An-Najah National University

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APPLYING CENTRALITY MEASURE FOR BUKHARI AHADITH ONTOLOGY OF NARRATORS

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Dedication

To my dear mother and my Father, from whom I learned steadfastness and love of life, no Matter the difficulties...

To those who encouraged me to continue my scientific career, my dear brothers...

To my dear sisters who supported and encouraged me...

To my friends and ambitious partners who supported me in every sense of the word...

Acknowledgment

Thanks and praise is to God Almighty for giving me the strength and ability to complete this study...

I also thank my family: my mother, my father, my brothers and my sisters for all that you do for me, your invitation, your patience, your motivation, your continuous support and encouragement to work on this thesis...

I would like to thank my friends for their moral support during my study journey...

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I would also like to thank them for their advice during the study period and their support for the general direction of this thesis, without the help, guidance, and continuous follow- up from them. this search will not be ...

Declaration

I, the undersigned, declare that I submitted the thesis entitled:

APPLYING CENTRALITY MEASURE FOR BUKHARI AHADITH ONTOLOGY OF NARRATORS

I declare that the work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

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List of Contents

List of Tables

List of Figures

List of Appendices

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Abstract

The two main sources of Islamic legislation are the Qur'an and Hadith. Ahadith are the narrations stemming from the sayings and deeds of the Prophet Mohammad (peace be upon him). The narrators transmitted hadith of the Isnad from the Prophet, and the importance of the Isnad, Muslim's keen interest in Isnad science because it helps to differentiate between accepted and rejected hadith, or in other words, authentic and weak hadith. Islamic scholars were the first to carefully study the Isnad to know and distinguish between trusted and non-trusted Ruwah, especially with the spread of Islam in non-Arabic countries and the increased number of Muslims from different cultures.

This work depends on the ontology of narrations of Jihad and Seiar Ahadith in Sahih Al Bukhari in order to apply different ontological centrality measures to generate a set of numbers related to each Rawi. These numbers were investigated to study the importance and extent of involvement of a particular narrator in the process of narrating hadith. For each centrality measure applied, we studied the calculated numbers for each Rawi in order to show how these numbers are related to the Ruwah importance in terms of their concerns in narrations, the amounts of their efforts, and their ranks of the narration process. These results are compared with the manual efforts applied by Islamic studies that rely on the manual categorization of Ruwah. We identified a list of Mokthreen narrators from the Sahaba (e.g., Abu Horaira, Ibn Abbas, Ibn Omar, etc.) as well as the Mokthreen of narrators from the second and third-generation (e.g., Shoaaba Ibn Alhajjaj, Alzohre, Sofian Ibn Aoyayna, Sofian Althori, etc.) who contribute significantly in the propagation of hadith collected in Sahih Al-Bukhari. To the best of our knowledge, this comprehensive and systematic study is based on ontology, representing narrators as a graph to analyze their contribution to the preservation and dissemination of hadith. When comparing the results of the system with the traditional

results, we obtained similar results, whether in the information of the narrator or his role in the process of narrating the hadith.

Keywords: Hadith, Hadith Isnad, Ontology, Hadith Ontology, Centrality measures

Chapter One
Introduction

This chapter presents the thesis by describing an overview, the thesis problem, the research objectives, the importance of the research, and related work.

1.1 Definitions

Hadith is an oral hadith related to the sayings and deeds of the Prophet Mohammad (PBUH). Traditional Islamic schools of jurisprudence on hadith constitute an important tool for understanding the Qur'an and for all matters relating to jurisprudence [1].

The hadith consists of two parts: the actual narration, known as the matn, and the chain of narrators in which the narration is transmitted, traditionally known as the Isnad. The Isnad consists of a chronological list of narrators, each who mentions the person from who he heard the hadith to the narrator from the matn, followed by the matn itself [1].

The hadith scholars agreed that the Isnad is required in the narration of the Sunnah of the Prophet, and it must be proven, otherwise, the hadith is not be accepted, Imam Abdullah Ibn Mubarak said, Isnad is part of the religion and without Isnad whoever would have said whatever he wants [2].

Researching Isnad is very important in the science of hadith. To know whether a hadith is authentic or not, hadith scholars have taken clear steps in studying hadith's Isnad through traditional methods.

Nowadays, software tools help study hadith narrators, such as hadith encyclopedias and some websites. In addition, information retrieval and search engines related to the semantic web can be used to determine the degree of hadith Isnad. The scholars agreed to encourage the use of computers and software in the service of religion and hadith.

Ontology is a semantic web concept that can be used in many implementations such as information retrieval systems and decision support systems [3]. Based on these applications, ontology can also be useful in the process of studying hadith narrators.

Ontology is defined as a formal explicit description of concepts in a domain of discourse (classes). Properties of each concept describe various features and attributes

of the concept (slots), and restrictions on slots (facets) ontology's together with a set of individual instances of classes constitute a knowledge base [4].

Centrality measures are among the most widely used indicators based on network data. Generally, reflects the importance of unity; in different objective situations, this may be their structural strength, or appearance. Studies often use measures of network-based centralization in efforts to account for differences between units in behavior or attitudes.

Centrality measures are divided into two parts:

- Local centrality measures that can be calculated using local node information such as degree centrality.
- Global centrality measures that use global network information e.g. Closeness centrality, and page rank, in which the entire network architecture is required.

In this research, the ontology was built consisting of the narrators of hadith in Sahih Al-Bukhari in Bab on Jihad and Seiar. And using the ontological development processes to design an ontology, which is based on a set of classes, relationships, and properties. And then we apply the centrality measures to all narrators in the ontology to judge the hadith narrator.

1.2 Statement of the Problem

Studying a hadith narrator, whether known or unknown, requires a lot of time, experience, effort, and the knowledge of hadith scholars. Many applications help researchers in the process of studying the narrator of the hadith, but they need automation in studying the Isnad of the hadith, and the researchers can only access the narration Isnad and translate the whole narrator by name, nickname, date of death, Tabaqa, Rutba, Shaikhs, and students.

Moreover, some of these applications derive a tree from the hadith Isnad, but then leave it to researchers to study the resulting data on the foundations and rules established by hadith scholars to determine the ruling of the hadith narrators.

The Statement problem in this research is how to build a system for classifying hadith narrators on an ontology basis that relies on the rules that hadith scholars follow in

studying hadith by applying centrality measures to each narrator. This would support the ruling of hadith narrators to achieve the required accuracy.

The main goal here can be summarized as follows:

1. Applying a set of centrality measures for a set (or all) narrators appeared in Sahih Al-Bukhari in Bab Jihad and Seiar.
2. Compare the results of applying these measures with a set of Islamic studies related to the same topics.
3. Visualize these measures as a connected graph of narrators each of which is a node attached to the node measures' values.

1.3 Objectives

In this section, we present the main and specific objectives of the research work.

1.3.1 Main Objective

The main goal of this study is to build an ontological basis for the Isnad of the hadiths collected and arranged by Al-Bukhari in the Bab Jihad and Seiar, then execute a set of centrality measures on this ontology.

1.3.2 Specific Objectives

The result will be studied and compared by the works related to studying the strength of Ruwah in their narration process. The output of this research will be a set of numbers for each Rawi in which these numbers:

- Reflects Rawi's role in the narration process.
- Quantify the amount of dependency for some Rawi.
- Categorize Ruwah according to their teacher.
- Ranking of Ahadith depending on the rank of their Ruwah.

1.4 Importance of the Research

Hadith is the second source of Islamic rule. Without it, we would have wasted the Sunnah. Therefore, it is important to study the Isnad and pay attention to it to know whether the hadith is authentic or not.

The research it will be useful for scholars and researchers, specialized and non-specialized, to ensure the confidence of the narrator and the extent of his honesty.

1.5 Related Work

Much of the work has been published, and in hadith, much research has been concerned with extracting knowledge from Arabic historical data, including literature on hadiths.

However, little of this work concerns issues of data visualization and interaction.

1.5.1 Hadith Electronic Encyclopedias

Many electronic encyclopedias help in studying Isnad in hadith, such as Shamela Library [5], the Encyclopedia of Narrators of Hadith (Nour al-Islam) [26], and the Encyclopedia of the Nine Books Harf [6], Encyclopedia of Harf also charts the Isnad of hadith tree.

Through our review, we noticed that they are all similar in their outcomes (related to the process of studying the Isnad of hadith). All attributed to the researcher. They usually provide the Isnad of narrators and a complete biography of the narrator along with the name, nickname, and date of death, rank, Rutba, Shaikhs, and students. Despite all these features in electronic encyclopedias of hadiths, they lead to time consumption, and a lot of effort falls on the responsibility of the hadith researcher. We want to support this method in our research using ontology.

1.5.2 Arabic and Islamic Ontology Development

In [7] it has been shown how new data mining techniques can extract Islamic knowledge from its sources and represent this knowledge in a useful way for the user. Furthermore, this study focuses on talk as a cognitive resource and proposes an approach to classify talk into its categories using supervised learning taxonomy. The results of this study show that there are several ways to extract knowledge from hadith according to the goal of knowledge.

To innovate an automatic Hadith Isnad processing system can help in automatic hadith judgment and distinguish between acceptable (Sahih) and weak (Da’ief) hadith is discussed in [8].

Ontology can be used to better understand all aspects of the life of the prophets and messengers in Islam [9]. The classes, relationships, and proprieties of this special domain have been collected and integrated to help researchers identify and explore knowledge about the prophets in Islam such as their lives, books, teachings, the nature of the messages they brought to their nations and tribes, and much more.

In [10], this study proposed by researchers to create an ontology of hadith sciences in Arabic, knowledge was collected from various sources such as hadith books and hadith experts, and the main goal is to improve the process of retrieving information and extracting knowledge. The ontology can be used in various fields such as document indexing systems, hadith classification, and hadith evaluation.

The mentioned works show a growing interest on the part of Arab and Islamic scholars in building an Arabic ontology to develop Arabic content on the semantic web. This is very useful in the development step of hadith science.

1.5.3 Centrality measures in hadith

Few published papers deal with the topic of centrality measures in hadith. In the work [11] it is about visualizing the narrators of the hadiths of the Prophet Muhammad (PBUH) as an interactive graph of both information related to the narrator and the hadiths. Furthermore, a set of graph centrality measures was implemented to determine the importance of each narrator in the hadith narration process.

In [12], this research aims to analyze Muslim scholars who had an important role in spreading the hadith in Sahih Al-Bukhari. The centrality measures algorithm is used to analyze which narrators have an important role in the network. The research found that Abu Hurairah (may God be pleased with him) and Ibn Abbas (may God be pleased with him) are the two most influential Sahaba of the Prophet (PBUH). While on the next generation, Al-zohre and Shoaaba Ibn Al-Hajjaj are the most influential narrators.

The above works show that centrality measures are useful for taking and extracting knowledge from ontology. This may be useful in deciding on the study of the hadith's Isnad.

1.6 Thesis Structure

This thesis mainly consists of seven chapters: introduction, Methods, Theoretical and Technical Foundations, Methodology, Centrality Measures, Results, and Conclusion and Future Work. The main points discussed in the chapters are given below:

- Chapter 1 (Introduction): gives the introduction on the Hadith, ontology, Centrality measures, and the statement problem and objectives.
- Chapter 2 (Theoretical and Technical Foundations): depicts the theoretical and technical foundations necessary for thesis work, Hadith science, Studying Isnad, Knowledge Representation, and ontology concepts.
- Chapter 3 (Methodology): presents methods used in the thesis, and describes the development steps of Isnad ontology and Ontology.
- Chapter 4 (Centrality Measures): describes using the centrality measures in the Isnad ontology.
- Chapter 5 (Results): presents the results for applying ten centrality measures to the Isnad ontology.
- Chapter 6 (Conclusions and future work): discusses the conclusions and presents future works.

Chapter Two
Theoretical and Technical Foundations

In this chapter, the basic concepts and technical knowledge that form the basis for understanding the thesis work are presented. We discussed the science of hadith and hadith Isnad, then the representation of knowledge, and Ontology.

2.1 The science of hadith and the Isnad of hadith

Every hadith has an Isnad that goes back to the Prophet Mohammad (PBUH). Studying the biography of each narrator in an Isnad that transmits the hadith and comparing it with another Isnad of narrators of the same hadith, if any, including studying circumstances that participate in the narration of a particular hadith and other factors that go into the recording are all considered hadith sciences.

Rules were established to identify between what is accepted and what is rejected in the hadiths. The scholars of Islam developed a science named Mustelah hadith, which is a Hadith terminology, through which the hadiths of the Prophet are examined for martyrdom, reviewed, and the different narratives from one class to another and from one generation to another.

The Importance of Isnad:

Narrators transmitted hadiths with Isnad and the importance of Muslims' interest in the science of Isnad because it helps to differentiate between accepted and rejected hadiths or in other words, Sahih and weak hadiths [13].

The narrators transmitted the words of the Prophet. Neither of them has lied to the other since the early times of the Prophet. They didn't need to search for the condition of the narrator until Fitna occurred in Islam. Sahaba and Tabieen did their best to memorize the hadith, and Muslims paid attention to Isnad and studied the conditions of the narrator.

Imam Mohammad Ibn Siren says, "They (the Sahaba) did not ask for Isnad, but when the Fitna occurred, they identified the Sunni men to follow them Bida' men to avoid them".

Imam Ibn Tamiya states: “Isnad is a unique feature of this Uma and Islam. Then from among the Muslims, it is a specialty of the Ahl AL-Sunnah and Al-Jama’ah.”

Isnad is a specific characteristic of the nation of the prophet (PBUH). No other nation, religion, or society can claim or boast of having such a precise analysis of the various aspects of its faith.

The early Muslim scholars examined and analyzed everything that came with them, whether it was the saying of the prophet Mohammad (PBUH), his Sahaba, may God be pleased with them, or others. They studied the lives and character of those who were part of Isnad as closely as possible.

Thus, the nation witnessed an amazing introduction to the “science of studying the reporters of Hadith” (Rijal Al-Hadith) that was unprecedented and unparalleled even today.

Recording the names, dates of birth, dates of death, attributes, and characteristics of thousands and thousands of people is something that only Muslims possess.

The importance of Isnad in this research is summarized as follows:

1. Reflects Rawi role in the narration process.
2. Quantify the amount of dependency for some Rawi.
3. Categorize Ruwah according to their teacher.
4. Ranking of Ahadith depending on the rank of their Ruwah.

2.2 Steps of Studying Isnad

2.2.1 Identifying the narrator

The hadith scholars got rid of the ambiguity related to the narrators and put the names of the narrators with their nicknames, they documented their dates of birth and dates of death clearly, and hadith scholars cited all these things accurately.

This is a primary step because the men’s names and nicknames may be similar, which puts the researcher in illusions. That is, a speaker may say something about the narrator, but the listener may guess that he is talking about another narrator.

2.2.2 The definition of a narrator whether weak or trusted is as follows

- Is the narrator reliable or weak, or does he need further investigation?
- Are his sheikhs trustworthy, weak, or do they need further investigation?
- Are his students trustworthy, weak, or do they need further investigation?
- Are all his narrations sound during his life or have they changed? Did the narrator narrate after he changed or not?
- Has the narrator called Muddles before? Has anyone proven that the narrator is Muddles?

2.2.3 Naming the narrators

According to what they agreed upon and what they did not agree upon. The steps that must be taken including:

- Study the narrator's conditions and indicate the Rutba he occupies.
- Ensure that Isnad is intact from the first narrator to the Bukhari.
- If the narrator is trustworthy, the Isnad is Sahih. If it is weak, then the Isnad is also weak.

2.3 Knowledge Representations

2.3.1 Definition

Knowledge representation is the field of artificial intelligence (AI) dedicated to representing information about the world in a form that a computer system can use to solve complex tasks. Knowledge representation also includes results from logic to automate different types of reasoning, such as the applying rules or relationships of sets and subsets.

Examples of knowledge representation formalisms include semantic networks, systems architecture, frameworks, and ontology.

2.3.2 Importance

Knowledge representation not only stores data in some database but also enables an intelligent machine to learn from that knowledge and experience so that it can act intelligently like a human. Knowledge representation is about understanding intelligence. Rather than trying to understand or build brains from the bottom up, its goal is to understand and build intelligent behavior from the top down and focus on

what the client needs to know to be have intelligently. It also specifies how reasoning procedures can make this knowledge available as needed.

2.3.3 Ways of Knowledge Representation

There are several main ways of representing knowledge which are listed as follows:

- Logical Representation: It is a language that has some concrete rules that deal with issues and there is no ambiguity in representation. Logical representation means drawing a conclusion based on various conditions. This representation establishes some important communication rules. It consists of well-defined syntax and semantics that support phonological inference. Each sentence can be translated into logic using syntax and semantics.

- Semantic Network Representation: For knowledge representation, semantic networks are an alternative to predicate logic. We can express our knowledge of semantic networks as graph networks. This network consists of nodes that represent objects and arcs that describe the relationships between them. Semantic networks may classify objects in several ways and link them together. This representation consists of two types of relationships:

- IS-A relation (Inheritance).
- Kind-of-relation.

- Frame Representation: A frame is a record-like structure that contains a set of properties and their values to describe a physical object. Frames are a type of AI data structure that divides knowledge into substructures by depicting typical situations. It consists of a set of slots and slot values. These slots can come in any shape or size. Facts are the names and values assigned to slots. Semantic networks gave rise to frames, which later evolved into modern-day classes and objects. A single frame is of limited utility. A-frames system consists of a set of interconnected frames. Knowledge about an object or event can be maintained within the knowledge base in the frame. A frame is a form of technology that can be used in a wide range of applications.
- Production Rules: The production rules system consists of pairs (condition, action) which means, 'if the condition then the action'. It mainly consists of three parts:

- The set of production rules.
- Working Memory.
- The recognize-act-cycled.

- Ontological: In this way of representing knowledge, an ontology is a data model that represents a set of concepts within a domain and the relationships between those concepts. It has a major role in representing knowledge as it is simple and easy to understand and implement, in addition to being a means that organizes concepts systematically.
- Taxonomy: Taxonomy is a hierarchical framework, or scheme, for classifying different types of living as well as non-living things, occasions, and/or ideas. As humans, we encounter taxonomies frequently but rarely give them much thought. The facts, filters, and search suggestions that you come across frequently on contemporary websites are called taxonomies.

Ontology and taxonomy can be compared in many ways since they both explain different categories of items and are set up in a hierarchy. A taxonomy is comparable to a tree, whereas an ontology is more like a forest, metaphorically speaking, to put it another way, ontologies allow for far more sophisticated linkages such as “has-a”- and “use-a”-relations, whereas taxonomies describe a collection of subjects with “is-a”-relationships.

Ontology is the more comprehensive, all-encompassing phrase, whereas a semantic network is a more focused method of information representation. One disadvantage of the semantic network is that the links between objects represent only binary relationships. For example, the statement Run (RajdhaniExpress, Chandigarh, Delhi, Tomorrow) cannot be asserted directly.

Since we have to traverse the entire network tree to find some answers, semantic networks require additional computation time during runtime. In the worst case, we may discover that the answer does not exist in this network after exploring the entire tree.

2.4 Ontology

This section introduces the definition of ontology, how we can develop it, and the tools and software used to implement it.

2.4.1 Introduction

Computer science introduced the term ontology to define ’what exits’ of a community of cooperating agents. Ontology is a specification of visualization. A description of the concepts and relationships that can exist for an agent or a community of agents, a logical theory that accounts for the intended meaning of formal terms, i.e. The intentional models of a logical language that use such vocabulary are constrained by their ontological commitment. Ontology indirectly reflects this commitment by approximating this intentional model.[14]

Ontology contains a set of clearly defined and articulated classes or concepts, the concepts property, slot, facet, restriction, and a series of examples related to a single class, which combine to form storage of knowledge. Class is the core of ontology, which describes concepts in some domain. The slot describes the property of the class and the instance.

2.4.2 Ontology Development

The general stage in designing and developing the ontology [15]:

- Step 1. Determine the domain and scope of the ontology:

Begin developing the ontology by defining its domain and scope. This means answering several basic questions: What domain will the ontology cover? Why do we use ontology? What types of questions should the information in ontology provide? Who will use and maintain the ontology? The answers to these questions may change during the ontology design process, but at any given time they help limit the scope of the model.

- Step 2. Consider Reusing Existing Ontology:

Check if we can improve and expand the existing resources for our specific domain and task. Reusing an existing ontology may be a requirement if our system needs to interact with other applications that have already committed to having a particular ontology or controlled vocabulary. Much of the ontology is already available in electronic form and

can be imported into the ontology development environment you are using. It often does not matter what formality is expressed in ontology, since many knowledge representation systems can import and export ontologies. It is usually not difficult.

- Step 3. Enumerate the Important Terms in the Ontology:

It is useful to make a list of all the terms that we want to either make statements about or explain to the user. What terms do we like to talk about? What are the properties of these terms? What would we like to say about these terms? To begin with, it is important to have a comprehensive list of terms without worrying about the overlap between the concepts they represent, the relationships between the terms, any properties the concepts may have, or whether the concepts are classes or slots.

- Step 4. Define the classes and the class hierarchy:

There are several possible ways to develop a class hierarchy: The top-down development process begins with the definition of the most general concepts in the domain and the subsequent specialization of the concepts. The bottom-up development process begins with the definition of more specific classes, hierarchical sheets, with these classes later grouped into more general concepts. The hybrid development process is a combination of top-down and bottom-up approaches. We first identify the most prominent concepts and then generalize and customize them appropriately.

- Step 5. Define the properties of classes—slots:

Describe the internal structure of concepts.

- Step 6: Define the facets of the slots:

Slots can have different facets that describe the type of value, allowed values, number of values, and other features of the values the slot can take.

- Step 7: Create instances:

The final step is to create individual instances of the classes in the hierarchy. Defining individual instances of a class requires the following:

1. Choosing a class.
2. Creating an individual instance of that class.
3. Filling the slot values.

2.4.3 Ontology Evaluation

An ontology assessment can target many different criteria [16]:

- Accuracy: Do the intuitions match the experience of one or more users? Does the ontology correctly capture and represent aspects of the real world?
- Adaptability: Does ontology anticipate its uses? Do they provide a conceptual basis for a range of expected tasks? Can ontology be expanded and specialized monotonically? How does ontology react to small changes in axioms?
- Clarity: Does the ontology effectively convey the intended meaning of the defined terms? Does the ontology use definitions or partial descriptions? Are the definitions documented? Is the ontology understandable?
- Completeness/ competency: Is the area of interest adequately covered? Have competency questions been identified? Can ontology answer it? Does the ontology include all relevant concepts and their lexical representations?
- Computational efficiency: How easy and successful is the logic of ontology processing? How quickly can the usual inference services be applied to ontology?
- Conciseness: Does the ontology include irrelevant axioms regarding the domain to be covered? Does it include redundant axioms? Does it impose a minimum existential commitment? How weak are philosophical ontology's basic assumptions about reality?
- Consistency/Coherence: Do axioms lead to contradictions? Are formal and informal descriptions of ontology consistent?
- Scalability: The ability to easily add new information sources without making fundamental changes to the existential components of the integrated system.

2.4.4 Ontology Tool

A graph database stores nodes and relationships instead of tables and documents, a flexible use method that allows data to be stored without having to limit it to a predefined form.

Graphs contain nodes (these are the entities in the graph), relationships (provide directed and named connections between two node entities), and properties. Neo4j and Cytoscape is a tool that gives developers and data scientists reliable and advanced tools for building smart applications.

Neo4j is fast to read and write code and is the only graph database that combines native graph storage, a scalable architecture optimized for speed, and ACID compliance to ensure the predictability of relationship-based queries. Neo4j provides a centralized measures computation library called Neo4j GDS Library.

Cytoscape provides basic network mapping and querying functionality, the Core can be extended through a direct plug-in architecture, allowing rapid development of additional analytics and computational features. Cytoscape includes the ability to calculate several centrality metrics.

2.4.5 Ontological measure

The metrics evaluate ontology from different dimensions. It measures the individual quality attribute of the ontology. Structural metrics included the total number of classes or concepts, the total number of properties, the total number of instances or individuals of the ontology, the maximum number of children, the number of subclasses of the top class in the ontology's inheritance tree, the average number of children and the average number of relationships between subclasses for each class in Ontology. Using these dimensions other measures are calculated.

The basic measure of ontology provides the number of many classes, objects, axioms, properties, and individuals used in the ontology. The goal of ontology is to provide knowledge about the real world. The extent of this knowledge is attributed to the quality of ontology. It ensures the efficiency of ontology design and indicates the amount of factual knowledge represented in the selected ontology.

Chapter Three
Methodology

In this chapter, we present the stages for developing an ontology based on the domain of Hadith Isnad.

3.1 Study design

Work has been done on the book Sahih Al-Bukhari and the of the Bab on Jihad and Seiar, this Bab contains 208 hadiths, where we converted the chain of narrators of each prophetic hadith into an Ontology that collects the narrators of the prophetic hadiths in this chapter from the Prophet Muhammad (PBUH) to Al-Bukhari. Each narrator in this series has characteristics such as ID, Name, Rank, Birth Date, and Death Date.

Then we apply 10 centrality measures to this ontology that contains all hadith narrators using two programs Neo4j and Cytoscape. Dividing the narrators of hadith into Sahaba, Tabieen, and the rest of all the narrators to judge them.

3.2 Study populations

The study population includes the narrators of the prophetic hadiths represented from the Prophet Muhammad (PBUH) to Al-Bukhari, through our research, we found 364 Narrators in this Bab, and they were divided into:

- Sahaba: It refers to the narrators who are the companions, friends, and family of the Prophet Muhammad (PBUH) and they have great attention and respect from Muslims, and after saying any name of a Sahaba Muslims say “Radia Allah Anh”, which means (may God be pleased with him). Through our research, we found 47 Sahaba in this Bab.
- Tabieen: They are the generation of Muslims that came after Sahaba, and the Tabiee had seen at least one of Sahaba. Through our research, we found 141 Tabiee in this Bab.
- Narrators: They are the rest of the narrators in the Isnad of hadith, not from Sahaba, or Tabieen. Through our research, we found 176 Narrators in this Bab.

3.3 Study sample

The study population includes all the narrators who participated in the transmission of the Prophet's hadith in the chapter on Jihad and Seiar in the book of Sahih Al-Bukhari.

3.4 Instruments of study and validation indicators

The range of research will be in one of the six books of hadith, which is Sahih Al-Bukhari. He strove to know the narrators and get to identify them which is easy to validate the result of the search.

3.5 Analysis plan

After creating the ontology, the measures of centrality were applied to all narrators within the ontology, so that we analyze the results that describe the case of the narrator, his role in the process of narrating the prophetic hadith, and its importance within the ontology.

The centrality measures used in this research are Degree Centrality, Closeness Centrality, Betweenness Centrality, Radiality, Eigenvector Centrality, PageRank Centrality, ArticleRank Centrality, HITS, and Stress Centrality.

3.6 Study procedures

The ontology of the narrators is built using the Neo4j program, and then centrality measures are applied to this ontology using the same program and Cytoscape program.

Neo4j The software is used for its speed in reading and writing code and is the only graph database that combines native graph storage, a scalable architecture optimized for speed, and ACID compliance to ensure the predictability of relationship-based queries. Neo4j provides a library for computing centrality measures called Neo4j GDS Library.

Cytoscape The program provides basic network mapping and querying functions, the Core can be extended through a direct plug-in architecture, allowing rapid development of additional analytics and computational features. Cytoscape includes the ability to calculate several centrality measures.

3.7 Ethical approvals

About the ethical issue, this research has relied on a reference, which is the comprehensive library program (Shamela) approved in the College of Sharia, this program includes all the books of hadiths of the Prophet Mohammad (PBUH) and also includes a summary of the narrators' lives, status and attributes.

3.8 Isnad Ontology Developments

We define the definitions, concepts, and relationships of the domain of Hadith Isnad. The development methodology is carried out according to the steps in Section 3.4.2 (Ontology Development). The steps as applied here are:

Step 1: Determine the Domain and Scope of the Ontology

The first step in developing ontology is to define the domain and scope of the ontology, where the ontology will be developed to answer some basic questions:

1. What is the domain that the ontology will cover?

The domain of ontology is the Isnad of hadiths in Sahih Bukhari, specifically the hadiths of the Prophet Muhammad (PBUH) in the Bab on Jihad and Seiar.

2. What is the use of ontology?

The ontology aims to provide a base schema for narrators, and users include hadith experts.

3. What types of questions would be answered by the information contained in the ontology?

Ontology will provide comprehensive answers to questions related to the domain of hadith such as:

- What is the First Name and Last Name of the Narrator?
- What are the Tabaqa and Rutba of the Narrator?
- Who are the Narrator's Teachers and Students?
- How many Hadiths were narrated by Al-Rawi?
- The journey in seeking knowledge.
- The narrator's popularity?

- How close is the narrator to the other narrators?

4. Who will use ontology?

Ontologies will be available to specify narrator information, which users interested in searching for hadiths will be interested in, especially information about hadith Isnad.

5. Source of knowledge:

Sahih Bukhari.

Step 2: Reuse Existing Ontology's

We didn't use any previous ontology, but we designed it to fit the required functionality and built it from scratch. Reusing an existing ontology for a new task requires a detailed evaluation of the candidate ontology because it may cover only a subset of domain concepts, contain redundant or misleading information, and have imprecise relationships and hierarchies between concepts.

Step 3: Enumerate the Important Terms in Ontology

The following questions help to define the conditions:

1. What are the main terms that we want to talk about?

The main terms we talk about are Hadith, Sink, Source, and Narrators.

2. What are the properties that are owned by these terms?

- The Hadith term has the following properties: hasNarrator.
- Sink term has the following properties: SinkID, Name.
- Source term has the following properties: SourceID, Name.
- Narrator term has the following properties: NarratorID, Name, FirstName, FatherName, BirthPlace, DeathPlace, BirthDate, DeathDate, Nickname, HeardFrom, and TransferTo.

Step 4: Define Classes and Class Hierarchy of Ontology

This step begins by defining classes. From the list, created in Step 3. The terms in Table 3.1 are classes in the ontology and will become anchor points in the class hierarchy.

Table 3.1
Ontology Classes

No.	Class	Description
1	Hadith	Represent Hadith Isnad and number of Hadith.
2	Sink	The sink node of all paths (Bukhari).
3	Source	The source node of all paths (Prophet Mohammad (PBUH)).
4	Sahaba	The narrators who are the companions and family of the Prophet Muhammad (PBUH).
5	Tabieen	They are the generation of Muslims that came after.
6	Sahaba	Narrator The rest of the narrator.

There are three ways to develop the class hierarchy: a top-down approach, a bottom-up approach, or a combination of both. In our approach, we use top-down concepts such as Book (Sahih Bukhari), Bab (Jihad and Seiar), Hadith, and Narrator. Then we create all other classes that could extend from Narrator.

Step 5: Define the Properties of Classes (Slots)

Once the classes are identified, we reflect and clarify the internal structure of the concepts. This is a property of advanced classes. These proprieties are extracted from the classes shown in Table 3.1.

Table 3.2
Hadith Ontology Object properties

Object Property	Domain	Range	Description
SinkOf	Sink	Book	The Book that the sink/author is an author.
hasSink	Sink	Book	Refers to the person who authored the book.
HeardFrom	Narrator	Narrator	The Narrator who heard the Hadith.
TransferTo	Narrator	Narrator	The Narrator who told the Hadith.
NarratedOf	Narrator	Narrator	The Narrator who narrated the Hadith.
hasNarrator	Hadith	Narrator	Narrator who narrate Hadith.

Table 3.3
Hadith Ontology Data properties

Data Property	Domain	Range	Description
ID	Narrator, Hadith	Integer	The identifier of the Narrator, Hadith.
Name	Narrator	String	The Name of the Narrator.
Nickname	Narrator	String	The Nickname/Luqab of the Narrator.
Rank	Narrator	Integer	The Rank/Tabaqa of the Narrator.
Birth Date	Narrator	Integer	The Birth Year of the Narrator.
Death Date	Narrator	Integer	The Birth Year of the Narrator.
Birth Place	Narrator	String	The Birth Place of the Narrator.

Step 6: Define the Facets of the Slots

In our state, most slot values are integer and string. For example, the value type of the rank type value is an integer, and the name property is a string.

Step 7: Create Instances

The creation of individuals (Ruwah) allows the recording of the properties of all classes. The created individuals in our ontology represent the chosen sample of Hadith Isnad, which is used in calculating the centrality measures.

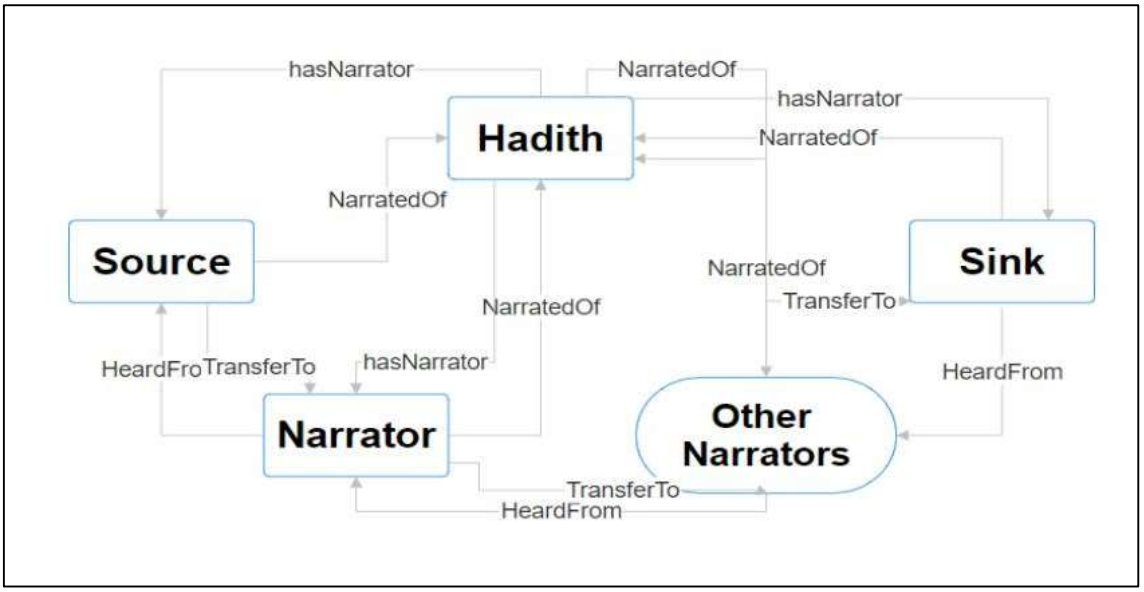
Information about Ruwah was obtained from the library program (Shamela) as previously explained in Section 2.7 (Ethical approval).

3.9 The Ontology

In this section, we will describe the ontology created in representing all the terms, properties, and relationships by the Isnad of hadith in Sahih AL-Bukhari and specifically the Isnad of hadith in the Bab on Jihad and Seiar. And then study the Centrality Measures and its importance in our study.

Figure 3.1 shows the ontology using Object-Role Modeling (ORM) including all concepts and relations.

Figure 3.1
Object-Role Modeling (ORM) for the hadith ontology



Building the Ontology:

First, we began to collect the Isnad of hadiths of the Prophet from sayings and deeds in the Bab on Jihad and Seiar to create the ontology of hadith Isnad. The ontology represents terms, properties, and relationships of hadith Isnad.

In short, if Narrator A describes a hadith he heard from the Prophet Muhammad (PBUH) to Narrator B; Narrator B narrates it to(relation) Narrator C, then we represent these three narrators (A, B, and C) as directed graph with three nodes.

An example of the chosen hadith is hadith number 2782:

٢٧٨٢- حَدَّثَنَا الْحَسَنُ بْنُ الصَّبَّاحِ:* حَدَّثَنَا مُحَمَّدُ بْنُ سَابِقٍ:*حَدَّثَنَا مَالِكُ بْنُ مِغْوَلٍ* قَالَ: سَمِعْتُ الْوَلِيدَ* بْنَ الْعَيْزَارِ ذَكَرَ عَنْ أَبِي عَمْرٍو الشَّيْبَانِيِّ* قَالَ: قَالَ عَبْدُ اللهِ بْنُ مَسْعُودٍ: سَأَلْتُ رَسُولَ اللهِ ﷺ قُلْتُ: يَا رَسُولَ اللهِ، أَيُّ الْعَمَلِ أَفْضَلُ؟ قَالَ: «الصَّلَاةُ عَلَى مِيقَاتِهَا». قُلْتُ: ثُمَّ أَيٌّ؟ قَالَ: «ثُمَّ بِرُّ الْوَالِدَيْنِ». قُلْتُ: ثُمَّ أَيٌّ؟ قَالَ: «الْجِهَادُ فِي سَبِيلِ اللهِ». فَسَكَتُّ عَنْ رَسُولِ اللهِ ﷺ، وَلَوِ اسْتَزَدْتُهُ لَزَادَنِي.

