How Do I Know If You Have A Quantum Computer

Information Theoretically Secure Hypothesis Test for Temporally Unstructured Quantum Computing

Daniel Mills[1], Anna Pappa[12], Theodoros Kapourniotis[13], and Elham Kashefi[14]

[1]School of Informatics, The University of Edinburgh

[2]Department of Physics, University College London

[3]Department of Physics, University of Warwick

[4]LIP6, CNRS, Pierre et Marie Curie University

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This Presentation

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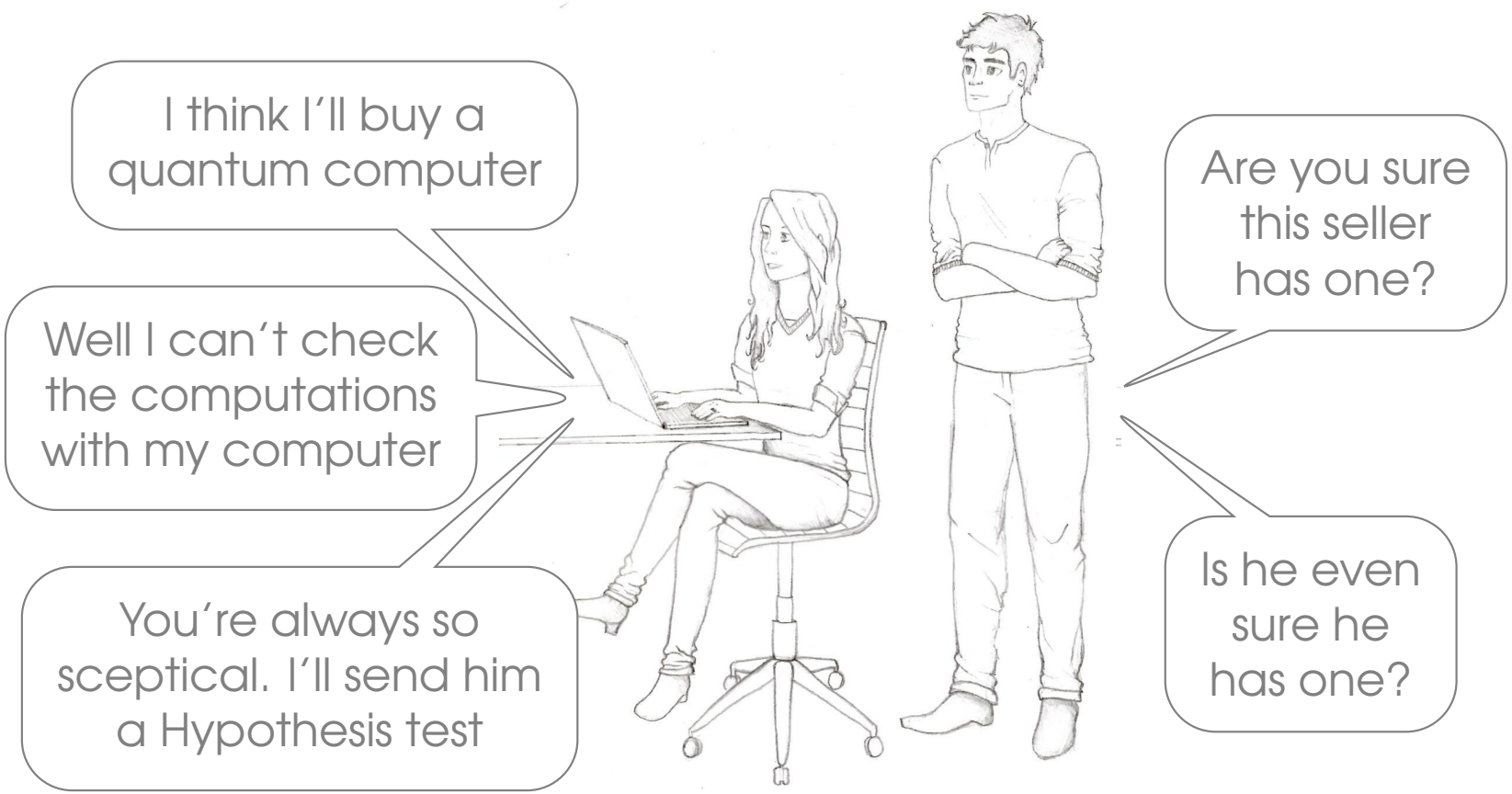
Introduction



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- A Client to ensure a malicious Server is capable of quantum computations.

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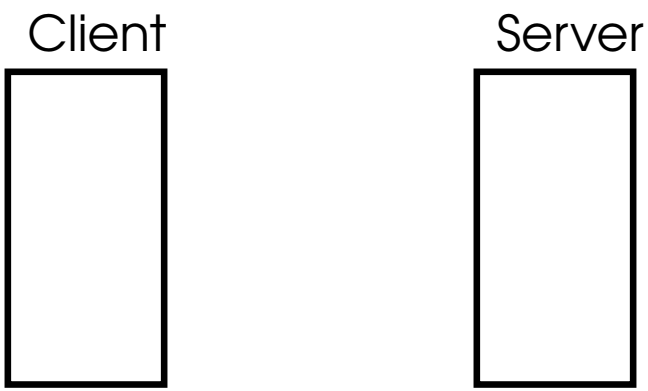
- A Client to ensure a malicious Server is capable of quantum computations.
- An engineer to check their machine is capable of quantum computations.

