Social Relationship Analysis of the Diffusion of Hadith in Sahih Al-Bukhari

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Abstract— *Hadith literally means narrative. From a sociological perspective, it is a narrative tradition that became a science owing to the social structure and the critical approach developed around it in the first century of Islam (Senturk, 1995). This research aims to analyze the Islamic scholars who have an important role in the diffusion of hadith in Shahih Al-Bukhari. This research uses 7.563 hadith dataset which referred from islamweb.com and muslimscholars.info. The dataset has been verified with the primary reference which is the book of Fathul Baari and Tahdib At-Tahdib. Centrality and betweenness degree algorithm used to analyze the scholars who have an important role in the network. While assortativity used to analyze the relationship among the scholars who have similar characteristic. The research finds that Abu Hurairah R.A and Ibn Abbas R.A are the most influential companions of Prophet SAW. While on the next generation (tabi'in and tabi'ut tabi'in) Al-Zuhri and Shu'bah bin Al-Hajjaj are the most influential scholars. Both are also considered as the highest betweenness score. Ibn Umar R.A is the companion of Prophet SAW who has the highest betweenness score. The research also finds the network is disassortative.*

Keywords— *Diffusion of Hadith, Sahih Al-Bukhari, Social Network Analysis.*

I. INTRODUCTION

Humans are social creatures that interact with one another. The human social interactions have made the emotional relationship between individuals. The relationship and social interactions have formed a separate field of study known as Social Science. The late 1900s and early 2000s were the beginning of the emergence of analytical, mathematical, and computational methods in Social Science such as agent based modeling (Macy and Willer, 2002) and social network analysis (Lazer et al, 2009).

The concepts of social network analysis developed out of a propitious meeting of social theory and application, with formal mathematical, statistical, and computing methodology (Wasserman and Faust, 1994). Diffusion of information is an indication of a social relationship among individuals in a community. The information diffused by individuals within a community will form a narrative network. Narrative networks refer to a class of social networks which are formed by creating edges between people who have narrated stories, reports, incidences, etc from one another (Ahmad, 2013). Narrative networks can be represented by a directed graph where the node in the beginning of a graph represents the first story teller.

Hadith literally means narrative. From a sociological perspective, it is a narrative tradition that became a "science" owing to the social structure and the critical approach developed around it in the first century of Islam (Senturk, 1995). In Islamic terminology, hadith is defined as something that comes from the Prophet Muhammad SAW in the form of words, deeds and or his consent (Khon, 2010).

This paper aims to analyze the hadith narrator who are considered to have an important role in the diffusion of hadith. This paper focuses on the book Sahih Al-Bukhari which is considered as the most authentic book of hadith in Islam (An-Nawawi, 2009).

II. RELATED WORK

Social relationship in the diffusion of hadith has impressed the researchers to research the various aspect of hadith. Dini et al. (2017) have analyzed the narrators and countries that considered have a paramount role in the diffusion of hadith. The research uses Centrality, Betweenness, and Closeness algorithms with dataset 7008 hadith of Sahih Al-Bukhari taken from the software encyclopedia hadith. They stated Shu'bah bin Al-Hajjaj as the most influence narrator. The hadith narration has diffused for more than 100 years through the beginning generations of Islam (Companion, Tabi'in, and Tabi'ut Tabi'in). Therefore, the categorization by the life period will give insight into the influence narrator for each generation. However, the research has not covered this concern.

Ahmad (2013) uses Page Rank, Centrality and Betweenness algorithms to discover the most influential of hadith narrator in Sahih Al-Bukhari with only around 5% dataset of hadith. He stated Abu Hurairah R.A is the most influence narrator. The small number of dataset makes this research could not to figure out the full picture of hadith narration in it.

Senturk (2004) has researched by exploring the literation structure of diffusion hadith regarding the social structures from the perspective of history. The research has categorized the narrators into seven layers by following the three beginning generation in Islam (Companion, Tabi'in, and Tabi'ut Tabi'in). He has solid argumentation about discovering the social structure of diffusion hadith. However, his research in the perspective of history makes the research not entirely relevant to this research.

There are also few another researches of Sahih Al-Bukhari such as text mining to judge the authenticity of hadith. However, none of them uses the book of Fathul Baari that contains the extensive explanation of Shahih Al-Bukhari to confirm the narrator chain.

