

Governing online forum interactions with multi-agent system: A Reddit use case with the JaCaMo platform

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Abstract. Autonomous agents are intelligent software systems that can carry out tasks on behalf of users without their intervention. On online forums, autonomous agents can operate to read and post messages on behalf of users. The proper regulation of agents' interactions are required for achieving the expected results on online forums. One way to govern these interactions is using multi-agent oriented programming platforms. Here we introduce the use of JaCaMo, a multi-agent oriented programming platform, for governing agents' interactions within online forums. We show its feasibility for regulating agents' interactions within a popular online forum, Reddit.

Keywords: Multi-agent systems · JaCaMo · Online forum · Reddit

1 Introduction

Online forums create opportunities for information sharing and collaboration. Yet they pose significant challenges in terms of information trust and reliability. Users often encounter inaccurate or misleading information, thus they may be hesitant to trust the advice and guidance provided by anonymous online sources. Multi-agent systems can support addressing the information credibility and reliability problem based on factors such as the source of information. For example, agents can analyze news articles' sources and claims by referencing them with other reliable sources of information. This analysis may allow agents to provide a trust score for the information, which could be used to filter out unreliable or false information, ultimately creating more trustworthy online communities.

A first step for tackling this complex issue, however, is the regulation of users' activities on online forums. Because human users and autonomous agents acting on behalf of human users can operate on these forums, any regulation approach has to take into account activities performed directly by both types of users. Multi-agent system (MAS) is a suitable approach for dealing with the regulation of online forums as MAS can abstract both types of users as agents and enables the regulation and enforcement of their interactions through norms.

This paper presents an application scenario exploiting JaCaMo [3]¹, a multi-agent oriented programming platform, for governing agents’ interactions on a popular online forum, Reddit².

JaCaMo is a powerful platform for the development of complex multi-agent systems that has been used in a wide range of domain applications, including smart home [12], finance [1] and accountability [2]. JaCaMo allows to build intelligent agents with sophisticated reasoning capabilities and to regulate their interactions within a shared environment. The JaCaMo meta-model [3] combines four MAS dimensions: Agent [5], Environment [13], Interaction [14] and Organization [11]. Each dimension is seamlessly connected with each other making possible for agents to interact with the environment and to participate in organizations situated on that environment. The situatedness of organizations is achieved through constitutive norms that extend the concept of artificial institutions. These constitutive norms connect the environment within which the agents interact with regulative norms used for regulating agents’ interactions in the context of the organization [10]. Constitutive norms express which environmental facts count as organizational facts used in regulative norms. Regulative norms are rules and guidelines that establish expected agents’ behaviors within a community. Regulative norms are essential for establishing trust, building relationships and promoting positive social interactions.

The remaining of the paper is organized as follows. First, we present a motivating scenario in which agents have to interact in the context of an online forum, Reddit (Section 2). We then introduce the JaCaMo platform and explain how it can be used to govern interactions on online forums (Section 3). We describe the implementation of agents’ interactions on Reddit using JaCaMo and provide a detailed explanation of the agents, organization, environment and normative and constitutive norms (Section 4). Next, we present a proof-of-concept based on the Reddit use case in which agents participate in an online forum discussion by retrieving and submitting posts under explicit regulative and constitutive norms (Section 5). Finally, we conclude the paper (Section 6).

2 Reddit Motivating Scenario

Reddit is a social network with individual communities (i.e., online forums) called *subreddits*. Subreddits are created and moderated by users and dedicated to specific topics from news and politics to hobbies and entertainment (e.g., Fig. 1). Reddit provides two main roles that users can adopt per subreddit: *subscriber* and *contributor*. A subscriber is a user who follows a particular subreddit, i.e., the user receives updates of new posts and can upvote or downvote them. A contributor is a user who can submit posts (i.e., links, images, videos, or text).