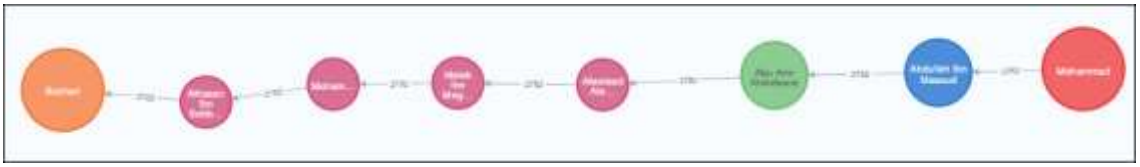
When we analyze the hadith Isnad, we find that it includes the narrators mentioned in Table 3.4.

Table 3.4
Narrator of Hadith number 2782

NO.	Narrator Name	ID
1	Abdullah Ibn Masoud	2
2	Abu Amr Alshebane	3
3	Alwaleed Ibn Alaezar	4
4	Malek Ibn Meghwal	5
5	Mohammad Ibn Sabeq	6
6	Alhasan Ibn Sabbah	7

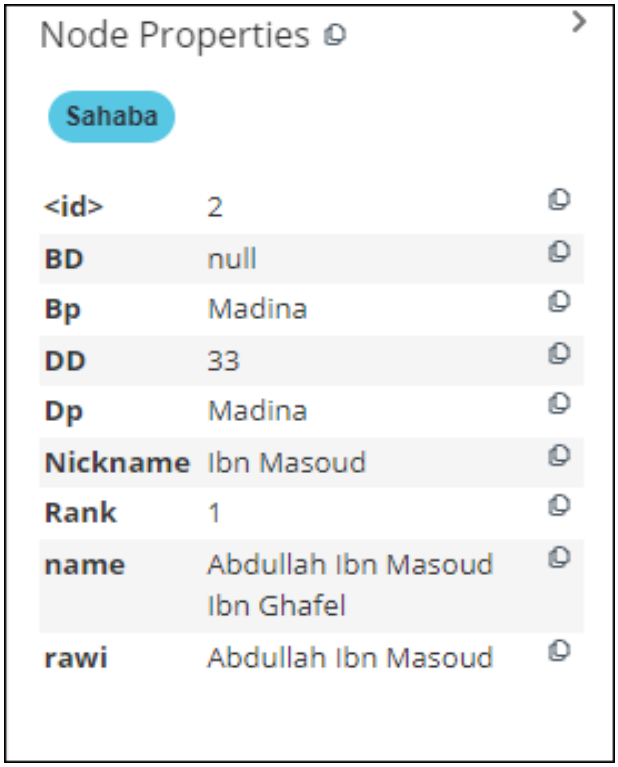
To convert the hadith Isnad into a graph, we used the Neo4j program so that each node refers to a specific narrator, and the relationship between the nodes indicates a sequence of a specific hadith with its number. So we have the Isnad in the graph, shown in Figure 3.2.

Figure 3.2
Hadith Narrators Isnad No. 2782



Each node contains the properties of each specified narrator. The properties are (ID, Name, Nickname, Rank, Birth Date, Death Date, Birth Place, and Death Place), as shown in the Figure 3.3.

Figure 3.3
Node proprieties for Abdullah Ibn Masoud



After entering all the Hadith Isnad in the Bab on Jihad and Seiar from Sahih Al-Bukhari, we get the graph of the Hadith Isnad as shown in the Figure in the link https://postimg.cc/qg7GQcFQ. It shows all classes of Hadith Isnad ontology: Sink, Source, and Narrator, the relation and properties are explained as follows: In the graph of the hadith Isnad ontology, we got 364 narrators (nodes) and 1434 relationships.

- The node in red color indicates the Prophet Muhammad (PBUH).
- The node in orange color refers to Al-Bukhari (may God be pleased with him).
- The nodes in blue color indicate the Sahaba (may God be pleased with them).
- The nodes in green color indicate the Tabieen.
- Finally, the rest of the hadith narrators, who were not among the generations mentioned, were grouped with pink nodes.

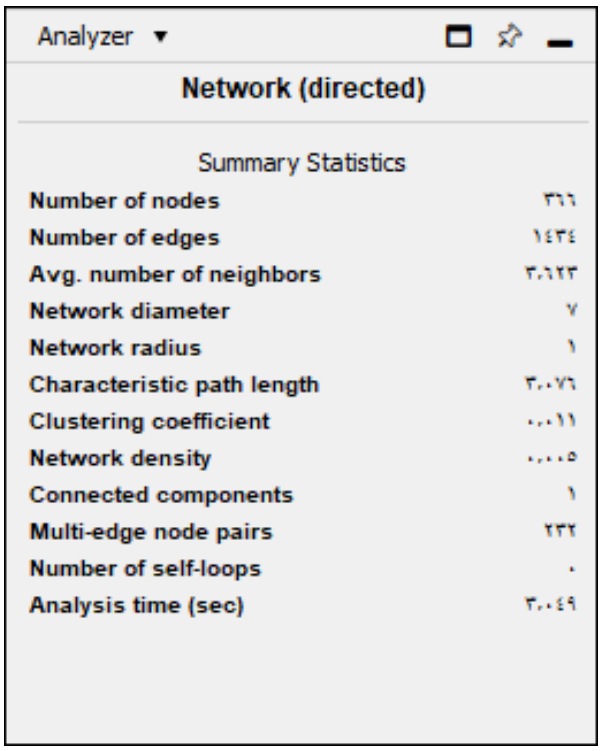
The Cytoscape program supports network analysis, Network-Analyzer calculates a comprehensive set of topological parameters for undirected and directed networks, including:

- Number of nodes, edges, and connected components.
- The network diameter, radius, and clustering coefficient as well as the characteristic path length.

Network-Analyzer will determine whether the network contains directed or undirected edges. Here we choose a directed edge because our network is Isnad of the hadith directed from the Prophet Mohammad (PBUH) to Bukhari through several narrators, and therefore in every hadith, every narrator narrated to another narrator, so the direction of the edge is to the narrator to whom it was narrated.

When the results are calculated, they will appear on the Analyzer panel as shown in the Figure 3.4.

Figure 3.4
Network Analyzer to b hadith ontology



Network Parameters:

- Number of nodes: This means the number of all nodes in the network is 366 nodes, and the nodes represent the narrators participating in the Isnad of the hadith.
- Number of edges: It means the number of all edges in the network, which are 1434 edges, and the edges represent the number of the hadith, they are the edges that represent the transfer of the hadith from one narrator to another.
- Avg. number of neighbors: It indicates the average connectivity of a node in the network.
- Network diameter: It is the largest distance between two nodes. The diameter can also be described as the maximum deviation of a node (the deviation is defined in

the separation of centrality measurement). It is 7, which is the longest hadith we have, consisting of 7 narrators.

- Network radius: It is the minimum between non-zero eccentricities of nodes in the network.
- Characteristic path length: It is also known as the average shortest path length and gives the expected distance between two connected nodes.
- Clustering coefficient: It is a ratio N / M, where N is the number of edges between the neighbors, and M is the maximum number of edges that can exist between n neighbors.
- Network density: Shows how densely the network is populated with edges. Connected components: Inside a network, all pairwise connected nodes form a connected component. The number of connected components indicates network connectivity and fewer connected components indicate a stronger connection. In our network, it is equal to 1, all paths that contain the nodes are first connected to the node that represents the Prophet Mohammad (PBUH) and end with the connection to the node that represents Bukhari.
- Multi-edge node pairs: This attribute indicates whether n is a partner in pairs of nodes with multiple edges.
- Number of self-loops: This attribute counts the number of self-loops at n. And in our network, it is equal to zero, because there is no narrator connected with him, i.e. he did not narrate the hadith from himself.
- Analysis time (sec): It represents the time taken to analyze the network.

Chapter Four
Centrality Measures

Centrality measures are a vital tool for understanding networks and are often known as graphs. These algorithms use graph theory to calculate the importance of any particular node in the network. They delete annoying data, and reveal parts of the network that need attention - but they all work differently. Each measure has its definition of importance, so you need to understand how it works to find the best measure for your graph applications.

In this research, we have applied 10 centrality measures of different work and importance to the graph of Hadith Isnad, and each measure will be explained separately.

4.1 Degree Centrality

The simplest measure of centrality is degree centrality; it simply indicates the number of neighboring nodes which is determined by the number of connections associated with each node. It is a measure of the centrality of a particular node, for directed graph centrality measures, they are divided into in-degree and out-degree parts, by calculating the incoming and outgoing link from a given node, respectively, as shown in equation 4.1:

$$DC\ (in/out)(v) = |Numberof(incoming/outgoing)edges(v)| \quad (4.1)$$

Nodes with higher degree centrality (In/out-degree centrality) are usually considered as more important nodes [17].

This measure indicates the importance of the narrator in the network, for example, the size of the narrator's narrations, that is, the number of hadiths narrated and heard by the narrator, and the number of direct 'one-hop' connections that connect each node to the other nodes in the network. We use it to find highly connected narrators, famous narrators, narrators likely to retain the most information, or narrators who can quickly connect to the broader network.

The narrator who has a high degree of centrality has narrated and listened to most of the hadiths, and this means that these narrators participated in memorizing the largest number of hadiths in Sahih AL-Bukhari.

The time complexity of this measure for an unweighted network is O(m) where m is the number of edges.

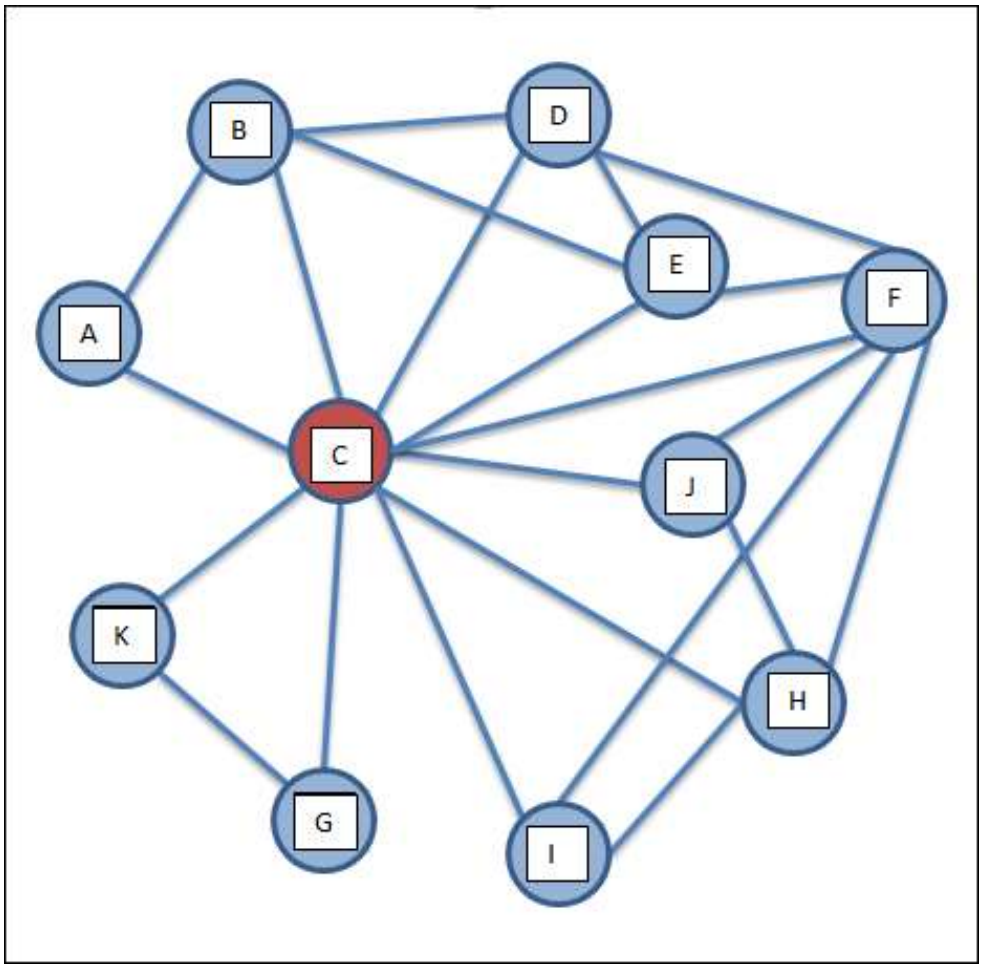
The main limitation of degree centrality is that it gives only local information about a network node. That is, this measure doesn't take into account the global structure.

So, the importance of the degree centrality can be summarized as follows:

- It is used to find very connected nodes.
- Find the famous nodes.
- Find the nodes that hold the most information.
- Find nodes that can quickly connect to the network.
- This measure can be considered a measure of popularity.

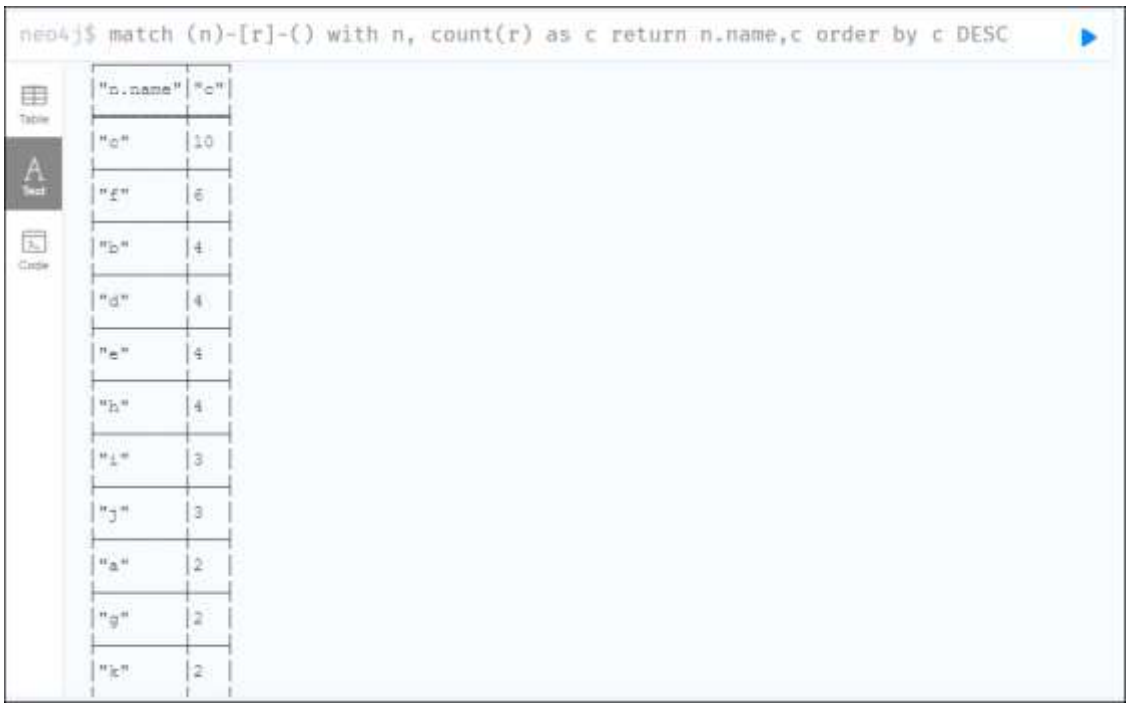
Example:

Figure 4.1
Example Degree Centrality



With the Neo4j program the result of applying the degree centrality code:

Figure 4.2
Degree Centrality result in Neo4j



We notice that node (c) has a high degree centrality that value equals 10 links with other nodes.

4.2 Closeness Centrality

As defined by Freeman (1979), the closeness centrality of a node is the sum of graph theoretical distances from all other nodes, where the distance from one node to another is defined as the length (in links) of the shortest path from one node to the another [18].

However, it is the total number of links that separate one node from another on the shortest possible path.

The proximity of each node to all the other nodes is measured in the graph to show the significance of each node, equation 4.2 [17]:

$$CC(v) = \sum \left(\frac{N-1}{d(v,u)} \right) u \in G \qquad (4.2)$$

Where d(v, j) is the minimum number of edges to move from node v to node u.

A node will have a high impact if it has a shorter distance than other nodes. This network property is captured by closeness centrality. The closeness centrality of a node indicates how close a node is to the given network [19]. They can interact quickly with other nodes because they are close to all others.

This measure is useful in our search to identify the inherent (Molazem), i.e., the narrator stayed with his sheikh and did not leave him for some time, to learn from him scientifically and educationally, and contemporary (Mo'asra), that is, the narrator lives in the same period in which his sheikh lived.

Closeness centrality results range from (0-1) and a node with a value of 1 is connected to all nodes in the network, and a node with a value of 0 is somewhat isolated.

The time complexity of this measure for a connected graph is O(m) where m is the number of edges.

This measure is preferred over degree centrality because it takes into account not only direct connections between nodes but also indirect connections, usually the used of this measure of how quickly information can spread from one node in a network to all other nodes, uses the network's global information.

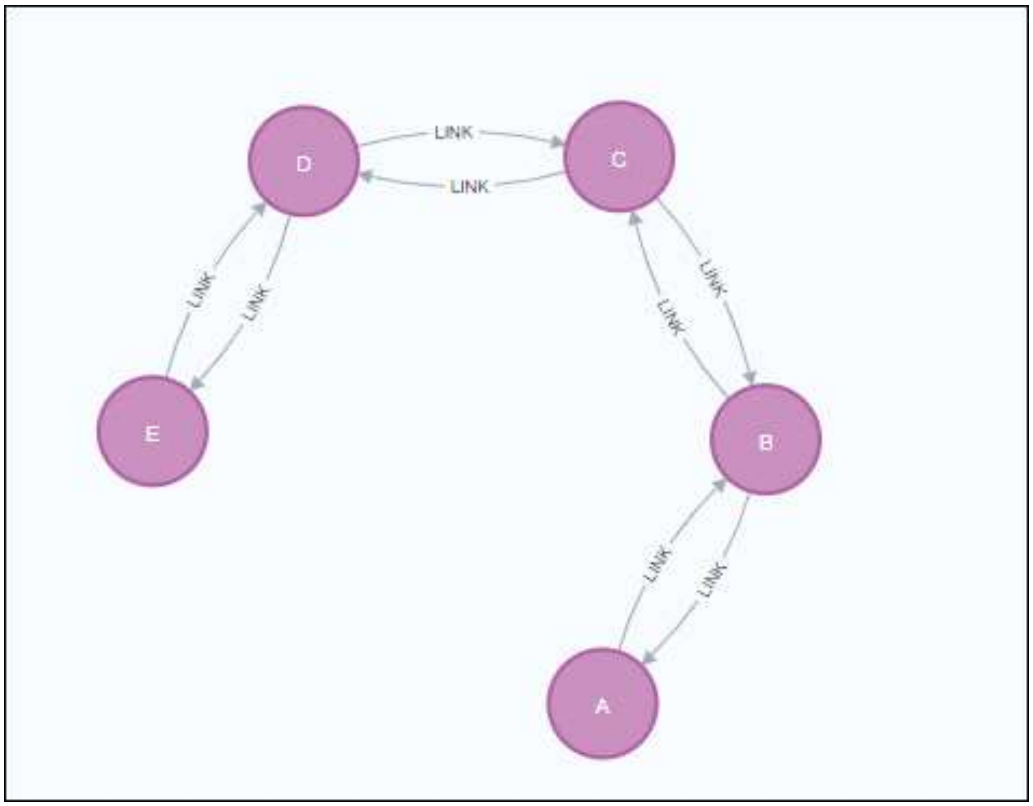
In disconnected graphs, at least one term in the sum will be ∞, so the sum will be ∞, and the closeness centrality of all nodes will be 0, so the definition of closeness centrality cannot be applied to disconnected graphs[19].

So, the importance of closeness centrality can be summarized as follows:

- Find the closest node of all nodes in the network.
- Finding a node plays a major role in information transmission due to its location in the network.
- Find the best impact nodes on the network as quickly as possible.
- The hops between one node and the other nodes are less.

Example:

Figure 4.3
Example Closeness Centrality



The result in Neo4j program 4.4:

Figure 4.4
Closeness Centrality result in Neo4j

```
1  CALL gds.beta.closeness.stream('MyGraph3')
2  YIELD nodeId, score
3  RETURN gds.util.asNode(nodeId).name AS name, score
4  ORDER BY score DESC
```

Table
Text
Code

"name"	"score"
"B"	1.0
"A"	0.6666666666666666
"C"	0.6666666666666666
"D"	0.5714285714285714
"E"	0.5714285714285714

Node C is the most connected node in this graph. Nodes A and E do not have close connections with many other nodes, so their scores are lower.

4.3 Betweeness Centrality

Node betweenness centrality is a globally importance measure that is the fraction of shortest paths in a network containing a particular node, this measure quantifies the number of times a node acts as a bridge along the shortest path between a pair of nodes [19].

Nodes with high betweenness centrality values participate in a large number of shortest paths. Betweeness centrality means that a node, for certain paths, is essential for maintaining node connections and a node will be important for disseminating information across communities, thus nodes were found that tightly controlled the flow of information around the network.

We apply the Betweeness Centrality in this research to measure the influence of the narrator, who acts as a mediator between communities [12], i.e., the extent of the narrator's presence among other narrators in the hadith series. The Betweeness Centrality measures the number of shorter narrations that pass through that narrator, this indicates his/her importance in narrating hadiths, and the trust he/she enjoys [11]. This measure is useful in determining the ascending and descending Isnad, and the meaning of the ascending Isnad is the Isnad that has fewer narrators about another Isnad, and the descending Isnad is known by the abundance of the men of the Isnad.

The time complexity of this measure for a connected graph is O(nm) where m is the number of edges and n is the number of nodes.

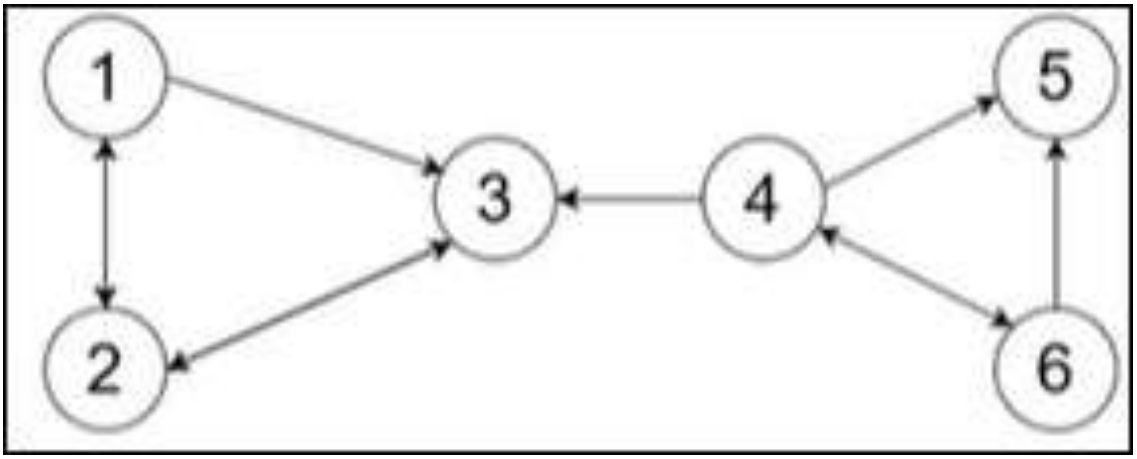
Betweeness Centrality considers just the number of shortest paths that pass through the node. It assumes that information always flows along the shortest path. But this may not always be true in real-world scenarios. Information can also pass through longer paths with some probability. Newman looked at this fact and proposed an interstitial measure that takes into account all paths but gives greater importance to shorter paths, the search[20].

So, the importance of the Betweeness Centrality can be summarized as follows:

- Finding the nodes that serve as a link or are considered a mediator in the network, that is, most of the links pass through it.
- Define node control.
- Finding nodes which information flows through.

Example:

Figure 4.5
Example Betweeness Centrality



The result in Neo4j program 4.6:

Figure 4.6
Betweeness Centrality result in Neo4j

```
1  CALL gds.betweenness.stream('myGraph4')
2  YIELD nodeId, score
3  RETURN gds.util.asNode(nodeId).name AS name, score
4  ORDER BY name ASC
```

Table | Text | Code

"name"	"score"
"1"	0.0
"2"	3.0
"3"	4.0
"4"	3.0
"5"	0.0
"6"	0.0

We note that node 3 has the highest score, followed by nodes 2 and 4. Studying the example graph we can see that these nodes are in bottleneck positions in the graph. Node 3 connects nodes 2 and 4 to all other nodes, which increases its score and since 3 is reachable from each other node, this causes the score for 3 to be high.

Conversely, there are no shortest paths that pass through either nodes 1,5, or 6 which causes their betweeness centrality score to be zero.

4.4 Eigenvector Centrality

This measure describes the effect of the node in the network, the importance of a node is taken from the importance of its neighbors and the incoming and outgoing links.[19]

$$\text{EiC(vi)} \quad = 1/\lambda \sum_{j=1}^{n} A(j,i) EiC(vj) \tag{4.3}$$

Where v is the neighbor of u and λ is a constant.

High eigenvector centrality means that a node has relationships with many other highly centralized nodes.

It is useful because it indicates the direct effect and effect on the nodes more than a 'hop' away. Applying this measure to our research determines the importance of the narrator to the number of narrations transmitted to him/her or the number of narrations he narrates. A narrator with a high value indicates a high density of the in and out links of his/her corresponding node, which reflects his competence in the process of narrating the hadith [11].

And determine whose narrator has a wide influence in the network. Eigenvector Centrality values range from [0-1], and the eigenvector can be calculated in O(N + M) time.[21]

If A and B have the same degree centrality, but A is related to all people of high degree and B is associated with all people of low degree, then intuitively we want to see A with a higher degree than B. So, a node may have a high degree (i.e. many connections) but a relatively low Eigenvector Centrality; if many of these connections are with nodes with similar low degrees, and vice versa.

So, the importance of the Eigenvector Centrality can be summarized as follows:

- If the node is connected to a very central node, it will affect it.
- Eigenvector measures the global importance of the network.
- Identifies the nodes that have an impact on the entire network.

Example Figure 4.7 -Appendix A-.

This graph will be applied to 4 measures (Eigenvector Centrality, PageRank Centrality, ArticleRank Centrality, and HITS Centrality) and describe the results for each measure.

The result in Neo4j program 4.8 -Appendix A-:

We note that node B got the highest result Eigenvector Centrality due to the strength of its links, which is evident from the graph, and we note that the value of the Eigenvector Centrality for node C is high because it is directly related to node B, which is highly central and not associated with weak central nodes.

The graph 4.7 also shows that nodes with the same number of connections are not necessarily the same color. The one connected to the central nodes is more important in this visualization.

4.5 PageRank Centrality

PageRank is a variant of the Eigenvector centrality measure for a directed network. It is used to calculate the node influence, it ranks the nodes based on the importance of other nodes related to the respective node [12]. It measures the importance of a single node based on the importance of its neighbors [19].

$$\mathrm{PR(A)} = (1 - \mathrm{d}) + \mathrm{d} * \left(\frac{PR(T1)}{C(T1)} + \cdots + \frac{PR(Tn)}{C(Tn)}\right) \tag{4.4}$$

Where, assume that node A has nodes from T1 to Tn pointing to it, d is the damping factor, usually set to 0.85, C(A) is defined as the number of links going out of node A.

A node is of great importance if it contains a large number of links incoming from very important nodes, it determines prominent people within the network, so it can help understand authority.

This measure is useful in our research to find the most influential narrators in the network; It is a global centrality measure that needs the entire network to measure the importance of a single node [12], it is also useful in determining the importance and competence of Sheikh for whom the narrator is apprenticed.

PageRank computing in directed graphs takes O(N+M) rounds, where n is the number of nodes and m is the number of edges.

The PageRank of a node is just dependent on the nodes that have a directed link towards it and are independent of out-going links of the node [12].

So, the importance of the PageRank Centrality can be summarized as follows:

- The PageRank measure is based on the node degree and ranks it based on the importance of the associated nodes related to it.
- It reveals nodes whose influence extends beyond their direct links.
- Detects frequently visited nodes.
- So it determines how popular the node is.

Example: Figure 4.9 -Appendix A-.

The result in Neo4j program 4.10 -Appendix A-:

After applying the code we found that node B has the highest PageRank, followed by node C. This point indicates that B is the most important node in this network.

4.6 ArticleRank Centrality

ArticleRank is a variant of the PageRank algorithm, PageRank assumes that connections coming from low-out-degree nodes might be more influential than those coming from high-out-degree nodes. Although Article Rank changes the syntax to lessen the impact of low-out-degree nodes, it retains the PageRank technique [22].

$$ArticleRanki(v) = (1 - \mathrm{d}) + d * \sum_{w\varepsilon N\ in\ (v)} \left(\frac{ArticleRank\ i-1\ (w)}{|N\ out\ (w)|+N\ out} \right) \qquad (4.5)$$

It is useful in this research to measure the transitive influence of narrators.

As an example in Figure A.4.11.

The result in the Neo4j program is shown in Figure A.4.12.

By running the ArticleRank on the graph, we will see that the node with the highest score is B.

4.7 HITS Centrality

Similar to PageRank, HITS (Hubs and Authorities Centrality) creates two popularity scores for each node based on in and out links. HITS has two theses: if a node points to a good authority, it is a good hub and should have a high hub score.[23].

Node with a high probability it will be an opinion leader [19], A node has a high hub value if it has a large number of outgoing edges that connect to other nodes that have high authority values; Similarly, a node with high hub values of incoming nodes also has high authority values. A node's hub is not only dependent on the total number of nodes you are referring to but also on the authority of those nodes.

This measure is useful in the research in determining the law of 'influenced by and influence on' the narrators in terms of the sheikhs and students of the narrator. During the occurrence of influence (influence by), which means the ability to change and develop ideas or decisions or through action, to modify a practice of modification or bias towards it, the influence (influence by) comes as a result of an impact on the same narrator from other narrators, the effect is an implementation and therefore influenced by this act and appeared on it.

A node is a good authority if it is pointed by a good hub, authority is a node with many in-links, and a hub is a node with many out-links.

Comparing PageRank is suitable for the entire graph and HITS is suitable for the neighborhood graph [23].

So, the importance of the HITS Centrality can be summarized as follows:

- Hub score estimates the importance of a node in a network.
- Authority Score estimates the value of the relationships of one node to the other.
- Node centralization depends not only on the number of nodes it refers to but also on the authority of these nodes.

Illustration of Authority and Hub in HITS as in Figures A.4.13.

Example:

The Authority in HITS A.4.14.

The result in Neo4j program A.4.15.

The result follows the order of the node value, which is B, E, D, F, A, C. Take back from the above explanation, the authority depends on the number of nodes they are linked to, and from the result, we can say that this rule holds. The nodes' authority (G, H, I, J, and K) is 0 because there is no node linked to it.

The example of the Hub in HITS is shown in Figure A.4.16.

The result in the Neo4j program is shown in Figure A.4.17.

As can be seen from the graph, the HITS algorithm also addresses the problem of low in-degree nodes from Eigenvector Centrality. These low-in-degree nodes become central hubs and contribute to other nodes.

Comparison of measures (Eigenvector, PageRank, ArticleRank, and HITS):

Table 4.1
Comparison of measures (Eigenvector, PageRank, ArticleRank, and HITS)

Rank	Eigenvector	PageRank	ArticleRank	HITS auth	HITS hub
1	B	B	B	B	F
2	C	C	C	E	G
3	D	E	E	D	J
4	F	D	D	F	K
5	A	F	F	A	E
6	E	A	A	C	D
7	G	G	G	G	V
8	H	H	H	H	H
9	I	I	I	I	I
10	J	J	J	J	B
11	K	K	K	K	A

From Table 4.1, we notice that node B obtained the highest centrality in the network in the four measures (Eigenvector, PageRank, ArticleRank, and HITS auth), followed by node C in the measures (Eigenvector, PageRank and ArticleRank) because these measures depend on the value of by the neighbors of that node, where we note that node C is connected to node B only, which it is highly central and node C not linked to other

weakly nodes. In HITS auth, node E got second place because they are associated with nodes that have a high Hub score, and thus the value of the Authority has increased.

We also note from the Table that the order of importance for the nodes is similar in the two measures (PageRank and ArticleRank), but the value of the results is different, as the value of the ArticleRank results is less than the value of the PageRank results, where the ArticleRank measure reduces the value of the result of nodes that have few outgoing links, to find the score for a given node, PageRank calculates all incoming scores and divides them by the number of out-links for each given incoming node. ArticleRank allocates a score by calculating all incoming scores and dividing them by the average number of out-links plus the number of out-links for each given incoming node.

Whereas in the HITS auth, the highest value of the nodes (K, G, J, and F) obtained the same result because these nodes refer to nodes with a high authority, which is (B and E) and therefore the value of the hub has increased, and we note that the node A got the result of 0 in this measure because it has no out-links with any node in the network.

4.8 Radiality Centrality

The Radiality is an indicator of node centrality. The Radiality of node v is calculated by calculating the shortest path between node v and all other nodes in the graph [24]. Nodes with high Radiality centrality are those that are close to all other nodes within their accessible neighborhood with their diameter.

$$Ra(v) = 1/\sum_{u \neq v} \Delta(\mathrm{G}) - (1/\mathrm{d}(\mathrm{u},\mathrm{v})) \tag{4.6}$$

Where ΔG is the diameter of the graph G.

As the diameter represents the greatest distance that can exist between nodes, high values will result from methodically subtracting the shortest pathways between node v and its neighbors if the paths are short, and low values if they are long. In general, a high Radiality indicates that the node is closer to the other nodes concerning diameter, whereas a low Radiality indicates that the node is circumferential [24]. The Radiality Centrality for an isolated node is taken as zero.

The measure is useful in this research to determine the implication (Molazma), that is, the narrator stayed with his sheikh and did not separate from him for a while, to learn from him scientifically and educationally.

The time complexity of this measure for the connected graph is O(mn) where m is the number of edges and n the number of nodes [24].

A high central location in the graph is always indicated by a node with high proximity, high eccentricity, and high Radiality. These three parameters should constantly be compared [24].

The example shown in Figure A.4.18.

The result in the Cytoscape program is in Figure A.4.19.

As shown, node C has the highest Radiality values in the entire network.

4.9 Stress Centrality

The total number of shortest paths that travel through the node determines the stress centrality. A node that is crossed by a significant number of shortest pathways is considered 'stressed' [24].

We applied Stress Centrality in this research to measure the influence of a narrator who acts as a mediator between communities.

Increased stress readings may not always imply that node v is required to keep communication between nodes whose pathways cross through intact. In actuality, there exist alternative shortest pathways that might connect two nodes without going through node v [24].

$$\mathrm{Cs(v)} = \sum_{s \neq t \neq v \in V} \mathrm{p\ st\ (v)} \tag{4.7}$$

Where p st (v) is the number of shortest paths passing through node v.

Betweeness is similar to stress but provides a much more detailed and informative central pointer. Thus, Stress and Betweeness can be used to obtain complementary

information, thus “quantifying” the importance of a node for two connected nodes, and “high” and “low” values being more significant.

Betweeness vs. Stress, in fig 5.20.a node 4, node 10, and node 9 present a high value of stress, in fig A.4.20 node 4 presents a high value in Betweeness. This is because in both networks, there are an equal number of shortest paths that go via node 4. However, node 4 is the only node in the second network that serves as a link between the two sections.

Betweeness is therefore more accurate than Stress in this regard, and details regarding the importance of a node within the network are also provided. Removing node 3 from fig 5.20.a has little effect on how the nodes in the network communicate with one another.

The network will be disconnected if we take node 4 out of fig 5.20.b.

Example A.4.21.

The result in Cytoscape program A.4.22.

