

A Comparative Analysis of Centralized and Decentralized Developer Autonomous Organizations Managing Conflicts in Discussing External Crises

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Abstract—Understanding whether and how online developer communities resolve conflicts that occur in discussions is critical. Few studies focused on the conflicts caused by external crises, such as geopolitical events (e.g., the 2022 Russo-Ukrainian Crisis). We comparatively studied how a decentralized autonomous organization (DAO), Aave project community, and a centralized autonomous organization (CAO), GitHub project community, managed external crises caused by conflicts. Our mixed-method analysis showed that a DAO could be better than a CAO for mitigating conflicts. And blockchain technologies (i.e., voting and cryptocurrency) played vital roles. To address the low voter turnout, we proposed adding a monetary incentive to engage more DAO members in forming common goals.

Index Terms—Blockchain, conflict management, contact theory, decentralized autonomous organization (DAO), online developer community.

I. INTRODUCTION

DEVELOPERS spontaneously organize together as an online community to collaboratively create and exchange software innovations with other developers and users [1]. Discussions about how the community should proceed as a whole are integral to the collaboration [2]. Previous research showed that discussions could reflect individual interests [3], benefit community development, and encourage software innovations [4]. However, discussions may also trigger community conflicts. If people cannot manage the conflicts in a discussion, the conflicts may lead to a breakdown in collaboration [5]. Therefore, it is critical to understand whether and how online developer communities resolve conflicts in discussions. There are four conflicts in developer communities [6]: 1) task conflict; 2) affective conflict; 3) process conflict; and 4) normative conflict. Previous research mainly focused on internal issues triggered conflicts and ignored conflicts caused by external influences [7]. The 2022 Russo-Ukrainian crisis split people into different groups [8]. The crisis also impacted the online developer communities. Members appealed to restrict the enemy, donate money to a particular government, etc., [9].

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Heated discussions and proposals triggered conflicts in many online developer communities [10].

As we studied how online developer communities had discussed the crisis and managed conflicts, we paid attention to a new kind of community: decentralized autonomous organization (DAO). Aave¹ project is a representative DAO whose mission is to develop and operate a Web 3 lending system. The Aave project community enables developers and users collaboratively to the project's development and hold blockchain-based voting to legislate how Aave should be governed. Comparatively, GitHub² project is the foundation of the world's largest open-source developer autonomous organization, GitHub [11]. Its mission is to develop and operate a platform system allowing numerous developers to deploy their software projects. The GitHub project community enables global developers as users to access GitHub's software services, provide feedback, and contribute to project development. The GitHub project has its staff to govern the community. Hence, it can be described as centralized autonomous organization (CAO). After the crisis broke out, members of the Aave and GitHub spontaneously called for action in communities. We are curious **RQ1** *Whether and how the DAO (i.e., Aave) and the CAO (i.e., GitHub) resolved the conflicts throughout the crisis discussions.* And we broke it down into two sub-questions: **RQ1.1** *What did a DAO and a CAO do to resolve the conflicts?* **RQ1.2** *Whether and how were the conflicts resolved by a DAO and a CAO?*

We analyzed the discussion and proposal data collected from Aave's governance platforms and GitHub's Discussion forum to answer the sub-questions. The data range from October 2021 to March 2022. By drawing the co-occurrence networks of the posts and timestamps of Aave and GitHub, we found that the two communities had immediate discussions about the crisis in February, and then cooled down in March. We observed the user activities and found that GitHub staff posted an official response to the crisis-related discussions and closed all these threads. Meanwhile, Aave vetoed a proposal supporting the Ukraine government financially. Discussions cooled down after the result revealing. However, sentiment analysis revealed that the original conflicts were transformed into affective conflicts in GitHub. The results indicate that

¹<https://aave.com/>

²<https://github.com/github>

simply banning discussions did not fully resolve the conflicts but transformed the original ones. In other words, the DAO can alleviate conflicts caused by external influences better than the CAO, which led us to research the second question: **RQ2** *Why was a DAO better than a CAO for mitigating the conflicts arising from crisis-related discussions?*

To answer **RQ2**, we applied the intergroup contact theory [12] for our context. The theory defines four conditions of interactions between groups of people (i.e., equal status, common goals, intergroup cooperation, and support of neutral authority) that should be met to reduce conflicts. Our study found that the DAO (i.e., Aave) meets the four conditions more easily than the CAO (i.e., GitHub). In the analysis above, blockchain-based voting and cryptocurrency played essential roles. Therefore, we would like to answer the final research question: **RQ3** *How did blockchain technologies make a DAO manage conflicts better than a CAO?* We found two pieces of evidence to answer this question. First, Aave's cryptocurrency is better than GitHub's achievement system in motivating developers to agree on a rational approach to resolving conflicts. Second, Aave enables developers to interact anonymously on the blockchain, but GitHub could not, which caused many personal attacks in crisis discussions.

Although the DAO showed great potential in resolving conflicts, we found that the turnout of Aave's blockchain-based voting was low. The turnout was never greater than 6.23%. Therefore, we proposed to improve the current mechanism by adding a monetary incentive to encourage people to vote. Anyone who casts their vote will receive small tokens, and the group of people who won will receive another small amount. In the future, we will cooperate with a DAO and run an experiment to examine how much turnout increase this monetary incentive-based improvement can be.

Our contributions involve innovative governance: 1) we did a comparative study between a DAO and a CAO in managing the conflicts that are caused by external crises; 2) our mixed-method analysis showed that the DAO was better for mitigating conflicts and blockchain technologies played critical roles; and 3) we proposed to add a monetary incentive so that more members can engage in forming common goals.

II. RELATED WORK

A. Conflicts in Online Developer Communities

Major online developer communities are autonomous organizations focused on Free and Open Source Software, where developers are collaborating with others dynamically [13]. In addition, obtaining user interaction and feedback is another essential role of online developer communities for software development [14], [15]. Discussing their different views and building consensus among developers and users is crucial to collaboration in these communities. Sometimes these discussions can be very intense, as Schneider et al. [16] found members could have a year-long and heated discussion about Linux development.

Four types of conflicts will emerge from the discussion in online developer communities [17]: 1) *task conflict* involves disagreements about tasks that need to be done, such as

GitHub's pull requests changes [18]; 2) *affective conflict* involves dissonance in group emotion or relationships, such as unfriendly comments to help-seeking [19]; 3) *process conflict* involves disagreements on how the work is done, such as conflicts during PNG format creation in open-source communities [20]; and 4) *normative conflict* involves dissonance between the community's policy or ideology and actual behavior, such as the conflict caused using non-free software in the Gnu's Not Unix (GNU) community [21]. In addition, task conflict is most likely to transform into other conflict types without promptly solving, which will amplify negative impact [7], [22].

Since the vital role of community managers, they can resolve conflicts by performing different tasks [23]. Besides, conflicts might be resolved by rational allocating resources [24], setting supportive rules [25], and actively responding to requests [26]. However, most studies focused on the conflicts triggered by internal issues, and few focused on the conflicts caused by abrupt and immense external influences (e.g., the 2022 Russo-Ukrainian crisis).

B. DAO and Web 3

Web 3 emphasizes the massive use of blockchain, such as smart contracts and cryptocurrencies [27]. The early Internet, where most users could only read content, was called Web 1 [28]. Then, the Internet allowing users to create and share content has been called Web 2. While Web 2 users can create, platform companies own the information centrally [29].

