facebook terms of service.

3.1.4 Model by Jones et al.

Jones et al. (2013) developed a logistic regression based-social tie strength model, which could determine how real-world tie strength can be inferred from easily measurable online behavior and demographics using Facebook. The created model was successful in differentiating between the closest friend from not-closest friends in real world relationships. Logistic regression provides the probability based on the provided data features, which in this case was to give the probability about whether two Facebook users of the study were close friends in the real-world. The model was based on only one feature, which was the

sum of all the interactions between the users known as summed interaction. This model also used some private Facebook data of the study participant like the pokes, messages. The social media data for this study was collected using the Facebook Id of the study participants. The study did not specify whether the data was crawled directly or using graph API.

3.1.5 Recent Social Tie Strength Models

In recent years, more social tie strength models have been developed. Many of these models are also listed in the paper by Liberatore and Quijano-Sanchez (2017). However, other than the above mentioned four social tie strength models, all the other social tie strength models are based on the minor modification of the earlier existing social tie strength models. For example, the social tie strength model by Quijano-Sánchez et al. (2014) and social tie strength model by Fogues et al. (2018) are based on the minor modification of the original social tie strength model by Gilbert and Karahalios (2009). Thus based on the existing literature related to the social tie strength model, the above mentioned four social tie strength models are the current state of the art. These four social tie strength models can be considered as representative of all the existing different social tie strength models.

From the description of the different social tie strength model, it can be observed that social tie strength models by Gilbert and Karahalios (2009); Kahanda and Neville (2009) and Xiang et al. (2010) used explicit social media relationship data in order to develop their social tie strength model. Also, the models by Gilbert and Karahalios (2009) and by Jones et al. (2013) used the private social media data of the study participants. Both the explicit relationship data and private user data are no longer accessible from social media. Thus, we want to understand how the changes in social media data access have impacted the utility of the current social tie strength models.

3.2 Impact of APIs on Data Access

The growth of the data on the internet in general and social media, in particular, resulted in the development of certain methods and standardization which could be used to access the data from these social media platforms resulting in the creation of application program interface commonly referred to as API. API became the de facto means by which data could be sent between devices and could be accessed from these platforms. The second most important aspect along with the API was the aspect of authentication, i.e., the authentication that servers use to identify clients (i.e., third parties that work on behalf of users) and provide personalized access based on which client is requesting what data. (Burgess and Puschmann, 2014; Hogan, 2018) The combination of API and authentication, resulted in the creation of a specific kind of API known as authenticated API. These authenticated API could now be used as a technological gatekeeper to the data stored on the social media platforms (Hogan, 2018).

The initial introduction of authenticated API was done to handle the data integrity and data access in a more technically efficient manner by the social media platforms. However, with the growth and proliferation of these social media platforms, these platforms became a significant and vast source of user data. The concept of big data and its commercial value was no longer a buzzword anymore, and the social media was now actually one of the primary examples of how big data could be used for commercial gains. Social media data became one of the most critical areas of the rapidly growing data market. The companies that directly collect and profit from social media data such as social media platforms like Facebook and Twitter and also third-party sellers of social media data like Gnip and Datasift attracted massive valuations. The business models of these companies moved towards providing privileged access to the social media data, and the resulting valuable insights which could be gained from this user-generated social media data. (Burgess and Puschmann, 2014) Researchers, analysts, and consultants suggested that advanced statistical techniques could not only be used to analyze social media data but also make predictions using social media data for multiple use cases in very different fields. Thus, social media platforms could now use their role as the social media data provider in order to drive their business models.

The social media data was now the most valuable asset of these social media platforms and their control of how and who could access this data was essential to their business model. The change in the business model of social media platforms has resulted in the change in the policy of the social media platforms from the initial era of Web 2.0 where the user had the power to a more media-centric business model relying firstly on advertising and corporate partnerships and, secondly on reselling the data produced collectively by the platform's millions of users (Burgess and Bruns, 2012). This shift has been realized practically in the architecture of the platform using the social media platform authenticated API and associated policies, affecting the ability of third-party develop-

Table 1: The major changes in the data access policy of Facebook and its impact on the tie strength related research.

