A New Approach to Practical Active-Secure Two-Party Computation

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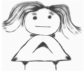
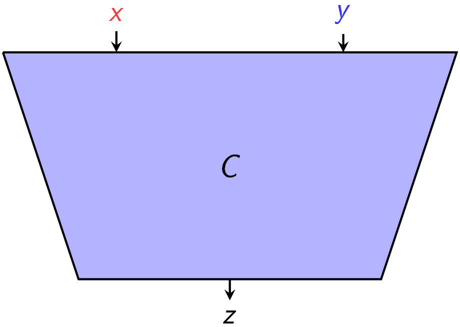
August 21, 2012

Active-Secure Two-Party Computation (2PC)





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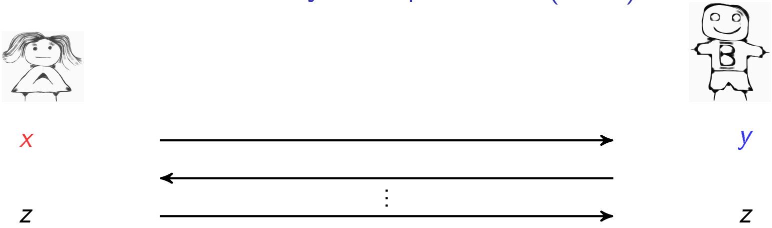

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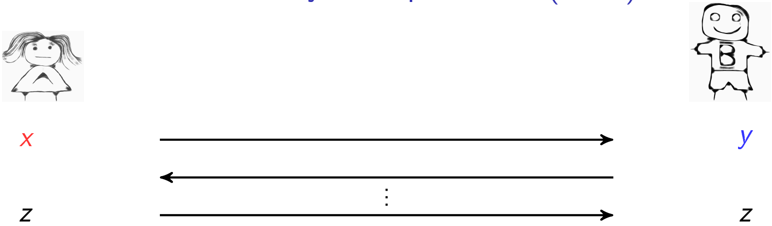

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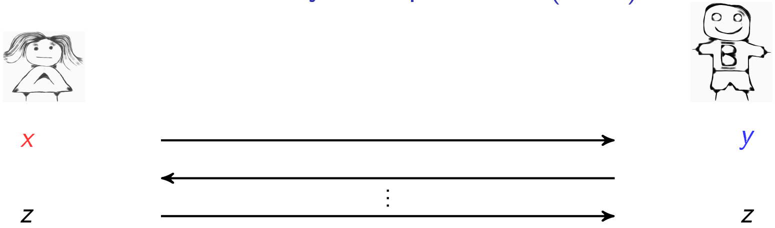

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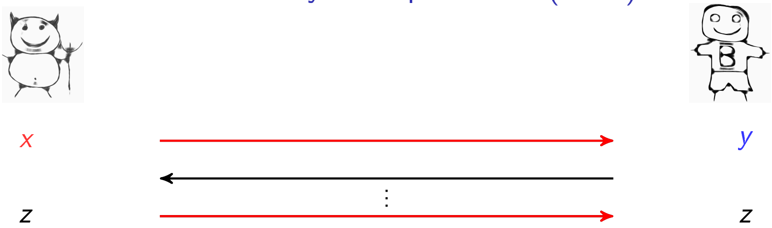

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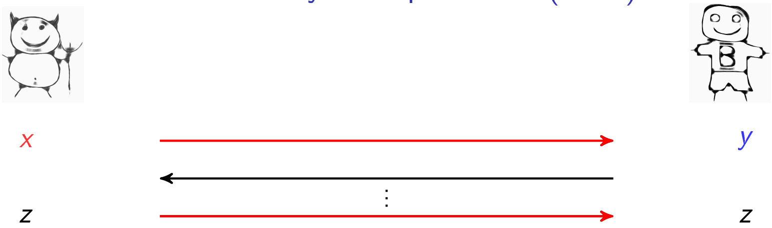

- Correctness: $C(x, y) = z$
- Privacy: Inputs are kept private.
- Practical: Runs in reasonable time for reasonable size circuits.

Motivation for this Work

- Solving real-world problems. E.g. computing outcome of auctions [BCD+09].

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- Lack of diversity in practical 2PC. In fact all previous practical approaches uses Yao's Garbled Circuits technique.

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- Information theoretic MACs: To ensure active security.
- OT-extension: A huge amount of OT at low amortized cost from the passive-secure protocol of [IKNP03].

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  - Faster than all implementations based on Garbled Circuits ... except for [KsS12].