DAO is a representative application of Web 3 [30]. Buterin et al. [31] described DAO as an organization that governs human behaviors with smart contracts on blockchain. Open-source blockchain platforms like Ethereum enable people to encode the rules in smart contracts, thus realizing distributed, automated, and autonomous governance without third-party intervention [32]. DAO's governance rules cannot be changed once they are written into a smart contract, except by voting [31]. Members' voting power is based on the amounts of the cryptocurrency (token) they hold related to the corresponding smart contracts [33].

C. Intergroup Contact Theory

The intergroup contact theory [12] attempts to reduce the widespread ethnic and racial conflicts. This theory provides four conditions for positive contacts: *Equal status*, participants must have equal status. *Common goals*, they must work on a common issue and share one goal. *Intergroup cooperation*, in a state of collaboration rather than competition in achieving their goals. Finally, *support of neutral authority*, contact has to be supported by neutral institutions, such as morals, laws, or social customs. Contact theory has been applied to community practice and proved validity, such as building collaboration in cross-cultural contexts education [34] and eliminating conflicts in cross-partisan online discussions [35].

III. GITHUB PROJECT AND AAVE PROJECT

The communities of the GitHub and Aave projects connect their developers and users to develop, access services, and

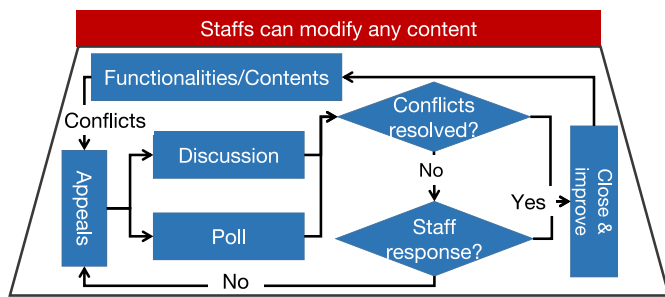


Fig. 1. Two-layer governance structure and conflict resolving processes in GitHub. Although developers and users have autonomy, GitHub staff have centralized rights to modify any content.

provide feedback. Their significant difference is the centralized or decentralized governance structure. GitHub (a CAO) has staff to govern and can adjust any content. In contrast, Aave (a DAO) is governed by blockchain-based voting.

A. GitHub Project

It is the foundation system of the GitHub organization. The GitHub project helps more than 80M developers deploy their software on GitHub. Millions of developers contribute 4357 repositories with over 1M issues and 650k pull requests to the GitHub project's development. The project community is governed by GitHub staff, who have permission to modify any content in the system,³ such as adjusting the access, locking discussions, and removing any user-generated content. Since previous mechanisms (like "issue" and "pull requests") cannot be efficient for collaboration after a software project becomes complex, the GitHub project released the "Discussion"⁴ at the beginning of 2021 and also has used in its own governance [36]. In this official forum, developers and users can appeal to improvements when they face conflicts during their development and use of the GitHub system. Through discussions and polls, they might make a consensus and have plans to resolve conflicts. Then, they can close the appeal by themselves. If not, they can wait for staff to respond and improve functionalities or contents. Hence, the GitHub project community has a two-layer governance structure. Developers and users form the underlayer, who collaborate on developing the GitHub project community. GitHub staff, who have centralized privilege, form the upper layer. GitHub can be described as CAO. Fig. 1 shows the governance structure and conflict resolving processes in GitHub.

B. Aave Project

It is a DAO whose members develop and govern a Web 3 lending system [37]. Since its launch in November 2017, Aave has grown into a Top 10 Defi project and Top 50 of all Web 3 projects.⁵ Currently, over 100k developers and users participate in the community. Aave's development and governance model is structured with four platforms and blockchain-based tokens, "AAVE." First, the DAO has a Discord server, which is the first place to generate proposals. For instance,

³<https://docs.github.com/en/site-policy>

⁴<https://docs.github.com/en/discussions>

⁵<https://coinmarketcap.com/view/defi/>

anyone with an idea to resolve community conflicts or improve the project can post it on the server and discuss it with others. After that, Aave provides a governance forum to form their ideas into the proposal and elaborate it to the community. The proposal in this step is called "Aave Request for Comment" (ARC). Then, the ARC initiators can create an OFF-chain, but blockchain data-based (the snapshot of token holdings) vote for the ARC on the Snapshot platform. This ON/OFF-chain mixed method is a compromise between efficiency (OFF-chain votes will cost less) and fairness (blockchain data are transparent and tamper-proof). If the ARC passes, the initiators prepare to submit an "Aave Improvement Proposal" (AIP) into the governance app, including a detailed description of the proposal and relevant codes. Anyone can join the initiator and contribute to the improvement during all the processes above. Finally, if the AIP passes the final vote (based on real-time token holdings), it will be embedded in Aave's smart contract and executed. The governance structure in Aave is flat due to blockchain's transparency, tamper-proof, and automation of smart contracts. No one can modify the community's consensus or user-generated content except through the processes above. Hence, Aave is a DAO. Fig. 2 shows the governance structure and conflict resolving processes in Aave.

As our research objects, the GitHub project community (CAO) and the Aave project community (DAO) are similar because they are the place for developers and users to collaborate in one software development. Considering their governance, both GitHub's official "Discussion" forum and Aave's four platforms are used to make consensus and resolve conflicts, reflecting autonomy. However, their differences are apparent. GitHub has a staff layer with higher authority than developers and users. Comparatively, the Aave community is supported and guaranteed by blockchain and smart contracts, and less centralization in the governance.

IV. METHODOLOGY

We used a mixed-method approach to study how DAOs and CAOs handled crisis-related discussions and whether they resolved the conflicts. We conducted qualitative observations of member behavior, NLP analysis of discourses, and ON-chain data analysis to compare these communities. We applied the intergroup contact theory to analyze the ability of a community to resolve conflicts qualitatively.

A. Data Collection

To analyze whether and how GitHub and Aave developer communities resolve conflicts arising from discussions about the crisis (RQ1), we collected the discussion messages from three places: 1) GitHub Discussion forum; 2) Aave Discord channels; and 3) Aave governance forum. We obtained the data from October 2021 to March 2022. We collected the titles, timestamps, messages, and user information of 5889 topics and 17 189 messages from the GitHub Discussion forum. We also collected the timestamps, messages, and user information of 42 998 messages from the Aave Discord channels; and the titles, messages, timestamps, and user information of 533 proposals and 1200 messages from the Aave governance

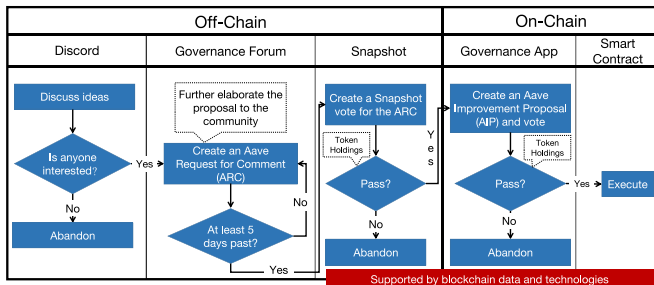


Fig. 2. Flat governance structure and conflict resolving processes in Aave. Blockchain data and technologies support critical processes.

forum. Furthermore, to study how blockchain, especially the voting mechanism, played a role in resolving conflicts (RQ3), we scraped the voter numbers and the results of the ARC and the AIP votes from the same period.

