Optimistic Fair Priced Oblivious Transfer

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IBBT

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Priced Oblivious Transfer: Definition

Vendor

$(m_1, \ldots, m_N), (p_1, \ldots, p_N)$

Buyer

$\tau \in \{1, \ldots, N\}$

m_τ

Properties:

- $\mathcal{V}$ does not learn τ.
- $\mathcal{B}$ does not get any information about other messages.
- $\mathcal{B}$ pays price p_τ.

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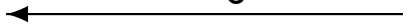
Priced Oblivious Transfer: Construction

Vendor

Buyer

ac_0



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Prepaid Mechanism

- $\mathcal{B}$ makes an initial deposit to $\mathcal{V}$.
- At each purchase, the price is debited from the deposit.
- $\mathcal{V}$ learns neither the price nor the deposit.

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Priced Oblivious Transfer: Security

Previous Work

Half-Simulation secure schemes [AIR01, Tob03].

- Vulnerable under attack in [DNO08].

UC-secure scheme [RKP09].

- Inefficient.

Efficient Full-Simulation Secure POT

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Previous Work

Usually, e-commerce protocols are analyzed to prove their fairness [Kre04].

- Non privacy-preserving protocols [EGL85, Gol83].
- Privacy-preserving protocols that provide buyers' anonymity [RR01].

However, no fair POT scheme has been proposed.

- Malicious $\mathcal{V}$ can claim $\mathcal{B}$ ran out of funds.
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Overview

Our POT scheme is based on the OT scheme of [CNS07] and thus follows an assisted decryption approach.

Generic POT scheme

$\mathcal{V}((m_i, p_i)_{i=1}^N)$		$\mathcal{B}(ac_0)$
$sk, \forall i, C_i = \text{POTInitV}(m_i, p_i)$	**Initialization** $(C_1, \ldots, C_N)$ →	Verify $(C_1, \ldots, C_N)$
ac_0	(ac_0) ←	ac_0
$\mathcal{V}$	**Transfer**	$\mathcal{B}(\tau)$
$\text{POTVerReq}(Q)$	(Q) ←	$(Q, Qpriv) = \text{POTReq}(C_\tau)$
$R = \text{POTResp}(Q, sk)$	(R) →	$\text{POTVerResp}(R)$
		$(m_\tau) = \text{POTComplete}(R, Qpriv)$

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Details: Initialization

$\mathcal{V}$ computes the ciphertexts $(C_1, \ldots, C_N)$.

- Computes bilinear map setup $(p, \mathbb{G}, \mathbb{G}_t, e, g)$.
- Pick secret key $h \in \mathbb{G}$.
- Ciphertext $C_i = (A_i = g^{1/(x+p_i)}, B_i = e(h, A_i) \cdot m_i, p_i)$.

$\mathcal{B}$ verifies each A_i and makes the initial deposit ac_0.

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Transfer phase "j": Request

$\mathcal{B}$ computes a request (POTReq) for item τ:

- $\mathcal{B}$ picks $v \leftarrow \mathbb{Z}_p$ and blinds $V = A_\tau^v$, computes a commitment C_j to new deposit value $ac_{j-1} - p_\tau$ and a proof that:
  - She possesses a signature on price p_τ.
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Transfer phase "j": Response

$\mathcal{V}$ verifies request (POTVerReq) and computes a response (POTResp):

- $W = e(h, V)$.
- and a proof that secret key h was used to compute W.

$\mathcal{B}$ verifies response (POTVerResp) and obtains the message (POTComplete):

- $m_\tau = B_\tau / (W^{1/v}) = (\frac{m_\tau \cdot e(A_i, h)}{e(h, A_i^v)^{(1/v)}})$

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Comparison with Previous Work

UC Secure vs Our Scheme

	[RKP09]	Our Scheme
UC	Yes	No
Standard Model	Yes	Yes
Static Corruptions	Yes	Yes
CRS	Yes	No
Assumptions	DLIN, TDH, HSDH	SDH, BDHE
Efficient	No	Yes

Efficiency

Given the upper bound of the deposit $D = d^a$.