Major changes to Facebook data access policy	***When***	***Overall impact to data access***	***Impact on Tie strength calculation***
Introduction of Open Graph API v1.0	2010	• Systematic way to directly access data from Facebook. • Every data item was assigned a unique id. • Any Facebook app could access all user's Facebook friends and their friend of friend.	• Enabled systematic collection of **large scale tie strength** related data including **explicit relationship data** (Facebook friends) using the unique id.
Introduction of Open Graph API v2.0	2014	• An app could only access user's friends if those friends also authorize the app. • Facebook replaced the like button with reactions button.	• Tie strength related data like **explicit relationship data** and other personal user data **no longer accessible**.
Introduction of Open Graph API 3.0	2018	• Access to data from open Facebook group and Facebook pages severely restricted. • No unique id for same user on different Facebook groups and pages. • Individual approval for every app giving more control to Facebook.	• Tie strength calculation using public data (**open Facebook groups and pages**) **not possible** due to restricted data access. • Severely **limit** the **collection** of **tie strength predictor** related **data** about user due to lack of unique user id.

ers, users, and researchers to access, exploit or innovate upon the social media data of these social media platform (Burgess and Puschmann, 2014). Hence, it is essential to take into account this crucial factor of data access and its impact on the social media related research in general and specifically towards the social tie strength related research. The current study looks specifically into how the changes in the data access policy of the social media platforms (specifically Twitter and Facebook) have impacted the previous research related to social tie strength.

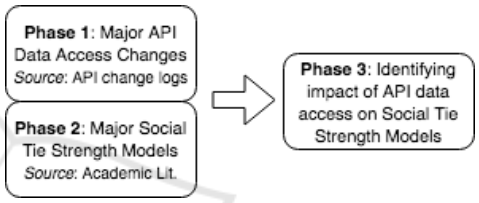

Figure 2: Different phases in conducting this study.

4 METHODOLOGY

In this section, how this research was carried out as explained. This research was carried out pragmatically in the following three different phases. In the first phase, the identification and tracking of the significant data access policy changes were done mainly by analyzing the API changelogs of Facebook and Twitter. In the second phase, the major social tie strength models were identified using particular selection criteria from the webofscience database. In the final phase, the data access policy changes identified in phase one were used to study the impact of these changes on the utility and applicability of the major social tie strength models identified in phase two. This process is also illustrated in Fig 2.

The first phase consisted of identifying and tracking the significant changes in terms of the data access policy of social media platforms that have taken place since the rise of social media platforms. During this phase, we decided to focus on the two most significant social media platforms, which were Facebook and Twitter. Another important reason for selecting these two social media platforms was the fact that these are the most studied platforms in social media research. In order to track and identify the major API changes of these two social media platforms, the API changelogs of Facebook and the API changelogs of Twitter were accessed and analyzed. Along with the API changelogs of the social media platforms, academic articles related to the changes in the API in social media platforms were also searched on the webofscience database, which provided some relevant results (e.g., Burgess and Puschmann (2014); Burgess and Bruns (2012)). The API changelogs of the social media platforms and the relevant academic articles were used in identifying the major data access policy-related changes.

In the second phase, the major social tie strength models were identified. The tie strength models were shortlisted based on a particular selection criterion. These criterion were that: the tie strength model should be based on the original definition of tie strength (hence studies like De Meo et al. (2014) were excluded as this study changed the basic definition of tie strength); the tie strength model should have an independent mathematical formulation; should use only social media data for tie strength calculation(e.g., tie strength models by Onnela et al. (2007) and by Mattie et al. (2018) were excluded since they used call log data and not social media data); should not just be

Table 2: The major changes in the data access policy of Twitter and its impact on the tie strength related research.

