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A proposed social network analysis platform for big data analytics

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ABSTRACT

This paper presents an important concept of Internet of People, a social network analysis approach to perform Big Data Analytics. The paper describes the development, management implications and analysis. To illustrate six points in the management issues, an in-house development of a SocialNetwork API with six functions has been demonstrated. The proposed method is focused on processing the contacts who click like or comment on the author's posts, as well as the queries and visualization. Results can be extracted and presented in data visualization. Six functions in the SocialNetwork API have evaluation tests, including a large scale of 50,000 simulations completed within 60,000 s. Results support our case of Big Data processing for social network analysis can be equivalent to CRM, ERP and MIS. Additionally, there are no costs involved. Related topics have been discussed in details. Our research contributions have been consolidated since our work have met research challenges for social network analysis and six management implications.

1. Introduction

The concept of the Internet of People (IoP) has started since Bruce (1999) has investigated the people's perceptions on the internet and has conducted survey with data analysis to support his points of view. This concept has been further exploited by McCown et al. (2001) who have conducted a similar study to understand men and women's perceptions about the use of internet. Both papers lack of any in-depth discussion about the IoP as follows. First, it was the Web 1.0 era at the time of the research and questionnaires were focused on Web 1.0 interaction and perception. Second, there was a lack of understanding about how people could interact with the use of the internet before the rise of social networks and the availability of smart phones to make such information widely available. Liu and LaRose (2008) focus on the people's satisfaction with the use of internet and have designed questionnaires for the use of Web 2.0. They use a college as an example to illustrate their concept but their approach does not show whether it is relevant for other organizations. Takahashi et al. (2009) have conducted a survey on IoP with depressive tendencies. They survey on people who have actively used social network analysis in order to understand their thoughts and behaviors. This paper is considered one of the early versions of research work to study IoP with the use of social networks, which is defined as a direct way to have communications, sharing of information and thoughts and build up friendship and trust over a period of time. Since then, there are research papers on social networks, which have used Cloud Computing, broadband networks, Big Data and smart devices like IoP does. Similar to IoP, the challenge for social networks is to understand the interaction between physical contexts and objects, between people and people and between communities and communities.

Social networks have been pervasive in our everyday part of many peoples' lives. It was illustrated by Mitchell (1969) who demonstrated the concepts and fundamental of social networks. However, in recent years, social network analysis has been used to study the relationship between different people and organizations, as well as dynamics, sentiment analysis and activities that other circles of networks being involved (Akuma et al., 2016; Karyotis et al., 2017). Social network analysis has become increasingly important for Big Data services since there are millions or billions of information, such as updates, exchanges of emails and updates, photographs, videos and sharing of all these items online on the daily basis. While there is a vast amount of information generated, intelligent algorithms and systems are required to extract, process and make sense of the information, so that the processed information can provide better values to the users, businesses and organizations involved. Social network analysis is relevant to Big Data development since a lot of data can be generated on the daily basis (volume); the rapid growth of data has always happened and will be expected to be more on demands (velocity); different types of data such as images, videos and text are required (variety); a high extent of accuracy for data processing and analytics is necessary (veracity) and all the information can provide real values to the society through fund raising, announcement of important news and support of humanity (value) (Chen et al., 2014; Chang, 2017). In order to illustrate effectiveness of social networks in the era of Web 3.0 and Industry 4.0 that

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use people, services and time (availability and responsiveness) as the key factors, websites and applications such as Facebook, LinkedIn, Twitter and any customer-relation services can be used to study the impacts of social networks and study how social networks can be used for business and management development.

Dated back in 2003, Facebook was started as a testbed platform of social network at Harvard University. It has become one of the most popular social network websites with more than 1 billion users on the Earth. According to Forbes (2017), Facebook and Mark Zuckerberg have the net estimated value of US $74 billions. Similar to other social network websites, Facebook become a platform for people to broadcast their headlines, share any information and interact with friends easily who can be geographically away or who do not meet as often as they can. Instagram is another social network website focusing on the posting photographs online in real-time. It was acquired by Facebook in 2010 to strengthen their lead in social network community. Together with Facebook, both websites have created a phenomenon of creating "selfies" online. This trend has both positive and negative impacts. In terms of positive impacts, friends and families can have live updates of their close ones and need not meet or call them to find out. However, the downside is that some users tend to post photographs to show off their recent activities and it has become websites for some people to show their luxurious life styles. These users tend to post pictures of visiting different countries, restaurants and places of interests with their thoughts and sharing frequently and regularly. This can create unpleasant feelings for friends who have lower social status since they are unable to afford all these (Scott, 2012).

LinkedIn is a social network website focusing on building professional network for each user, so that they can strengthen their network power and activities which include job hunting, sharing of opinions and posts, community building and recommendation to their peers. The positive side is that people can stay in touch with their networks even if they have not met for years or they can use LinkedIn to improve their professional relationships with their peers. One commonly-use feature is the recommendation to their networks since it can be influential to the human resource recruiters who do not know the applicants and use their networks' recommendation as sources of references. However, the downside can be that the recommenders only knows certain aspects of their recommendees and it can be only a glimpse of their overall abilities and skills. Additionally, skills can be "variables". If person A worked as a Security consultant but did not practice his skill for more than five years after changing jobs, the recommendation on his LinkedIn profile is perhaps not as accurate as his most recent CV and recommendation from his most recent employer. Twitter is another popular social network website, which allows users to post their live updates, thoughts and sharing of pictures, links and videos. It allows organizations and individuals with high social status to promote their events, campaigns, products and services. Individuals of any social status can do the same without problems. Providing information in real-time can reach to many communities and individuals and this is particularly useful when there are disasters, accidents and calamities that many people can know such catastrophes have happened and then prevent themselves from being near to the places of disasters, or share their condolence with their networks. However, the downside of using Twitter is similar to the case of Facebook and Instagram, in which some people do show off their lavish life style and influence their opinions to win over the controversial cases. Another downside is that people have posted their thoughts and personal feeling (the text such as "I am hungry" or "I am going home now") which provide little or no values to the research community. It has become a platform to know their people's private lives since users can know secrets of their preferred celebrities and idols. The abilities to process and analyze a large amount of data, and even in real-time, can be important for businesses and management. Up-to-date and accurate information can be obtained and presented in real-time, so that businesses can always stay competitive by making better decisions and strategies. They can get close to users and customers' real opinions about their products, services and feedback (Grzywaczewski and Iqbal, 2012; Mahmud et al., 2016).

There are different types of technologies that can process and analyze a large amount of data. The use of Application Programming Interfaces (APIs) have been commonly used to reduce the level of complexity of running the large scale simulations. The level of code writing is reduced and streamline. Facebook APIs were available for developers to organize thousands and millions of user data efficiently (Facebook, 2013). The creation of Facebook API can help achieve this target with the following reasons. First, some data available in the social network websites are not fully exposed. The intelligent methods are required to extract and present the data. Social networks such as Facebook have released their API development and guideline. Second, the use of API can extract data from Facebook seamlessly and make use of the existing APIs or API methods in Facebook to analyze and present the data. For example, data visualization is used to present multiple data analysis and reduces the level of complexity of explaining tough issues such as mathematical modeling of data analysis, correlation between different data and variations in user behaviors (Chase, 2013). This motivates us to develop an innovative and easy to use API that can process data and present the results in a way that anyone without much prior knowledge can understand.

