# Considering Stakeholders' Feedback in Requirements Prioritization using Social Network Analysis

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***Abstract*—***Requirements prioritization plays a significant role to ensure successful planning of software releases. It helps software stakeholders to discover the most desirable requirements. In this paper, we propose requirements prioritization approach using social network analysis based on stakeholders' feedback. The social network models the relationships among stakeholders, their feedback and the system requirements. A string-matching algorithm is used to automate the discovery process of the relationship between stakeholders' feedbacks and requirements specifications based on text similarity. Then, the network is analysed to identify the priority of requirements depending on relevant groups of stakeholders and their feedbacks. As an attempt to validate the results, focus group is conducted to discover the relationship between the stakeholders' feedbacks and the requirements by manually matching each feedback with its related system requirement. Then, social network is built based on the results of the focus group and the system requirements are prioritized based on the network. The results of the two approaches are compared. The experimental results proved that there is a difference between the approach that uses string-matching and the focus group approach. The string-matching approach does not seem to be very appropriate in capturing the real relationship between the stakeholders' feedbacks and the requirements.*

Keywords—*Requirement; Feedback; Social Network Analysis; Requirements Prioritization*

## I. Introduction

Prioritization of software requirements is a complex process and has become an indispensable part of the software development process to establish a software product that meets customer needs. The prioritization process faces many challenges in most software development projects, as there are many stakeholders who would like to see some of their requirements included in the final output of the project. Although, some of these requirements may consume a lot of resources, time, and cost. Thus, this will create a significant conflict between those requirements. We need to reduce the conflicts inherent and hidden between stakeholders, especially when they are evaluating requirements according to their interests. [1][2].

Stakeholders seek to find more effective and efficient methods to prioritize software requirements. For this reason, many authors have attempted to find proper requirement prioritization techniques[3]. Generally, these methods can be divided into two types; qualitative andquantitative. The qualitative approaches rely mostly on the direct or indirect qualitative assessment of stakeholders. One of the disadvantages of these approaches is the fact that they do not show the relativedifference between the priorities of requirements. On the other hand, the quantitative approaches have been seen as more effective, but they are considered difficult and complex, as they lack structure and consistency [4].Quantitative methods can be used to avoid the objective reality of qualitative ones, but they need to use more accurately measurable parameters for prioritization process. Although, there are a significant number of prioritization techniques, but the empirical studies still reflect a clear lack of evidence for what method is favorable. These studies lead to varying conclusions[5]. The reason, maybe the variables used to compare the techniques were not always the same in all studies. For that reason, the existing techniques hold many limitations and not adequate for all applications.

Social networks are one of the best new developments on the web that allow you to connect with others; like Instagram, Facebook, and Email network. Social networks structure is a set of nodes (representing individual actors, organizations, or things within the network) connected by edges (relationships/interactions). Usually, a social network is visualized by a graph to make sense of network data.Social Network Analysis (SNA) is the process of investigating network structures. SNA helps analysts to understand and visualize reciprocal interactions between individual actors. SNA techniques can be used to deal with practical challenges of requirements prioritization. The requirements management is somewhat similar to the social network in various aspects. For example, requirements form a network of interdependencies which are changing over time, and also for selecting the requirements a group of stakeholders are interacting for taking a group decision.

A system analyst needs to know the stakeholders who are working on the project, to bridge the gap between them. The analyst must find a way to get them to work together. The analyst should be able to communicate effectively with stakeholders. The existing techniques may work well and suitable by using a direct assessment approach. The direct approach used only when the system analyst and stakeholders can have a direct communication between them. This approach has three main advantages; 1) directly measured 2) easy to administer 3) Take a short time to carry out. A major shortcoming of the direct approach is that its focus on a limited number of participants.

The following is an example using the direct approach, in [6], P. Fitsilis et al. presented how Social Network Analysis SNA technique can be used to improve the prioritization process. They have used a direct assessment approach to rating the relative importance of each requirement to that stakeholder. They used a very limited number of stakeholders (set of five different stakeholders used to build a social network). So, the assessment process has become easier to assign values to each requirement based on stakeholder's perspective, who are directly involved in using this technique.

Therefore, there are two questions that should be answered, before using the direct assessment approach in the SNA technique. First question, what are the types of connections between stakeholders and requirements (direct or indirect) in other words, Is it possible to reach important stakeholders easily?. The second question, Is the number of stakeholders limited or very large?. The direct approach will only be useful when the number of stakeholders is small. It provides a simple instruction of creating relationship matrix between the proposed system requirements and stakeholders to build a social network. All prioritization techniques differ from each other, but they all still used the direct approach to estimating the importance of each requirement by stakeholders.

In some cases, there are a large number of participants and they cannot directly communicate with each other. Thus, the direct approach would be difficult to apply in practice and does not fit all issues. So, we attempt to find an indirect approach be able to overcome those causes. Despite the inherent limitations of the indirect assessment approach, such as; 1) hard to administer 2) takes a time to carry out 3) requires much effort. We have to use indirect assessment approach in SNA technique. Because in our case, there is a huge number of stakeholders and harder to reach them directly.

Therefore, we aim to automate the process of recognizing the relationships among important stakeholders, their feedback and the system requirements and construct a social network model to better represent the relationships. Proposing such approach, we aim to apply indirect assessment. First, we need to identify the most important stakeholder groups according to the importance of their feedback. Second, we create a relationship matrix that reflexes a relationship between the requirements and stakeholders. The matrix can be represented as a social network to facilitate the analysis process.

In this context, it would be reasonable to approach the challenge of requirement prioritization using Social Network Analysis (SNA). Therefore, this study is based on the Explicit Relevance Feedback (ERF) in a social network. Explicit relevance feedback is easy to use, but sometimes hard to obtain. Basically, there are three general families of relevance feedback; explicit feedback, implicit feedback, and pseudo (blind) feedback. Explicit feedback can be captured directly from actors of relevance indicating the relevance of a comment or participation retrieved for a query. For instance, specifying keywords, or terms, to represent the information content of users comments about their interests through watching their natural interactions with systems. This family of relevance feedback is defined as explicit only when the actors or stakeholders know that the feedback provided is interpreted as relevance judgments. The explicit feedback is given actively and consciously by the user to instruct the system what to do, while the implicit feedback based on user's behavior that indirectly expresses user's preferences[7][8].

In order to avoid as many ambiguity problems as possible compared to natural language and to reduce its complexity. In this context, we present two resolution approaches. In the first approach, an exact pattern-matching algorithm is proposed to find a relationships matrix between the requirements and feedback. These types of algorithms do not require any preprocessing, especially when we take the distinctive characteristics of the technical language into consideration. Boyer-Moore algorithm[9] (one of the most important string-matching algorithms) is used to identify the ratio of a relationship between requirements and stakeholder's feedback. According to these ratios, we can generate the proposed social network. In the second approach, we used graduate students to link feedback with requirements in order to create another relationships matrix. After generating the relationships matrices, we can build a social network based on these relationships in order to facilitate further analysis. The analysis process will be helpful to examine the weight of all the requirement.The goal of this study is handling the problem of prioritizing requirements based on Social Intelligence and SNA depending on the ERF.

SNA is used in prioritization process based on two factors only; 1) interdependence between requirements. 2)and stakeholders priorities, without involving users feedback[6]. We introduce a social network that is based on relationships between requirements, stakeholders and their feedback.

The rest of this paper is organized as follows; Section II is dedicated to the background in which we define the basic concepts. In section III, we present the proposed approach in details. Section IV, we describe the case study that we used to demonstrate the proposed approach. In section V, we describe general considerations for the validation attempt for the obtained results. In section VI, we present limitations for the validity of the validation process. Related work is discussed in section VII. Finally, we conclude and outline the future work suggestions in section VIII.

## II. Background

For many software projects, determining what needs to be done within the project is more difficult than getting it done. Proper requirements and specifications are critical for having a successful (and high-quality) software project. Also, the proper requirements management process is critical to maintaining awareness level of any type of development. Therefore, in this section,we will define and clarify the terms relevant to the concepts we use in this work, including: Requirements Engineering, Requirements Management, Requirements Prioritization, Social Network Analysis, and Using SNA in Requirements Prioritization.

### A. *Requirements Engineering*

The requirements express the problem domain or actual customer needs. According to the quality criteria of requirements, they should be able to realize customer needs and meet project goals. Customer needs often lack clarity in purpose, precision, and may seem not mature enough to be implemented. The description of needs depends on customer awareness and general knowledge, whereas requirements are highly dependent on the technical feasibility.

In most cases, the terms; features, specifications, and requirements seem to be the same, especially during the product conceptualization process. In fact, there are important differences among these terms. For this reason, these terms should not be used interchangeably by others. Features explain the product from end user perspective. Specifications stage describes the product from available technology perspective through the eyes of business experts, who are not familiar with the software development process. Requirements explain the product from software engineer's or implementer's perspective. Requirements have a larger scope and more technical focus than features and specifications. Therefore, the features must pass through another stage to become requirements, such as product specifications. Moreover, any feature can be divided into one or more specifications and one specification also can have one or more requirements [10] [11].