A Proposal



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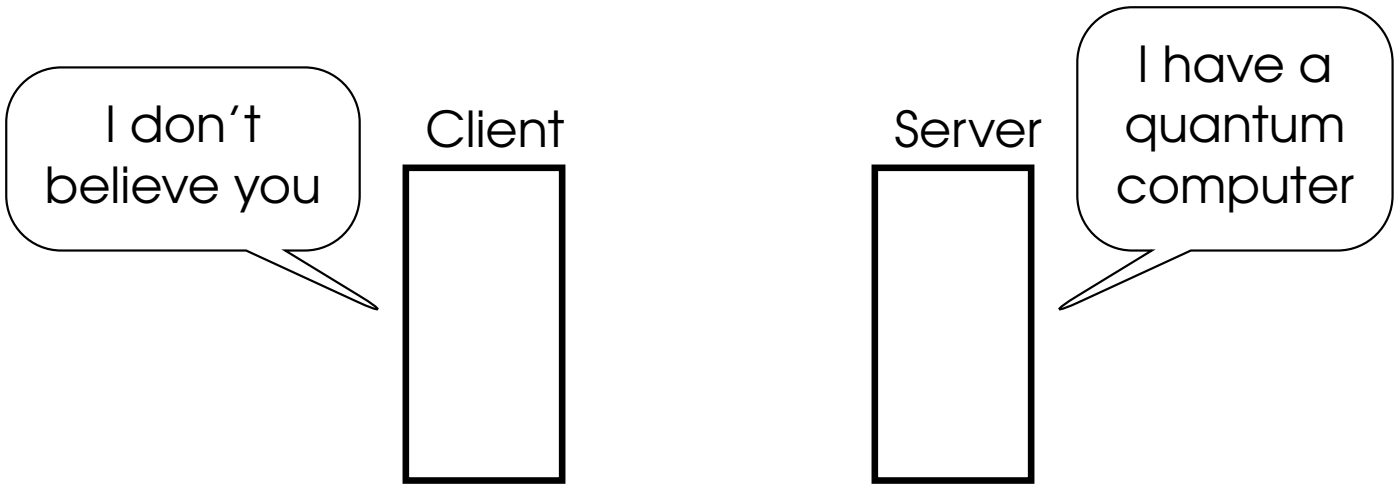

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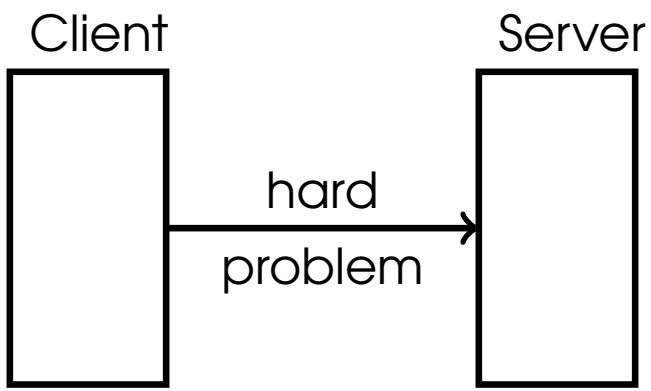

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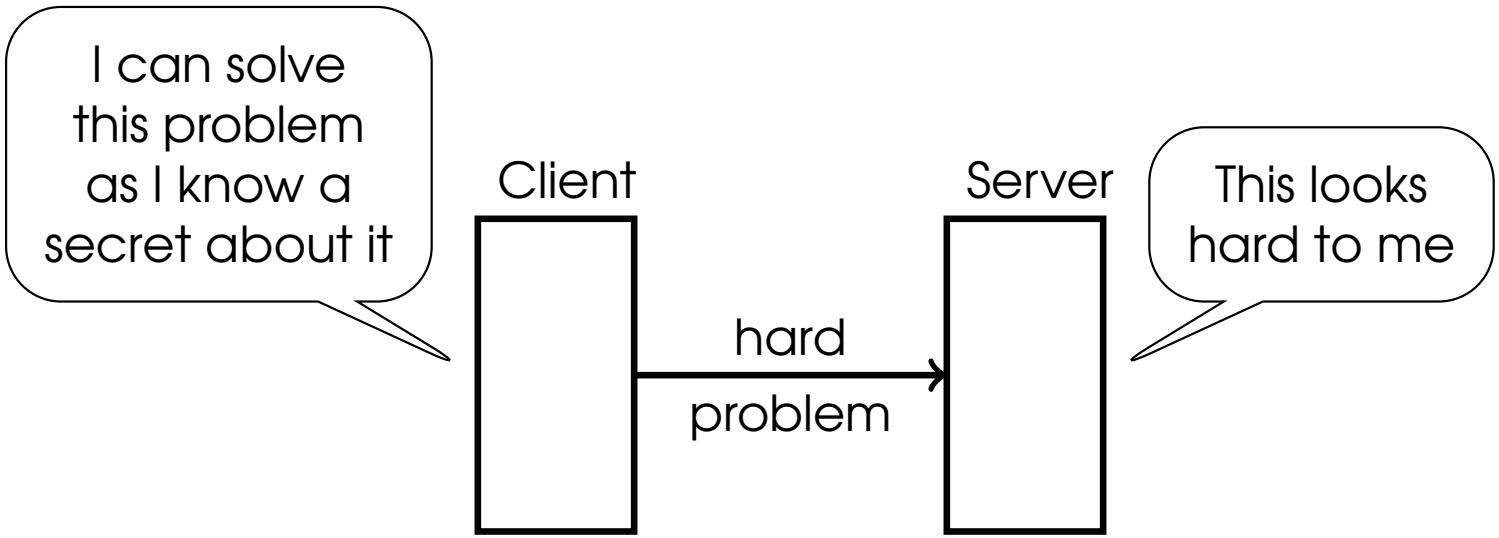
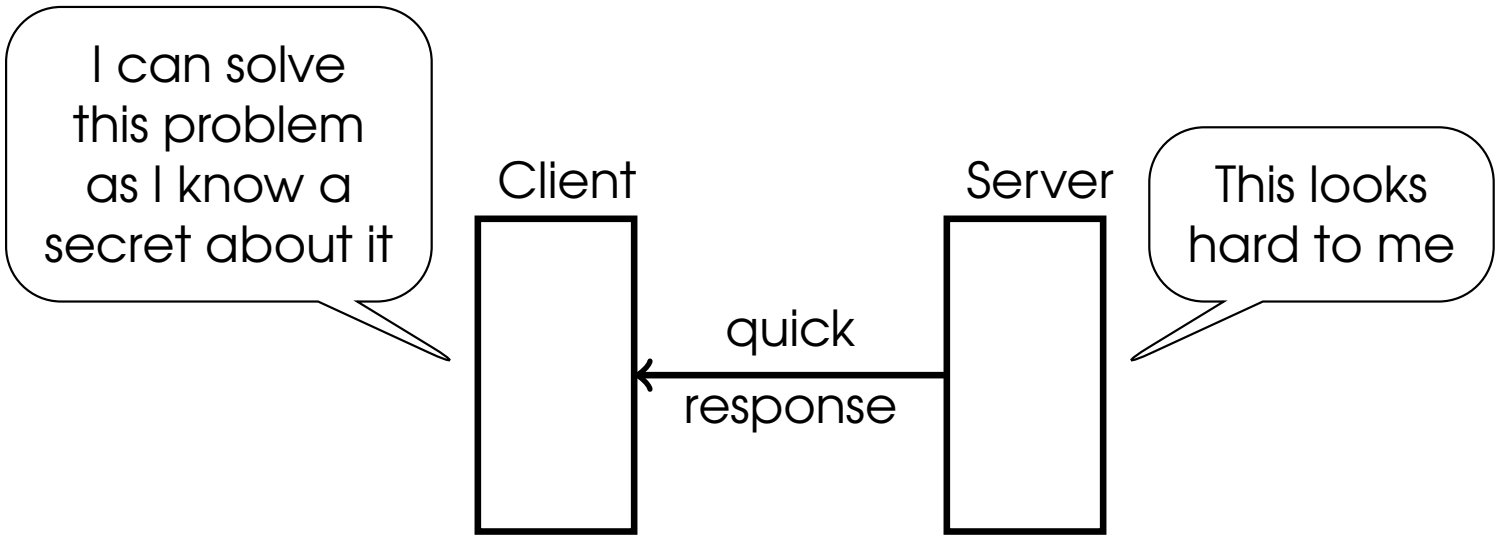