To demonstrate this, we have proposed a Social Network Analysis Platform focusing on a proposed social network analysis approach, represented by developed SocialNetwork API, and explain the architecture, the usage scenario, results and analysis of the user behaviors in the social network. Social network analysis is designed to extract and process data utilized by Facebook and is presented in visualization (graphs, analytics and reporting system) so that users without technical background can understand the complexity in social network science for Big Data. To demonstrate a good flow throughout this paper, the structure of this paper is as follows. Section 2 describes the related literature and the proposed social network analysis platform. Section 3 explains the use of Social Network API with the examples and scenarios adopted. Section 4 illustrates performance evaluation of using SocialNetwork API. Section 5 presents topics of discussion to justify our research contributions and Section 6 sums up Conclusion and Future work.

2. Related literature and the proposed social network analysis platform

This section presents literature that leads to the development of this research and the architecture required to make it happen.

2.1. The literature review

Social networks provide Web 2.0 model to allow each user to broadcast about themselves and then interact with their peers. The speed of interaction is in real time and instant to allow contacts to know places and events that they have never been but they are able to feel as if being present in the event. Detailed information of important moments such as the wedding, graduation ceremonies and birthday celebrations for big ages have attracted many contacts clicking likes and leaving their comments. There are no costs involved in doing this. Social networks have changed the way that people interact with one another with behavioral changes (Gross and Acquisti, 2005; Farkas, 2007; Glanz et al., 2008). Researchers have identified reasons as follows. First, a variety of communications such as live update, chats and videos allow contacts in the social network to communicate directly and indirectly with each other and their network's friends. Second, a vast amount of information can be shared and posted on the daily basis which have changed the pattern of social interactions for some people, since some are on the receiving end (read updates and seldom respond) and some are on the giving end (regularly updates regardless of feedback). Third, more people can follow their celebrities that they can

never have the privilege to have in the past such as live update of wedding and birth of Prince and Princess of Cambridge. However, such behaviors have their downside as follows. First, not everyone is interested in every post and sharing. Second, if sharing of the same news have frequent updates, or sharing of extreme personal emotions and comments, it can lead to uncontrolled status beyond just the "removal of friendship online". In extreme cases, the social networks have no ways to prevent the spread of words of hatred and terrorism. Although they have improved their terms and conditions, incidents of recruiting jihadi brides and replicating the events of terrorism have been reported on the news (González et al., 2014). Third, disagreement on some points of views can lead to disputes from the virtual world to the real life. The extent of the relationship can be sour, or damaged. This can be caused by an event or a religious belief or a political stand, misuse of trust or personality clash which can happen in a short period of time (Sadock and Sadock, 2011; Newman, 2013). Topics such as inequalities in sex and religions, as well as social topics such as same-sex marriage, independence of a "country", sacking of a celebrity due to "misconduct" (such as Jeremy Hunt of TopGear) and social welfare reform can create debates on the social networks. Negative comments are unavoidable due to clash of opinions. The extent of debates can become viral and damaging and spread the impacts from the virtual to the real world. In another example, a clothing designer has criticized that gay couples should not adopt children with offensive comments, Sir. Elton reacted furiously in response to boycott the brands. However, before such incidents happen, understanding the behaviors of users is useful to categorize user behaviors and monitor any behavioral changes. If new methods can be deployed to understand any correlation or what causes the trigger, then the proposed social media platform can provide recommended actions to prevent extreme cases to happen or reduce the extent of damage caused by the viral events. As a result, the review of literature is necessary to identify whether any systems can detect user behavior, preference and tendency, so that the system can intelligent enough to predict the user behaviors and even their next moves.

While social networks are pervasive to our day-to-day lives, billions of data including chats, posts, photographs, videos, clicks, figures of emotions, messages and forums have been generated. Two types of research work have been investigated. First, Chard et al. (2010, 2012) develop their Facebook APIs for their proposed architecture, known as Social Cloud, to manage thousands of social network data. Second, Suh et al. (2010) demonstrate how millions of twitter tweets can be managed by their Twitter Network. The quantity and the growth of data are relevant to Big Data research. Examples demonstrated by Chard et al. (2010, 2012) and Suh et al. (2010) can help scientists manage Big Data for social networks (BDSN), which is an emerging area to manage and organize a large amount of data generated daily. Hence, researchers and developers can classify the type of data and develop suitable algorithms for different purposes. To elaborate on this, business intelligence system can be adopted to provide a faster, more organized and more efficient approach. A business intelligence service can quantify the relationship between different contacts, query all exchanged messages and rank contacts in the order of query and get results within seconds (Han et al., 2006; Guo et al., 2014; Chang, 2017). In other words, a business intelligence service can monitor and collect daily data on social networks, analyze them and present them in analytics form, so that users can understand all their activities in one glance without going through detailed queries and threads of messages. As a result, a multi-disciplinary approach is required to understand the implication, complexity and interpretations of Big Data research. This motivates us to propose and develop a Social Network Analysis Platform based on Cloud Computing and Big Data techniques. The aim is to process a large amount of data with optimization and use data visualization to present complex data retrieved from the analysis.

2.2. Management implications of social networks

As explained in Section 1, there are massive amounts of data to be collected for analysis and a large percentage of them do not provide added values (Witten and Frank, 2005; Gelman et al., 2014). Special techniques such as machine learning and Bayesian model can be applied to ensure all outputs can provide useful results and meaningful outcomes. Although there are papers describing the benefits of Twitter and their contributions in Section 1, millions of text and data may have to be collected and analyzed over a period of time, some of which may carry significant values for businesses. This can pose management challenges as follows.

First, if these users are customers and user communities, their comments can then pose important market research outputs. Businesses can understand customers' opinions and feedback for improvements, particularly when there are prototypes or trial services before the official release. Details information can be received in a short period of time (Von Krogh et al., 2000; Romero and Molina, 2011).

Second, combining social networks and technologies in the platform of "social network analysis platform", it allows the management of the companies can have a more up-to-date information about the customers' mindsets and market trends. The management can then update their strategies involved with products, regions of services, sales and prices (Hüllmann, 2017). For example, if they can get a few hundreds of customers' feedback and they know in their online communities, users' favorites, habits and emotions, it can be useful for their product or service development. Similarly, this can be used as an alternative customer relationship management (CRM), since we can strengthen understanding and mutual interests between customers and firm representatives, and customers can know more about events and promotion of services more easily (Rapp et al., 2013).

Third, similar to previous point, employee relationship management (ERM) can be fostered since the real sentiments of the employees are often can be reflected on the social networks (Kelly, 2012). It is easy for some people not to hind their real emotions and express their thoughts and feelings in social network platforms, whether positive or negative feelings and emotions.

Fourth, management can get more up-to-date analytics about their business performance in general, which include sales, profits, growth of products and the situations of their branch offices in their internal social network platform that core business information can be updated, exchanged and disseminated for the management, so that all the business operations and performance can be checked easily (Mahmud et al., 2016).

Fifth, a new management information system (MIS) for social networks analysis platform should be developed and the objective is to show the robustness, such as running a large number of simulations (Zhou et al., 2011). This can ensure that if a large number of users (one user represents a simulation) is online, the social network analysis platform can still function without suffering from downtime. Robustness checks and tests will be performed to justify the resiliency of the proposed solution. Results will be presented in Section 4 undergoing tests of different conditions as well as stress tests with large scale simulations.

Sixth, government can use IoP to track people with negative intents, such as criminal gangs or terror groups or any networks under police investigations involved with drugs, money laundry and terrorism. Government can use social network analysis to track the sources of drugs, tax avoidance bombs and criminal activities (Bolz et al., 2016; Kappeler and Potter, 2017).