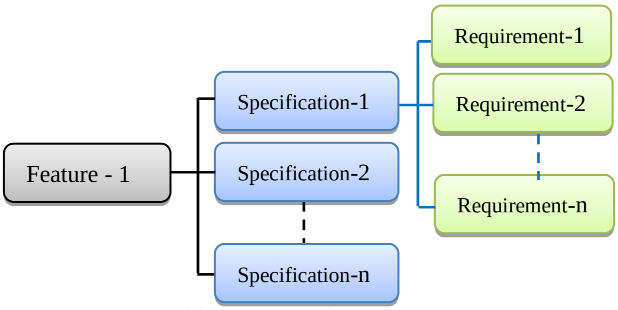

**Fig. 1. Structure of features, specifications and requirements.**

Usually, requirements explain what we have to do, but they should be accompanied by some constraints that reflect the limits of this work[10]. Requirements can be classified into functional and non-functional. Each one can be further classified into three categories; Business or Customer requirements, System requirements and Product or Component requirements[11].

Functional Requirements FRs are considered the area of functionality. They represent functional system properties and also specify why the project should exist or what the system should do. FRs define the functional behavior of the project. As an example "the user should be able to make and receive video calls or video chat via Google". In other words, they are like "a pocket of trousers", that has the ability to carry many things without losing. FRs specify the set of inputs, behavior, and outputs, that should be executed to allow users to perform each usage case. Generally, the FRs include; external interfaces, goal rules, regulatory requirements, adjustments or modifications, and cancellations, .. etc. but only within the best correct solution among all the correct solutions that can be designed and successful implemented[12].

Non-Functional Requirements NFRs are often called quality requirements that should be able to describe and identify system properties. NFRs also reflect the global constraints imposed on the system that should be taken into consideration such as the cost of operation and development. NFRs can be taken as an early indicator to prioritization process and requirements selection [13][14].

Generally, the NFRs include; privacy, safety, security, maintainability, scalability, capacity, usability, and performance such as (response time, throughput, utilization) [15].The goal is to ensure the system's ability to adapt to the environment and also to address the risks resulting from misuse or abuse, such as taking into account the ratio of output to input. There are more than 250 types of NFRs and 114 definitions[16][17].

### B. *Requirements Management*

Requirements management process is one of the core project management methods. It directly affects the scope, schedule, budget and quality of each software product. As it is a continuous process in the life cycle of the product and does not end with its release. Requirements management is a systematic approach that includes; elicitation, organization, as well as documentation of project requirements. This process establishes and maintains agreement between various stakeholders in order to achieve the consistent and clear communication between stakeholders, as well as share all needed changes with relevant stakeholders effectively. The good requirements management process has a positive effect on the entire development process.Briefly, the requirements management process should be able to access, capture and share the right information to the right stakeholder at the right time[18].

The purpose of this process is to ensure that the customer and the project team have a common understanding of software product plan in order to meet the needs of its customers and stakeholders. Thus, requirements management must be done again with each new software release, as it is a part of the software development plan.

### C. *Requirements prioritization*

Requirements prioritization is an essential part of the decision-making process. The biggest challenge is how to find the actual importance of each requirement among existing requirements. In order to address the differing visions between stakeholders about the specific value of a certain requirement, or to reduce the gap between two values.Good prioritization techniques will be the solution through quick access to right evaluation of requirements.

It is the norm for the new requirements to be prioritized by your project stakeholders. There are often many project stakeholders, including operation staff, developers, managers, analysts, and so on. Product owner dominates the prioritization process even though direct stakeholders still have strong input in the process. Especially those who have responsibility for registering the results of the assessment process. There are a number of different types of prioritization techniques. The basic principle shared by all of these techniques is to prioritize a set of requirements by projects' stakeholders. All of them rely on a direct-access method between the requirements analyst and the stakeholders. Therefore, we propose that the problem of requirement prioritization can be overcome by using the indirect access method based on stakeholders' feedback data.

The process of requirements prioritization is still hard to combine views of multiple stakeholders because they have different backgrounds that directly affect process evaluation. Ignoring such issues can raise the risk level for a software project. Therefore, the prioritization process is considered an important difficult activity in software product development. The difficulty lies when we take into consideration all relevant factors that have an influence on the priorities. So, developers still feel the need to unveil information about customer tendencies, because the developers do not know enough information about customer preferences.

Requirements prioritization is a way to manage the relative importance of several requirements based on collaboration with stakeholders. This strategy identifies which requirements have more importance, and which ones are nearest to the product. The purpose of prioritization is to achieve the maximum benefit from the project implementation schedule[19][20][21].

We believe, the non-traditional approaches of prioritization have the ability to overcome many difficulties efficiently. Therefore, we think the SNA will be able to facilitate the prioritization procedure. In addition, it can be used for selecting the team members according to their experiences and communication analysis among them according to their feedback[22][23].

In general, there are many effective techniques available for prioritizing software projects, but most of them seem to work effectively and well with a small group of requirements. While at the same time, these techniques have serious shortcomings and limitations on medium to large numbers of requirements.

Each of these prioritization techniques has specific strengths and weaknesses, and limitations, which make them suitable for some and not other problems. These limitations have been one of the main reasons or motivations for our study.

In[24], Muyassar et al compared eleven techniques. Table 1 below shows the strengths and weaknesses of these different prioritization techniques. In this research effort; prioritization techniques are classified to three main categories, which include: 1) Heavyweight and Lightweight techniques. 2) Dependency-aware and Dependency Non-aware techniques. 3) Traditional and Non-Traditional techniques. (See Fig. 2.).

Heavyweight techniques referring to the techniques that explicitly considers multi-criteria in decision-making environments. These techniques are based on the relative importance of requirements according to the stakeholder experience in all stages of the prioritization process. This type of classification includes negotiation approach in the requirements priorities; such as AHP, SNA, Fuzzy, PWC, and the PG technique.

While the Lightweight techniques indicate the primitive activities which are used to rank each requirement depending on to importance for the stakeholder. In other words, techniques that apply the single-criterion rather than multiple criteria, which are based on the absolute importance of each of the requirements or on their raw values; such as NAT, BPL, PGT and MoSCoW. This approach usually exploits one variable (e.g. importance or cost,..etc).

**Table 1. Summary of requirements prioritization techniques**

| Method | AHP | SNA | Fuzzy | TPWC | PG | MoSCoW | 100$ | CV | Numeral Assignment | BPL | Priority Groups |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scale** | Ratio | Ratio | Ratio | Ratio | Ordinal | Nominal | Ratio | Ratio | Nominal | Ordinal | Ordinal |
| **Speed** | Slow | Fast | Fast | Fast | Average | Average | Fast | Fast | Average | Average | Average |
| **NO. of REQ.** | Small | Medium, Large | Medium | Medium, Large | Small, Medium | Small, Medium | Medium, Large | Small, Medium | Medium, Large | Small, Medium | Medium, Large |
| **Dependency** | No | Yes | Yes | No | No | No | No | No | No | No | No |

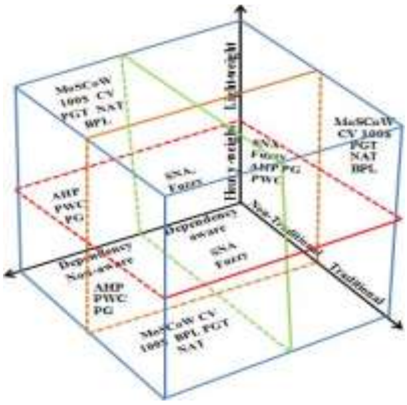

**Fig. 2. Categories of requirement Prioritization techniques**

Dependency-aware techniques will take into consideration the mutual influence of requirements when they calculated the priority of requirement. Such SNA and Fuzzy techniques.

Dependency Non-aware techniques ignore or do not allow to take into account of all the interactions or dependence among the requirements. This category includes all methods that are not included in the previous class. AHP, PWC, PG, MoCSoW, CV, 100$, PGT, BPL, and NAT.

Traditional techniques refer to the techniques that used by normal people in their daily lives to ranking their business. In this type, stakeholders used explicit criteria only. this type is uncomplicated, easy to implement and does not require too much effort or thought, but may actually carry more risks, because these techniques have limited capabilities for prioritization process (as soft computing techniques). Such MoCSoW, CV, BPL, 100$, PGT, and NAT.

Non-traditional techniques refer to the techniques that used by specialists person highly skilled in a specific field, because they depend mainly on technical skills. The purpose of using nontraditional techniques is generally to optimize the prioritization process and to find more accurate solutions, than with traditional techniques. These techniques can be thought to be among the latest advances in the requirements prioritization techniques. This kind of techniques is called smart techniques (hard computing techniques). But, they cannot be successfully applied to every type of problem. Such as AHP, SNA, Fuzzy, and PWC.

The following criteria should be taken into consideration to reduce selection bias or hidden agendas, while choosing an appropriate technique of prioritization. Table 2. below identifies criteria commonly used in prioritization processes:

**Table 2: Commonly Used Prioritization Criteria**

| No. | Criteria to Identify Prioritization Technique |
|---|---|
| 1- | *The Nature of application.* |
| 2- | *Size of problem or  Number of requirements.* |
| 3- | *Type of the desired scale.* |
| 4- | *Degree of accuracy desired.* |
| 5- | *Time-factor.* |

## *D. Social Network Analysis*

SNA is a competent science that analyzes relations in social networks or is a process or a set of processes for investigating relational aspects in the structures of networks using software and unique theories of graphs. It's also a key to problems solving, and we can imagine this structure through SNA which may be one of the most interesting sciences.

