Round-Function-Recovery Attacks Against Feistel Networks

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Abstract

Feistel Networks (FN) are now massively being used to encrypt credit card numbers through format-preserving encryption (FPE). In our work, we focus on FN with two branches, entirely unknown round functions, modular additions, and when the domain size of a round function (called $N$) is small. We investigate round-function-recovery attacks.

The best-known attack so far is an improvement of Meet-In-The-Middle (MITM) attack by Isobe and Shibutani from ASIACRYPT 2013 with optimal query complexity $q = r \frac{N}{2}$ and time complexity $N^r \left\{ \frac{r-4}{2} N + o(N) \right\}$, where $r$ is the number of rounds. We construct an algorithm with a surprisingly better complexity when $r$ is too low, based on partial exhaustive search. When the query complexity varies from the optimal to the one of a codebook attack $q = N^2$, our time complexity can reach $N^r \left\{ O \left( \frac{N^{1-\frac{1}{r-2}}} {r-3} \right) \right\}$. It crosses the complexity of the improved MITM for $q \sim N \frac{\text{e}^3}{r^2}$. We also estimate the lowest secure number of rounds depending on $N$ and the security goal. We show that the FPE constructions FF1 and FF3 form NIST and ANSI standards cannot offer a 128-bit security (as they are supposed to) for $N \leq 11$ and $N \leq 17$, respectively, and improve the results by Durak and Vaudenay from CRYPTO 2017.