While all these five examples are important for the management, social network platforms need to collect a large volume of business data reflecting the up-to-date information about the business (operations,

performance and KPIs) and individuals' emotions and sentiments (customers and employees). Management can get a more accurate information, particularly customers and employees' true thoughts and sentiments about their services, strategies and past performance, so that they may make better judgement on their future investment, decisions and human resources (Alhabashneh et al., 2017; Iqbal et al., 2017).

Social networks can be useful for the government. The sentiment analysis is an area to understand the overall feeling of the general public. It can be used to study the sentiments of important events such as major elections, government policies and terror attacks (Birkland, 2014; Bolz et al., 2016; Kappeler and Potter, 2017). Government can also understand which regions or groups of the residents have certain negative sentiments that they can pay more attention to resolve part of the issues.

To manage all these up-to-date information effectively, current applications services such as SugarCRM, ERP, social network analysis and financial analysis software are unable to provide a service that can be highly adaptive and customized to the management's requirements (Rainer et al., 2013). This means that in-house development will be required. If there is an internal software service that can be used to analyze business data and KPI data daily, it will provide huge benefits to the management since strategies can be adjusted and decisions to be made in real-time. However, an in-house development of the "business social-network platform" will be developed to meet business demands and management requirements.

In order to understand people's behaviors, the ability to collect and analyze a large amount of information such as posts, comments, uploading and sharing pictures, clicking likes, joining communities and sharing of thoughts, links and videos will be handful. However, the difficulty is to get the real business data and customer data since it will be challenging to get very confidential data. In order to demonstrate this "business social-network platform can be achieved, author's data on Facebook including his personal and conference management accounts, have been used to illustrate the research contributions for MIS. A Social Network Analysis Platform is designed to query and understand the sentiment analysis and strength of relationship of the social network.

2.3. The proposed social network approach

Since billions of information can be generated and exchanged on daily basis by social network. It has become increasingly significant to propose a new language that can extract information quickly and process the selected information efficiently. Although MapReduce framework is popular and used by Google to ensure the required information can be queried and presented correctly, other types of searching and presentation of information should be investigated, since Google's search cannot work directly on some social network websites such as Facebook. Google search can be used to query the persons on the Facebook but cannot search and display what type of content a person has posted up if not related to the person as a friend. Additionally, security and privacy settings have been enforced and not directly approved by each vendor like Facebook. The proposal of the Social Network analysis can be used to illustrate Internet of People (IoP) to ensure that all the required information can be retrieved intelligently while using the Facebook's available information while fulling its requirements for security. Social network analysis is designed to allow each short command to be executed to retrieve the required information and be processed in a way that scientists can understand in a matter of seconds. In the process of doing so, visualization is suitable since it can present complex data in a way that is interactive and easy to understand to users. To move this forward, the author's personal data is used to illustrate the concept of Big Data analytics, which includes analyzing threads of information and datasets about friendship between Year 2007 (whereby the author started using the Facebook) and 2015. It is designed to interact with Facebook information and extract these information seamlessly.

Social network analysis is composed of the following functionality:

1 Extraction: It refers to the process of extracting information from the Facebook API, which normally already has extracted information from each user in the form of the contacts, types of activities, dates of activities and any other relevant information according to the privacy setting.
2 Processing: Processing of the data will be focused on the three aspects as follows.
   - Text: This includes a wide range of basic information about the user IDs, their friends' user IDs, quantity of friends, posts, posted information and the type of the related information. It includes SQL queries and additional queries written in different forms to allow successful extraction.
   - Arithmetic calculations which aims to calculate the strength of the friendship based on the number of posts and interactions on Facebook.
3 Visualization: This is a step in social network analysis that takes on the processed outputs and translate to visualization by presenting results in graphs, analytics and reports. Visualization is an important step to ensure that outputs can be understood by people without prior background and knowledge.

The advantage of adopting social network analysis is to present all three different functions together at one go and then present all the outputs and analysis to be further explained in Section 3.

2.4. Related work

This section describes the related work that uses social network analysis. Mislove et al. (2007) illustrate their social network approaches with their measurement methodology. They explain that presenting results in a way that people can understand, such as visualization, is a research challenge. They describe their method, experiments, results and analysis, including techniques to retrieve and present a large data. However, their work was not updated for 6 years. While acknowledging their work that visualization and analytics are challenging, a new approach should be developed to allow researchers and developers to build and improve on the existing services. Ronen and Shmueli (2009) explain the use of their SoQL, a language that can query and process data in social network. They explain the fundamental in their SoQL and show examples of how to query and get the expected results. Their approach is closely related to SQL for social network and does not deal with Facebook GraphAPI directly, which can contain information about the data owner's friendship status. However, there are no use of real data and no in-depth analysis of the social network and interactions between different people. It is more like a validation of their language rather than a proof-of-concept or a prototype, which can take on Big Data processing in social network analysis.

Neville and Jensen (2003) use a data mining approach to retrieve and query information about social network. Their proposal is similar to SoQL except more towards conceptual data mining approach. He and Singh (2008) use graph approach similar to the Facebook API to interpret the graph databases and can manage to query some simple commands similar to the function of SQL statements. However, all the approaches mentioned above do not work directly with any social network data and interpret the data offered by social network website such as Facebook. A more direct approach with a real data should be investigated and this paper has used the real data from the author between Year 2007 and first half of Year 2015. Suggestions from these research work can be considered if using the real data for analysis. While it is challenging to get data from businesses, and also if businesses have such data, the aim of this research is also to demonstrate that once Big Data from social networks analysis can be collected, what we can do and should do next. To further demonstrate how to bridge the gap, author's own data from Facebook can be used for analysis. The use of SocialNetwork API can unlock the implicit meanings and hidden

interpretations from social network analysis. Section 3 will give a full detail on how to analyze Big Data from social networks analysis and bridge the potential gaps, in which maybe more applicable for small and medium enterprises, or individual businesses or institutes that have global presence and networks with different people with different roles and relationship.

3. Social network analysis platform and the design of usage scenarios of the SocialNetwork API

This section presents the Social Network Analysis Platform, the usage scenarios of SocialNetwork API to demonstrate how to interpret and analyze social network, with detailed examples and the outputs of each usage scenario should be presented. Six specific examples of using SocialNetwork API will be illustrated.

3.1. Illustration of social network analysis and IoP by the development of SocialNetwork API

This section describes the functionality of SocialNetwork API to demonstrate the concept of IoP. The aim is to illustrate proofs-of-concept by the use of SocialNetwork API. One of the best approaches to illustrate a new language is by the development of an API, known as "SocialNetwork", which reads and extracts the required information on the Facebook account, processes all the information on the servers in the Cloud and sends results back to the server. The use of API can interface between hardware and software and process data directly from hardware and sends results back to the Software as a Service layer.

This section describes developed functions offered by SocialNetwork API.

- **SocialNetwork ["name"]** which gives information about the social media entity. Most of the cases, and "name" is usually Facebook by default.
- **SocialNetwork ["name", "property"]** which gives the value of the specified property for the social media entity. This is a commonly used command to retrieve the information for the user and process on the Big Data Cloud servers.

Additional explanations for commands of SocialNetwork API include the followings:

- "Friends": list of friends
- "FriendIDs": list of friend IDs
- "UserData": user data
- "Posts": post data
- "Feeds": feed data

While taking users into accounts for explanations, advanced features are as follows:

- "FriendNetwork": x is connected to user y if x and y are friends.
- "LikeCommentNetwork": x is connected to y if x and y like or comment on the same post
- "LikeNetwork": x is connected to y if x and y like the same post.
- "CommentNetwork": x is connected to y if x and y comment on the same post.