III. METHODOLOGY

This research uses the Social Network Analysis (SNA) methodology. In a few words, Social Network Analysis (SNA) can be described as a study of human relationships by means of graph theory (Tsvetovat and Kouznetsov, 2011). This research focuses on the hadith narrators who have an important role for each generation. To cover this objective, we use centrality and betweenness degree algorithms. While on the other hand, this research also concerning about the assortativity of the network. Assortativity is a preference for a network's node to attach to others that are similar in some way. Therefore, the assortativity coefficient of hadith narrator chain will be computed as well in this research.

A. Centrality Degree

Opsahl et al. (2010) proposed an approach to compute the centrality degree in the directed weighted graph. They combined the number of degree and amount of weight in a relationship formed between two connected nodes. The correlation between these two aspects defined through parameter tuning. This approach described in the following equation :

$$C_{D-\,out}^{w\alpha}(i) = k_i^{out} \times \left(\frac{s_i^{out}}{k_i^{out}}\right)^{\alpha} \qquad (1)$$

$$C_{D-\,in}^{w\alpha}(i) = k_i^{in} \times \left(\frac{s_i^{in}}{k_i^{in}}\right)^{\alpha} \qquad (2)$$

Where:

α is a positive tuning parameter between 0 and 1.

k is node's degree (in / out).

s is node's weight (in / out).

In this research we are using $\alpha = 0.5$ which means the important proportion between node's degree and node's weight 50% each.

B. Betweenness Centrality

Betweenness centrality defined as the actors who act as bridges between two or more communities in the network, therefore without these actors, the communication between these communities could not be formed (Tsvetovat dan Kouznetsov, 2011). Freeman (1977) defined an equation to compute betweenness centrality of a node in a graph.

$$C_B(v) = \sum_{s \neq v \neq t \in V} \frac{\sigma_{st}(v)}{\sigma_{st}} \qquad (3)$$

Where:

$\sigma_{st}(v)$ is the number of shortest path between node s and t through node v.

σ_{st} is the number of shortest path between node s and t.

Barrat et al. (2004) proposed an approach to compute the shortest path in the weighted graph. They stated the shortest path computation in the weighted graph done by sum the weighted in an edge that adjacent of two nodes. This approach described in the following equation:

$$S_i = \sum_{j=1}^{N} a_{ij}\, w_{ij} \qquad (4)$$

Where:

a_{ij} is the number of degree between connected node i and j.

w_{ij} is the number of weight between connected node i and j.

C. Assortativity

Assortativity is a preference of a node to be connected by having a similar characteristic. Newman (2003) stated if people prefer to associate with others who are like them, then the network shows assortative mixing or assortative matching. This paper focuses on analyzing the scalar assortativity that is the number of degrees. The network will be considered as the assortative if the nodes with a high degree tend to connect with the other nodes that also have a high degree.

Assortativity Coefficient is a method to measure the assortativity. Assortativity Coefficient is the Pearson correlation of degree between pairs of linked nodes (Newman, 2002). In the directed graph, the assortativity coefficient measurement represented in the four forms these are. Newman (2003) proposed an approach to compute the assortativity coefficient by using the following equation:

$$r_{\alpha,\beta} = \frac{\sum_{jk} jk\left(e_{jk}^{\alpha,\beta} - q_{\leftarrow j}^{\alpha}\, q_{\rightarrow k}^{\beta}\right)}{\sigma_{\leftarrow}^{\alpha}\,\sigma_{\rightarrow}^{\beta}} \qquad (5)$$

Where:

α refer to the *in* indices

β refer to the *out* indices

e_{jk} is the probability that a randomly chosen directed edge leads into a vertex of in-degree *j* and out of a vertex of out-degree *k*.

$\sigma_{\leftarrow}^{\alpha}$ and $\sigma_{\rightarrow}^{\beta}$ are standard deviations.

IV. DATASET

Sahih Al-Bukhari is the book of hadith which considered as the most authentic book of hadith in Islam (An-Nawawi, 2009). This book is compiled by Al-Imam Muhammad bin Ismail Al-Bukhari (194 – 256 H) which contains 7653 of hadith and categorized within the 97 chapters. He did not include the hadith into his book except those considered as the authentic hadith which the chain of narration connected to the Prophet Muhammad SAW (Khon, 2010).