To find the unique shortest paths on previous search modifications is necessary. As Dijkstra searches, we get the following shortest paths: 3-2-1, 4-3-2-1, 4-3-2, 6-4-3-2-1, 6-4-3-2, 6-4 -3. So, node 3 got the highest Stress Centrality in the network because the shortest paths in the network passed through it.

4.10 Eccentricity Centrality

The Eccentricity Centrality is determining the shortest path between a node and every other node in the graph, the shortest path is selected, hence determining the centrality of node v. calculating the path’s reciprocal (1/dist) is necessary after defining it by length and distance.

$$CE(v) = \frac{1}{maxdist(u,v)} : u \in V \tag{4.8}$$

If the Eccentricity is low, this means that at least one node (and all of its neighbors) is far from the node. It is useful in this research in defining how the narrator is close to other narrators in the graph and his importance in connecting the network.

The time complexity of this measure for the connected graph is O(mn) where m is the number of edges and n the number of nodes [24].

Example A.4.23.

The result in Cytoscape program A.4.24.

We note that node C got the highest value in this measure because most of the shortest paths in this graph passed through it.

By comparing the results of Closeness Centrality, Radiality Centrality, and Eccentricity Centrality, we note that the centrality of the nodes and their arrangement are similar, and this means that node C is generally closer to other nodes because it has the highest values, while nodes A and E have low values, which means that these nodes are peripheral.

To identify the key components in a network, centrality measures are a mathematical tool used in ontology. Over time, numerous centrality measures have been developed and applied to various ontological subjects. These categories apply to centrality measures:

- Reachability: This class shows if there is a direct or indirect path connecting two actors (nodes). To determine a node's ability to reach every other node in this class, centrality measures are employed. Accessibility-based centralities include degree, closeness, Radiality, and eccentricity centralities.
- Shortest Path: Every pair of nodes in the network has a different path connecting them. To determine the shortest path from the source (start node) to the sink (end node), this class's centrality measurements are employed. The shortest path-base centralities include stress centrality and betweenness centrality.
- Feedback: If a node's neighbor is significant, then so will the node itself. Every node is measured to determine the node centrality. Forms of feedback-based centrality include Eigenvector, PageRank, ArticleRank, and HITS centralities.

Chapter Five
Results and Conclusion

In this section, We provide a full description of the behavior of the Isnad ontology and the results will be presented for all narrators in the 10 centrality measures that were applied to the ontology and then select a sample from each generation of the narrator's Sahaba, Tabieen and the rest of the narrators to analyze and describe the importance of the measure used, We will discuss the results of applying the centrality measures for the narrators who obtained the highest results in the hadith ontology.

5.1 Centrality measures Results

5.1.1 Degree Centrality

As mentioned previously in Section 4.1 Degree Centrality measure indicates the importance of the narrator in the network, for example, the size of the narrator s narrations, i.e., the number of hadiths that were narrated and heard by the narrator, and how many direct one hop connections each node has to the other nodes in the network (Sheikh and Student).

We use it to find highly connected narrators, famous narrators, narrators likely to hold the most information, or narrators who can quickly connect to the broader network.

The results of applying the degree measure appeared as follows in Table B.5.12 for all narrators. Based on the results we obtained in Table B.5.12, we note that the lowest value obtained by the narrator is 2, meaning that the narrator narrated only one hadith in this Bab (Jihad and Seiar), meaning that he has two relationships, a relationship that is incoming to him from the narrator, and a relationship that outgoing from him to another narrator.

Many hadiths were narrated from the Prophet Mohammad (PBUH) among those who met him or his Sahaba, and the narrations of one differed from the other in terms of the number.

Some of them narrated thousands of hadiths from the prophet, and they are Mokthreen, some of them narrated hundreds of hadiths and some never narrated from him.

Sahaba (may God be pleased with them) made great efforts to verify the accuracy and authenticity of the hadiths, and all of them are (ثقات عدول). There are 7 Sahaba who are famous for the abundance of hadith, and their results appeared high Degree of Centrality as shown in the Table 5.1 in our ontology.

Table 5.1
The result of D.C for Sahaba Mokthreen

	Name	**D.C**
1	Anas Ibn Malek Ibn Alndr Alansare Alnjare	106
2	Abdalrahman Ibn Sakhr	80
3	Abdullah Ibn Omar Ibn Alkhattab	44
4	Jaber Ibn Abdullah Ibn Amr Alansare Alkhzrje Alslme	28
5	Abdullah Ibn Abbas Ibn Abdalmotaleb Alqrshe Alhamshe 26	26
6	Aisha Bnt Abu Baker Alsdeq	18
7	Saad Ibn Malek Ibn Snan Alansare Almdane	8

- Anas Ibn Malek: he is Anas Ibn Malek Ibn Alndr Alansare Alnjare, he is of the Sahaba who served the Prophet (PBUH) and gained the honor of serving him, and he was one of the Mokthreen from the hadith[27]. Anas Ibn Malek as shown in Figure 5.1 -Appendix A-, narrated in the Bab on Jihad and Seiar 51 hadiths from the prophet Mohammad (PBUH) and 2 hadiths from the narrator, Om Haram, and he narrated to 17 narrators.
- Abu Horaira: he is Abdalrahman Ibn Sakhr and the value of the degree Centrality for him is 80. Abu Horaira adhered to the Prophet Muhammad (PBUH) and memorized the hadiths about him until he became the narrator and memorizer of the Prophet's hadith, and his ability to memorize helped him to absorb a large number of hadiths [27].
- Abu Horaira as shown in Figure 5.2 -Appendix A- narrated 40 hadiths from the prophet Mohammad (PBUH) in the Bab on Jihad and Seiar, and he narrated to 14 narrators.
- Abdullah Ibn Omar: he is Abdullah Ibn Omar Ibn Alkhattab, Ibn Omar was one of the narrators who most followed the biography of the Prophet Muhammad (PBUH) and one of the most followed of Prophet Traces. Ibn Omar shared several scenes with the Prophet Muhammad (PBUH) [27]. Abdullah Ibn Omar as shown in Figure 5.3 -Appendix A- narrated 22 hadiths from the prophet Mohammad (PBUH) in the Bab on Jihad and Seiar, and he narrated to 3 narrators.

- Jaber Ibn Abdullah: he is Jaber Ibn Abdullah Ibn Amr Alansare Alkhzrje Alslme, when the Prophet Muhammad migrated to Yathrib, Jaber Ibn Abdullah was one of the supporters of the Prophet Muhammad who gathered around him, as Jaber Ibn Abdullah was one of those who did not hesitate for a moment to rally around the Prophet, and participated in all the Prophet's battles, after the battles of Badr and Uhud, and he had councils of knowledge after the death of the Prophet, the hadith is taught in it, and what he heard and witnessed from the Prophet is transmitted in it. And Jaber Ibn Abdullah narrated from the hadiths that he heard from the Prophet or from Sahaba who heard from the Prophet [27]. Jaber Ibn Abdullah as shown in Figure 5.4 -Appendix A- narrated in the Bab on Jihad and Seiar narrated 13 hadiths from the prophet Mohammad (PBUH) and 1 hadith from the Sahabe, Abu Saeed Alkhodare, and he narrated to 6 narrators.
- Ibn Abbas: he is Abdullah Ibn Abbas Ibn Abdalmotaleb Alqrshe Alhamshe, his companionship to the Prophet Muhammad After immigrated, he adhered to the Prophet Muhammad and took from him, and his companionship to the Prophet was about thirty months. And his kinship to the Prophet had an impact on that, so his aunt Maymoona Bnt Al-Harith was the wife of the Prophet, and Ibn Abbas used to enter the Prophet's house, and he would sleep in his aunt's room for days, and serve the Prophet [27]. Ibn Abbas as shown in Figure 5.5 -Appendix A- narrated in the Bab on Jihad and Seiar narrated 12 hadiths from the prophet Mohammad (PBUH), and 1 hadith from the narrator, Alsaab Ibn Jathman, and he narrated to 4 narrators.
- Aisha: she is Aisha Bnt Abu Baker Alsdeq, Aisha s family, the center in which she grew up, and the house to which she moved as a wife, helped her in the narration of hadith, and some factors helped her, on top of which was her diverse culture, and her conscious and deep awareness of the role of the Prophet s hadith and Sunnah in the life of the Islamic nation [27]. Aisha as shown in Figure 5.6 -Appendix A- narrated in the Bab on Jihad and Seiar 18 hadiths from the prophet Mohammad (PBUH), and she narrated to 6 narrators.
- Abu Saeed Alkhudri: he is Saad Ibn Malek Ibn Snan Alansare Almdane, he was one of the Sahaba of the Prophet, so he accompanied him for a long time, which is the period of the Prophet's stay in Al-Medina, and he was not absent from his council. Scholars mentioned that he comes in the seventh rank among the Sahaba who narrated many hadiths [27]. Abu Saeed Alkhudri narrated in the Bab on Jihad and

Seiar 4 hadiths from the prophet Mohammad (PBUH), and he narrated to 3 narrators See Figure 5.7 -Appendix A-.

The reasons for the large narration about them compared to other narrators [27]:

- Characteristics shared by all the many Sahaba:

- The length of their Malazama with the Prophet Mohammad (PBUH).
- Their longevity after the death of the Prophet Mohammad (PBUH).
- The abundance of their knowledge and the height of their status and distinction have become references for people asking them about what is permissible for them and what is forbidden for them.

- The personal reasons singled out by some of the Sahaba who are Mokthreen:

- Taking them as circles to teach people and make them hear the hadith of the Prophet.
- Their relationship to the Prophet: Aisha (Mother of the Believers) is the wife of the Prophet, Abdullah Ibn Abbas is the cousin of the Prophet and his aunt Maimunah (Mother of the Believers) is the wife of the Prophet, and Abdullah Ibn Omar is the brother of Hafsa Bnt Omar Ibn Alkhattab (Mother of the Believers) the wife of the Prophet.
- The people of their household learned from them, including children, brothers, and Mwal, (موال) and the narration of their hadith, which helped to preserve and transmit their narrations, and the narrators received them after them.

Tabieen followed the methodology of Sahaba in protecting, adhering to, and disseminating the Sunnah of the Prophet Mohammad (PBUH), so they adhered to methodologies that serve the purpose of publishing Sunnah while ensuring that they are preserved from wrong, lies, and distortion.

A sample of 8 narrators from the Tabieen who have a high value was selected in Table 5.2 and we will describe the results.

Table 5.2
The result of D.C for Tabieen

	Name	D.C
1	Mohammad Ibn Muslim Ibn Obaidallah Alqrshe Alzohre 68	68
2	Amr Ibn Abdullah Ibn Obaid	32
3	Nafea	32
4	Humid Ibn Abu humid Altawel Albasre	24
5	Amr Ibn Denar Almacce	22
6	Qatada Ibn Daama Ibn Qatada	22
7	Suleiman Ibn Mahran Alasde Alkahle	6
8	Yehia Ibn Abu Kather Saleh Ibn Almotwakel	4

The general Isnad of the six books revolve around several imams, and they are: Ibn Shehab Alzohre: Mohammad Ibn Muslim Ibn Obaidallah Alqrshe Alzohre attained a high value in the generation of Tabieen, which is 68 because he is a scholar who collected many sciences, the most famous of which is the science of the Qur'an and Sunnah. He was famous for his strong memory and the quality of his memorization; he used to ask his companions questions to seek the hadith[26].

In Figures 5.8 -Appendix A-, we apply the code on our ontology to show the sheikhs of Alzohre in the Bab on Jihad and Seiar.

We notice from Figures 5.8, the nodes, and the links incoming to it that he has 34 relationships and 16 nodes, relationships mean the number of the Hadiths, and the nodes are related to the name of the narrator in the Isnad.

In the next Figures 5.9, we show the students of Alzohre in the Bab on Seiar and Seiar. We notice from Figures 5.9 -Appendix A- the nodes and the links outgoing from Alzohre node that he has 23 relationships and 11 nodes.

It appeared that Alzohre had narrated 34 hadith from 16 sheikhs and narrated to 11 students, meaning that he heard from 16 and spoke to 11, and this led to a high degree centrality.

- Abu Ishaq Alsabeae: he is Amr Ibn Abdullah Ibn Obaid, He was famous for a lot of knowledge seeking, and he was patient with the knowledge, learning, and teaching [28].

He narrated from 3 sheikhs, and he narrated to 6 students. Nafea: he is Nafea mawla (مولى) of Abdullah ibn Omar ibn Alkhattab, he had a value of 32-degree centrality,

which means a high value in the Tabieen generation, Nafea is one of the imams of the Tabieen of Medina and one of the trustworthy (ثقات) narrators of the Prophet's hadith[27]. He narrated from 2 sheikhs, and he narrated to 7 students.

- humid: he is humid Ibn Abu humid Towel Albasre, in this search it appeared that he narrated from 1 Sheikh, and narrated to 7 Students.
- Amr Ibn Denar: He was a memorizer and proficient, and a large number of students knowledge learned from him, including Sofian Ibn Aoyaynaa, and he is the most reliable of people in him, and Abdul Malik bin Abdul Aziz[29]. He narrated from 6 sheikhs, and he narrated to 2 students.
- Qatada Ibn Daama: he has a degree centrality value of 22, he was aware of knowledge despite being blind and was famous for his memorization and proficiency [27]. He has one sheikh, Anas Ibn Malek, Qatada narrated 11 hadiths from his authority, and he has 4 students.
- Suleiman Ibn Mahran: He was the mohadeth of the people of Kufa in his time, and AlMosahaf was named because of its sincerity, and he was called the Saied Al-Mohadethen [29].

He narrated from 2 sheikhs, and he narrated to 2 students.

- Yehia Ibn Abu Kather: he is Yehia Ibn Abu Kather Saleh Ibn Almotwakel, He was the scholar of Al-Yamamah people in his time [30]. He narrated from 1 sheikh, and he narrated to 2 students.

As for the rest of the narrators present in our research, we will take narrators who have a high value to study them and discuss their results, the following Table 5.3 shows the results for the narrators who are after Tabieen generation:

Table 5.3
The result of D.C for the rest of Narrators

	Name	D.C
1	Sofian Ibn Aoyayna Ibn Abu Imran Maymon Alhelale	48
2	Abdullah Ibn Mohammad Ibn Abdullah Aljaafe	46
3	Malek Ibn Anas Ibn Malek	40
4	Shoaaba Ibn Alhajaj Ibn Alward Alaatke Alazde	40
5	Sofian Ibn Saeed Ibn Masroq Althori	34
6	Ali Ibn Abdullah Ibn Jafar Alsaadi	26
7	Ibrahim Ibn Mohammad Ibn Alhareth	24
8	Maamar Ibn Rashed Alazde Alhdane	22
9	Qotaiba Ibn Saeed Ibn Jamel Althqfe	22
10	Yehia Ibn Saeed Ibn farokh Alqatan ALhafez	20
11	Msddad Ibn Msrhad Ibn Msrbal Alasde	20
12	Shoaib Ibn Abu Hamza Denar Alqrshe Alomawi	20
13	Alhakam Ibn Nafea	20
14	Abdullah Ibn Youssef Altnise	20
15	Moawia Ibn Amr Ibn Almhlab Alazde Almaane	20
16	Allaith Ibn Saad Ibn Abdalrahman Alfhme	18

- Sofian Ibn Aoyayna: he is Sofian Ibn Aoyayna Ibn Abu Imran Maymon Alhelale, he learned from many hadith scholars and it appeared in our research that Abdullah Ibn Mohammad Ibn
- Abdullah Aljaafe: is one of the scholars and one of the great narrators of hadith among Ahl al-Sunnah wal-Jama'ah, and he was known as the Musnadi [27]. He had a 46-degree centrality and this is a high degree because he narrated a lot of hadiths. We notice from applying the code to show the nodes and the links incoming to it that he has 23 relationships and 5 sheikhs. He has no students, i.e. he is the latest name of the narrators in the Isnad of the Hadith before Bukhari.
- Malek Ibn Anas: He began to seek knowledge from a young age under the influence of the environment in which he grew up, and he took care of memorizing and collecting the Sunnah, so students of knowledge flocked to him from different places to learn from him[31].

Malek was famous for taking from many sheikhs, and in our research, it appeared that he narrated from 10 sheikhs, and among the most famous of his sheikhs: were Nafea, Zaid Ibn Aslm, and Alzohre. And he has many students, it appeared in our research that he narrated to 4 of them.

- Shoaaba: he is Shoaaba Ibn Alhajaj Ibn Alward Alaatke Alazde, Shoaaba was very careful to ask for Isnad of the hadith because by it he knew the authenticity or weakness of the hadith [32]. He narrated from 9 Shaikhs and narrated to 10 students.
- Sofian Althori: he is Sofian Ibn Saeed Ibn Masroq Althori, he learned knowledge from a young age and became an imam when he was a young man [33]. He heard from many sheikhs, 11 sheikhs were mentioned in this research, among them: Ibn Joraij, Abu Ishaq Alsabeae, Mansour, and Abu Hazem. Many students narrated about him, 9 of them were mentioned in the research, and the most famous of them are Yehia Ibn Saeed and Abdalrahman.
- Ali Ibn Abdullah Ibn Jafar Alsaadi: obtained a high centrality of 26, as he is considered one of the imams of hadith. He has 4 sheikhs, Sofian Ibn Aoyayna narrated 9 hadiths from his authority, Maen Ibn Issa narrated 1 hadith from his authority, Beshr Ibn Almofaddal narrated 2 hadiths from his authority, and Yehia Ibn Saeed narrated 1 hadith from his authority. He doesn't have any students.
- Abu Ishaq: he is Ibrahim Ibn Mohammad Ibn Alhareth, he has 2 Sheikhs in this research and 2 students.
- Maamar: he is Maamar Ibn Rashed Alazde Alhdane, He was smart, quick to memorize, and had a strong memory, he was very eager to seek knowledge and he had a high scientific status. Due to his travels to work and seek knowledge together in many regions [35], he had a large number of sheikhs from whom he studied and learned from them, and in our research, 2 famous sheikhs were mentioned: Alzohre and Hammam Ibn Monabh. Maamar had many students, and some of them were widely known. In our research, 3 students were mentioned, and they are Abdalrazaq Ibn Hammam, Hisham, and Abdullah Ibn Almobarak.
- Qotaiba Ibn Saeed: he is Qotaiba Ibn Saeed Ibn Jamel Althqfe, he narrated from 10 Sheikhs, and he doesn't have students in this research.
- Yehia Ibn Saeed Ibn farokh Alqatan ALhafez: He is an imam in the hadith, and he has a reliable saying. He narrated 10 hadiths from 4 sheikhs, and he has 4 students.
- Msddad Ibn Msrhad Ibn Msrbal Alasde: he is one of the most famous narrators of hadith.

He narrated 10 hadiths from 5 sheikhs and no students. Shoaib Ibn Abu Hamza Denar Alqrshe Alomawi: he is considered one of the trustworthy and masterful (الثقات المتقنين)

narrators from the students of Alzohre. He narrated 10 hadiths from 2 sheikhs and 1 student.

- Alhakam Ibn Nafea: he is one of the scholars and one of the narrators of the hadith according to Ahl al-Sunnah wal-Jama ah. He narrated 10 hadiths from 1 sheikh, and he doesn't have any students.
- Abdullah Ibn Youssef: he narrated 10 hadiths from 3 sheikhs, and he doesn't have any students.
- Moawia Ibn Amr: he is Moawia Ibn Amr Ibn Almhlab Alazde Almaane, he narrated 10 hadiths from 1 sheikh, and he narrated to 1 student.
- Allaith: Allaith Ibn Saad Ibn Abdalrahman Alfhme, memorized many hadiths, and he was a jurist. In this research, Allaith heard from 6 sheikhs, including Jafar Ibn Rabeaa and Nafea, and 4 of his students spoke about him including Abdullah Ibn Youssef.

5.1.2 Betweeness Centrality

As we mentioned in Section 4.3 the importance of using Betweeness centrality in this research, as it measures the influence of the narrator who acts as a mediator between societies, i.e., the extent of the narrator's presence among other narrators in the hadith series. The Betweeness Centrality measures the number of shorter narrations that pass through that narrator, this indicates his/her importance in narrating hadiths and the trust he/she has. This measure is useful in determining the high and low Isnad, and the meaning of the high Isnad is the Isnad that has fewer narrators about another Isnad, and the low Isnad is known by the abundance of the men of the Isnad.

If we looked at the Isnad of narrators of al-Bukhari, we would find that they mostly between five and six narrators between al-Bukhari and the Prophet (PBUH), meaning that if we counted the narrators between Bukhari and the Prophet (PBUH), we would find them five or six, this Isnad for al-Bukhari is considered a low Isnad. If there are only three or four narrators in it, this Isnad is high.

The results of applying the Betweeness Centrality measure appeared as follows in Table B.5.13 for all narrators.

In our research, we will select high values for narrators to discuss. Figure A.5.1.2.12 describes the Betweenness centrality of the high value in Sahaba.

Anas Ibn Malek has the highest betweenness among the Sahaba. He is considered a bridge of spreading the hadith between two generations. He narrated hadiths from several sheikhs among the Sahaba and spreading to the next generations.

The reason for the high value of Anas in Betweenness Centrality is that Anas narrated many hadiths whose Isnad is shared by a narrator who narrated this hadith only in this Bab. For example, we took Hadith No. 2851, where Abu Al-Tayyah narrated from Anas Ibn Malek, as Abu Al-Tayyah only narrated this hadith in this Bab, and thus affected the value of Anas Ibn Malek, as shown in Figure A.5.1.2.11.

The Betweenness Centrality of the narrator, Ibn Abbas, is high, indicating that he has an important position as a mediator in the network. Since most of the hadiths were passing through him. His importance is also known from history as already discussed above in Degree Centrality section 5.1 because he is among the 7 Mokthreen narrators of the Sahaba. Jaber Ibn Abdullah also received a high value, and this indicates his importance in spreading hadiths between generations.

For the narrators from the generation of Tabieen, 7 Tabieen were selected who have the highest values in Betweenness Centrality as shown in Figure A.5.1.2.13.

The Betweenness Centrality shows that Alzohre is considered the most influential narrator, and he fell in a lot of high Isnad in hadiths.

Also, Musa Ibn Oqba has a high value; Musa was keen on narrating and memorizing the hadith. He had a good number of sheikhs because of the abundance of scholars among the young Sahaba and Tabieen, and among most of his sheikhs: Nafea, Salem Abu Alndr, and Alzohre. Among his most prominent scientific works:

- The large number of his students, through this the fame of the narrator and the accuracy of his information is known, and among the most prominent of his students: Abu Ishaq Alfzari, Ismaiel Ibn Ibrahim, and Sofian Althori.
- His writings, where he has a book (Maghazi) he wrote and classified it.

Musa fell in the middle of the Isnad of hadiths he narrated and thus became a medium for the spreading of the hadiths.

We found that Abu Ishaq Alsabeae, Aorwa Ibn Alzobair, Amr Ibn Denar, Yehia Ibn Saeed Ibn Qais, and Ayob are among the top-ranked narrators from the Tabieen generation based on betweenness centrality.

For the rest of the narrators, the 7 highest values for the narrators were chosen, and they are shown in Figure A.5.1.2.14.

The same thing happens to the rest of the narrators. Based on the result, Sofian Althori is the highest value which means that it came among most of the short hadith Isnad formed by the narrators.

Sofian Ibn Aoyayna, Shoaaba Ibn Alhajaj, and Abdullah Ibn Almobarak are considered influential narrators; they fell in many high hadiths. Maamar Ibn Rashed and Yehia Ibn Saeed Ibn Farokh these narrators have the most influence on the network, they mediate between the narrators in the network, in other words, they maintain the cohesion of information in the network by acting as a mediator or bridge connecting other narrators in the network.

Thus, the Betweenness Centrality embodies the role of the node that acts as an intermediary in the transfer of information between other nodes in the network. This indicates the reasons for the bridge nodes.

5.1.3 Stress Centrality

We applied Stress Centrality in this research to measure the influence of a narrator who acts as a mediator between communities.

After applying the Stress Centrality to our ontology, the values of the narrators resulted in Table B.5.14.

Concerning the Sahaba, many of the Sahaba attained high values, the most prominent of them are see Figure 5.10 -Appendix A-:

We note that Anas Ibn Malek has the highest value, as it appears in Figure A.5.1.3.15 that Anas Ibn Malek has great connections with narrators and he is located on the

shortest paths in the ontology, which consists of 4 narrators between the Prophet and Bukhari, and as we explained earlier that Anas Ibn Malek devoted himself to narrating the hadith and collected a crowd of students surrounded him, learning from him and taking hadiths from him.

Followed by Sahaba (Abdullah Ibn Omar, Abu Hurairah, and Albaraa Ibn Azeb), they were a destination for the students of hadith.

For the Tabieen, the results appeared the most prominent of them as follows in Figure A.5.1.3.16.The highest value obtained by Alzohre, as he is a narrator known for his great efforts in spreading the Sunnah and teaching hadith students, he fell is many shortest paths as shown in Figure A.5.1.3.17.

Followed by the rest of the Tabieen, whose names appear in Figure A.5.1.3.16, and they are well known for their effort in spreading the hadith.

As for the rest of the narrators in the Ontology, the most prominent narrators whose values are high are shown in Figure A.5.1.3.18.

The highest result appeared by Shoaaba Ibn Alhajjaj, who is known for his abundance of knowledge and his correct narration, as he was interested in selecting the sheikhs, so he did not take the hadith of everyone, and he asked the sheikhs to mention the Isnad of the hadith, his narration of the narrator was strengthening for him. He used to warn against the hadith of the weak, disparage strange hadiths, and recommend writing famous hadiths [35]. Figure A.5.1.3.19 shows the graph of Shoaaba that he spreads the hadiths between two generations, between Tabieen and other narrators.

We also have other narrators whose names appear in the Figure, they are known for their preservation of the hadith, its writings, and its dissemination among the community.

A node with high betweenness is the only node that connects groups of nodes to other groups of nodes, and if it appears in many shortest paths, i.e. the more narrators depend on a narrator to make connections with other narrators, the higher that narrator’s betweenness centrality becomes. Betweenness centrality depends not only on

connectedness but also on the directionality of connections; narrators with high betweenness centrality often connect with narrators found in a different generation.

A node has high stress if it is traversed by a high number of shortest paths, i.e. the narrator narrated many high Isnad and he spreading hadiths from generations.

5.1.4 Closeness Centrality

As we indicated in Section 4.2, the importance of Closeness Centrality, this measure is useful in our search to identify the inherent (Molazem), i.e., the narrator stayed with his sheikh and did not leave him for some time, to learn from him scientifically and educationally, and contemporary (Mo'asra), that is, the narrator lives in the same period in which his sheikh lived.

The results appeared after applying Closeness Centrality to our ontology of the narrators as follows in Table B.5.15.

We note that the value of the first 47 narrators is 1 and they are the Sahaba who obtained the highest value of Closeness Centrality, which indicates that the narrator is directly connected to all narrators in the network, they are the closest to the Prophet Mohammad (PBUH) and are connected directly with him. Sahaba are famous for their Molazma to the Prophet Mohammad (PBUH), alternating with his sitting, and hearing from him, this Molazma gave them acumen (الفطنة) and the strength of Aldabt (الضبط) over what he is narrated to [36].

As shown in Table B.5.15, we found that the numbers ranging and close to the value of 0.5 refer to the Tabieen mainly, and this suggests that because of their place in the network, the Tabieen play a significant part in hadith transmission. This also suggests that they lived during the period when hadiths were passed down from Sahih Bukhari to the Prophet Muhammad (PBUH). Some scholars stipulated in the Tabieen the length of the Molazma.

It was also found that there are values of 0.5 or so, but these nodes don't belong to the Tabieen, and we found that they belong to the narrators from the generation of the Tabiee Tabieen, who are the ones who met the Tabieen, and did not realize the Sahaba. They are Shoaaba Ibn Alhajaj, Hatem Ibn Ismaiel, Talha Ibn Abu Saeed, Beshr Ibn Almofaddal, Jowairia, Almke Ibn Ibrahim, Othman Ibn Alaswad, and Khalid Ibn Saeed.

As for the rest of the nodes, a value of 0.4 or less indicates the rest of the narrators in the network, who are relatively unrelated to each other.

5.1.5 Radiality Centrality

The measure is helpful as described in section 4.8 in identifying the inherent (Molazma). The most important requirements of Molazma are the length of the Molazma, accompanying the sheikh in travel, and the exploitation of Molazma times in narrating from the sheikh on the most delicate issues, and the scientific and educational impact of Molazma on the narrator who is accompanying (Molazem) his sheikh [37].

The results of applying the Radiality Centrality measure appeared as follows in Table B.5.16 for all narrators.

Top 10 who received the highest values from the Sahaba:

Table 5.4
The result of R.C for Sahaba who have a high value.

Name	R.C
Anas Ibn Malek Ibn Alndr Alansare Alnjare	**4.01E-04**
Abdalrahman Ibn Sakhr	**4.00E-04**
Om Haram Bnt Melhan Malek Ibn Zaid	**3.98E-04**
Aisha Bnt Abu Baker Alsdeq	**3.97E-04**
Saad Ibn Malek Ibn Senan Alansare Almdane	**3.96E-04**
Abdullah Ibn Abbas Ibn Abdulmutallab Alqrshe Alhamshe	**3.96E-04**
Sahl Ibn Saad Ibn Malek Alansare	**3.96E-04**
Abdullah Ibn Omar Ibn Alkhattab	**3.95E-04**
Abdullah Ibn Qais Ibn Salem	**3.95E-04**
Jaber Ibn Abdullah Ibn Amr Alansare Alkhzrje Alslme	**3.95E-04**

All Sahaba have high values because they lived in the era of the Prophet Mohammad (PBUH) and adhered to him.

The high Radiality score was for Anas Ibn Malek and the second for Abu Huraira. Many of the Tabieen narrated from Anas Ibn Malek as shown in Figure A.5.1.5.20 and memorized what he narrated from the prophet Mohammad (PBUH) because he was a Molazem to the Prophet for ten years; his companionship was the most complete, and his Molazma was long [38]. Many students narrated from Anas, including Thabit Al-Banani, who was the most Molazem to Anas, he stayed with him for 40 years, Suleiman

Ibn Tarkhan Al-Taymi, and Humaid Al-Taweel. Figure 5.34 shows the number of hadiths narrated by Anas Ibn Malek from the Prophet Muhammad (PBUH) in the Bab on Jihad and Seiar, the number of hadiths that Anas narrated from the Prophet reached 51 hadiths. And also the hadiths narrated by the students of Anas Ibn Malek from him.

Abu Huraira was one of the scholars of the Sahaba who undertook a trust to communicate and spread the knowledge they learned from the Prophet Mohammad (PBUH), he was one of the most active Sahaba in this field due to his wide knowledge of the Prophet and his complete Molazma to the Prophet, so he became one of the Sahaba who memorized, and many Sahaba and Tabieen took from him [39]. Many Sahaba and Tabieen narrated from Abu Huraira.

Many of the Sahaba are known for their Molazma to the Prophet and their interest in spreading knowledge to the next generations.

The top 7 narrators have the highest values of the Tabieen, in Table 5.5:

Table 5.5
The result of R.C for Tabieen who has a high value

Name	R.C
Mohammad Ibn Muslim Ibn Obeidallah Alqrshe Alzohre	**3.96E-04**
Aorwa Ibn Alzobair Ibn Alaawam Alqrshe Alasade	**3.96E-04**
Humaid Ibn Abu Humaid Altawel Albasre	**3.95E-04**
Amr Ibn Abdullah Ibn Obaid	**3.95E-04**
Nafea	**3.95E-04**
Mohammad Ibn Jubair Ibn Motaem Alqrshe Alnofle	**3.95E-04**
Salem Ibn Abdullah Ibn Omar	**3.95E-04**

The highest value he obtained is Alzohre, Alzohre Molazem to some of the Sahaba, such as Anas Ibn Malek and Sahl Ibn Saad Al-Saadiand. There are 8 narrators in our research who adhered to Alzohre, they describe memorization and perfection, and they are Shuaib Ibn Abu Hamzah, Younis Ibn Yazid, Mammar Ibn Rashid, Saleh Ibn Kisan, Sufyan Ibn Aoyayna, Ibrahim Ibn Saad Alzohre, Imam Malek Ibn Anas. Figure A.5.1.5.21 shows the hadiths that Alzohre narrated from the Sahaba and the hadiths that Alzohre narrated to his students.

Aorwa Ibn Alzobair was highly valued in the Tabieen, Aorwa Molazem to his aunt, the mother of the believers, Aisha. And, the most prominent of his students Alzohre, as he adhered to him (Molazem) and sought knowledge from him, and transferred the hadith from him.

Other Tabieen received their knowledge from Sahaba, and they learned from their knowledge and memorized their narratives, wrote down their hadiths, and conveyed them to all people at that time. The generation of the Tabieen was distinguished by the abundance of scholars and jurists among them, and they had the credit for spreading knowledge.

As for the rest of the narrators who got the top 5 values, they are in Table 5.6 -Appendix B-.

Shoaaba Ibn Alhajaj acquired a high value because he learned from many sheikhs and narrated from him many students, and among the most prominent of his students was Yahia Ibn Saeed Alqattan, as it took him (Molazma) twenty years.

Also, he received a high value, the narrator Hammad Ibn Zaid. Ayob Alsakhtiani was the most influential of his sheikhs, as he stayed with him for 20 years [40], and from his student Soliman Ibn Harb, he stayed with him for 19 years. In our research, he took 3 hadiths from him.

Molazma leaves a clear scientific and educational impact on the personality of the seeker of knowledge who sticks close to his sheikh (Molazem), as the seeker of knowledge benefits from the knowledge, and behavior of his sheikh, and among its effects is the student's specialization in the legacy of his sheikh and his service to him, and the adoption of his saying as a specialist in it [37].

5.1.6 Eccentricity Centrality

Eccentricity is taken into account for determining the influential nodes in the network; these nodes would be considered the most influential nodes. As mentioned previously in Section 4.10, Eccentricity Centrality is useful in this research in defining how the narrator is close to other narrators in the graph, and his importance in connecting the network. The results appeared for the narrators after applying this measure, as shown in Table B.5.17.

If the eccentricity of node x is less than that of y, then x is more central than y. The smallest value means that the narrator has reached all parts of the network and that at least there is one narrator narrated from him who participated with him in only one Isnad.

For the Sahaba, the values with the highest influence are in the Table 5.7 -Appendix B-.

Ali Ibn Abu Taleb was a student of the Prophet Mohammad (PBUH) from his youth until the last day of the Prophet's life, and this led to an abundance of his knowledge, so he was the most knowledgeable of people in the rulings of Islam and knew of them of the Qur'an and Sunnah, and thus he won the admiration of the narrators and they were interested in transmitting the hadith from him.

The value of Ali Ibn Abu Taleb is low, but it means that he is influential in the network. We note in Hadith No. 2931 that there are narrators in the Isnad of this hadith who did not narrate another hadith other than this hadith, and therefore in ontology, this affected Ali because these narrators depended on him in the network, and if one of them separates from it, the network becomes disconnected. The same thing happened in Hadith No. 3007, where the narrator Hasan Ibn Mohammad participated in the Isnad of this hadith, and he only narrated this hadith in this Bab.

In the same sense, the narrator Abbas Ibn Abdulmutallab fell in the Isnad of a hadith No.2976, and the narrator Nafea Ibn Jubair participated in its Isnad, and he did not narrate another hadeeth on this Bab.

Alsaab Ibn Jathman was in Isnad of Hadith No. 3012, the narrator Alsaab Ibn Jaththama participated in its Isnad, and he did not narrate another hadeeth on this Bab.

The value of the Eccentricity for most of the Sahaba is smaller than the value of these three narrators in Table 5.7. This probably means that the nodes that represent these three Sahaba are primary narrators for most of the relationships in the graph that reach single narrators in the graph they only narrated one hadith in the Bab Jihad and Seiar, and that the nodes that represent the other Sahaba are important only in connections between narrators.

For the generation of Tabieen the Tabieen who attained high value are in Table 5.8 -Appendix B-.

Obaidullah Ibn Abu Rafea was a writer for Ali Ibn Abu Taleb, he participated only in the Isnad of Hadith No. 3007. This hadith is narrated from Obaidullah, by the narrator Hasan Ibn Mohammad, and this narrator only narrated this hadith in this Bab (Bab Jihad and Seiar) therefore he is well connected with Obaidullah, and through ontology, if this narrator is separated from the network, the network becomes separate because there is only one relationship.

