# Social Networks of an Emergent Massively Collaborative Creation Community

**Case Study of Hatune Miku Movie on Nico Nico Douga**

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**Abstract.** The Web technology enables numerous people to collaborate in creation. We designate it as *massively collaborative creation via the Web*. It is coming to produce important activities such as Wikipedia and Yahoo Answers. As an example of massively collaborative creation, we particularly examine video development on *Nico Nico Douga*, which is a video sharing website that is popular in Japan. We specifically examine videos on *Hatsune Miku*, a version of a singing synthesizer application software that has inspired not only song creation but also songwriting, illustration, and video editing. As described herein, creators interact to create new contents though their social network. As described in this paper, we analyzed the process of developing thousands of videos based on creators' social networks. The purpose of this paper is to investigate the relations among social networks and creation activities.

## 1 Introduction

The Web was created as a publishing platform, but it is increasingly becoming a two-way communication platform for people. Thanks to the flexibility of the Web, communications of various types have emerged. As a platform for communications, the Web presents various advantages over older systems. For example, it eliminates the sense of distance because people at any place can mutually communicate. It supports massive interactive collaboration through large-scale BBS and social tagging, which is impossible in real-world communication channels. It also enables large-scale information sharing not only of texts but also of various multimedia contents such as videos. This activity has already produced valuable digital contents such as Wikipedia and Yahoo Answers, which could never have been born without the Web. We designate activities of this type as *massively collaborative creation* by which a huge number of people mutually collaborate to create contents on the Web.

Massively collaborative creation on the Web has features that augment traditional collaborative creation; one is the style of participation. Vastly numerous people are involved. For that reason alone, they often do not know each other.

Numerous evolved or inspired versions of a video can be created if a video explores a new idea or if it "catches on". Another difference is the digital reuse of contents. Some components of a work are reused in evolved or inspired versions. For example, an image or sound in a video can be reused in a new version of the video. Consequently, digital work can be developed among people via the Web.

We are interested in the development of such digital works, particularly in the process as it unfolds in a video-sharing website. We selected a video-sharing website called Nico Nico Douga [3], in which intense collaborative video creation is occurring. We specifically address Hatsune Miku [4], which is a version of singing synthesizer application software that has inspired many people to produce various music, picture, and video compositions. The Hatsune Miku phenomenon is interesting because different creators interact in projects: song creators, illustrators, and CG creators.

Some analyses of massively collaborative creation that have specifically elucidated relations among contents and creators have been described in the literature. Kittuer analyzed the effects of sharing roles on the quality of created content [1]. Adamic analyzed a social network among questioners and helpers on a QA site [2]. Results of these analyses contribute to our understanding of the massively collaborative creation activity of users. Our research was undertaken to analyze types of massively collaborative creation that differ from those of earlier studies. In Wikipedia or Yahoo Answers, people create and modify shared objects; they often communicate with one another to coordinate their collaboration. However, on video sharing sites such as Nico Nico Douga and YouTube, people create their own contents freely; little explicit coordination takes place to create contents. Cheng et al. [3] investigated data of video posts and networks of users and videos on YouTube. Their analysis of large amounts of data is interesting, but the analysis is superficial: it does not address the semantics of video creation. Halvey and Keane [4] made a similar analysis of YouTube.

The purpose of this paper is describe our investigation of the relation among social networks and creation activities in massively collaborative creation communities. We adopted a method of social networking analysis as a basic method to investigate the phenomenon. Applying social network analysis methods to web contents has yielded important results for explicating the structure of interaction among people (see [5]). In our case, we investigate how different types of creators interact to create new content through their social network.

The sections of this paper are organized as follows. We briefly describe the target of our analysis—Nico Nico Douga and Hatsune Miku—in Section 2. Subsequently, we explain our data extracted from the website and the preliminary process for the analysis described in Section 3. We present the results of our analysis in Section 4 and summarize this report in Section 5.