Fathul Baari has widely known in Islamic literacy as the book which contains the commentary of Sahih Al-Bukhari. The book had written by Al-Imam Ibnu Hajar Al-Asqalani

(773 – 852 H) around 500 years after the life of Imam Al-Bukhari.

This research uses 7563 hadith in Sahih Al-Bukhari as the datasets. The dataset that has taken from the digital source then compared to the book of Fathul Baari. This comparison is necessary with the following considerations, these are :

1. Condensation of Chain

Fig. 1. Condensation of Hadith Chain.

Figure 1 describes the condensation of hadith chain in Sahih Al-Bukhari. In number hadith 1206 we will find the narration of hadith was begun from Imam Al-Laits bin Sa'ad (94 – 175 H). If we are looking at the life period of Imam Al-Laits we will see that he lived in a different era with Imam Al-Bukhari (194 – 256 H). Therefore the book of Fathul Baari explains that there is someone between Imam Al-Laits and Imam Al-Bukhari who narrated this hadith. He is Al-Imam 'Asim bin 'Ali (died in 201 H), he is the teacher of Imam Al-Bukhari as well.

Fig. 2. Commentary upon Condensation of Chain.

2. Implicit Narrator

Fig. 3. Implicit Narrator.

There is also a certain case in Sahih Al-Bukhari where the name of the narrator was not explicitly mentioned. The figure 3 describes in the hadith number 7063 Imam Al-Bukhari mentioned that Imam Hammad has received the hadith narration from someone who did not mention his name. The book of Fathul Baari explains that Imam Al-Bukhari is talking about 'Amru bin 'Ubaid (died in 143 H). 'Amru bin 'Ubaid was the Islamic scholar of mu'tazilah (the rationalist group in Islam).

Fig. 3. Commentary upon the Implicit Narrator.

Regardless of his controversial thought as the mu'tazilah (rationalist) scholar, this research aims to describe that the book of Fathul Baari able to explain the information which not explicitly mentioned in Sahih Al-Bukhari.

V. NETWORK ANALYSIS

The verified dataset then formed as the weighted directed graph. The following figure describes how the hadith chain transformed into a weighted directed graph.

Fig. 4. Example of Hadith Narration.

The following picture describes the extraction of hadith chain where the first node in this graph represents the first narrator who sees or hear the narration from Prophet Muhammad SAW.

Node	Narrator	Node	Narrator
1	Ka'b bin 'Ajra al-Salmi al-Ansari	5	Abdullah bin Abi Najih
2	Abdur Rahman bin Abi Layla	6	Sufyan bin Sa'id Ats-Tsauri
3	Mujahid bin Jabir	7	Qabaysa bin 'Uqba
4	Ayoub al-Sakhtiyani		

Fig. 5. Example of Chain Extraction.

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When the extraction of the hadith chain has completed, this chain will form a network with 1534 nodes and 5669 edges (links).
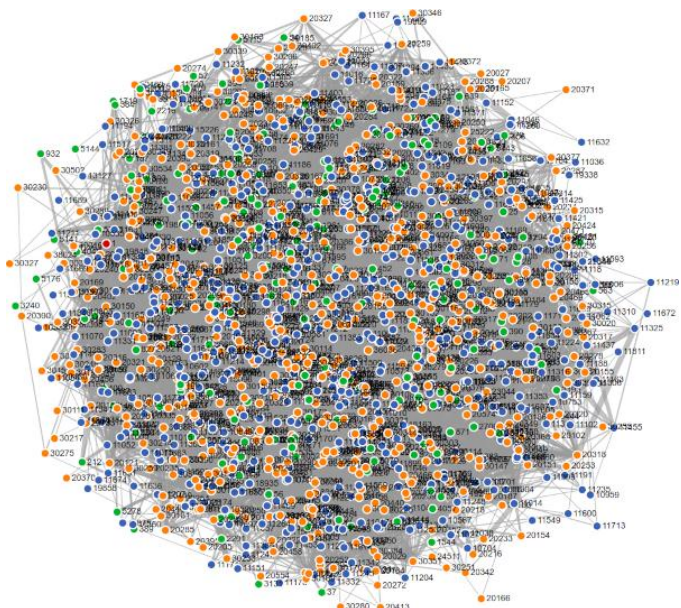

Fig. 6. Hadith Narration Network.