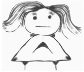
Overview

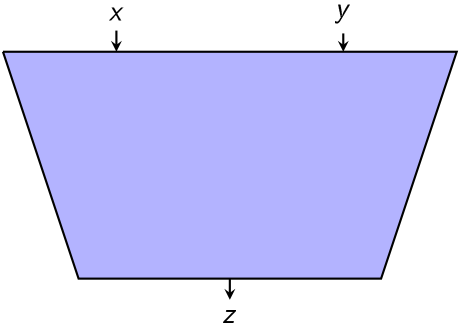
Protocol Overview

MACs

Concluding

Passive-Secure 2PC [GMW87]





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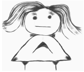

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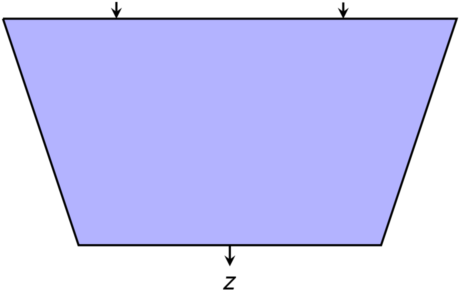

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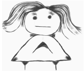

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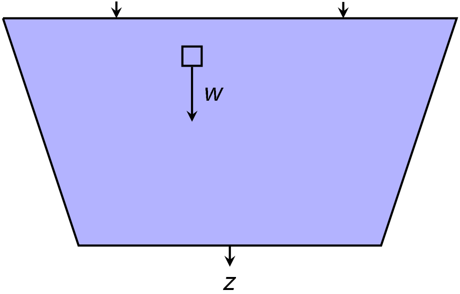

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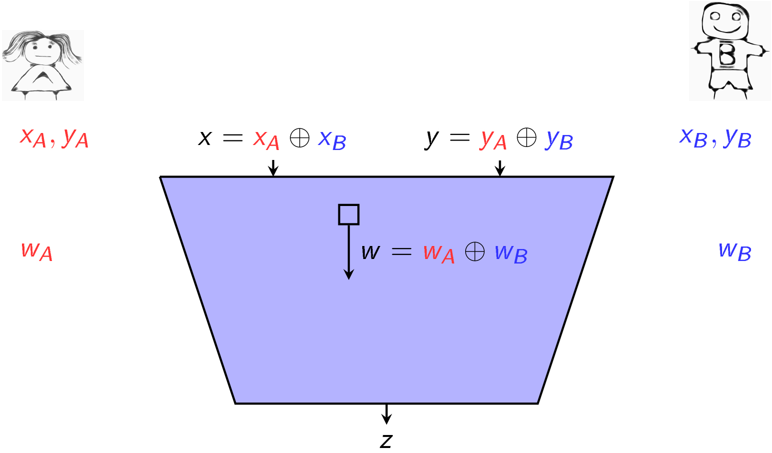

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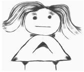

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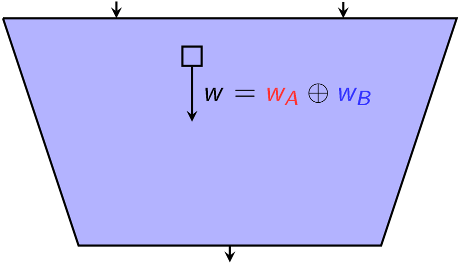

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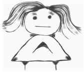

