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Sub-Space Modeling: An Enrollment Solution for XOR Arbiter PUF using Machine Learning

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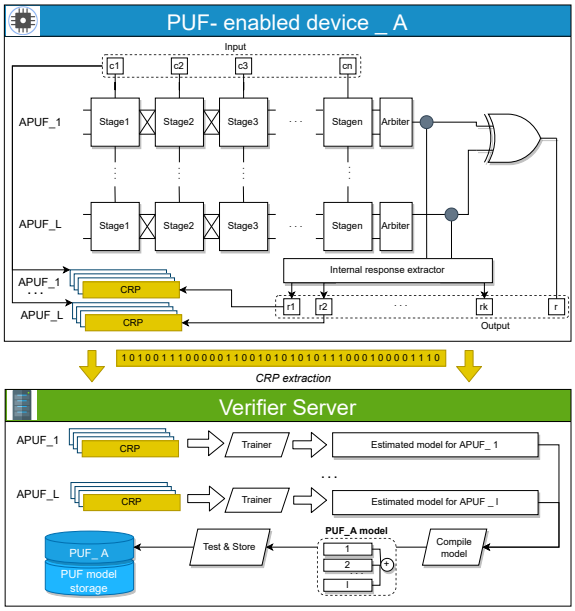
***Abstract*—In this work we present sub-space modeling of XOR Arbiter PUF as a cost efficient solution for enrollment for the designers' community. Our goal is to demonstrate a method which can reduce the overall cost in terms of number of CRPs required for training, training time and memory. Here we propose to reduce the complexity of the modeling target by dividing the PUF into smaller sub-components and model each sub-component of the PUF independently. Our early experimental assessment show that our sub-space modeling can significantly reduce the cost of training compared to some of the latest works, thus it is potentially a cost-efficient solution to enroll strong PUF with high complexity.**

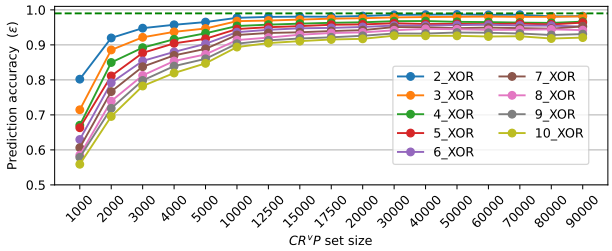
***Index Terms*—Physically Unclonable Function (PUF), XOR Arbiter PUF, PUF Enrollment, Machine Learning (ML)**

I. Introduction & Proposed Method

Our proposed solution can be used in emerging authentication and key generation protocols which demand to generate an equivalent predictive model of a target XOR arbiter PUF on a trusted third party (TTP) verifier server [1]–[3]. This solution should collectively reduce the number of CRPs in order to obtain an accurate model of XOR Arbiter PUF with large XOR size. A schematic of our proposed method is shown in Fig. 1a. Here the illustration shows sub-space modeling of n-bit L-XOR Arbiter PUF (n is the challenge size and k is the XOR size). As shown in Fig. 1a, the internal data from each internal Arbiter PUF ($r1$ to rL), in conjunction to their corresponding challenge values (e.g. $\{c1\ ...\ cn\}$ + $\{r1\}$ for APUF_1, $\{c1\ ...\ cn\}$ + $\{r2\}$ for APUF_2, etc.) are fed separately to trainer functions to discretely generate estimation models of each Arbiter PUF. After the trainer functions provide accurate estimated models, we merge the sub-models into forming a whole model which represents the whole PUF. An early demonstration of the prediction accuracy of the models generated with our method for variant XOR sizes are shown in Fig. 1b. Collectively, our generated models use considerably lower number of CRPs for modeling, compared to the conventional techniques for modeling XOR Ariber PUF [4].



(a) Schematics of the proposed sub-space modeling method for n-bit L-XOR Arbiter PUF.



(b) Convergence of prediction accuracy (ϵ) with respect to training set size (CR^vP) in modeling PUFs with various XOR sizes.

Fig. 1: Schematics and performance of our proposed method.

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