Recent activities can be queried and presented by visualization with the following functions:

- "ActivityRecentHistory": investigates the recent history engaged by the author and other contacts.
- "ActivityTypes": categorizes the types of activities engaged by the author and other contacts.
- "ActivityWeeklyDistribution": combines the best part of "ActivityRecentHistory" and "ActivityTypes" except it is focused on the weekly updates.

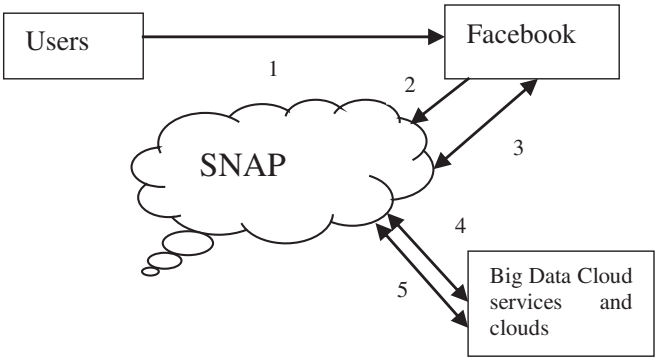

Fig. 1. The architecture of deploying the SNAP.

SocialNetwork API can seamlessly blend these functions to allow the Cloud servers to retrieve the required information, process them and present results as analytics and visualization.

3.2. The proposed architecture

This section describes the proposed architecture to illustrate the proofs-of-concept for our Social Network Analysis Platform (SNAP), which is a hybrid cloud based in Southampton and can be used to directly interact with Facebook based in US. A large amount of information can be extracted by a developed API through Facebook, so that they can be further synthesized. This supports Big Data research since a lot of data will be processed and analyzed. Important outputs will be presented in analytics and visualization. To demonstrate steps involved, Fig. 1 has the sequence of events in the set-up and their explanations as follows.

- It is essential to have real identities of users who have used Facebook.
- The Social Network Analysis Platform (SNAP) can render a Facebook application within the Facebook interface.
- A developed SocialNetwork API can be used to extract information and analyze them from the user's account and contacts.
- SNAP can communicate with Cloud in Southampton and Facebook Cloud in the US to create service requests, query user credits and perform execution of services and so forth.
- All the results on the Big Data Cloud services will be returned to the users on the same platform. Outputs will be presented as statistical analysis and visualization. For the purpose of demonstration, visualization simulated by APIs will be presented in this paper.
- The technical setup and experiments of large scale simulations to validate resiliency will be presented in Section 4.

3.3. The first example of using SocialNetwork API

This section describes results generated by the proposed SNAP based on Facebook and our SocialNetwork API. The author has undertaken the evaluation process by using his network as an example to illustrate analysis presented by SocialNetwork API. He has the four groups of network based in Taiwan, Singapore, Australia and United Kingdom. The first approach is to identify the relationship within his network and study any relationship dependency and the extent of interactions on the social network, followed by the explanations of the outputs and syntax for queries. The use of SocialNetwork API is simplified to the extent that a one phrase of command can be used to perform that task, which is

SocialNetwork ["Facebook", "FriendNetwork"]

Results and their discussions for the author's entire network are presented as follows.

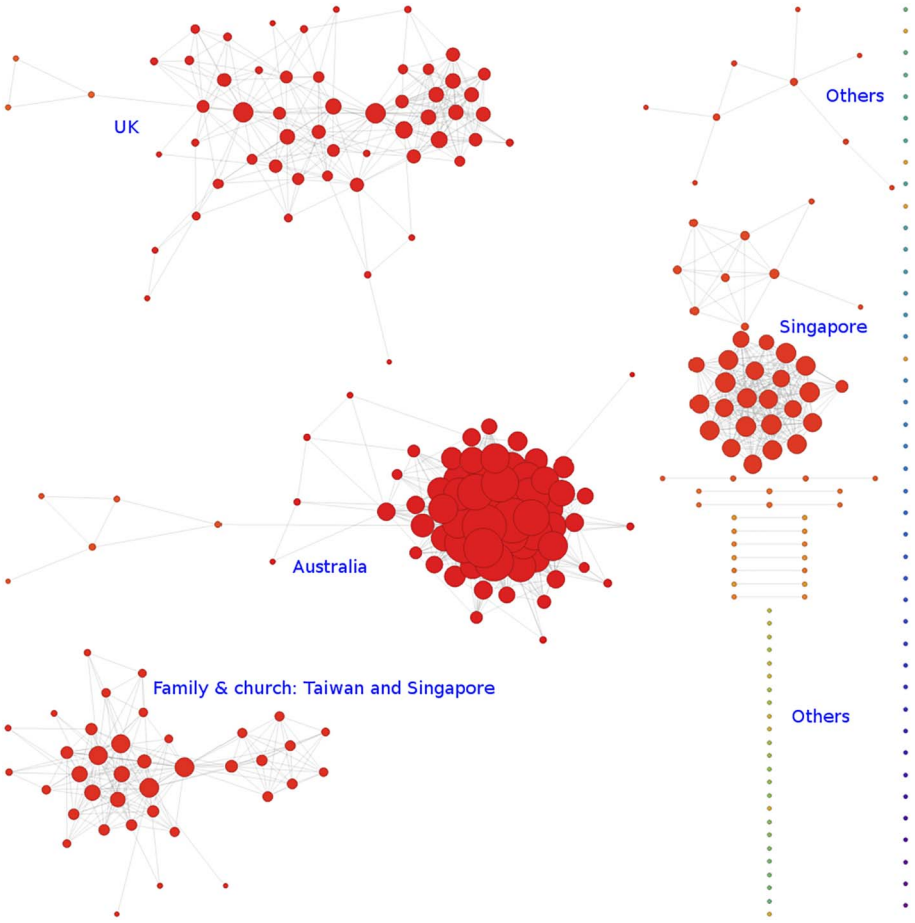

Fig. 2. The author's entire network.

3.3.1. The analysis of the author's network through "FriendNetwork" in the SocialNetwork API

Using the author's network as the source of illustration for the business data. Fig. 2 shows the author's entire network queried based on the geographical location, which can be seen divided into five groups as follows.