I can solve this problem as I know a secret about it
Client
hard problem
Server
This looks hard to me

A Proposal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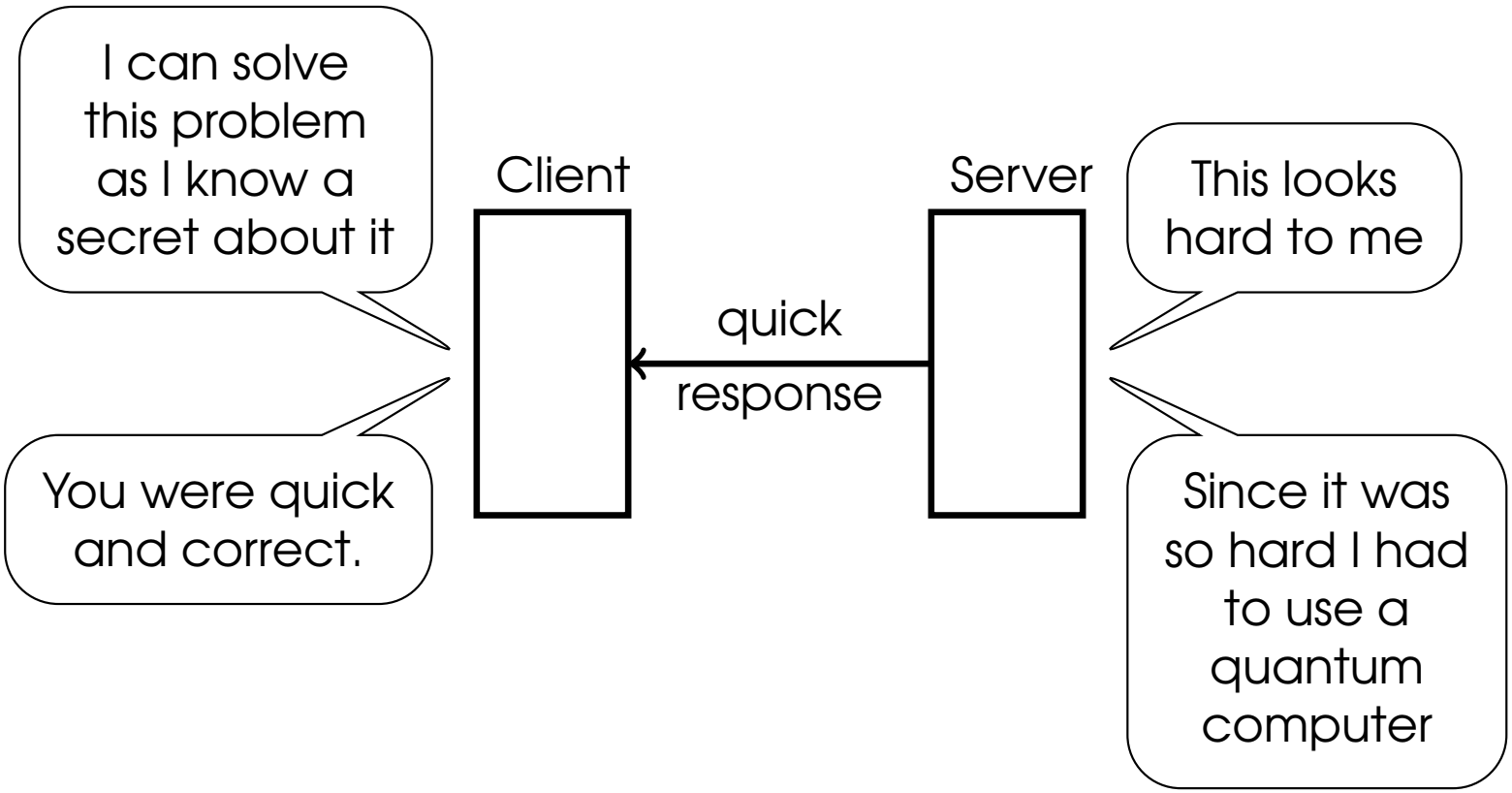
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Client
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This looks hard to me
quick
response
You were quick and correct.
Since it was so hard I had to use a quantum computer