B. Data Analysis

To answer RQ1, we used how many kinds of conflict emerged and whether the conflict type transformation happened as the dimension to compare the two communities' conflict resolution performance during the crisis. We made a quantitative comparison for the types of conflict that could be quantified or visually compared. Otherwise, we made qualitative observations and discussions. To study RQ1.1, we described what happened in GitHub and Aave during the crisis. For an in-depth comparison, we preprocessed the obtained discourses with NTLK suite.⁶ To explore RQ1.2, we used TextBlob⁷ to compare the sentiment changes in the pre-processed data. Then, we conducted semantic network analysis provided by KH Coder [38]. This method avoids the subjective influence of human coders and is widely used in the topic study of online discourses [39]. We used the first 200 frequently co-occurring keywords in both the communities to get month frames and keep the whole spanning tree. Keywords were located based on the Fruchterman and Reingold algorithms. The words in each frame reveal a theme. And correlations between keywords are calculated by the Jaccard coefficient and linked by edges and lines.

To answer RQ2, we used how many conditions of the contact theory a community has met as the dimension to conduct a qualitative comparative analysis (QCA). The QCA method allows cross-case analysis, often used to compare social issues caused by multiple elements [40]. We compared whether the two communities fulfilled the theory to analyze the factors behind their reactions. To explore RQ3, we used the findings of the questions above and the extensively collected data to do the comparative study.

V. RESULTS AND ANALYSIS

We use observations and collected data to answer the research questions mentioned above. The results of each question are discussed in Sections V-A–V-D.

⁶<https://www.nltk.org/>

⁷<https://textblob.readthedocs.io/>

A. Centralized and Decentralized Resolving for Task Conflict

Observations of discussions can tell us whether task conflict occurred. Then by clustering the frames, it can reveal the relationships between new proposals and previous tasks. We first analyzed the results of the co-occurrence network. And then, we manually summarized the main content of dominant frames and compared the monthly changes in these two communities. Topic frames were expressed in the same number and color among sub-graphs if they have similar keywords. The keyword circle's size indicated the word's frequency in the discussions of a particular month. To compare the influence of the external crisis, we used the same yellow highlights to indicate crisis discussions in these two communities.

1) *GitHub*: On GitHub, the crisis discussions lasted from February 25 to March 2. The first message appeared about half a day after the military action. It called on the community to “Cut Russia from Github due to massive invasion of Ukraine” (Part 1 of Fig. 3). We observed people expressed different views on how the community should respond. Some supported the initial post, such as “...GITHUB HAS TO SHOW ITS SUPPORT! RUSSIA USES IT AS A WEAPON!” However, someone doubted that restricting Russians' access could effectively stop the geopolitical conflicts, for example, “Blocking GitHub will just bring me troubles and it has no effect on our President.” These discussions related to what the community should do next, so they indicate task conflict happened on GitHub. On February 28, the original author chose a user's message about prohibiting the usage of open-sourced code in military applications as the best answer. A GitHub senior manager (michellemerrill) canceled the best answer on the same day. Then, on March 2, GitHub staff made an official statement and set it as the answer for all related discussions. The team also locked all these discussions (Parts 2–4 in Fig. 3). This was the end of direct discussions of the crisis on GitHub.

Fig. 4 shows the monthly co-occurrence network analysis of GitHub discourse. Fig. 4(a) October 2021 sub-graph identifies eight major frames in October 2021, which exhibit main tasks in GitHub. Five of them are connected through keywords of “filter-star,” “create-list-add,” “file-code-search,” “github-editor-web,” “request-review,” and “account-status.” Three other clusters, “developer,” “link,” and “good idea,” are completely unconnected to others and have less presence. Frame 01 is mainly related to developers' coding work on GitHub. Frame 02 is mainly related to repositories issues. It connects the other four majors and plays the combiner in GitHub's community workflow. Frame 03 is about projects and issues. Frame 04 is mainly related to application review and submission. Frame 05 talks about debugging and disposal. Then, although there are slight variations, we can observe a roughly similar task arrangement in the sub-graphs of Fig. 4(b) November 2021, Fig. 4(c) December 2021, and Fig. 4(d) January 2022. The task conflict happened in Fig. 4(e) February 2022. The yellow highlights frame 26 indicates the crisis discussions. This frame links to frames 01, 03, and 15. All these frames are crucial tasks in GitHub. Therefore, after the outbreak of the crisis, the relevant discussions on GitHub attracted attention and caused task conflict. Then, Fig. 4(f)

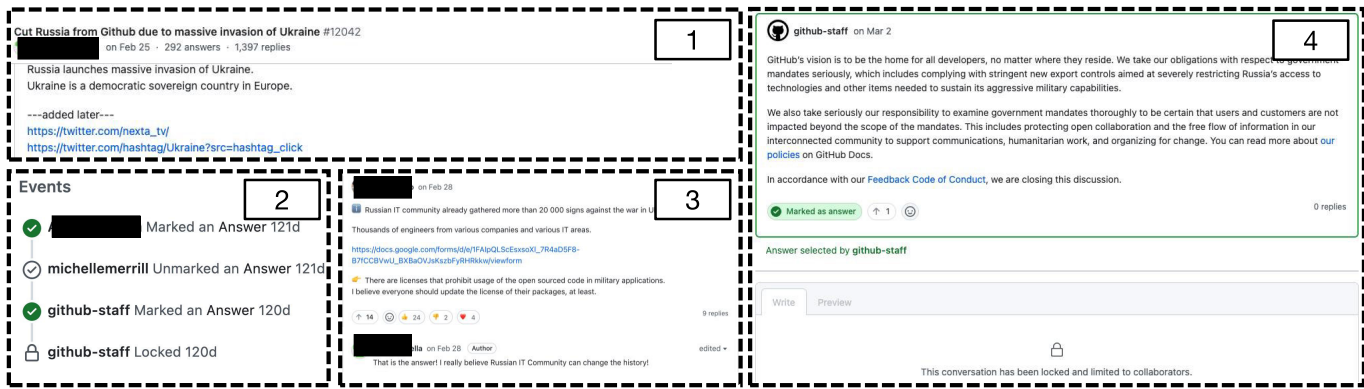


Fig. 3. Crisis discussions on GitHub. 1—The first task request, 2—the timeline of the whole discussion, 3—the original author chose one reply as the answer, and 4—the changed final answer from the GitHub staff. And the staff closed the discussion.

