Network of networks: Uncovering the secrets of entrepreneurs' networks

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CHAPTER 2

Methodology for Extracting Entrepreneurs’ Online Social Network Data

Abstract

In this chapter we introduce and apply the theory of a Network of Networks (NoN) developed in previous research. We present a novel approach to collecting data on entrepreneurs’ online social networks and propose that these are in fact NoNs. In an NoN, each node participates in one or more networks hosted by other nodes. We propose that none of these networks are independent, and rather than the individual network, it is the NoN that contributes to an entrepreneur’s venture performance. Furthermore, we suggest that the NoN model can be applied in other social science disciplines. Our approach can be used to collect NoN data simultaneously from different online social networks, and we used this methodology to collect data from LinkedIn, Facebook and Twitter. The data collected is used for empirical studies in Chapters 3 and 4. In addition, the data is used to study entrepreneurial processes using a simulation model, which is briefly introduced in this chapter. We also suggest that this simulation model could be used to study the entrepreneurial process based on a given network.

1 This chapter is adapted from preliminary research presented at Babson College Entrepreneurship Research Conference (BCERC 2010), ‘Entrepreneurs’ network of networks: studying entrepreneurs’ social network structure using smart-phone data’, June 10, 2010, Lausanne, Switzerland.
Chapter 2 | Exploring Online Social Network Data

2.1 Introduction

The network approach has been applied to explain different phenomena in the social sciences as well as physics. As social network analysis focuses more on relationships rather than the attributes of the research objects, it has also become a prominent theoretical perspective within the literature on entrepreneurship, and it has been suggested (Aldrich & Zimmer, 1986) that it is a relevant method for explaining why some entrepreneurs are more successful in starting and maintaining businesses than others. It is argued that entrepreneurs with a large and diverse network receive more support from their connections, and this can lead to greater success (Brüderl & Preisendörfer, 1998).

Social relationships and networking are key components of human life but historically they have been bound by time and space limitations (D’Andrea et al., 2010). Moreover, traditional social network analysis has generally been constrained in accuracy, breadth and depth due to a reliance on self-reported data (Eagle, Pentland, & Lazer, 2009), with the majority of studies only providing static snapshots and temporal mappings of networks. However, due to the vast growth of the internet and the use of computers, it is now possible for us to collect and analyse data on entrepreneurial behaviour extracted from records saved on computers and other devices that can access the internet. Research suggests that successful entrepreneurs have more online connections and in particular more connections with peers from their alumni network than less successful entrepreneurs (Nann et al., 2010).

Due to the multiple communication purposes and functions that can be fulfilled by online social networking sites (SNSs), different types of network data can be extracted from them and linked in order to study various types of networks simultaneously, such as friendship networks, advice networks, kinship networks and business networks (Song & Vinig, 2012). Moreover, online SNSs support automatic data collection, on the basis of which it is possible to study entrepreneurs’ networks and their potential.

In this chapter, we present a novel approach for studying entrepreneurs’ online social networks. This approach is based on the use of computers and the popularity of online SNSs and will examine to what extent they can be used to explain the behaviour of entrepreneurs and entrepreneurial processes over time. This approach automatically collects data on entrepreneur’s behaviour from multiple online SNSs, which can be used to model and study the emergence, patterns, structures and dynamics of entrepreneurial networks. Moreover, it allows us to identify the main variables and important relationships vis-à-vis the entrepreneurial process and its outcome.
2.2 Network of networks (NoN)

Individuals are usually members of a number of different social networks, each based on different types of relationships and, perhaps, different communication media. We refer to the amalgamation of these networks as a Network of Networks (NoN) (Craven & Wellman, 1973; de Jesús Cruz Guzmán & Oziewicz, 2004; Garton, Haythornthwaite, & Wellman, 1997). Previous research has suggested that a network of networks should offer methodological support, promote sound design and standardization of practices, and generate up-to-date overviews of each field (Ioannidis et al., 2005). As a research approach to the study of social networks, the concept of an NoN implies that ties between individuals and ties between network clusters need to be included in the analysis of social networks (Craven & Wellman, 1973; Garton et al., 1997). For example, the concept of an NoN has been proposed in the context of human genome epidemiology studies, with the creation of an NoN which includes groups of investigators collecting data for human genome epidemiology research. Twenty-three networks of investigators addressing specific diseases or research topics and representing several hundreds of teams have already joined this initiative (Ioannidis et al., 2005). In addition, the notion of an NoN is also suggested as a new metaphor for the sociology of network society (Castells, 2000) and a dominant technological structure (De Jesús Cruz Guzmán & Oziewicz, 2004). Yet another example of the emergence of an NoN is related to the transformation of telecommunications worldwide from national network monopolies to a new system – the network of networks that it is today.

