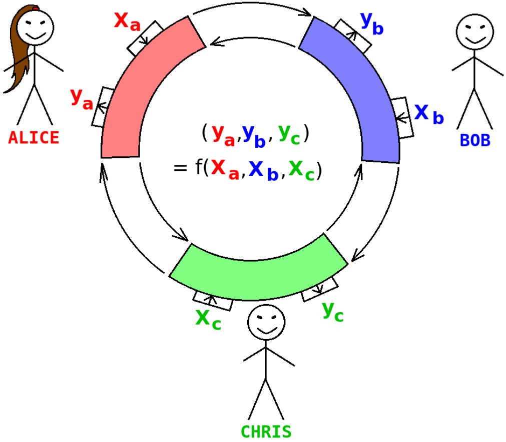
Preprocessing Based Verification of Multiparty Protocols with an Honest Majority

20.07.17

Peeter Laud   Alisa Pankova   Roman Jagomägis

Secure Multiparty Computation



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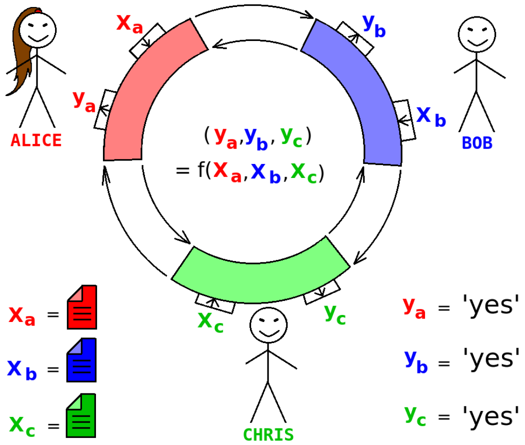

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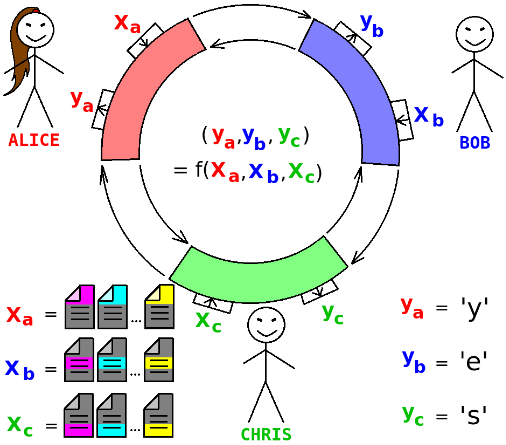

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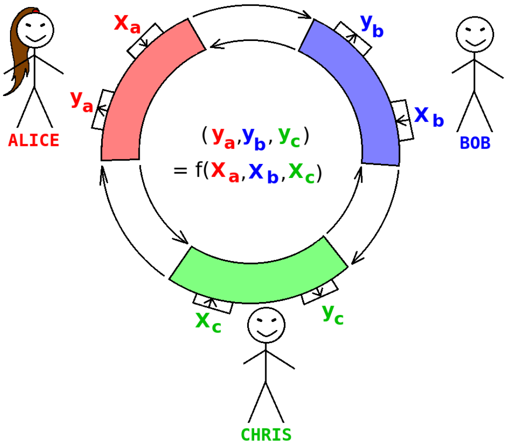

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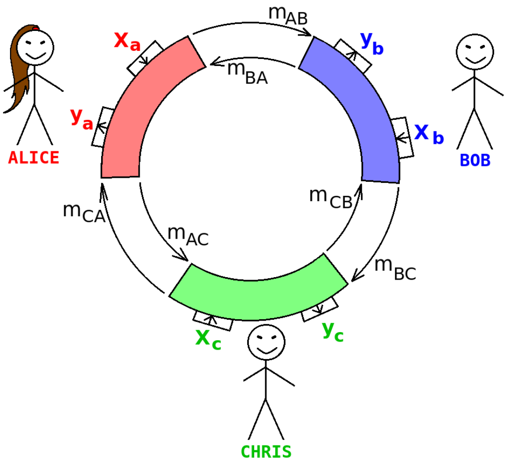

- Passive adversary: all parties follow the protocol.