1. The first group is the church and family members based in Taiwan and Singapore, whereby the author's place of origin is Taiwan and have moved to Singapore. He has family members who are in the same situations and thus are connected to both Taiwan and Singapore. This excludes the private messages exchanged between different users. Although there are other contacts between the author and this group outside Facebook, communications presented here are based on Facebook excluding non-Facebook interactions.
2. The second group is the author's former classmates based in Singapore whereby the author had met them during his early days of education. The majority of the author's former classmates uses Facebook frequently although they seldom meet each other. Facebook provides an easy-to-use way for communications. There is another group of former classmates who have used Facebook less frequently due to their family and work commitment and thus they have a weaker network of communications.
3. The third group is the author's friends and church members in Australia when the author went to Australia for his undergraduate education. The number of online interactions has been so frequent that circles overlap with each other. Contacts in Australia have posted their pictures, updates and entered their comments and clicked likes on daily basis. They have blended their online and offline events and activities successfully. Hence, the circle of influence and friendship for each contact has overlapped with one another.
4. The fourth group is the colleagues that the author had met in different stages of his career and studies in the UK based in Cambridge, Southampton, London, Leeds and other locations. The author is the one that links to all the networks and one of the largest circle on the right to link to different contacts. Some distant and smaller circles are contacts based in Cambridge or author's contacts met them between 8 and 15 years ago, with fewer interactions between them. The right half of the UK network belongs to the author's contacts in Southampton and London, and some of them have interactions with each other. Through the author's network, mutual friends can communicate with one another. Authors' mutual friends know each other based on their locations.
5. The last group is classified others, (1) who had met the authors had different stages and had either left the UK or (2) who are in the UK but unrelated to any of the author's networks. For the type one, the majority of them come from other countries and have returned their home countries at different stages of their career. The type two of friends are the ones that the author has met them at different time scale. The majority of them live in the UK but have no any communications or no mutual friends with authors in this group.
For others, they appear a single dot without link suggesting they know none of the author's network. There are single dots joining to another, meaning that either their mutual friends are related to the author or they have known each other recently. For example, if John and George are the author's friends but they had never met each other until a social event, both have become friends in real life with similar interests. When John and George have become friends on Facebook, they have single dots. Since they do not know any of the author's network, they appear to have two dots joining to each other without any other connections.

Table 1
The core syntax for SocialNetwork ["Facebook", "FriendNetwork"].

```
Select author.contact from contact.groups
    where (contact.active) and (contact.interact)
    order by contact.groups
```

The first four groups have inter connections between each other and thus the author can make a greater influence on their social network. Similarly, they can make a greater influence on the social network since they have more interactions with one another and with the author. This example demonstrates how to extract the extent of relationship based on locations, which can be applied for organizational MIS to list their customers of priorities or a better work relationship.

3.3.2. The core syntax that presents "FriendNetwork" in the SocialNetwork API

This section presents the queries behind the SocialNetwork API. Referring to Table 1, the syntax for each term is as follows.

- "author.contact": all the friends in the author's Facebook account.
- "contact.groups": they are five groups presented in the previous sections.
- "contact.active": these friends have public interactions with the author, which mean they have clicked "likes", or commented on the author's post.
- "contact.interact": all the friends who posted or commented on the author's post, they also interacted between themselves and the author's mutual friends.

Both conditions of "contact.active" and "contact.interact" must be met and all query results can be presented by groups, categorized geographically. SocialNetwork API can utilize Facebook graphic feature to enable visualization.

3.4. The second example of using SocialNetwork API

This section describes the second example of using SocialNetwork API for data extraction and presentation. The second example is to collect the information about the number of times and the people who click "likes" on Facebook. Final outputs are in analytics and visualization. The command is as follows:

SocialNetwork ["Facebook", "LikeNetwork"] .

3.4.1. The result of using "LikeNetwork"

Fig. 3 shows data visualization of the author's contacts who have clicked likes on the pictures, links and status updates posted by the author. This command analyze all the contacts who have clicked likes since the start of online friendship with the author regardless of their locations. Each circle represents each contact who have clicked like. Each link between each circle means both have clicked likes on the same post and thus they have established a direct relationship through choosing the post in common. The circles at the center are the one that have clicked the most of likes since they have established more links to the other circles and have very dense intensity of their links. The intensity of the links also indicate whether they know more of author's mutual friends. If they know more mutual friends and have the tendency to click likes they tend to be become the central circles with more links to others.

3.4.2. The core syntax that presents "LikeNetwork" in the SocialNetwork API

The core syntax of the "LikeNetwork" is shown in Table 2 with four conditions to be met for the authors' networks. First, "contact.active" must be present. Second, all the contacts should be mutual friends. Third, "contact.likes" means there are contacts who have clicked the

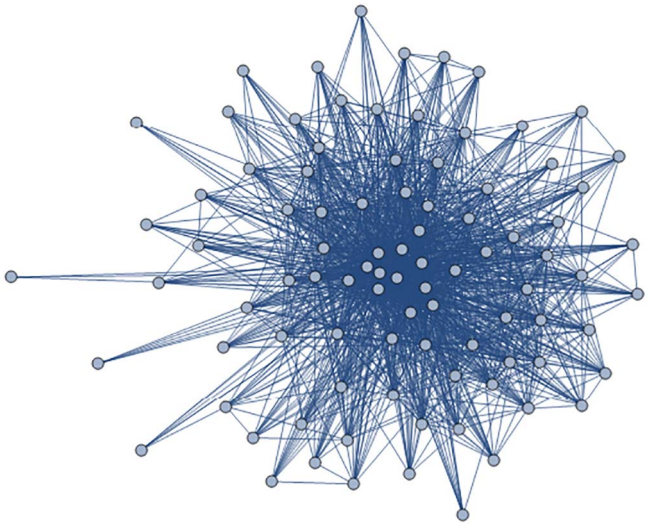

Fig. 3. Representations of the SNAP based on the author's contacts who have clicked likes.

Table 2
The core syntax for SocialNetwork ["Facebook", "LikeNetwork"].

```
Select author.contact from contact.groups
    where (contact.active) and (contact.interact) and (contact.likes) and (count)
```

authors' posts. Fourth, "count" is the number of times the contact have clicked likes, which is presented by the number of links between different circles. It queries the head counts and the frequencies of those clicking likes.

3.5. The third example of using SocialNetwork API

This section describes the third function of SocialNetwork API to extract information from the Facebook. The third function is to collect the frequency, the contacts who click "like" and also have commented on Facebook. Outputs can be in analytics and visualization. The command is as follows:

SocialNetwork ["Facebook", "LikeCommentNetwork"] .

3.5.1. The result of using "LikeCommentNetwork"

This command is the same as above except having one more condition: any contacts who have commented on the author's posts. There are similar explanations to Fig. 3, except that Fig. 4 includes some circles at a distance from the center. It corresponds to some contacts who have commented without clicking likes and vice versa, while some contacts have done both. To quantify conditions, they are as follows.

- Contacts who commented without clicking like
- Contacts who commented and also clicked like

This explains how and why Fig. 4 looks similar to Fig. 3 except there are some distant dots, since they represent contacts that seldom use Facebook or only click likes, or click likes more than leaving comments. This command allows SocialNetwork API to extract the information about whom and when to click likes, and whom and when to comment, and present final outputs in visualization.

3.5.2. The core syntax that presents "LikeCommentNetwork" in the SocialNetwork API

The core syntax of the "LikeCommentNetwork" is shown in Table 3 with four conditions to be met for the authors' networks. Conditions are identical to "LikeNetwork", except the condition: Queries can accept

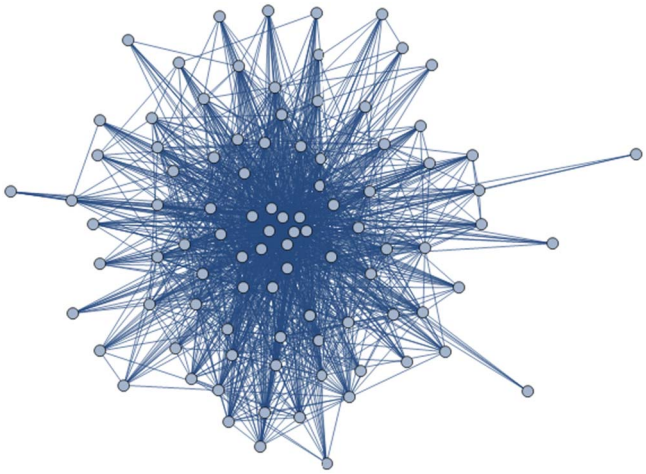

Fig. 4. Representations of the SNAP based on the author's contacts who click like or comment.