Major changes to Twitter data access policy	***When***	***Overall Impact to data access***	***Impact on tie strength calculation***
Introduction of Restrictive API structure	2011	• Twitter streaming API only provides a certain small percentage of overall Twitter live stream data. • No free access to all the past tweets and restriction on amount of data that can be accessed from Twitter.	• **Significant restrictions** to the **volume** and **time period** for which the **user data** could be **accessed** and **collected**. • Streaming API **reduced** the **volume** and **general representation** of **live data** which could be **collected** for tie strength .
Introduction of New Terms of Service	2012	• New rules that favour only large institutions or corporations to collect data. • Restricting large scale data collection (including Twitter metadata & historical data) by apps through limited access tokens. • Push for buying Twitter data officially.	• Limited access tokens **heavily restrict speed**, **duration** & **volume** of **tie strength** related **data** collection from REST API. • **Limited or no access** to **historical explicit relationship data** & other **tie strength** related **predictors** .
Introduction of Premium API and New API restrictions	2018	• New Premium API resulting in reduced access to free REST API & shutting down all data re-sellers. • Data access (REST API) limited to 7 days. • Individual approval for all apps.	• **Access** to the **longitudinal tie strength** related **data** was **severely impacted** as the time window for collecting the historical Twitter data was reduced to just 7 days.

a minor modification of an older tie strength model (e.g., the tie strength model by Fogues et al. (2018) was excluded as it was just a minor modification of Gilbert and Karahalios (2009) model; and other studies had cited the tie strength model. Based on these selection criteria, a total of four major social tie strength models were identified from the webof-science database.

In the third phase, the identified major data access policy changes of the social media platform of phase one were used to study the impact of these data access changes on the major social tie strength models identified in phase two. This allowed the third phase to identify the major impacts the data access policy has had on the tie strength calculation research based on social media. This resulted in the creation of table 1 and table 2.

5 FINDINGS

In this section, the results are presented in the form of two tables (see Table 1 and Table 2). The structure of Table 1 and Table 2 are similar. The first column of both the tables shows what caused a major change in the data access policy of the social media platform. The second column gives the year from when these changes were introduced. The third column provides the overall impact of these changes in the data access policy had to access data from this social media platform. The third column explains impacts to data access related to what kind of data and metadata could be accessed or became inaccessible, the volume of data that could be accessed, the period for which data could be accessed and also the purpose for which the data could be accessed from the social media platform. The final column of the tables explains the specific impact these data access changes had on the tie strength calculation using social media data. It can be seen from Table 1 and Table 2 that the first major changes related to data access policy to Facebook and Twitter happened in 2010 and 2011, respectively. Facebook and Twitter introduced these changes, the primary method of accessing the data from these social media platforms was not just limited to using the API of the respective platforms.

From Table 1, it can be seen that the initial introduction of open graph API v1 made it very easy to get access to large scale tie strength related data including the explicit relationship data about Facebook Friends. This data has been used by all the tie strength models based on social media data, which were described in section 3.1. However, this access to explicit relationship data about Facebook Friends was practically removed with the introduction of open graph API v2. The introduction of open graph API v3 has even made an access and the linking of the public Facebook information about a user almost impossible. Thus, it can be seen that after the introduction of these changes, it is not possible to directly use the tie strength predictors which were used in social tie strength models that were described in section 3.1.

From Table 2 it can be seen that when Twitter introduced streaming API and revoked access to the unlimited historical Twitter data which could be accessed by researchers, it massively reduced the ability of the researchers to get historical Twitter data. There was a further decrease in the volume of data that could be collected from Twitter with the introduction of a limited number of access tokens. For the

tie strength model based on social media in general and specifically the tie strength model developed by Gilbert (2012), it was no longer possible to get access to some significant tie strength predictors like the historical number of followers (explicit relationship data), direct messages and some other relevant predictors. The access to explicit relationship data is essential for the model by Gilbert as it relies on it for accurate tie strength predictions. The introduction of Premium API by Twitter has further reduced the amount of longitudinal tie strength related data that can be accessed.