This paper is an extended version of a preliminary report [6]. We herein describe results of the analysis in greater detail, in addition to new results obtained using different analyses.

[3] http://www.nicovideo.jp/
[4] http://www.crypton.co.jp/mp/pages/prod/vocaloid/cv01.jsp


**Fig. 1.** Screenshot of Nico Nico Douga. This video is an extremely popular video related to Hatsune Miku.

## 2 Target

### 2.1 Nico Nico Douga

Nico Nico Douga is the most popular video sharing website in Japan. Started in December 2006, it now has more than 13.4 million users (July 2009); it has published more than 2.8 million videos. Its basic service closely resembles that of YouTube, but it includes some unique functions and has gathered many users rapidly. The most interesting and unique function is the direct overlaying of comments on videos. A user can add comments about a specific playback time at a specific position in the video (see Fig. 1), which gives people a sense of sharing the viewing experience virtually. Furthermore, the creator can instantly know which specific moment or specific scene is appreciated by a viewer. That feedback inspires the original creator or other creators to produce new videos to match such effects.

In Nico Nico Douga, a popular category of video is a so-called MAD movie. It is a fan-made video produced by combining video clips and sounds taken from anime videos to create a new sense that differs from that of the original animated production. It can be characterized as a mash-up style of video creation: a video is created by mashing up existing video, sound, and image parts. Because of that feature of Nico Nico Douga, creators of MAD movies are mutually inspired and have produced and uploaded many videos on Nico Nico Douga.

The key feature of a MAD movie is that the extracts that are used are often taken from commercial anime programs. That feature has merit for people because it is fun to view different versions of popular programs. Nevertheless, it is problematic because it often engenders copyright violations. The birth and development of Hatsune Miku suggests a new direction to MAD movies. In Hatsune Miku videos, extracts are not taken from commercial programs; instead, the community creates videos.

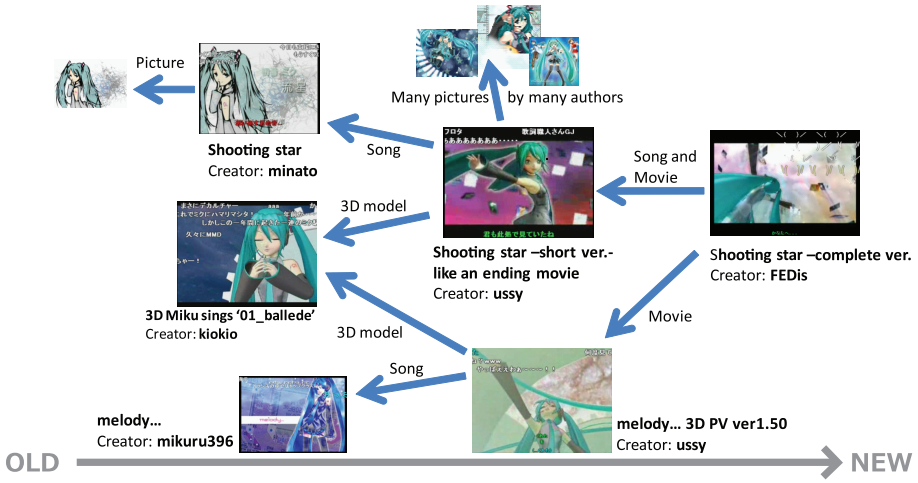


**Fig. 2.** Reuse networks on Nico Nico Douga and Hatsune Miku. These pictures are videos or illustrations on the Nico Nico Douga or web. Bold text shows the title and that below is a handle name of a creator. Arrows among pictures indicate citations from the source to the destination. A label on the arrows displays reused parts.

### 2.2 Hatsune Miku and Its Boom

Hatsune Miku developed by Crypton Future Media is a version of singing synthesizer applications called Vocaloid2; its uniqueness is that it adopted recorded vocals of a famous voice actress. Vocaloid2 developed by YAMAHA Corp. enables users to synthesize songs that include singing by inputting lyrics and melody on computers just like computer music. Amateur songwriters can publish their songs using Hatsune Miku. However, Hatsune Miku affected them more. They regard Hatsune Miku as a pop singer so that they write and publish songs that are suitable for her.