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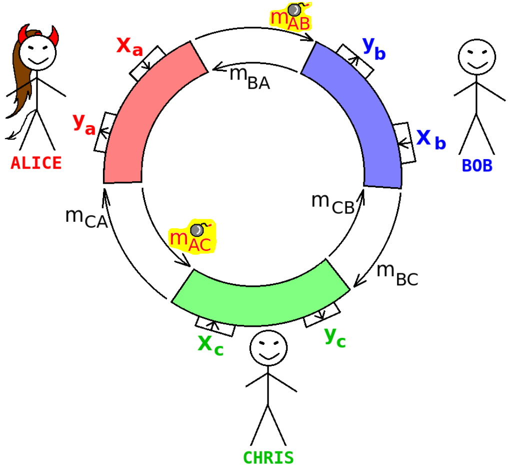

- Passive adversary: all parties follow the protocol.
- Active adversary: corrupted parties may cheat.

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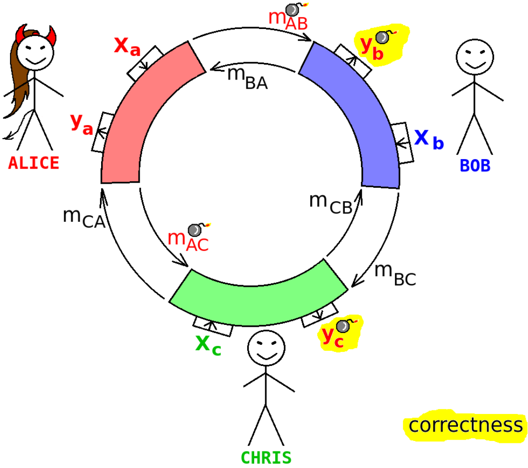

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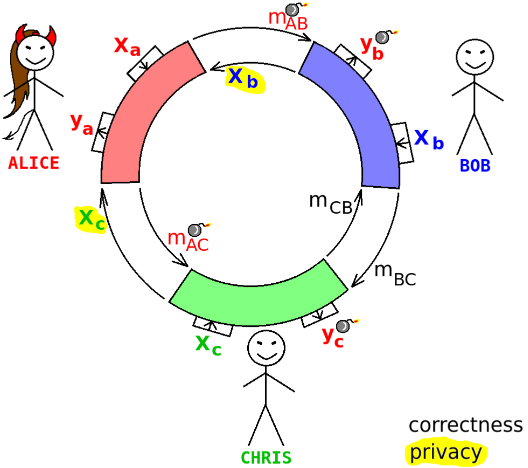

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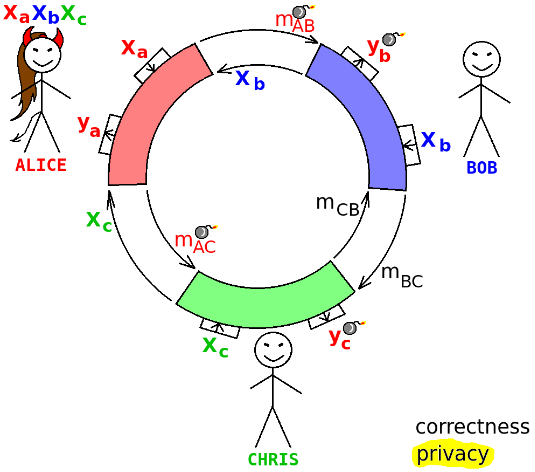