SNA can be used to face problems of requirements prioritization since a social network is somewhat similar to a prioritization process in terms of structure. They represent an interdependency network between stakeholders and requirements.So, SNA can be exploited to gain an optimal number of requirements that must be implemented in each release through applying some distinct centrality measures of techniques SNA [22].

SNA provides a set of measures to achieve goals such as; mapping, measuring relationships between pairs of actors, and knowledge flow between the entities. This leads to the determination of the location of the main nodes and marginal nodes.[25].

So we need to provide a brief explanation of what we mean by these measures in terms of the definition and the influence in order to gain a comprehensive understanding of these main measures. They are very important and most commonly used in the fields of SNA. So, they are considered the fundamental properties of social structures and individuals, which represent the power even if there is dispute or inconsistencies about their definitions and consequences [26][27].

**Table 3. The most common approaches which enable analysts to study and assess power Influence**

| Distinct measures | Definition | Influence |
|---|---|---|
| ***Degree Centrality*** | Number of links for an actor.<br>(index of the node's communication activity) | Having more opportunities and alternatives, such as a 'connector' or 'hub' in the network. |
| ***Closeness Centrality*** | That has the shortest paths to all nodes, located in an excellent position to monitor data flow in the network, and it has the best visibility into what is happening in the network.<br>(index of the node's efficiency) | Direct bargaining and exchange with other actors, because it's based on the sum of geodesic distances from a given actor to all others. |
| ***Betweenness Centrality*** | Standing between each other pair of actors, that has a strong influence over what flows. ( index for control of communication) | Having a high capacity to control relation-ships among other actors (as a broker/distributor). |

### *E. Using SNA in Requirements prioritization*

The standard SNA measures can be used to analyze relationships between the requirements and stakeholders. These measures take into account the entire pattern of connections in the network. They are also used to assess factors that shape their structure in order to determine significant nodes that were created based on roles of actors in the network.

In[6]P. Fitsilis et al proposed a UML model to represent the main classes for software requirements release planning.This model included seven major classes: Stakeholder, Requirement, Project, Task, Release, Knowledge, and Agent by using UML class model for software. These seven classes seem sufficient from the author's perspective, at least they can easily represent the main parameters of software release planning (Fig. 3).

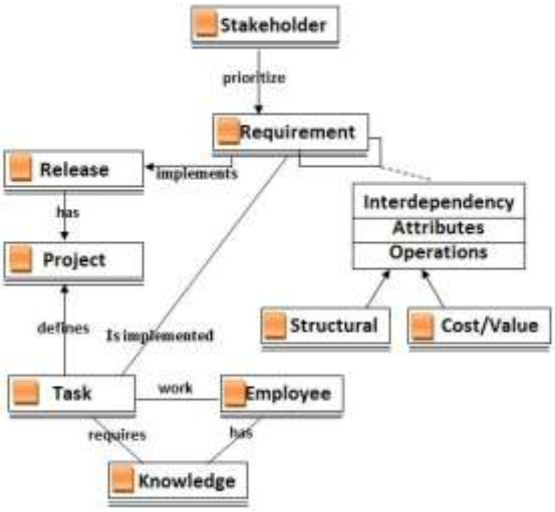

**Fig. 3. UML class model for software requirements release planning.**

In this model, the team provides a number of requirements which are considered more useful depending on certain criteria for each release. Then the Stakeholders class (for representing the human resources working on a project), assign priorities to requirements through their personal experience in order to define the Mandatory, High Priority, Desirable requirements. The Task class determines the list of tasks that will be implemented sequentially during a given project phase. Interdependency class defines the strength of association between two or more requirements, or determines which requirements are dependent on others. Knowledge class presents the required information for implementing a specific task. Employee class, uses to secure sufficient resources to meet needs and maintain standards of good practice. Requirements class, are associated with each other according to the dependency principle.

The structure of the above model is based on the direct assessment method because all the stakeholders are directly related to requirements in order to assign their priorities.Therefore, this model can be expanded using more classes or concepts, especially when the stakeholders are not directly associated with the requirements.The idea of the expansion of this model will be explained in detail in section III.

## III.THE PROPOSED APPROACH

All The proposed approach exploits features and benefits of social networking functionalities to improve software requirements management and the prioritization process. Our approach focuses on detecting the relative importance of stakeholders' feedback, and the strength or degree of association between these feedbacks and requirements. All prioritization techniques assume a direct relationship between stakeholder class and requirement class. These techniques also use a limited number of stakeholders. So, the stakeholders can easily and quickly assess the weight or the relative importance of each requirement. In general, the direct assessment approach is markedly easier to handle than the indirect assessment approach.

On the other hand, there are many cases where these techniques do not fit. Especially when the analyst becomes unable to reach all relevant stakeholders directly or there are many stakeholders involved in the evaluating process. In short, the rapid diffusion of the Internet technology was the most important motivating factor for increasing numbers of stakeholders. In order to exploit large numbers of stakeholders and enable them to participate in decision-making[28].

The approach;that is proposed;extends the UML model in Fig. 3. We propose to adopt the indirect assessment process to evaluate the relative importance of each requirement. This modification requires changes in the UML model structure, because the indirect assessment process requires adding new classes called Question class and Feedback class. The new middle classes are considered to be an intermediate link between the concerned classes (upper-class and lower). These classes represent an important reference in the indirect assessment process, with recurrent debates about the importance of these requirements. Thus, in this part of the proposed model, we can trace connections, if not direct lines, between the stakeholders-class and the requirements-class, then we will be able to complete the assessment process indirectly. The modification is illustrated in Fig. 4.

These classes can be briefly described as follows:

- Question class represents the different questions that can be answered by the other stakeholders or team members.
- Feedback class offers some practical answers to a Forum question.

In this model, Stakeholders class defines a priority for each requirement (Stakeholders as a different entity than team members, representing the participants who are working on a specific website). This approach can be added to the prioritization techniques list which belongs to the ratio scale category, therefore, you can distinguish the relative difference between any pair of requirements.

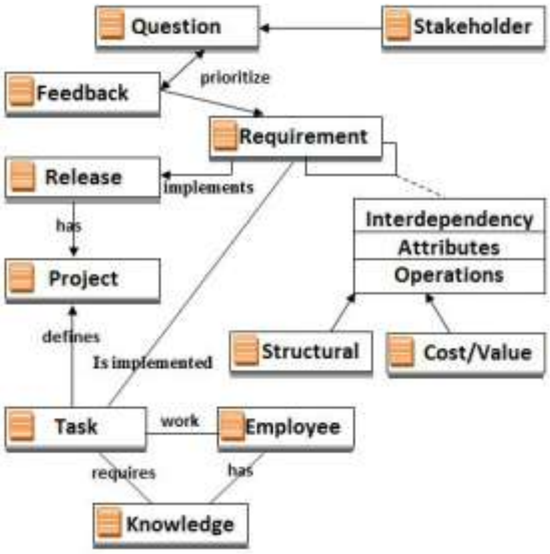

**Fig. 4. The proposed UML class diagram for software requirements release planning.**

## IV. CASE STUDY

In this section, the case study will clarify the approach we use. Our approach provides a new insight into traditional requirement prioritization based mainly on the value of a stakeholders' feedback.MicrosoftTechnet forum allows users to submit feedback in form of ratings and reviews to downloaded applications. This platform has become very popular to the application developers. We investigate, when users provide feedback, we look closely at this feedback content, and analyze its impact on the requirements prioritization process. Part of these feedbacks are superficial while others include useful comments that can help to classify users' feedback to prioritize requirements.

To exploit the knowledge available in Microsoft Technet forum and to achieve the goal of the research, we conducted a case study at Microsoft Technet forum. This forum is a Microsoft web portal which provides online training, discussion forums, generates traffic from 11.5 million users per month and host approximating 11 Million documents. We observed the collaboration patterns of a multi-stakeholders feedback and development project team. Technet Forum is mostly used to alert contributors about changes of features. Also, resolving customers' queries and responding to their feedback[29].

Feedback example; *"excel 2016 slow performance, Hi Dennis, Based on your description, this issue only appear in a specific Excel sheet. Now I wanted to ask you several questions: Did your Excel file contain any code or formulas?. Did this issue only happen when you tried to add images to Excel? How about adding a new sheet or formulas?. Where did you store this Excel file?. First I suggest you try to repair this workbook manually. (Please don't forget backup your Excel file first.). As you're using Office 2016, I suggest you update the latest version for graphics card driver and DirectX for your computer and check if it works for you. Please try these methods and any updates please let me know, I'm glad to help you. Emi Zhang, TechNet Community Support"* [30]

We find all feedbacks and information that relate to the system requirements from the MicrosoftTechnet forum in order to support the study. These feedbacks will be indexed by their stakeholder's weight. Sort the list of stakeholders in descending order by their weight. Stakeholder weight depends on the number of their participation and prior experience. In order to exclude the non-active stakeholder. Our goal is to contribute to developing prioritization process principles to improve the functionality of software projects, leading in turn to greater user satisfaction. By assigning priorities correctly for these requirements, based on the feedback and take it into account when issuing the next release.