A. Centrality Degree

This chapter describes the centrality degree measurement of the three beginning generation in Islam.
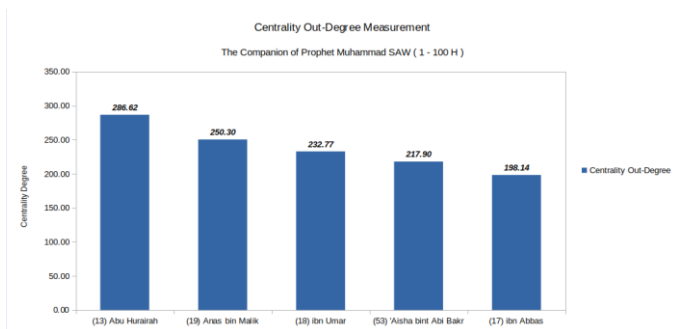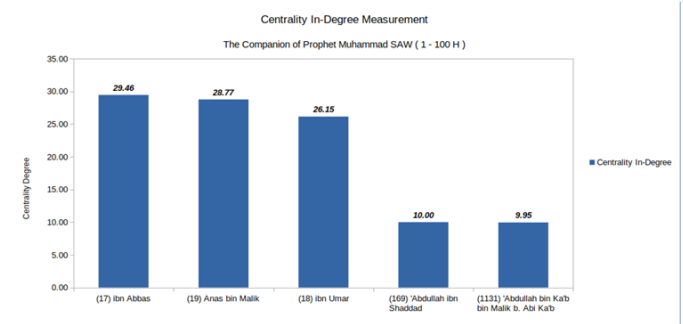

Fig. 7. Centrality out-degree the Companion of Prophet SAW.

Figure 7 describes the centrality out-degree of the companion of the Prophet Muhammad SAW. Abu Hurairah R.A (died in 57 H) is the companion of Prophet SAW who has the highest centrality out-degree. Even though his social interaction with the Prophet SAW is only around for two or three years, he taught about hadith to the next generation around 47 years after the Prophet SAW died. He is also the one of Ahlus Suffah, the companion of the Prophet SAW who lives in the back of the Prophets Mosque. Therefore, this is an accurate indication that he had intensive social interaction with the Prophet SAW.

Fig. 8. Centrality in-degree the Companion of Prophet SAW.

Figure 8 describes the centrality in-degree of the companion of the Prophet Muhammad SAW. Based on the measurement, Ibn Abbas R.A is the companion of the Prophet SAW who has the highest centrality in-degree. He was the cousin of the Prophet SAW who receive the hadith not only from him directly, but also from the several companion others. Therefore, his in-degree centrality considers higher than the other companions.
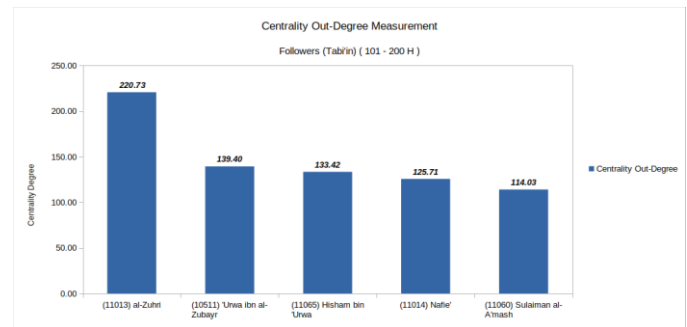
Fig. 9. Centrality out-degree the Followers (Tabi'in).
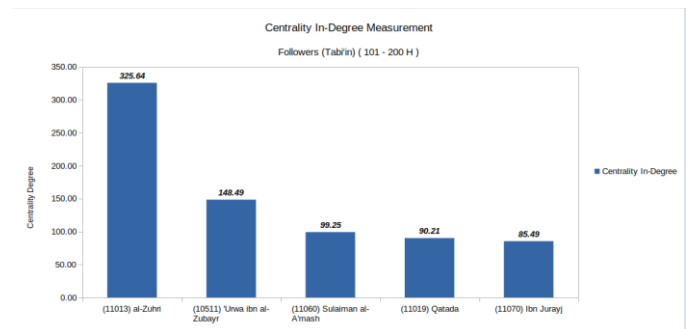
Fig. 10. Centrality in-degree the Followers (Tabi'in).

