Chapter VIII
On Noise, Steganography, and the Active Warden

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ABSTRACT

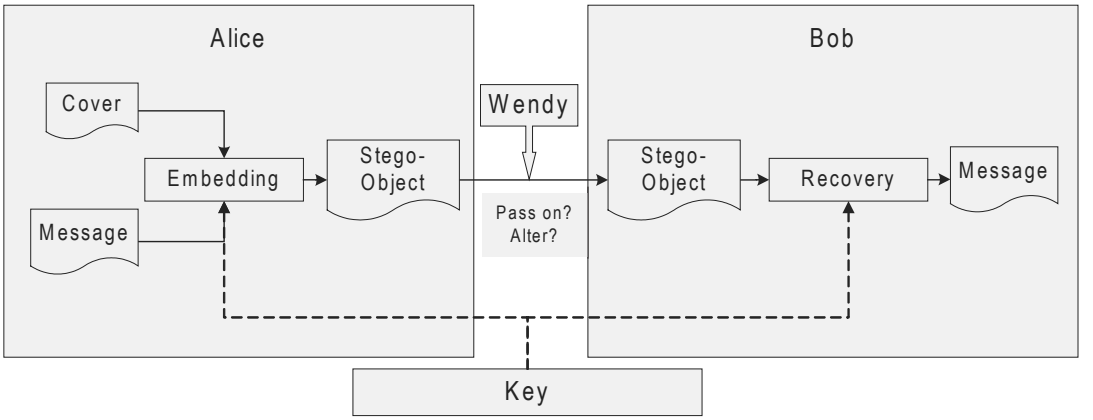
Modern digital steganography has evolved a number of techniques to embed information near invisibly into digital media. Many of the techniques for information hiding result in a set of changes to the cover image that appear, for all intents and purposes to be noise. This chapter presents information for the reader to understand how noise is intentionally and unintentionally used in information hiding. This chapter first reviews a series of noise-like steganography methods. From these techniques the problems faced by the active warden can be posed in a systematic way. Results of using advanced clean image estimation techniques for active warden based steganalysis are presented. This chapter is concluded with a discussion of the future of steganography.

INTRODUCTION

The *prisoner's problem* was introduced in 1982 by Gus Simmons (Simmons, 1984),

Two accomplices in a crime have been arrested and are about to be locked in widely separated cells. Their only means of communication after they are locked up will be the way of messages conveyed for them by trustees – who are known to be agents of the warden. The warden is willing to allow the prisoners to exchange messages in the hope that he can deceive at least one of them into accepting as a genuine communication from the other either a fraudulent message created by the warden himself or else a modification by him of a genuine message. However, since he has ev-

Figure 1. Prisoner's problem



ery reason to suspect that the prisoners want to coordinate an escape plan, the warden will only permit the exchanges to occur if the information contained in the messages is completely open to him – and presumably innocuous. The prisoners, on the other hand, are willing to accept these conditions, i.e., to accept some risk of deception in order to be able to communicate at all, since they need to coordinate their plans. To do this they will have to deceive the warden finding a way of communicating secretly in the exchanges, i.e. establishing a "subliminal channel" between them in full view of the warden, even though the messages themselves contain no secret (to the warden) information. Since they anticipate that the warden will try to deceive them by introducing fraudulent messages they will only exchange messages if they are permitted to authenticate them.

Thus began the modern study of steganography. The two prisoners have since been named Alice and Bob, the warden is Wendy or Eve. Figure 1 shows an illustration of the basic scenario.

The modern warden, Wendy, has a challenge. Wendy's role is either to detect the presence of or to manipulate the message in order to prevent the undesirable escape of the two prisoners. Wendy practices the art and science of steganalysis. The proliferation of electronic media has only increased the challenge of steganalysis.

In Wendy's more active role, the active warden scenario, she can modify each message that goes by. This can be based on a passive detection modifying only those messages that contain hidden data or by modifying all messages in a hope to prevent unknown hidden messages from making it through. The modification can be a simple attempt to scrambling any hidden messages, to prevent communication, or could include a sophisticated attempt to modify the message in the hopes of planting false messages to thwart the prisoner's escape plans.

This chapter explores the role of the active warden and how to exploit the noise-like properties of modern digital media. Here the focus is on image-based digital steganography. An overview of the topics covered appears in Figure 2. The next section discusses noise and the digital image. Including various types of noise and how steganography techniques can also appear as noise. The final section presents the active warden scenario from the perspective of removing artificial noise. This chapter is concluded with some discussion of the implications of noise and clean image estimation for steganalysis.