

# The Dynamics of Online Commenting Systems

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## ABSTRACT

Several websites such as 4chan, reddit, Stack Overflow, Quora and Facebook provide a commenting mechanism to allow users to partake in online discussions about news articles, engage in question and answer and discuss general matters of interest. In this paper we investigate the relationship between comment structure and user engagement times. Our hypothesis is that radial and non-radial comment structures have different user engagement times. To test our hypothesis we crawled over 6000 4chan threads and determined that the level of user engagement is independent of the comment structure if the post has less than 100 comments. For discussions with greater than 100 comments, the commenting structure has a significant impact on the level of user engagement.

## Categories and Subject Descriptors

K.4.3 [Computers and Society]: Organizational Impacts, Computers Supported Collaborative Work.

## General Terms

Measurement, Performance, Experimentation, Verification

## Keywords

Discussion network, radial graphs, user engagement

## 1. INTRODUCTION

Discussion platforms combined with the anonymity of the internet provide a large social influence. Discussion forums permit people to be exposed to differing views and arguments. In certain instances, they also result in people becoming more staunch in their beliefs; this is especially true if the conversation is primarily with like-minded individuals. At other times, discussion forums can result in a grand consensus to be formed.

While it is clear that discussion forums further the exchange of information, it is less obvious as to the degree that the underlying structure is responsible for the evolution of the conversation. Today many websites such as Facebook and Stack Overflow host discussion forums as part of the services that they provide. For websites such as 4chan, reddit and Quora, a discussion platform is the primary product that they offer. It is well known that all the aforementioned websites rely upon user retention to drive advertising revenue. Given the online advertising revenue that is at stake, it is pivotal to determine the characteristics of a commenting structure that best promote user interest in the

comment discussion. Finding the relation between user activity and commenting structure can possibly help increase user retention and thus lead to greater income from advertisements.

The rest of this paper is as follows. First, we define key terminology that we use in this paper. We also provide a preliminary overview of the two main comment structures that are found on the internet and proceed to discuss some related work. We then discuss some of the key structural characteristics of discussion networks found on popular websites. We then explain our hypothesis test and examine the statistical properties of the commenting data that we extracted from several 4chan threads. Our claim is that there exists a dependency between the underlying comment structure and the intensity by which users are encouraged to further contribute towards the comment discussion. Our results show that such a dependency does in fact exist. Finally, we conclude by summarizing our findings.

### 1.1 Preliminary

We define user engagement as the time required for a certain proportion of total replies of a discussion to be achieved. For example, if 75% of the total replies to a post occur within 3 hours, then we say that the 75% user engagement time of the post is 3 hours. User engagement provides a succinct indication of the level of user contribution to a thread over time. Our interpretation of user engagement is that shorter user engagement time for a fixed proportion is indicative of greater user interest in the discussion topic and comment conversation.

From a preliminary survey of the popular discussion forums, there are two main classes of comment structures which we refer to as radial and non-radial. A radial comment structure typically permits one or sometimes two levels of replies to the original post. An example is Facebook's commenting framework on user posts. A non-radial comment structure allows an arbitrary depth of replies to a comment with sometimes no maximum depth. An example of a platform with a non-radial comment structure is reddit.

### 1.2 Related Work

Gonzalez-Bailon et al. investigated political discussion networks on the technology news website Slashdot [1]. They discovered that political discussion networks on Slashdot typically have wider and deeper depth than discussions on other topics. Furthermore, their study revealed that there are four common types of discussion networks that emerge. The four discussion types differ in the intensity of user interactions.

Optimal Social, a Facebook analytics company, found that 75% of user engagement occurs within the first 180 minutes of the posting [2]. The aim of their research was to determine early in a post's lifetime whether a post would become viral. Their goal was to use this information to allow marketers to direct their advertising

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budget towards posts that were predicted to obtain high user engagement and visibility.

## 2. STRUCTURE OF DISCUSSION NETWORKS

As a first step towards proving our hypothesis that there exists a connection between user engagement and commenting structure we sought to model discussion threads of a few popular platforms including reddit, Stack Overflow, 4chan and Facebook.

We model a discussion thread as a rooted tree. We identify the root of the tree as the original post; and we characterize a branch from a child node to a parent node as a comment by the child node directed to the parent node. Each layer of the tree thus represents a nested tier of comments in an online discussion.

In modeling the structure of discussion networks we also extracted user engagement times. We present our findings in **Figure 1-8**. The root of the tree is colored red while all other nodes of the tree are colored a shade of blue. The shade of blue is indicative of the relative time elapsed between the original post and the time that the comment was posted. The darker blue colors indicate that the comment was posted soon after the original post.