In this scenario, *Alice* and *Bob* are two Reddit users interacting with the “Movies” subreddit. *Alice* is a subscriber to this subreddit, i.e., she can access the “Movies” subreddit and view movie-related content; *Bob* is a contributor to

¹ <https://github.com/jacamo-lang/jacamo>

² <https://www.reddit.com/>

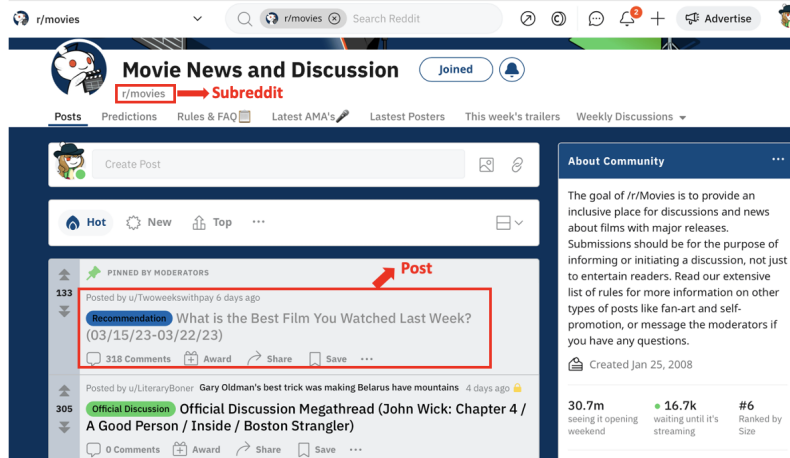


Fig. 1. Structure of the “Movies” subreddit in Reddit

this same subreddit, i.e., he can share interesting movie-related content with the subreddit community. One day, *Bob* posts a new movie trailer that has just been released. *Alice* sees the post and finds it interesting. She clicks on the post to know more about the movie and decides to upvote it, helping the post to gain visibility and popularity within the community. Through this interaction, *Alice* and *Bob* are able to engage with each other and the community, sharing their knowledge and opinions about the world of movies. This type of social interaction and collaboration is made possible by the structure of Reddit and the specific roles and functions assigned to users within their communities.

In online forums like Reddit, users often interact with others who they do not know, which can lead to trust issues. There is a risk that people may post false information, engage in trolling or even use the online forum to spread malicious content. The lack of trust in online forums is a significant issue. On Reddit, norms are used to enforce behavior in order to overcome this issue. Firstly, norms can be established by the community itself through discussion, voting and consensus building. For instance, users can agree on what constitutes acceptable behavior in a particular subreddit, such as keeping discussions on-topic or refraining from personal attacks. These norms can be communicated through subreddit rules, guidelines and community standards, which moderators can enforce. Secondly, norms can be reinforced by moderators or through social pressure and community expectations. For instance, users who consistently violates community norms may face negative feedback from other users in the form of comments, downvotes or reports. This social pressure can discourage rule-breaking behavior and encourage users to conform to community norms.

Norms in online forums are usually expressed in a human-readable format. A challenge is to express them into a machine-readable format that autonomous agents can handle and to relate instances of these norms with actions being

performed in the online forum. This requires to identify the actions in the online forum that hold regulatory significance for the community and to situate these norms on the web due to the nature of online forums. By effectively addressing these challenges, online forums can be an environment for human users and autonomous agents to engage in meaningful discussions and share information.

Here we propose using multi-agent systems, in particular the JaCaMo platform, to enforce these community norms through automated processes tackling the regulation of users' activities. In JaCaMo, we can establish clear and agent-readable norms and explicitly relate them to users' behaviors in the context of an organization. This automate regulation enables agents regulation more precise and consistent than humans would be able to achieve manually.