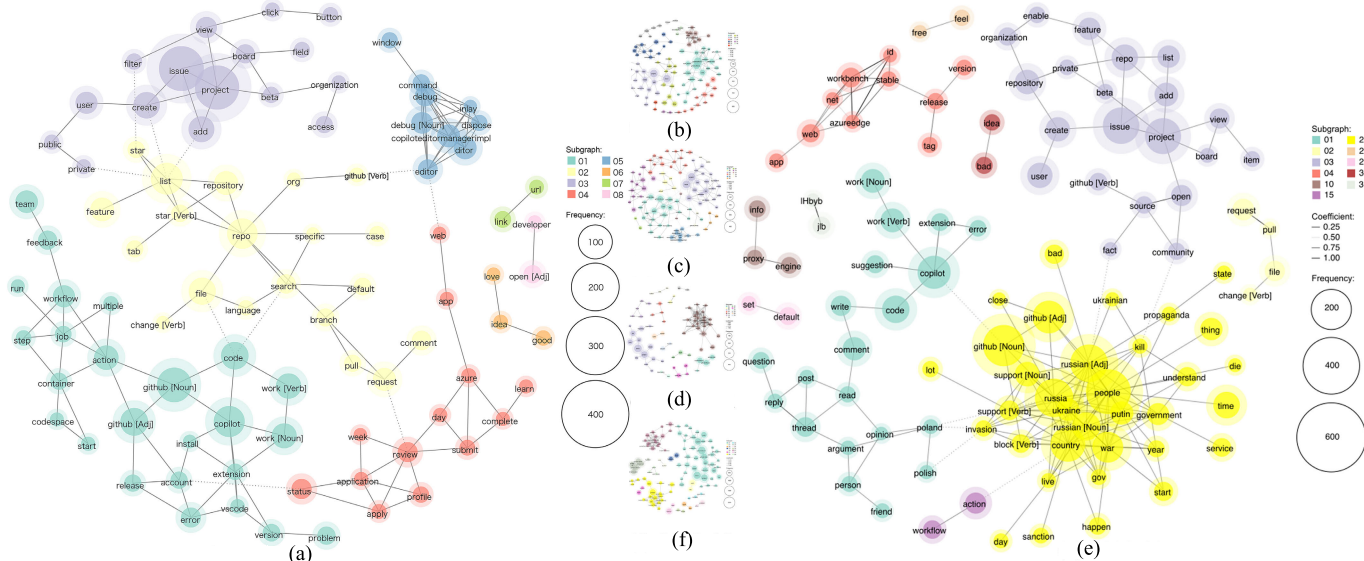


Fig. 4. GitHub’s topic frame co-occurrence network (October 2021–March 2022). Each subfigure corresponds to the clustering result of one-month discourses. (a) October 2021. (b) November 2021. (c) December 2021. (d) January 2022. (f) March 2022.

March 2022 shows 14 frames in the community for March 2022. We noted that crisis discussions were reduced (frame 26). This indicates that direct banning of discussions can mitigate task conflict on GitHub.

2) *Aave*: Before the crisis broke out, some discussions appeared on Aave’s Discord server, “*war is coming*.” (Part 1 in Fig. 5). On February 24, some DAO members showed their worries, “...*everyone is panicking with Russia doing their thing*.” Also some found their ON-chain operations failed: “...*network error. May be caused by the invasion*.” However, we did not observe many related discussions. An Aave member created an ARC “*Donation from the Aave protocol treasury to support people in Ukraine*” on February 27. The proposal requested the community to donate U.S. \$2 million from its treasury (Part 2 in Fig. 5). It needed to adjust the smart contract. Some users agreed, “*Any help is welcome*...” while others believed that Aave should remain neutral, “*Aave should stay apolitical*...” Moreover, people discussed who should be the donation object. Hence, the task conflict also happened. Aave used blockchain-based voting, a decentralized method, to resolve the task conflict. Some Aave members suggested that the DAO could create a vote to solve the debate. “...*the magic of DAOs is that this is easily solvable with voting*.”

Hence, the initiator created a Snapshot voting on February 27. About 98.18% voters chose “No,” and 1.82% chose “Yes.” After voting, the initiator announced the result and abandoned the proposal on February 28. The initiator said, “The community has decided to remain neutral...so be it.” Then, since there were no more replies on this ARC, it was closed on March 7 (Parts 3 and 4 in Fig. 5).

Fig. 6 shows Aave’s monthly co-occurrence networks. Fig. 6(a) October 2021 shows 13 frames. The largest frame 01 relates to the Discord and scam risk. This is also reflected in software development, such as frame 06 “parameter risk” and frame 13 “factor health.” In addition, unlike tasks in GitHub that focus on software, the governance frames are another main part of Aave. Frame 31 emphasizes user proposals and ideas. It is indirectly connected to frame 05, the Snapshot-based voting. These connections align with Aave’s governance process: the community votes on the Snapshot after people have a proposal based on their own ideas. Frames 09, 26, 27, 32, and 33 relate to the development and use of the protocol. Frames 12, 17, and 18 are about marketing and community events. These basic tasks are almost identical in the results of Fig. 6(b) November 2021, Fig. 6(c) December 2021, and Fig. 6(d) January 2022. In Fig. 6(e) February 2022, the crisis

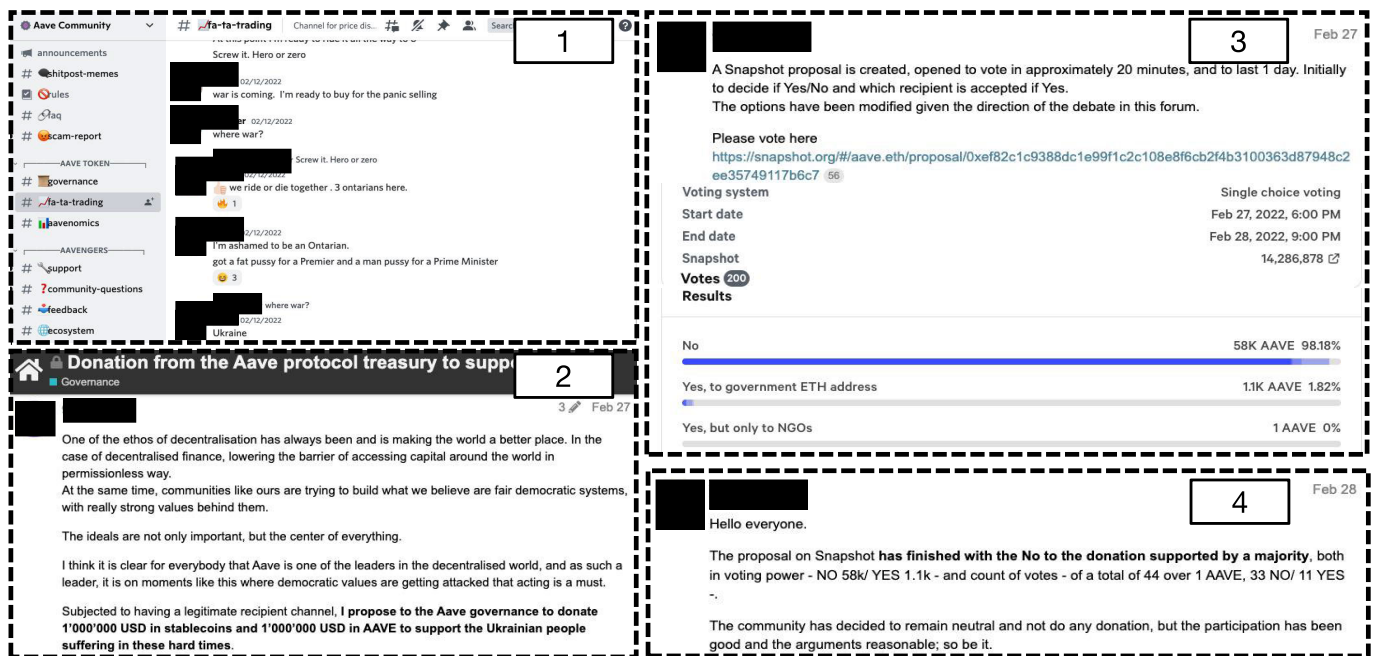


Fig. 5. Crisis discussions and voting on Aave. 1—Users talked about the crisis in early February, 2—the donation ARC on the Aave governance forum, 3—the initiator created Snapshot-based voting and its result, and 4—the initiator announced the result to the community and abandoned the proposal.

