

# Robust Cooperation in Multi-Agent Systems

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## Abstract

*In large-scale multi-agent systems (MAS) the ability of agents to form coalitions of trusted partners and reputation networks is vital to autonomous operation. This paper investigates the dynamic formation of cooperative communities within a simulated MAS. In particular this work considers the requirements for stable high-trust coalitions to self-organise and survive, while some percentage of agents in the population is defecting. A model of dynamic group formation is presented which enables the rapid formation of a self-organising cooperative agent community. The results presented indicate that by utilizing a self-reinforcing cooperative trust model, a very high degree of resilience to perturbation and defection can be achieved. A number of critical parameters are investigated which indicate a phase transition in the formation and resilience of the cooperative structures that emerge.*

**Keywords:** Autonomous Agents, Trust, Adaptive Behaviour

## 1 Introduction

The aim of this paper is firstly to investigate the possible strategies a MAS community may adopt in order to build a community of cooperating agents with a high degree of communal trust. A significant body of work has also emerged in agent based network authentication systems [Helmer et al. 1998], and reputation development between agent brokers in e-commerce systems [Braynov & Sandholm 1999].

### 1.1 The Problem

While agent reputation systems [Abdul-Rahman & Hailes 2000], and [Yu & Singh 2002] have been extensively reviewed there is still a lack of understanding in terms of how processes of trust and reputation evolve dynamically over time. This work therefore follows the concept of social processes of trust construction as set out by Yu and Singh [2003]

## 2 Dynamics of Trust

An agent's interaction in any complex environment requires a continuous reassessment of the degree of trust it should assign to external agents and events. Agents shift their probability of cooperation or defection based on the *expected behaviour* of the majority of its neighbours, i.e. if the majority of neighbours play defect then each agent will increase the probability that it defects, and the same for cooperation.

### 2.1 Experimental Model

The REPAST agent simulation platform [<http://repast.sourceforge.net>] was used to simulate a number of agents.

## 3 Results

The key result obtained from this method of cooperative social group formation is the degree of resilience and resistance to defection achieved. A series of experiments were then applied to the set of agents after such clusters had emerged in order to determine the degree to which they could resist defection by internal and external agents.

## 4 Conclusions

The formation of cooperating agent communities is a fundamental requirement for the large-scale deployment of MAS. In this work a flexible approach is adopted that accommodates dynamic variation in the degree of trust allocated to an agent.

The key behaviour of the agents to enable them to form cooperative groups is that they shift their probability of cooperation or defection based on the *expected behaviour* of the majority of its neighbours, i.e. if the majority of neighbours play defect then each agent will increase the probability that it defects, and the same for cooperation.

The result is that a group of agents using such a dynamic trust model becomes highly resistant to defection by external or internal agents, once a sufficiently large cooperative group has formed. However, below the critical group size the agents are susceptible to defection strategies, which then dominate the system