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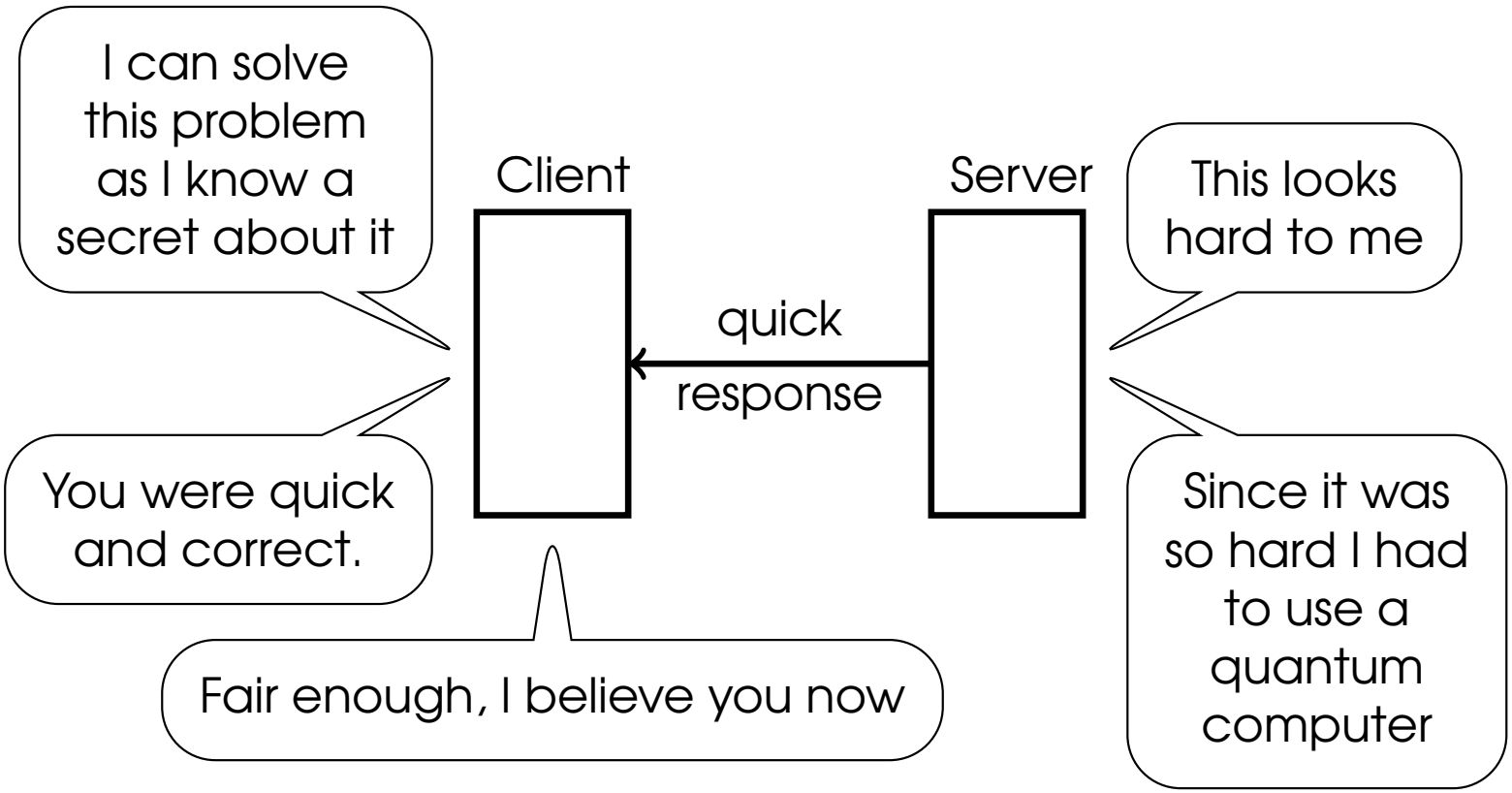
I can solve this problem as I know a secret about it
Client
Server
This looks hard to me
quick
response
You were quick and correct.
Fair enough, I believe you now
Since it was so hard I had to use a quantum computer

A Proposal

So three conditions for a successful hypothesis test might be:

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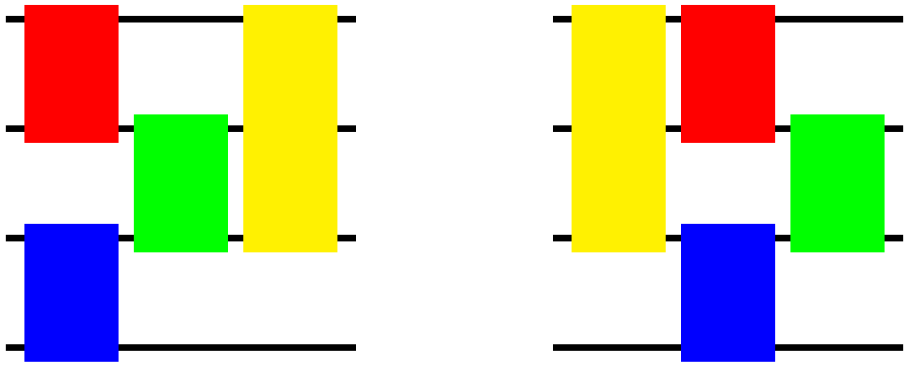
So three conditions for a successful hypothesis test might be:

- The Server must complete a hard IQP computations
  - This means it is an IQP machine
- The Client knows a secret allowing them to check the outcome
  - Must be sure that this does not add structure to the problem which the Server can use
- The Server hides the secret something

This Presentation

The Instantaneous Quantum Polytime Machine (SB)

Commuting gates:



In particular:

$$\exp\left\{ i\theta \bigotimes_{i:q_i=1} X_i \right\}$$

where $q \in \{0,1\}^{n_p}$, $\theta \in [0, 2\pi]$.

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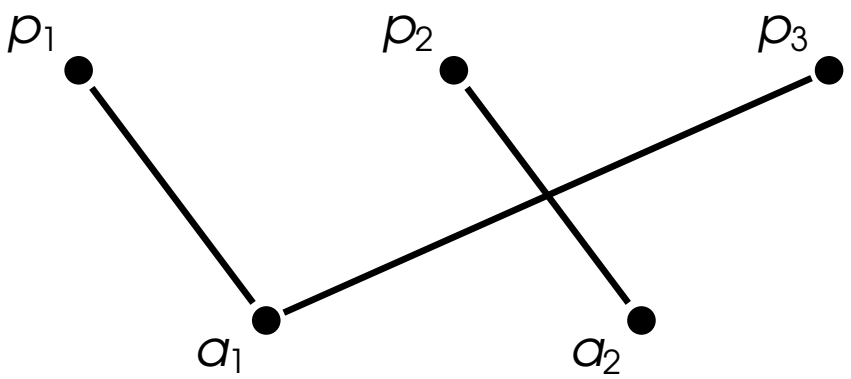
An IQP program may consist of many of these gates, and so many different q. Hence we may represent the whole computation by, for example:

$$\mathbf{Q} = \begin{pmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$$

where, in this case, we have two gates defined by $q = (101)$ and $q = (010)$.
The input is $|0^{n_p}\rangle$ and the output is the resulting state measured in the computational basis.