There are many active contributors on this site that tend to one or more of the requirements. This tendency appears clear through feedback and interaction with the function of requirements. These tendencies will greatly help to check for relations existence between requirement and stakeholders' feedback. When you are converting all these tendencies into relationships, surely they will help you establish your own network. By gathering contributors' feedback from Technet Forum, we will able to identify valuable feedbacks that have a relationship with some requirements . In proposed network, all connections will be mapped through knowledge-based feedback, that gains connections relevance within the context of the network structure. A graph was used to represent the network that was built in order to improve the requirements prioritization process.

In practice, we use samples that may be only a tiny fraction of all requirements for reasons of cost, time and because they are adequate for the purpose. Six requirements were selected, two of them are non-functional and four functional. These requirements that we chose are important because we believe, they can have a deep effect upon the architecture of the whole system. Since it is generally impossible to study an entire population. Therefore, we typically rely on sampling to acquire a section of the population to perform an experiment. In any case, the group was chosen to represent the population as a whole and not biased in a systematic manner. Moreover, I have chosen a small number of requirements to simplify the research process and the calculations, in any case, I expect, a large number of requirements does not greatly alter the conclusions that will be reached. For these reasons, we have selected the following requirements:

**Table 4. The Requirements Description**

| Label | REQ. name | Description |
|---|---|---|
| REQ1 | Scalability | The Excel should be able to adapt to future requirements, (add new function easily ) [ CONCAT, IFS , TEXTJOIN, SWITCH, MAXIFS etc. ]. |
| REQ2 | Performance | Access to the secure site must be no longer than 2 sec delay. Otherwise, users receive notification. |
| REQ3 | Manage User | Users can easily view and Edit the shared files that are stored on one drive. Add, Remove, Verify or Store user details. |
| REQ4 | Excel<br>Renewal | Advanced charts, (Treemap, Sunburst (hierarchical), Histogram, Box & Whisker, Waterfall (financial) and Pareto (statistical)). |
| REQ5 | Compatibility | Users should be able to start a chat, call or video with co-editors. |
| REQ6 | Collaboration | Digital content design should be compatible with a variety of devices that have different screen resolution, colors, and size. ( regardless of what device you're using such as iPhone, laptops. |

The data preparation process is performed according to results found by the string-matching algorithm, that identifies the potential data. The following steps provide a general overview of the proposed approach.Subsequent sections will cover each of these steps in more detail.

1. Create two text files named: Feedback, and Requirements.
2. Gather data from Microsoft TechNet site that is related to Microsoft Excel 2016 using the Google search engines to identify all questions containing the same or similar text.
3. Fetch new requirements of Microsoft Excel 2016 and save it in the requirements.txt file using the Google search engines.
4. Use text matching software policy for detecting similarities among texts, such as Boyer-Moore, customizing some of the search parameters to maximize the chances of detecting. Such, exclude function words such as “the”, “and”, “but”, etc from the text.
5. Using a scale of 0 to 100 to determine their relative relationships between the requirements and feedback.
6. Generating nodes of feedback and requirements that have relations with them.
7. Composing social network of stakeholders questions, feedback and requirements nodes. (See Fig. 5)
8. Analyzing social network to calculate the distinct centrality measures (degree centrality, closeness, and betweenness).

Using this algorithm, we can verify whether a certain pattern occurs in the text or not, this will help us to find all occurrences of any given pattern and their positions. Simple data summaries will include all relations between requirements and contributors with their feedback, this might lead to an elimination of unimportant data, this would also be suitable for investigation.

The correlation or relationship matrix is generated based on the comparison process, using exact string-matching algorithms for detecting the relationship between requirements and stakeholders' feedback.

### A. Acquire Stakeholder feedback

Stakeholders' feedback plays an important role in the software development projects and often is a critical component of being more successful. Stakeholders' feedback should be taken into consideration when conducting the requirement prioritization process. It has a decisive impact on reprioritizing process and could help in reducing the ranking difference. It allows you to gain a set of standardized results, increasing our choices when making decisions about any changes we wish to make, this could be achieved by merging it with any technique [7].

This study shows the SNA usage in the framework of requirements prioritization. Hereby, we'll explain specifically how the requirements can be prioritized:

- Based on the actors' feedback according to their past participation (Contribution) and their observations, as they subscribed to the Microsoft TechNet site[31].
- Based on the team experience, skills, and knowledge [32].

The string-matching algorithm provides an easy way to compute the ratio of similarity between two texts. We used the similarity ratio to find more accurate alignments and exclude the fragile values. The string-matching algorithm is used for two main reasons:

a. Product requirements describe the product from engineer's, developer's or implementer's perspective. This description requires careful use of some technical terms, according to the quality criteria of requirements.

b. To prevent or avoid natural language ambiguity (to a certain degree).

The string-matching algorithm can be used to detect relationships or associations between requirements and stakeholders' feedback, and then build a social network based on this relationships.

### B. Capturing Relationship Between Requirements and Stakeholders' Feedback

we can now formulate our sample software project (problem) into three sets as follows:

- Requirements: REQ={REQ1, REQ2, …, REQ6}.
- Stakeholder: ST={ ST1, ST2, …, ST60}.
- Questions: Q={Q1, Q2, …, Q13}.
- Feedback: FB={FB1, FB2, ..., FB73}.

The selection process of requirements depends on the participants' actual contributions, their diverse visions, and also the relationships between these requirements. In general, we've chosen some of the requirements, which own a large number of positive feedback only, where these requirements represent the focus of great interest, also, we think they represent an objective test case for prioritization problem[33].

Usually, users assess those requirements according to their tendency. These tendencies often based on the importance of requirements, by independent manner. It becomes clear to us, what is the importance of this requirement of an actor perspective, through the extent of interaction between them.If there is little or no interaction with any requirement, this means the requirement does not have much value or importance. For this reason, the actor does not care for this requirement, and there is no opinion thereon, or maybe even he is unaware of their actual role.

We propose a social network representing a set of; 1) requirements that were selected earlier in order to be prioritized, and 2) stakeholders with their feedback and comments on the questions or concerns about those requirements with relationships among all. The SNA can be used to acquire the information representing the interdependencies between requirements with actors. It can also be used to improve the requirements prioritization process and to alleviate this problem, as not all requirements are at the same level of importance.

The structure of the proposed social network, represents all those elements and communication links among contributors that relate requirements with each other or with other stakeholders.Where every node represents a requirement, which has been created, or an actor which can be displayed as programmer, analyst, amateur or anyone interested.

Moreover, each directed edge (one-way street) joining a pair of individual nodes indicates the existence of a connection between two nodes and the direction of the data flow, (also known as ties, links or relationships). The thickness ratios, a tag of number or colors can be used to represent the frequency of the information exchange "see Fig. 5.". And therefore, we can acquire and capture all relevant information to raise the awareness and benefits that lead us towards a wiser decision.

So, the social network can be generated based on communication patterns among contributors and requirements, using their effective information and consultation [29]. This enables us to an early assessment of their individual and collective impact of all requirements as well as other necessary information, such as:

- Actor's role, (from "Points History") which refers to his activities and past experience[32]. Point History is a statistical measure provided by Microsoft Technet forum. It represents accumulated points overtime that illustrates the importance of stakeholder role.
- Direction of the data flow.
- Amount of information flowing from one actor to another, or from actor to requirements.
- Information exchange frequency.
- Determining the relationships between requirements and actors.
- Identifying the most interesting group of requirements that must be taken into account.
- Explore any additional relevant information, if required.
- Easiest way to identify the actors in a specific requirement.

Social network-building requires capturing relationships among its entities or components. The relationships between these components are found by applying text-matching strategy. The initial relationship matrix in Table 5. a, is identified based on string-matching algorithm. This matrix illustrates the strength or degree of association between all the requirements and stakeholders' feedback. A ratio in Table 5. b, shows a relationship between two or more components of the proposed network, after a threshold has been applied. The threshold is used to avoid an unwarranted appearance of precision. The threshold value is set equal to 9%. (more details in section V. B). The relationship matrix in Table 5. c, will be transformed into a social network (see Fig. 5).