Nafea Ibn Jubair, the narrators were taking from him and giving fatwas, he participated only in the Isnad of Hadith No. 2976, for this reason, his value has increased because he connects parts of the graph and without his node and that relationship the graph becomes disconnected.

The value of the Eccentricity for most of the Tabieen is smaller than the value of these two narrators in Table 5.8. This probably means that the nodes that represent these two Sahaba are primary narrators for most of the relationships in the graph that reach single narrators in the graph they only narrated one hadith in the Bab Jihad and Seiar and that the nodes that represent the other Tabieen are important only in connections between narrators.

Concerning the rest of the narrators, the important values, we chose 4 of them, and they are in the Table 5.9 -Appendix B-:

We note that they are from the generation of the Tabiee of the Tabieen. Thawr Ibn Yazeed participated only in the Isnad of Hadith No. 2924, his order in the Isnad of this hadith was the 4th narrator, so the maximum distance for his hadith to reach Bukhari was 3.

Likewise, for the rest of Rawah, Alawzaei participated only in Hadith No.2902, Khalid Ibn Saeed participated only in Hadith No.3071, and Malek Ibn Meghwal participated only in Hadith No.2782.

A node with high Eccentricity, high Closeness, and high Radiality indicates a central position in the graph.

Table 5.10 -Appendix B- shows a summary of the narrators who obtained the highest values in the Eccentricity Centrality measure and a comparison of their results in the Closeness Centrality measure and the Radiality Centrality measure.

It appeared that among the Sahaba in the Closeness Centrality measure, their results appeared to be 1, which is the closest to all narrators in the network, as we explained previously in section 5.4, and about the Radiality Centrality measure, their results appeared relatively high compared to all the Sahaba.

For the Tabieen, their results appeared in the Closeness Centrality measure, and the results also showed that their values were relatively high between the Tabieen, and for the Radiality Centrality measure, their values were high as we explained about this result in Section 5.1.5.

For the rest of the narrators, their results appeared in the Closeness Centrality measure, and we also the conclusion that some values that range between 0.5 are close, and the nodes that belong to the narrators are the Tabiee Tabieen generation, as for the Radiality Centrality measure, their values are high, as we explained in Section 5.5.

5.1.7 Eigenvector Centrality

Eigenvector centrality is designed to be characteristically different from degree centrality when some high degrees are connected to many other low degrees (its centrality will be relatively low), or some low degrees are connected to some other high degree (its centrality will be relatively high) [41].

This is done by scoring the narrators on the number of narrators they are associated with, and therefore the number of narrators those narrators are connected to, in the entire network. That is, we will look at the sheikhs and the students for the narrator who got a high value, and then we will look at the sheikhs and students for these narrators.

The knowledge of the sheikhs of the narrator received special attention from the authors in the biographies (تراجم) of the narrators, among the most important benefits of knowing the sheikhs are the following [41]:

- Knowing the elders from the narrators or the younger ones.
- Knowledge of the fathers' hadith about the sons.

- Knowing the son’s hadith about the fathers.
- Find out who participated in the hadith about him two narrators.
- Knowing who did not tell about him except one narrator.

The results appeared for the narrators after applying this measure, as shown in Table B.5.18.

The highest Sahaba that attained high values in Eigenvector Centrality is as shown in Figure A.5.1.7.22.

As we mentioned previously, Anas Ibn Malek is one of the Mokthreen in narrating hadiths, as it turned out that he is the narrator who narrated hadiths in the Bab of Jihad and Seiar from the Prophet Mohammad (PBUH). The number of hadiths that he narrated in this Bab reached 51 hadiths. Anas Ibn Malek was not limited to the Sunnah that he received directly from the Prophet, but he narrated another section from many of the Sahaba [42], and in our research, it became clear that he narrated two hadiths from Om Haram. This led to a high centrality value in the Eigenvector Centrality. The degree centrality of the Prophet and the closeness of Om Haram to the Prophet and her high centrality influenced Anas Ibn Malek and thus increased his value.

In Figure A.5.1.7.23, the sheikhs of the narrator Anas Ibn Malik, who are the Prophet Mohammad (PBUH) and Om Haram, the number of hadiths that Anas narrated from the Prophet and the importance and degree of Om Haram affected the value of Anas and thus increased his value.

The highest Tabieen obtained a high value on the Eigenvector Centrality shown in Figure A.5.1.7.25.

Saleh Ibn Kaisan got a high value in the generation of Tabieen, Ibn Kaisan was a student of the great scholars of his time, became clear from our research and it is clear through the network that the sheikhs of Saleh Ibn Kaisan are: Alaaraj, Alzohre, and Salem Ibn Abdullah. Likewise, his sheikhs have many students, and among the most prominent of his sheikhs, Alzohre has 11 students in our research, Alaaraj has 3 students, and Salem Ibn Abdullah has 2 students. Saleh Ibn Kaisan is associated with sheikhs who have a high centrality and thus influenced him.

Musa Ibn Oqba was famous for taking from a large number of sheikhs, in our research he took from 8 shaikhs, the most prominent of his sheikhs, Alzohre and Nafea, therefore the centrality of Alzohre and Nafea and the large number of them students affected the centrality of Musa and increased his value.

Amr Ibn Denar obtained a high centrality, as he had 6 sheikhs, the most prominent of whom was Jaber Ibn Abdullah, who was a Mokthreen of Sahaba who narrated a lot of hadiths, and also Alzohre, and therefore their high centrality affected Amr Ibn Denar.

For the rest of the narrators, the high values in this measure were for them, because they are located in the middle of the network and thus connect the entire network. The top 4 narrators who obtained the highest values are shown in Figure A.5.1.7.26.

The highest values were for the rest of the narrators shown in Figure A.5.1.7.26, and they are among the great learners of the Tabiee Tabieen (كبار الآخذين عن تبع التابعين).

As we also mentioned previously that Jaber Ibn Abdullah is one of the Mokthreen of narrating hadiths, as it turned out that he narrated several hadiths in the Bab on Jihad and Seiar from the Prophet (PBUH), Abu Saeed Alkhodare, who is also one of the Mokthreen of narrating hadiths, and therefore his centrality and closeness to the Prophet affected the centrality of the Eigenvector Centrality of Jaber Ibn Abdullah and increased its value, the sheikhs of Jaber Ibn Abdullah shown in Figure A.5.1.7.24.

The highest value was for the narrator Msddad Ibn Msrhad, who has 5 sheikhs as shown in Figure A.5.1.7.27, and the most central one is the narrator Yahia Ibn Saeed Alqattan, as he has 4 students, and Msddad narrated 6 hadiths from him, and for this reason, he affected and increased Msddad centrality.

The next narrator is Mohammad Ibn Almothanna, a group of scholars who agree that he is trusted. In our research as shown in Figure A.5.1.7.28, he has two sheikhs; one of them is Yahia Ibn Saeed Alqattan. The narrator Mohammad got a lower value than Msddad because the number of links with Sheikh Yahia is less, he narrated two hadiths from him, and therefore the number of links is less, and for this, he took a lower value than Msddad.

The narrator, Ali Ibn Abdullah, also received a high value. Ali was one of the great imams of hadith, and he has several books. His father, Abdullah Ibn Jaafar, was weak in hadith, so Ali was a wrapper talking about his father [43]. Thus, this gives us a clear idea of its hardness in Jarh and Ta'adeel. In our research, it was found that he had 5 sheikhs, the most prominent of whom was Yahia Ibn Saeed Alqattan, who narrated one hadith from him, and Sofian Ibn Aoyayna, Ali narrated 8 hadiths from him, and therefore their centrality affected Ali Ibn Abdullah so that increased his importance.

Amr Ibn Ali also attained a high value. The scholars agreed on his high status, and what they described him with was that he was truthful and memorized, and he was one of the nobles of Hadeeth. There is no doubt that such descriptions indicate the great status of its owner and his mastery of sciences [44]. In our research, it became clear that he had 3 sheikhs, the most prominent of whom was Yehia Ibn Saeed Alqattan, Amr narrated one hadith from him, and Sofian Ibn Saeed Althori, who narrated one hadith from him. Sofian centrality affected Amr Ibn Ali, so it increased his importance.

So, the interest in knowing the sheikhs of the narrator is summarized in:

- Knowing the extent of the influence of the sheikhs on the narrator in his knowledge, intelligence, and interests, if the sheikh had a specific methodology, in belief, jurisprudence, behavior, or scientific specialization; the effect appears on his students.
- Clarity in the narrator’s mastery of the Sunnah, and his control of its methods, narrations, and words.

5.1.8 PageRank Centrality

As we mentioned in section 4.5, PageRank Centrality is useful in our research to find the most influential narrators in the network; it is a global centrality measure that needs the entire network to measure the importance of a single node, It is also useful in determining the extent and competence of the sheikh with whom the narrator learned. This is very convenient for understanding which of the narrators is more interesting than the others than the others this is a great use case for the PageRank algorithm.

We take the value of the sheikhs for the narrator and the sheikhs for them. After applying the PageRank Centrality measure to our ontology, the results for all narrators are shown in Table B.5.19.

Based on the PageRank algorithm on the directed graph that we developed based on the Sahaba of Sahih AlBukhari, the top 2 sahaba that obtained a high value are shown in figure A.5.1.8.29.

We found that Abdullah Ibn Abbas was the most important node in the Sahih AlBukhari network of Sahaba and Anas Ibn Malek was the second most important narrator of Sahih AlBukhari according to PageRank.

Abdullah Ibn Abbas took a high value because he is associated with two sheikhs, the Prophet Mohammad (PBUH) and Alsaab Ibn Jathama. The narrator, Alsaab Ibn Jathama, narrated only one hadith from the Prophet and transmitted it to Abdullah Ibn Abbas, hadith NO. 3012, and for this the measure gave him a high value, meaning that he transmitted all the hadiths in this section from the Prophet Mohammad to Abdullah Ibn Abbas. In the figure A.5.1.8.30, the sheikhs of the narrator Ibn Abbas.

Likewise, Anas Ibn Malek as shown in figure A.5.1.8.31, where narrated from the Prophet Mohammad (PBUH) and the narrator Om Haram, but in this case; Om Haram took 3 hadiths from the Prophet, but she transmitted two hadiths to Anas Ibn Malek, meaning that she transferred two-thirds of her knowledge to him. For this reason, he took a lesser value than Ibn Abbas.

The rest of the other Sahaba are narrated from the Prophet only and they don’t have hadiths in Bab Jihad and Seiar that they narrated from other Sahaba, this is why their value decreased because the Prophet had no incoming links to him, and this is why this measure gave them low values. move on to the Tabqa of Tabieen, and those who obtained the highest values from them, Figure A.5.1.8.32.

Alzohre obtained the highest value, he is the narrator who is well-known for his frequent listening and transmission of hadiths since he has 16 sheikhs whom Alzohre transmitted from them, and most of them are from the Sahaba and Tabieen. Also, the reason for his high value is that most of the hadiths in which there is a narrator involved, and this narrator only transmitted one hadith within this Bab.

Likewise, for the other narrators, the number of their Sheikhs is less, and therefore they obtained a lower value.

In the following Figures, we show the sheikhs to these narrators and the sheikhs to their sheikhs in Figures A.5.1.8.33, A.5.1.8.34, A.5.1.8.35.

We can compare the topical influence of the top 10 narrators from Sahih Bukhari by looking at Figure A.5.1.8.36, which shows the ranked list of narrators based on PageRank. As previously mentioned, among the names of well-known narrators are Sofian Ibn Aoyayna, Musa Ibn Ismaiel, Abdullah Ibn Mohammad, and Ali Ibn Abdullah are to be expected in this list. Shoaaba Ibn Alhajaj is ranked prominently. Msddad who is ranked 6 is prominently in the network.

In the Figure below A.5.1.8.37, we show the sheikhs of Sofian Ibn Aoyayna and their sheikhs, and we note that the majority of them are from the generation of Tabieen, and this affected the value of Sofian Ibn Aoyayna and thus increased.

We note that the high values in PageRank Centrality are mostly from the second and third generations, and therefore they are the most influential generation in the network because they heard from narrators closer to the Prophet Mohammad (PBUH).

5.1.9 ArticleRank Centrality

ArticleRank Centrality is a slight variation of the popular PageRank Centrality. To find the score for a given node, ArticleRank challenges PageRank's presumption that relationships from nodes with a low out-degree are more significant than those from nodes with a high out-degree.

The results of applying the ArticleRank Centrality measure appeared as follows in Table B.5.20 for all narrators.

In comparison with the results of the previous PageRank Centrality measure, we note that among the Sahaba who obtained the highest score is shown in Figure A.5.1.9.38 Anas Ibn Malek, then Ibn Abbas, Anas Ibn Malek obtained a higher score than Abdullah Ibn Abbas, unlike the previous measure, because in this ArticleRank measure additionally takes into account the outgoing links by the narrator himself, and Anas Ibn Malek owns more outgoing links than Ibn Abbas, and thus obtains a higher value, as the

number of links issued by Anas Ibn Malek, which is the number of hadiths narrated by 53 hadiths (outgoing link), while the number of the hadiths narrated by Ibn Abbas are 26.

That is, Ibn Abbas is fully linked with his Sheikh Alsaab because he is the only one who narrates about him in Bab Jihad and Seiar. From this assumption, his value increased than that of Anas in the PageRank measure, but its value decreased in the ArticleRank measure because this assumption takes into account the opposition of outgoing relationships as well, and we have noted before that Anas owns a large number of outgoing relationships, which is why his value has increased.

We notice in the generation of Tabieen that the ranking of the first 3 narrators did not differ from their ranking in the PageRank Centrality measure as shown in Figure A.5.1.9.39.

For the rest of the narrators, we took the top 7 values from the narrators, and they show as in Figure A.5.1.9.40.

In Figure A.5.1.9.40, we took the highest values for the first 7 narrators from the rest of the narrators, and we compared the result with the result of the narrator in the PageRank Centrality measure.

The highest value obtained in the two measures is the narrator Sofian Ibn Aoyayna. The sheikhs and students of the narrator Sofian Ibn Aoyayna were prominent imams; among the most prominent of his sheikhs: were Alzohre, Soliman Alaamash, and Malek Ibn Anas. Among his most prominent students: is Malek Ibn Anas, who is also one of his sheikhs. It has been said about Imam Sofian Ibn Aoyayna about his knowledge, memorization, and trust. Many sayings indicate his Imamate, majesty, and knowledge of hadith and its sciences [45].

Abdullah Ibn Mohammad got the second rank, and he has high values in the PageRank measure as well, because he was close to Al-Bukhari, as he narrated 23 hadiths to him, he was called Almasnade because he was searching for the Isnad of the hadiths, and he is the freed slave of AlBukhari. He narrated from Sofian Ibn Aoyayna, Hisham Ibn Yosif, Abd al-Razzaq Ibn Hammam, and others. He took a high value in the Article Rank measure because this measure takes the students of the narrator and the students of

his sheikhs, and from this assumption, Abdullah Ibn Mohammad took a high value because Al-Bukhari narrated many hadiths from him, and

for our network, Al-Bukhari gathers all the hadiths in the network, his importance is great for this network, and this importance affected Abdullah Ibn Mohammad. Shoaaba got the third rank, compared to his ranking in the Page Rank measure, which is higher; because the number of students he has is higher than the number of sheikhs, but not only this assumption, the prominence of his sheikhs and students and their importance gave him great importance, as he was known for his personality distinguished by the characteristic of research and exploration for the truth, as he was searching for the Isnad of the hadith. It was his habit that he was not satisfied with hearing the hadith once from the sheikh, but rather he heard it from him at intervals of time; to make sure that the sheikh was strong in memorization. Shoaaba was the first who is speaking of men's knowledge (علم الرجال) [47].

We explain the importance of the students of Shoaaba, in our research it was found that he had 10 students, the most prominent of whom are:

- Adam Ibn Abu Eyas: They claimed that he was of great value to Shoaaba [32]. Al-Bukhari narrated from his path, and that is why he was important.
- Abdullah Ibn Al-Mubarak: Where Shoaaba said about him to a man from Marw: that has not come from your side like him [32]. In our research, he had 7 sheikhs other than Shoaaba and 6 students, and this increased his value and thus affected the value of Shoaaba.
- Yahia Ibn Saeed Al-Qattan: Shoaaba honored him and praised him among his community [32].

In our research, it appeared that he had 5 sheikhs and 4 students, and this result affected Shoaab's value. For these reasons, the value and importance of his students increased his importance and thus increased his value in our research.

5.1.10 HITS Centrality

As mentioned previously in Section 4.7, this measure is useful in the research in determining the law of 'influenced by and influence on' the narrators in terms of the sheikhs and students of the narrator.

Hubs can be seen as pointers to high-quality resource nodes, whereas authority is the resource nodes themselves. A larger value of hub indicates that the nodes point to many of the same authorities. The results appeared for the narrators after applying this measure, as shown in Table B.5.21.

As it is clear from Table B.5.21 regarding the Sahaba, it became clear to us that the Sahaba took the highest values in the measure of authority, as the first 47 narrators are all Sahaba, and that is because they all have the authority to control the hadith and transmit it, and they have every confidence in that, and all of them are linked to the same root of the tree (the root reference the prophet), they are Mokthreen of hadith that all hadiths passed through them, and from them the hadith branches and transmits, thus they are the most authority and power in the network.

Anas Ibn Malek took a high value because he is associated with the prophet (PBUH), who refers to the important node and has high authority, and also associated with another node, which is Om Haram, and her students in Bab Jihad and Seiar are Anas Ibn Malek and Amr Ibn Al-Aswad, and thus Amr Ibn Al-Aswad took the highest value in Authority among the Tabieen. As a result, Om Haram obtained the highest value among the Sahaba in the Hub measure, because it indicates two high values in the authority measure.

As shown in Figure A.5.1.10.41. It has been mentioned that Omair, who is Amr Ibn Al-Aswad, narrated from the Sahaba and the Tabieen, he has narrations about them, and it was mentioned in our research that he narrated from Om Haram, as shown in Figure A.5.1.10.41, and many narrators narrated from him, in our research in this Bab, Khalid Ibn Maadan narrated from him, so he takes high value in the Tabieen generation.

Ataa Ibn Yasar has two sheikhs shown in Figure A.5.1.10.42, Abu Huraira and Abu Saeed alKhudri. All the students of these two sheikhs have a high authority because they influenced their students in the measure of authority and increased their value, and thus increased their value in authority and hub.

Looking at the Sahaba who obtained a high value in the hub measure, we notice that they all point to narrators (their students) who have a high authority measure, and their students are shown as in the following Figures A.5.1.10.43, A.5.1.10.44.

In the hub measure in the generation of the rest of the Narrators, all the Narrators who only communicated with Bukhari took high values, and then Malek Ibn Anas got a high hub value, and therefore his students will have a high value of authority, and his students are as shown in Figure A.5.1.10.45.

In the hub measure, we mentioned that the node that indicates important nodes has a high hub measure, about the generation of Tabieen, among the narrators who attained high values are shown in Figure A.5.1.10.46.

All the students of these narrators are important and their values are in the authority measure as shown in Table B.5.21, and that is why the value of their hub increased, and they are known, as we mentioned earlier about them, for the abundance of asking for knowledge from them and the students' turnout for them to take knowledge from them, and therefore they are influenced by their sheik, so their knowledge is reliable.

We note that the highest values of the hub measure are most of them from the generation of the rest of the Narrators, as they were closer to Al-Bukhari, as shown in Figure A.5.1.10.47 and therefore they obtained a high value because they are directly connected with him or closer to him. Al-Bukhari is considered an important node because all links lead to him, and therefore any node that is linked to him increases the value of the hub it has.

Eigenvector centrality quantifies a node's strength or sway. A node's power in a directed network originates from its incoming neighbors. Therefore, a node's eigenvector centrality score is determined by both the strength of its incoming neighbors and the number of in-links it has. The node's score is influenced more by connections from high-scoring nodes than by connections from low-scoring nodes.

PageRank can be described as follows: A narrator ranks high if the sum of his incoming ranks is high. This covers both the case when the narrator node has many incoming and when the narrator node contains a few highly rated incoming.

ArticleRank maintains the basic PageRank methodology while making some modifications. When a node passes its rank among its outgoing links, it does not divide the rank equally by the degree out of that node, but by the sum of the out-degree of that node and the average of the out-degree of all nodes.

Hyperlink represents a latent human judgment: the root of the network, gives to some extent vested authority in the nodes connected to it. Hence, it is accurate to select nodes with a large indegree such as authorities. The idea of the HITS algorithm is that nodes that have links are authorities to multiple trusted nodes related to the hubs.

Evaluation:

This section presents the ontology evaluation mechanism as described in Section 2.4.3 (Ontology Evaluation).

To achieve this, we have explained and clarified the following criteria:

- Accuracy: How close are the results of the test (query) to the real results? To ascertain this, we compared the results generated by the centrality measures of ontology with the manual works of the scholars. The narrator (Abu Horaira) was selected and the result was made by applying the centrality measures of ontology, as shown in Table B.5.11 and comparing it with the manual works of the scholars.

- Degree Centrality: As we indicated previously in section 5.1, Abu Horaira revealed that he narrated 40 hadiths from the Prophet Mohammad (PBUH) in the Bab on Jihad and Seiar, and he, as we mentioned, is one of the narrators Mokthreen in the hadith.
- Betweenness Centrality: Abu Huraira narrated many hadiths and thus is considered a mediator in transmitting hadiths between generations.
- Stress Centrality: his value is also high in this measure because he connects many hadiths.
- Closeness Centrality: His value was 1 because he is a Sahabe, and all the Sahaba, as we explained in the 5.4 section, result is 1 because they are the closest to the Prophet Mohammad (PBUH).
- Radiality Centrality: His value in this measure is high, he narrated many of hadiths and many hadiths with high Isnad, because he is inherent (Molazem) to the Prophet Mohammad (PBUH).
- Eccentricity Centrality: Abu Huraira's hadiths reached most parts of the network and he participated in most of the hadiths.
- Eigenvector Centrality: His value is high for the Sahaba.

- PageRank Centrality: He gained a relatively high value among the Sahaba, as his sheikh was the Prophet Mohammad (PBUH), he narrated 40 hadiths from him in this Bab.
- ArticleRank Centrality: He gained a relatively high value among the Sahaba, as his sheikh was the Prophet Mohammad (PBUH), he narrated 40 hadiths from him in this Bab.
- HITS Authority: He got a high value because the Prophet Muhammad (PBUH) gave him some of his value in Authority.
- HITS Hub: His central value is high since he refers to important nodes in the network, i.e. they are the students of Abu Horirah.

Thus, it is clear to us that all his values are high and that it is an important node in the network, thus indicating the importance of Abu Huraira in the hadith.

For the sayings of scholars, we have referred to two books, the book Tahdheeb Al-Tahdheeb and the book Tahdheeb Al-Kamal fi Asma' Al-Rijal.:

- In the book Tahdheeb Al-Tahdheeb: The saying of the scholars about Abu Huraira is that he is the companion of the Prophet Mohammad (PBUH), and the Hafez of the Sahaba.
- In the book Tahdheeb Al-Kamal fi Asma' Al-Rijal: The saying of the scholars about Abu Huraira also is that he is the companion of the Prophet Mohammad (PBUH), and the Hafez of the Sahaba. He narrated a lot from the Prophet Mohammad (PBUH) and from the Sahaba. Al-Bukhari said: About eight hundred men or more from (Ahl Ala'elm) from the Sahaba, the Tabieen, and others have narrated from him.

- Adaptability: How predictable the response of the ontology is, by implementing the process of displaying the extent of links and nodes to which the node is connected, as described earlier.
- Clarity: By designing it in a way that facilitates the appearance of the sheikhs or students of the narrator.
- Completeness: The domain is completely covered, and it is Bab Jihad and Seiar.
- Computational efficiency: By applying Centrality measures to ontology.

- Conciseness: We determine the all narrators who narrated hadiths in the Bab Jihad and Seiar that the ontology covered to ensure that they do not contain irrelevant elements.
- Consistency/Coherence: By building the ontology, where the number of hadiths that came out from the Prophet Mohammad (PBUH) through relationships to the narrators until it reached Bukhari is equal to the number of hadiths that reached Bukhari.
- Scalability: Since the ontology in this research is specialized in the narrators of one Bab of Sahih al-Bukhari's book, which is Bab on Jihad and Seiar, it is easy to expand the scope of ontology by adding nodes to the narrators in other Babs and establishing relationships between them with the same mechanism used in the application of Bab on Jihad and Seiar.

5.2 Conclusion and Future Work

At a time when information has become closer to us than pressing a button on the keyboard, and since there is an interest in representing knowledge from the books of hadiths that has led to the development of several classifications and algorithms for extracting knowledge, the need has become to develop Islamic content that still needs to be improved and developed better. Given the mutual relationship between the Holy Qur'an and the noble Prophetic hadiths, the hadiths came to clarify some of the provisions that were mentioned in the Holy Qur'an or to inform about legislation that was not mentioned in it.

Ontology facilitated the process of extracting knowledge from Arabic historical texts and transforming them from unorganized texts into organized texts.

In this research, we presented the application of centrality measures to the ontology of Isnad in Sahih al-Bukhari. We first provide a summary of existing electronic encyclopedias and apps for hadiths, demonstrating that their main shortcomings stem from their inability to accommodate Isnad.

We present 10 centrality measures of our ontology and introduce their role in demonstrating the importance and centrality of narrators. We support this with the narrators who had high score values.

Centrality measures combine the features of ontology with the importance of hadith narrators, to identify narrators in the Isnad. The centrality measures we used are Degree, betweenness, stress, closeness, Radiality, eccentricity, eigenvector, PageRank, article rank, and HITS.

The main contribution of this research is that ontology can support hadith Isnad and the importance of narrators at a higher rate than the manual judgment of Isnad.

Since centrality measures are implemented on the Isnad in the Bab on Jihad and Seiar, we look forward to future work on the implementation of centrality measures on all Isnad in Sahih Al-Bukhari. The success of its application to our ontology supports us in searching for ways to extend this research to include more books on hadith.

List of Abbreviations

Abbreviation	Meaning
D.C	Degree Centrality
C.C	Closeness Centrality
B.C	Betweeness Centrality
Ev.C	Eigenvector Centrality
P.C	PageRank Centrality
A.C	ArticleRank Centrality
R.C	Radilaity Centrality
S.C	Stress Centrality
E.C	Eccentricity Centrality

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Appendices

Appendix A

Figures

Figure 4.7
Example Eigenvector Centrality

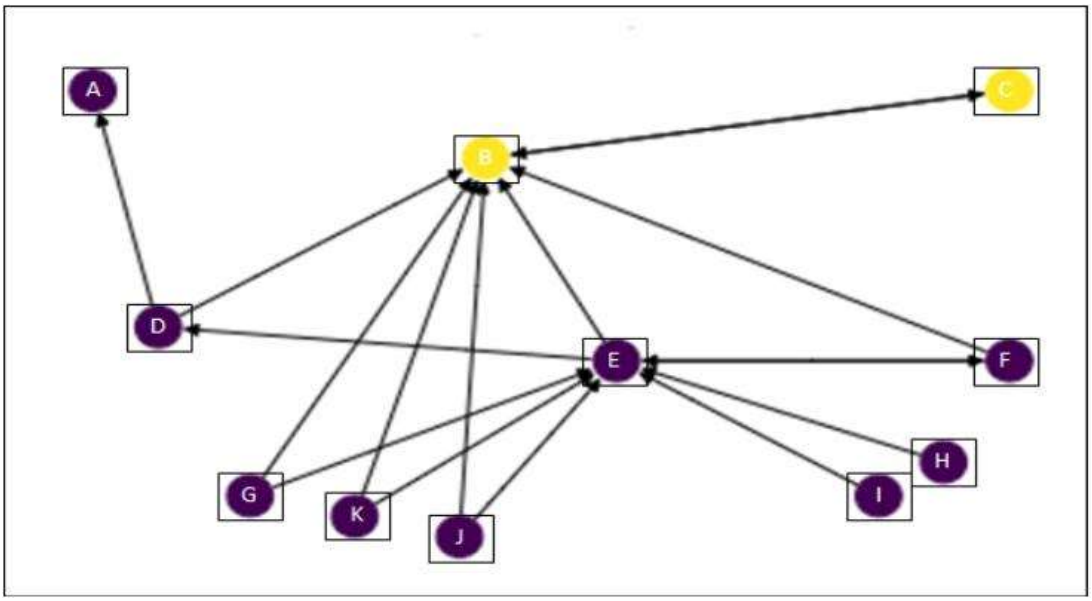


Figure 4.8
Eigenvector Centrality result in Neo4j

```
1  CALL gds.eigenvector.stream('myGraph')
2  YIELD nodeId, score
3  RETURN gds.util.asNode(nodeId).name AS name, score
4  ORDER BY score DESC
```

Table | Text | Code

"B"	0.7197576267027497
"C"	0.6919923236812789
"D"	0.02853773852739508
"F"	0.02853773852739508
"A"	0.027081153307171892
"E"	0.027081153307171892
"G"	4.533501817209545e-32
"H"	4.533501817209545e-32
"I"	4.533501817209545e-32
"J"	4.533501817209545e-32
"K"	4.533501817209545e-32

Figure 4.9
PageRank Centrality example

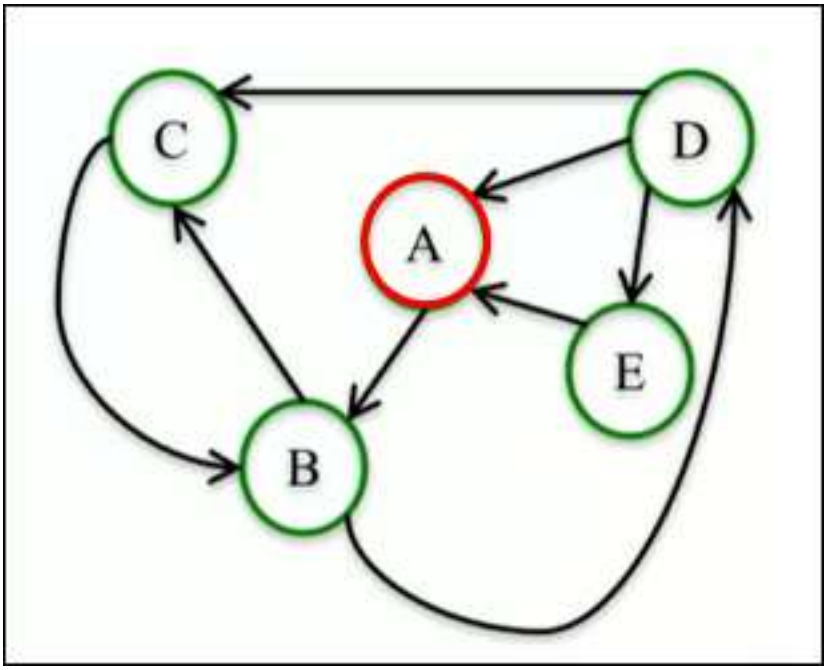


Figure 4.10
PageRank Centrality result in Neo4j

```
1 CALL gds.pageRank.stream('myGraph')
2 YIELD nodeId, score
3 RETURN gds.util.asNode(nodeId).name AS name, score
4 ORDER BY score DESC
```

Table | Text | Code

"B"	3.4051865749737806
"C"	3.0124320171205525
"E"	0.750355248685849
"D"	0.3626006381917901
"F"	0.3626006381917901
"A"	0.30410524868584926
"G"	0.15000000000000002
"H"	0.15000000000000002
"I"	0.15000000000000002
"J"	0.15000000000000002
"K"	0.15000000000000002