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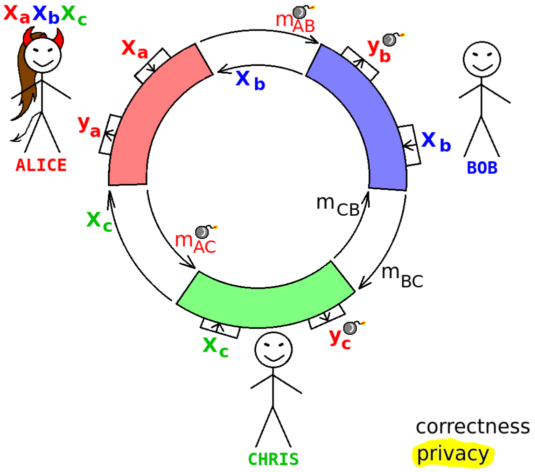
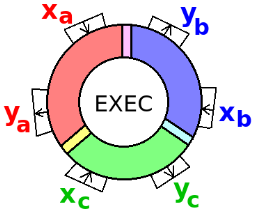


- Passive adversary: all parties follow the protocol.
- Active adversary: corrupted parties may cheat.
- Covert adversary: will not cheat if it will be caught.

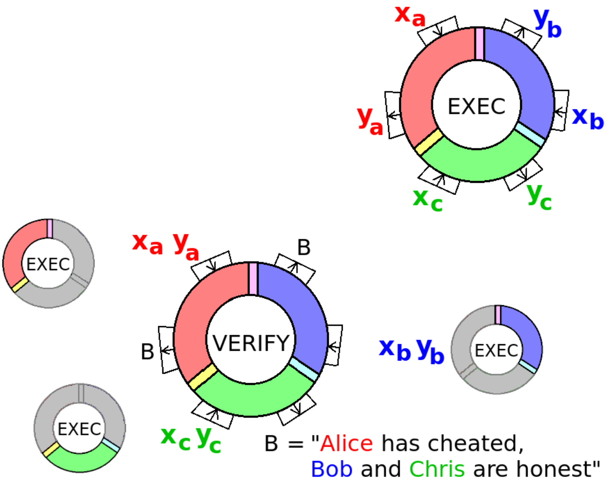
Verifiable MPC with Honest Majority

- Execution: run the passively secure protocol.



Verifiable MPC with Honest Majority

- Execution: run the passively secure protocol.
- Verification: each party proves that it followed the protocol.



Verifiable MPC with Honest Majority

- Preprocessing: generate correlated randomness.
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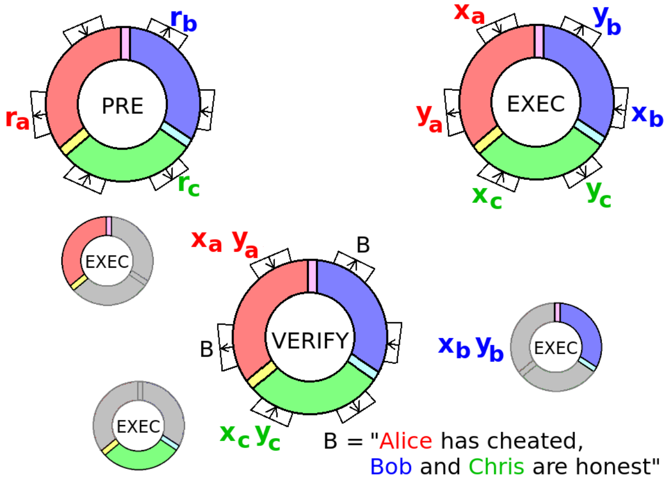

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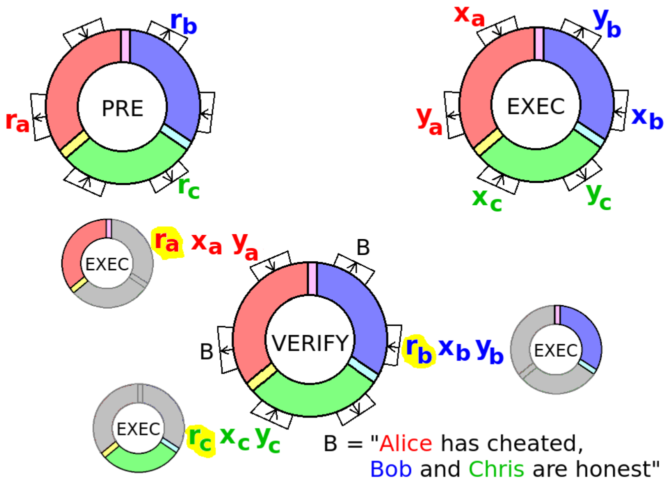
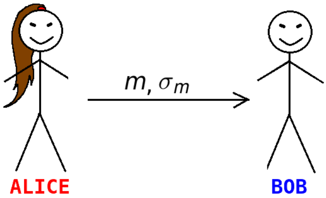