**Table 5. a, b, c, Partial list of relationship matrix based on string-matching algorithm.**

**a. Initial partial list of relationship matrix**

| No | FB. Name | REQ1 | REQ2 | REQ3 | REQ4 | REQ5 | REQ6 |
|---|---|---|---|---|---|---|---|
| 1 | Linda Zhang | 13.54 | 1.9 | 3.11 | 18.89 | 5.54 | 2.86 |
| 2 | Ehren-MSFT | 8.21 | 4.31 | 0 | 3.41 | 0 | 4.9 |
| 3 | Gil Raviv | 4.26 | 3.47 | 4.08 | 7.47 | 3.41 | 5.21 |
| 4 | Emi Zhang | 3.87 | 12.24 | 3.69 | 4.08 | 7 | 6.65 |
| 5 | Melon Chen | 2.56 | 5.71 | 8.12 | 0 | 0 | 3.85 |
| 6 | Hans Vogelar | 24.88 | 0 | 4.79 | 5.19 | 0 | 3.32 |
| 7 | Charlie Liao | 12.32 | 3.89 | 7.84 | 4.31 | 0 | 1.9 |
| 8 | KKhipple | 0 | 0 | 0 | 2.24 | 7.7 | 13.74 |
| 9 | Linda Zhang | 9.7 | 8.23 | 0 | 20.23 | 0 | 3.19 |

**b. Partial list of relationship matrix after a threshold has been applied.**

| No | FB. Name | REQ1 | REQ2 | REQ3 | REQ4 | REQ5 | REQ6 |
|---|---|---|---|---|---|---|---|
| 1 | Linda Zhang | 13.54 | 0 | 0 | 18.89 | 0 | 0 |
| 2 | Ehren-MSFT | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | Gil Raviv | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | Emi Zhang | 0 | 12.24 | 0 | 0 | 0 | 0 |
| 5 | Melon Chen | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | Hans Vogelar | 24.88 | 0 | 0 | 0 | 0 | 0 |
| 7 | Charlie Liao | 12.32 | 0 | 0 | 0 | 0 | 0 |
| 8 | KKhipple | 0 | 0 | 0 | 0 | 0 | 13.74 |
| 9 | Linda Zhang | 9.7 | 0 | 0 | 20.23 | 0 | 0 |

**c. Final partial list of relationship matrix**

| No | FB. Name | REQ1 | REQ2 | REQ3 | REQ4 | REQ5 | REQ6 |
|---|---|---|---|---|---|---|---|
| 1 | Linda Zhang | 1 | 0 | 0 | 1 | 0 | 0 |
| 2 | Ehren-MSFT | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | Gil Raviv | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | Emi Zhang | 0 | 1 | 0 | 0 | 0 | 0 |
| 5 | Melon Chen | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | Hans Vogelar | 1 | 0 | 0 | 0 | 0 | 0 |
| 7 | Charlie Liao | 1 | 0 | 0 | 0 | 0 | 0 |
| 8 | KKhipple | 0 | 0 | 0 | 0 | 0 | 1 |
| 9 | Linda Zhang | 1 | 0 | 0 | 1 | 0 | 0 |

### *C. Analysis of The Social Network*

The social network will be analyzed to aid the prioritization process. Distinct measures of SNA have been used to analyze the relationships among actors or nodes in a network.A graph is used to represent the network built in order to extract data for each requirement, which provides a general framework to describe the influence and impact of any node. The National Security Agency (NSA) looks up to some nodes in order to determine the greatest leaders by calculating who is most central and who has a crucial role as a betweenness or as closeness within terrorist network in the Sep 11 attacks, because the SNA allows us both a visual and a mathematical analysis to analyze the relationships among actors or nodes[34][35].

Most important considerations in our opinion are to assess the "Node Location", which has similar properties to real estate location, that also has a major impact on the real estate markets. We applied Connectivity techniques, Hubs, and Authorities, Cohesion to the MicrosoftTechnet network analysis.

For the network analysis part of the study, we used SNA tools. The SNA tool is a graphical visualization software which has wide applications. It facilitates quantitative or qualitative analysis of social networks. There are a wide range of different tools available, built primarily for network visualization, some of them contain social network analytic features. The SNA tools consist of either packages based on graphical user interfaces, or packages built for programming languages. The graphical user interfaces packages are easier to learn and use , but programming languages tools are more powerful and extensible. [36].

In our study, we used the Gephi-0.9.1, to analyze information. Gephi is a good choice for analyzing data from projects with many nodes and edges, also, it enables us to validate the model according to actors' feedback and their observations (as express their opinion, reactions, and comments). Gephi was selected because it offers a large number of available application cases[37].

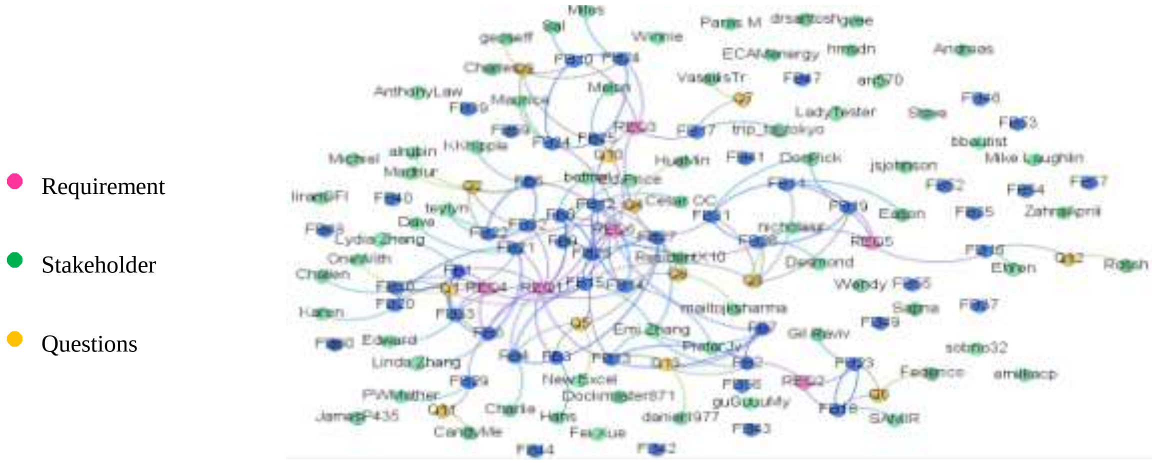

**Fig. 5. Social Network Structure using the relationship matrix based on the string-matching algorithm.**

### D. Discussion of Result

Now, We will discuss three common measures of power in the proposed networks above. Many SNA techniques and metrics are based on graph theory. The most popular centrality metrics used in SNA are degree centrality, betweenness, and closeness. The centrality is an important concept in SNA. It can be considered a micro-level indicator to understanding an individual node's power, ranking, and inequality in a graph and social network structures. especially when there is little variance between the degree of each node. Therefore, centrality can be described as a modern sailing boat, that denotes a most important relationship in the network structure. The centrality concept represents a critical factor in evaluating the importance of the nodes[38][39].

The most important requirement can contribute actively to create a so-called critical mass, in order to ensure a majority.(i.e. achieved, a large number of interactions between individuals within the network). Maybe the concept of critical mass or snowball is an easy answer for: How to determine the most important requirement?.

The requirement can be represented as an individual node in the proposed network structure. The node's identifier can be represented as a unique id within a data table of the network. The requirement importance is determined according to the following steps:

- Calculates the degree of centrality, betweenness, and closeness.
- Capture all the requirements that received the highest possible scores.
- Arrange requirements according to their importance.

The priorities can be arranged according to the analysis results (See Table 6 a&b). The arranging process requires sorting all fields based on their values. The results of arranging process appear in a Table 6.b, that identifies which requirements have higher priorities. The requirements are ranked based on their location within the proposed network. The influence of these measurements in this study, can be summarized as follows:

We calculated the Degree Centrality of each requirement individually, which is the requirement related closely to other requirements. In Table 6.a, requirement REQ1 has the highest degree centrality. This mean, REQ1 is required mostly by other requirements and stakeholders. If the requirement has a high degree centrality measure, that means it has a high level of importance. This measure can be considered as a good indicator of the requirement's communication activity in the network.

The Betweenness Centrality is defined as a requirement as being in a preferred position to the extent that the requirement falls on the geodesic paths between other pairs of requirements or stakeholders in the network. That explains, the more requirements depend on it to establish strong relationships with other requirements.If the requirement has a high between's centrality measure, that means it has a high level of importance. This measure can be considered as a good indicator of the requirement's efficiency.

The Closeness Centrality confirms on the distance of a requirement to all others in the network by focusing on the distance from each requirement and stakeholders to all others.

The centrality measures are used to determine the value of each requirement in the network. The requirements values are listed in Table 6.a of SNA measures. The result shows that the requirements REQ1and REQ6 have the maximum value of the other values.

In Table 6.b, we have arranged the requirement priorities according to their values in Table 6.a. Each requirement has a high value that means, it will take a high priority. We can say that the relationship between the requirement value and its priority is a directly proportional relationship.

**Table 6.a Ranking of requirements based on Exact Matching Algorithm using SNA measures**

| Id | Label | Degree Centrality | Closness Centrality | Betweeness Centrality |
|---|---|---|---|---|
| 1 | REQ1 | 15 | 0.339552239 | 1721.917607 |
| 2 | REQ2 | 3 | 0.19612069 | 512 |
| 3 | REQ3 | 5 | 0.25 | 582.3155372 |
| 4 | REQ4 | 6 | 0.269230769 | 203.7178796 |
| 5 | REQ5 | 4 | 0.21563981 | 370.8818348 |
| 6 | REQ6 | 12 | 0.325 | 1408.152726 |

**Table 6.b Ranking of requirements based on Exact Matching Algorithm using SNA measures**

| Id | Degree Centrality | Closness Centrality | Betweeness Centrality | Priority after voting |
|---|---|---|---|---|
| 1 | REQ1 | REQ1 | REQ1 | REQ1 |
| 2 | REQ6 | REQ6 | REQ6 | REQ6 |
| 3 | REQ4 | REQ4 | REQ3 | REQ4 |
| 4 | REQ3 | REQ3 | REQ2 | REQ3 |
| 5 | REQ5 | REQ5 | REQ5 | REQ5 |
| 6 | REQ2 | REQ2 | REQ4 | REQ2 |

## V. VALIDATION ATTEMPT

In this section, we present an attempt for validation the obtained results from the proposed approach. In the following, we describe how university graduate students have been involved in the validation process of relationships between the requirements and stakeholders' feedback.