In this thesis, we draw upon previous work on NoN theory and apply this to networks in entrepreneurship. We propose that entrepreneurs’ networks are in fact networks of networks. In such networks each node (e.g. entrepreneur) hosts and participates in one or more networks hosted by other nodes. We propose that none of these networks are independent, and rather than the individual network, it is the NoN that contributes to entrepreneurs’ performance.

We assume that entrepreneurs use multiple online social networks. In this study, we refer to entrepreneur’s online SNSs as NoNs, including LinkedIn, Facebook and Twitter. Nodes and links can overlap in an entrepreneur’s NoN. We use those overlapping nodes to link the different online social networks of entrepreneurs into their NoNs. In this chapter, we will introduce a method to collect NoN data from the online social networking sites themselves.
2.3 Network data

Social network analysis provides a formal, conceptual means for thinking about the social world (Wasserman & Faust, 1994), and has been used as an approach in many fields. According to Wasserman and Faust (1994), relationships defined by linkages among units are a fundamental component of network theories. Thus, the unit of network analysis is an entity consisting of a collection of individuals and the relationships between them rather than the individual alone. Previous studies have addressed two approaches in social network analysis: socio-centric network analysis and ego-centric analysis. ‘Socio-centric’ or ‘whole’ networks comprise relationships between all the actors within a bounded group. ‘Ego-centric’ or ‘personal’ networks comprise the relationships among the people known by individuals. An ‘ego’ is an individual ‘focal’ node. Egos can be persons, groups, organizations, or whole societies (Hanneman & Riddle, 2005).

When analysing the social networks formed through online interaction, the focus can be on using a graph structure (nodes and links) or on semantics (content analysis and text analysis) (Chin & Chignell, 2010). Data collection can also be used for online social network studies. As mentioned, traditional social network analysis has generally been constrained in accuracy, breadth and depth due to a reliance on self-reported data (Eagle et al., 2009), and the majority of studies provide static snapshots and temporal mappings of networks. The internet serves as an instrument for expanding social networks in a number of ways (Ahn et al., 2007). We draw upon Boyd and Ellison’s (2007) definition of online social networks as ‘web-based services that allow individuals (1) to construct a semi-public profile within a bounded system, (2) to articulate a list of other users with whom they share a connection, and (3) to view and traverse their list of connections and those made by others within the system’.

Both socio-centric analysis and ego-centric analysis can be applied to online social networks to study and map the structure of virtual social networks (D’Andrea et al., 2010). The socio-centric data can be used to map the whole range of relationships between nodes, while an ego-centric analysis can be used to study the individual actors.

There are various ways of collecting data from online social networking sites. For data mining from online social networks, the techniques can be divided (according to the analysis target) into web-content mining, web-structure mining, oriented to the structure of websites, and web-usage mining, which focuses on how websites are used (Dráždilová, Obadi, Slaninová, Martinovič, & Snášel, 2010). As we proposed at the beginning of this chapter, it is the NoN rather than the individual network that contributes to entrepreneurial behaviour. In order to explore the structure and configurations of these NoNs, we collected data from the well-
known online social network sites of LinkedIn, Facebook and Twitter. In the following section we will present the sources of our network data.

2.4 Data from online social network sites

Due to the widespread accessibility of the internet, more and more people have started using online social networking sites. Before we start our data mining, we will introduce the characteristics of the three online networking sites used in this dissertation. Each site uses its own mechanisms and security settings. Below, we will focus on the manner in which each online social network is used.

The ubiquitous use of computers makes it possible for people to communicate and interact with each other through online social networks such as LinkedIn, Facebook and Twitter. These three networks have become the standard social networks for contacting other people and for gathering information. Entrepreneurs find these networks especially useful for developing important contacts, which can also assist them in starting up a business. Online social networks make it easier for everybody to establish connections. Below we will discuss the main characteristics of each online social networking site.