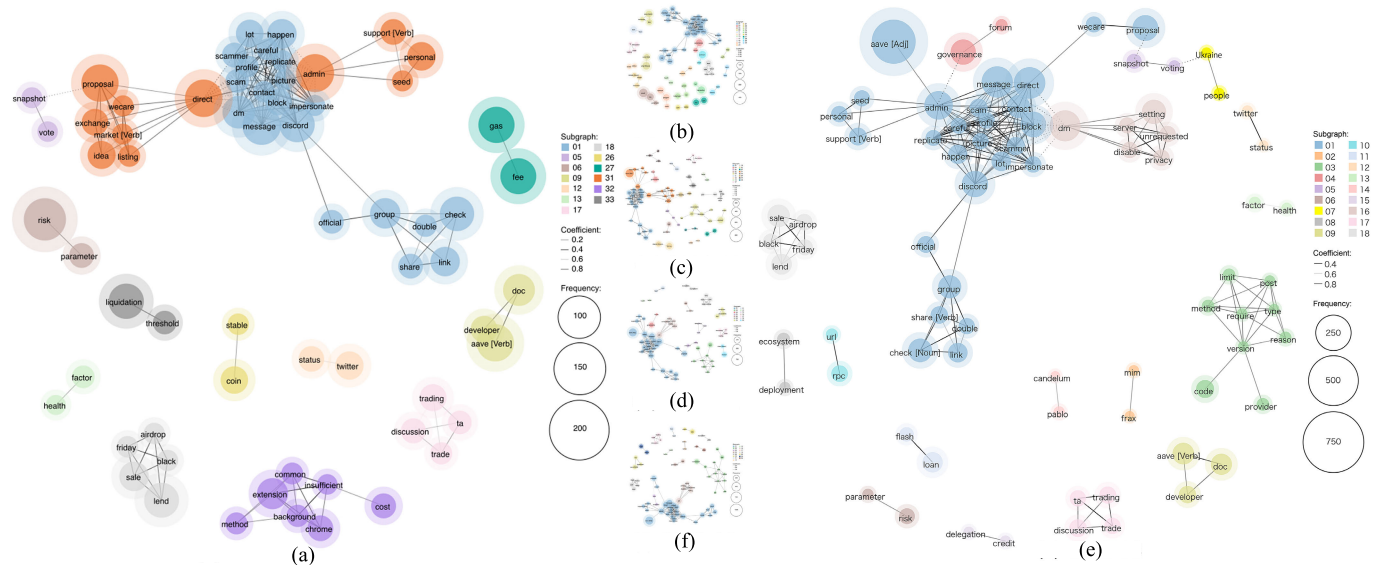


Fig. 6. Aave’s topic frame co-occurrence network (October 2021–March 2022). (a)–(e) Clustering result of one-month discourses.

discussions only appeared in a small frame 07 (coloring with the same yellow highlights as GitHub). The main body of the community tasks remained as in previous months. Notably, the crisis is linked to the “voting on snapshot” (frame 05) and finally attached to the main community topics (frames 01 and 16). Beyond that, the crisis frame 26 does not link to the community workflow or development issues. In Fig. 6(f) March 2022, frame 26 does not appear.

We found the following.

- 1) Crisis discussions occurred in these two communities, and members proposed new tasks. Hence, the task conflict was triggered by the external influence in both the communities.
- 2) On GitHub, new tasks were linked to previous ones and occupied a large space. Comparatively, new tasks were

isolated from Aave’s main works by the voting process and only occupied small ones.

- 3) GitHub staff posted an official response to the discussions and closed all these threads. Meanwhile, Aave developers initiated a blockchain-based proposal.
- 4) The centralized way (i.e., banning discussions) and decentralized way (i.e., voting) can cool down discussions and alleviate task conflict.

B. Conflict Type Transformation

After determining that CAO directly banned discussion, while DAO used voting to resolve task conflict, we used observation and sentiment analysis to investigate whether conflict transformed in these two communities.

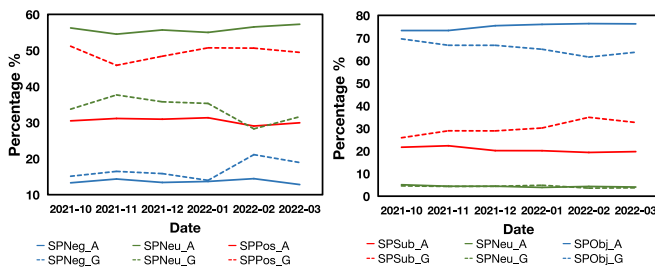


Fig. 7. Polarity and subjectivity analysis between Aave and GitHub. 1—The solid lines represent Aave, while the dotted lines represent GitHub. 2—The left shows polarity comparison. The blue ones show the monthly changes in negative discourse. The green ones are the changes in neutral. And red ones present the changes in positive. 3—The right shows subjectivity comparison. The blue ones show objective. The green ones are neutral. And the red ones present subjective.

1) *Affective Conflict*: On GitHub, we observed the transformation from task conflict to affective conflict as the debate intensified. Many voices pointed out that the behavior of Russia does not represent its people and the community should treat them separately, “*Most of Russian people against war!*” However, the opposite thought “*...only RUSSIANS (ppl) can stop it.*” and “*Maybe if you’ll loose access to GitHub you’ll at least care enough to try and change it.*” Moreover, the pro-Russia users defended the rationality of military action, “*It is not an invasion of Russia in Ukraine, it is a prevention of NATO invasion in Russia.*” and “*people from there and Russia were a part of one country...*” Subsequently, more radical discourses appeared, “*Modern Russia is a Nazi State.*” “*Why should the entire population get banned because of someone else’s doing, quite literally racist?*” etc. In contrast, we did not observe similar situations on Aave.

We conducted sentiment analysis on two communities’ discourses. To facilitate the comparisons, we define the sentiment percentage $SP = (\text{Num.S}/\text{Num.T})\%$. In this equation, Num.S means the number of discourses with one kind of polarity (positive/neutral/negative) or subjectivity (subjectivity/neutral/objectivity) property. And Num.T means the total number of discourses in the same period. We can determine people’s sentimental variation by comparing the monthly change in the percentage of polarity and objectivity (see Fig. 7).

In the **polarity aspect**: 1) CAO and DAO kept stable before the crisis; 2) after the eruption of the crisis in February, the percentage of negative comments increased more in GitHub than in Aave; 3) since the GitHub staff closed the discussions, the percentage of negative comments slightly dropped on GitHub and is smaller than on Aave; and 4) GitHub consistently had a higher percentage of positive comments than Aave over the six months. Meanwhile, neutral discussions were dominant on Aave. In the **subjectivity aspect**: 1) the comments mainly performed objective in both CAO and DAO, which is rational for developer communities; 2) discourses in Aave consistently had a higher percentage of objective than GitHub; and 3) since October 2021, the percentage of objective comments on GitHub had decreased while the percentage of subjective had increased. This trend changed after GitHub closed crisis discussions. In contrast, the subjectivity of Aave had not changed notably.