### A. Focus Group Capturing Relationship

To build an effective social network, we must find all links between related data items, in order to determine the relationships between the candidate set of requirements and stakeholders. These relationships will represent the edges between nodes in the network, and nodes represent the various stakeholder entities and requirements.

A focus group was created in order to help determine whether there was a relationship between requirements and stakeholders' feedback.This group consists of nine graduate students. They should work individually, but at the same time to ensure the independence of their opinions in orderto explore the relationship between requirements and feedback, as follows:

- Divided the list of feedbacks (FB) into three groups (Group A, Group B, Group C). each group contain 20 feedback:
  A={FB1, FB2, .., FB20}, B={FB21, FB22, ..,FB40}, and C={FB41, FB42, .., FB60}.
- Graduate students also divided into three sub-groups. (Group X, Group Y, Group Z). each group include three graduate students:
  X={ST1, ST2, ST3}, Y={ST4, ST5, ST6}, and C={ST7, ST8, ST9}.
- All graduate students within the same group receive a different set of feedback.
- Graduate students will evaluate the relationship independently. Table 7. below shows the distribution process:

**Table 7. Feedback distribution and assessment mechanism among graduate students.**

| | | |
|---|---|---|
| A & X[STU1] | B & X[STU2] | C & X[STU3] |
| FB. 1.. 20 | FB. 21.. 40 | FB. 41.. 60 |
| A & Y[STU4] | B & Y[STU5] | C & Y[STU6] |
| FB. 1.. 20 | FB. 21.. 40 | FB. 41.. 60 |
| A & Z[STU7] | B & Z[STU8] | C & Z[STU9] |
| FB. 1.. 20 | FB. 21.. 40 | FB. 41.. 60 |

In this way, we will get three independent evaluations for each requirement, which reflects the relationship weight between the requirement and feedbacks. Based on graduate students' opinions. Through a two-dimensional matrix containing 60-rows representing feedbacks and 6 columns represent requirements. Each cell in the matrix contains one of the following values:

0, x, xx, xxx, where x represents the number of votes and 0 means there is no relationship between requirements and feedbacks.

x = weak correlation, xx = Average correlation, xxx = strong correlation.

This relationship has been modeled in the matrix FB x REQ. (see Table 8).

**Table 8. Partial list of relationship matrix based on graduate students' opinions.**

| No. | FB. Name | REQ1 | REQ2 | REQ3 | REQ4 | REQ5 | REQ6 |
|---|---|---|---|---|---|---|---|
| 1 | Linda Zhang | | | | XX | | |
| 2 | Ehren-MSFT | X | | | | | |
| 3 | Gil Raviv | | X | | | | |
| 4 | Emi Zhang | | XX | | | | |
| 5 | Melon Chen | | | | | | |
| 6 | Hans Vogelar | XXX | | | | | |
| 7 | Charlie Liao | | | | | | |
| 8 | KKhipple | | | | | | XX |
| 9 | Linda Zhang | | | | XXX | | |

The students' matrix in Table 8., is generated based on graduate students' opinions. This matrix represents the relationships between the stakeholders' feedback and requirements. The students' matrix has been transformed into a social network.(See Fig. 6)

In Table 9. a&b, the values are presented showing the result of prioritization process based on the graduate students' perspective using SNA measures. In Table 9. a, the result shows that the requirements REQ3, REQ1, REQ4 respectively they've obtained the highest values of all other values. According to these values of centrality measures in Table 9. a, we determined the priority of each requirement in the Table 9.b.

**Table 9.a Ranking of requirements using Graduate Students Matrix**

| Id | Label | Degree Centrality | Closness Centrality | Betweeness Centrality |
|---|---|---|---|---|
| 1 | REQ1 | 6 | 0.305084745 | 1241.066667 |
| 2 | REQ2 | 4 | 0.273556231 | 410 |
| 3 | REQ3 | 11 | 0.31358885 | 1908.5 |
| 4 | REQ4 | 6 | 0.30508474 | 925.1666667 |
| 5 | REQ5 | 4 | 0.22900763 | 494 |
| 6 | REQ6 | 5 | 0.22900763 | 528.2 |

**Table 9.b Ranking of requirements using Graduate Students Matrix**

| Id | Degree Centrality | Closness Centrality | Betweeness Centrality | Priority After Voting |
|---|---|---|---|---|
| 1 | REQ3 | REQ3 | REQ3 | REQ3 |
| 2 | REQ1 | REQ1 | REQ1 | REQ1 |
| 3 | REQ4 | REQ4 | REQ4 | REQ4 |
| 4 | REQ6 | REQ2 | REQ6 | REQ6 |
| 5 | REQ2 | REQ6 | REQ5 | REQ2 |
| 6 | REQ5 | REQ5 | REQ2 | REQ5 |

By comparing Table 6.b with Table 9.b, where the last column of Table 6.b has results of algorithm approach, while the last column of Table 9.b has results of students approach. (see Tables 6.b & 9.b).The comparison shows different results between SNA technique based on string-matching algorithm and SNA technique based on the graduate students' perspective.

For example, Requirement REQ1 and REQ6 in the Table 6.a has the highest centrality (Degree, Betweenness, Closeness) since it is required mostly by other requirements. While requirement REQ3, REQ1 in the Table 9.a has also the highest centrality. Accordingly, we find that the

The experimental results proved that the difference between the two methods is clear. The matching algorithm approach is not a satisfactory approach in terms of accuracy. It does not seem to be an appropriate method because it was not able enough to overcome the ambiguity of languages. Algorithm approach may not produce reliable results. Therefore, it requires further modification and these results need further verification.

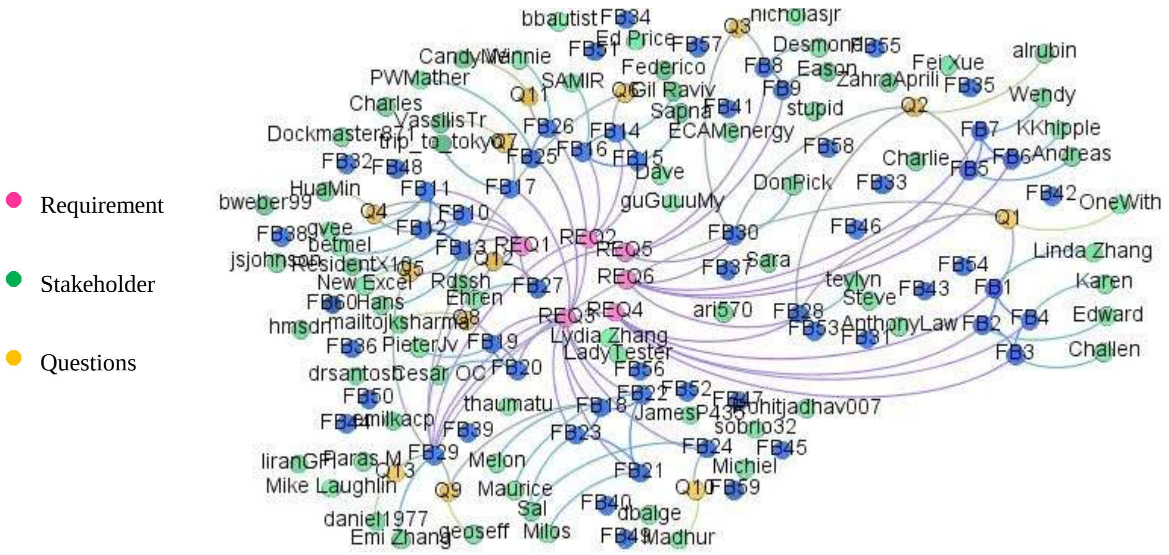

**Fig. 6. Social Network Structure using the relationship matrix based on the focus group**

The SNA that based on the relationships matrix of graduate students' perspective is a satisfactory approach to support the requirements prioritization process and it achieves more accurate results compared to the previous approach. This approach has been found to be very effective, but it requires a significant human effort and time. The experiment shows that this approach provides results of high reliability, performance.