IQP in MBQC



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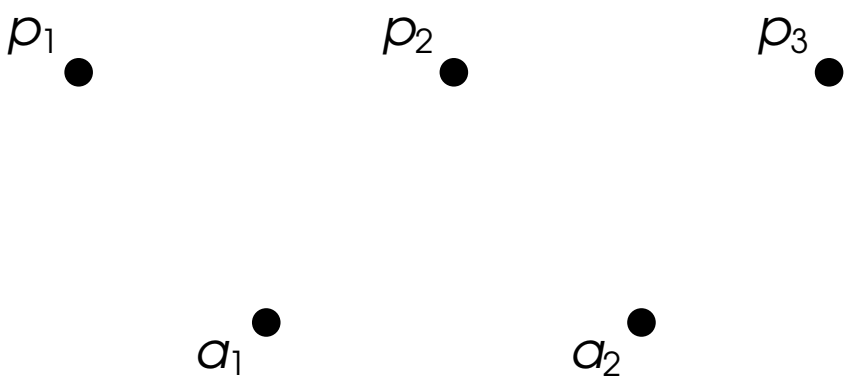

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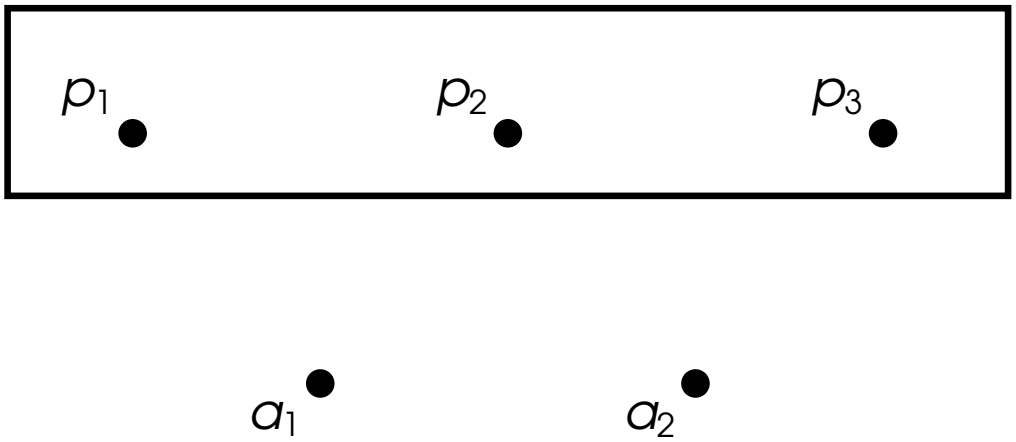

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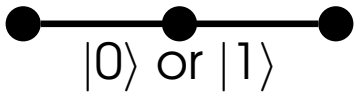
Bridge and Break (FK)



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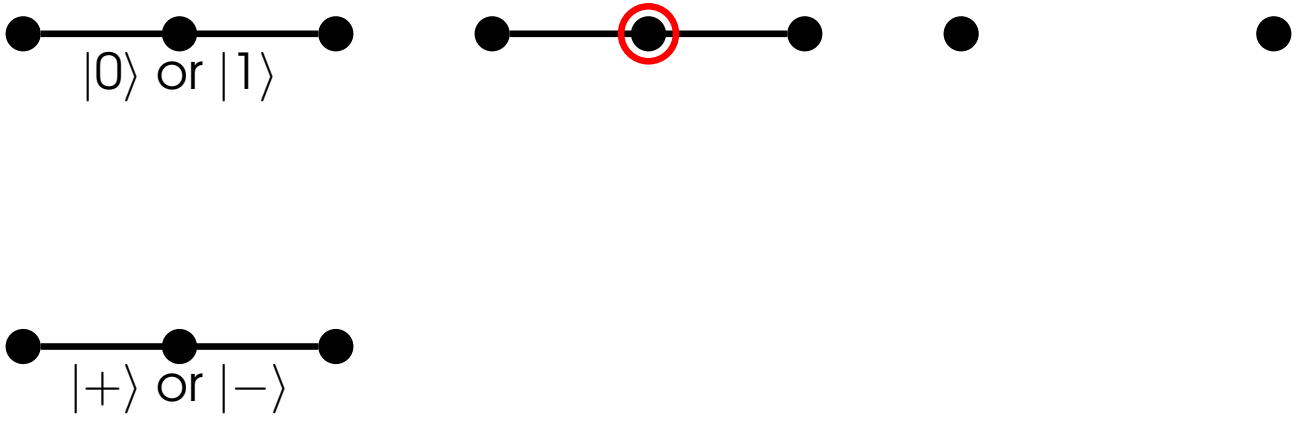

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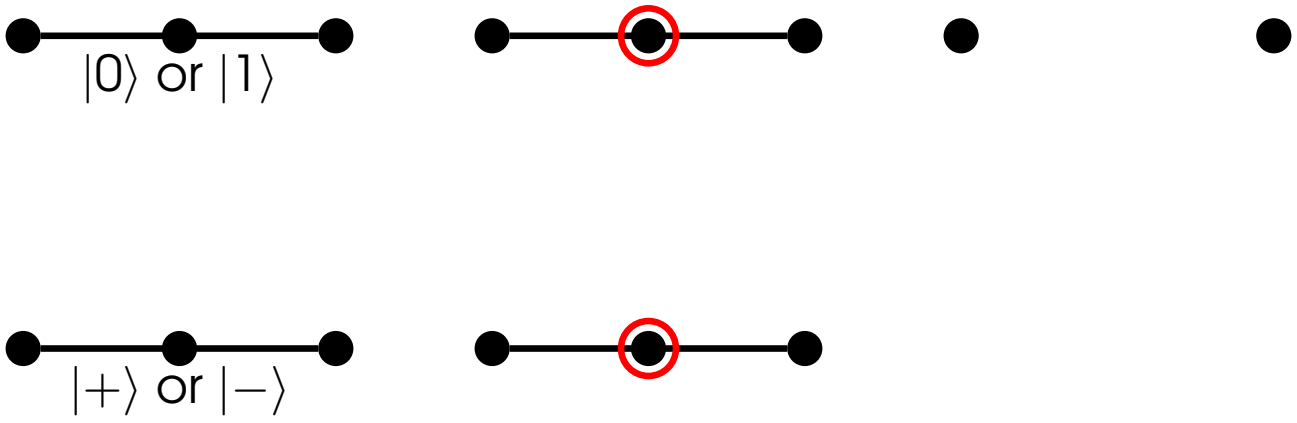