TABLE I
COMPARATIVE RESULT OF CONFLICT RESOLUTION

	Task Conflict	Affective Conflict	Process Conflict	Normative Conflict	Conflict Type Transformation
GitHub	Y	Y	N	N	Y
Aave	Y	N	N	N	N

Thus, through observation and sentiment analysis, we found that simply banning the crisis discussions did not fully resolve the conflicts but transformed the original conflicts into affective ones on GitHub. But this kind of transformation was not evident in Aave. In other words, DAO performed better than CAO in resolving affective conflict.

2) *Other Conflicts*: On whether GitHub should respond to crisis-related tasks, some were opposed, “*Cutting off Russians would harm to the free software community*” and “*Github is used as a platform of freedom for people who can develop software tools ...*” Considering the value of “Open Source” [41], GitHub ended up not restricting Russian users. However, there might have been tension because of GitHub closing these discussions. Comparatively, after voting, Aave members expressed their positive views about the solving process in line with its values, such as “*While the Snapshot did not pass, it is inspiring. ...*” And the voting process kept with the rule of DAO. Hence, at least in our study, we did not observe process conflicts and normative conflicts on GitHub and Aave.

In summary, our comparative analysis revealed the following.

- 1) Task conflict transformed into affective conflict on GitHub because of its centralized conflict management, directly banning discussions. Members showed significant negative and subjective emotions in the discussion. This aspect was not evident in Aave.
- 2) As a CAO, GitHub’s response to the conflict aligned with its community rules and without process and normative conflict. Aave’s DAO model also averted the transformation into these conflicts. Hence, for RQ1, the DAO model can alleviate conflicts arising from discussions about external influences better than the CAO. Table I shows the comparative result from the five dimensions.

C. Sociological Reasons for DAO’s Conflicts Alleviation

Aave alleviated conflicts arising from discussions about the external crisis and supported collaboration better than GitHub. Therefore, we introduced the contact theory (see Section II-C) which examines conflict and collaboration in groups to study the reasons for different conflict alleviation performances between the CAO and DAO models. We found that the DAO meets better than the CAO with the four conditions proposed by the theory to eliminate conflicts and promote collaboration.

1) Equal Status:

a) *Between staff and users*: As described above, the GitHub community exhibits a more hierarchical structure. Its staff are employed by GitHub, and they manage the users’ behavior on the CAO. They have more privileges in

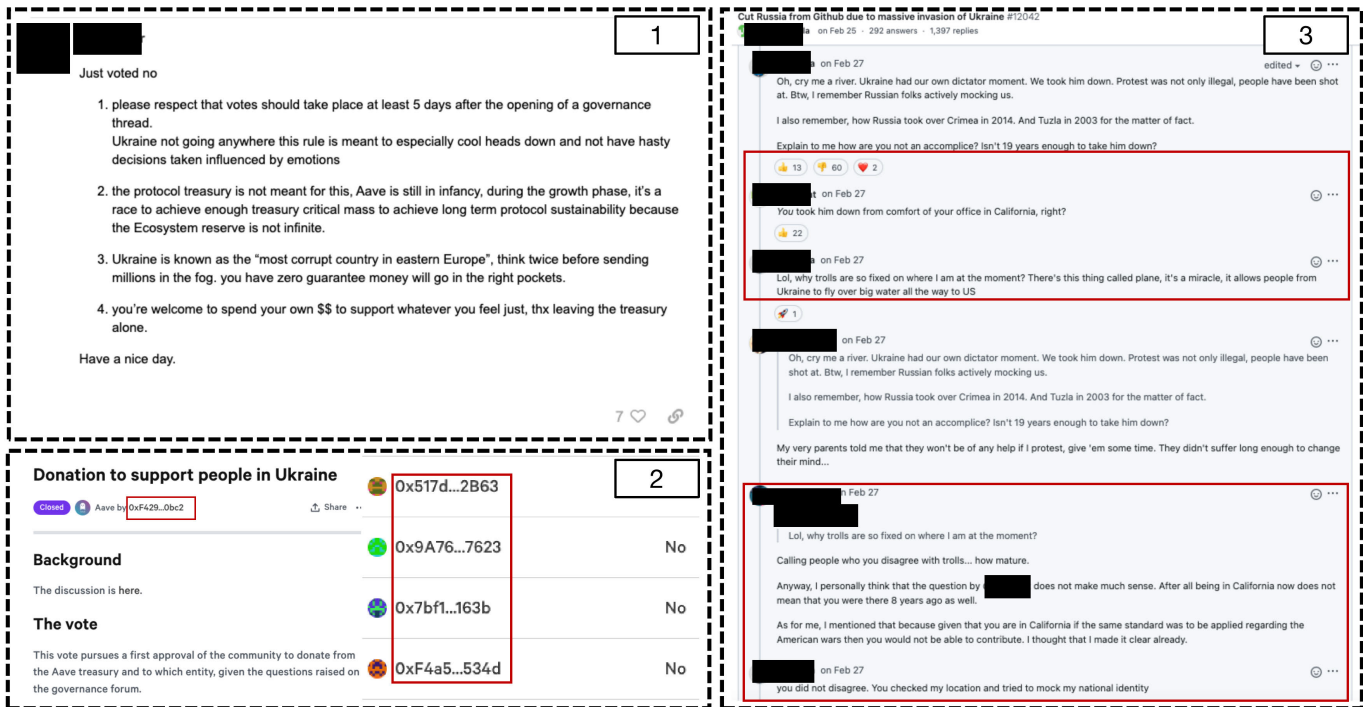


Fig. 8. Evidences of these two communities' members having different equal statuses. 1—An Aave administrator needed to participate in community governance through voting, 2—the voting based on blockchain data did not reveal users' backgrounds, and 3—others doubted one user's message during war because of the geographic information disclosed on GitHub.

discussions than regular developers and users, such as the right to modify and lock discussions. Comparatively, although Aave also has administrators, they are not privileged in the community due to the DAO model. In Part 1 of Fig. 8, an administrator of Aave participated in ARC discussion. He stated his opinion on the discussion and participated in the voting.

b) *Between users and users:* The DAO has a better equal status between users. As shown in part 2 of Fig. 8, the voting page only showed the blockchain address of the participants without their backgrounds such as geographic location. This can reduce the interference of identity information and help users to focus on the discussion. However, GitHub users can easily discover others' backgrounds, likely leading to gaps and forming different groups. As part 3 in Fig. 8, others think one user had no qualifications in the discussion since "...you are in California..." The discussion deteriorated into an attack based on identity politics.

2) *Common Goals:* Obviously, there are common goals in both the CAO and the DAO. But analyzing the message posted by GitHub staff in shutting down discussions (part 4 in Fig. 3), we can find that as a company that serves the world's largest open-source software community, GitHub has to reconcile the interests of developers ("GitHub's vision is to be the home for all developers..."), the government ("We take our obligations with respect to government mandates seriously..."), and the platform itself in the face of the external crisis. Hence, the common goals of the community are mixed and complex. Similar situations have happened with platform companies such as Twitter and Facebook. When faced with conflicts of multiple parts' goals and interests, it is hard for a CAO to ensure the harmonious coexistence of all the

stakeholders [42]. Aave is much simpler. Most members are Aave token holders. Therefore, donating the DAO treasury to Ukraine directly affects the interests of all the holders, including the proposal initiator, administrators, and all the voting participants. The goals between the community and the users are much more overlapping. Hence, in the discussion, we observed the following statements: "I've donated myself and encourage others to do so on a personal level. (But using the treasury,) I vote no," "...leave the public treasury out of it," etc.