### *B. Setting of Threshold*

We have two matrices; the first matrix represents the relationship matrix in Table 5. a. It is based on string-matching algorithm. The second matrix represents the relationship matrix in Table 8. It is based on graduate students' opinions. The two matrices have the same dimensions. These matrices were compared to ensure that there was no measurable difference in composition. The comparison process was done in order to calculate the highest score. The comparison process between these matrices has been implemented according to following conditions:

```
If Students[i, j] & Algorithm[i, j] = 0
    then Score = Score +1;
if Students[i, j] & Algorithm[i, j] $\neq$ 0
    then Score = Score + S[i , j];
if Students [i, j] = 0 & Algorithm [i, j] $\neq$ 0
    then Score = Score – 5;
if Students [i, j] $\neq$ 0  & Algorithm [i, j] = 0
    then Score = Score – S[i , j].
```

In this experiment, the two matrices (Tables 5. a& 8) are examined under various threshold conditions to find the best threshold. The highest score represents the best possible threshold. We found the best fit of the highest score when the threshold is equal to 9%. (see Fig. 7)

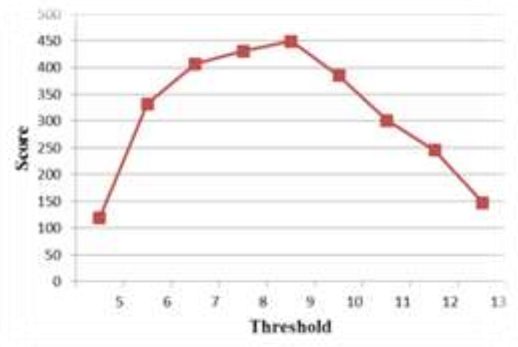

**Fig. 7. The optimal threshold value is selected based on statistical tests.**

## VI. LIMITATION OF VALIDITY

Consider that this research is pilot case study, we focus on a limited number of stakeholders, stakeholders' feedback, stakeholders' question, and requirements. In [40], Mikkoet al. classified the projects according to their size of requirements into three levels; small, medium and large or complex projects. They categorized the requirements into three categories

- Small size, the number of requirements not more twenty ( < 20).
- Medium size, the number of requirements between (21 − 100).
- Large size, the number of requirements more than (> 100).

The number of requirements is a critical factor in the selection process for requirement prioritization techniques.

In our study, we demonstrate our approach on a small number of requirements. The small social network was built, in an attempt to overcome some of the constraints or challenges such as;

- Text similarity, in most cases, it was not enough suitable, but it was more suitable for a pilot case study.Natural language processing (NLP) is still one of the greatest challenge facing text-similarity algorithms.
- Number of graduate student, requires additional effort with large numbers of students.
- Number of requirements, It gives more accurate results, but does not reflect the structural properties of a network when adding or removing a node in the network.

The number of requirements determines the size of the project. When the project has a large number of requirements that leads to generating an extensive network. In case of analyzing large network, we are face by the following challenges:

- Long Processing Time: As network size increases, the time for analyzing networks grows rapidly.
- Large Computational Resource Requirement: Processing large social networks will require a great amount of computational resources, such as; processor memories in computers.

Furthermore, breaking up large networks into smaller ones does not contribute significantly to detection of compositional characteristics for large networks. Thus, this also does not contribute significantly to structural analysis. As a result, it is not an easy task to find those structural parameters which control a given property. Therefore, the social network analysis is different from other issues or problems that can be partitioned in order to have an easy solution.

## VII. RELATED WORK

This section provides an overview of techniques for prioritization of requirements for software projects. Also, in this section, we discuss the related work and provide an understanding of the contribution of our approach presented in the next section.

Today, there are many different approaches are floating around us, ranging from the basic to the highly sophisticated. While there are still many limitations on their accuracy. So, the question that hesitates on everybody's mind: "Which method, should be used?". Any planning approach or technique has its advantages but also drawbacks. Therefore, these techniques need careful consideration and analysis when used effectively.

Several different prioritization techniques are suited to different types of decisions, groups, and data. Most of these techniques can best meet the required of a particular community. The techniques for prioritization can be used at a number of different levels in the requirements management process, ranging from a broader level to a more specific project level.

To ensure the project success and being on schedule, this requires an appropriate prioritization process. In literature, many techniques have been proposed for prioritizing software requirements during development processes. These techniques can be broadly divided into three different categories based on the results they give; ratio scale, ordinal scale, and nominal scale. Analytical Hierarchy Process (AHP) seems to be the most frequently used technique for prioritizing alternatives including software requirements.

AHP is a purely mathematical technique for analyzing complex decision problem with multiple criteria. It is a quite different strategy from a more traditional approach. AHP has been successfully applied to many fields of applications. This technique reduced the number of costly decision reversals that were present under the old methods. AHP technique belongs to a ratio measurement scales. The relative difference between the priorities of the requirements is very clear, but other prioritization techniques only provide the correct order.

The main disadvantages of AHP technique are; (1) it doesn't save time, (2) may be complex, (3) difficult and, (4) It is the artificial limitation of the use of the 9 points scale. In many cases, the stakeholder might find difficult to distinguish among them. Based on these drawbacks, this technique isn't quite suitable when we have a large number of requirements to prioritize[41].

Several other methods, prioritize requirements into three or four priority categories or piles as low, medium or high.You can also apply the pair-wise comparisons on the requirements of each group, which allows you to perceive more accurately. But, they are still not feasible for large projects and may have limited ability to support decision-making in complex projects[42]. Such as Planning Game technique (PG)[43] and Binary Priority List (BPL)[44]. Binary valued approach for prioritizing requirements that combines the benefits and costs for each requirement using a simple binary scale ('0' or '1'). This approach is quite easy to implement, but the quality attributes in most cases are incomplete[45]. Those techniques belong to the ordinal scale categories, (See Table 1). In general, ordinal scales possess categories that are ranked, from high to low, largeto small, and far to near.

In nominal scale prioritization techniques, all requirements will be categorized into groups or lists. All requirements have equal priority if they fall within the same group. These approaches rank requirements based on their absolute importance as Priority Groups Technique[40], MoSCoW[46].Perhaps the biggest challenge facing developers in this category is capturing the true value of each requirement, but they are often unable to achieve it. Despite the fact that most stakeholders have sufficient experience and knowledge.

Among the approaches that have been proposed to support the process of prioritization is a Fuzzy approach, that determines the priority of each requirement depending on the expected value manner (i.e. using fuzzy variables rather than using pure value). This provides a mathematical means and requires approximation of the expected values to get ranking fuzzy numbers, that indicates the importance of those requirements[47][48].

In the fuzzy technique, the result shows that the priority will be high when the customer importance will high also. Thus, Fuzzy approach prioritizes the requirements using the importance of both customers and developers, depending on the direct evaluation of stakeholders (from their perspective only) to each requirement.

Organization Risk Analyzer (ORA) is a dynamic network evaluation and analysis tool[49]. It is also used to determine which requirements have high, medium, and low priorities depending on the stakeholder's priorities and requirements interdependencies[6].

In[6], the authors used five different stakeholders to evaluate each requirement with a scale from one to three. Depending on these evaluations, the author found the relationships between requirements and stakeholders to build a social network. Thus, this technique based on direct assessment approach in order to capture the value of each requirement by stakeholders. Since all the previous techniques also focus directly on the stakeholder preferences. Therefore, this technique does not differ much from the previous methods, because all techniques use the same approach to capturing the requirement value.

## VIII. CONCLUSION AND FUTURE WORK

In this paper, we presented how social network analysis can be used in order to improve the process of software requirements prioritization in the case of having many stakeholders that you do not have access to them.The proposed approach extends the UML model used for software requirements release planning. We propose to adopt the indirect assessment process to evaluate the relative importance of each requirement. The indirect assessment process requires adding new classes called Question class and Feedback class.These classes represent an important tracing reference in the indirect assessment process, to link the stakeholders feedback to the related requirement.A matching algorithm is used to automate the discovery process of the relationship between stakeholders’ feedbacks and requirements specifications based on text similarity as this is a pilot case study. The social network is created to explore the importance (or stakeholder priority) of each value requirement.

As an attempt for validation of the results that we obtained from the proposed approach, we use focus group technique in order to capture the correct relationships between the requirements and stakeholders' feedback, and comparing them with relationships that produced from string-match algorithm.

The results showed a clear difference between the two methods,where the results proved that the matching algorithm method based on text similarity is not a satisfactory method in terms of accuracy.The social network that based on the relationships matrix of graduate students' opinion is used as reference for the validation process as it achieves a more accurate result.

In the case study, we used a small number of requirements, that generates small network.The following can be considered as a limitation of validity for this research effort:

1) Text similarity, it was considered only as this a pilot case study.

2) Number of graduate student is small considering that it requires a significant human effort and time.

3) Number of requirements is small. This has a significant effect on the network structure.

Furthermore, in large projects that have a large number of requirements and stakeholders, because the analysis process of a large social networks is not a trivial task, because of ;

1) Long Processing Time: As network size increases, the time for analyzing networks grows rapidly.

2) Large Computational Resource Requirement: Processing large social networks will require a great amount of computational resources, such as; processor memories in computers.

As future work, we plan to further investigate the logical assessment of computed mappings, which could help to improve the quality of the mappings that are provided. Moreover, we intend to investigate composition-based ontology matching for further domains[50][51].We plan also to analyze larger project that will lead to generate larger social network because larger number of requirements, stakeholders and participants are considered.

## REFERENCES

[1] M. Asaem, M. Ramzan & A. Jaffar, "Analysis and optimization of software requirements prioritization techniques", IEEE, DOI,10.1109/ICIET.5625687, pp: 3-9,, Pakistan (2010).

[2] J. Azar, R. K. Smith & D. Cordes, "Value-oriented requirements prioritization in a small development organization", IEEE, vol. 24, no. 1, pp: 32 - 37, USA(2007).

[3] P. Berander, "Evolving Prioritization for Software Product Management", Ph.D. Dissertation, ISBN 978-91-7295-108-2, No:07, Sweden (2007).