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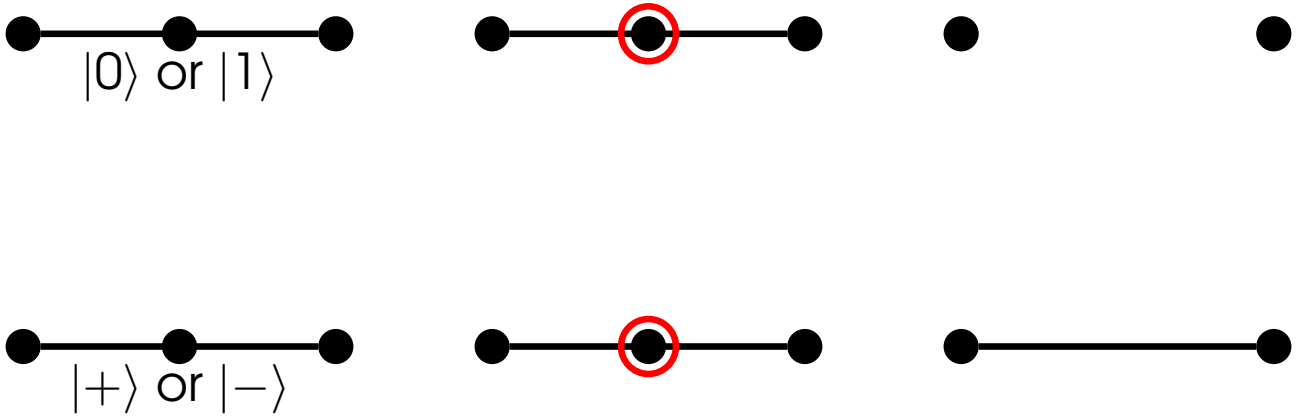

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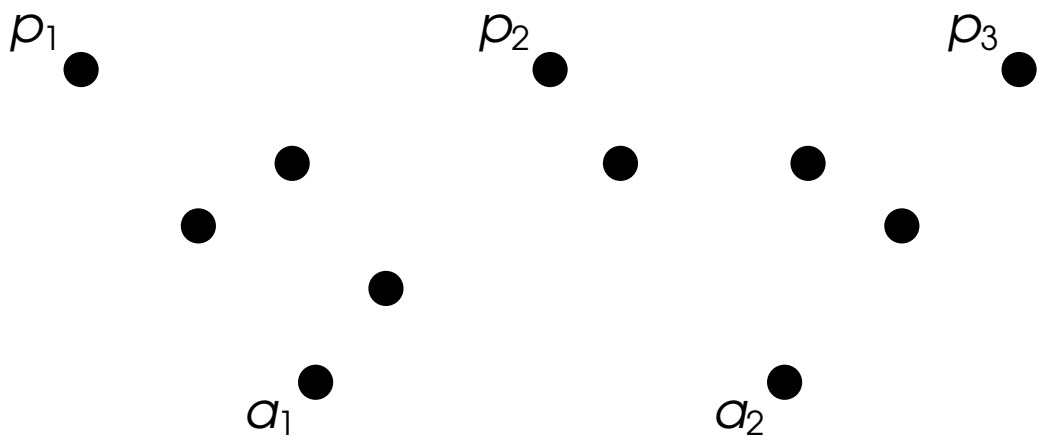

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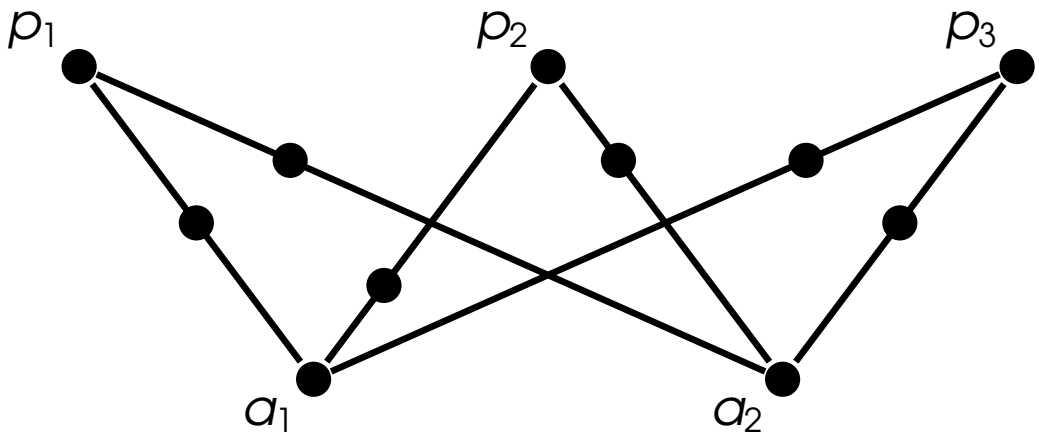

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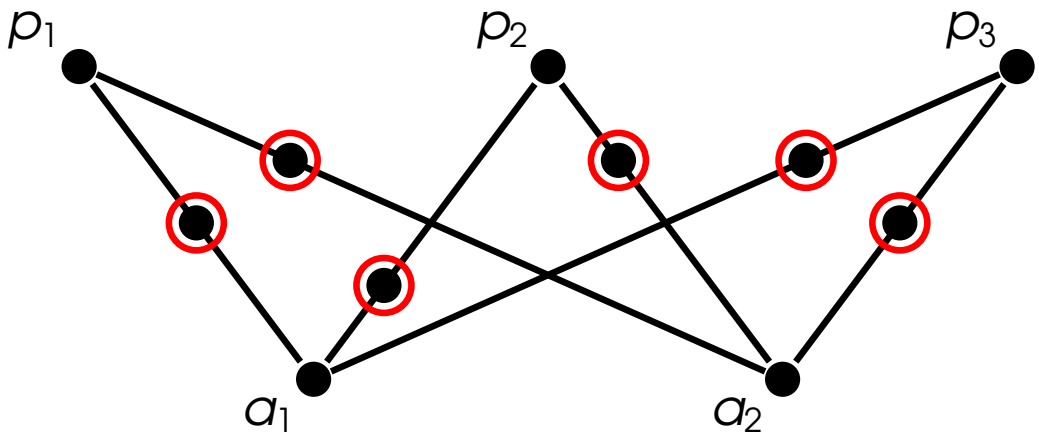

