PUF Evaluation Metrics

What follows shows a number of metrics used to evaluate PUF designs:

Intra Hamming distance

On flipping a bit in the challenge to a PUF, ideally, the hamming distance between the responses should differ 50% of total responses bits. For each chjp i, we find the average of the hamming distance of each pair of R_1 and R_2 responses given then their relayed challenges (C_1 and C_2, respectively) are different in only **1** bit.

Assume that we have M pairs of (C_1,C_2) with the above constraint given to each chip, and also R_1 and R_2 each are *n* bits. In this case for each chip:

$$Intra\ HD\ (chip\ i) = \frac{1}{M}\sum_{i=1}^{M}\frac{HD(R_1, R_2)}{n} \times 100\%$$

Inter Hamming distance

On applying the same challenge to two different PUF designs, ideally, the hamming distance between their responses should differ 50% of total responses bits. If there are k-chips, then the inter HD between all chips is found as below:

$$Inter\ HD = \frac{2}{k(k-1)} \times \frac{1}{S}\sum_{i=1}^{k-1}\sum_{j=i+1}^{k}\sum_{r=1}^{S}\frac{HD(R_{i,r}, R_{j,r})}{n} \times 100\%$$

where 'i' and 'j' are two different chips. $R_{i,r}$ is the response from chip 'i' to challenge C_r while $R_{j,r}$ is the response from chip 'j' to challenge C_r, and n is the bitlength of each response. Also S is the total number of challenges. Moreover, k denotes to the number of all chips.

Uniformity

This metric defines how uniform the proportion of '1's and '0's in the response bits of a PUF. If the PUF has a bias towards '1' or '0' in its responses, then the attacker can guess that response. For an ideal PUF, the proportion of '1's and '0's in its responses should be equal. For each chip 'i' with the challenge response pairs of (C_r, R_r), 1<r<S (S is total number of challenges), the Uniformity of each chip i is found as below. Note that HW of each vector is the number of values '1' in that vector. For example HW(10011)=3.

$$Uniformity_i = \frac{1}{n \times S}\sum_{r=1}^{S} HW(R_r)$$