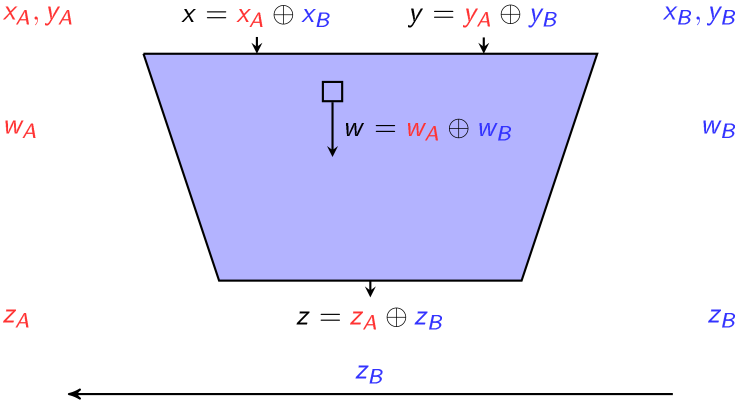

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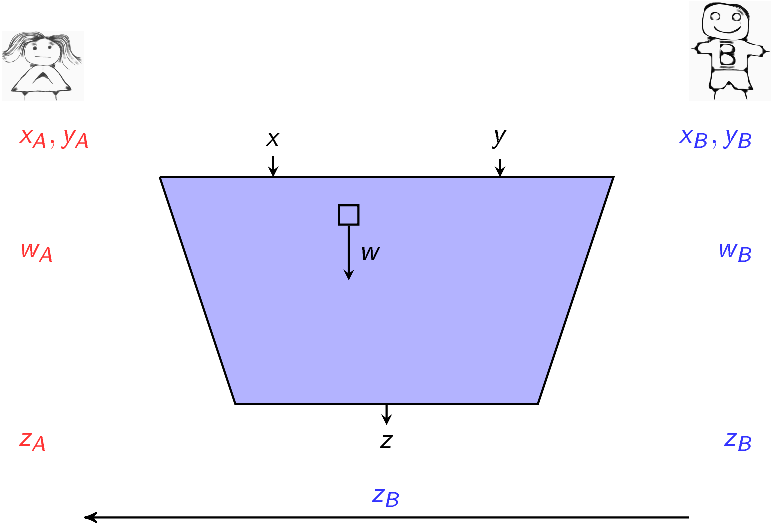

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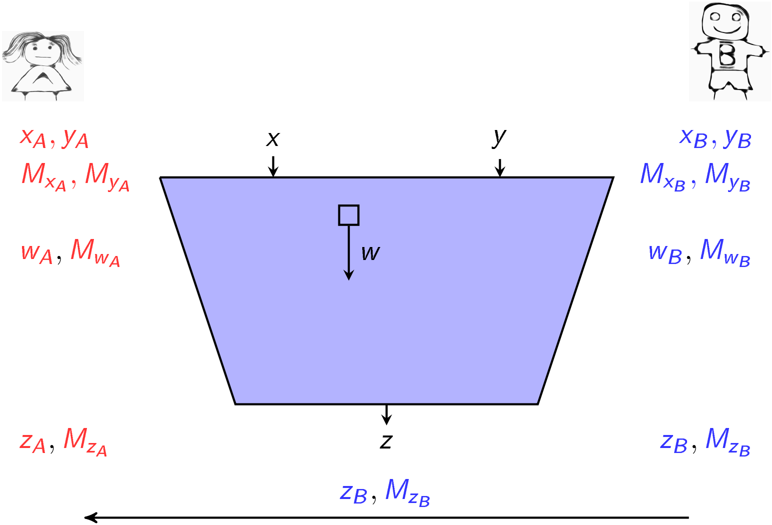

Add message authentication codes (MACs)

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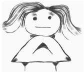

Message $x \in_R \{0,1\}$

MAC $M = K \oplus x\Delta$

Global key $\Delta \in_R \{0,1\}^n$

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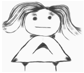

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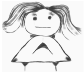

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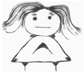

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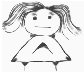

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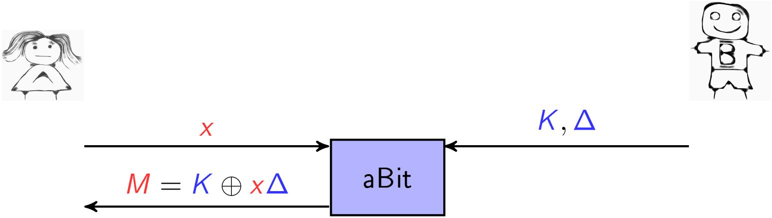
Obtaining MACs: The Functionality

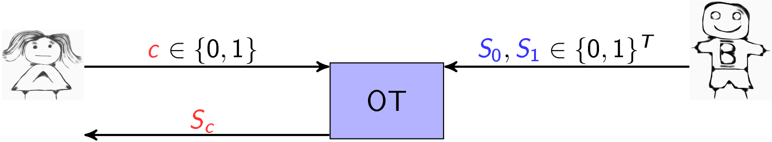


Obtaining MACs: Protocol Steps

- Step 1: Obtain a *few*, *long* MACs on Alice's random bits.
- Step 2: Turn into *many*, *short* MACs on Bob's random bits.