LinkedIn is one of the major business-related social networking sites in the world. As of 2 August 2012, LinkedIn operated the world’s largest professional network on the internet, with more than 175 million members in over 200 countries and territories. LinkedIn encourages users to construct an abbreviated CV and to establish ‘connections’ (Skeels & Grudin, 2009). The users can decide what and how much data they want to share with other people. In the LinkedIn network, nodes represent people, while edges represent the connections among people. The LinkedIn online social networking site keeps a profile of each LinkedIn user. The profile information is available to the public unless the user setting is changed manually. The profile includes a user’s full name, headline, location, current position, previous position, education and other information. The public can view a user’s information only if the user wishes to share the data. Profiles are strictly professional, with little or no information about hobbies, political or religious affiliations, favourite music, books or movies (Skeels & Grudin, 2009). In addition to their basic profile information, the connection information for a user may also be available.

The LinkedIn graph is undirected. Edges between individuals are called ‘connections’, and are formed using the mutual consent model. The nodes of those who joined the LinkedIn
online social network earlier have a higher connection number. This is not simply because they joined earlier but because the activity of LinkedIn users tends to slowly increase over time (Leskovec, Backstrom, Kumar, & Tomkins, 2008). The LinkedIn online social networking site can be used for employment pooling, career opportunities, consulting offers, new ventures, expertise requests, business deals, reference requests and instant messaging between contacts.

**Facebook** is a social networking site founded in 2004. Connections among nodes in the Facebook network represent relationships of ‘friendship’ between people. In comparison with LinkedIn, Facebook profiles can be extensive and may include marital or relationship status, religious and political views, hobbies, birthday, favourite books, movies, music and quotations (Skeels & Grudin, 2009). Similar to the LinkedIn network, the connections on Facebook are also mutual. According to earlier research based on a Facebook graph, the Facebook network degree distribution does not follow a strict power-law model (Ugander, Karrer, Backstrom, & Marlow, 2011). The Facebook site has strict security mechanisms that protect user’s data from unauthorized access, which in part accounts for its great popularity (Mavridis, Kazmi, & Toulis, 2010).

**Twitter** is a free social networking and micro-blogging service that enables its users to send and read messages known as ‘tweets’. The users of Twitter are only allowed to post 140 characters of text to display their current status. By default, these ‘tweets’ are available to everyone. A Twitter user can search these tweets and follow other Twitter users they are interested in without gaining their permission to do so.

The Twitter graph differs from that of the LinkedIn and Facebook networks, since the edges are directed. However, the Twitter network clearly shows that it is more likely (88%) for users to be connected in a balanced two-way relationship, which might indicate strong ties when the edges are reciprocal.

The three online social networks have an official application programming interface (API) for developers who are interested in the data arising from online social networks. The online social network API can offer access to a large amount of information depending on the target or the purpose of the developer. Table 3 depicts the information that we will collect through the API of each online social network. However, the online social networks we use do not included the removal of nodes or edges, thus in this research we did not address the loss of connections between different nodes.

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In order to extract an NoN from online social networking sites and explore the functions and structures of entrepreneurs’ online social networks, we designed an online survey to collect data on entrepreneurs’ online social networks. The survey website used the official Application Programming Interface (API) to collect data from the different online social networks. We used the API of each of the online social networks we studied to extract the entrepreneurs’ profile and network data. Using the official API, we were able to collect actual behavioural data on the entrepreneurs – including profile information and connection information – from different social networking sites. We did not use self-reported data on networks.

We first received permission from the online social networking sites to allow us to use the official API. We then used the online social network API to obtain entrepreneurs’ profiles and connection information by building a feature into our data collection website which leverages the respondent’s online network data. To achieve this, respondents were asked to log onto their online social network using their own login credentials after they had been informed about the purpose of the study and how the data would be used. In other words, the network data could only be obtained after consent by the entrepreneurs, that is, after they logged in. Subsequently, the network data was transferred automatically to our server, where we stored the data from different points in time in order to allow us to model the structural network dynamics.