Communication Efficiency

	[RKP09]	Our Scheme
Ciph	$(12N + 3d + 11) \cdot \lvert\mathbb{G}\rvert + \lvert\mathbb{Z}_p\rvert$	$(2N + 2d + 2) \cdot \lvert\mathbb{G}\rvert + (N + 1) \cdot \lvert\mathbb{Z}_p\rvert + 2 \cdot \lvert\mathbb{G}_t\rvert$
Req	$(86 + 30a) \cdot \lvert\mathbb{G}\rvert$	$(a + 7) \cdot \lvert\mathbb{G}\rvert + (2a + 7) \cdot \lvert\mathbb{Z}_p\rvert + (a + 1) \cdot \lvert\mathbb{G}_t\rvert$
Resp	$28 \cdot \lvert\mathbb{G}\rvert$	$3 \cdot \lvert\mathbb{G}_t\rvert + \lvert\mathbb{Z}_p\rvert$

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Transformation that turns any secure POT scheme into an Optimistic Fair POT scheme.

Properties:

- Third party $\mathcal{A}$ to resolve disputes.
- $\mathcal{A}$ is only involved in case of dispute (optimistic).
- $\mathcal{A}$ must be neutral to guarantee fairness.
- Privacy-properties of POT are guaranteed (even if $\mathcal{A}$ is corrupted).
  - $\mathcal{A}$ and $\mathcal{V}$ cannot learn τ.
  - $\mathcal{A}$ and $\mathcal{B}$ cannot learn non-purchased messages.
- Without harming efficiency.

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Verifiably Encrypted Signatures

A VES scheme consists of algorithms

- $\mathsf{Kg}(1^\kappa)$, $\mathsf{Sign}(sk, m)$ and $\mathsf{Vf}(pk, \sigma, m)$.
- $\mathsf{AdjKg}(1^\kappa)$ output a key pair (ask, apk) for $\mathcal{A}$.
- $\mathsf{Create}(sk, apk, m)$ computes a VES ω.
- $\mathsf{VesVf}(pk, apk, \omega, m)$ verifies a VES ω.
- $\mathsf{Adj}(pk, ask, apk, \omega, m)$ extracts σ form ω.

Properties:

- Unforgeability.
- Opacity.

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Protocol based on VES

Non privacy-preserving e-commerce protocol based on VES:

- $\mathcal{B}$ requests an item and sends a VES.
- $\mathcal{V}$ sends the item.
- $\mathcal{B}$ reveals a valid signature.
- If $\mathcal{B}$ does not reveal it, $\mathcal{V}$ complains.
  - $\mathcal{A}$ verifies $\mathcal{V}$ fulfills delivery.
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- In non-privacy preserving protocols, $\mathcal{A}$ can easily verify whether $\mathcal{V}$ fulfills delivery.
- In POT $\mathcal{A}$ can learn neither $m_1, \ldots, m_N$ nor τ.
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$sk, \forall i, C_i = \text{POTInitV}(m_i, p_i)$	$\xrightarrow{(C_1, \ldots, C_N)}$	Verify $(C_1, \ldots, C_N)$
ac_0	$\xleftarrow{(ac_0, \sigma(0, ac_0))}$	ac_0
$\mathcal{V}$	**Transfer "j"**	$\mathcal{B}(\tau)$
POTVerReq(Q)	$\xleftarrow{(Q, \omega(j, Q))}$	$(Q, Qpriv) = \text{POTReq}(C_\tau)$
$R = \text{POTResp}(Q, sk)$	$\xrightarrow{(R)}$	POTVerResp(R)
	$\xleftarrow{(Q, \sigma(j, Q))}$	$(m_\tau) = \text{POTComplete}(R, Qpriv)$

OFPOT based on VES: disputes

$\mathcal{V}$ complains:

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Conclusion

POT scheme.

- Full-simulation secure.
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- Efficient.

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