3) *Intergroup Cooperation:* The different organization models of GitHub and Aave dictate they have different approaches to conducting intergroup cooperation. Since GitHub staff are the ultimate decision-makers and community action executors, the general cooperation ways can be summarized as users making requests and waiting for feedback or executions. On the other hand, Aave cooperates through members voting together to decide on community actions. The data we obtained revealed that GitHub's method was not effective enough during external war discussions. We found there are 359 identified requests from community users to the GitHub platform. These requests accounted for 21.20% of all relevant answers and replies. However, GitHub ignored all of them. In addition to removing the best answer set by the original author, GitHub only replied with the official statement and locked the discussion at the end. Compared with the number of related discussions, GitHub's reply accounted for only 0.06%.

4) *Support of Neutral Authority:* When we expanded our study to look at the subsequent impact of the external war on these communities, we found that Aave provides more neutral support of authority than GitHub. After the ARC closed

TABLE II
QCA RESULT THROUGH CONTACT THEORY

	Equal Status	Common Goals	Intergroup Cooperation	Support of Neutral Authority
GitHub	N	Difficult	N	Doubtful
Aave	Y	Y	Y	Y

on March 7, the community did not make any announcement restricting users' access in specific geographic areas. We adjusted our IP address' geolocation several times via VPNs and tried to access Aave platforms and protocol. There were no hidden restrictions we found. Hence, we infer that Aave keeps neutral according to the voting result. Yet GitHub showed a potential tendency in governing, even though its staffer promised to consider both the interests of the government and its developer users. One negative case is that a user found "*Ukrainian numbers (+38) are not in the list of two-factor authentication*" on April 7. Subsequently, the GitHub staff replied that Ukraine and Russia are currently not on the list of supported countries. Through a web archive service,⁸ we found that Russia and Ukraine were still on the list, at least before October 2021. Given some platform companies use a straddle strategy to protect their interests in geopolitical conflicts [43], perhaps GitHub has adopted a similar strategy.

Above, we conducted the QCA on GitHub and Aave through the four conditions of the contact theory. Table II shows the result. We found that in face of an external crisis, Aave fits the four conditions well depending on its DAO model. While GitHub does not meet the "Equal Status" and the "Intergroup Cooperation." It is more difficult to implement the "Common Goals" together with doubt about the fulfillment of "Support of Neutral Authority." Thus, according to the contact theory, following the DAO model is more likely to alleviate community conflicts caused by immense external influences.

D. Vital Role of Web 3 Technologies for the DAO Model

There may be an illusion that if Web 2 CAOs add functions such as voting, linking governance behaviors to users' interests, and better privacy protection, these centralized communities can also fit the contact theory and have a better performance of conflict solving. But we found those functions, such as voting, do not perform effectively in the Web 2 context without the support of Web 3 technologies.

1) *Combining the Governance With Personal Interests and Rewarding Participants' Contributions*: One assumption is that if there has been a connection between users' governance behavior and their personal interests, perhaps the interests of the Web 2 community platform and users can be reconciled to form a more unified common goal. We found GitHub published the "Achievements" feature in April 2021.⁹ The function intends to give developers an approach to show their contributions to the community, which is a way to examine developers' abilities and help future employers understand

⁸<https://web.archive.org>

⁹<https://github.blog/>

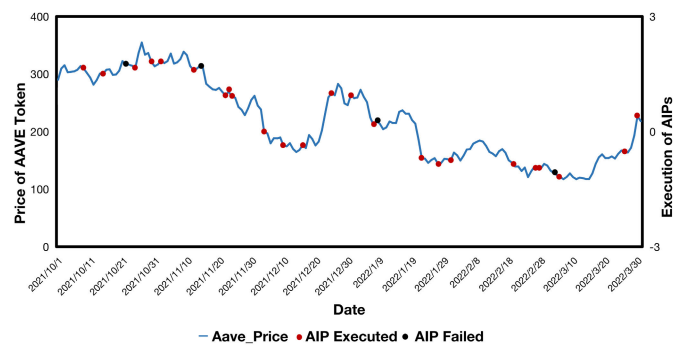


Fig. 9. Price change of AAVE token and executed AIP proposals. The blue line shows the change in the token price. The red dots represent AIP proposals in Aave that had been implemented through a community vote and blacks represent failed AIPs.

them better. The system contains six badges, and developers can display their achievements in the profiles.

We logged all achievements' discussions in the GitHub community and categorized them by their contents. We found that community members generally appreciate the achievements' feature, since it shows users' contributions and might lead to more personal benefits in the future. However, it seems not to operate very well. About 14.3% feedback clearly expressed users' love for this function. However, 21.9% discussions had expressed opposition, such as "*yolo badge does not pass the right message especially to recruiters*" and "*I don't want badges, ...I want a place to store my code.*" Moreover, 32.8% developers expressed confusion about how to get achievement badges, "*How often are the new Github achievements being updated?*" Also, 30.8% gave feedback on various bugs, like "*My 2x Pull Shark achievements are missing somehow.*" Clearly, assessing members' contributions within an organization has always been difficult. A centralized evaluation has not always resulted in a reasonable assessment of members' contributions and brought individual benefits [44].

In the blockchain-based DAO, a direct financial approach solves the problem. The proposals' initiators in Aave, the discussants of governance topics, the participants of votes, and the community managers are all Aave token holders. In Web 3, one project's token-based economics not only allows all these people to form a community with shared interests financially but also plays as a medium to easily combine users' governance behavior in the community with individual rewards. We obtained the token prices of AAVE (USD) P from its ON-chain data from October 2021 to March 2022. We also logged the AIP proposal numbers, Num , in the Aave community during the same period (each executed AIP records 1 and failed one records -1). The result is shown in Fig. 9.

As Table III, the ADF test of Num and P is -4.69^{***} and -1.29^{**} , respectively. Hence, we could use the VAR model to examine how the proposal affects the token price. We had chosen the optimal lag order at a value of 1 and obtained the impulse response of P from Num (see Fig. 10). It reveals that the impulse of the proposal to token prices is greatest on the second day at U.S. \$35.65 ($-46.36, 118.36$ at 95% CI) and tends to zero after 20 days. For token holders, the price is directly related to their interests. And their participation in governance will give them positive rewards. Hence, unlike

TABLE III
ADF TEST AND OPTIMAL LAG ORDER RESULTS

ADF	t	P	Lag Order	logL	AIC	SC	HQ	FPE
Num	-4.69	0.002***	0	-126.498	5.498	5.597	5.523	244.223
P	-1.29	0.033**	1	-105.779	4.486*	4.784*	4.556*	89.067*
			2	-100.052	4.805	5.303	4.913	124.466

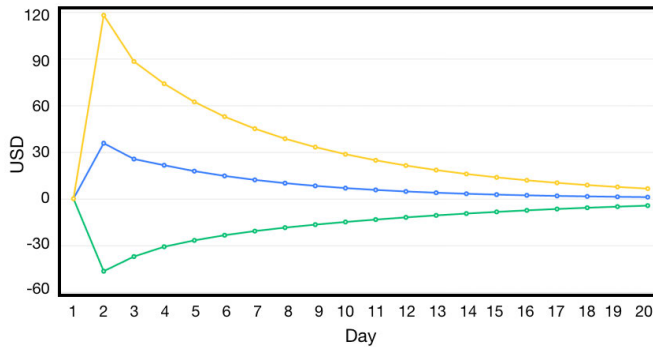


Fig. 10. Impulse of the proposal to token prices. The impact is greatest on the second day after voting.

