

# SoftSpokenOT protocol

Silence Laboratories

March 2025

This protocol refers to the protocol described in Fig.10 [1] with changes in the reduction of communication by a factor of  $k$  due to an increase in computation by a factor of  $2^{k-1}/k$ .

The protocol uses an arbitrary stretch pseudorandom generator, PRG, and a hash functions  $H_1 : \{0, 1\}^* \rightarrow \{0, 1\}^s$ ,  $H_2 : \{0, 1\}^* \rightarrow \{0, 1\}^\kappa$ , modeled as a random oracle.

$s = 128$ ,  $k = 4$ .

## Initialize:

1. R samples  $\kappa$  pairs of random  $\kappa$ -bit seed,  $\{(\mathbf{k}_0^i, \mathbf{k}_1^i)\}_{i=1}^\kappa$
2. S samples a random  $\Delta = (\Delta_1, \dots, \Delta_\kappa) \in \mathbb{F}_2^\kappa$ .
3. The parties call  $\kappa \times OT_\kappa$  with inputs  $\Delta$  and  $k_0, k_1$ .
4. S receives  $\mathbf{k}_{\Delta_i}^i$ , for  $i = 1, \dots, \kappa$ .
5. R and S run protocols described in Fig.13 and Fig.14 [2] to convert their  $\kappa \times \binom{2}{1}$ -OT to all-but-one  $(\kappa/k) \times \binom{2^k}{2^k - 1}$ -OT. In  $\binom{2^k}{2^k - 1}$ -OT a random function  $F : \mathbb{F}_{2^k} \rightarrow \mathbb{F}_2^l$  is known to R, while S has a random point  $\Delta$  and the restriction  $F^*$  of  $F$  to  $\mathbb{F}_{2^k} \setminus \{\Delta\}$ .

## Extend:

1. According to Fig.7 [2], R computes:

$$r_x^i = \text{PRG}(F^i(x)) \in \mathbb{F}_2^{l'} \quad \text{for } x \in \mathbb{F}_{2^k},$$

$$u^i = \sum_{x \in \mathbb{F}_{2^k}} r_x^i, \quad \text{and} \quad v^i = - \sum_{x \in \mathbb{F}_{2^k}} r_x^i \cdot x \quad \text{for } i \in 1, \dots, \kappa/k.$$

2. S computes:

$$r_x^i = \text{PRG}(F^{*i}(x)) \in \mathbb{F}_2^{l'} \quad \text{for } x \in \mathbb{F}_{2^k} \setminus \{\Delta\},$$

$$w^i = \sum_{x \in \mathbb{F}_{2^k} \setminus \{\Delta\}} r_x^i \cdot (\Delta^i - x) \quad \text{for } i \in 1, \dots, \kappa/k.$$

3. R inputs the choice bits  $x_1, \dots, x_l \in \mathbb{F}_2$ . Let  $l' = l + s$ , and assume that  $s|l$ . R picks random  $x_{l+1}, \dots, x_{l+s} \in \mathbb{F}_2$  and sets  $\mathbf{x} = (x_1, \dots, x_{l'})$ .

R computes:

$$u^i = u^i + \mathbf{x} \quad \text{for } i \in 1, \dots, \kappa/k,$$

$$\chi_j = H_1(j||u) \quad \text{for } j \in 1, \dots, m.$$

*Consistency check:* Let  $m = l/s$ . We divide  $l'$  OTs into  $m + 1$  blocks of  $s$  bits, writing  $\mathbf{x} = (\hat{x}_1, \dots, \hat{x}_{m+1}) \in \mathbb{F}_{2^s}^{m+1}$ , and similarly  $v^i = (\hat{v}_1^i, \dots, \hat{v}_{m+1}^i) \in \mathbb{F}_{2^s}^{m+1}$ . Then R computes the following values over  $\mathbb{F}_{2^s}$ :

$$x = \sum_{j=1}^m \hat{x}_j \cdot \chi_j + \hat{x}_{m+1}, \quad t^i = \sum_{j=1}^m \hat{v}_j^i \cdot \chi_j + \hat{v}_{m+1}^i \quad \text{for } i \in 1, \dots, \kappa/k$$

and sends  $u^i, x, t^i$  to S.

4. S computes:

$$\mathbf{q}^i = \Delta^i \cdot u^i + w^i, \quad \text{for } i \in 1, \dots, \kappa/k$$

$$\mathbf{q}^i = (\hat{q}_1^i, \dots, \hat{q}_{m+1}^i) \in \mathbb{F}_{2^s}^{m+1}$$

$$\chi_j = H_1(j||u), \quad \text{for } j \in 1, \dots, m$$

$$q^i = \sum_{j=1}^m \hat{q}_j^i \cdot \chi_j + \hat{q}_{m+1}^i, \quad \text{for } i \in 1, \dots, \kappa/k$$

and checks that  $q^i = t^i + \Delta^i \cdot x$ , for all  $i \in 1, \dots, \kappa/k$ . If any check fails, output **AbortAndBanParty**.

**Transpose and randomize:**

1. Let  $\mathbf{q}_j$  denote the  $j$ -th row of the  $l' \times \kappa$  bit matrix  $[\mathbf{q}^1 | \dots | \mathbf{q}^\kappa]$  held by S, and similarly let  $v_j$  be the  $j$ -th row of  $[v^1 | \dots | v^\kappa]$ , held by R.

2. R outputs

$$out_{x_j, j} = H_2(j||v_j), \quad j \in [l].$$

3. S outputs

$$out_{0, j} = H_2(j||\mathbf{q}_j) \quad \text{and} \quad out_{1, j} = H_2(j||(\mathbf{q}_j + \Delta)), \quad j \in [l].$$

♡

## References

- [1] Marcel Keller, Emmanuela Orsini, and Peter Scholl. Actively secure ot extension with optimal overhead. In *Annual Cryptology Conference*, pages 724–741. Springer, 2015.
- [2] Lawrence Roy. Softspokenot: Communication–computation tradeoffs in ot extension. *Cryptology ePrint Archive*, 2022.