We see that Facebook and Stack Overflow only permit two levels of comments while 4chan and reddit allow an arbitrary number of layers. This leads to the reddit and 4chan discussion networks having a very rich range of topology. In fact we sometimes find that discussions with a small number of posts on 4chan and reddit often have a network structure that closely resembles the radial structure of Stack Overflow and Facebook. We note that the 4chan discussion network is particularly unique because the website permits a child to have two different parents, in essence allowing a post to respond to two posts simultaneously.

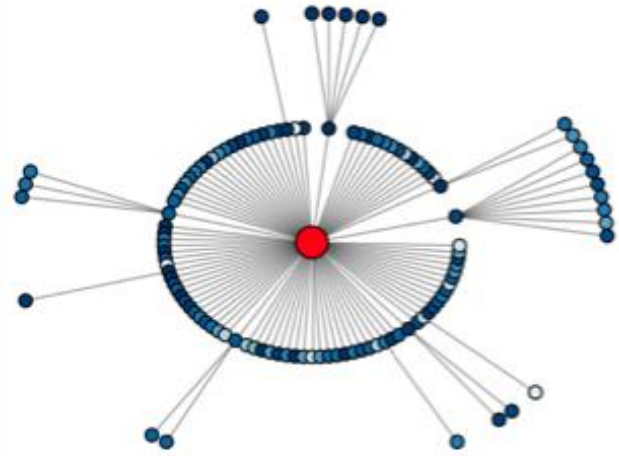
We find that user engagement is horizontally asymptotic with a few sporadic discontinuous jumps. The asymptotic behavior is expected because users are likely discouraged to participate as the discussion becomes large, probably from believing that the majority of viewpoints have been exhausted. The discontinuous jumps are typically as a result of two events: a person contributes a highly regarded post that many others appreciated and expanded upon; or a person posts a highly controversial comment that spurs a series of condemning comments and opposing arguments. In both cases the two type of posts lead to a subsequent increase in user engagement

## 3. EXPERIMENT

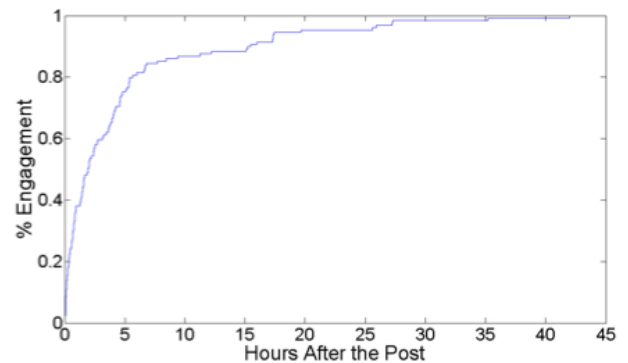
We aim to determine whether user engagement times differ between radial and non-radial comment structure platforms. To accomplish this, ideally we would crawl two websites, one with a radial comment structures such as Facebook and another website with a largely non-radial comment structure such as 4chan and determine the average user engagement times across multiple discussion threads. However after careful consideration, we concluded that this method would not be appropriate as this approach would be susceptible to biases including but not limited to user base, range of topics, website popularity and more.

To minimize our biases we altered our approach to consider a single platform only. As discussed in the prior section, at times websites whose structure permits for non-radial comment structure can sometimes produce conversations that are radial in structure. We chose 4chan for this experiment for two reasons. One, the 4chan API is very rich, user friendly and fast. Second,

the posts within 4chan are divided according to topic which provides a way to achieve diversity across topics. During our crawl of 4chan we classified threads as radial and non-radial according to the average depth of the thread.



**Figure 1 Facebook Comment Structure - 49ers rookie Dontae Johnson studies tall CBs**



**Figure 2 Facebook Engagement Plot - 49ers rookie Dontae Johnson studies tall CBs**

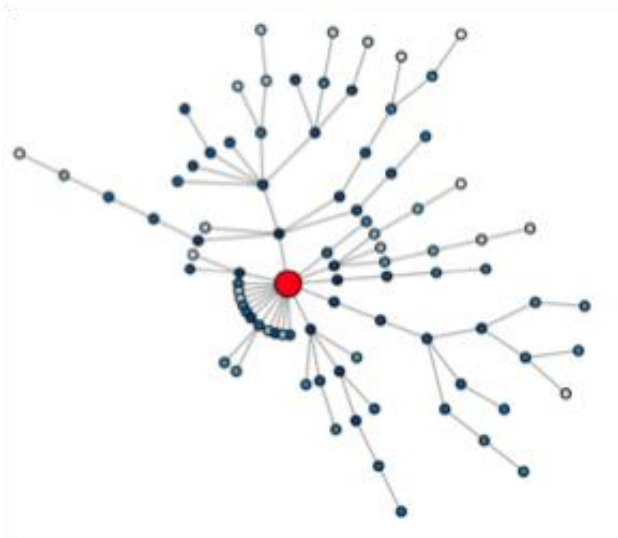


Figure 3 Reddit Comment Structure - Relief of medical marijuana off-limits at N.J. hospitals