Figure 5.1
Anas Ibn Malek relationships: his sheikhs and his students

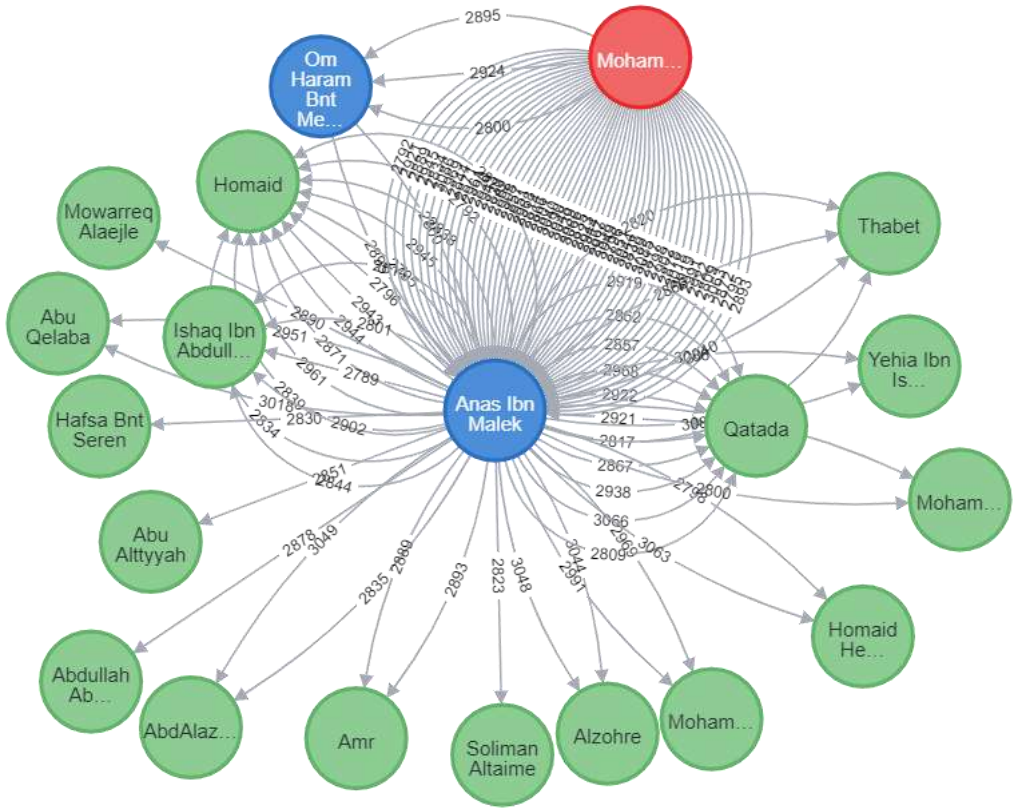


Figure 5.2
Abu Horaira relationships: his sheikhs and his studen

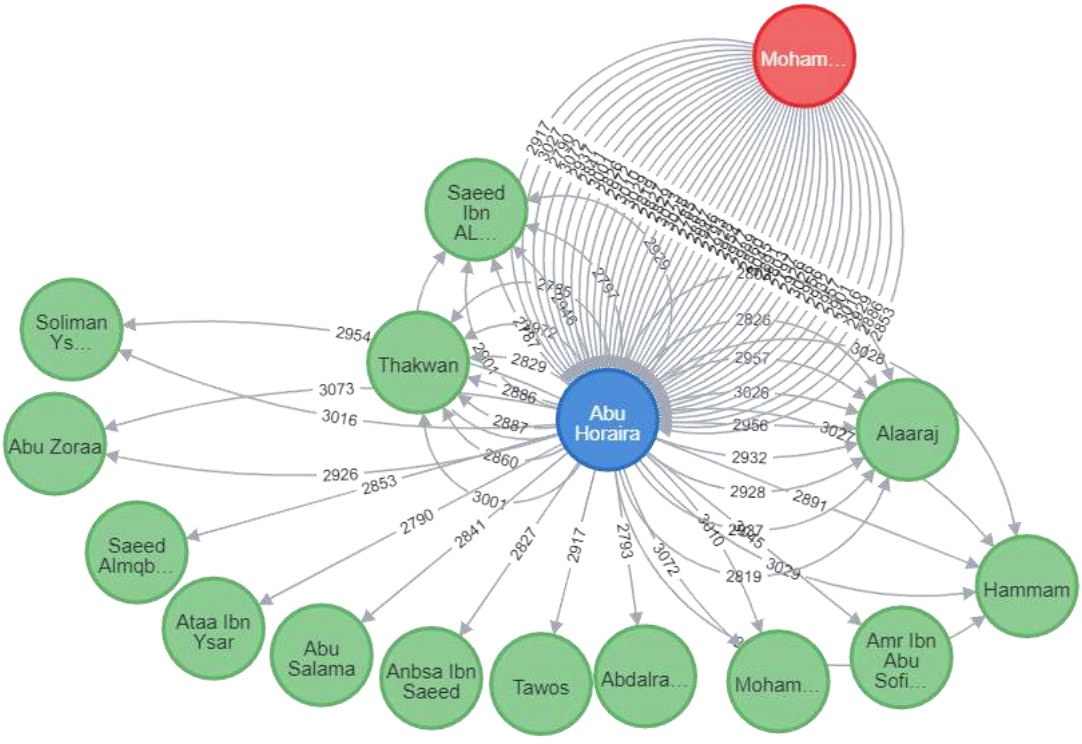


Figure 5.3
Ibn Omar relationships: his sheikhs and his students

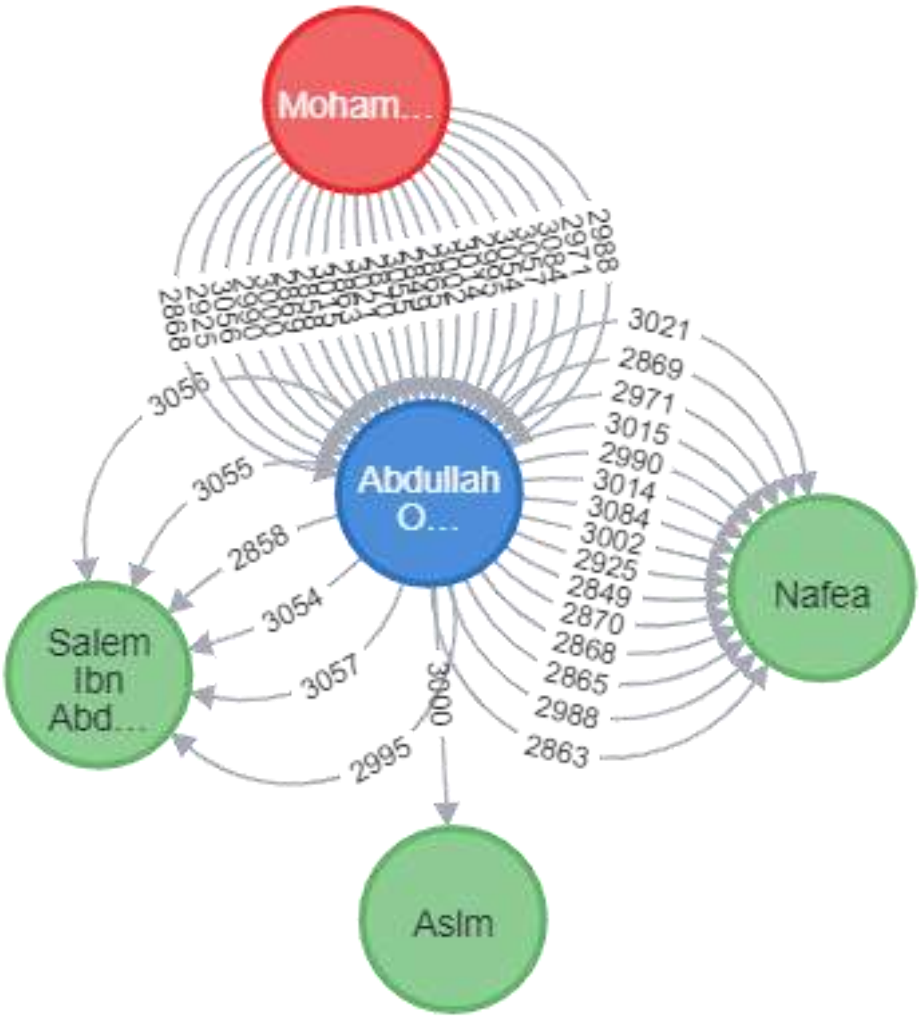


Figure 5.4
Jaber Ibn Abdullah relationships: his sheikhs and his students

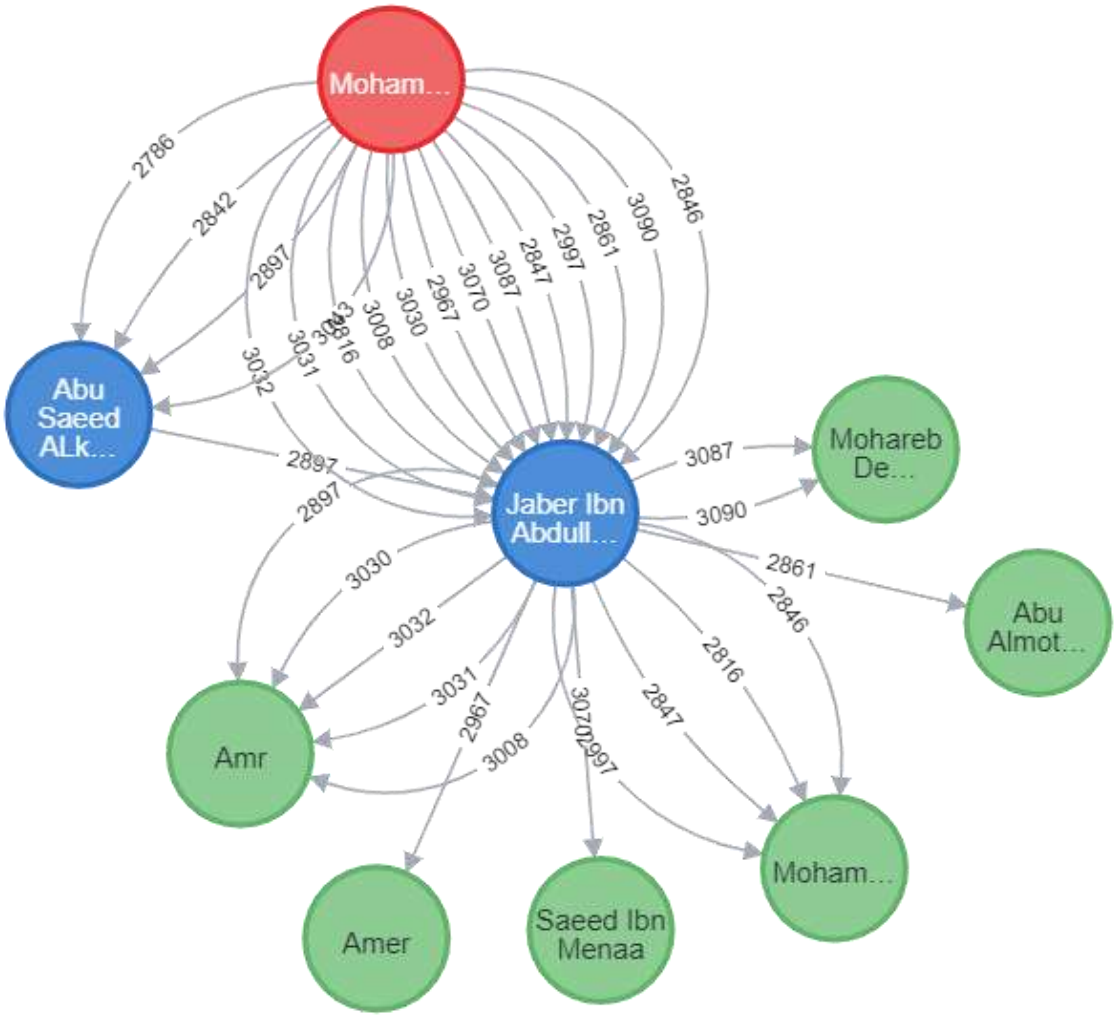


Figure 5.5
Ibn Abbas relationships: his sheikhs and his students

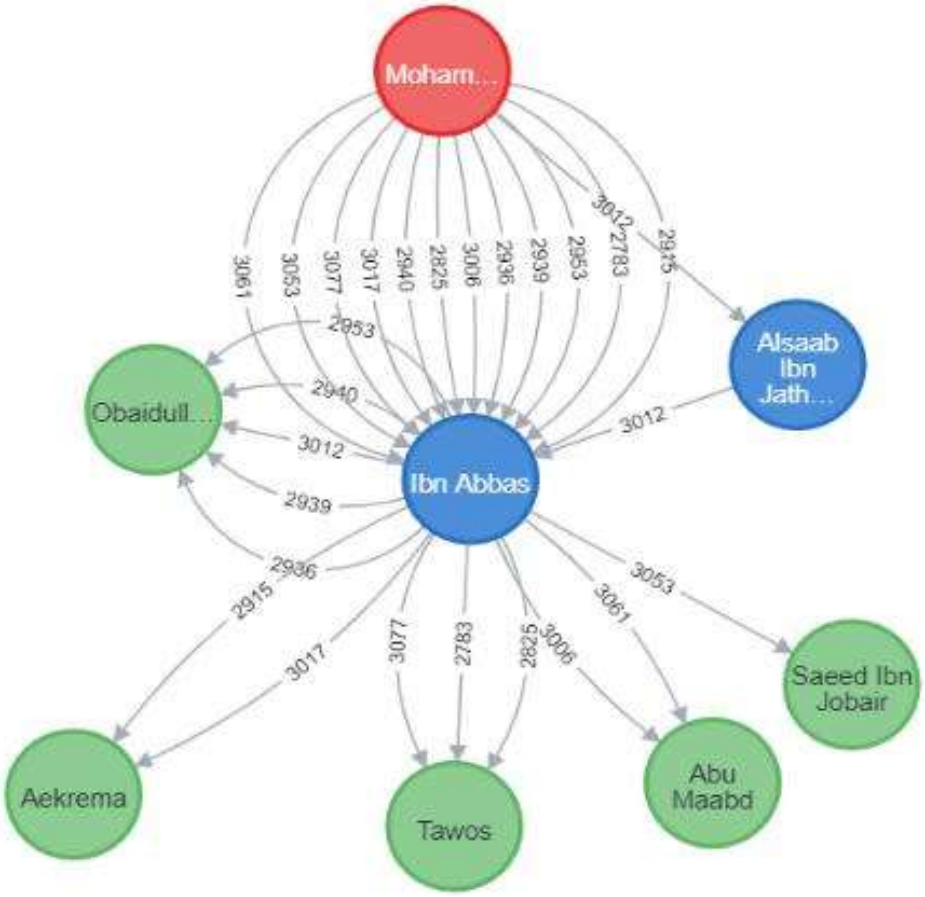


Figure 5.6
Aisha relationships: his sheikhs and his students

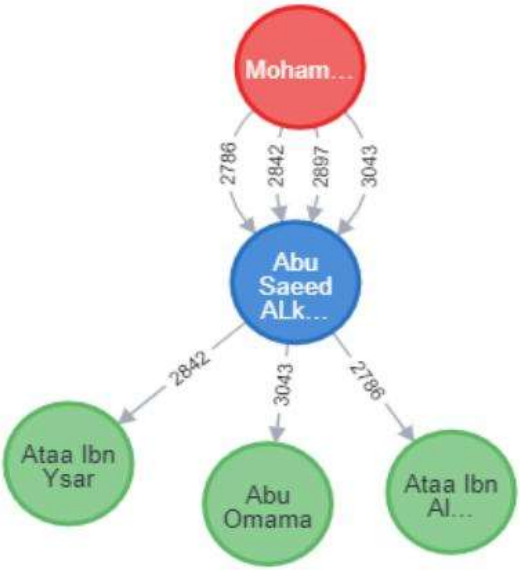


Figure 5.7
Abu Saeed Alkhudri relationships: his sheikhs and his students

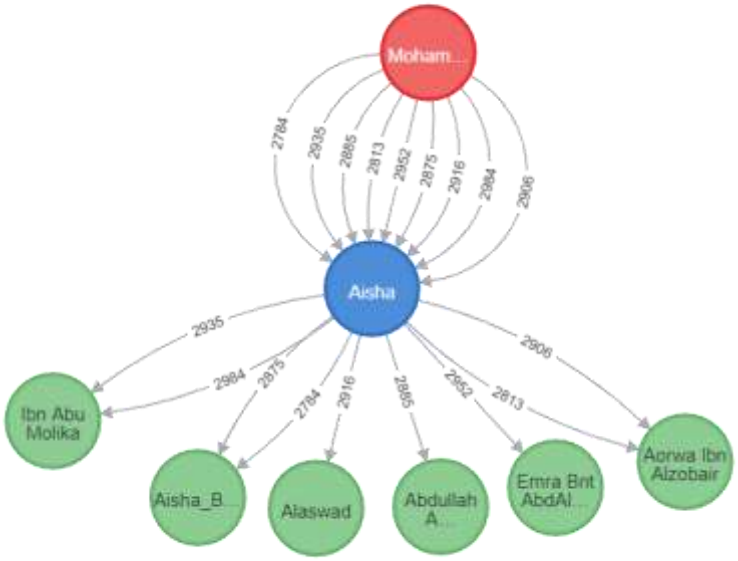


Figure 5.8
Alzohre Shaikhs

```
match (:Narrator{rawi:'Alzohre'})←[r:Narrated_us]-(Narrator)
return Narrator.name as name,r as Hadith_id
order by name asc
```

"name"	"Hadith_id"
" AbdAlrahman Ibn Kaab Ibn Malek "	{"Hadith_id":2950}
" AbdAlrahman Ibn Kaab Ibn Malek "	{"Hadith_id":2949}
" Malek Ibn Aws Ibn Alhadathan "	{"Hadith_id":2904}
"AbdAlrahman Ibn Abdullah Ibn Kaab"	{"Hadith_id":2948}
"Alssaeb Ibn Yazed Ibn Saeed"	{"Hadith_id":3083}
"Amr Ibn Abu Sofian Ibn osaid"	{"Hadith_id":3045}
"Anas Ibn Malek Ibn Alndr Alansare Alnjare"	{"Hadith_id":3044}
"Anas Ibn Malek Ibn Alndr Alansare Alnjare"	{"Hadith_id":3048}
"Anbsa Ibn Saeed Ibn Alaas"	{"Hadith_id":2827}
"Aorwa Ibn Alzobair Ibn Alaawam Alqorashe Alasade"	{"Hadith_id":2987}

"Ataa Ibn Yazed Allaithe Aljndae"	{"Hadith_id":2786}
"Jaafar Ibn Amr Ibn Omya"	{"Hadith_id":2923}
"Mohammad Ibn Jobair Ibn Motaem Alqorashe Alnofle"	{"Hadith_id":3050}
"Obaidullah Ibn Abdullah Ibn Atba Alhthle"	{"Hadith_id":3012}
"Obaidullah Ibn Abdullah Ibn Atba Alhthle"	{"Hadith_id":2953}
"Obaidullah Ibn Abdullah Ibn Atba Alhthle"	{"Hadith_id":2939}
"Obaidullah Ibn Abdullah Ibn Atba Alhthle"	{"Hadith_id":2936}
"Obaidullah Ibn Abdullah Ibn Atba Alhthle"	{"Hadith_id":2940}
"Omar Ibn Mohammad Ibn Jobair Ibn Motaem Alqorashe Al nofle Almdne"	{"Hadith_id":2821}
"Saeed Ibn ALmosieb Ibn Hzn Alqorashe Almkhzome"	{"Hadith_id":2929}
"Saeed Ibn ALmosieb Ibn Hzn Alqorashe Almkhzome"	{"Hadith_id":2901}
"Saeed Ibn ALmosieb Ibn Hzn Alqorashe Almkhzome"	{"Hadith_id":2787}

"Saeed Ibn ALmosieb Ibn Hzn Alqorashe Almkhzome"	{"Hadith_id":2946}
"Saeed Ibn ALmosieb Ibn Hzn Alqorashe Almkhzome"	{"Hadith_id":2977}
"Saeed Ibn ALmosieb Ibn Hzn Alqorashe Almkhzome"	{"Hadith_id":2797}
"Sahl Ibn Saad Ibn Malek Alansare"	{"Hadith_id":2832}
"Salem Ibn Abdullah Ibn Omar"	{"Hadith_id":3057}
"Salem Ibn Abdullah Ibn Omar"	{"Hadith_id":3054}
"Salem Ibn Abdullah Ibn Omar"	{"Hadith_id":2858}
"Salem Ibn Abdullah Ibn Omar"	{"Hadith_id":3055}
"Salem Ibn Abdullah Ibn Omar"	{"Hadith_id":3056}

Figure 5.9
Alzohre Students

```
match (:Narrator{rawi:'Alzohre'})-[r:Narrated_us]→(Narrator)
return Narrator.name as name,r as Hadith_id
order by name asc
```

"name"	"Hadith_id"
"Amr Ibn Denar Almacce"	{"Hadith_id":2904}
"Ibrahim Ibn Saad Ibn Ibrahim Alzohre "	{"Hadith_id":2923}
"Maamar Ibn Rashed Alazde Alhdane"	{"Hadith_id":3056}
"Maamar Ibn Rashed Alazde Alhdane"	{"Hadith_id":3057}
"Maamar Ibn Rashed Alazde Alhdane"	{"Hadith_id":2950}
"Maamar Ibn Rashed Alazde Alhdane"	{"Hadith_id":3055}
"Maamar Ibn Rashed Alazde Alhdane"	{"Hadith_id":2901}
"Maamar Ibn Rashed Alazde Alhdane"	{"Hadith_id":3050}
"Malek Ibn Anas Ibn Malek "	{"Hadith_id":3044}
"Mohammad Ibn Abdullah Ibn Mslm"	{"Hadith_id":2936}
"Musa Ibn Oqba Ibn Abu Ayyash Alqorashe Alasde Almtrfe"	{"Hadith_id":3048}
"Oqail Ibn Khalid Ibn Oqail Alayle Abu Khalid Alqorashe Alomawi"	{"Hadith_id":2939}
"Oqail Ibn Khalid Ibn Oqail Alayle Abu Khalid Alqorashe Alomawi"	{"Hadith_id":2977}
"Oqail Ibn Khalid Ibn Oqail Alayle Abu Khalid Alqorashe Alomawi"	{"Hadith_id":3054}
"Saleh Ibn Kaisan Almdne"	{"Hadith_id":2832}
"Saleh Ibn Kaisan Almdne"	{"Hadith_id":2940}
"Shoaib Ibn Abu Hamza Denar Alqorshe Alomawi"	{"Hadith_id":2821}
"Shoaib Ibn Abu Hamza Denar Alqorshe Alomawi"	{"Hadith_id":3045}
"Shoaib Ibn Abu Hamza Denar Alqorshe Alomawi"	{"Hadith_id":2797}
"Shoaib Ibn Abu Hamza Denar Alqorshe Alomawi"	{"Hadith_id":2946}
"Shoaib Ibn Abu Hamza Denar Alqorshe Alomawi"	{"Hadith_id":2858}
"Shoaib Ibn Abu Hamza Denar Alqorshe Alomawi"	{"Hadith_id":2787}

"Shoaib Ibn Abu Hamza Denar Alqorshe Alomawi"	{"Hadith_id":2786}
"Sofian Ibn Aoyayna Ibn Abu Omran Maymon Alhelale"	{"Hadith_id":2929}
"Sofian Ibn Aoyayna Ibn Abu Omran Maymon Alhelale"	{"Hadith_id":3083}
"Sofian Ibn Aoyayna Ibn Abu Omran Maymon Alhelale"	{"Hadith_id":2827}
"Sofian Ibn Aoyayna Ibn Abu Omran Maymon Alhelale"	{"Hadith_id":3012}
"Sofian Ibn Aoyayna Ibn Abu Omran Maymon Alhelale"	{"Hadith_id":2953}
"Younis Ibn Yazed Ibr Abu Alnajad"	{"Hadith_id":2987}
"Younis Ibn Yazed Ibn Abu Alnajad"	{"Hadith_id":2949}
"Younis Ibn Yazed Ibn Abu Alnajad"	{"Hadith_id":2948}

Figure 5.10
Sahaba Stress Centrality: the highest value in Sahaba generation

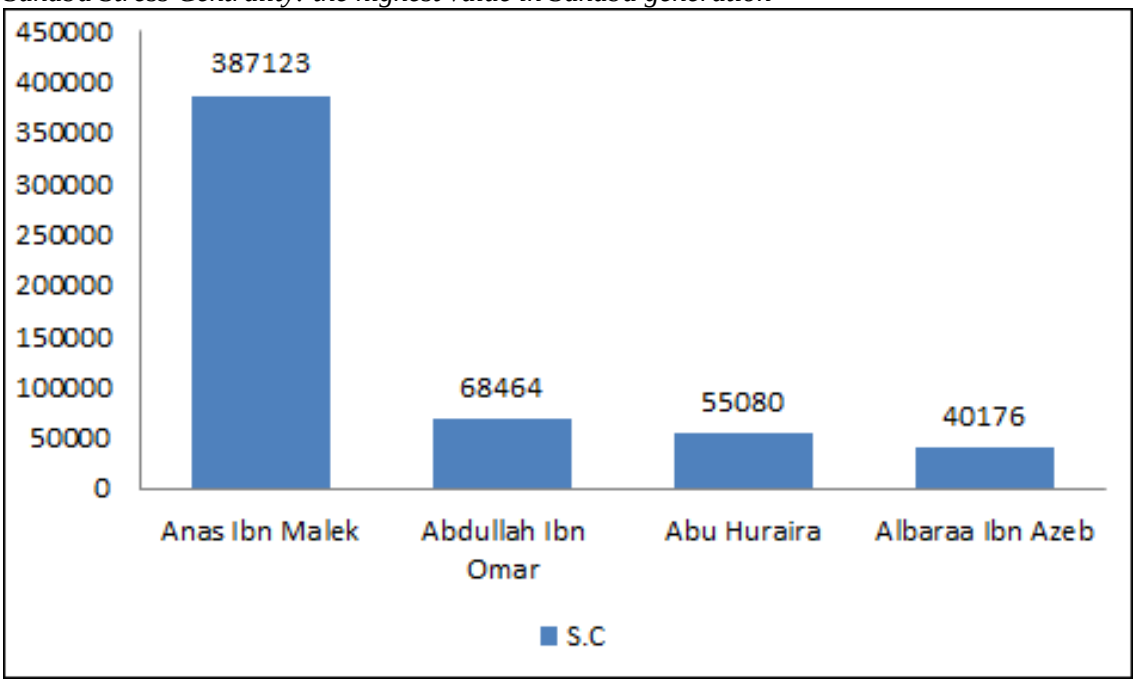


Figure A.4.11
ArticleRank Centrality example

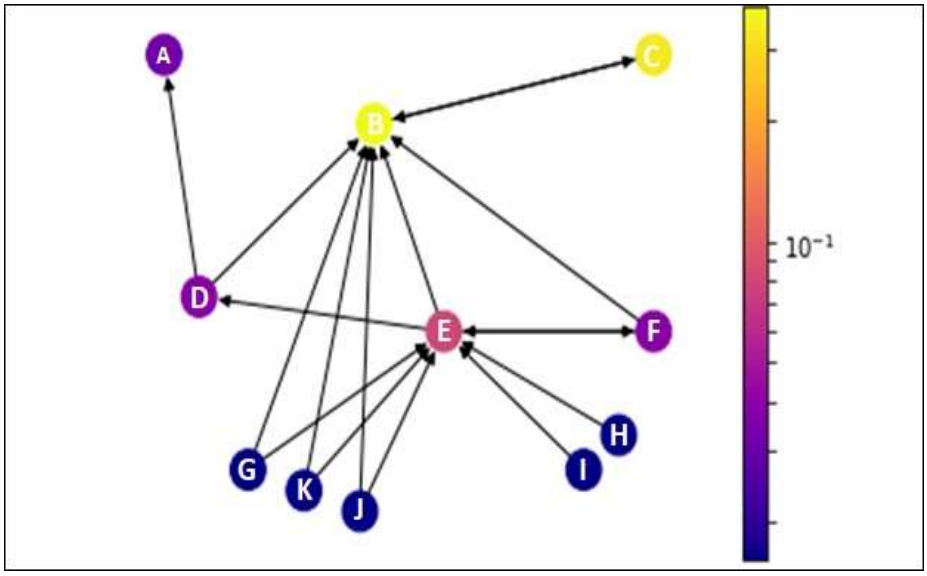


Figure A.4.12
ArticleRank Centrality result in Neo4j

```
1 CALL gds.articleRank.stream('myGraph')
2 YIELD nodeId, score
3 RETURN gds.util.asNode(nodeId).name AS name, score
4 ORDER BY score DESC
```

Table | Text | Code

"B"	0.5560277646044396
"E"	0.4125187854180978
"C"	0.3356735571089825
"D"	0.22714099952850528
"F"	0.22714099952850528
"A"	0.2044555986049109
"G"	0.15000000000000002
"H"	0.15000000000000002
"I"	0.15000000000000002
"J"	0.15000000000000002
"K"	0.15000000000000002

Figure A.4.13
Authority and Hub in HITS

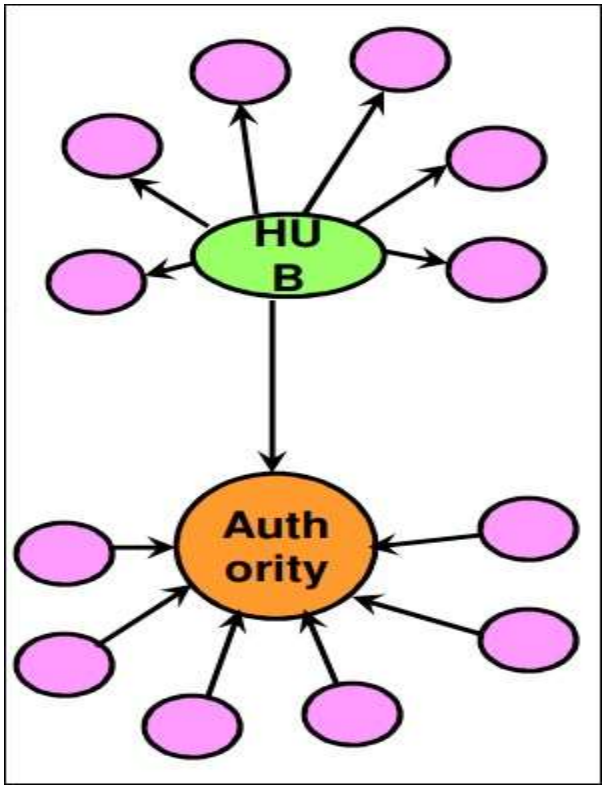


Figure A.4.14
HITS Authority example

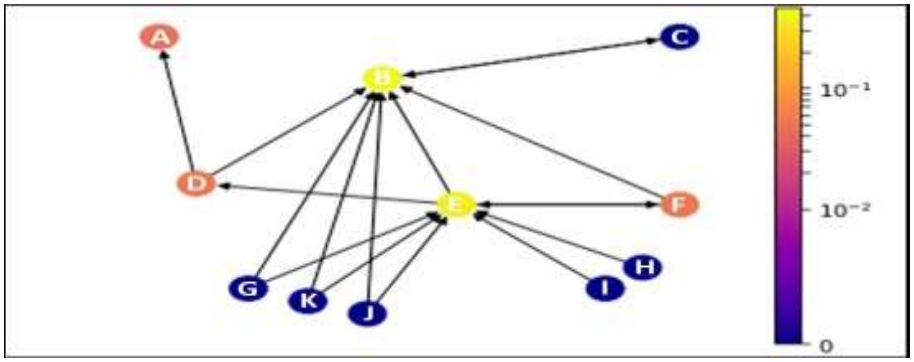


Figure A.4.15
HITS Authority result

```
1  CALL gds.alpha.hits.stream('myGraph', {hitsIterations: 20})
2  YIELD nodeId, values
3  RETURN gds.util.asNode(nodeId).name AS Name, values.auth AS auth
4  ORDER BY auth DESC
```

"B"	0.7549152285128702
"E"	0.6395989076318456
"D"	0.08656114395002673
"F"	0.08656114395002673
"A"	0.07765875650988925
"C"	2.8413402665912133e-21
"G"	0.0
"H"	0.0
"I"	0.0
"J"	0.0
"K"	0.0

Figure A.4.16
HITS Hub example

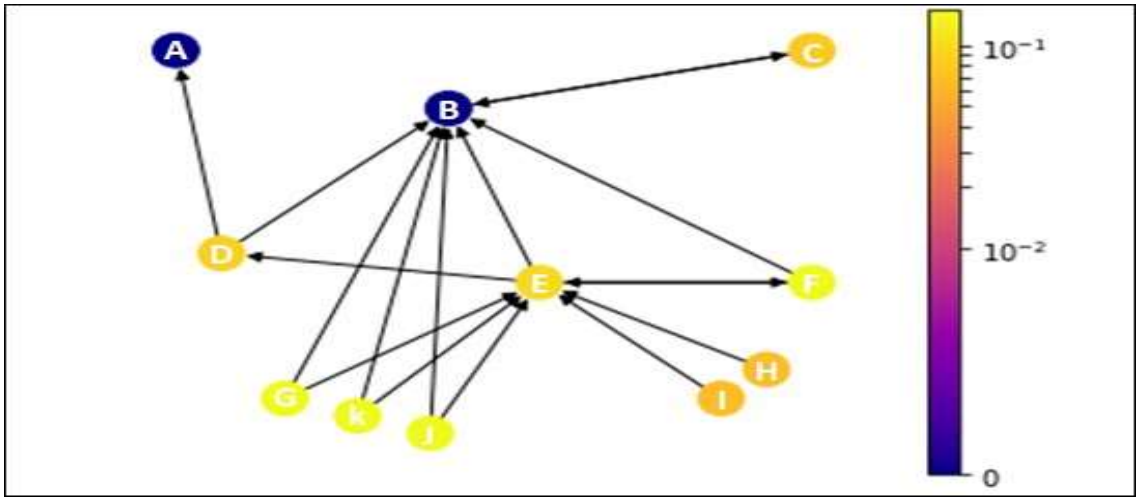


Figure A.4.17
HITS Hub result

```
1 CALL gds.alpha.hits.stream('myGraph', {hitsIterations: 20})
2 YIELD nodeId, values
3 RETURN gds.util.asNode(nodeId).name AS Name, values.hub as hub
4 ORDER BY hub DESC
```

"F"	0.42589412387041725
"G"	0.42589412387041725
"J"	0.42589412387041725
"K"	0.42589412387041725
"E"	0.2834289841365533
"D"	0.2542731600416885
"C"	0.23055625720136805
"H"	0.19533786666904918
"I"	0.19533786666904918
"B"	8.677646874223033e-22
"A"	0.0

Figure A.4.18
Example

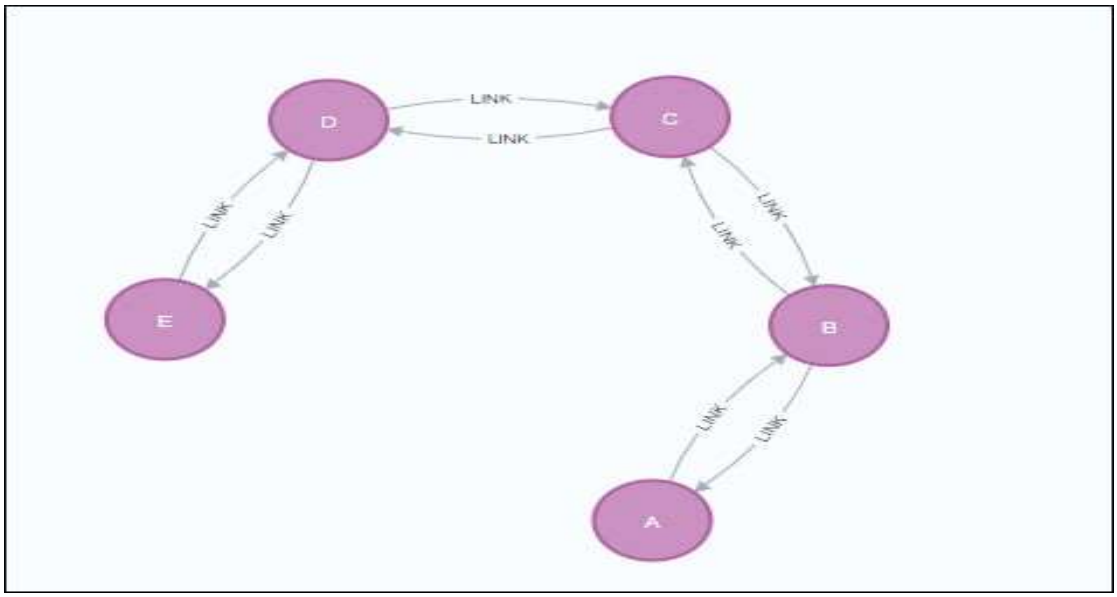


Figure A.4.19
Radiality result in Cystoscope

id	Radiality
C	0.75
D	0.625
B	0.625
E	0.25
A	0.25

Figure A.4.20
Betweenness Centrality vs. Stress Centrality

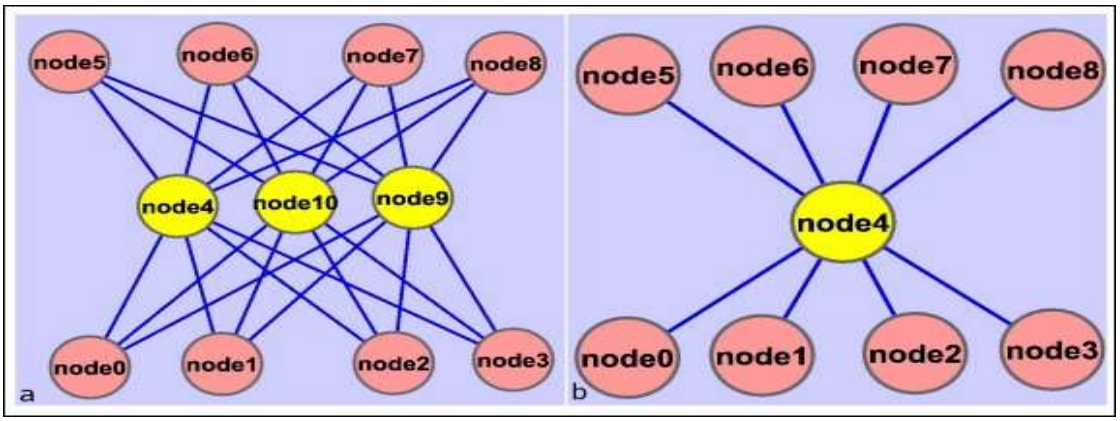


Figure A.4.21
Example

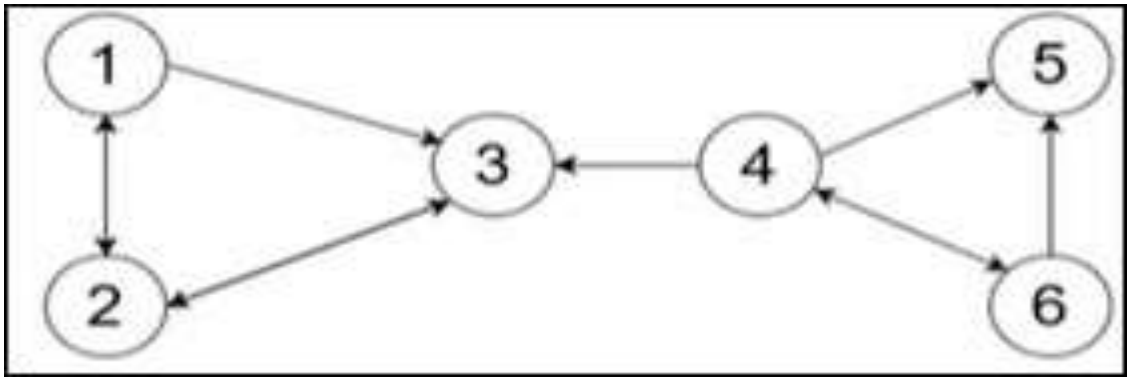


Figure A.4.22
Radiality result in cystoscape

id	Stress Dir
3	4.0
2	3.0
4	3.0
6	0.0
1	0.0
5	0.0

Figure A.4.23
Example

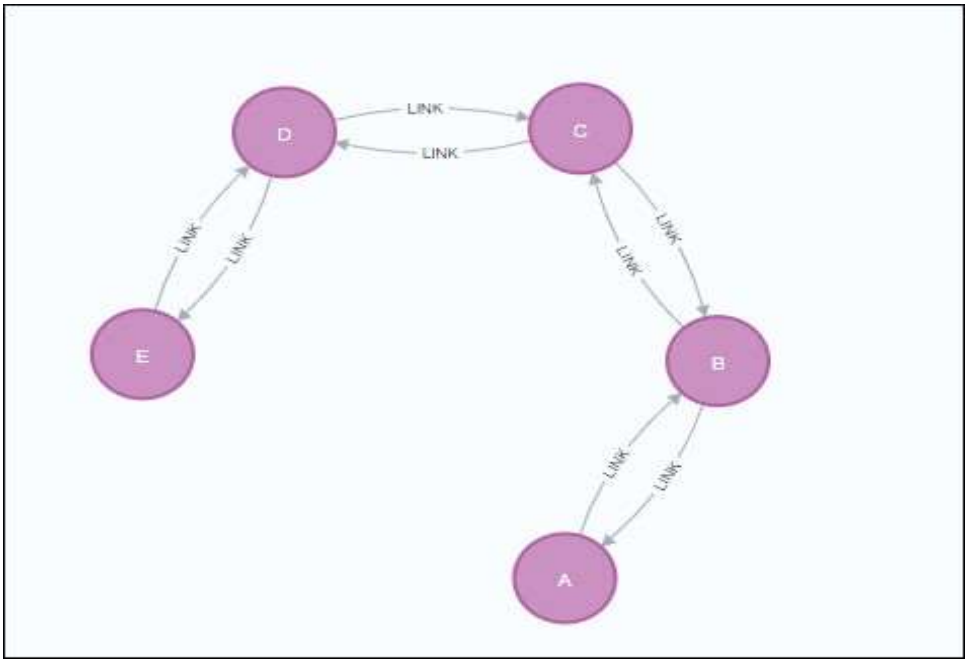


Figure A.4.24
Eccentricity result in Cytoscape

id	Eccentricity Dir
C	0.5
B	0.3333333333333333
D	0.3333333333333333
A	0.25
E	0.25