Execution Phase

- Run the initial passively secure protocol.
- Each message m is provided with a sender's signature σ_m.



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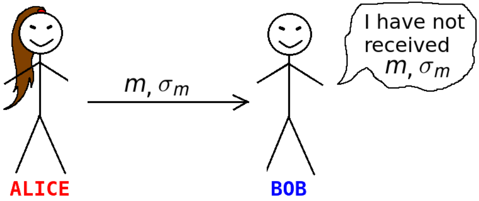

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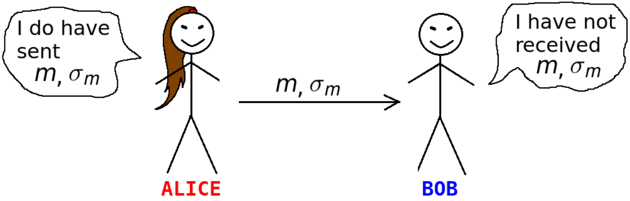

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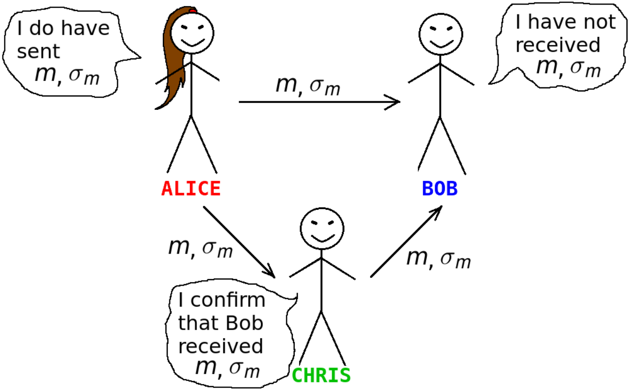


- If Alice refuses to send (m, σ_m) Bob asks Chris to deliver it.
- If Alice or Bob is corrupt, (m, σ_m) is already known to the attacker anyway.

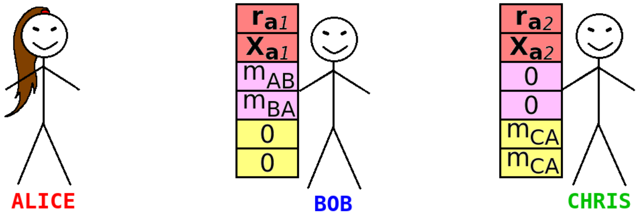
Verification phase

Each party (the prover P) proves its honesty
to the other parties (the verifiers V_1 and V_2) .

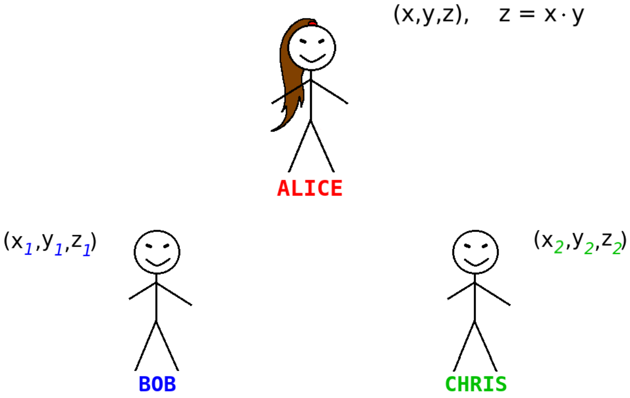
All relevant values of P are shared among V_1 and V_2:

- Message m: $m + 0$ or $0 + m$
- Input x: $x_1 + x_2$
- Correlated randomness r: $r_1 + r_2$
  known by P, shared in the preprocessing phase.

