Dynamic Programming and Time Related Strategies in Sports
With an Application to Onside Kicks

Harold Sackrowitz
Rutgers University, USA
sackrowi@rci.rutgers.edu

1 Introduction

Since their introduction by Bellman (beginning with Bellman 1952) in the 1950's the ideas of dynamic programming have become among the most fundamental methods of operations research. A good source for the methodology and extensive literature is Sniedovich 1992. In Sackrowitz and Sackrowitz 1996 and Sackrowitz 2000 dynamic programming methodology was applied, respectively, to the notion of ball control in sports and two-point conversion strategy decisions in football. The goal of this paper is twofold. We will investigate strategy considerations related to the onside kick option in football. More importantly we hope, during this process, to demonstrate dynamic programming's ideal suitability for dealing with certain types of strategy issues that are almost unavoidable in most sports. By studying the various aspects of this problem we will be able to see what can and cannot be accomplished. In these settings a complete determination of an optimal strategy is usually not possible due to vagaries in the model. However, this approach can greatly improve a coach's understanding of game situations and improve decision making. In particular, we will demonstrate a strong indication that onside kicks should be used much more frequently than in current practice.

The type of situations we refer to arise in the following natural way. The rules of any sport contain provisions indicating when a game has ended and who has won. Most games are designed to be played for a fixed amount of time. Included, for such games, are rules for stopping the clock for reasons such as penalties and time outs. For example, football and hockey are played for 60 minutes while professional basketball takes 48 minutes. Of course time is not always used. Baseball is supposed to be a nine inning game while golf is to be played for 18 holes. In the most typical scenario, teams alternate playing "offense" and "defense". When a team gains possession of the ball (or puck, etc.) it has an opportunity to score points (or runs, etc.). The time consumed during any one possession can be very important in time constrained games.
The rules also explain how to proceed if the game is tied at its intended end and how a winner can be determined. It is awareness of the approaching end of play that forces time to enter strategy conditions. We often see players and teams behaving differently near the end of a game than they do at the beginning or middle of the game.

The setting we have chosen for this exposition is the game of football. The attention paid to time strategy is more pronounced in football than any other major sport. Perhaps because each team, typically, gets only 10 – 15 possessions of the ball during a game. In many ways football is ideally suited for a dynamic programming approach. There is a stoppage of action (but not necessarily the clock) between plays so that the teams can decide what play to use next. The clock is stopped after a score again giving teams an opportunity to review its options before action is resumed.

The aspect of football we have chosen to study here is the onside kick. Strategy relating to the onside kick option is not well understood. After a team has scored either a field goal or a touchdown it “kicks off” to the other team. By rule, once the kicked ball has traveled 10 yards it is a free ball. That is, the kicking team and the receiving team are equally entitled to recover the ball. The term “onside” kick describes a situation in which the kicking team makes an obvious attempt to recover its own kickoff. Typically the ball is kicked in such a way that it is difficult to catch and that it does not travel much further than 10 yards. The advantage of such a strategy to the kicking team is that they would have, at least, a modest chance to regain possession of the ball while with the standard kick the likelihood of regaining possession is near zero. However, failure by the kicking team to gain possession usually results in the receiving team gaining possession of the ball relatively close (perhaps 40 – 45 yards) to the goal line. This can dramatically improve the receiving team’s chances of scoring.

Use of the onside kick is usually thought of as an act of desperation. However, without resorting to the onside kick a team that is behind with very little time remaining might not even get the opportunity to score more points. Because of the game situation and positioning of the players on the field most onside kick attempts are obvious to the receiving team. Yet, surprisingly, during the 2000 and 2001 NFL seasons, approximately 26% of onside kicks were actually recovered by the kicking team. This number suggests that, perhaps, onside kicks can and should be used more often. This is, of course, the coach’s decision and most coaches do realize that score and time remaining are the key ingredients. Unfortunately, it would be impossible for even the most experienced coach to have accumulated enough empirical data to make an informed decision.

How can a team that is about to kick off, properly decide whether or not to attempt an onside kick? The answer depends on many parameters. In addition to the current score and the amount of time remaining in the game,