Thus, it can be seen from Table 1 and Table 2 that it is not possible to directly use the major social tie strength models described in section 3.1 as the access to explicit relationship data which is used by all these tie strength models is no longer possible.

6 DISCUSSION AND CONCLUSIONS

Based the analysis of this study regarding the major social media platforms' data access policies and major-related changes, it seems evident that there have been a lot of significant changes specifically in Facebook's and Twitter's data access. As seen in the previous analysis, these changes are significantly impacting the social media based tie strength research in general, as well as the usefulness and accuracy of currently existing social tie strength models.

In more detail, first it can be seen from the previous analysis that all the current social tie strength models rely heavily on using either explicit relationship data (e.g., friendship data) or private user data (e.g., direct messages) or both from social media platforms. However, this kind of social media data is either no longer accessible (e.g., Facebook Friends, direct messages) or severely restricted (e.g., follower/followee)from access from social media platforms.

Secondly, it can be observed that when some of the initial social tie strength models were created (e.g., Gilbert and Karahalios (2009)) there existed many ways to legally collect social tie strength related data from social media platforms. However, now, APIs are the only legitimate way of accessing and collecting the data from social media platforms (specifically Facebook and Twitter).

Third, researchers cannot access the historical, social media data (e.g., past five years daily Twitter follower count). The current social tie strength models were built using a lot of historical longitudinal social media data. This historical data allowed a more in-depth and accurate tie strength evaluation and calculation, which is no longer possible with the current data access policies of the social media platforms.

To the best of our knowledge, this is the first study that analyses how the changes in the data access policies of the social media platforms have impacted the usefulness and application of the existing social tie strength models.

6.1 Implications to Research

The results of this study have some important implications for the research and researchers of tie strength. First, overall, the relatively recent changes in major social media platforms' policies mean that in the case of all the currently existing social tie strength models, it is impossible to use these models directly, as such, for accurate tie strength prediction and evaluation. This is because all these social tie strength models rely on explicit relationship data and private data from social media, which is no longer accessible.

Second, we are aware that many factors like regulations (such as GDPR), platform business model changes and experiments, public exposure of unethical use of social media data can quickly and sometimes even quite unexpectedly impact the data access policy decisions of social media platforms. However, based on table 1 and table 2, we can see that there is a long-term trend related to particularly limiting or removing the access to explicit relationship data and metadata from social media. We find that tie strength researchers should be prepared to even further significant changes in data policies, which are impacting tie strength research. Tie strength researchers should make themselves quite aware of the risks of such potential changes to their tie strength research.

Third, there is a strong need to shift focus in tie strength research to such approaches that can enable the use of currently available data sources and data items. Tie strength researchers should focus more on using methods that are mainly or solely based on available social media discussions and content. For example, instead of explicit relationship social media data, researchers can use implicitly deduced ties (see e.g., Gupta et al. (2016)) for developing new social tie strength models.

Fourth, tie strength researchers should look at the existing wide variety and different kind of theoretical approaches and other approaches that have been used in other research areas or with other kinds of social data (e.g., Mattie et al. (2018))and may be suitable for social tie strength research. For example, such methods could include different kinds of existing and recently built triadic closure models (see Huang et al.

(2015)) that help to make use of implicitly deduced or predicted and potential social ties.

Finally, researchers should try to identify new legal, sustainable, and innovative ways to access social media data. These include buying social media data, collaboration with other researchers in gaining necessary social media data, and also combining additional data and other data sets to existing social media data. For example, making better use of location and co-location data and combining it with existing social media data to make new social tie strength models.

6.2 Limitations and Future Research

This study has certain limitations. Firstly, this study only focused on analyzing the changes to data access policy of two social media platform - Facebook and Twitter and not the other social media platforms. Secondly, this study did not explain the exact technical details of the limitations introduced by the different social media API versions(e.g., exact rate limits, exact accessibility of different data items). Finally, this study did not analyze how the new social media platform feature changes (e.g., increase in the Tweet length from 140 to 280 characters) can impact the current social tie strength models.