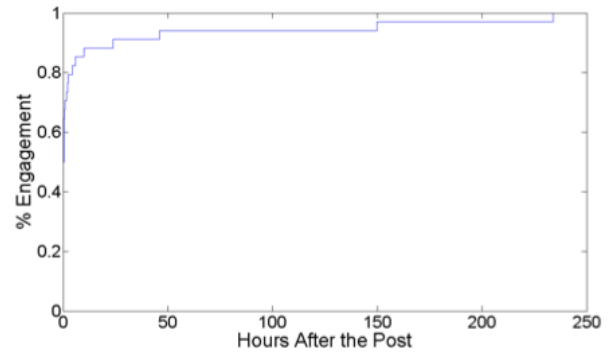


Figure 6 Engagement Plot for Stack Overflow Thread

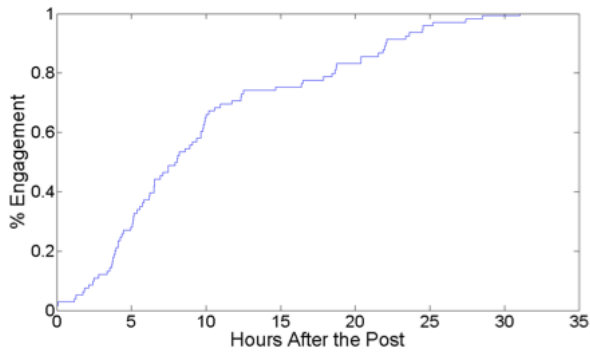


Figure 4 Reddit Engagement Plot - Relief of medical marijuana off-limits at N.J. hospitals



Figure 7 4chan Comment Structure - What is Kirby supposed to be?

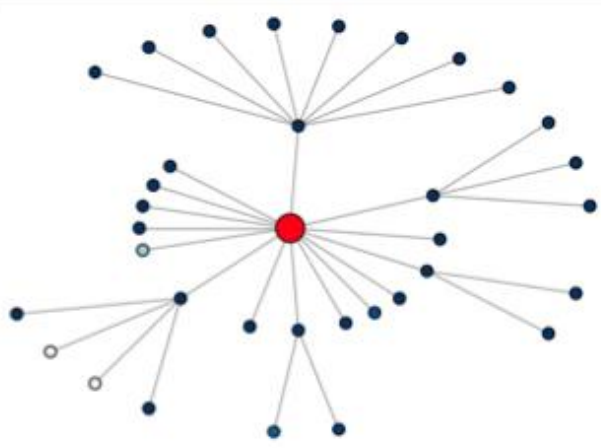


Figure 5 Stack Overflow Comment Structure - When should std::string be used over character arrays?

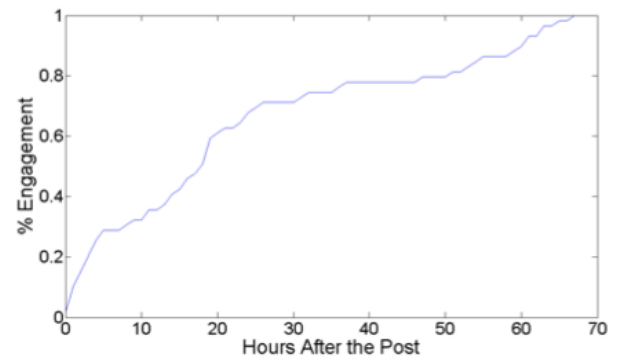


Figure 8 4chan Engagement Plot - What is Kirby supposed to be?

## 4. RESULTS

We crawled approximately 6000 4chan discussion threads. We classified a discussion as having radial structure if the average depth of the discussion was less than 1.1 layers; and we classified a discussion as having non-radial structure if the average depth of the discussion was greater than 2.3 layers.

