

MANIAC Challenge: A Diversity Adaptive Approach for Cooperative Behavior

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Abstract—MANIAC Challenge is a problem of game theory, where a team’s success in playing the game depends on the other teams’ strategies and team cooperation is self-enforcing. In such a competition, notebooks from several teams form a mobile ad hoc network and multiple data flows are generated towards each team, requiring a multi-hop routing in order to reach any destination. Each team wins ten points for each packet belonging to its flows that reaches the destination, whereas it loses one point for each packet forwarded by one of its notebooks. In this paper, we propose an *adaptive* routing strategy based on a *diversity* paradigm which resorts to the different team player behaviors.

I. STRATEGY OVERVIEW

According to the game theory, the MANIAC Challenge can be classified as an *iterated prisoner’s dilemma* (IPD) game in which the teams are motivated to play uncooperatively, namely to defect. Each iteration of an IPD game can be represented by means of a *payoff matrix* (illustrated in Fig. 1) satisfying the following constraints [1]:

$$T > R > P > S, \quad R > \frac{S + T}{2} \quad (1)$$

where the parameter represents T the temptation to be uncooperative, R is a reward for mutual cooperation, P is the punishment for mutual defection and finally S is the sucker payoff for a single cooperator.

According to (1), if both players choose to cooperate, then each of them receives the reward payoff R , which is larger

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		Node B	
		Cooperate	Defect
Node A	Cooperate	(R, R)	(S, T)
	Non cooperate	(T, S)	(P, P)

Fig. 1. Prisoner’s dilemma payoff matrix

		Node B	
		Cooperate	Defect
Node A	Cooperate	$(-1 + p_a 10, -1 + p_b 10)$	$(-1, p_b 10)$
	Non cooperate	$(p_a 10, -1)$	$(0, 0)$

Fig. 2. MANIAC Challenge payoff matrix

than the punishment payoff received for mutual defection P . However, if the players select different strategies, the defecting player receives the maximum temptation payoff T while the cooperating one receives the sucker’s payoff S . In such conditions, the dilemma becomes apparent: regardless of the opponent’s choice, the rational decision is to defect, and mutual defection is the stable equilibrium (or Nash equilibrium) as no one has an incentive to change the strategy.

However, in the iterated form of prisoner’s dilemma, actions in a given round can have repercussions in future play and thus, participants have an incentive to cooperate early to build trust, benefiting so from mutual cooperation later. In fact, also if the *evolutionary stable* strategy (a strategy for an iterated game is evolutionary stable if defection to a new strategy reduces your score) is *always defect*, cooperative strategies can perform better, provided that non-rational players (non always defect strategies) attend to the game [2].

According to the literature [3], a successful cooperative strategy for an IPD game should satisfy the following conditions: i) *nice*, it is better to cooperate until the opponent cooperates as well; ii) *retaliating*, a strategy must not be a blind optimist; iii) *forgiving*: a strategy should fall back to cooperate if the opponent does not continue to defect; iv) *clear*: making it easier for other strategies to predict its behavior so as to facilitate mutually cooperation.

The *Tit-for-Tat* (TFT) strategy [4] (cooperate in the first round, and play in the round n your opponent’s strategy from round $n - 1$) satisfies the previous conditions, and it won the

Algorithm 1 Free rider forwarding

```
if packet.dst == turncoat.add then
  if packet.deliveryProbability is not negligible then
    forward(packet)
  else
    queue(packet)
  end if
  if opponent is resiliating AND cooperating then
    forward(packet, nextHop)
  else
    drop(packet)
  end if
end if
```

first IPD tournament in 1984 and dominated for the following twenty years.

However, MANIAC Challenge differs from traditional IPD games for several features. In MANIAC Challenge, a cooperative behavior of a neighbor does not assure a reward since it does not imply that the packet will reach its destination, unless the neighbor is the last hop, as accounted in Fig. I by the terms $p_a \in (0,1)$. In other words, the MANIAC challenge exhibits a kind of multi-player behavior, since the player's reward depends on the opponent behavior as well as on the behaviors of a time-variant set of other players. Moreover the game is asynchronous, since each player makes a decision when it receives a packet, independently of other players. Finally, each team has two players which can cooperate and communicate.

The cooperation among team's players has been exploited by the University of Southampton to win the 20th anniversary tournament. In such a strategy, two players belonging to the same team, namely a *master* and a *slave*, resort to the same strategy (TFT) against opponent players and different strategies when one plays against the other (the slave always cooperates and the master always defects). Although such a choice is not suitable for the MANIAC challenge since the team performance is the sum of the points gained by each player, the Southampton's proposal clearly shows how cooperation among team's members makes the difference.

II. STRATEGY DESCRIPTION

Our proposal introduces a diversity paradigm by imposing that the two players of the team adopt different strategies. From a functional point of view, the former player, namely the *free rider*, implements an always defect strategy, while the latter, namely the *turncoat*, plays according to a Tit-for-Tat with Forgiveness (TFTF) strategy. In such a way, the free rider is able to benefit from opponents which adopt not retaliating strategies, while the turncoat establishes successful cooperation with retaliating players.

By acquiring the free rider's knowledge about the opponents' behaviors, the turncoat is able to improve its reward by recognizing the non-resilient players (the ones which collaborate

Algorithm 2 Behavior classification

```
if cooperationFactor(opponent,free rider) < 0 then
  opponent.behaviour = non-retaliating
else
  if cooperationFactor(opponent,turncoat) < 0 then
    opponent.behaviour = retaliating
  else
    opponent.behaviour = non-cooperator
  end if
end if
```

with the free rider) and by stopping to collaborate with them. In the same way, the free rider can benefit from turncoat's knowledge by trying to collaborate with the resilient players. The proposed solution is thus *adaptive*, since each player can adjust its strategy to opponent's behavior in order to maximize its reward, and based on the *diversity* paradigm, since each player can take advantage by the different knowledge (due to different strategies) of the team-mate in order to take the best decision. Listing 1 describes the free rider's strategy and Listing 2 illustrates the player's behavior classification, both with high-level language.

We note that, taking into account the overall strategy played by both the team members, our proposal satisfies the four conditions for a successful cooperative strategy (Sec. I).

We are currently investigating on some issues that arise due to the distinctive features of MANIAC challenge with respect to traditional IDP games. The first issue is who has to be considered as *opponent* in a packet forwarding: the destination node or the previous forwarder (the last hop)? The question is not trivial, since the destination certainly takes advantage of the player decision but it can not be aware of this unless it is a neighbor node, while the previous hop is able to acquire knowledge of the player decision (by means of promiscuous listening) but usually it has not any advantage by such a decision.

Another issue regards what is the best strategy against the team-mate. An *always collaborate* strategy has no sense if the probability that a packet will reach the destination is negligible. However, the estimation of such a probability, which involves nodes whose strategies are unknown to the player, is not trivial.

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