Step 1: Long MACs for Alice

To authenticate bits $x_1, x_2, \dots, x_n$:



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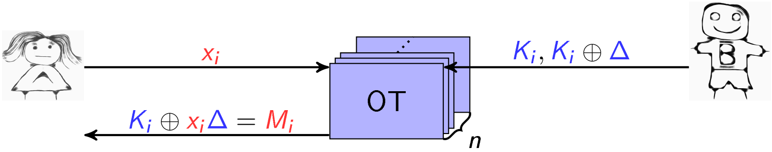

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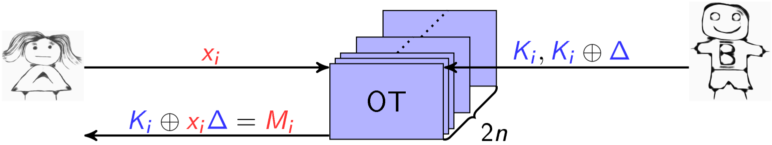

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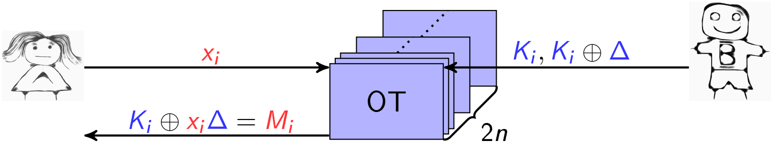

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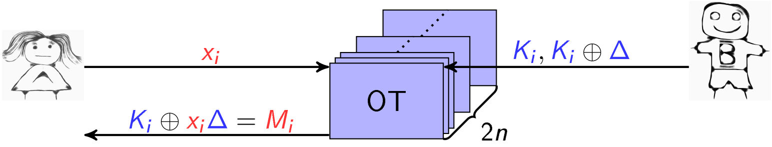

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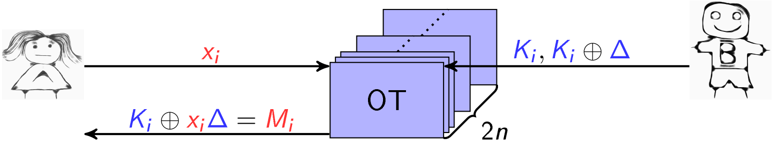

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- Solution:
  - Do $2n$ OTs.
  - Force Bob to use consistent Δ, using a "cut-n-chose"-like technique.
  - Sacrifice half of the authenticated messages.

Step 2: Short MACs For Bob

$$M_1 \; M_2 \; \cdots \; M_n = K_1 \; K_2 \; \cdots \; K_n \oplus x_1\Delta \; x_2\Delta \; \cdots \; x_n\Delta$$

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$$\begin{array}{c} (K_{1,1},\dots,K_{1,n}) \\ (K_{2,1},\dots,K_{2,n}) \\ \vdots \\ (K_{T,1},\dots,K_{T,n}) \end{array} = \begin{array}{c} (M_{1,1},\dots,M_{1,n}) \\ (M_{2,1},\dots,M_{2,n}) \\ \vdots \\ (M_{T,1},\dots,M_{T,n}) \end{array} \oplus \begin{array}{c} (x_1,\dots,x_n)\Delta_1 \\ (x_1,\dots,x_n)\Delta_2 \\ \vdots \\ (x_1,\dots,x_n)\Delta_T \end{array}$$

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$$\begin{bmatrix} N_1 \\ N_2 \\ \vdots \\ N_T \end{bmatrix} = \begin{bmatrix} L_1 \\ L_2 \\ \vdots \\ L_T \end{bmatrix} \oplus \begin{bmatrix} (x_1, \ldots, x_n)\Delta_1 \\ (x_1, \ldots, x_n)\Delta_2 \\ \vdots \\ (x_1, \ldots, x_n)\Delta_T \end{bmatrix}$$

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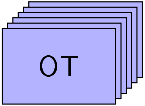
- $N_i = L_i \oplus y_i \Gamma$, i.e. N_i is a MAC on y_i w. keys L_i, Γ.

Obtaining MACs: Summary



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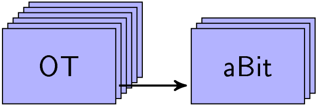

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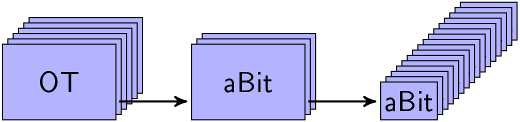

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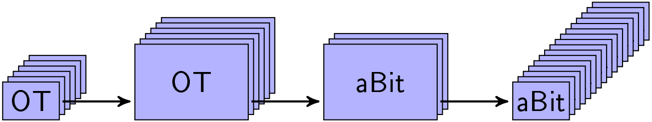

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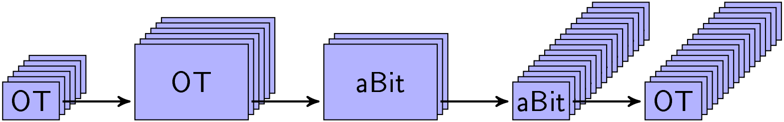

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- Note 2: Can get short OT from short aBit (i.e. OT-extension).

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Thank you.