To provide a level of granularity, we used three fixed user engagement proportions. These were the time for the 50<sup>th</sup>, 75<sup>th</sup> and 100<sup>th</sup> percentile user engagement times. To account for the number of comments in the thread, each thread was classified as small, medium and large based on the number of comments. A thread with a small number of comments had less than 100 comments, a thread with a medium number of comments had between 100 and 200 comments and a thread with a large number of comments had greater than 200 comments.

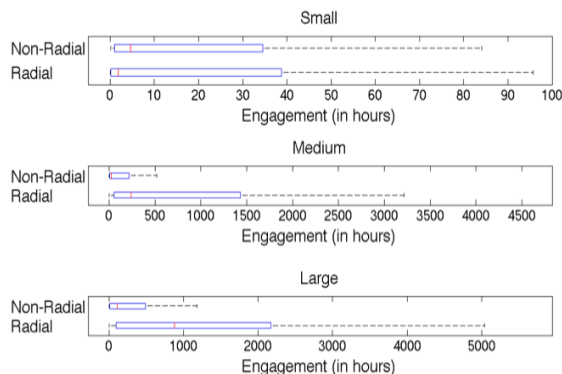
The classification scheme provides a distribution of user engagement across the structure type and the number of comments. We performed a simple Student’s t-test to determine whether the distributions were different. Our null hypothesis is that radial and non-radial structures have different engagement times.

The results are tabulated in Table 1.

**Table 1. T-test Results From Crawling 4chan**

T-test	Small	Medium	Large
50th percentile	0.2950	$8.17 \times 10^{-7}$	$1.95 \times 10^{-6}$
75th percentile	0.2207	$2.76 \times 10^{-7}$	$2.93 \times 10^{-8}$
100th percentile	0.3312	$4 \times 10^{-9}$	$7.18 \times 10^{-10}$

Our results show that the null hypothesis is upheld for threads with medium and large number of comments. Hence there is a significant difference between the user engagement times for radial and non-radial discussion structures across threads that have medium or large number of comments. Moreover, the null hypothesis is upheld for all three user engagement proportions as well. We observe that the null hypothesis fails for all three engagement proportions when the number of comments is small.



**Figure 9 4chan non-radial v. radial distribution for 75<sup>th</sup> percentile user engagement**

## 5. CONCLUSION

The internet has propelled new forms of written discussion and conversation. Websites that offer discussion platforms such as Quora, 4chan and reddit are some of the most heavily trafficked sites on the internet. The two main discussion structures in use are radial and non-radial networks. The purpose of this study was to determine whether user engagement times are dependent on the underlying comment structure.

To begin our study we characterized a discussion thread as a rooted tree and we also calculated user engagement time. We found that user engagement is horizontally asymptotic with jumps in engagement accounted by sudden bursts of comments, typically in response to either a very informative or highly controversial comment.

To test our hypothesis we crawled 4chan across multiple threads and topics. We segmented the discussion networks from the threads into radial and non-radial structures by the average depth of the discussion. We found that user engagement of online discussion does depend on the underlying topology; however it depends on the number of comments of the discussion as well. For discussions with large and medium number of comments, non-radial structures have greater user engagement. For small number of comments this is not true and the user engagement times are similar.

## 6. WORK DISTRIBUTION

Throughout this research we aimed to have the work divided equally.

The first part of our task required us to become familiar with the APIs of Facebook, reddit, Stack Overflow, 4chan and Quora in order to obtain an understanding for the user engagement waveforms across different platforms. Tabish was assigned the task of obtaining the user engagement plots for Facebook, reddit and Stack Overflow while Vijay was tasked with gathering the user engagement plots for 4chan and Quora.

The second part of our project consisted of two objectives:

1. Visualizing the comment tree structures.
2. Gathering user engagement data and conducting hypothesis testing.

We segmented our work for the second part of the project across API familiarity. Given that Tabish was familiar with the APIs of Facebook, reddit and Stack Overflow, Tabish developed the visualization code. As part of this, he also modified Vijay’s 4chan user engagement script to support visualization.

Vijay was given the responsibility of crawling 4chan to obtain user engagement data across multiple topics, comment sizes and tree structures. He was then tasked with developing the hypothesis testing model. Given Tabish’s familiarity with the reddit API, he developed a similar script for reddit. The data from the reddit crawl was provided to Vijay who then conducted hypothesis testing for reddit. We decided to exclude reddit data from our results as it was difficult to find a sizeable number of radial discussion networks for a fair comparison.

Together we jointly collaborated on the presentation and final report.

## 7. ACKNOWLEDGEMENTS

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## 8. REFERENCES

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