3 Background

JaCaMo is a multi-agent oriented programming platform particularly relevant for the development of complex systems. By allowing agents to interact with each other through communication and coordination, the JaCaMo platform enables effective decision-making and efficient resource allocation in complex systems. The JaCaMo meta-model [3] provides a comprehensive view of multi-agent systems by defining four dimensions: Agent, Environment, Interaction, and Organization. Concepts and primitives of the agent dimension defines the agents involved in the system, their beliefs, goals and their behaviors. The environment dimension defines the artifacts (i.e., encapsulation of operations and observable properties) used by agents to achieve their goals. The interaction dimension deals with the means by which agents communicate with each other to coordinate their actions. The organization dimension focuses on the rules and norms that govern the behavior of agents within the system.

Several extensions enable connecting JaCaMo platform with the web [7]. For instance, Charpenay et al. [6] propose Hypermedea, a framework that extends JaCaMo by enabling agents to operate on the web. In Hypermedea, agents can interact with physical devices and access data on the web, allowing for more sophisticated and diverse applications. However, bringing agents onto the web introduces new challenges related to regulation and control. In order to address these challenges, it is necessary to ensure that actions taken on the web are properly accounted for in the regulation of the system. Ciortea et al. [4,8] provide valuable insights into some of these challenges.

Although used to enable agents to interact on the web, JaCaMo has not yet been explored in regulating online forum interactions. Online forums are intricate systems that involve multiple agents with different objectives, preferences and behaviors. Investigating the potential of JaCaMo to regulate online forum interactions could have significant implications for improving user experience and engagement in these virtual environments. Further research is necessary to explore the feasibility, identify challenges and uncover opportunities of JaCaMo platform in this domain application. Here we provide insights into how the JaCaMo platform can be used to regulate agents' interactions in online forums.

One interesting JaCaMo’s feature is enabling the direct connection between the organization and the environment, thus eliminating the need for agents to explicitly update the organization status. This feature is facilitated by the use of constitutive and regulative norms. Constitutive norms are rules that define what counts-as institutional facts. These institutional facts are used in regulative norms that define what is considered valid, acceptable and appropriate within the organization. For example, the commitment of an agent to an organizational goal is represented in the organization as a regulative norm obliging the agent to achieve such goal. Constitutive norms are used to inform the organization that a goal has been achieved once an action leading to the achievement of that goal is performed in the environment. Thus, signaling that the agent has fulfilled its obligation without requiring the agent to inform the organization about the achievement of the goal. Together constitutive and regulative norms create a set of rules that enables the automated regulation of agents’ interactions and behavior. In the next section, we offer a novel perspective on how JaCaMo can help on this task.

4 JaCaMo-based Reddit Specification

In this section, we provide a description of the various elements that constitute the JaCaMo-based Reddit specification used in Section 5 to implement a use case. We describe the agents (Section 4.1), the organization with the regulative norms stating their expected behavior (Section 4.2), the environment in which they operate (Section 4.3), and the connection between the organization and actions performed in the environment with a focus on constitutive norms (Section 4.4).

4.1 Agents

Agents aim to successfully achieve their respective goals. They may work together and collaborate, each contributing with their skills and perspectives to the group.

On the JaCaMo-based Reddit specification, agents are responsible for performing tasks on behalf of users, i.e., submitting posts to and retrieving posts from subreddits. These agents have beliefs about the tasks they have to perform. Specifically, agents have beliefs about the subreddit where to post, the post’s title and content when posting on Reddit; and they have beliefs about the subreddit from where to retrieve the post and the post ID when retrieving a post from Reddit.

Listing 1 shows the plan in AgentSpeak(L) allowing agents to submit a post to a subreddit on Reddit using JaCaMo.

```
+!submit_post: subreddit_post(SP) & title(T) & content(C)
  <- submitPost(SP, T, C);
  .wait(700).
```

Listing 1. Submit post plan

The `#!submit_post` defines a plan to submit a post whenever the agent has such goal and also has in its belief base the post’s title (`title(T)`) and content (`content(C)`) to be submitted to a specific subreddit (`subreddit_post(SP)`). The plan uses the subreddit, the title and the content of the post to call the `submitPost` operation (see Section 4.3 for further details) that actually submits the post to Reddit.