All shares are signed by the prover.

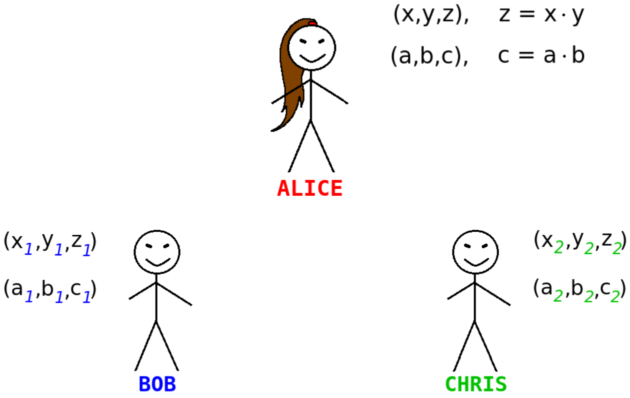


Verification phase (reproducing computation of *P*)



Verification phase (reproducing computation of P)

- P takes precomputed correlated randomness (e.g. Beaver triples (a, b, c) s.t. $c = a \cdot b$).



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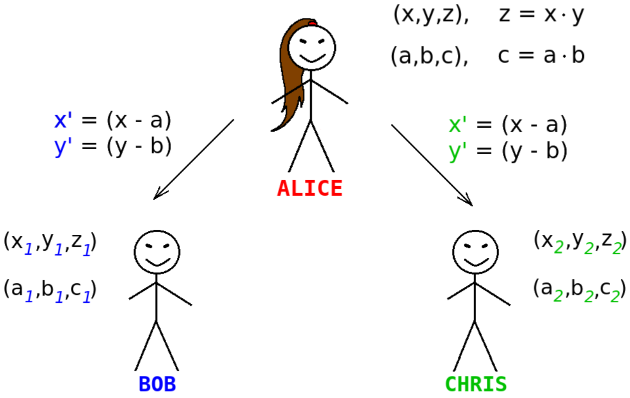

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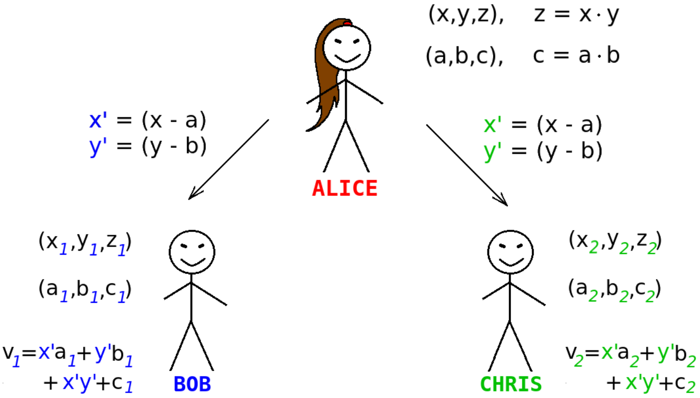

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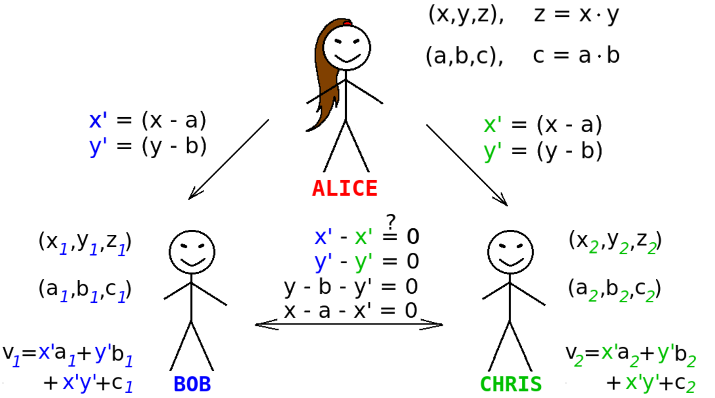