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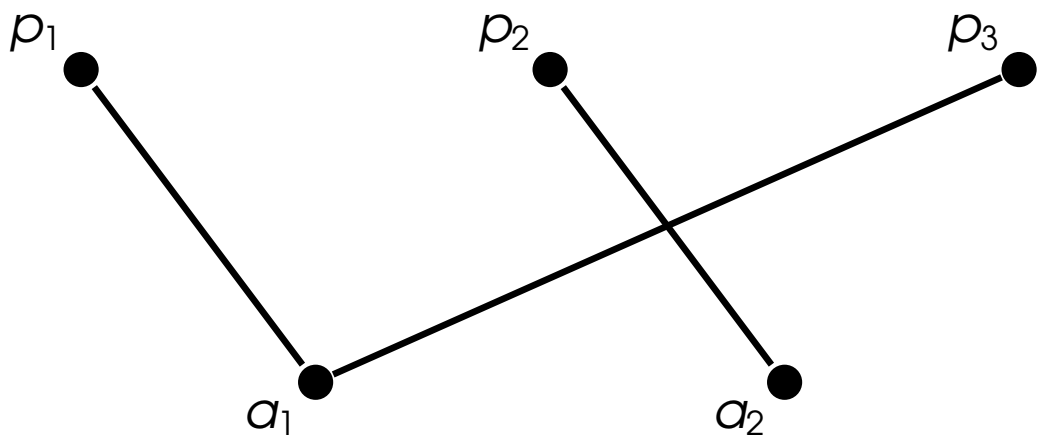

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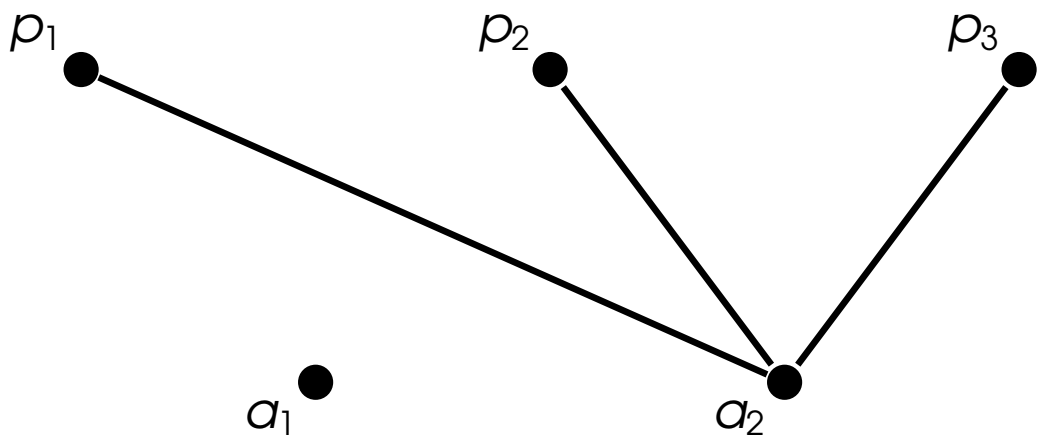

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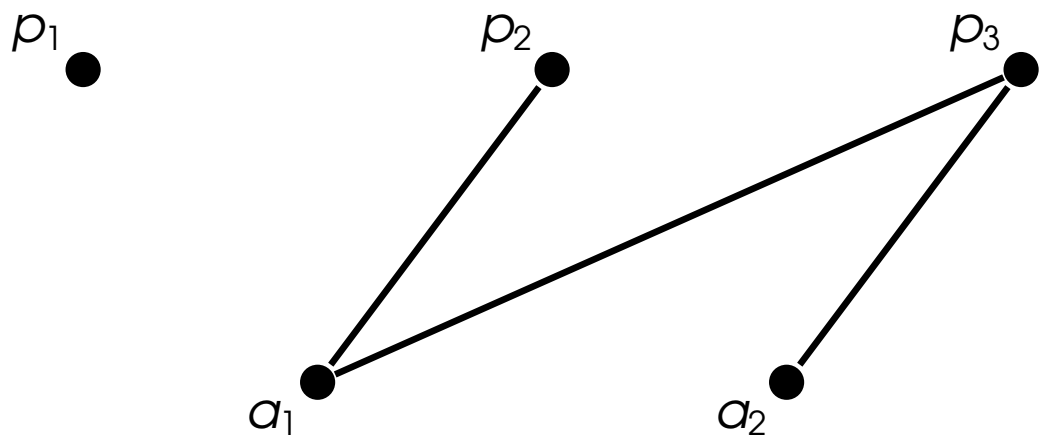
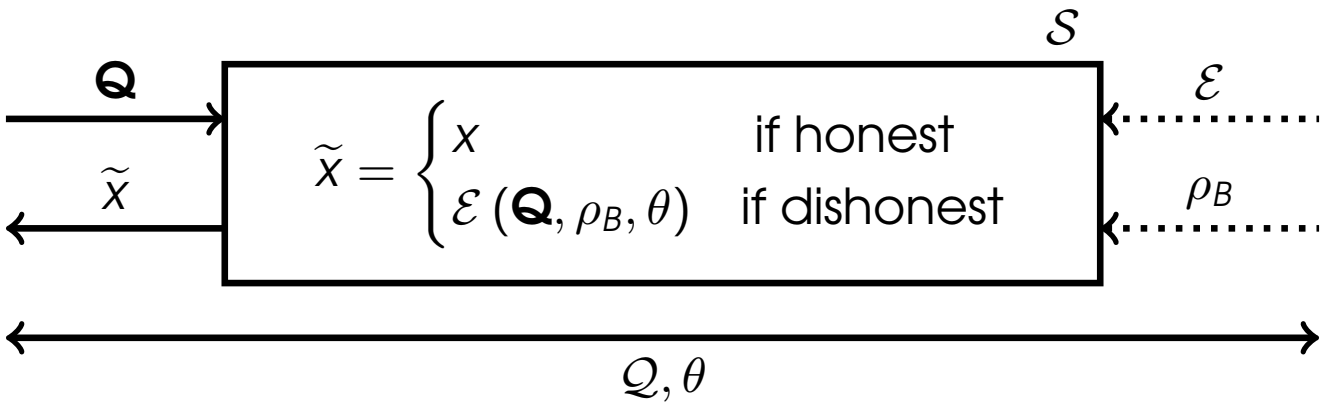