Moreover, a mascot image of Hatsune Miku has caught on. There is only a single illustration of Hatsune Miku: it is printed on the software package. People draw and post different illustrations of Hatsune Miku. Then people started to create videos, such as promotion videos for musicians, with such original songs and drawings. Some people even create 3D models of Hatsune Miku and create 3D animation videos.

Figure **??** portrays an example of collaborative content creation on Hatsune Miku. In this case, *minato* uploaded the video named "Shooting star". It consists of an original song and one original illustration. That user created an original song and tuned Hatsune Miku with it. Furthermore, he used one illustration drawn by another creator when he created the video.

Another user, *ussy*, created a video resembling a promotion movie of Hatsune Miku. It used the original song, a 3D model of Hatsune Miku and many pictures. All had been created by other creators. He downloaded the video "Shooting star"

and extracted music data. In addition, he downloaded the 3D polygon model data and many pictures to create the video. This collaborative content creation continued. A different user, $FEDis$, created a new video: a longer version of the $ussy$'s video.

Then videos are created in the manner of MAD movies. Videos published already are used as materials to create new videos. For example, one selects lyrics and a melody from a video to refine songs; another picks up illustrations from various videos to create scenes that are good for a new song. Fundamentally, creators welcome the use of those materials because it indicates that their works are valuable to others. As a result, many videos are created and published as collaborative works.

The mixture of different creation types is very interesting. Hatsune Miku gathered creators of different types: songwriters from the computer music field, illustrators who come from 'doujinshi'— the self-published manga culture—and even CG creators. Most are amateurs, but some are professionals. They are stimulated by the work of others.

We found the following types of creations on Hatsune Miku.

- (a) **Songwriting**: Amateur songwriters are eager to promote their songs, but it takes time and money to produce promotional tapes with professional singers. Using Vocaloid, they can produce sound with vocalizations as computer music.
- (b) **Song creation**: It is not easy to make Hatsune Miku sing songs naturally. Certain techniques are necessary to tune Hatsune Miku, but it is fun to tune the software to create songs with nice singing voices. They vie with each other to create them.
- (c) **Illustration**: The Hatsune Miku image is a typical anime character that attracts anime fans. Many fans are used to drawing their favorite characters by themselves. When doing so, they produce many different scenes and facial expressions. They even produce different versions of the character, such as Hachune Miku (an infantilized version of Hatsune Miku) and Yowane Haku (a fainthearted version). Those with more expertise produce animations using such illustrations. Some even generate 3D models for Hatsune Miku and produce 3D animations.
- (d) **Editing**: There are so many Hatsune Miku videos that some people collect them and produce summary videos, with ranking programs of Hatsune Miku videos. That latter form is another kind of creation, but we exclude this type. Videos of this type are, in fact, connected with other videos, irrespective of their content. Nevertheless, they are only related via data, such as those reflecting popularity.

We will analyze the creative activity on Hatsune Miku using the category of creation described above.

## 3 Data Collection

### 3.1 Data

In all, 36,709 videos had the tag 'Hatsune Miku' on Nico Nico Douga (31 May 2008). From among them, we selected 7,138 videos that had been viewed more

than 3,000 times as data for this study. We crawled their metadata during 1–5 June 2008. The metadata include view times, the upload date, the uploader name, tags, and a simple description. The most popular video had been viewed 4,425,208 times. The median number of views of the collected videos is 7,281. These 7,138 videos were uploaded by 2,911 unique contributors [5].

