

Lecture 16: Encrypting Long Messages

Objective

- Earlier, we saw that the length of the secret key in a one-time pad has to be at least the length of the message being encrypted
- Our objective in this lecture is to use smaller secret keys to encrypt longer messages (that is, secure against computationally bounded adversaries)

Recall

- Suppose $f: \{0, 1\}^{2n} \rightarrow \{0, 1\}^{2n}$ is a one-way permutation (OWP)
- Then, we had seen that the function $G: \{0, 1\}^n \times \{0, 1\}^n \rightarrow \{0, 1\}^{2n+1}$ defined by

$$G(r, x) = (r, f(x), \langle r, x \rangle)$$

is a one-bit extension PRG

- Let us represent $f^i(x)$ as a short-hand for $\overbrace{f(\cdots f(f(x))\cdots)}^{i\text{-times}}$. $f^0(x)$ shall represent x .
- By iterating the construction, we observed that we could create a stream of pseudorandom bits by computing $b_i(r, x) = \langle r, f^i(x) \rangle$ (Note that, if we already have $f^i(x)$ stored, then we can efficiently compute $f^{i+1}(x)$ from it)
- So, the idea is to encrypt long messages where the i -th bit of the message is masked with the bit $b_i(r, x)$

Encrypting Long Messages

- Without loss of generality, we assume that our objective is to encrypt a stream of bits $(m_0, m_1, \dots)$
- $\text{Gen}()$: Return $\text{sk} = (r, x) \xleftarrow{\$} \{0, 1\}^{2n}$, where $r, x \in \{0, 1\}^n$
- Alice and Bob shall store their state variables: state_A and state_B . Initially, we have $\text{state}_A = \text{state}_B = x$
- $\text{Enc}_{\text{sk}, \text{state}_A}(m_i)$: $c_i = m_i \oplus \langle r, \text{state}_A \rangle$, and update $\text{state}_A = f(\text{state}_A)$, where $\text{sk} = (r, x)$
- $\text{Dec}_{\text{sk}, \text{state}_B}(\tilde{c}_i) = \tilde{m}_i = \tilde{c}_i \oplus \langle r, \text{state}_B \rangle$, and update $\text{state}_B = f(\text{state}_B)$, where $\text{sk} = (r, x)$
- Note that the i -th bit is encrypted with $b_i(r, x)$ and is also decrypted with $b_i(r, x)$. So, the correctness holds. This correctness guarantee holds as long as the order of the encryptions and the decryptions remain identical.
- Note that each bit $b_i(r, x)$ is uniform and independent of all previous bits (for computationally bounded adversaries). So, the scheme is secure against all computationally bounded adversaries