Listing 2 shows the plan in AgentSpeak(L) language allowing agents to retrieve a post from a subreddit on Reddit using JaCaMo.

```

+!retrieve_post: subreddit_get(SG) & post_id(ID)
  <- retrievePost(SG, ID);
    .wait(700).

```

Listing 2. Retrieve post plan

The `#!retrieve_post` defines a plan to retrieve a post whenever the agent has such goal and also has in its belief base the post ID (`post_id(ID)`) to be retrieved from a specific subreddit (`subreddit_get(SG)`). The plan uses the subreddit and post ID to call the `retrievePost` operation (see Section 4.3 for further details) that actually retrieves the post from Reddit.

4.2 Organization

JaCaMo provides a comprehensive framework for modeling Reddit in an organizational context. The JaCaMo-based Reddit organization reflects the structure and functions of Reddit as an organization within JaCaMo. This mapping enables autonomous agents to effectively understand Reddit’s functionalities through JaCaMo representation and to achieve the goals of submitting and retrieving posts on subreddits. The `reddit_organization` organization in JaCaMo defines the roles, group structure, missions and goals that align with Reddit’s functionalities, and the norms that outline the expected behavior of agents within subreddits.

The Reddit organization specification is structured around the (`reddit_group`) group that represents a subreddit. Groups are composed of agents playing the subscriber (`reddit_subscriber`) and the contributor (`reddit_contributor`) roles. Agents may adopt multiple roles in a group or participate in various groups. Different groups may have a different sets of agents that adopt different roles. The social scheme `reddit_scheme` defines the organizational goals (Fig. 2).

Figure 3 details how the `reddit_scheme` is structured. The main organizational goal (`interact_reddit`) is composed of two sub-goals that can be performed in parallel (i.e., `submit_post` and `retrieve_post`). Goals are achieved through missions that agents can commit to. The `submit` mission is associated to the `submit_post` goal for submitting a post to Reddit and the `retrieve` mission is associated to the `retrieve_post` goal for retrieving a post from Reddit.

Norms are defined specifying that only agents playing the `reddit_subscriber` role are allowed to commit to the `retrieve` mission and achieve the goal of retrieving posts from a subreddit (i.e., `retrieve_post`); and only those playing

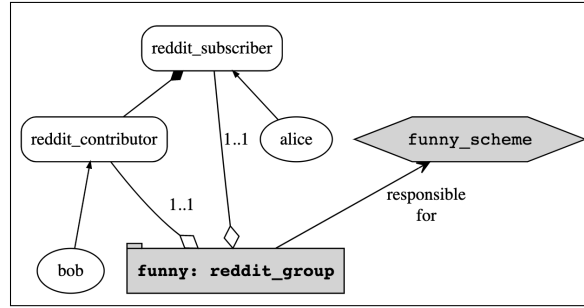


Fig. 2. Instance of the `reddit_organization` composed of a `reddit_group` group called `funny`, which is responsible for the instance of the `reddit_scheme` social scheme called `funny_scheme`, and composed of the `reddit_subscriber` and `reddit_contributor` roles played by the *Alice* and *Bob* agents

the `reddit_contributor` role are allowed to commit to the `submit` mission and achieve the goal of submitting posts to a subreddit (i.e., `submit_post`).

4.3 Environment

To enable agents to interact with Reddit, we developed an artifact called `RedditMgmt`. The `RedditMgmt` provides a set of primitives that enables agents to interact with the Reddit API and collect data on user’s interactions on Reddit. This artifact provides a range of methods for accessing Reddit’s REST API, enabling agents to retrieve posts from and submit posts to subreddits.