Table 3
The core syntax for SocialNetwork ["Facebook", "LikeCommentNetwork"].

```
Select author.contact from contact.groups
    where (contact.active) and (contact.interact) and
    (count) and ((contact.likes) or (contact.comment))
```

any contacts who have either clicked like, or have commented, as long as one criteria is fulfilled.

3.6. The fourth example of using SocialNetwork API

This section presents the fourth example, ActivityRecentHistory. This function investigates the recent history engaged by the author and other contacts, whereby posting on status, links, pictures and videos have been counted and summarized as "Data". The output can be presented by visualization. The associated command is.

SocialNetwork ["Facebook","ActivityRecentHistory","Data"] .

3.6.1. The result of using "ActivityRecentHistory"

This function can trace the activities on Facebook in the past nine months. Fig. 5 shows the outputs of the ActivityRecentHistory based on the author's outputs of the ActivityRecentHistory function.

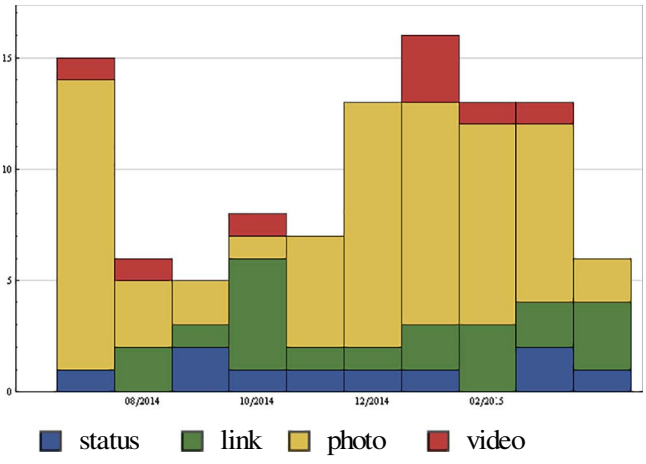

Fig. 5. Outputs of the ActivityRecentHistory function.

Table 4
The core syntax for SocialMedia ["Facebook", "ActivityRecentHistory"].

```
Select author.activity.history from contact.groups
    where (data.status) and (data.link) and (data.photo) and
    (data.video) and (count) and (graph)
```

3.6.2. The core syntax that presents "ActivityRecentHistory" in the SocialNetwork API

The core syntax of "ActivityRecentHistory" is shown in Table 4. The queries select all the author's activities from his contacts with six conditions to be satisfied. The first four conditions are to select all the updates on status, link, photographs and videos. The last two conditions are to count the number of times and present output by visualization.

3.7. The fifth example of using SocialNetwork API

This section presents the fifth example, ActivityTypes. This function categorizes the types of activities engaged by the author and other contacts, including the status, links, pictures and videos which have been counted and summarized as "Data". The output can be presented by visualization. The associated command is

SocialNetwork ["Facebook","ActivityTypes","Data"] .

3.7.1. The result of using "ActivityTypes"

This function can classify all the types of activities on Facebook in the past 9 months. Fig. 5 shows the outputs of the ActivityTypes based on the author's contacts, with photographs as 64 times, links 20 times, status 10 times and videos 8 times of updates which have the contact's backing (likes or comments).

3.7.2. The core syntax that presents "ActivityTypes" in the SocialNetwork API

The core syntax of the "ActivityTypes" is shown in Table 5 with six conditions to be met for the authors' networks. The first four conditions are to select all the updates on status, link, photographs and videos. The last two conditions are to count the number of times and present output by visualization (Fig. 6).

3.8. The sixth example of using SocialNetwork API

This section presents the sixth example, ActivityWeeklyDistribution, which has the best sides of "ActivityRecentHistory" and "ActivityTypes". This function which records the weekly activities engaged by the author and other contacts, including the status, links, pictures and videos which have been counted and summarized as "Data". The command is

SocialNetworkData ["Facebook", "ActivityWeeklyDistribution", "FormattedData"]

3.8.1. The result of using "ActivityWeeklyDistribution"

This function can record all the weekly activities and query the most recent week. Fig. 7 shows the weekly activities of the author's Facebook account, which includes any networks that have mentioned the author's names, or any updates, pictures, links and status related to the author such as clicking likes and entering comments. The week began from the April 19, 2015 Sunday and April 25, 2015, Saturday. Most of the updates happened between10 am and 10 pm the the GMT time, since the period overlapped with the majority of the author's network.

Table 5
The core syntax for SocialNetwork["Facebook", "ActivityTypes"].

```
Select author.activity.types from contact.groups
    where (data.status) and (data.link) and (data.photo) and
    (data.video) and (count) and (graph)
```

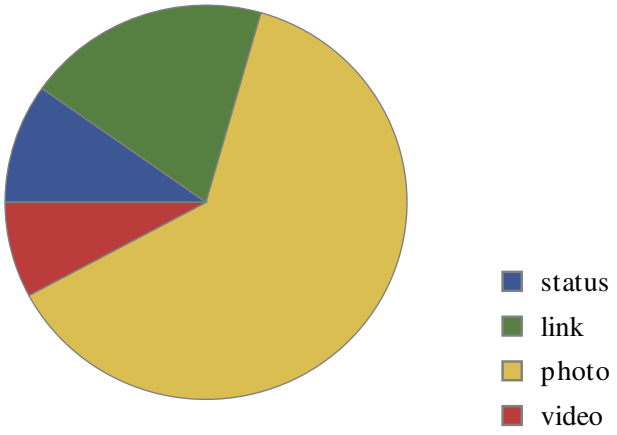

Fig. 6. Outputs of the ActivityTypes function.

3.8.2. The core syntax that presents "ActivityWeeklyDistribution" in the SocialNetwork API

The core syntax of the "ActivityWeeklyDistribution" is shown in Table 6 with five conditions to be met for the authors' networks. The first four conditions are to select all the updates on status, link, photographs and videos. The last condition is to count the number of times.

4. The experiments for the social network analysis platform

This section describes the hardware setup to use the Social Network Analysis Platform and SocialNetwork API for performance evaluation. The first objective is to verify that each API function can be executed successfully within seconds. The second objective is to test whether SocialNetwork API can be robust to run a large number of simulations, similar to managing a large number of requests and users concurrently. The desktop machine has 3.0 GHz Intel Xeon Quad Core and 8 GB of memory (800 MHz). The private cloud is used and it involves four sites in total; two in London and two in Southampton. The full details of the infrastructure have been described in (Chang, 2014). However, this research is focused on Social Network as a Service and not business intelligence to support the proofs-of-concept and illustration of social network for Big Data analytics.

4.1. Single simulation for each API function

This section describes the execution time when running each API function. In the local environment, each API function only takes less than 1.17 s including standard deviations as shown in Fig. 8. Big data processing and analytics can be completed as efficient as possible, which is essential for any SNAP, MIS and CRM service.