Figure 9 and 10 describe the centrality measurement (in and out-degree) of followers (Tabi'in) generation. In this era, Al-Zuhri considered as the most influential narrator. His original name was Muhammad bin Shihah Al-Zuhri. He also one of the Islamic scholars who involved in compiling the hadith in the Umayyad caliphate era which governed by Umar bin Abdul Aziz.
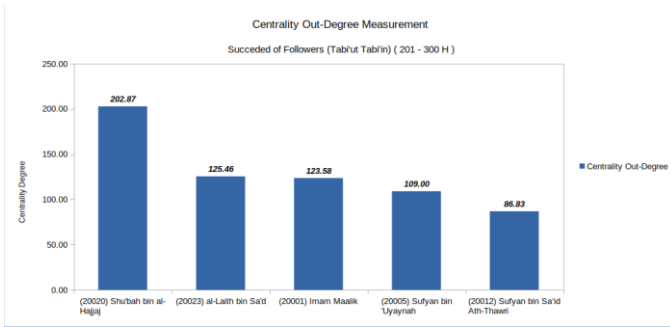
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Fig. 11. Centrality out-degree the Succeeded Followers (Tabi'ut Tabi'in).
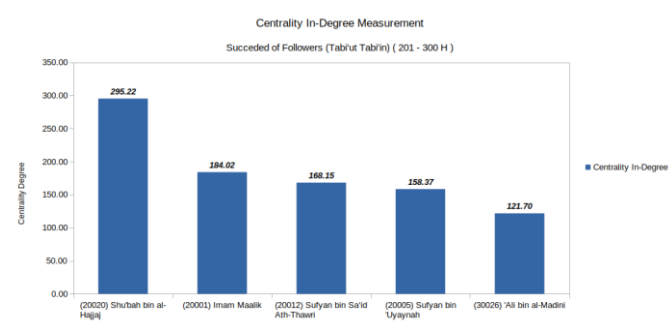

Fig. 12. Centrality in-degree the Succeeded Followers (Tabi'ut Tabi'in).

Figure 11 and 12 describe the centrality measurement (in and out-degree) of Succeeded of the Followers (Tabi'ut Tabi'in). Based on the measurement, Shu'bah bin Al-Hajjaj considered as the most influential narrator. He was the Islamic scholars from Basra, Iraq and became a pioneer of diffusion of hadith in Basra.

B. Betweenness Centrality

This chapter describes the betweenness degree measurement of the three beginning generation in Islam.
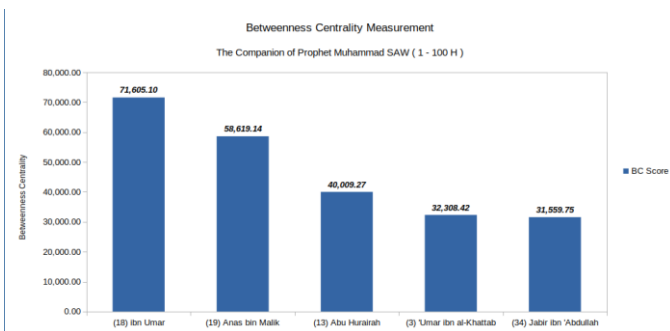
Fig. 13. Betweenness Centrality the Companion of Prophet SAW.

Figure 13 describes the betweenness centrality of the companion of the Prophet Muhammad SAW. Based on the measurement, Ibnu Umar R.A is the companion who has the highest betweenness score. He considered as the bridge of diffusion hadith between two generations. He narrated hadiths from the several elder companions and spreading to the next generations. Nafi'e, Sa'id al-Musayyib and his sons Salim bin Abdullah bin Umar and Hamzah bin Abdullah bin Umar are several narrators who receive hadith from him.
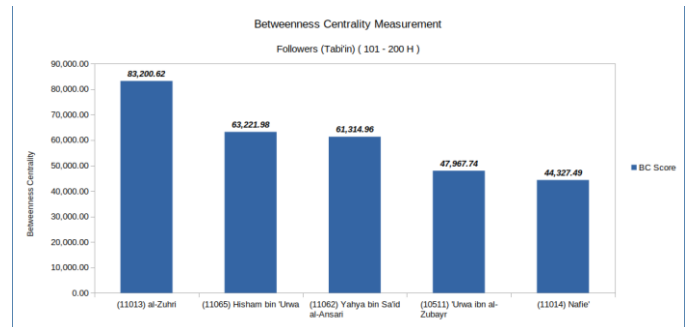

Fig. 14. Betweenness Centrality the Followers (Tabi'in).