In particular, the `RedditMgmt` artifact provides the retrieve (`retrievePost`) and submit (`submitPost`) operations. The retrieve operation retrieves a post from a particular subreddit, while the submit operation submit a post to a subreddit. The retrieve operation takes two input parameters, the subreddit and the post ID, and returns a JSON string of the post retrieved from the subreddit. The submit operation takes five input parameters, subreddit, title, content, url and topic. But before submitting, the submit operation checks if the topic of the post is related to the subreddit. If so, it submits the post to the subreddit. Otherwise, the artifact generates an error message to signal to the agent that there was a problem with the post submission.

4.4 Organization and Environment

Here we describe how to monitor and control the regulation based on the operations performed in the environment. For such, we define a set of constitutive norms that state that events created in the environment count-as states in the organization (i.e., status functions).

For example, when an agent on a subreddit adopts a role as a `reddit_subscriber` or `reddit_contributor`, this can be considered as a state change in the organization that reflects the agent’s role as a member of a group; if an agent subscribes

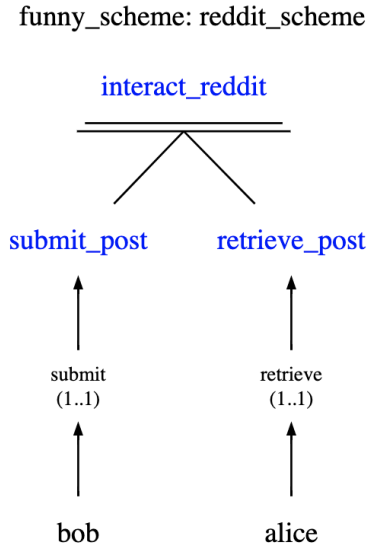


Fig. 3. Organization scheme with goal decomposition

to a specific subreddit, this can be considered as a state in the organization that reflects their interest in a particular topic; if an agent commits to contributing to a particular discussion thread or subreddit, this can be considered as a state in the organization that reflects their commitment to contributing to the community. By defining these state changes through constitutive norms, we can establish a clear connection between agent’s actions in Reddit and the organization’s status functions. This connection can be used to monitor and control the agents’ behavior while pursuing their goals within the context of the organization.

Constitutive norms are used to assign status-functions to concrete elements, following the formula: X count-as Y in C [9]. A constitutive norm can be defined to state that an agent (X) count-as playing the role of a `reddit_contributor` (Y) in the context of the `funny` group (C), where the agent can participate in discussions and contribute to the community’s content. JaCaMo provides other status-functions in addition to “play” including “responsible” (i.e., assigns responsibility to a group or individual for certain tasks), “committed” (i.e., establishes a commitment to a specific mission or goal), “achieved” (i.e., denotes the successful completion of a task), “mission_role” (i.e., defines the role of an individual within a mission), “done” (i.e., indicates the successful completion of a task), and “well_formed” (i.e., implies that the group is functioning effectively). The constitutive norms we define to establish the relationship between the status-functions and concrete elements within the context of Reddit are shown in Figure 4.

Rule 1 and 2 use the status-function of “play” to define that agents *Bob* and *Alice* adopt respectively the `reddit_contributor` and `reddit_subscriber`


```

status_functions:
states: play(A,R,G), responsible(G,S), committed(A,Mission,S), achieved(S,G,A),
mission_role(M,R), done(S,G,A), well_formed(Group).

constitutive_rules:
1: count-as play(bob,reddit_contributor,"funny") .
2: count-as play(alice,reddit_subscriber,"funny").
3: count-as responsible("funny","funny_scheme")
   while play(A,reddit_contributor,"funny") | play(A,reddit_subscriber,"funny").
4: play(A,reddit_contributor,"funny")
   count-as committed(A,submit,"funny_scheme")
   while responsible("funny","funny_scheme").
5: play(A,reddit_subscriber,"funny")
   count-as committed(A,retrieve,"funny_scheme")
   while responsible("funny","funny_scheme").
6: count-as done(funny_scheme,submit_post,A)
   when submit(funny, test, test, "https://i.imgur.com/Hyo0tWD.jpeg",
fun)[sai__agent(A)].
7: count-as done(funny_scheme,retrieve_post,A)
   when retrieve(funny)[sai__agent(A)].