Table 6
The core syntax for SocialNetwork ["Facebook", "ActivityWeeklyDistribution"].

```
Select author.activity.weekly from contact.groups
    where (data.status) and (data.link) and (data.photo) and
    (data.video) and (count) and (graph)
```

4.2. Large scale simulations

To demonstrate the capacity and capability to handle a large number of users and requests, up to 50,000 simulations had been tested for six functions of SocialNetwork API. The execution time was taken and the mean value was finalized based on five attempts. The aim is to test resiliency of our SNAP. To enable API functions, the following commands can be used:

SocialNetwork ["Facebook", "FriendNetwork", "50,000"].
SocialNetwork ["Facebook", "LikeNetwork", "50,000"].
SocialNetwork ["Facebook", "LikeCommentNetwork", "50,000"].
SocialNetwork ["Facebook", "ActivityRecentHistory", "50,000"].
SocialNetwork ["Facebook", "ActivityTypes", "50,000"].
SocialNetwork ["Facebook", "ActivityWeeklyDistribution", "50,000"].

Commands above can be used to simulate up to 50,000 times, starting from 5000 simulations and increasing 5000 simulations each time for six API functions.

4.3. Experiments on six API functions for running up to 50,000 simulations

This section describes large scale simulations to understand how well the SNAP services can cope when there are large number of concurrent users or requests. This is an important step to keep resiliency and quality of our proposed solution.

The objective is to test if there are 50,000 concurrent users or 50,000 concurrent queries and analysis, social network analysis platform can be robust enough. All simulation could be successfully completed. Simulations were performed five times to get the mean values and standard deviation of execution time on the local environment, and between Southampton Private Cloud clusters.

Fig. 9 and Fig. 10 show experiment results of six API functions with 50,000 simulations in the local environment and Southampton cluster. Each horizontal unit in the figure represents 50,000 simulations, which could be completed within 60,000 s, or 16 h and 40 min. "FriendNetwork" function took the longest and "LikeNetwork" function took the shortest with 5% difference in between these two.

5. Discussion

Social network analysis presented in this paper can analyze and synthesize big data collected and utilized in social network platform, by

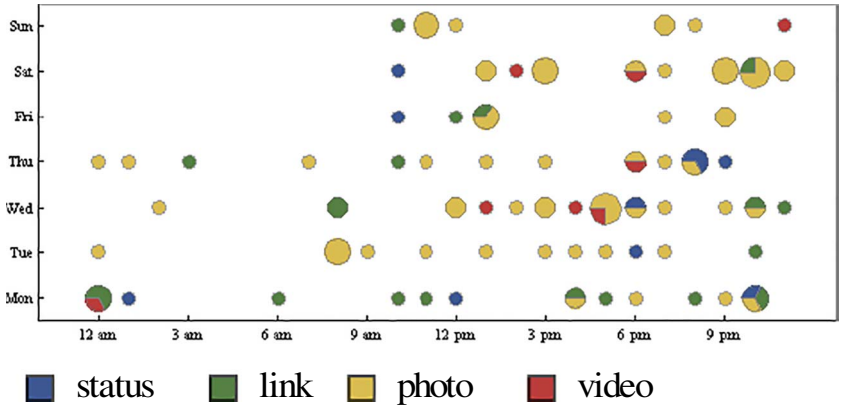

Fig. 7. Outputs of the ActivityWeeklyDistribution function.

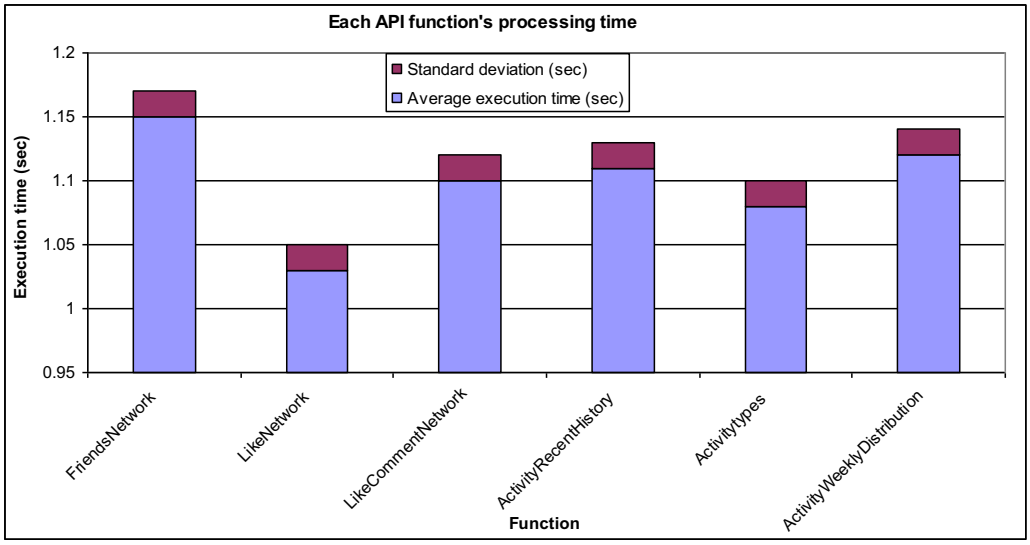

Fig. 8. Execution time for running each API function.

using Facebook as a platform to extract and present our processed outputs. Three topics are discussed to help validate our SNAP approach that supports Big Data processing and IoP in the Cloud.

5.1. Transferrable concepts for management science

This paper demonstrates that social network analysis can query the status of the personal business data and the relations between the owner and all the contacts. Queries can simulate all the contacts based on the strengths of friendships, locations and categories. Similarly, this can be applied to CRM, ERP and applications that can consolidate trust and friendship between the business owners, clients and close networks. If applying this concept for small and medium enterprises, the same principal can be applied to other individuals who wish to know their status of their relationship and the extents of their influences among their peers, colleagues, collaborators and suppliers.

These support important concepts for IoP. The details of the network and the extent of relationship can be extracted and presented. All the information in SNAP can be analyzed by SocialNewtwork API, which can process and analyze Big Data from Facebook. Large scale simulations were performed to validate resiliency of our SNAP, a new way to demonstrate importance of MIS and IoP for business and management.

Six points of management implications for social network analysis have been illustrated by the use of SocialNetwork API that can extract information in the hidden social networks and present the outputs in a way that can be understood easily. All information can be updated, processed and analyzed, so that the best parts of the data analysis can be reported in real-time and also in large scale simulations.

Additionally, APIs can be used as a way to extract information, prioritize the type of information to be processed and analyze the more important or urgent information. This paper uses the author's personal data for analysis to demonstrate that companies and institutes can similar concepts to extract and analyze their business details if they have Facebook or a similar SNAP service. Similarly, the proposal of this paper is relevant for CEO and CIO of small and medium enterprises (SMEs) who need to study the relations with networks such as customers, VIPs, shareholders, suppliers, salesmen and business partners.