### 3.2 Category of Creation Activity

We presented four categories for activity related to Hatsune Miku movie creation: Songwriting, Song creation, Illustration, and Editing. In this section, we present analyses of data based on these categories. The editing activity here is excerpting and combining multiple videos. Therefore, it does not actually create new contents of videos. For that reason, we used the former three categories. We manually excluded 179 Editing videos that were responsible for viewing of the 7,281 videos.

We classified videos and creators into creation categories automatically using tags for videos. Tags on Nico Nico Douga include not only review or content categories such as 'cool', 'great', and 'music', but also kinds of creations: 'Original song', 'Make It Sing', and 'Make It Dance'.

We checked the top 50 popular tags and selected tags that are important for specific creation categories. Furthermore, we checked tags that have a high probability of co-occurrence with selected tags. Then, we provided 24 tags to categorize videos and creators. For example, if a video has the tag "Miku Original Song", then we classify it as "Songwriting". If a video has the tag "3D Hatsune Miku Project", then we classify it as an "Illustration". A video can be classified into more than one of these categories simultaneously if a video has tags of different categories.

We also determine the creator's category by aggregating that person's works. A single creator is classified into multiple categories if the videos are classified into more than a single category [6].

Among the 2,911 creators, we were able to distinguish eight categories: three basic categories, four others by variously combining the basic categories, and an unknown category.

### 3.3 Reference Network

Each video has a title and a description written by the creator. The description often includes hyperlinks to other videos that can reflect details of the video's creation. A customary practice on Nico Nico Douga is that a creator cites other videos if a sound, image, or any part of another video is used. By tracing these

[5] On Nico Nico Douga, only the uploader is named. That person is not necessarily the creator of the video. However, for this study, we regard an uploader as the video creator.

[6] Some videos cannot be categorized correctly using this method. We checked some top-ranking videos and creators and corrected them manually.

hyperlinks, we generated a reference network of videos. Among the collected videos, 4,585 videos include hyperlinks in the description; we obtained 12,507 links among videos.

We infer a relation between the creators of videos $A$ and $B$ when video $A$ has links to video $B$. Consequently, we generated a network among the creators. This network has 2,920 nodes (creators) and 2,757 links (relations among the creators). As described in this paper, we regard this network as a social network of creators.

## 4 Results of Analyses

### 4.1 Reference Network Structure

The most cited video gathered 237 links. The video used an original song. These well-cited videos have also collected many viewers. The most cited video was the most popular video. The correlation coefficient of the number of cited links and the viewed times is 0.81. That coefficient indicates that these videos are really user-generated contents because the creator's behavior resembles the viewers' behavior.

### 4.2 Category of Creation Activity

Figure **??** portrays the relation among creation categories. Table in Fig. **??** presents the number of creators and the number of in-links per creator by these categories. It might be readily apparent that the Songwriting and Song Creation category attract many links, although Illustration does not. That fact indicates that Songwriting and Song Creation triggers creative activities. On the other hand, Illustration acquires many creators. Illustration activity is good at attracting collaborators.

In this network of Fig. 3, the node size represents the number of creators of each category; the arc width shows the number of relations among creators. We draw an arc among categories when the relations number is greater than 30. By following the links inversely, we can observe how the creative activity is diffused among creators of different types. Songwriters and Song Creators are the major source of the diffusion. Then Song Creators (only) and Illustrators followed the diffusion. Illustrators were followed by themselves, which indicates that they diffuse Hatsune Miku in their community.

### 4.3 Community on Creators Network

In this section, we analyze the creators' community. The term "creators' community" designates a tight group of nodes within a social network of creators. We adopt Newman clustering [7] to detect such communities from the social network of creators.