Figure A.5.1.2.11
Abu Altayyah connected with only Anas Ibn Malek in hadith NO. 2851, so this increased the importance of Anas Ibn Malek

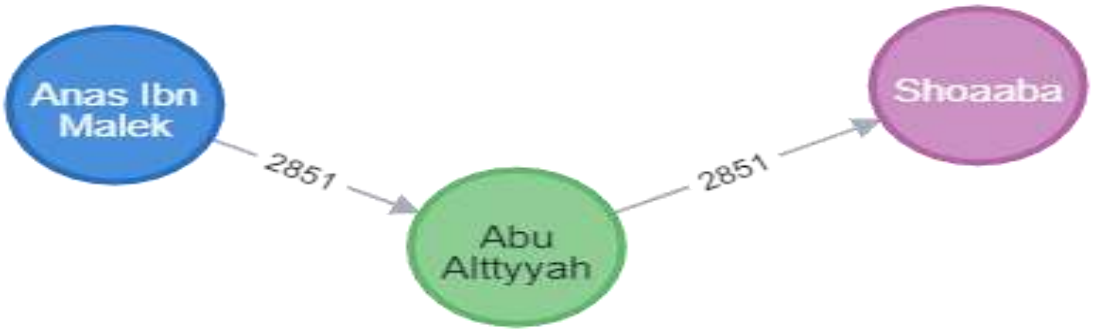


Figure A.5.1.2.12
Betweeness Centrality for high value in Sahaba

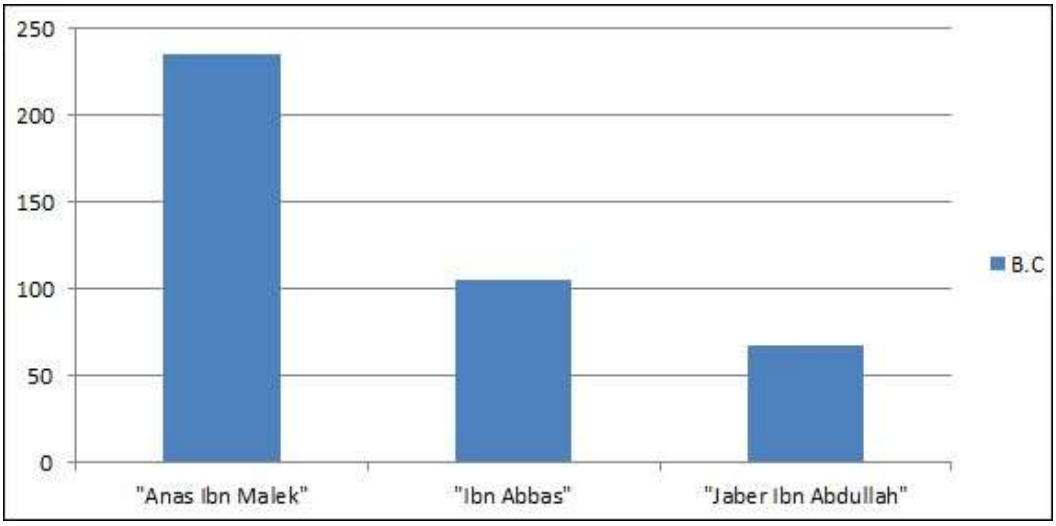


Figure A.5.1.2.13
Betweeness Centrality for high value in Tabieen

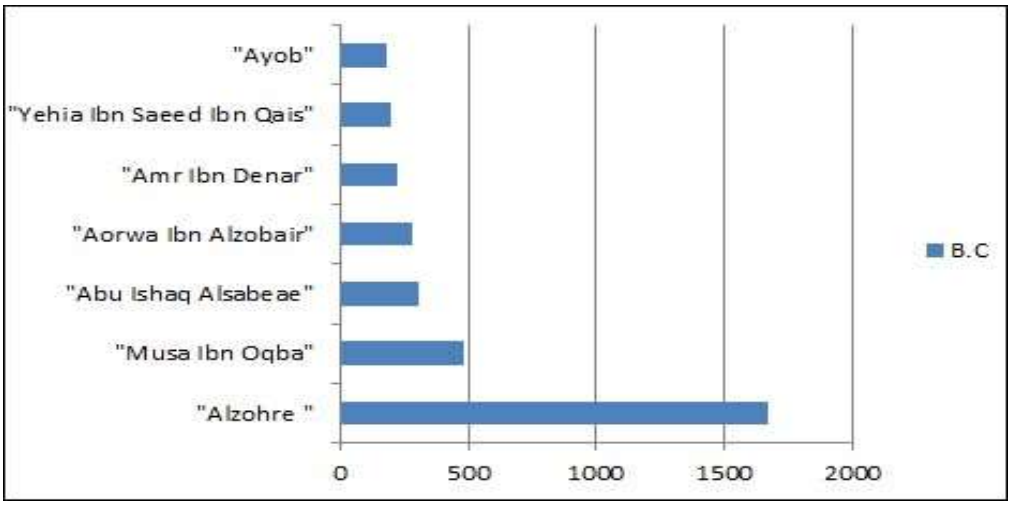


Figure A.5.1.2.14
Betweeness Centrality for high value in The Rest of Narrators

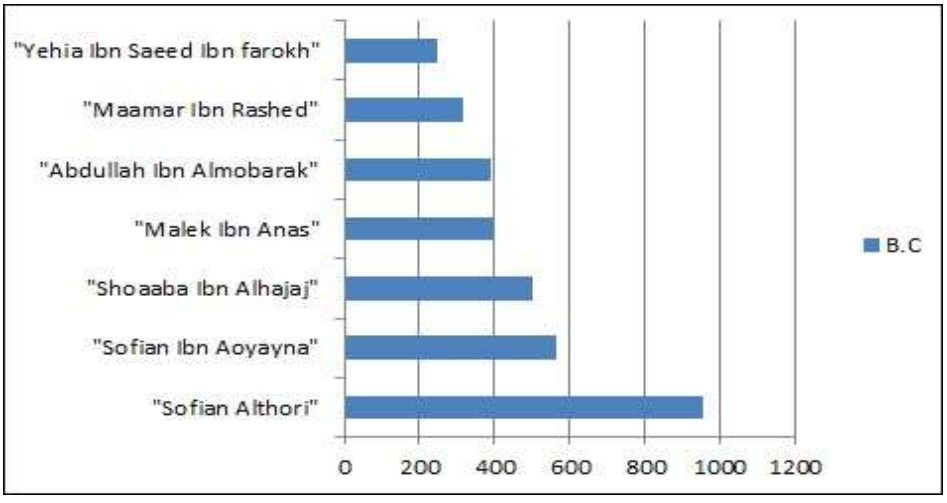


Figure A.5.1.3.15
Anas Ibn Malek spreading the hadiths from the prophet to the Sahaba

Figure A.5.1.3.16
Tabieen Stress Centrality: the highest value in Tabieen generation

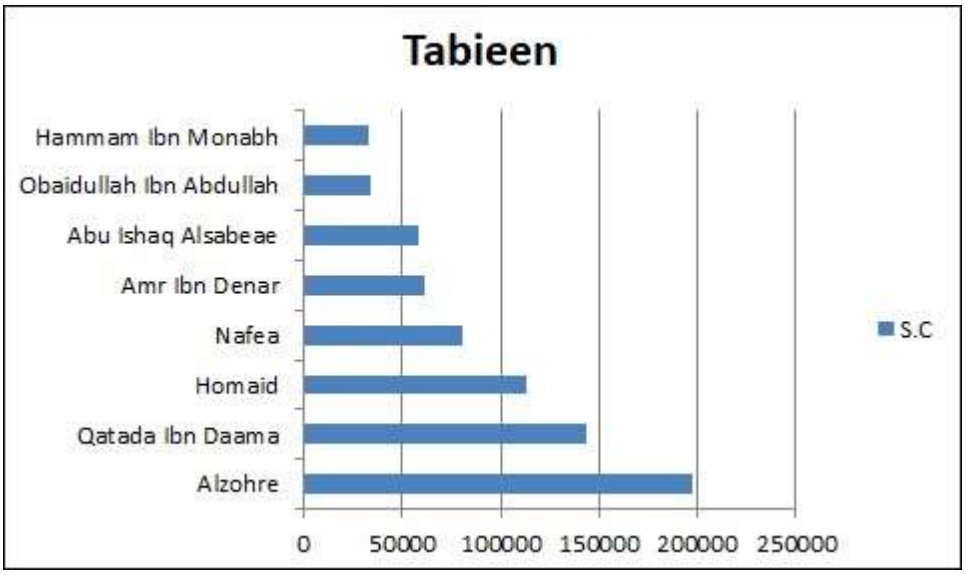


Figure A.5.1.3.17

Alzohre spreading the hadiths between two generations: in the above figure Alzohre spreading the hadiths from Sahaba to Tabieen, in the below figure Alzohre spreading the hadiths from Tabieen to narrators

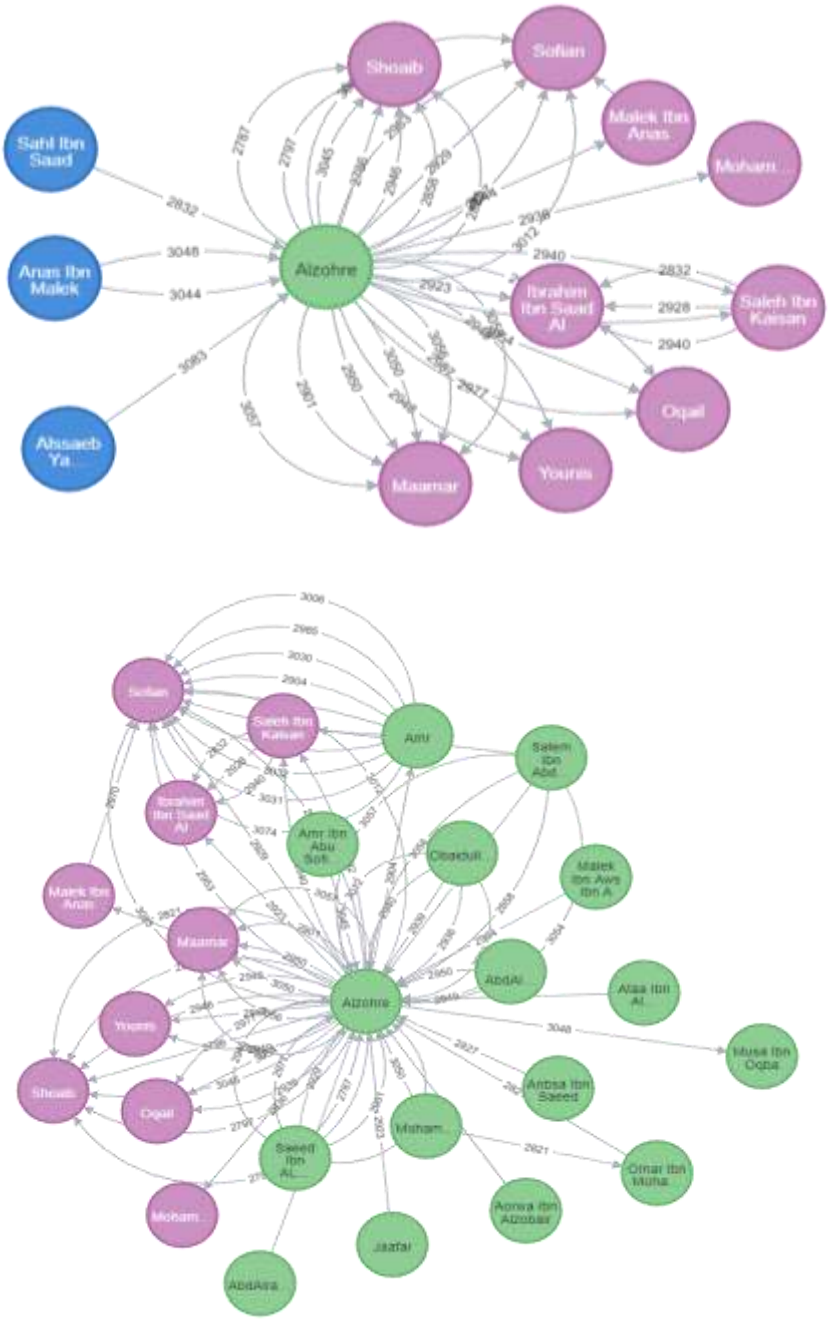


Figure A.5.1.3.18
The rest of narrators Stress Centrality

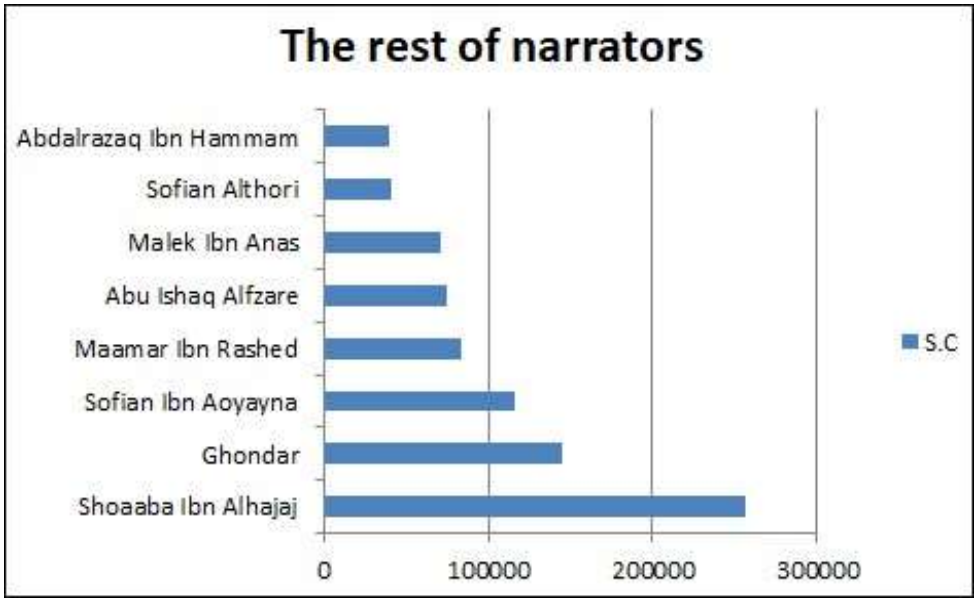


Figure A.5.1.3.19
Shoaaba Ibn Alhajaj spreading the hadiths from the Tabieen to the Narrators

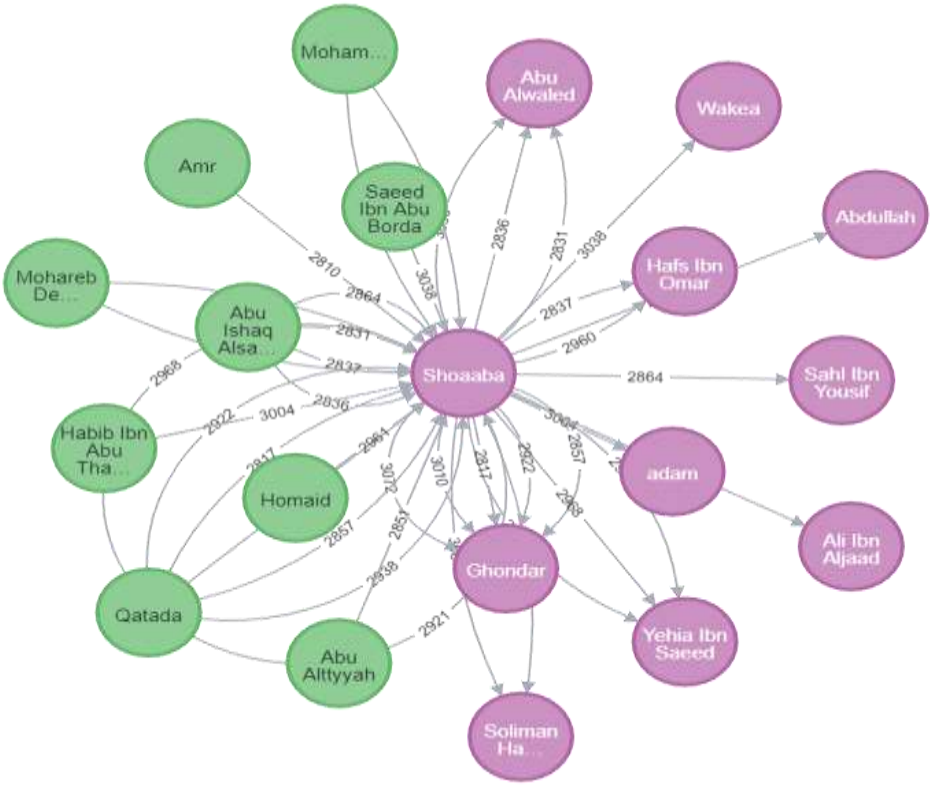


Figure A.5.1.5.20
Anas Ibn Malek Molazma

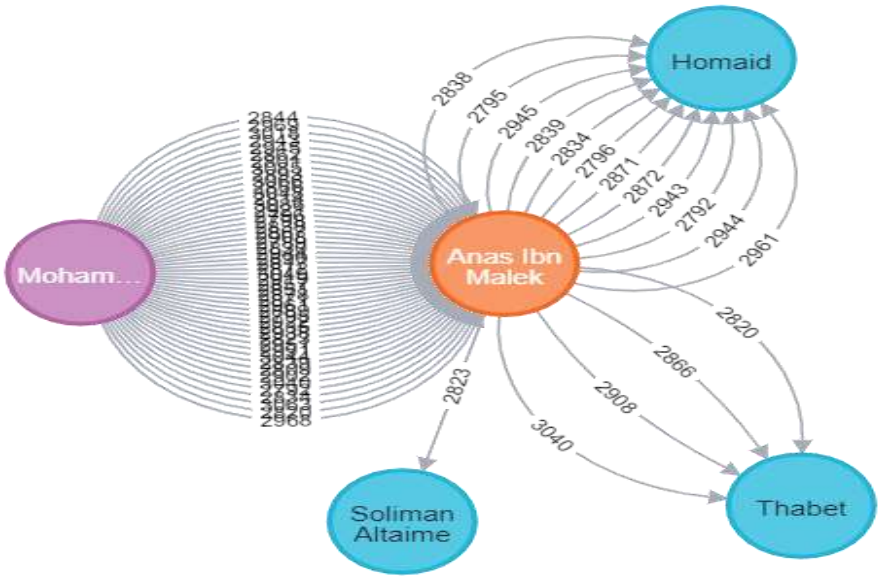


Figure A.5.1.5.21
Alzohre Molazma

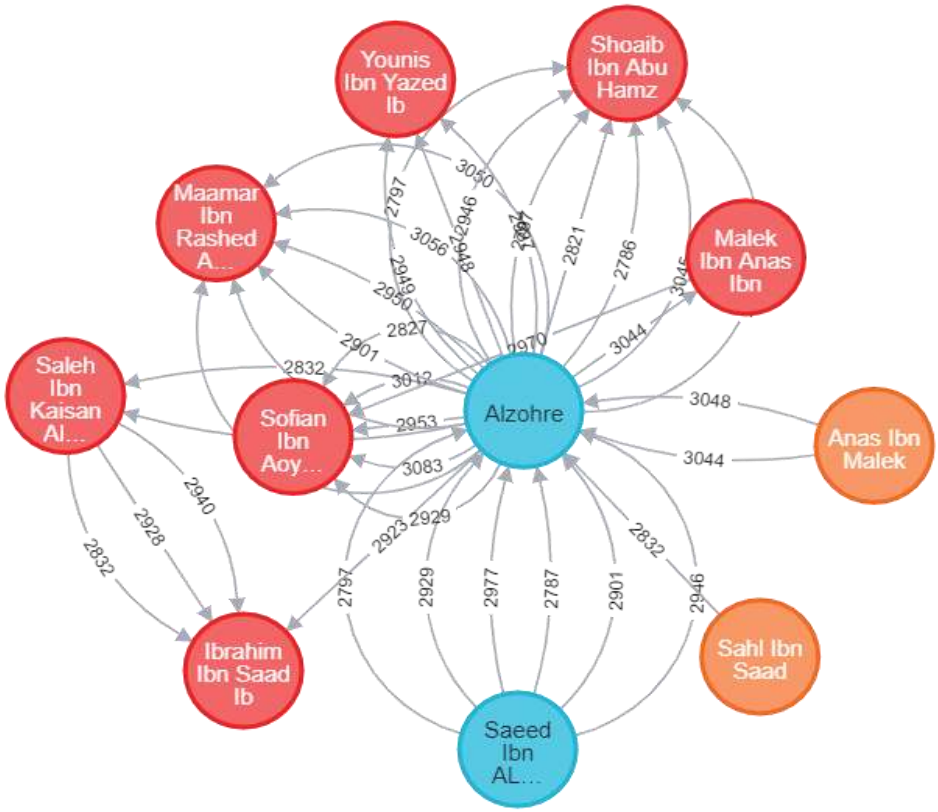


Figure A.5.1.7.22
The names of the highest Sahaba who attained high values in Eigenvector Centrality

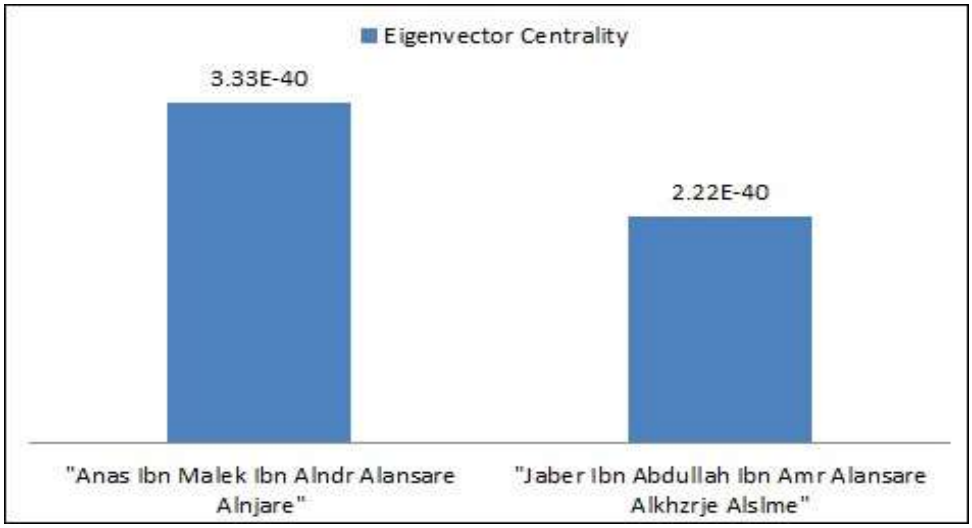


Figure A.5.1.7.23
The sheikhs of Anas Ibn Malek and their connections

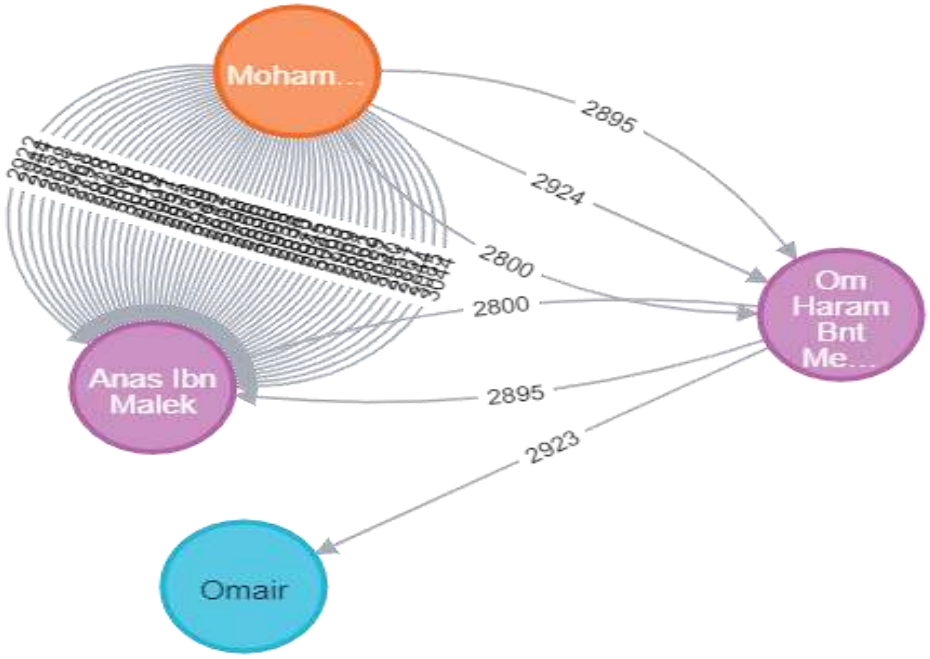


Figure A.5.1.7.24
The sheikhs of Jaber Ibn Abdullah and their connections

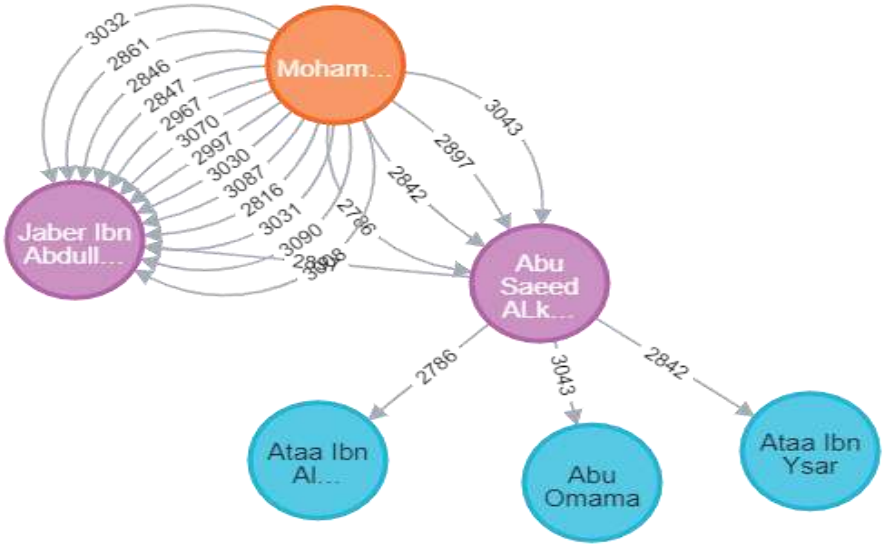


Figure A.5.1.7.25
The names of the highest Tabieen who attained high values in Eigenvector Centrality

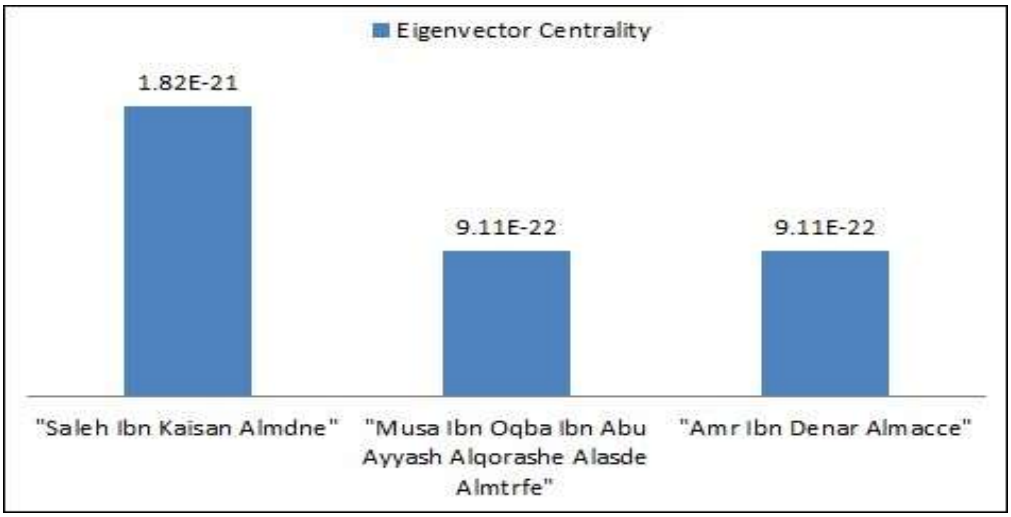


Figure A.5.1.7.26
The names of the highest in the rest of the narrators who attained high values in Eigenvector Centrality

