Chapter 12
Near Field Authentication

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ABSTRACT

Counterfeiting affects many different sectors of the world trade, including the pharmaceutical and the aerospace industries, and, therefore, its impact is not only of financial nature but can also have fatal consequences. This chapter introduces a new robust RFID system with enhanced hardware-enabled authentication and anti-counterfeiting capabilities. The system consists of two major components, namely the near-field certificates of authenticity (NF-CoAs), which complement typical RFID tags and serve as authenticity vouchers of the products they are attached to, and a microcontroller-enabled, low-power and low-cost reader. The high entropy and security of this framework stem from the unique, conductive, and dielectric, physical structure of the certificate instances and the highly complex electromagnetic effects that take place when such a certificate is brought in the reactive near-field area of the reader's antenna array. In particular, the reader's main task is to accurately extract the 5 to 6 GHz near-field response (NF fingerprint) of the NF-CoAs. The characterization of the reader's components, with an emphasis on the accuracy achieved, is provided. Rigorous performance analysis and security test results, including uniqueness among different instances, repeatability robustness for same instance and 2D to 3D projection attack resistance, are presented and verify the unique features of this technology. Rendering typical RFID tags physically unique and hard to near-exactly replicate by complementing them with NF-CoAs can prove a valuable tool against counterfeiting.

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INTRODUCTION

In contrast with piracy, where the buyer is confident that the purchased object is not genuine due to a very low price or some discrepancy with the quality of the product, counterfeiting is the illegal trade in which the adversary fools the buyer into believing that the merchandise is authentic. As a result, the counterfeiter collects substantial revenue with profit margins typically higher than that of the original manufacturer.

Counterfeiting is as old as the human desire to trade and exchange. For example, historians possess evidence of counterfeit coins of the world's first coin, the Lydian Lion (Goldsborough, 2010b). Revealing the interior metal with test cuts, i.e. slashing of the surface of a coin with a hammer, was the first counterfeit detection procedure (Goldsborough, 2010a). To try to prevent detection, some counterfeiters made coins with already engraved fake test cuts; this initiated the cat-and-mouse game of original manufacturers against counterfeiters that lasts to date.

Though it is hard to assess and quantify the market for counterfeit objects of value today, there is no doubt that counterfeiting accounts for a huge economic impact. The World Customs Organization and the International Chamber of Commerce, according to Interpol, estimate that roughly 8% of world trade every year is in counterfeit goods (Robyn, 2008). A 2010 study estimated that the volume of counterfeit U.S. currency in the form of banknotes (paper currency) in circulation worldwide is in the neighborhood of $60 to $80 million (Judson & Porter, 2010). Approximately 8.1 million Americans, or 3.5% of the total U.S. population, experienced fraud in 2010 (Global Card Fraud, 2010). At a global level, the "Global Card Fraud" Nilson Report estimated card fraud losses of $6.89 billion on $14.6 trillion in purchases of goods and services and cash advances in 2009 and projected the amount of fraud losses to rise to $10 billion by 2015 (Global Card Fraud, 2010).

Unfortunately, however, the impact of counterfeiting is not only of financial nature. The numbers get scary when counterfeiters attack industries, such as the pharmaceutical and the aerospace. In particular, Glaxo-Smith-Kline, in a study with the US Food and Drug Administration, estimates that counterfeit drugs account for 10% of the global pharmaceuticals market (Glaxo-Smith-Kline, 2009). U.S. Federal Aviation Authority estimates that each year, 2 percent (520,000 parts) of the 26 million parts installed on airplanes are counterfeit (Stern, 1996). From 1973 to 1993, bogus parts played a role in at least 166 U.S.-based aircraft accidents or less serious mishaps. Four of those were accidents involving commercial carriers that resulted in six deaths (Stern, 1996).

In the battle against counterfeiting, extremely reliable and robust certificates of authenticity, or, in other words, instances of proof of value, that can be used conveniently may prove valuable. This chapter presents the full implementation of a novel near-field (NF) anti-counterfeiting RFID system that aims to address counterfeiting in a hardware-based way (Lakafosis et al., 2011). The fundamental idea is to complement any type of RFID tag with an inexpensive physical object that behaves as a certificate of authenticity (NF-CoA) in the near electromagnetic field so that this "supertag" is not only digitally but also physically unique and hard to near-exactly replicate. This enables, on one hand, the extraction of the data related to the product in the far field and, on the other hand, the offline verification of its authenticity within its near field with low probability of a false alarm.

Based upon the characterization of the Super High Frequency (SHF) components that comprise the NF-CoA reader and the radiation behavior of the antenna elements of the array, the performance analysis of the reader is presented. Its high efficiency, albeit its simple and low cost implementation, is demonstrated with robustness and repeatability tests using 3D random NF-CoA structures formed by an arbitrary constellation of