Newman clustering generated 83 clusters (communities) from the social network of creators. We especially investigated 10 clusters of which the size is greater

| Category | N | $E_{in}$ |
|---|---|---|
| W | 111 | 589 |
| I | 346 | 487 |
| C | 254 | 263 |
| W&C | 49 | 351 |
| W&I | 15 | 21 |
| I&C | 33 | 176 |
| W&I&C | 11 | 36 |
| unknown | 543 | 347 |
| sum | 1, 362 | 2, 270 |

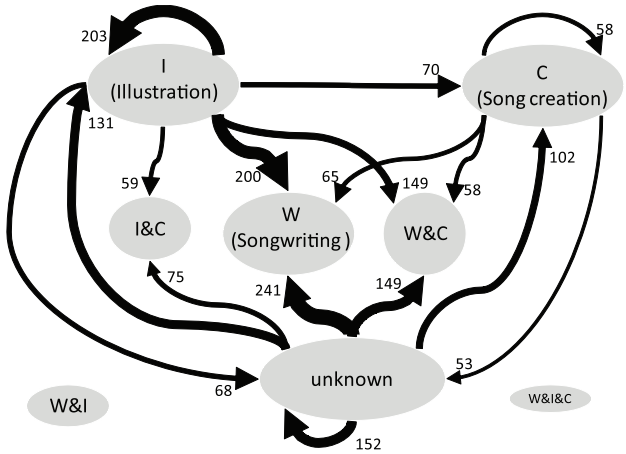


**Fig. 3.** Relation among creation categories. The left table presents creators of each category. Therein, $W$ signifies *Songwriting*, $C$ means *Songcreation*, and $I$ represents *Illustration*. In addition, $N$ and $E_{in}$ respectively denote the number of creators and in-links.

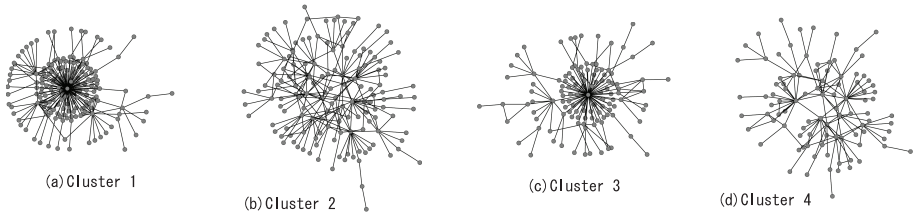


**Fig. 4.** Structure of networks in the clusters.

than 50. Table 1 shows the parameters of these 10 clusters. Furthermore, Fig. 4 shows the structure of the networks in the largest four clusters.

In Table 1, *Size* denotes the number of creators in the cluster. *Centralization* is an index of the centrality of a network in terms of degree [8]. In fact, $\chi^2$ shows a degree of bias of tags in the clusters. When creator $A$ has a video tagged $B$, we consider that creator $A$ is tagged $B$. Then we can find the distribution of creators' tags in the cluster.

The category of the key person (K-Cat) denotes the key person's creative category. We set a node that has the most links as a key person of a cluster. However, we do not set a node as a key person if the number of links of the node is less than 10 percent of all links of the cluster. In such a case, no key person exists in the cluster. A category of majority (M-Cat) is the most popular creative category of creators in the cluster.

Cluster 1 is the network whose center is the creator of the most famous video. The number of creators is 161. It is the biggest cluster on the network. The central creator's category is songwriting and the majority category is illustration.

**Table 1.** Parameters of the biggest clusters. The K-Cat and M-Cat columns respectively show categories of key persons and the majority.

| # | Size | Centralization ($\times 10^{-3}$) | $\chi^2$ | K-Cat | M-Cat |
|---|---|---|---|---|---|
| 1 | 161 | 4.293 | 2130.5 | W | I |
| 2 | 144 | 0.080 | 1747.3 | - | I |
| 3 | 118 | 5.257 | 1921.0 | I&C | I, C |
| 4 | 95 | 1.868 | 1857.7 | - | I |
| 5 | 91 | 5.897 | 2799.9 | I | I |
| 6 | 90 | 7.055 | 2333.7 | W&C | C |
| 7 | 79 | 5.164 | 1942.8 | W | C |
| 8 | 56 | 3.012 | 1797.1 | - | C,C&I |
| 9 | 55 | 6.923 | 2079.6 | W&C | C |
| 10 | 51 | 4.000 | 1761.1 | - | I |