[4] A. Hermann & M. Daneva, "Requirements prioritization based on benefit and cost prediction: An agenda for future research", IEEE DOI 10.1109/RE, pp: 125-134, Spain(2008).

[5] D. Port, A. Olkov & T. Menzies, "Using simulation to investigate requirements prioritization strategies", IEEE, DOI: 10.1109/ASE.37, pp: 268 - 277, Spain(2008).

[6] P. Fitsilis and G. Vassilis, "Supporting the Requirements Prioritization Process Using SNA Techniques", IEEE, DOI 10.1109/WETICE.2010.24, No 11465613,pp: 110-115, Greece(2010).

[7] L. Azzopardi, G. Kazai, Stephen, "Advances in Information Retrieval Theory", Second ICTIR, ISBN 13-978-3-642-04416-8, UK(2009).

[8] G. Zuccon, S. Geva, H. Joho, "Information Retrieval Technology", 11th Asia Information Retrieval Societies Conference, ISBN: 978-

3-319-28939-7, Asturalia(2015).

[9] G. Bongiovanni, G. Gambosi, "Algorithms and Complexity", 4th Italian Conference, CIAC, ISBN 3540671595, Italian (2000).

[10] Institute of Electrical & Electronics IEC, "Systems and Software Engineering - System Life Cycle Processes", SEBoK, ISO/IEC/IEEE 15288 > System Requirements, http://sebokwiki.org/wiki/ISO/IEC/IEEE_15288, Geneva(2015).

[11] Syllabus, "Advanced Level Requirements Management", Version 2.0, http://reqb.org/docs/REQB_ALRM_Syllabus.pdf , (2015).

[12] U. Eriksson, "The difference between functional and non-functional requirements", ReQtest, article, (2015).

[13] N. Afreen, A. Khatoon & M. Sadiq, "A Taxonomy of Software's Non-functional Requirements", Springer, DOI: 10.1007/978-81-322-2517-1_6, (2016).

[14] S. Izukura, et al, "Bridging Non-functional Requirements and IT Service Design", Elsevier, DOI:10.1016/j.procir.02.104, Vol. 30, pp;24-29, Japan(2015).

[15] W. Maalej & A.K. Thurimella, "An Introduction to Requirements Knowledge", Springer, DOI 10.1007/978-3-642-34419-0_1, pp: 398, Berlin(2013).

[16] D. Mairiza & D. Zowghi, "Constructing a catalogue of conflicts among non-functional nrequirements", Springer-CCIS 230, pp: 31–44, Berlin(2011).

[17] D. Mairiza and et al, "An investigation into the notion on non-functional requirements", SAC10, DOI:10.1145/1774088.1774153, pp. 22–26, Australia(2010).

[18] R. Lutz, et al, "Mining requirements from operational experience. In: Managing requirements knowledge", Springer, Chapter 3, DOI:10.1007/978-3-642-34419-0_3, pp 49-73, Berlin (2013).

[19] M. Pergher; B. Rossi, "Requirements prioritization in software engineering: a systematic mapping study", IEEE, DOI:10.1109/EmpiRE.6615215, pp: 40–44, Italy (2013).

[20] P. Tonella, A. Susi, F. Palma, "Interactive requirements prioritization using a genetic algorithm", Information and Software Technology, Vol. 55, Issue 1, pp. 173–187, Italy(2013).

[21] P. Achimugu, and et al, A systematic literature review of software requirements prioritization research, Information and Software Technology, Vol. 56, Issue 6, pp. 568–585, Malaysia(2014).

[22] P. Nielsen, and G. Tjørnehøj, "Social networks in software process improvement", J. Softw. Maint. Evol., Vo.l 22, Issue 1, DOI: 10.1002/spip.419, pp. 33–51, Denmark(2010).

[23] H. Wi and e. al, "A team formation model based on knowledge and collaboration", IEEE, Vol.40, Issue:1, DOI:10.1109/EMR.2012.6172769, pp.44 - 57, Korea(2009).

[24] M. Dalli, W. Abdelmoez, A. Elsayed, et al , "Software Product Requirements Prioritization Techniques: Hardly Easy", IJAIM, Vol 4, Issue 6, ISSN 2320–5121, Egypt(2016).

[25] B. Hoppe, C. Reinelt, "Social network analysis and the evaluation of leadership networks", ELSEVIER,Vol. 21, Issue 4, DOI:10.1016/j.leaqua.2010.06.004, pp.600 - 619, U.S(2010).

[26] My T. Thai; Nam P. Nguyen; Shen Huawei, "Computational Social Networks", 4th International Conference on (CSoNet 2015), pp. 382-386, China(2015)..

[27] A. Srivastava, Anuradha and D. J. Gupta, "Social Network Analysis: Hardly Easy", IEEE, DOI: 10.1109/ICROIT.2014.6798311, pp.128 - 135, India(2014).

[28] OECD, NEA, "Stakeholder Involvement in Decision Making: A Short Guide to Issues, Approaches and Resources", ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, © OECD 2015 9, Nuclear Energy Agency, NEA report No. 7189,, USA(2015).

[29] [Online] MicrosoftTechnet Forum is available at [https://technet.microsoft.com/], (2016).

[30] technet.microsoft/Forums, https://social.technet.microsoft.com/Forums/en-US/0351895a-3985-43d8-8bf8-1902a2cab8de/excel-2016-slow-performance?forum=Office2016ITPro, (2016).

[31] https://social.technet.microsoft.com/Forums/en-US/home?brandIgnore=True&sort=relevancedesc&searchTerm=Excel+2016.

[32] https://social.technet.microsoft.com/profile/george_zhao/.

[33] Y. Zhang, M. Harman and S. L. Lim, "Empirical evaluation of search based requirements interaction management", Information and Software Technology, Vol. 55 Issue, pp:126-152, USA (2013).

[34] Greg, "How The NSA Uses Social Network Analysis To Map Terrorist Networks", http://www.digitaltonto.com/2013/how-the-nsa-uses-social-network-analysis-to-map-terrorist-networks/, (2013).

[35] X. Li and N. Lavrac, "Analysis of the NETSCIENCE Social Network", Atlantis Press(CISIA), DOI:10.2991/cisia-15.2015.124, pp.456-459, Thailand (2015).

[36] KDnuggets, "Top 30 Social Network Analysis and Visualization Tools", www.kdnuggets.com/2015/06/top-30-social-network-analysis-visualization-tools.html, (2016).

[37] M. Bastian, S. Heymann and M. Jacomy, "Gephi: an open source software for exploring and manipulating networks", Third International ICWSM Conference pp.361-362, USA(2009).

[38] M. Uhl-Bien and R. Marion, "Complexity Leadership. Part I: Conceptual Foundations", IAP Information Age, USA (2008).

[39] E. Kolaczyk, "Statistical Analysis of Network Data Methods and Models", Springer Series in Statistics, ISBN: 978-0-387-88145-4, USA(2009).

[40] M. Vestola, "A Comparison of Nine Basic Techniques for Requirements Prioritization", Helsinki University of Technology, Helsinki (2010).

[41] T. Saaty, Vargas and G. Luis, "Models, methods, concepts & applications of the analytic hierarchy", 2nd Edition, (2012).

[42] J. Karlsson, C. Wohlin and B. Regnell, "An evaluation of methods for prioritizing software requirements", Inf. and SW Technology, Vol. 39, No.14-15, pp: 939-947 , Sweden(1998).

[43] A. S. Danesh and R. Ahmad, "Study of prioritization techniques using students as subjects", IEEE, DOI:10.1109/ICIME.2009.37, pp. 390–394, Malaysia(2009).

[44] R. Wieringa and A. Persson, "Requirements Engineering: Foundation for Software Quality", https://books.google.iq/books?isbn=3642141919, 16th International Working Conference, REFSQ, Germany, (2010).

[45] C. Otero, E. Dell, A. Qureshi and L. Otero, "A quality-based requirement prioritization framework using binary inputs", IEEE, DOI:10.1109/AMS.2010.48, pp. 187-192, Malaysia(2010).

[46] N. Kukreja, "Decision theoretic requirements prioritization A two-step approach for sliding towards value realization", ICSE 2013, ,ACM Student Research Competition IEEE, No 13799249, pp:1465-1467, USA(2013).

[47] A. Ejnioui, C. Otero and A. Qureshi, "Software requirement prioritization using fuzzy multi-attribute decision making", IEEE, DOI: 10.1109/ICOS.2012.6417646, pp. 1-6, Malaysia (2012).

[48] D. Lima, F. Freitas, G. Campos and J. Souza, "A Fuzzy Approach to Requirements Prioritization", Vol. 6956 of the series Lecture Notes in Computer Science, pp. 64-69, Hungary(2011).

[49] K. Carley and J. Reminga, "ORA: Organization Risk Analyzer", CMU-ISRI-04-106, pp:1- 45, USA (2004).

[50] A. Tordai, et al, "Lost in Translation? Empirical Analysis of Mapping Compositions for Large Ontologies", Stanford University, Proc. Ontology Matching Workshop @ ISWC, USA(2010).

[51] "Ontology Alignment Evaluation Initiative":, http://oaei.ontologymatching.org .