```

Fig. 4. Constitutive norms

roles in the `funny` group. Rule 3 defines that the `funny` group is responsible for the `funny_scheme` scheme as long as there is an agent playing the `reddit_contributor` or `reddit_subscriber` role. Rule 4 and 5 define that agents playing the `reddit_subscriber` or the `reddit_contributor` are committed respectively to the `retrieve_post` or `submit_post` mission in the `funny` group. Rule 6 defines that using the `submit` operation on the `funny` subreddit count-as achieving the goal of submitting a post. Rule 7 defines that using the `retrieve` operation from the `funny` subreddit count-as achieving the goal of retrieving.

5 JaCaMo-based Reddit Use Case

In the previous section, we presented a JaCaMo-based Reddit specification, that outlined the roles, goals and actions of the agents in Reddit. In this section, we will instantiate a use case by defining the agents and their interactions using JaCaMo³.

The use case involves two agents, *Alice* and *Bob* who are assigned to the `funny` group. *Alice* adopts the `reddit_subscriber` role and can read and engage with other people’s posts, while *Bob* adopts the `reddit_contributor` role in this group and can submit posts to Reddit. Below we show a proof-of-concept of how *Alice* and *Bob* can interact with each other using JaCaMo and achieve their goals in the scenario. First, we tasked *Bob* with the goal of submitting a post related to the topic “fun” to the `funny` subreddit and *Alice* with the goal of retrieving a

³ Source-code available at https://github.com/Nesrine-Hafiene/JaCaMo_Reddit

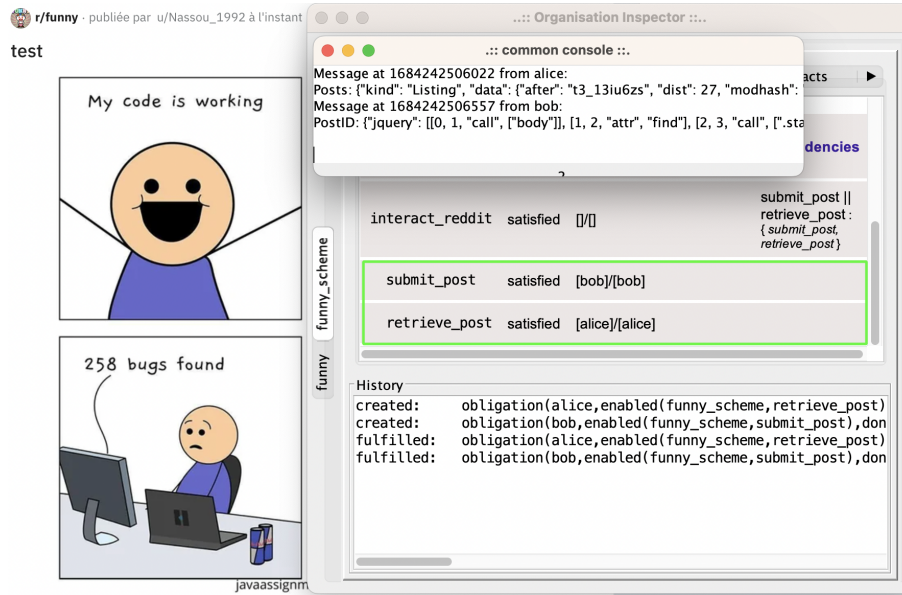


Fig. 5. Alice and Bob achieved their goals

post from the same subreddit. Figure 5 illustrates that both agents are able to fulfill their goals successfully.

In the second situation, however, we deliberately tasked *Bob* with the goal of submitting a post not related to the topic “fun” to the *funny* subreddit. Figure 6 illustrates that *Bob* failed to achieve his goal as the topic of the post was not one of the main topics of the subreddit.