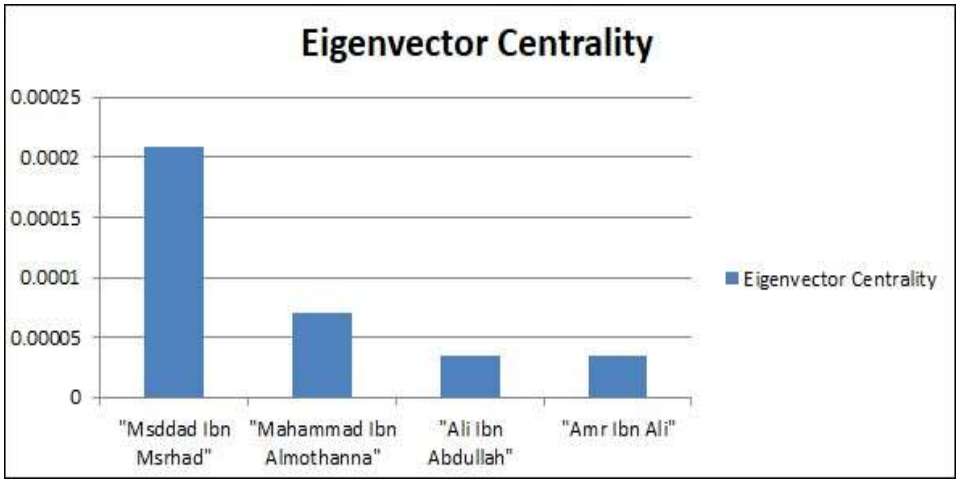


Figure A.5.1.7.27
The sheikhs of Msddad Ibn Msrhad and their connections

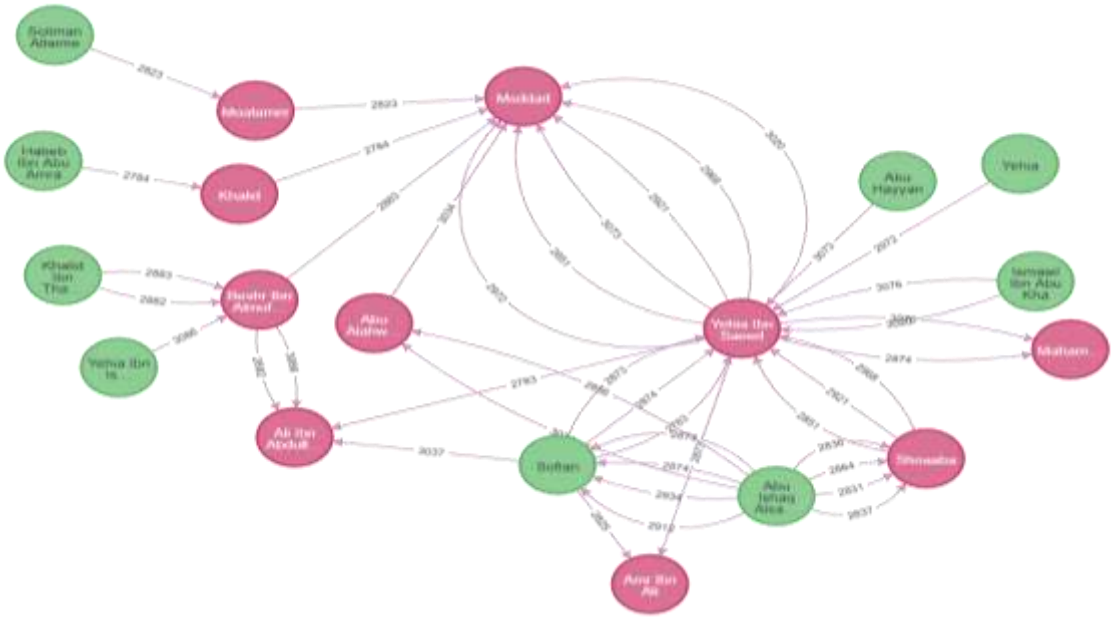


Figure A.5.1.7.28
The sheikhs of Mohammad Ibn Almothanna and their connections

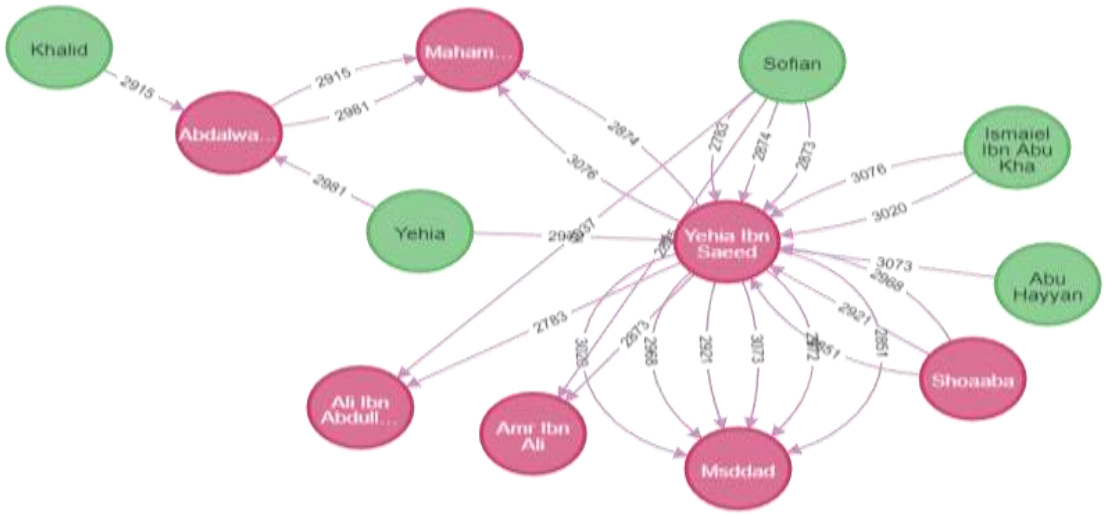


Figure A.5.1.8.29
The top 2 sahaba who obtained a high value

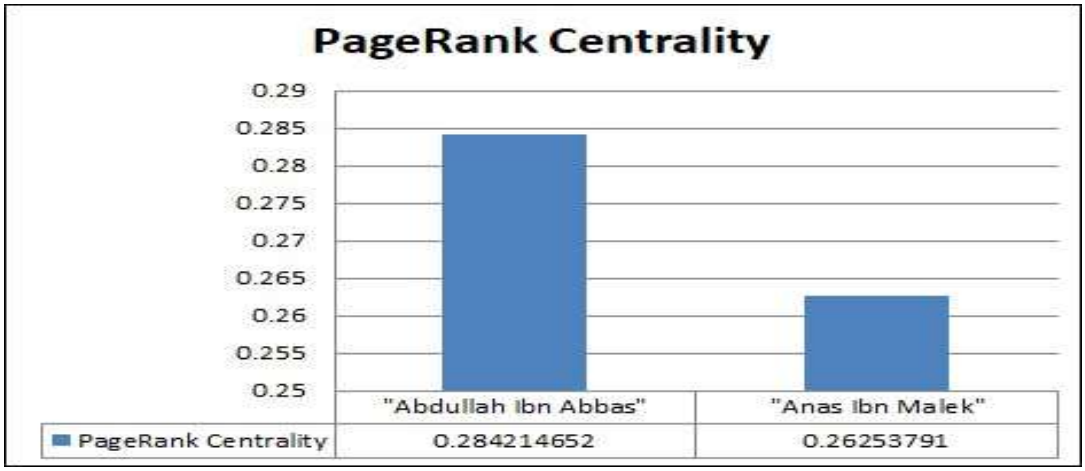


Figure A.5.1.8.30
Sheikhs of Ibn Abbas and their Sheikhs

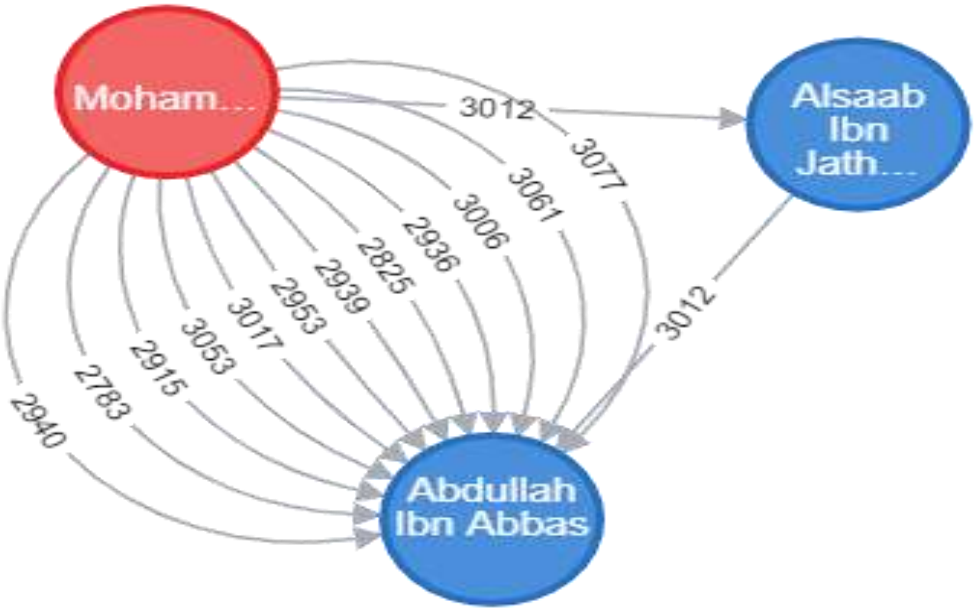


Figure A.5.1.8.31
Sheikhs of Anas Ibn Malek and their Sheikhs

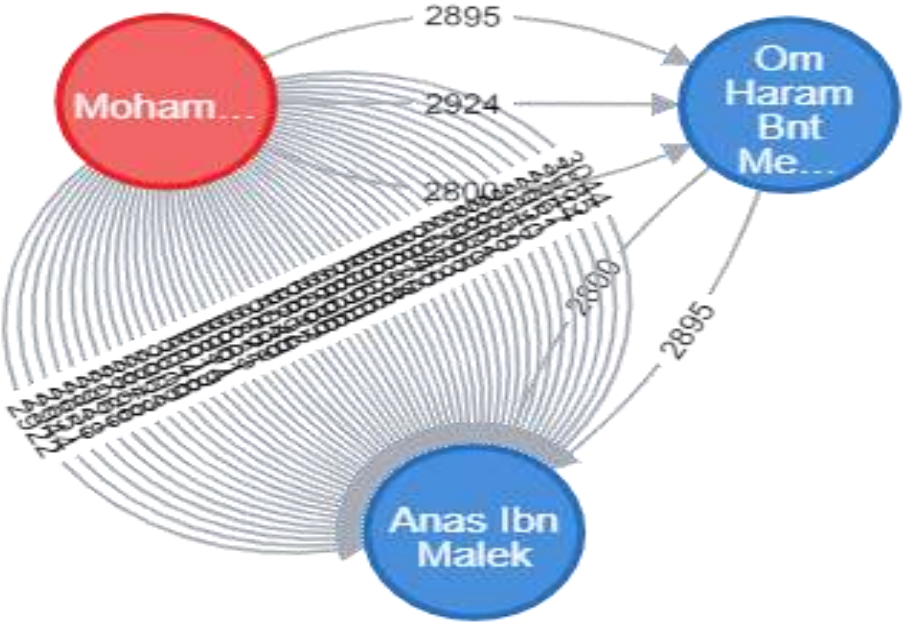


Figure A.5.1.8.32
The top 3 Tabieen who obtained a high value

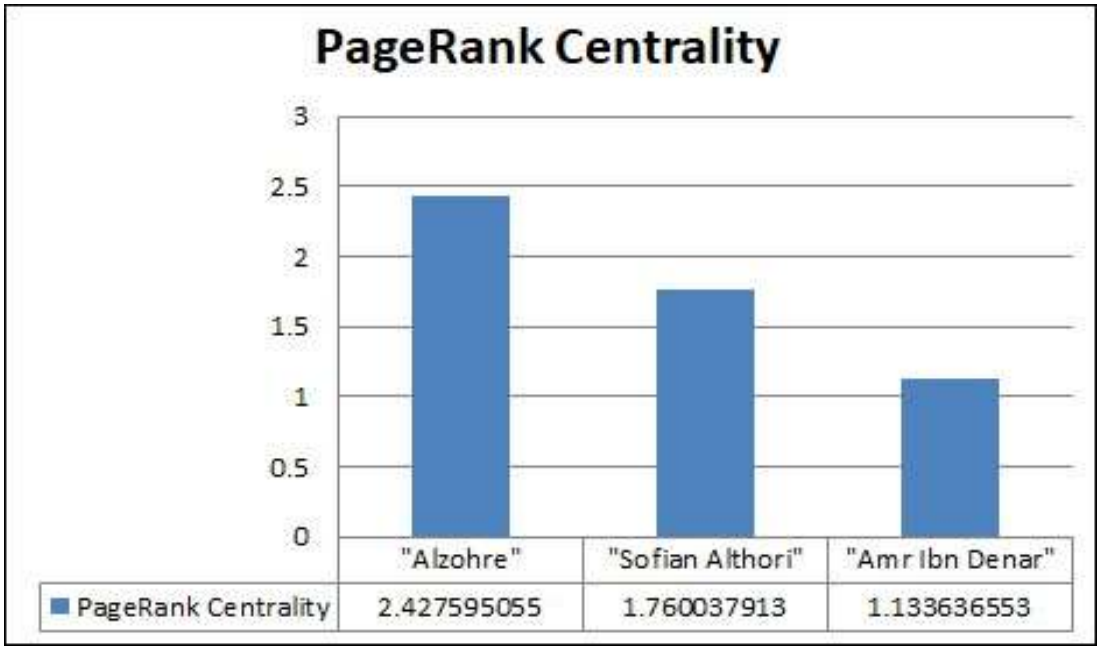


Figure A.5.1.8.33
The sheikhs of Alzohre are among the Sahaba and Tabieen and their sheikhs

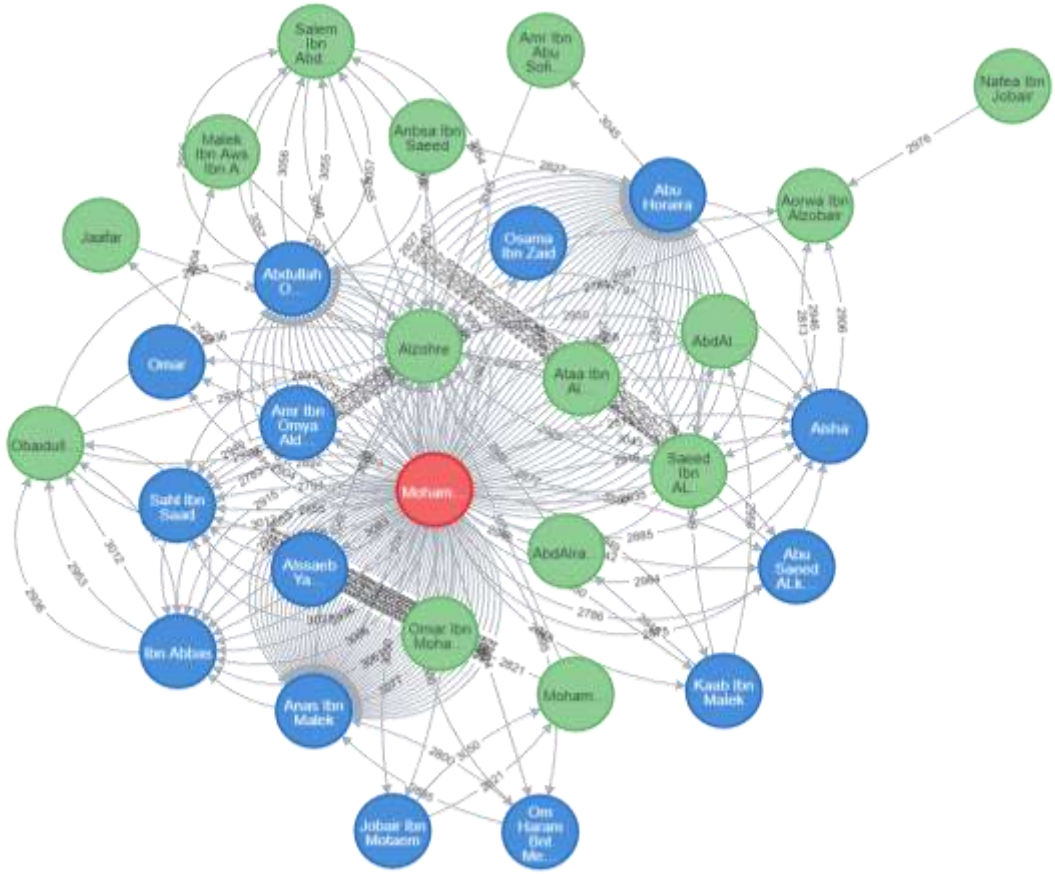


Figure A.5.1.8.34
The sheikhs of Sofian Althori are among Tabieen and their sheikhs

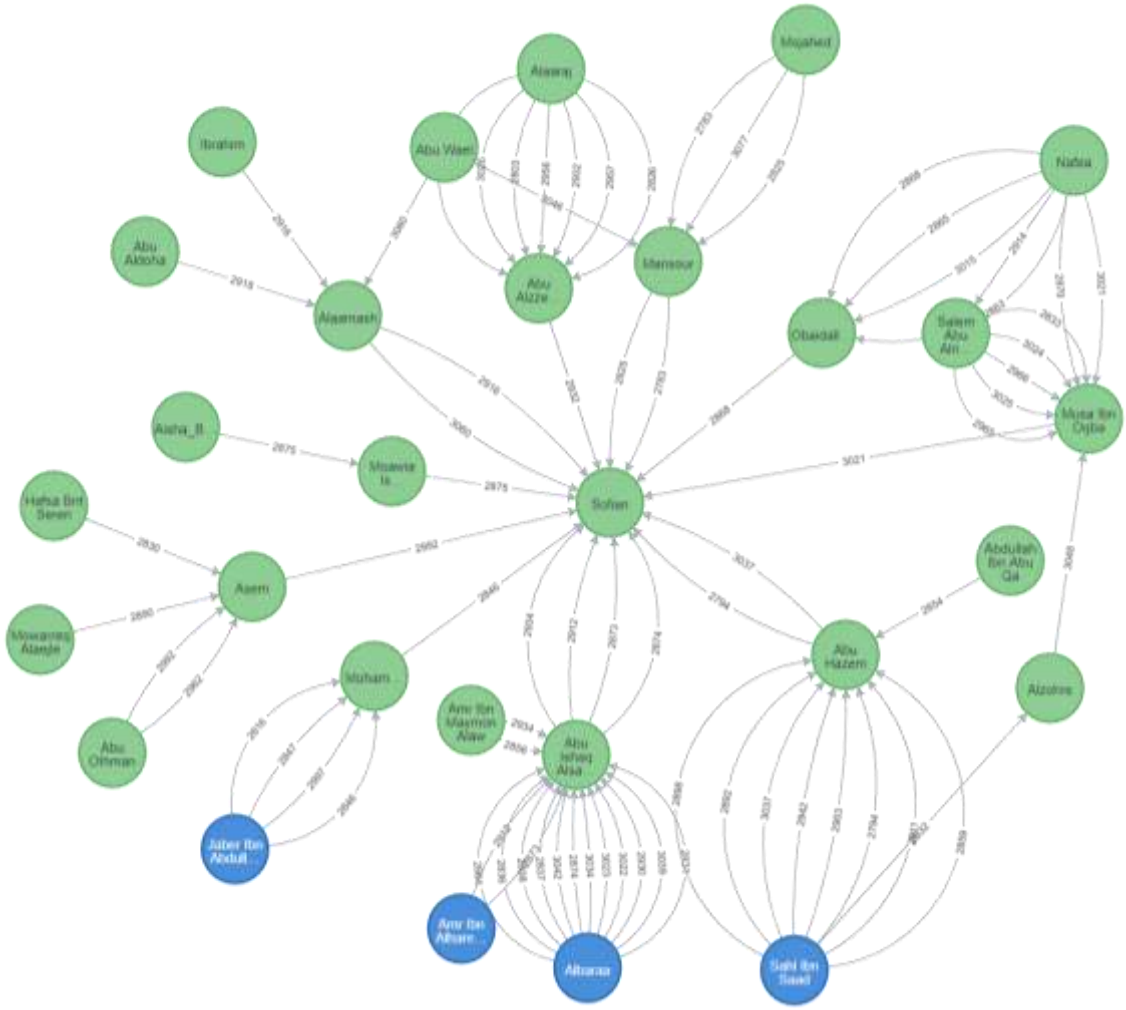


Figure A.5.1.8.35
The sheikhs of Amr Ibn Denar are among the Sahaba and Tabieen and their sheikhs

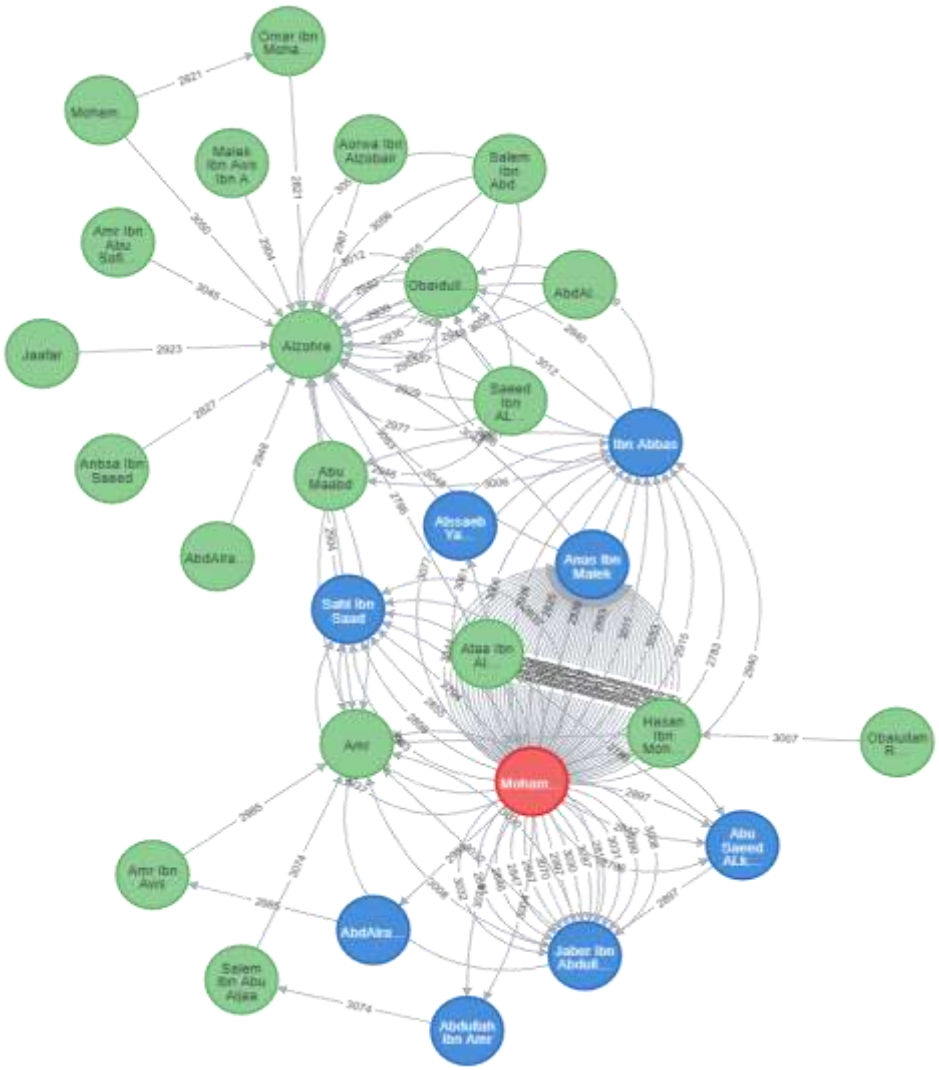


Figure A.5.1.8.36
The top 10 of the rest of the narrators who obtained a high value

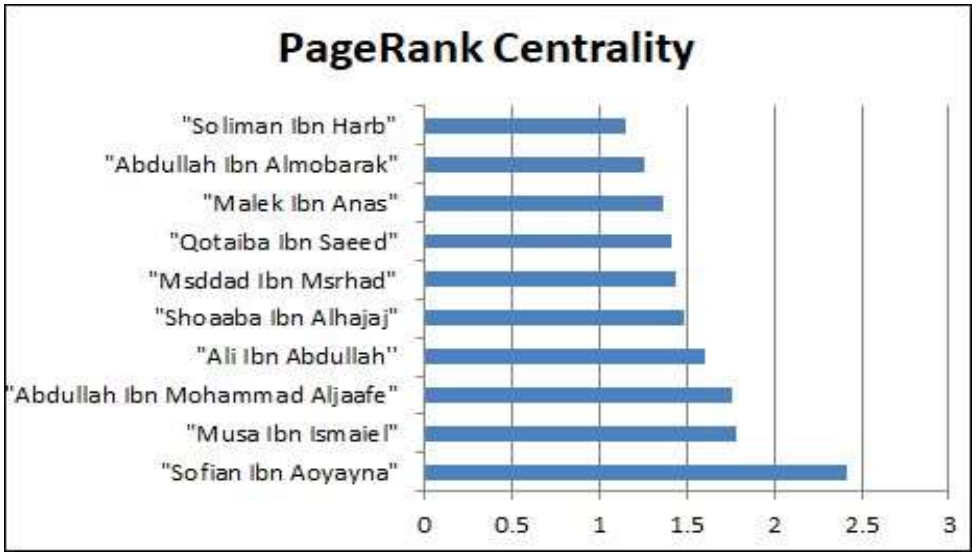


Figure A.5.1.8.37
The sheikhs of Sofian Ibn Aoyayna are among the Sahaba and Tabieen and their sheikhs

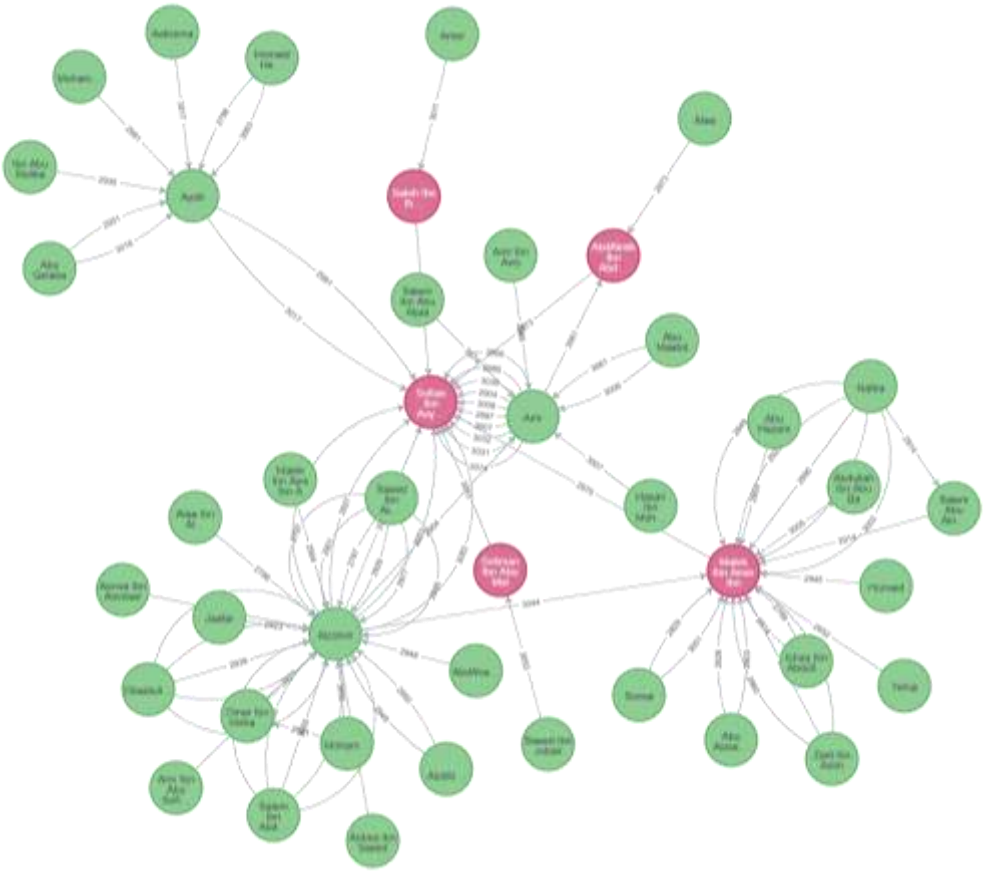


Figure A.5.1.9.38
comparison with the results of PageRank Centrality and ArticleRank Centrality in Sahaba generation

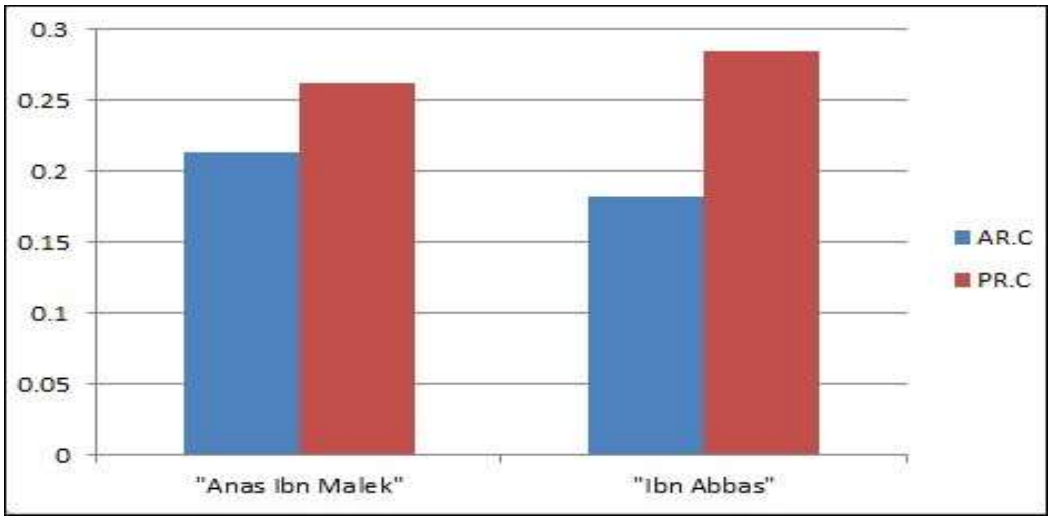


Figure A.5.1.9.39

comparison with the results of PageRank Centrality and ArticleRank Centrality in Tabieen generation

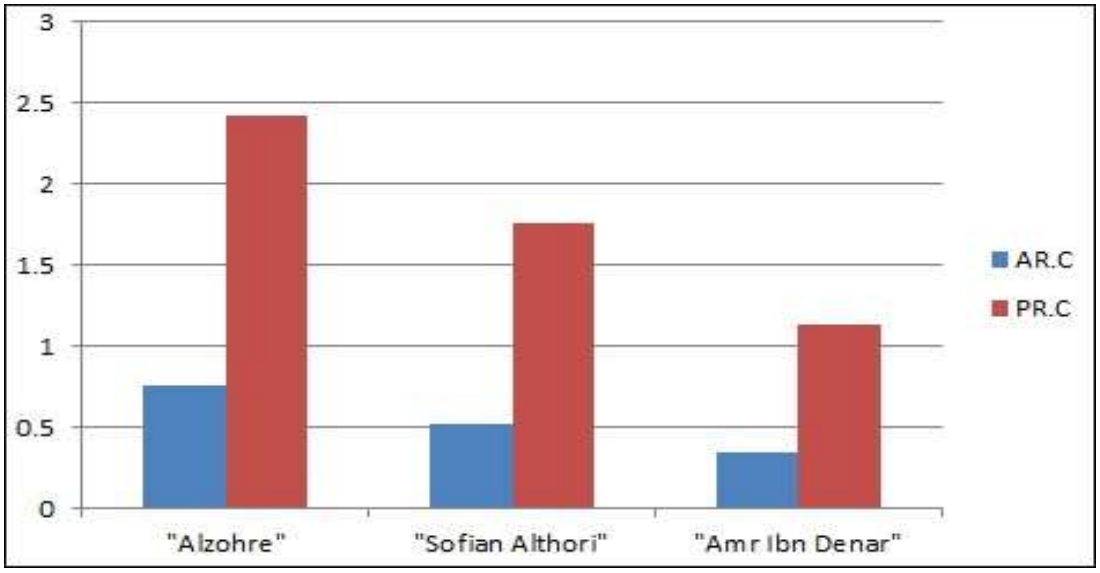


Figure A.5.1.9.40

comparison with the results of PageRank Centrality and ArticleRank Centrality in the rest of the narrators

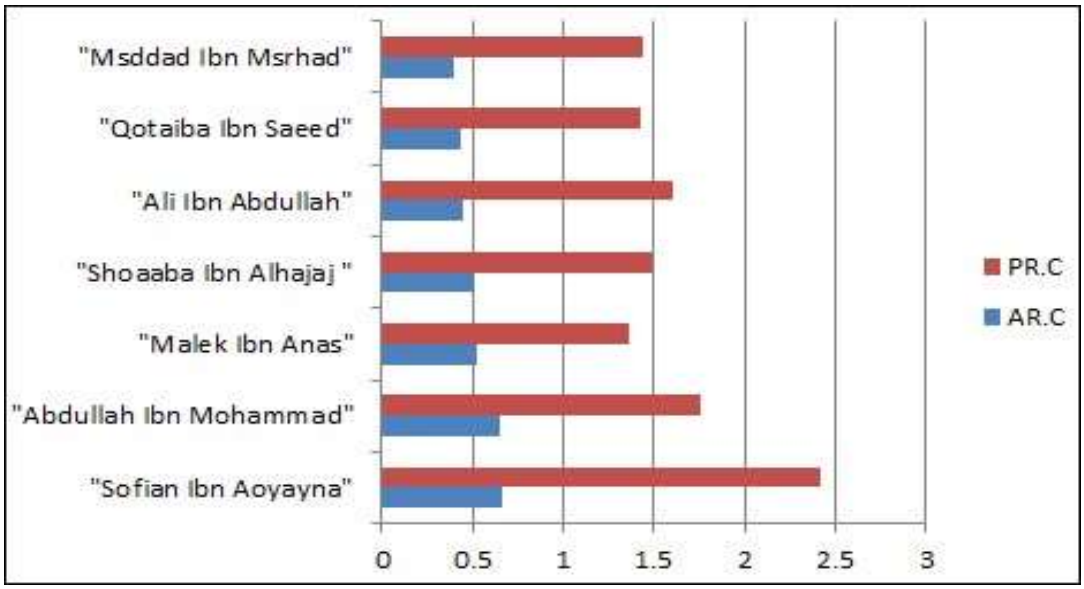


Figure A.5.1.10.41

Authority and Hub: Anas Ibn Malek associated with Om Haram, and her students in this Bab are Anas Ibn Malek and Amr Ibn Al-Aswad, and thus Amr Ibn Al-Aswad took the highest value in Authority among the Tabieen. As a result, Om Haram obtained the highest value among the Sahaba in the Hub measure, because it indicates two high values in the authority measure

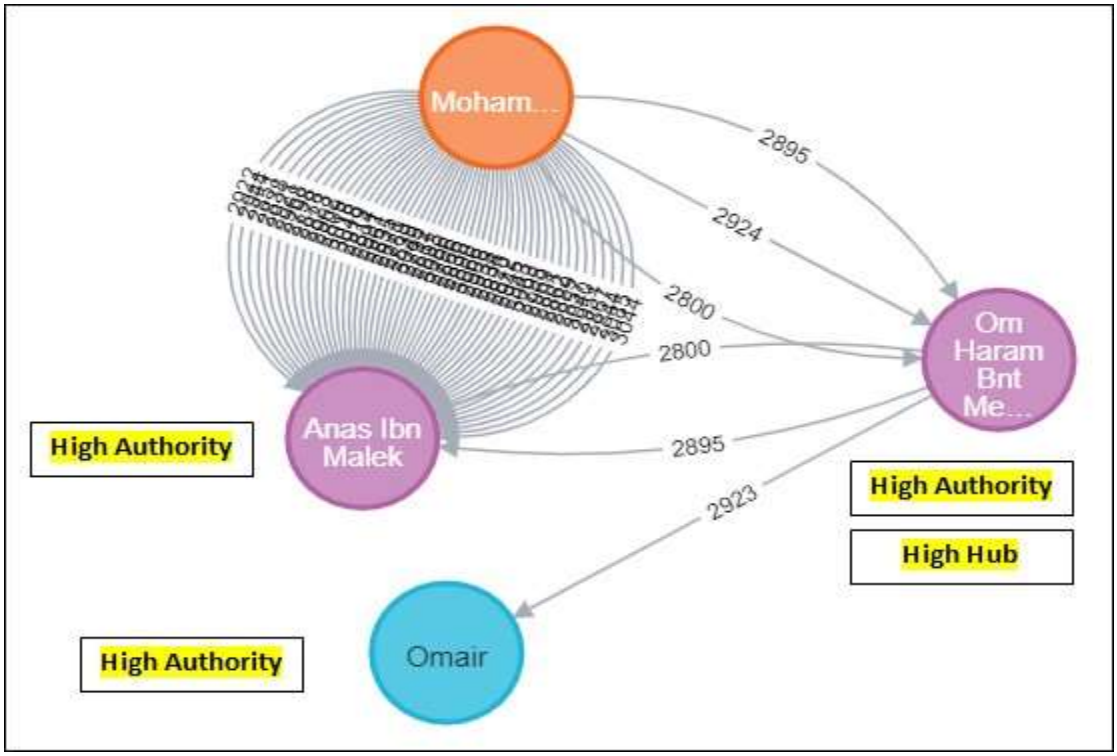


Figure A.5.1.10.42

Ataa Ibn Yasar has two sheikhs, Abu Huraira and Abu Saeed al-Khudri. All the students of these two sheikhs have a high authority because they influenced their students in the measure of authority and increased their value, and thus increased their value in authority and hub