In order not to violate privacy regulations, our survey asked for the consent of the respondents before they logged into their online social networks. The participants first logged into their online social networks through links embedded in our online survey. Then we automatically generated a coded ID to be used rather than the respondent’s name. The data was coded and stored in our database for analysis. The survey was distributed to entrepreneurs from different industries in the Netherlands. We used three ways of contacting entrepreneurs to

### Table 3: Summary of data for each online social network

<table>
<thead>
<tr>
<th>Online network users</th>
<th>Their connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>LinkedIn First name, last name, headline, location, country, industry, current status, picture-url</td>
<td>First name, last name, headline, location, country, industry, picture-url</td>
</tr>
<tr>
<td>Facebook First name, last name, user name, gender, location, picture-url</td>
<td>First name, last name, user name, gender, location, picture-url</td>
</tr>
<tr>
<td>Twitter Name, user name, description, location, time-zone, friend number, follower number, picture-url</td>
<td>Name, user name, description, location, time-zone, friend number, follower number, picture-url</td>
</tr>
</tbody>
</table>

**2.5 Extracting NoN from online social networking sites**

In order to extract an NoN from online social networking sites and explore the functions and structures of entrepreneurs’ online social networks, we designed an online survey to collect data on entrepreneurs’ online social networks. The survey website used the official Application Programming Interface (API) to collect data from the different online social networks. We used the API of each of the online social networks we studied to extract the entrepreneurs’ profile and network data. Using the official API, we were able to collect actual behavioural data on the entrepreneurs – including profile information and connection information – from different social networking sites. We did not use self-reported data on networks.

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participate our survey: (1) we invited entrepreneurs randomly through the people we had in our own networks, (2) we administered surveys through entrepreneur organizations such as consulting and social media companies and (3) we made personal visits to entrepreneurs to overcome their reluctance to participate. In addition, we put the survey website link on the server of the University of Amsterdam (UvA), and thus the domain name of the survey link contained ‘UvA’, which proved its legitimacy to entrepreneurs. In total the full online survey had twenty questions, the details of which are presented in Table 4.

As shown in Table 4, we first asked for the participants’ gender and age. For the purposes of this study we defined people as entrepreneurs by asking whether they were the owner/founder or co-owner/co-founder of one or more ventures. If a participant was an entrepreneur, we then asked for venture demographic information to measure entrepreneurial performance in terms of the founding year, company name, revenue at the launch of the company and current situation, employee numbers at the launch of the company and current situation. Before entrepreneurs logged into their online social network sites, they consented to us using their online social network data. The online social networks used in this dissertation were LinkedIn, Facebook and Twitter. Figure 1 depicts the flow chart of the entire data collection process. The screenshots of the survey are presented in the Appendix of this dissertation.

The whole data collection process lasted for six months from April 2011 to September 2011, with 345 respondents participating in our survey. The online social networks analysed in our study consisted of LinkedIn, Facebook and Twitter, with 95,076, 59,365 and 114,907 connections respectively (see Table 5). In Chapters 3–5, we will investigate the data using different methodologies.

2.6 Simulation of entrepreneurial processes

The entrepreneurial process can be complicated in many ways. From an organizational perspective, the entrepreneurial process involved in starting and running a new venture can be described by various managerial and development life-cycle theories (Mueller, 1972; Quinn & Cameron, 1983; Smith & Miner, 1983; Torbert, 1987; Vinig, Blocq, Braafhart, & Laufer, 1998). We found that all the models follow the S-diagram. According to Torbert (1987), the entrepreneurial process can be divided into six stages: 1) Conception, 2) Investment, 3) Incorporation, 4) Experimental, 5) Systematic productivity and 6) Collaborative. In particular, entrepreneurs tend to expand their networks during the second stage of their firm’s life cycle, which includes building up relationships, making personal, structural and financial commitments. Thus, we conclude that entrepreneurs tend to find their collaborators during a search period prior to starting up their business.
### Table 4  Survey for data collection