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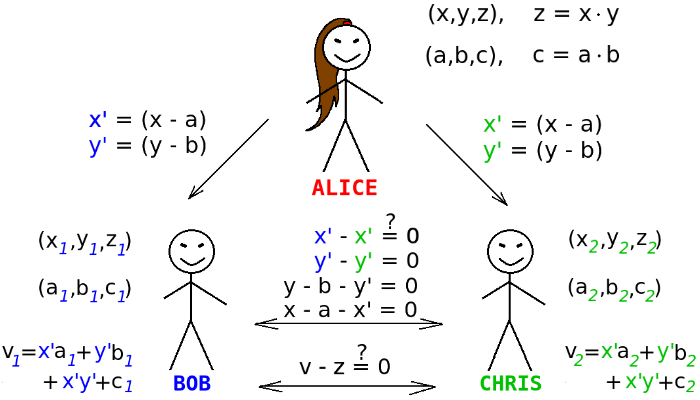
- V_1 and V_2 check if they get committed messages of P.



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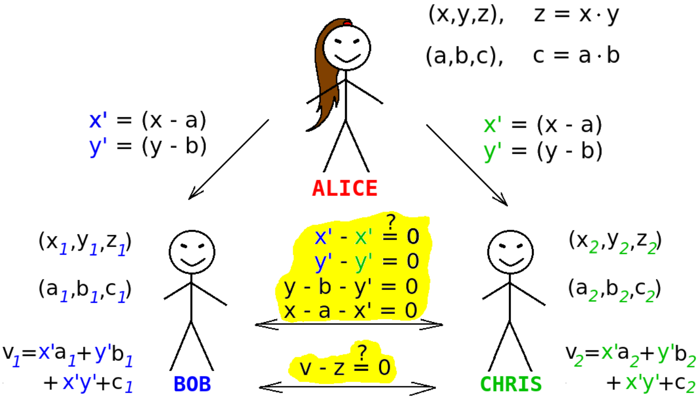
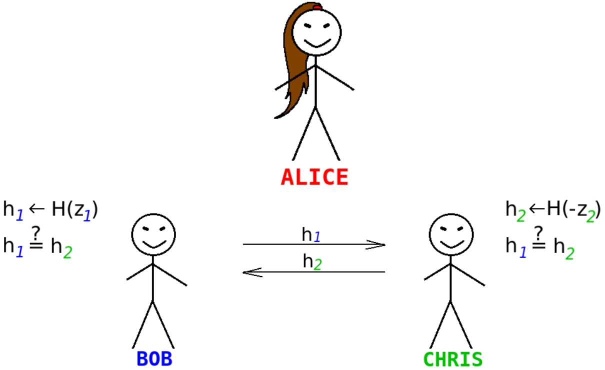


Verification phase (checking if $z = 0$)

- V_1 and V_2 exchange $h_1 = H(z_1)$ and $h_2 = H(-z_2)$, and check $h_1 = h_2$.



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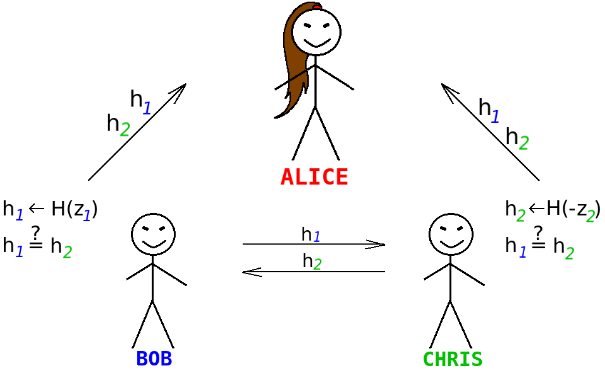
- V_1 and V_2 exchange $h_1 = H(z_1)$ and $h_2 = H(-z_2)$, and check $h_1 = h_2$.
- If $h_1 \neq h_2$, they send h_1 and h_2 to P.