The agent’s successful submission and retrieval of posts from Reddit demonstrates its ability to operate effectively within the organization without requiring knowledge of the organization’s content or objectives. The constitutive norms make possible to monitor the progress of the regulation based on the action performed in the environment. This proof-of-concept shows the usefulness of JaCaMo in facilitating goal achievement in the Reddit context, but also highlight the importance of carefully selecting relevant topics for successful agent performance. Overall, these findings suggest that JaCaMo holds potential for use in facilitating efficient and effective human-agent collaboration in online communities.

6 Conclusions

The compatible characteristics of multi-agent systems and the web, such as distributed, adaptable and flexible, provide several advantages for using the former to develop governance systems for the latter. By distributing decision-making

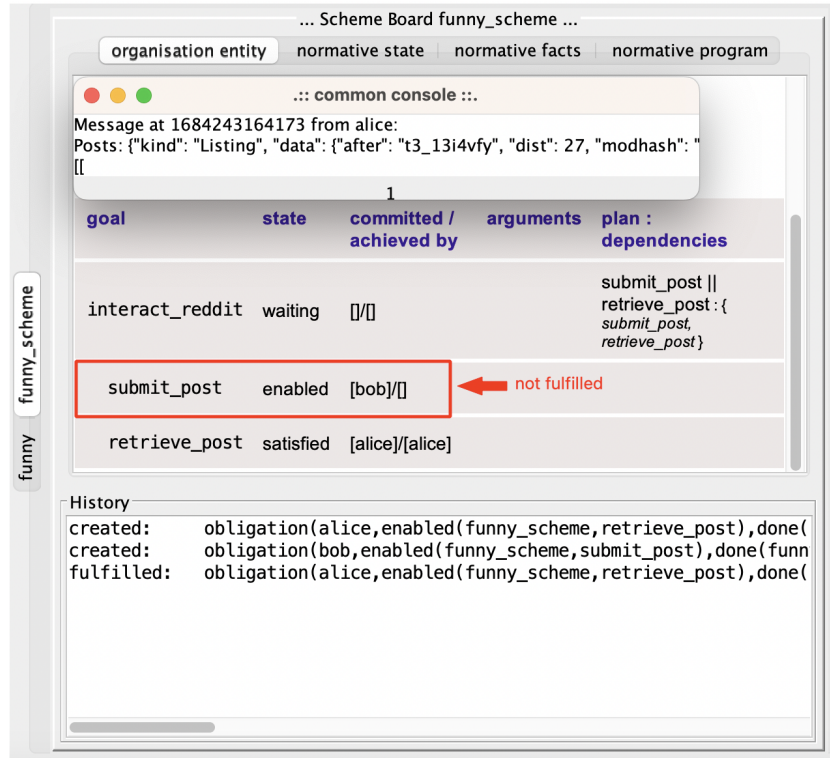


Fig. 6. Bob failed in achieving his goal

and enabling agents to autonomously learn and adapt, multi-agent systems provide a resilient and context-specific governance solution. Here, we showed the use of JaCaMo in combination with Reddit’s API as a powerful tool for developing and governing autonomous agents interacting within Reddit. Our case study showed the feasibility of using JaCaMo to effectively regulate the agents’ actions to submit and retrieve posts in Reddit with the purpose of achieving their goals. Moreover, the separation of concerns between regulative and constitutive norms in JaCaMo offers a promising approach to develop more sophisticated and nuanced regulations for online forums. By developing constitutive norms that analyze the content of a post and determine whether it meets certain standards, we can create a more targeted regulation to online forums. Future works should be conducted to highlight the advantages and explore the potentials offered by multi-agent systems for governing web components. Additionally, more extensive experimental validation, including a broader range of scenarios and larger-scale experiments, is required to fully evaluate and demonstrate such advantages and potentials. Besides contributing to the advancement of the field, such experimental validations will contribute to the development of more effective and trustworthy social network systems.

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