Web 2 CAOs, Web 3’s token-based economics and governance allow the DAO members to receive direct financial benefits for their governance behaviors.

2) *Anonymizing Backgrounds and Guaranteeing Governance*: The last change in the social aspect due to Web 3 technologies is a completely different anonymity mechanism in DAOs. During discussion, we observed how GitHub members judged a user’s opinion by checking the geographic information. In fact, by retrieving all these crisis discussions on GitHub, we found that among the total 474 discussion participants, a total of 26 users from Poland (5.48%), 42 from Russia (8.86%), and 37 from Ukraine (7.81%) had to self-disclose their geographic information. The self-disclosure or disclosure of others’ background information in online communities is very common. People tend to gain social resources through this behavior, leading to bias [45]. However, Web 3 can change the dilemma by affording anonymity. For example, applying zero-knowledge proof technology to the blockchain can further reduce the need to disclose user account information. Thus, it can promote the focus on governance details without the influence of user information [46].

VI. DISCUSSION: IMPROVING THE DAO VOTING

While DAO resolved conflicts better than CAO during the 2022 Russian–Ukrainian crisis. However, we find that it still has a limitation in its vote governance process. The percentage of people voting is relatively low among all the token holders. As mentioned above, we observed that only 0.17% of the population participated in the voting about the war, which is significantly lower than the regular voting percentage 6.23%. That means most people are often silent in dealing with potential conflicts. The low willingness to vote is not unique to Aave. In other DAO cases, proposals cannot achieve a quorum is also a problem [47]. The low voting participation limits the ability of DAO to resolve conflicts. Based on Aave’s study, we summarized the reasons for this dilemma.

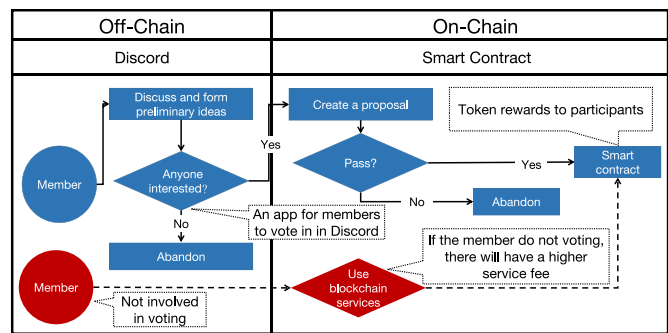


Fig. 11. Prototype of the improvement voting system: bidding-incentive voting. It provides incentives to voting participants. Correspondingly, it penalizes members who do not participate. In addition, like the bidding mechanism, there are different incentives among the participants. Finally, it simplifies the way to participate in voting.

- 1) No direct rewards for voting participation. Governance in Aave can bring financial incentives to its cryptocurrency holders by increasing the currency price. However, this mechanism lacks direct rewards for governance behavior. This problem is the same like traditional voting cannot circumvent the free rider issue [48]. In other words, cryptocurrency holders who do not participate in voting can also be benefited from others’ voting actions. Therefore, the voting system needs to be improved so that voting participants can obtain direct rewards for their voting behaviors in addition to the financial incentive of higher cryptocurrency prices.
- 2) The process of participating in voting requires a cross-platform operation. The voting process in Section III-B is quite complex. Therefore, the inability to vote directly where DAO members communicate daily also constrains voting participation.

Hence, we proposed an improved prototype for DAOs with the Aave similar voting system. We named it bidding-incentive voting.

- 1) Our prototype is inspired by “giving the voting a betting nature and rewarding those who vote for the right option together with punishing those who vote for the wrong option” [49]. Our study shows that the act of voting deserves to be rewarded by the community.
- 2) 25% of the DAO treasury will be set aside as a reward pool.
- 3) Voting participants will receive cryptocurrency sent by the smart contract as rewards. The total reward amount per vote positively correlates with the total number of participants in this voting as a percentage of the DAO’s total cryptocurrency holders.
- 4) Participants whose voting options match the voting result will receive 10% more incentive than participants who do not.
- 5) For cryptocurrency holders who do not participate in voting, a percentage more processing fee can be added to their use of the DAO’s blockchain service than members who have participated in the vote. This “punishment” should balance the treasury’s expenses to reward voting participants.

- 6) Design a portal that allows DAO members to vote directly in the Discord channel. Fig. 11 shows the process of our prototype.

VII. LIMITATIONS AND FUTURE WORK

First, there are limitations in our study sample. Our study chose GitHub and Aave to represent CAOs and DAOs, respectively. But there are other types of developer communities (e.g., the Stack Overflow forum) that may run in different ways. Moreover, the cause of conflict in our study is the 2022 Russo-Ukrainian crisis. But conflicts could change if other major external crises cause them. Therefore, future work needs to analyze how other DAOs and CAOs manage conflicts caused by various external crisis discussions. Second, although the centralized and decentralized governance models are the main difference between GitHub and Aave, their different conflict management might also stem from other factors. Hence, future work should consider more comprehensive elements. Third, while we introduced the intergroup contact theory as a metric to analyze the mechanism of why DAO maintains a better community atmosphere and productivity, we only used a comparative analysis method and discussed qualitatively. Future research may use a modeling method to gain more quantitative evidence and deeper insights. Finally, we did not validate the effectiveness of our proposal to improve the voting mechanism for DAOs. In the future, we will cooperate with a DAO and run an experiment to figure out how much turnout increase this monetary incentive-based improvement can be. We will also explore other approaches of voting improvement, including designing NFTs that represent the “I Vote!” stickers, designing a virtual billboard for voting campaigns, etc.

VIII. CONCLUSION

In this work, we conducted a comparative analysis of the differences between GitHub (a CAO) and Aave (a DAO) in managing the conflicts caused by discussing how to deal with the 2022 Russo-Ukrainian crisis. The motivations of our study include: 1) discussion and accompanying conflicts are crucial for collaboration, but few studies focused on the conflicts caused by abrupt and immense external crises such as geopolitical events; 2) the 2022 Russo-Ukrainian Crisis is one of the most impactful geopolitical events after the cold war, and its effects are still ongoing; and 3) there is little research on the performance of DAO, blockchain technology-based innovative organization, in conflict resolution.

Hence, we chose two open-source developer communities, GitHub and Aave, as our research objects not only because they have both been influenced by the crisis but also because the centralized/decentralized governance model is their significant difference. We considered whether they had emerged specific conflicts or transformations as the dimensions to compare their performance during the Russo-Ukrainian Crisis. **We mainly found that:** 1) while both of them triggered task conflict due to crisis discussions, the centralized governance in GitHub caused transformation, and affective conflict occurred and 2) Aave’s DAO model averted the transformation into other conflicts. Hence, we assumed that DAOs might be better

than CAOs for mitigating the conflicts arising from external crises.

Our study used the contact theory to interpret this phenomenon. **We found that** the DAO meets better than the CAO with the four conditions proposed by the theory to eliminate conflicts and promote collaboration, which gives evidence for our assumption from the social science area. Then, **we inferred that** blockchain technologies, voting mechanisms, and cryptocurrency played critical and fundamental roles in DAOs’ managing and resolving conflicts. We also found the voter turnout of a DAO may be low. Therefore, we proposed to add a monetary incentive to improve the blockchain-based voting mechanism for DAOs so that the DAO can engage more community members in forming common goals.

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