<table>
<thead>
<tr>
<th>Survey question</th>
<th>Answer &amp; question purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Please choose your gender</td>
<td>• Female&lt;br&gt;• Male</td>
</tr>
<tr>
<td>2) Please select your year of birth</td>
<td>Range from 1940–2000</td>
</tr>
<tr>
<td>3) Are you the (co)founding or (co)owner of a company?</td>
<td>• Yes-&gt;continue to question 5)&lt;br&gt;• No-&gt;jump to 12)</td>
</tr>
<tr>
<td>4) Please state the name of your company</td>
<td>Name of the company (optional)</td>
</tr>
<tr>
<td>5) Please select the year when your company was launched</td>
<td>Range is from 1953–2011</td>
</tr>
<tr>
<td>6) How many employees (full-time and part-time) were involved at the launch of your company</td>
<td>• 1–5&lt;br&gt;• 6–10&lt;br&gt;• 11–20&lt;br&gt;• 21–50&lt;br&gt;• 51–100&lt;br&gt;• 101–500&lt;br&gt;• More than 501</td>
</tr>
<tr>
<td>7) Please choose current employee numbers (both full-time and part-time employees) at your company</td>
<td></td>
</tr>
<tr>
<td>8) What was the percentage of annual revenue growth from the first fiscal year to the second fiscal year after the launch of your company</td>
<td>• 1%–10%&lt;br&gt;• 11%–20%&lt;br&gt;• 21%–30%&lt;br&gt;• 31%–40%&lt;br&gt;• 41%–50%&lt;br&gt;• more than 50%</td>
</tr>
<tr>
<td>9) Please choose the annual revenue growth of your company in the last fiscal year</td>
<td></td>
</tr>
<tr>
<td>10) What is the average annual revenue growth since the launch of your company</td>
<td></td>
</tr>
<tr>
<td>11) Do you have a LinkedIn account?</td>
<td>• Yes-&gt;continue to question 12)&lt;br&gt;• No-&gt;jump to 14)</td>
</tr>
<tr>
<td>12) Please click the LinkedIn icon to log into your LinkedIn account</td>
<td>Note: By logging into your LinkedIn account, you will allow us to use your online data</td>
</tr>
<tr>
<td>13) For what purpose do you use the LinkedIn network?</td>
<td>• Personal&lt;br&gt;• Business&lt;br&gt;• Personal &amp; Business</td>
</tr>
<tr>
<td>14) Do you have a Facebook account?</td>
<td>• Yes-&gt;continue to question 15)&lt;br&gt;• No-&gt;jump to 17)</td>
</tr>
<tr>
<td>15) Please click the Facebook icon to log into your Facebook account</td>
<td>Note: By logging into your Facebook account, you will allow us to use your online data</td>
</tr>
<tr>
<td>16) For what purpose do you use the Facebook network?</td>
<td>• Personal&lt;br&gt;• Business&lt;br&gt;• Personal &amp; Business</td>
</tr>
<tr>
<td>17) Do you have a Twitter account?</td>
<td>• Yes-&gt;continue to question 18)&lt;br&gt;• No-&gt;jump to 20)</td>
</tr>
<tr>
<td>18) Please click the Twitter icon to log into your Twitter account</td>
<td>Note: By logging into your Twitter account, you will allow us to use your online data</td>
</tr>
<tr>
<td>19) For what purpose do you use Twitter network?</td>
<td>• Personal&lt;br&gt;• Business&lt;br&gt;• Personal &amp; Business</td>
</tr>
<tr>
<td>20) Please enter your email address</td>
<td>Optional</td>
</tr>
</tbody>
</table>
Although we know that entrepreneurs obtain information and resources from their networks across the entire entrepreneurial process, the extent to which social networks or online social networks contribute to the entrepreneurial process remains a gap to be filled in the fields of entrepreneurship and social networks. In order to determine the influence of social networks...
on the entrepreneurial process, we focus solely on the networking part of the entrepreneurial life cycle. To do this we adapted the model of Arent Greve (1995) and Wilken (1979), rather than that of Torbert (1987). The former clearly explains the entire entrepreneurial life cycle in terms of a three-phase entrepreneurial process, which still accords with the six stages of Torbert’s model but in a simplified form.

Entrepreneurs founding a business are assumed to go through three phases of entrepreneurship: 1) idea development, 2) organizing the founding of a firm, and 3) running a newly established firm (Arent Greve, 1995; Wilken, 1979). During the entire entrepreneurial process, the network supplies entrepreneurs with connections which could assist in finding information and resources. However, the mechanisms and processes whereby particular ties play a role in the development of an emerging firm remain unclear (Elfring & Hulsink, 2003). We suggest that the use of a simulation model could assist in evaluating the value of social networks in the entrepreneurial process.

