Convention Emergence Through Spreading Mechanisms

(Extended Abstract)

Norman Salazar, Juan A. Rodriguez-Aguilar and Josep Ll. Arcos
IIIA, Artificial Intelligence Research Institute
CSIC, Spanish National Research Council
norman,jar,arcos@iiia.csic.es

ABSTRACT

In this paper we identify the spreading components required to design convention emergence mechanisms. We have empirically tested the effectiveness of our approach to emerge conventions in scenarios where the space of conventions is large. Moreover, we identify their shortcomings when used for the emergence of stable, global conventions despite unreliable communications (be them because of noise, maliciousness, or errors). Therefore, in order to guarantee the robust emergence of conventions we propose to endow agents with a self-protection component.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*Multiagent Systems*

General Terms

Algorithms,Experimentation

Keywords

conventions,emergence, spreading, MAS

1. MOTIVATION

The study of convention emergence has become a subject of interest for different disciplines. In multi-agent systems (MAS), conventions are useful as coordination schemes that allow agents to agree on useful behaviors/strategies/policies/rules. Moreover, the emergence of conventions is specially important to allow an open MAS to regulate its overall behavior in a distributed manner (no central authority). Therefore, a distributed mechanism that prompts useful conventions to emerge appears as a powerful tool to support coordination in open MAS.

Sociologically speaking, a convention results when members of a population adhere to some behavior, which is neither dictated nor enforced by a central authority. It can be regarded as a behavior followed by most members of a society, which is created and self-perpetuated by such members. In MAS, which is the area of interest in this paper, a convention balances the agents individual interests with respect to those of the society in such a way that each agent can pursue its individual goals without preventing other agents from pursuing theirs [8]. Moreover, conventions must emerge organically during the operation of MAS and according to their needs [10][9][3].

Spreading is a natural phenomenon whose objective is to propagate some characteristic (e.g. property, belief, cultural trait) over the members of a population to prompt a significant number of them to adopt such characteristic (either voluntarily or involuntarily). This phenomenon is present in different aspects of the world. For instance, in nature infectious diseases spread through contagion, in societies opinions spread through gossip, and in computer networks viruses spread through communications. The dynamics of spreading have been analyzed by different fields, such as epidemiology [4], statistical mechanics [6], and social sciences[5].

The propagation employed by spreading-based approaches has shown to be capable of establishing *single* conventions in distributed environments [1]. We propose that spreading can be exploited to develop *robust* convention emergence mechanisms to help agents *coordinate* in open MAS. Specifically, we argue that spreading can be employed to design a mechanism to make conventions dynamically emerge as a result of a learning process within the population of agents in an open MAS [8]. Nevertheless, before constructing such mechanism, firstly we identify the challenges that such convention emergence mechanism must tackle.

The current proposals in the literature are mainly based on an epidemiological approach, limiting themselves to analyzing how a *single* pre-established characteristic (e.g. disease, opinion) spreads through the population. In such scenarios, each population member may take on one out of two possible states: either one where the characteristic is not present or another one where it is (e.g. susceptible vs infected, no-opinion vs opinion). These results are encouraging but do not cope with the spreading complexity required by an open MAS.

In an open MAS a number of different, alternative conventions may exist, since each agent may have a different behavior(s)/opinion(s)/policy(ies) (characteristics) that tries to spread to other agents. In other words, typically in a MAS *there will be a space of multiple convention alternatives* (hereafter referred to as *convention seeds*) from which the agents have to make a collective choice. This space of convention alternatives is known as the *convention space* [2]. Hence, unlike epidemiological studies, now multiple convention seeds (instead of two) compete with each other to

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spread through the population. Moreover, it may be the case that some convention(s) is(are) particularly preferred for the MAS to function properly. Thus, in general not all convention seeds are equally effective for a MAS, and hence a spreading mechanism must be able to emerge those that are more beneficial to its performance, namely to support the most effective coordination.

Nonetheless, in a MAS there is no guarantee that the most beneficial convention seed is already known by one of the agents. Hence, this would limit the spreading ability to reach a preferred convention since agents would only be able to agree on one out of all the conventions they aware of. Therefore, a spreading approach for MAS must allow agents *to build (search for) new convention seeds* when needed.

Moreover, since spreading relies on propagating information among the members of a MAS, if the agents' communications become unreliable, convention emergence may fail. In an open MAS, the quality of communications can easily be jeopardized (e.g by noise, maliciousness, errors). Hence, it is fundamental for the mechanism we aim at *to be resilient to unreliable propagations* while guaranteeing the emergence of conventions.

2. THE SPREADING MECHANISM

The main goal of our research is to investigate the fundamental components required by a spreading-based convention emergence mechanism to fulfill all the requirements presented in the previous section.

With the purpose of designing a robust spreading mechanism, we performed an empirical analysis to help us identify and assess the fundamental components of spreading. The most basic components required by each agent in a MAS can be summarized as follows:

Information-transfer, the main component responsible for actually spreading the seeds. It is adversely affected by unreliable communications (e.g noisy communication channels, lying agents, errors). In particular instances it facilitates the creation of new seeds.

Selection, the guiding component of the mechanism. It provides direction to the conventions emergence by selecting which transfers to accept. In other words, it can cause the emergence any convention, or the emergence of one with useful (preferred) characteristics.

Innovation, the exploration component. Its task is to create new convention alternatives; this is particularly useful when no agent has the preferred alternative. Therefore, innovation increases the likelihood of emerging the preferred convention.

A spreading mechanism constructed with these components is capable of emerging preferred conventions even when the space of convention alternatives is large (the scenario used for the analysis is the same as the one presented in [7]). Nevertheless, since the main component (information-transfer) is susceptible to unreliable communications, the mechanism fails under the presence of not so low levels of noise (which is likely to occur in a realistic scenario).

To that end a robust spreading mechanism requires an additional component that allows each agent to *self-protect* against the unreliability of information-transfers. The basic idea behind the self-protection component is that agents dynamically control the acceptance rate of incoming transfers based on their local experiences. The acceptance rate can be understood as a state that determines if an agent is open

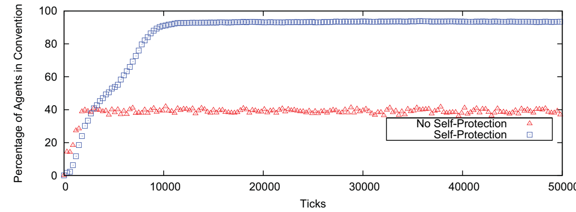

Figure 1: Effectiveness of the self-protection component under the presence of noisy communications

or not to accept incoming convention seeds. Figure 1 shows the effectiveness of self-protection against noisy communications. Observe that a mechanism with self-protection provides a drastic improvement (a near global convention with $> 90\%$ of the agents) with respect to a mechanism without it (a convention with only ~ 40 of the agents.).

To conclude, the `information-transfer + self-protection + selection + innovation` spreading mechanism can emerge near-global conventions, deal with multiple alternative conventions, address convention preferences and withstand unreliable communications). To the best of our knowledge, no convention emergence mechanism in the literature has addressed all these issues.

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