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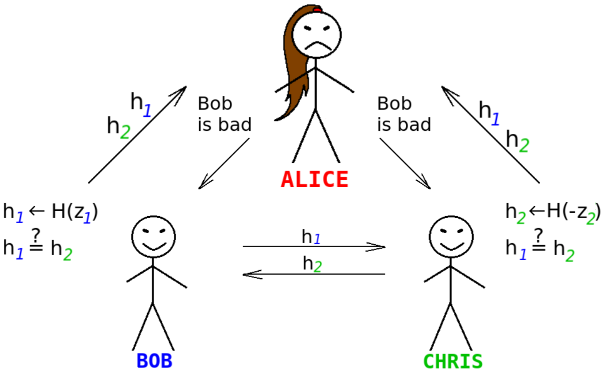

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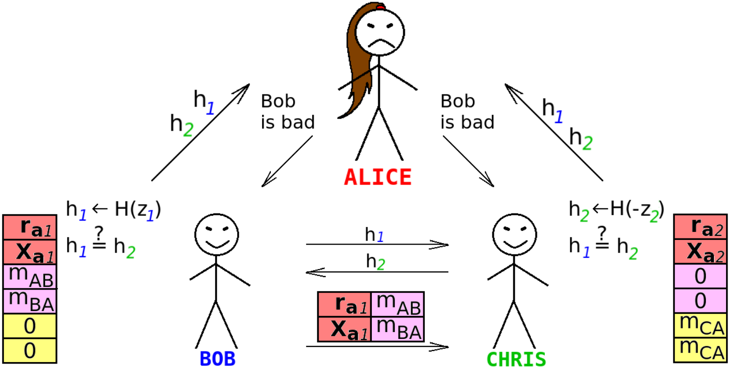
- V_1 opens its shares of P commitments with all signatures.



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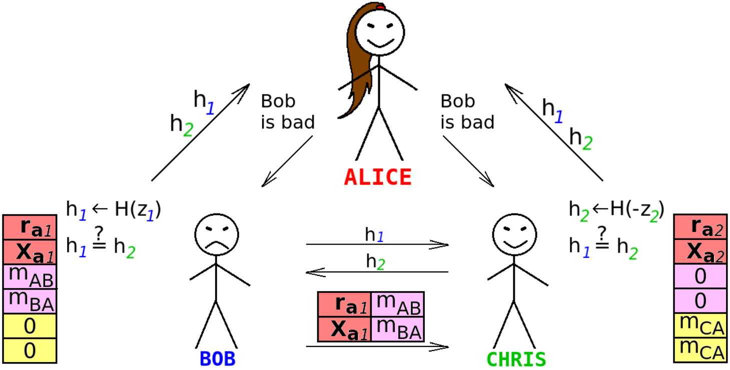
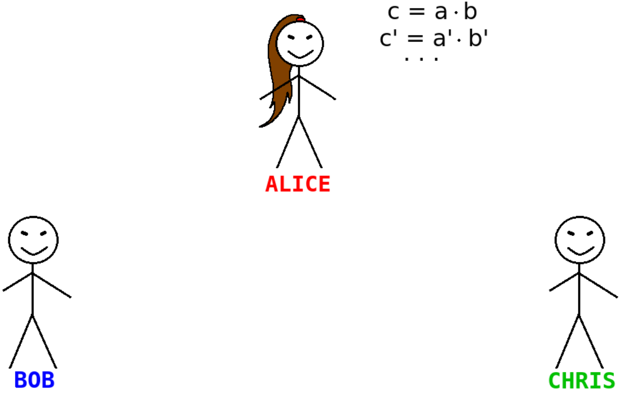
- V_1 opens its shares of P commitments with all signatures.
- V_2 repeats the computation of V_1, getting h_1.



Preprocessing Phase

- The prover *P* generates correlated randomness (e.g. Beaver triples in a certain ring $\mathbb{Z}_m$).