According to the model developed in a previous study (Arent Greve, 1995; Wilken, 1979), entrepreneurs require different resources and information for different phases. At the beginning of the start-up phase, entrepreneurs need to find business ideas through their networks. In the first phase, they always face problems related to limited capacity, resources and new technologies. During the start-up phase, entrepreneurs search for potential collaborators from the network. The information and ideas they obtain come from strong ties in their network, such as friends, family and existing business contacts. In the second phase, entrepreneurs will start organizing their business based on the idea developed in the first phase, and strong network ties are still very important. However, during the third phase the entrepreneurial process is mainly driven by weaker ties (indirect contacts) and these become important. The connections supplied by the network assist entrepreneurs to find information and resources throughout the entire entrepreneurial process.

Table 5  Raw data

<table>
<thead>
<tr>
<th></th>
<th>LinkedIn</th>
<th>Facebook</th>
<th>Twitter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrepreneur profiles</td>
<td>261</td>
<td>188</td>
<td>174</td>
</tr>
<tr>
<td>Links</td>
<td>95,076</td>
<td>59,365</td>
<td>114,907</td>
</tr>
<tr>
<td>Average/median links</td>
<td>364/249</td>
<td>272/215</td>
<td></td>
</tr>
</tbody>
</table>

Following: 396/174
Followed by: 628/238
The simulation approach can be used to examine how entrepreneurs use networks to start up a business. We will present a network simulation model to describe entrepreneurial growth as dependent on the entrepreneur’s position in a given network. The network structure that we used was extracted from the LinkedIn network. This simulation model can be used to predict entrepreneurs’ maximum survival time based on a given start-up time frame and initial wealth allocated. In our model, we found that entrepreneurial growth is not only related to wealth but also related to the extent of an entrepreneur’s network. Although we were not able to determine the threshold for entrepreneurial survival at a given time, we could still infer the survival probability from wealth allocated and time needed for start-up.

2.7 Discussion and conclusion

In this chapter we first reviewed the methodology used to collect social network data. Second, we introduced three online social network sites and the data stored on multiple websites. We analysed the reasons why people use online social networks and why we used the online social network to study NoNs. Third, we developed a methodology which can be used to collect NoN data. We also noted that NoN theory can be used to explain phenomena in other social science fields. In particular, we theorized that entrepreneurs’ networks are networks of networks. We proposed that the structure of an NoN can be studied through data extracted from online social networking sites. NoN theory provides a new perspective for studying the entrepreneurial process throughout a venture’s life.

The core idea related to NoNs is that entrepreneurs are embedded in multiple networks. Rather than individual networks, the NoN may contribute most to the entrepreneurial process in the future. We developed a methodology to collect NoN data through online social networks. However, in relation to this data, we can only observe when a new node is added to the existing network but not when connections are broken. Thus, we cannot predict from the online network whether connections will be maintained after two entrepreneurs become connected. Nonetheless, we can still test the structure of online social networks. We suggested that a simulation model can be used to study the influence of online social networks during different phases of the entrepreneurial process. In Chapter 5, we will use the simulation model to test the parameters that might be important for entrepreneurs’ networks.

Our methodology and approach will contribute to the fields of entrepreneurship and social network analysis. First, we can infer entrepreneurial behaviour and social network structures. Second, our study will contribute to our understanding of how network structures influence entrepreneurial processes. Understanding the emergence of NoNs can improve our
understanding of how new ventures, industries and, in fact, economies are interlinked. A
deeper understanding of the structure of entrepreneurial networks can offer new ways of
designing entrepreneurial business strategies and new ways of propagating new ventures,
products, services and technologies. Last but not least, our methodology also contributes
a novel way to access the internet to extract long-term, large-scale data on users’ online
social networks that can potentially be applied in other research areas. Furthermore, our
approach resolves the privacy issue by inviting respondents to log onto their networks from
within the online survey application, which we designed on the basis of the official API of
each online social network.

This chapter introduced NoN theory and developed a novel approach to collecting data from
online SNSs. In the next chapter, we will examine the data we collected through the above-
mentioned approach. The aim of the next chapter is to test the methodology introduced in
this chapter and explore the characteristics of each online social network.