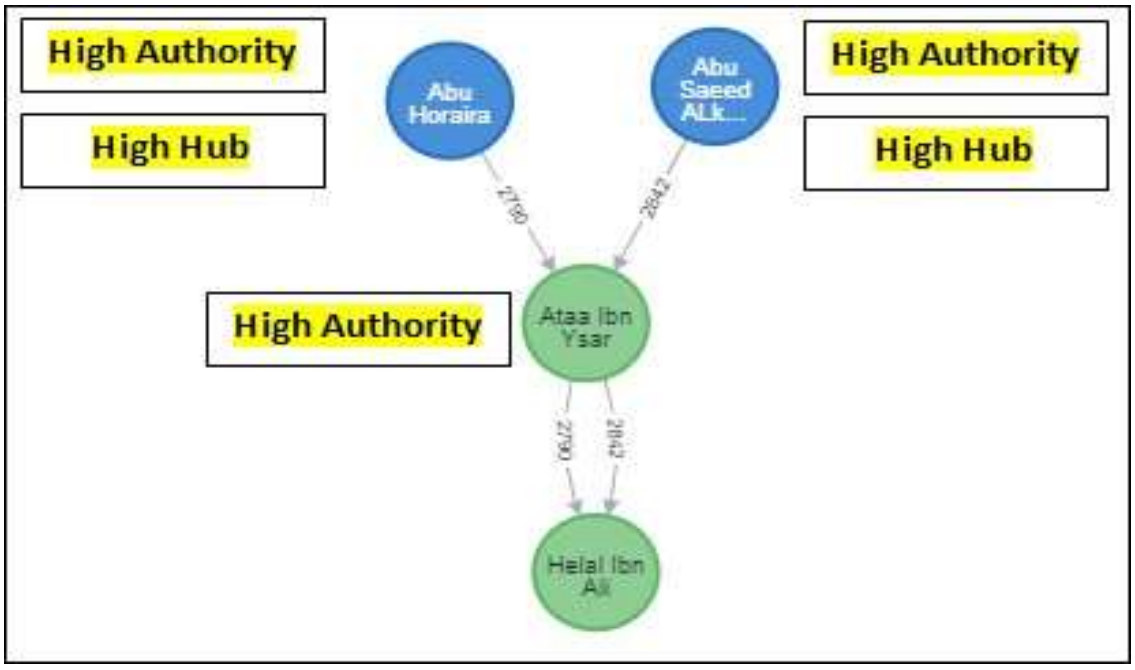


Figure A.5.1.10.43
Sahaba who obtained a high value in the hub measure

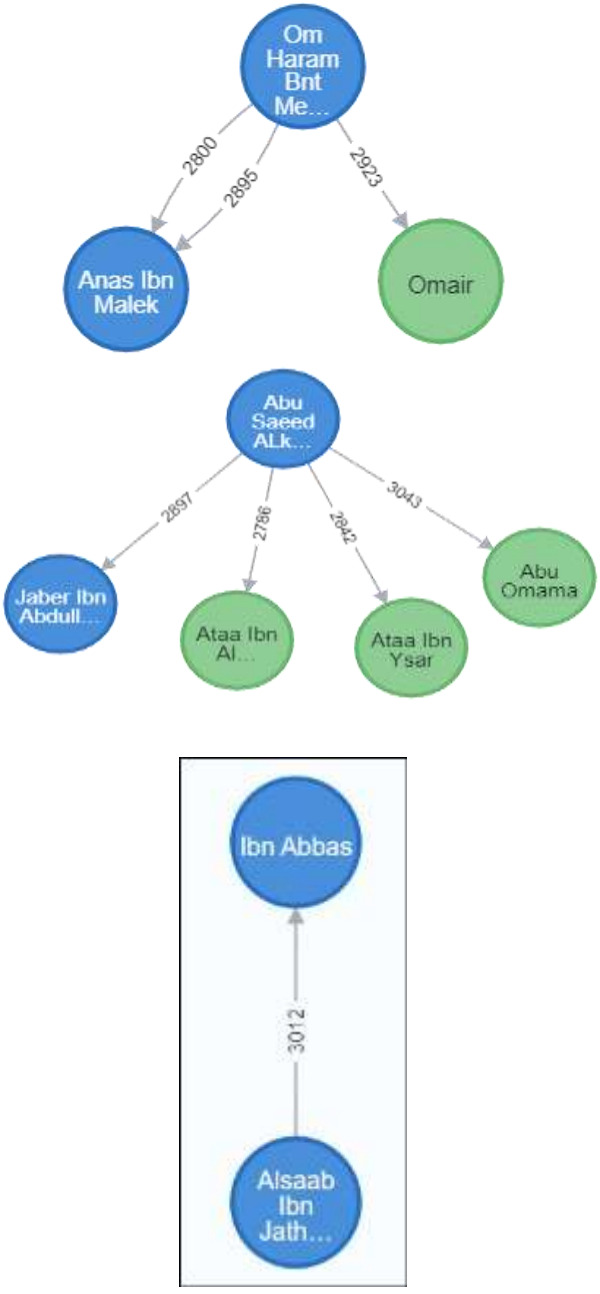


Figure A.5.1.10.44
Sahaba who obtained a high value in the hub measure

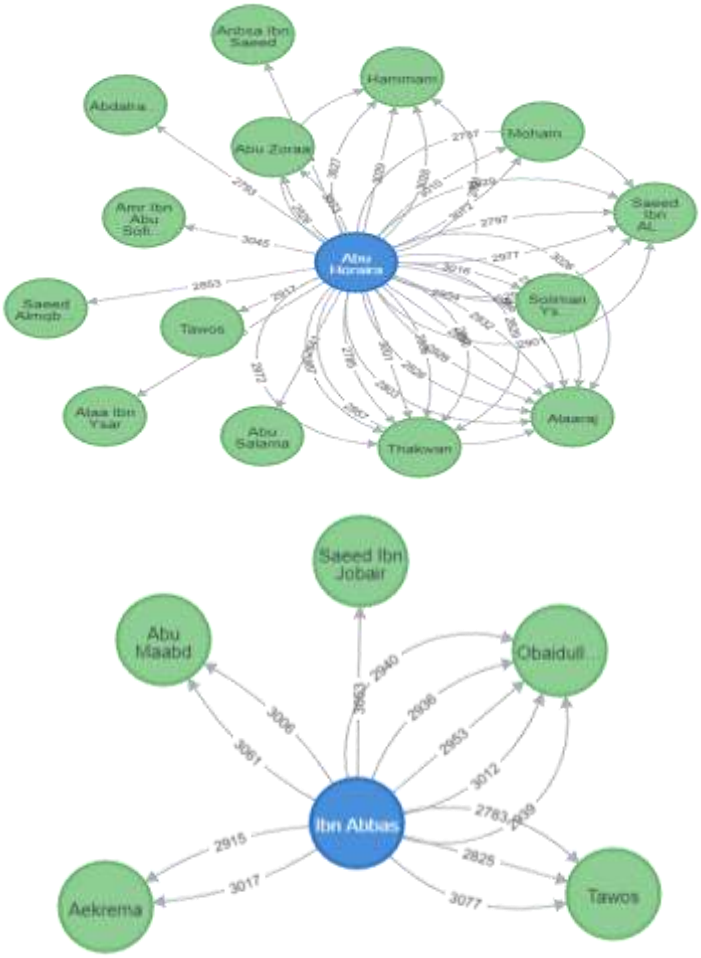


Figure A.5.1.10.45
The students for Malek Ibn Anas

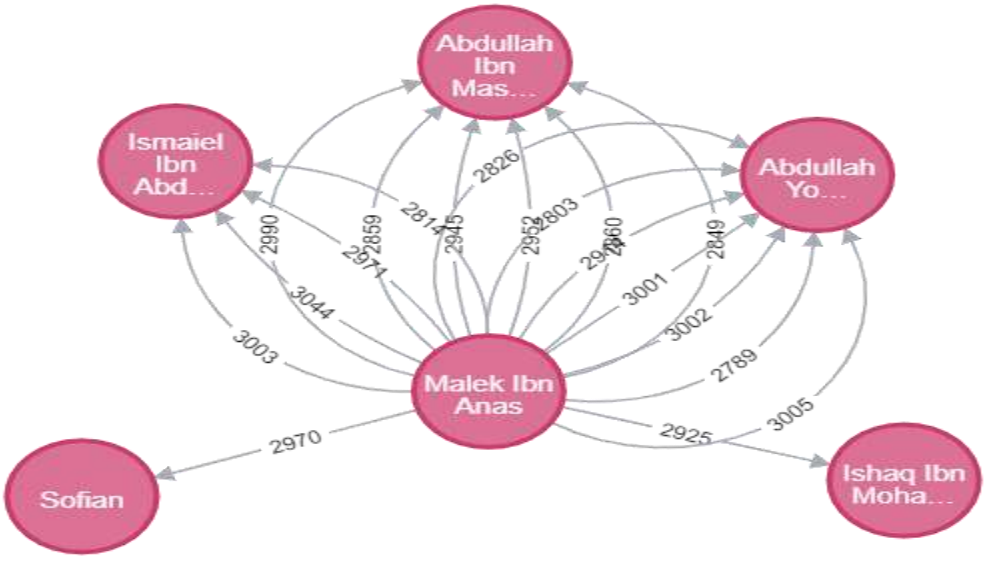


Figure A.5.1.10.46

Tabieen who obtained a high value in the hub measure, and they are: Bosr Ibn Saeed, Amr Ibn Denar, and Alzohre

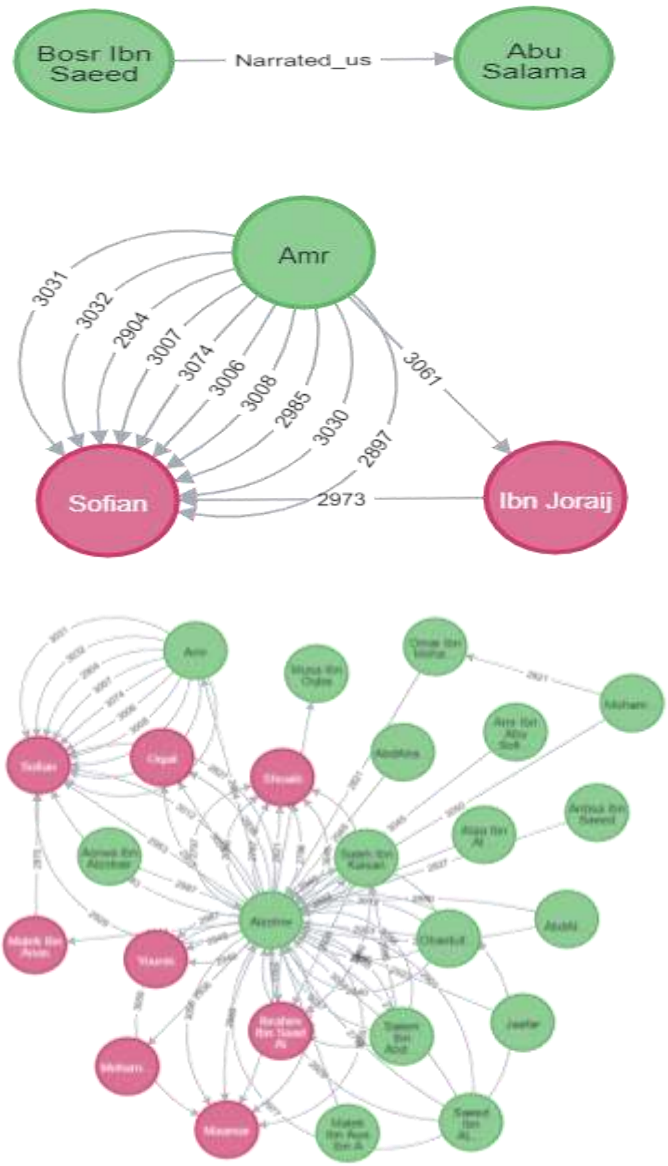
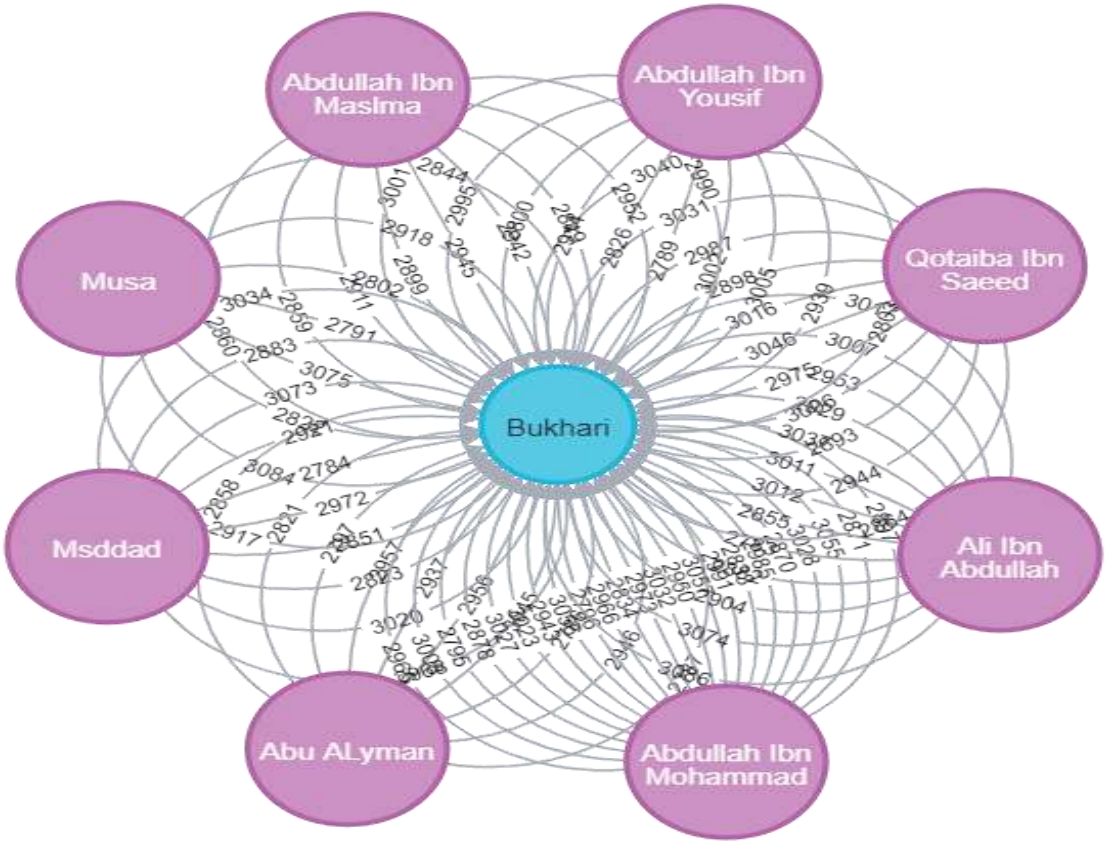


Figure A.5.1.10.47
Narrators who obtained a high value in the hub measure



Appendix B

Tables

Table 5.6
The result of R.C for the rest of the narrators who have a high value

Name	R.C
Shoaaba Ibn Alhajaj Ibn Alward Alaatke ALazade	**3.94E-04**
Abdullah Ibn Al-Mubarak Ibn wadeh Alhanthale Altamimi	**3.92E-04**
Hammad Ibn Zaid Ibn Drhm ALazade Aljhdme	**3.92E-04**
Hammam Ibn Yehia Ibn Denar Alothe Almhlme	**3.92E-04**
Allaith Ibn Saad Ibn Abdalrahman Alfhme	**3.92E-04**

Table 5.7
The highest result of E.C for Sahaba

Name	E.C
Ali Ibn Abu Taleb Abd Mnaf ibn Abdulmutallab Sheba	0.142857
Alabas Ibn Abdulmutallab Ibn Hashim Alqrshe Alhamshe	0.142857
Alsaab Ibn Jaththama Ibn Qais	0.142857

Table 5.8
The highest result of E.C for Tabieen

Name	E.C
Obaidullah Ibn Abu Rafea Aslam	0.166667
Nafea Ibn Jubair Ibn Mtam	0.166667

Table 5.9
The highest result of E.C for the rest of the narrators

Name	E.C
Thawr Ibn Yazeed Ibn Ziad Alklaei	0.333333333
AbdAlrahman Ibn Amr Ibn Abu Amr Yhmd Alshame Aldmshqe	0.333333333
Khalid Ibn Saeed Ibn Amr	0.333333333
Malek Ibn Meghwal Albgle	0.333333333

Table 5.10
The highest result of E.C and compare it with C.C and R.C

Name	C.C	R.C	E.C
Ali Ibn Abu Taleb Abd Mnaf ibn Abdulmutallab Sheba	1	3.93E-04	0.142857
Alabas Ibn Abdulmutallab Ibn Hashim Alhamshe	1	3.94E-04	0.142857
Alsaab Ibn Jaththama Ibn Qais	1	3.95E-04	0.142857
Obaidullah Ibn Abu Rafea Aslam	0.66667	3.92E-04	0.166667
Nafea Ibn Jubair Ibn Mtam	0.66667	3.94E-04	0.166667
Thawr Ibn Yazeed Ibn Ziad Alklaei	0.45455	3.92E-04	0.166667

AbdAlrahman Ibn Amr Ibn Abu Amr Yhmd Alshame	0.45455	3.92E-04	0.3333333
Khalid Ibn Saeed Ibn Amr	0.5	3.92E-04	0.3333333
Malek Ibn Meghwal Albgle	0.45455	3.92E-04	0.3333333

Table B.5.11
The result of applying Centrality measures to narrator 'Abu Huraira'

Name	Abu Huraira
D.C	80
B.C	46.88135753
S.C	55080
C.C	1
R.C	4.00E-04
Ecc.C	0.166666667
EV.C	4.65E-46
PR.C	0.17090164
AR.C	0.17057132
HITS.Auth	0.536834548
HITS_Hub	4.39E-07

Table B.5.12
The highest results in Degree Centrality Result

Name	D.C
Anas Ibn Malek Ibn Alndr Alansare Alnjare	106
Abdalrahman Ibn Sakhr	80
Mohammad Ibn Muslim Ibn Obaidullah Alqrshe Alzohre	62
Sofian Ibn Aoyayna ibn Abu Omran Maymon Alhelale	48
Abdullah Ibn Mohammad Ibn Abdullah Aljaafe	46
Abdullah Ibn Omar Ibn Alkhattab	44
Malek Ibn Anas Ibn Malek	40
Shoaaba Ibn Alhajaj Ibn Alward Alaatke ALazade	40
Sofian Ibn Saeed Ibn Masroq Althori	34
Amr Ibn Abdullah Ibn Obaid	32
Nafea	32
Jaber Ibn Abdullah Ibn Amr Alansare Alkhzrje Alslme	28
Abdullah Ibn Abbas Ibn Abdulmutallab Alqrshe Alhamshe	26
Ali Ibn Abdullah Ibn Jafar Alsaadi	26
Albaraa Ibn Azeb Ibn Alhareth Alkofe Alharethe Alansare Alawse	24
Humaid Ibn Abu Humaid Altawel Albasre	24
Ibrahim Ibn Mohammad Ibn Alhareth	24
Amr Ibn Denar Almacce	22
Maamar Ibn Rashed ALazade Alhdane	22
Qatada Ibn Daama Ibn Qatada	22
Qotaiba Ibn Saeed Ibn Jamel Althqfe	22
Abdullah Ibn Yousif Altnise	20
Alhakam Ibn Nafea	20
Muawiya Ibn Amr Ibn Almhlab ALazade Almaane	20
Msddad Ibn Msrhad Ibn Msrbal Alasade	20

Sahl Ibn Saad Ibn Malek Alansare	20
Shoaib Ibn Abu Hamza Denar Alqrshe Alomawi	20
Yehia Ibn Saeed Ibn Farrokh Alqattan ALhafez	20

Table B.5.13
The highest results in Betweeness Centrality Result

Name	B.C
Mohammad Ibn Muslim Ibn Obaidullah Alqrshe Alzohre	1670.142173
Sofian Ibn Saeed Ibn Masroq Althori	956.4193688
Sofian Ibn Aoyayna ibn Abu Omran Maymon Alhelale	566.5323403
Shoaaba Ibn Alhajaj Ibn Alward Alaatke ALazade	501.7891083
Musa Ibn Oqba Ibn Abu Ayyash Alqrshe Alasade Almtrfe	480.6511121
Malek Ibn Anas Ibn Malek	397.6505307
Abdullah Ibn Al-Mubarak Ibn wadeh Alhanthale Altamimi	387.6360196
Maamar Ibn Rashed ALazade Alhdane	314.1673682
Amr Ibn Abdullah Ibn Obaid	306.2136584
Aorwa Ibn Alzobair Ibn Alaawam Alqrshe Alasade	279.6694479
Yehia Ibn Saeed Ibn Farrokh Alqattan ALhafez	247.8907527
Anas Ibn Malek Ibn Alndr Alansare Alnjare	235.4105845
Amr Ibn Denar Almacce	223.557762
Yehia Ibn Saeed Ibn Qais	195.7649604
Ayob Ibn Abu Tamima Kisan ALstikhane	183.7103411
AbdAlmlk Ibn Abdulazeez Ibn Joraij Alqrshe Alomawi	168.310241
Amr Ibn Maymon Alawdie	156.9314677
Younis Ibn Yazeed Ibn Abu Alnajad	145.3839465
Asem Ibn Soliman Alahwal	128.9040348
Mansour Ibn Almoatamer Ibn Abdullah	121.6781756
Ibrahim Ibn Mohammad Ibn Alhareth	120.9881423
Allaith Ibn Saad Ibn Abdalrahman Alfhme	116.865523
Soliman Ibn Mahran Alasade Alkahle	112.3543854
Nafea	108.8043343
Ibrahim Ibn Saad Ibn Ibrahim Alzohre	106.561437
Abdullah Ibn Abbas Ibn Abdulmutallab Alqrshe Alhamshe	105.0227896

Table B.5.14
The highest results in Stress Centrality Result

Name	S.C
Anas Ibn Malek Ibn Alndr Alansare Alnjare	387123
Shoaaba Ibn Alhajaj Ibn Alward Alaatke ALazade	256457
Mohammad Ibn Muslim Ibn Obaidullah Alqrshe Alzohre	197901
Mohammad Ibn Jaafar Alhathle	144875
Qatada Ibn Daama Ibn Qatada	143519
Sofian Ibn Aoyayna ibn Abu Omran Maymon Alhelale	116206
Humaid Ibn Abu Humaid Altawel Albasre	112860
Maamar Ibn Rashed ALazade Alhdane	83719
Nafea	80828
Ibrahim Ibn Mohammad Ibn Alhareth	75316
Malek Ibn Anas Ibn Malek	70759
Abdullah Ibn Omar Ibn Alkhattab	68464
Amr Ibn Denar Almacce	61255
Amr Ibn Abdullah Ibn Obaid	58480
Abdalrahman Ibn Sakhr	55080
Sofian Ibn Saeed Ibn Masroq Althori	41345
Albaraa Ibn Azeb Ibn Alhareth Alkofe Alharethe Alansare Alawse	40176

Abdulrazak Ibn Hammam Ibn Nafea Alhmere	39295
Abdullah Ibn Mohammad Ibn Abdullah Aljaafe	34109
Obaidullah Ibn Abdullah Ibn Atba Alhathle	33650
Hammam Ibn Monabh Ibn Kamel	32750
Obaidullah Ibn Omar Ibn Hafs	28120
Musa Ibn Oqba Ibn Abu Ayyash Alqrshe Alasade Almtrfe	26733
Jaber Ibn Abdullah Ibn Amr Alansare Alkhzrje Alslme	25782
Shoaib Ibn Abu Hamza Denar Alqrshe Alomawi	21870
Ali Ibn Abdullah Ibn Jafar Alsaadi	21645

Table B.5.15

The highest results in Closeness Centrality Result

Name	C.C
AbdAlrahman Ibn Abu Baker Alsdeq Abdullah ibn Abu Qhafa Othman Alqrshe Altmimi	1
Abdalrahman Ibn Jabr	1
Abdalrahman Ibn Sakhr	1
Abdullah Ibn Abbas Ibn Abdulmutallab Alqrshe Alhamshe	1
Abdullah Ibn Abu Awfa Alqma Ibn Khaled	1
Abdullah Ibn Amr Ibn Alaas	1
Abdullah Ibn Masoud Ibn Ghafel	1
Abdullah Ibn Omar Ibn Alkhattab	1
Abdullah Ibn Qais Ibn Slem	1
Abu Basher Alansare Almdane Alasade Almazne	1
Abu Qatada Alansare	1
Aisha Bnt Abu Baker Alsdeq	1
Alabas Ibn Abdulmutallab Ibn Hashim Alqrshe Alhamshe	1
Albaraa Ibn Azeb Ibn Alhareth Alkofe Alharethe Alansare Alawse	1
Ali Ibn Abu Taleb Abd Mnaf ibn Abdulmutallab Sheba	1
Almoghera Ibn Shoaaba Ibn Abu Amer	1
Alrobaiea Bnt Moaweth Ibn Afraa Alnsarya Alnjarya	1
Alsaab Ibn Jaththama Ibn Qais	1
Alsaab Ibn Yazeed Ibn Saeed	1
Amr Ibn Alhareth Ibn Abu Derar	1
Amr Ibn Omya Ibn Khuwaylid	1
Amr Ibn Tghleb Alnmre	1
Anas Ibn Malek Ibn Alndr Alansare Alnjare	1
Hothaifa Ibn Alyman Hsel	1
Jaber Ibn Abdullah Ibn Amr Alansare Alkhzrje Alslme	1
Jarer Ibn Abdullah Ibn Jaber	1

Table B.5.16

The highest results in Radiality Centrality Result

Name	R.C
Anas Ibn Malek Ibn Alndr Alansare Alnjare	4.01E-04
Abdalrahman Ibn Sakhr	4.00E-04
Om Haram Bnt Melhan Malek Ibn Zaid	3.98E-04
Aisha Bnt Abu Baker Alsdeq	3.97E-04
Mohammad Ibn Muslim Ibn Obaidullah Alqrshe Alzohre	3.96E-04
Saad Ibn Malek Ibn Senan Alansare Almdane	3.96E-04
Abdullah Ibn Abbas Ibn Abdulmutallab Alqrshe Alhamshe	3.96E-04
Sahl Ibn Saad Ibn Malek Alansare	3.96E-04
Aorwa Ibn Alzobair Ibn Alaawam Alqrshe Alasade	3.96E-04
Humaid Ibn Abu Humaid Altawel Albasre	3.95E-04
Abdullah Ibn Omar Ibn Alkhattab	3.95E-04

Amr Ibn Abdullah Ibn Obaid	3.95E-04
Nafea	3.95E-04
Abdullah Ibn Qais Ibn Slem	3.95E-04
Jaber Ibn Abdullah Ibn Amr Alansare Alkhzrje Alslme	3.95E-04
Alsaab Ibn Jaththama Ibn Qais	3.95E-04
Mohammad Ibn Jubair Ibn Motaem Alqrshe Alnofle	3.95E-04
Abdullah Ibn Qais Ibn Slem	3.95E-04
Salem Ibn Abdullah Ibn Omar	3.95E-04
Omar Ibn Mohammad Ibn Jubair Ibn Motaem Alqrshe Alnofle	3.95E-04
Amr Ibn Abu Sofian Ibn osaid	3.95E-04
Anbsa Ibn Saeed Ibn Alaas	3.95E-04
Alsaab Ibn Yazeed Ibn Saeed	3.95E-04
Ataa Ibn Yazeed Allaith Aljndae	3.95E-04
AbdAlrahman Ibn Abdullah Ibn Kaab	3.95E-04
Jaafar Ibn Amr Ibn Omya	3.95E-04
Malek Ibn Aws Ibn Alhadathan	3.95E-04
AbdAlrahman Ibn Kaab Ibn Malek	3.95E-04
Saeed Ibn ALmosieb Ibn Hzn Alqrshe Almkhzome	

Table B.5.17

The highest results in Eccentricity Centrality Result

Name	E.C
Alsaab Ibn Jaththama Ibn Qais	0.142857143
Alabas Ibn Abdulmutallab Ibn Hashim Alqrshe Alhamshe	0.142857143
Ali Ibn Abu Taleb Abd Mnaf ibn Abdulmutallab Sheba	0.142857143
Obaidullah Ibn Abu Rafea Aslam	0.166666667
Abdullah Ibn Amr Ibn Alaas	0.166666667
Osama Ibn Zaid Ibn Hartha	0.166666667
AbdAlrahman Ibn Abu Baker Alsdeq Abdullah Ibn Abu Qhafa Othman Alqrshe Altmimi	0.166666667
Nafea Ibn Jubair Ibn Mtam	0.166666667
Yaala Ibn Omya Ibn Abu Obaida Abeed	0.166666667
Kaab Ibn Malek Ibn Abu Kaab Amr	0.166666667
Amr Ibn Omya Ibn Khuwaylid	0.166666667
Almoghera Ibn Shoaaba Ibn Abu Amer	0.166666667
Omar Ibn Alkhattab Ibn Nfel	0.166666667
Zaid Ibn Khaled Aljhne	0.166666667
Jubair Ibn Motaem Ibn Odai Alqrshe Alnofle	0.166666667
Om Haram Bnt Melhan Malek Ibn Zaid	0.166666667
Saad Ibn Malek Ibn Senan Alansare Almdane	0.166666667
Abdalrahman Ibn Sakhr	0.166666667
Aisha Bnt Abu Baker Alsdeq	0.166666667
Abdullah Ibn Abbas Ibn Abdulmutallab Alqrshe Alhamshe	0.166666667
Rafea Ibn Khdej Ibn Rafea	0.2
Omma Bnt Khalid Ibn Saeed	0.2
Hothaifa Ibn Alyman Hsel	0.2
Amr Ibn Abu Sofian Ibn osaid	0.2
Jarer Ibn Abdullah Ibn Jaber	0.2

Table B.5.18
The highest results in Eigenvector Centrality Result

Name	Ev.C
Msddad Ibn Msrhad Ibn Msrbal Alasade	0.000208823
Mahammad Ibn Almothanna Ibn Obaid	6.96077E-05
Ali Ibn Abdullah Ibn Jafar Alsaadi	3.48809E-05
Amr Ibn Ali Ibn Bahar Alserfe Albahle Albsre	3.48124E-05
Abdullah Ibn Mohammad Ibn Abu Shaiba	1.16013E-05
Amr Ibn Alabbas Albahle	1.16013E-05
Abdullah Ibn Mohammad Ibn Abdullah Aljaafe	5.23793E-06
Yosif Ibn Musa Ibn Rashed	2.07E-07
Ishaq Ibn Mansour Ibn Bahram Alkosj	5.13E-08
Saeed Ibn Mohammad Ibn Saeed	5.12E-08
Qabesa Ibn Aqaba Ibn Mohammad Alsawae	3.42E-08
Abdullah Ibn Alzobair Ibn Issa	2.57E-08
Sadaqa Ibn Alfadl	2.57E-08
Yehia Ibn Saeed Ibn Farrokh Alqattan ALhafez	2.56E-08
Mohammad Ibn Kather Alabde	2.56E-08
Qotaiba Ibn Saeed Ibn Jamel Althqfe	1.72E-08
Alfadl Ibn Dken Amr Ibn Hammad	1.71E-08
Mohammad Ibn Yousif Ibn Waqd	1.71E-08
Malek Ibn Ismail Ibn Durham	8.56E-09
AbdAlrahman Ibn Mahde Ibn Hassan	8.54E-09
Jaafar Ibn Awn Ibn Jaafar	8.54E-09
Alfadl Ibn Sahl Ibn Ibrahim Alaaraj Alhamshe	7.58E-09
Mohammad Ibn Yehia Ibn Abdullah Althohle	7.58E-09
Muawiya Ibn Amr Ibn Almhlab ALazade Almaane	1.15E-10
Ahmad Ibn Mohammad Ibn Musa	6.86E-11
Yehia Ibn Abdullah Ibn Bokair Alqrshe Almkhzome	6.86E-11

Table B.5.19
The highest results in PageRank Centrality Result

Name	P.C
Mohammad Ibn Muslim Ibn Obaidullah Alqrshe Alzohre	2.42759505
Sofian Ibn Aoyayna ibn Abu Omran Maymon Alhelale	2.41322907
Musa Ibn Ismaiel Almnqre ALhafez	1.77870941
Abdullah Ibn Mohammad Ibn Abdullah Aljaafe	1.76126972
Sofian Ibn Saeed Ibn Masroq Althori	1.76003791
Ali Ibn Abdullah Ibn Jafar Alsaadi	1.60376119
Shoaaba Ibn Alhajaj Ibn Alward Alaatke ALazade	1.48491966
Msddad Ibn Msrhad Ibn Msrbal Alasade	1.43318862
Qotaiba Ibn Saeed Ibn Jamel Althqfe	1.42030087
Malek Ibn Anas Ibn Malek	1.36559595
Abdullah Ibn Al-Mubarak Ibn wadeh AlhanthaleAltamimi	1.25668221
Soliman Ibn Harb Ibn Bajel ALazade Alwashehe	1.15457229
Amr Ibn Denar Almacce	1.13363655
Yehia Ibn Saeed Ibn Farrokh Alqattan ALhafez	1.04318837
Ishaq Ibn Ibrahim Ibn Makhld	1.01979765
Ishaq Ibn Mansour Ibn Bahram Alkosj	1.01350376
Alfadl Ibn Dken Amr Ibn Hammad	0.9958051
Allaith Ibn Saad Ibn Abdalrahman Alfhme	0.93690601
Abdullah Ibn Yousif Altnise	0.91978828
Alwaddah Ibn Abdullah Alyshkre	0.8857381
Amr Ibn Ali Ibn Bahar Alserfe Albahle Albsre	0.82512517

Yehia Ibn Saeed Ibn Qais	0.82205001
Soliman Ibn Mahran Alasade Alkahle	0.81579018
Ismaiel Ibn Abdullah Ibn Abdullah Alasbahe	0.79275199
Yehia Ibn Hamza Ibn Waqed Alhadrame	0.77849399

Table B.5.20

The highest results in ArticleRank Centrality Result

Name	AR.C
Mohammad Ibn Mslm Ibn Obaidallah Alqrshe Alzohre	0.75743307
Sofian Ibn Aoyayna Ibn Abu Omran Maymon Alhelale	0.65669695
Abdullah Ibn Mohammad Ibn Abdullah Aljaafe	0.64609963
Sofian Ibn Saeed Ibn Masroq Althori	0.52028631
Malek Ibn Anas Ibn Malek	0.51886898
Shoaaba Ibn Alhajaj Ibn Alward Alaatke ALazade	0.50364637
Ali Ibn Abdullah Ibn Jafar Alsaadi	0.44100208
Qotaiba Ibn Saeed Ibn Jamel Althqfe	0.42716702
Msddad Ibn Msrhad Ibn Msrbal Alasade	0.40135106
Musa Ibn Ismaiel Almnqre ALhafez	0.37674934
Yehia Ibn Saeed Ibn farokh Alqatan ALhafez	0.37086327
Abdullah Ibn Yousif Altnise	0.35523255
Alhakam Ibn Nafea	0.35363331
Abdullah Ibn Almobarak Ibn wadeh Alhanthale Altamimi	0.35239913
Allaith Ibn Saad Ibn Abdalrahman Alfhme	0.35148319
Ibrahim Ibn Mohammad Ibn Alhareth	0.34948512
Amr Ibn Denar Almacce	0.34897046
Amr Ibn Abdullah Ibn Obaid	0.34736971
Maamar Ibn Rashed Alazde Alhdane	0.3399786
Abdullah Ibn Maslma Ibn Qaabn Alqaanbe Alharthe	0.33938836
Moawia Ibn Amr Ibn Almhlab Alazde Almaane	0.33662002
Soliman Ibn Harb Ibn Bajel Alazde Alwashehe	0.3345977
Shoaib Ibn Abu Hamza Denar Alqorshe Alomawi	0.33343235
Ayob Ibn Abu Tamima Kisan ALstikhane	0.31123974
Hammad Ibn Zaid Ibn Drhm Alazde Aljhdme	0.30361215
Yehia Ibn Saeed Ibn Qais	0.2941852

Table B.5.21

The highest results in HITS Centrality Result

Name	Auth	Hub
Aabaya Ibn Rafaaa Ibn Rafeaa Ibn Khadej Alansare Alrzqe	9.94E-68	1.33E-69
Aabda Ibn Soliman Alklabe	1.28E-21	1.27E-75
Abbad Ibn Tmem Ibn Ghzya	9.48E-74	1.27E-75
Abbas Ibn Sahl Ibn Saad	4.97E-21	1.27E-75
AbdAlaala Ibn Hammad Ibn Nasr Albahle	4.10E-21	8.13E-12
AbdAlazez Ibn Abu Hazem Slama Ibn Denar Almkhzome	7.41E-18	6.16E-14
AbdAlazez Ibn Sohaib	2.39E-20	2.52E-61
AbdAlmlk Ibn AbdAlazez Ibn Joraij Alqorshe Alomawe	2.44E-15	5.60E-15
AbdAlrahman Ibn Abdullah Ibn Denar Alqrshe Aladwe Alamre	3.71E-18	1.33E-69
AbdAlrahman Ibn Abdullah Ibn Kaab	1.81E-60	1.10E-19
AbdAlrahman Ibn Abu Baker Alsdeq Abdullah Ibn Abu Qhafa Othman Alqorshe Altmimi	0.013420864	1.27E-75
AbdAlrahman Ibn Amr Ibn Abu Amr Yhmd Alshame Aldmshqe	4.49E-18	4.79E-15
AbdAlrahman Ibn Kaab Ibn Malek	3.61E-60	2.19E-19
AbdAlrahman Ibn Mahde Ibn Hassan	5.37E-18	1.27E-75
AbdAlrahman Ibn Ml	2.38E-51	3.00E-54

AbdAlrahman Ibn Soliman Ibn AbdAlrahman	9.48E-74	1.44E-19
AbdAlwahed Ibn Ziad Alabde	1.45E-18	5.19E-21
AbdAlwareth Ibn Saeed Ibn Thekwan Altamimi	1.53E-59	1.55E-56
AbdRubh Ibn Nafea Alknane	1.25E-19	9.71E-15
Abdalazez Ibn Abdullah Ibn Yehia	3.17E-57	2.44E-11
Abdalmlk Ibn Amr Alqaisi	9.48E-74	8.13E-12
Abdalmlk Ibn Omair Ibn Swaid Alqorashe	5.75E-33	4.44E-66
Abdalrahman Ibn Abu Amra Yaser Ibn Amr	5.89E-09	7.28E-62
Abdalrahman Ibn Hrmz Ibn Kesan Alaaraj	5.30E-08	3.62E-17

جامعة النجاح الوطنية

كلية الدراسات العليا

تطبيق المقاييس المركزية على انطولوجيا أسانيد الحديث النبوي الشريف في صحيح البخاري

إعداد

رولا مهيوب أبو رويس

إشراف

د. أمجد هواش

د. محمد جيطان

قدمت هذه الرسالة استكمالا لمتطلبات الحصول على درجة الماجستير في الحوسبة المتقدمة، من كلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس–فلسطين.

2023

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الملخص

المصدران الرئيسيان للتشريع الإسلامي هما القرآن والحديث. الأحاديث هي الروايات الواردة من أقوال وأفعال النبي محمد (صلى الله عليه وسلم). وقد نقل الرواة أقوال عن النبي بالإسناد، وأهمية اهتمام المسلم الشديد بعلم الإسناد لأنه يساعد على التمييز بين الحديث المقبول والمرفوض، أو بمعنى آخر الحديث الصحيح والضعيف. وكان علماء الإسلام أول من قام بدراسة الإسناد بعناية لمعرفة والتمييز بين الروايات الموثوقة وغير الموثوقة، خاصة مع انتشار الإسلام في البلاد غير العربية وتزايد أعداد المسلمين من مختلف الثقافات.

يعتمد هذا العمل على أنطولوجية رواية أحاديث باب الجهاد والسير في صحيح البخاري، من أجل تطبيق مقاييس مركزية وجودية مختلفة لتوليد مجموعة من الأعداد المرتبطة بكل راوي. وقد تم التحقيق في هذه الأرقام لدراسة أهمية ومدى مشاركة راوي معين في عملية رواية الحديث. ولكل مقياس مركزي مطبق قمنا بدراسة الأعداد المحسوبة لكل راوي لنبين مدى ارتباط هذه الأعداد بأهمية الرواة من حيث اهتماماتهم بالروايات، وحجم جهودهم، ومراتبهم في عملية السرد. وتمت مقارنة هذه النتائج مع الجهود اليدوية التي طبقتها الدراسات الإسلامية والتي تعتمد على التصنيف اليدوي للرواة.

الكلمات المفتاحية: الحديث، إسناد الحديث، الأنطولوجيا، أنطولوجيا رواة الحديث، مقاييس المركزية.