The betweenness centrality of Followers (Tabi'in) shows that al-Zuhri still considered as the most influential narrator.
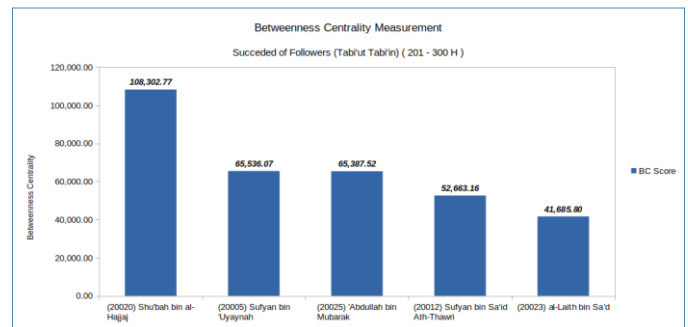

Fig. 15. Betweenness Centrality the Succeeded of Followes (Tabi'ut Tabi'in).

The same thing happens in the succeeded of followers (tabi'ut tabi'in). Based on the measurement, Shu'bah bin Al-Hajjaj considered as the most influential narrator.
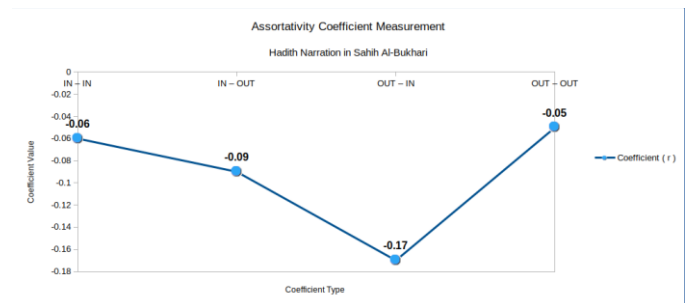
C. Assortativity

Fig. 16. Assortativity Coefficient of the Network.

Figure 16 describes the assortativity coefficient of the narration hadith network in Sahih Al-Bukhari. Based on the measurement we can see the network is disassortative that means the hadith narrator who has a high degree tend to connect with the other narrator who has a low degree.

VI. CONCLUSION

Based on the discussion and analysis result explained in the previous chapter, it can conclude as follows:
1. Abu Hurairah R.A is the companion of the Prophet Muhammad SAW who has the highest out-degree centrality. And Ibn Abbas R.A is the companion who has the highest in-degree centrality. In the next generation, Al-Zuhri and Shu'bah bin Al-Hajjaj are the hadith narrators

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who have the highest degree centrality for the follower (tabi'in) and succeeded (tabi'ut tabi'in) generation.

2. Ibn Umar R.A is the companion of the Prophet Muhammad SAW who has the highest score of betweenness centrality. While on the next generation, Al-Zuhri and Shu'bah bin Al-Hajjaj are the hadith narrators who have the highest score of betweenness degree for the follower (tabi'in) and succeeded (tabi'ut tabi'in) generation.

3. The assortativity coefficient describes the network of hadith narrator in Sahih Al-Bukhari is disassortative.

VII. FUTURE WORKS

Even though Sahih Al-Bukhari considered as the most authentic the book of hadith, there is also another book that grants as the pair of Sahih Al-Bukhari. That is the book of Sahih Al-Muslim.

Sahih Al-Muslim had compiled by Al-Imam Muslim bin Al-Hajjaj Al-Qusyairi (died in 261 H). He was the most loyal student of Imam Al-Bukhari. There is a lot of hadith narration in Sahih Al-Muslim which also mentioned in Sahih Al-Bukhari. The difference is Imam Al-Muslim narrated those hadiths with the different chain from his teacher Imam Al-Bukhari. Therefore, in the literature of hadith Sahih Al-Bukhari and Sahih Al-Muslim are the pairs of primary reference in the field of hadith.

From the social network perspective, concatenate the chain in the Sahih Al-Bukhari and Sahih Al-Muslim into a single network will give more comprehensive insightful to discover the hadith narrators who have a paramount role in the diffusion of hadith.

ACKNOWLEDGMENT

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