Figure 4(a) shows the network of cluster 1. We can find the center node, which has many links from other nodes. Cluster 2 is the second biggest cluster. No centralized node exists on the network. In Fig. 4(b), some nodes exist which gather some links, but the center of the network is not clear. Both Centralization and $\chi^2$ are respectively lower than the values of other clusters. Cluster 3 shows the network centered around the creator who produced the second popular video. Creation categories are not the same, but the centralization and $\chi^2$ are similar. Figure 4(c) shows a network that has a structure resembling that of Cluster 1; it has a readily identifiable network center.

We observed that communities of two types exist from the viewpoint of network structure: a centralized community and non-centralized community. The former includes clusters 1, 3, 5, and 6, in which there is only a single key person with an extremely high number of in-links. The latter includes clusters 2 and 4, which do not have key persons.

The key person in a community is often of the Songwriting category, which indicates that Songwriting triggers creative activity. We also find that some communities have key persons with the Illustration category. In such communities, new ideas are developed intensively such as new characterizations of Hatsune Miku and a 3D modeling tool. Such communities contribute to widening the world of Hatsune Miku and stimulating additional creative activities.

The results of the community-based analyses strengthen and refine the conclusion from the category-based analysis described in the previous subsection. Collaboration of two types is identifiable. One type originates with Songwriting creators, which involves Song Creation and Illustration creators. It represents the birth of a creative idea and diffusion of a new topic. The other is collaboration among Illustration creators, where creators are mutually dependent. It is the next phase within which diffusion takes place among Illustration creators.

Apart from the diffusion process, results show that centralization of the network and localization of the tag are mutually correlated. The correlation coefficient among centralization and $\chi^2$ is 0.63, which represents a strong positive correlation, meaning that a strongly centralized community tends to have

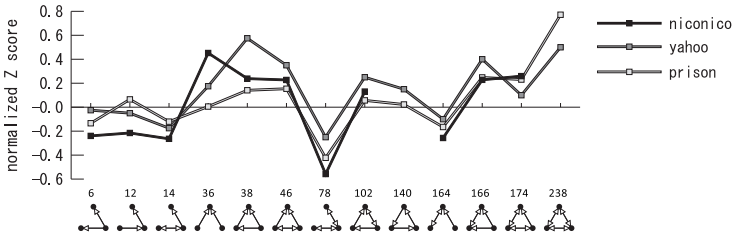


**Fig. 5.** Results of motif analyses with three social networks. The networks are as follows (where $N$ and $E$ respectively denote the number of nodes and links): (i) creators' citation network on Nico Nico Douga (niconico $N = 1454$, $E = 2339$); (ii) a users' question and answer relationship network on the Wrestling community of Yahoo Answers (yahoo $N = 9,959$, $E = 56,859$); (iii) a friendship network of prison inmates (prison $N = 67$, $E = 182$).

community-specific tags that are used by many creators in the community and vice versa. In fact, tag analysis might be used to identify communities, which can be quite beneficial because link identification is very costly and is often impossible.

### 4.4 Analysis Network Motif

Motif analysis is a method used to investigate particular social dynamics using small local patterns of a network [9]. The salient hypothesis of motif analysis is that networks display certain patterns, termed "network motifs," at much higher frequency than expected in randomized networks. We applied motif analysis to our creators' social network (Fig. 5). We also present the motifs of the two social networks for comparison. One is a social network of prison inmates [10], as analyzed by Milo. The other is a social network of a QA site (Yahoo Answers), as analyzed by Adamic [2].

The normalized $z$-scores of 13 network motifs are presented in Fig. 5, the motif of which normalized $z$-score is high, meaning that it is a characteristic pattern of the network. We used the motif analysis tool *FANMOD* [7] to carry out our motif analysis. In Fig. 5, our social network shows no triad 140 or 238. The absence of triad 140 arises from the fact that our social network does not include such a local pattern. On the other hand, the absence of triad 238 occurs from the fact that the random network has no such local pattern because the number of links to the number of nodes is too small.