This study leaves room for future studies. First, in the future, a similar study could be done for some other popular social media platforms Second, a study about how the current social tie strength models are adapted to the current data access situation. Finally, do new studies to develop tie strength models which can deduce social relationships(implicit relationship) using just publicly available social media comments and discussions.

REFERENCES

Burgess, J. and Bruns, A. (2012). Twitter archives and the challenges of "big social data" for media and communication research. *M/C J.*, 15.

Burgess, J. and Puschmann, C. (2014). Twitter and Society: The Politics of Twitter. In Weller, K., Bruns, A., Marth, M., and Puschmann, C., editors, *Twitter and society*, volume 89, chapter 4, pages xxix–xxxviii. Peter Lang Inc.

De Meo, P., Ferrara, E., Fiumara, G., and Provetti, A. (2014). On Facebook, most ties are weak. *Communications of the ACM*, 57(11):78–84.

Fogues, R. L., Such, J. M., Espinosa, A., and Garcia-Fornes, A. (2018). Tie and tag: A study of tie strength and tags for photo sharing. *PLoS ONE*, 13(8):e0202540.

Gilbert, E. (2012). Predicting tie strength in a new medium. In *CSCW '12*, page 1047. ACM.

Gilbert, E. and Karahalios, K. (2009). Predicting tie strength with social media. In *CHI 09*, page 211. ACM.

Granovetter, M. S. (1973). The Strength of Weak Ties. *American Journal of Sociology*, 78(6):1360–1380.

Gupta, J. P., Menon, K., Kärkkäinen, H., Huhtamäki, J., Mukkamala, R. R., Hussain, A., Vatrapu, R., Jussila, J., and Pirkkalainen, H. (2016). Identifying weak ties from publicly available social media data in an event. In *AcademicMindtrek '16*, pages 11–19. ACM.

Hogan, B. (2018). Social media giveth, social media taketh away: Facebook, friendships, and APIs. *International Journal of Communication*, 12(0):592–611.

Huang, H., Tang, J., Liu, L., Luo, J., and Fu, X. (2015). Triadic Closure Pattern Analysis and Prediction in Social Networks. *IEEE TKDE*, 27(12):3374–3389.

Huhtamäki, J. and Olsson, T. (2018). Digital Social Matching Ecosystem for Knowledge Work. In *KMIS 10*, pages 194–199. SCITEPRESS.

Jones, J. J., Settle, J. E., Bond, R. M., Fariss, C. J., Marlow, C., and Fowler, J. H. (2013). Inferring Tie Strength from Online Directed Behavior. *PLoS ONE*, 8(1):e52168.

Kahanda, I. and Neville, J. (2009). Using transactional information to predict link strength in online social networks. *ICWSM09*, pages 74–81.

Liberatore, F. and Quijano-Sanchez, L. (2017). What do we really need to compute the Tie Strength? An empirical study applied to Social Networks. *Comput Commun*, 110:59–74.

Mattie, H., Engø-Monsen, K., Ling, R., and Onnela, J.-P. (2018). Understanding tie strength in social networks using a local "bow tie" framework. *Scientific Reports*, 8(1):9349.

Onnela, J.-P., Saramäki, J., Hyvönen, J., Szabó, G., Lazer, D., Kaski, K., Kertész, J., and Barabási, A.-L. (2007). Structure and tie strengths in mobile communication networks. *PNAS*, 104(18):7332–6.

Quijano-Sánchez, L., Díaz-Agudo, B., and Recio-García, J. A. (2014). Development of a group recommender application in a Social Network. *Knowledge-Based Systems*, 71:72–85.

Xiang, R., Neville, J., and Rogati, M. (2010). Modeling relationship strength in online social networks. In *WWW '10*, page 981.

Zhang, B., Kärkkäinen, H., Gupta, J. P., and Menon, K. (2017). The role of weak ties in enhancing knowledge work. In *AcademicMindtrek '17*, pages 210–215. ACM.