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- The prover P generates correlated randomness (e.g. Beaver triples in a certain ring $\mathbb{Z}_m$).
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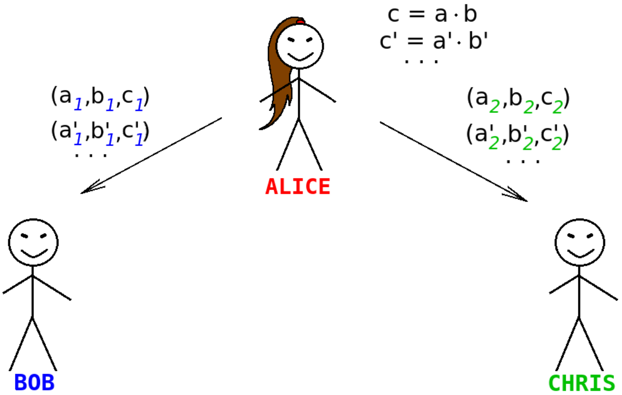

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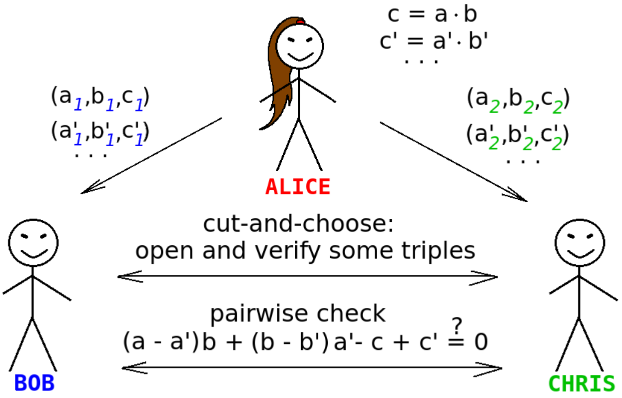

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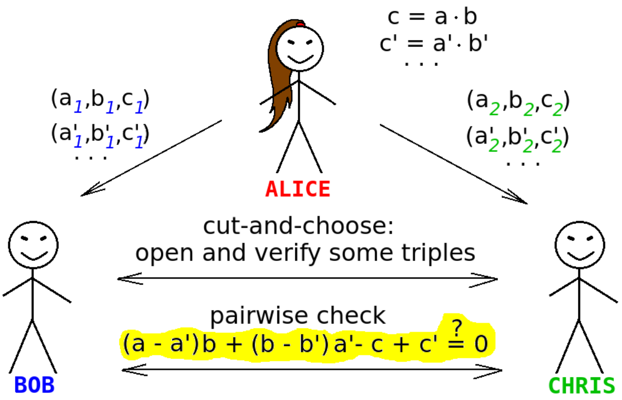
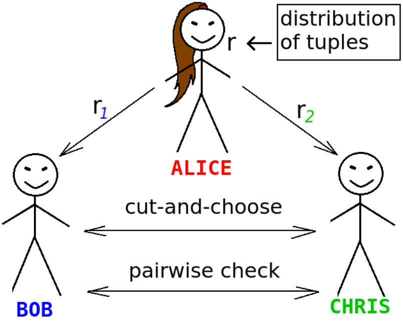


Preprocessing Phase (other preprocessed tuples)

- We also have other types of preprocessed tuples:
  - Trusted bits $b \in \{0, 1\}$ shared over $\mathbb{Z}_{2^m}$.
  - Characteristic vector tuple $(r, \vec{b})$ (i.e $b_r = 0$ iff $i \neq r$).
  - Rotation tuple $(r, \vec{a}, \vec{b})$ s.t the vector $\vec{b}$ is $\vec{a}$ rotated by r.
  - Permutation tuple $(\pi, \vec{a}, \vec{b})$ s.t $\vec{b} = \pi(\vec{a})$.
- Their generation and verification is analogous.



Summary

- We proposed a generic method for achieving covert security under honest majority assumption.
- Applying it to Sharemind SMC platform, we get efficient actively secure protocols with identifiable abort.
- The overhead of the execution phase is insignificant.
- In practice, the bottleneck of active security is generation of preprocessed tuples.