Milo analyzed social networks among prison inmates, first year students, and other students. In addition, Adamic analyzed social networks of questioners and helpers on a QA site. All of these networks show relationships among people; however, they are networks of different types. The former is based on real-world communication; the latter is based on online communication, especially questions and answers. Our network is based on unique collaboration.

[7] http://theinf1.informatik.uni-jena.de/ wernicke/motifs/

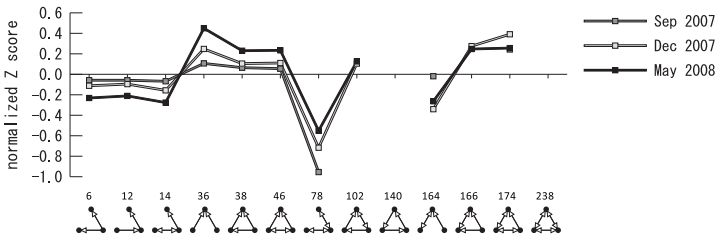


**Fig. 6.** Results of motif analysis with social networks of three types. The networks are as follows: (i) Sep. 2007 ($N = 240$, $E = 296$); (ii) Dec. 2007 ($N = 976$, $E = 1450$); (iii) May 2008 ($N = 1,454$, $E = 2339$).

Figure 5 shows that three results are fundamentally similar. It is clearly different from other networks such as WWW [9]. However, each network has a different highest scored motif from the others. It is triad 36 in the case of our network, triad 238 in the case of the prison network, and triad 38 in the QA site network.

The prison network is based on real-world communication, although the others are based on online interaction. It is probably easier than for others to generate a complete graph (triad 238) in the network. Adamic interpreted the meaning of triad 38 on the QA site network as follows. In triad 38, one person was helped by two others, but one helper has helped the other helper.

A star graph (triad 36) in our network is important in comparison to the other social networks. In this motif, a user is cited by two others; no relation exists anymore, which indicates that a few popular creators attract many non-popular creators.

Results show that the creators' social network has characteristics resembling those of other social networks. Furthermore, its remarkable characteristic is the existence of popular nodes (trigger persons). How did such a network evolve? The next question is how this characteristic is formed. We investigated the evolutionary nature of the network to answer the question. To investigate this point, we generated networks in the specific periods and compared them. We split the whole period into three: the first stage (to September 2007), the second stage (September–December 2007), and the third stage (December 2007 to the end). Then we generated the network for the first stage, the network for the first and the second stage, and the whole network (stages 1–3). We analyzed motifs of these networks (Fig. 6).

The characteristic triad (triad 36) is exaggerated as time passes. The initial network is rather similar to the prison network, which indicates that the initial collaboration is as close as that in the real world. The participants tend to cite mutual work. However, the late participants do not. They are less cited and merely cite the previous creators. It is interesting that the style of collaboration is shifted from a dense mode to a sparse mode, even in such a purely online environment. It might be a hint indicating when and why the networks burst in online environments.

## 5 Conclusion

We have investigated how creators of different types interact in massively collaborative creative efforts. We extracted and analyzed the social networks of creators, revealing some interesting facts. Creators' behavior is similar to audiences' behavior. The creators' network is large and sparse, and different categories of creators have different roles in evolving the network. Some communities in the network are centralized, and some are not. Centralization of the network and localization of the tag are mutually correlated. Results also demonstrate that the style of collaboration shifts from a close one to a sparse one depending on the evolutionary phase of the network.

Social media sites are expected to be interactive, but interactivity is not simple. As explained herein, creators of different types form interactions of different types. It is also different depending on the evolution of the network. We should take these points into account when designing new social media, particularly those that support creative activities.

## 6 Acknowledgments

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