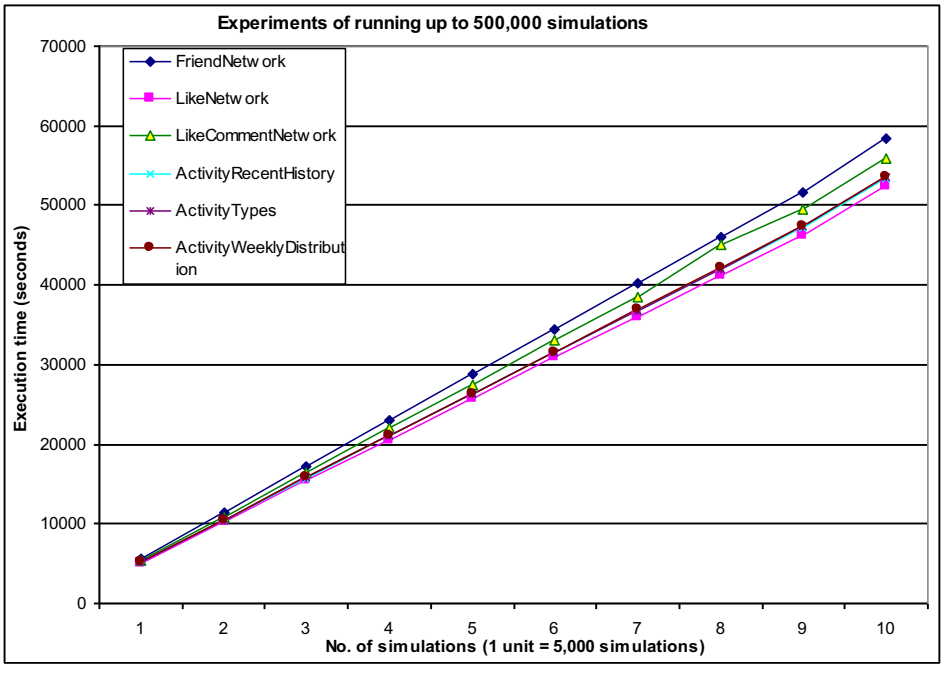

Fig. 9. Experiments of six API functions with 50,000 simulations in the local environment.

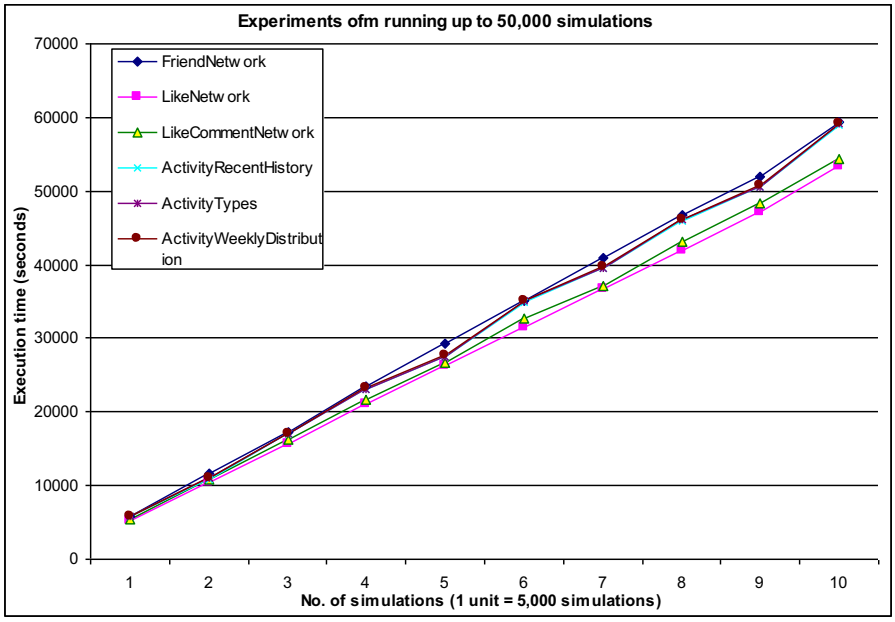

Fig. 10. Experiments of six API functions with 50,000 simulations between Southampton clusters.

Understanding the relationship with key contacts will be useful for businesses.

5.2. Criticism and controversies of Facebook

This section describes criticism and controversies of Facebook. While the data is owned by each user, each user cannot easily understand how their social network data is and the related deep analysis. On the other hand, it is complicated to understand the API, how to query and how to interpret the data as illustrated in this paper. The purpose is to understand the sentiment analysis and the strength of the relationship of the author's networks. Instead of a straight forward process, this paper demonstrates in-depth MIS approach to explain the implications and relevance to SNAP and IoP. Facebook has own all our data and it is not easy to understand the implications. It should be the other way around. We should be extremely careful for what types of data, including messages, videos, personal information and private images to Facebook.

5.3. Contributions to the big data services

Social network services can generate a massive amount of data. As discussed in Section 2.1, BDSN has been the research focus for different researchers. It is not just on data collection but more importantly, data processing and analysis, as well as comprehension and understanding of research outputs. This paper can demonstrate how our work can meet requirements of BDSN as follows.

1. The proposed solution can process the Big Data on Facebook via SocialNetwork API. Analytics allows scientists to focus on the implications of outputs rather than managing petabytes of data directly.
2. Analysis of contacts have been presented, such as contacts who click like or comment on the author's posts, as well as the recent history and types of activities in the previous nine months and the distributions of activities in the most recent week.
3. Complex analysis can be presented in a form that can be more easily comprehended, such as visualization.
4. A single request for data processing took 1.16 s. Large scale of 50,000 simulations can be completed within 60,000 s. Resiliency of the service has been thoroughly tested.
5. No cost are involved to process and analyze data. This provides organizations competitiveness to adopt such a proposal.

Security and privacy are raising concerns for social network analysis. The integrated approach can be jointly used to enforce security, which includes: (1) access control and firewall; (2) an identity management and (3) encryption (Chang and Ramachandran, 2016).

Volume, velocity, variety, veracity and value are five characteristics of Big Data (Chen et al., 2012). Our research can clearly demonstrate velocity, variety and value as follows. First, a large quantity and volume of data, in the form of the relationship to other networks, have been stored and updated live with Facebook. SocialNetwork API extracts and synthesizes those information. Second, there are different varieties of data, including text messages, pictures, videos, games and some interactions with Facebook and SocialNetwork APIs. They can be differentiated so that the relations between different people and communities can be processed and presented by visualization. Value is illustrated in Section 5 where the analysis of the author's network has been presented in details. The same principle can be applied to supply chain management and customer relationship management to study the relationship between different networks. The status and extent of the relationship can be changed due to the rise of circumstances and the way to handle the change of circumstances. The API developed by social network analysis can intelligently understand the differences and make the “best possible outcome” from the data and outputs. Subsequently, analytics and visualization can make analysis easy to comprehend and understand.

6. Conclusion and future work

This paper presents our proposal for the Social Network Analysis Platform (SNAP). We present how to extract information from Facebook from our developed SocialNetwork API, which processes Big Data of the author's network. The details of network have been discussed and the techniques to analyze and visualize data have been presented in details. Six functions of SocialNetwork API can be used to analyze the data, clarifies relationship between different networks. They can illustrate that SNAP can be used as an ERP, CRM and future MIS platform to extract information of our networks and perform deep analysis of every possible situation. Additionally, six functions of SocialNetwork API have been tested extensively with large scale simulations. Results support the resiliency of our SNAP proposal, so that the services can be up-and-running when there are 50,000 concurrent users or requests. This can also test the velocity and veracity of our Big Data social network analysis.

Topics of discussion have been presented. Based on the author's network, the analysis of addition and removal of friendship have been illustrated. Four groups that removed friendship were identified with rationale explained. Key lessons have been summarized with recommendations to the research community illustrated. The contribution in Big Data analysis have been consolidated by using our innovative API to process thousands of data and presented outputs in numerical and visualization forms within seconds. This principle can be applied to business applications to allow business directors understand the behaviors of their customers and understand what their customers like and dislike and understand the latest trend in the market, so that business strategies can be adapted and executed as soon as possible to ensure the businesses stay ahead of the market demands and competitions.

Future work will plan to develop more functions for SocialNetwork API and then use it for other social network platforms such as Twitter and LinkedIn to understand the correlation between the human relationship and business development. The second stream will investigate further on management implications for social network analysis and how the analysis based on Big Data can provide real incentives for organizations and institutes adopting our approach.

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