Blind IQP Ideal Resource (V)



This Presentation

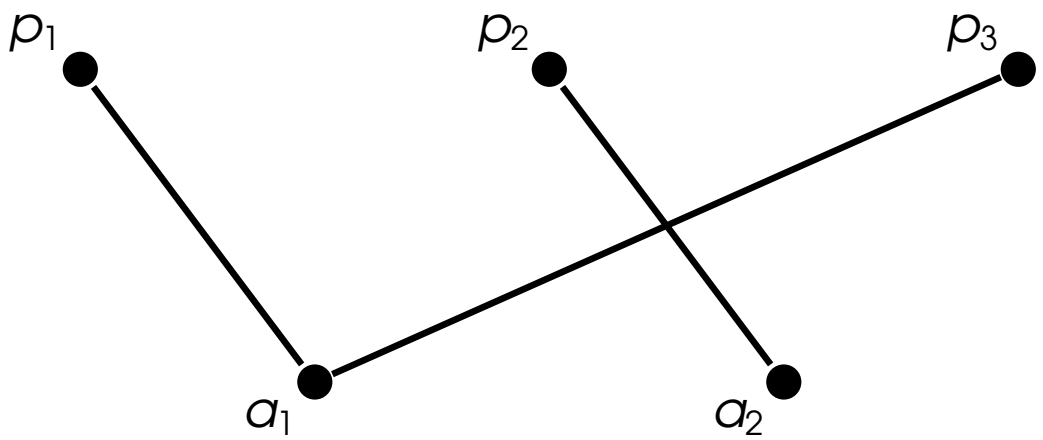
Hypothesis Test

Bias of a random variable, $X \in \{0,1\}^{n_p}$, in a direction $s \in \{0,1\}^{n_p}$.

$$\mathbb{P}\left(X \cdot s^T = 0\right)$$

Can be easily calculated, for some IQP computations, if one knows s.

Hypothesis Test



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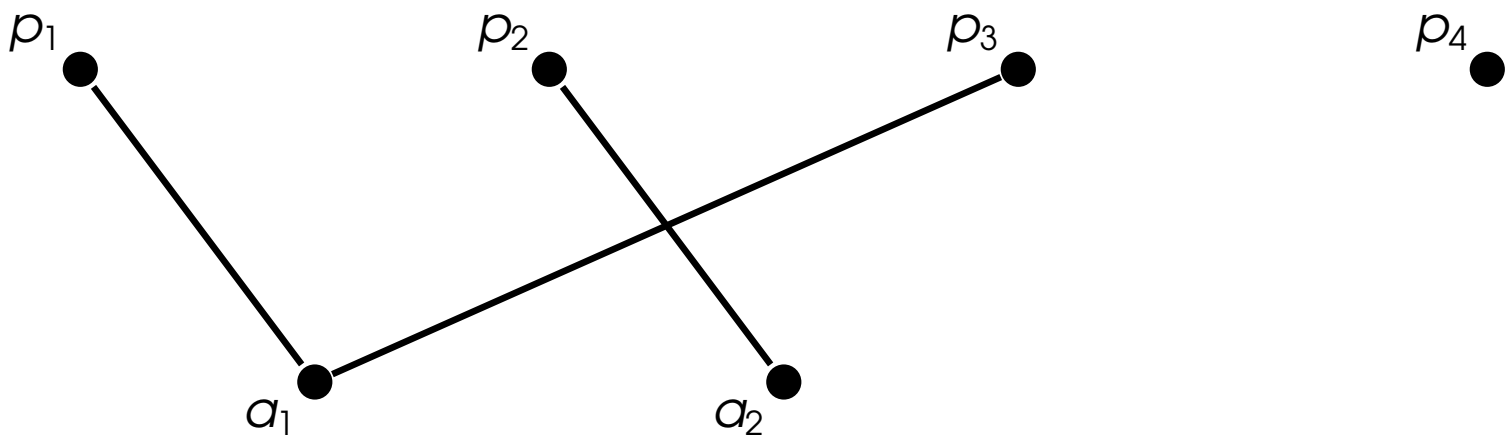

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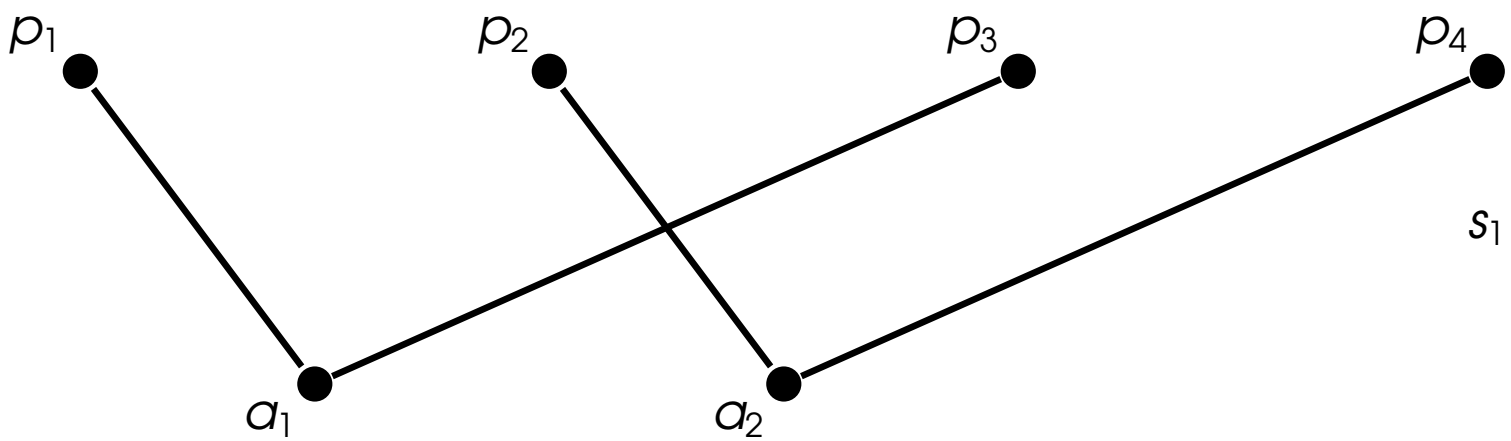

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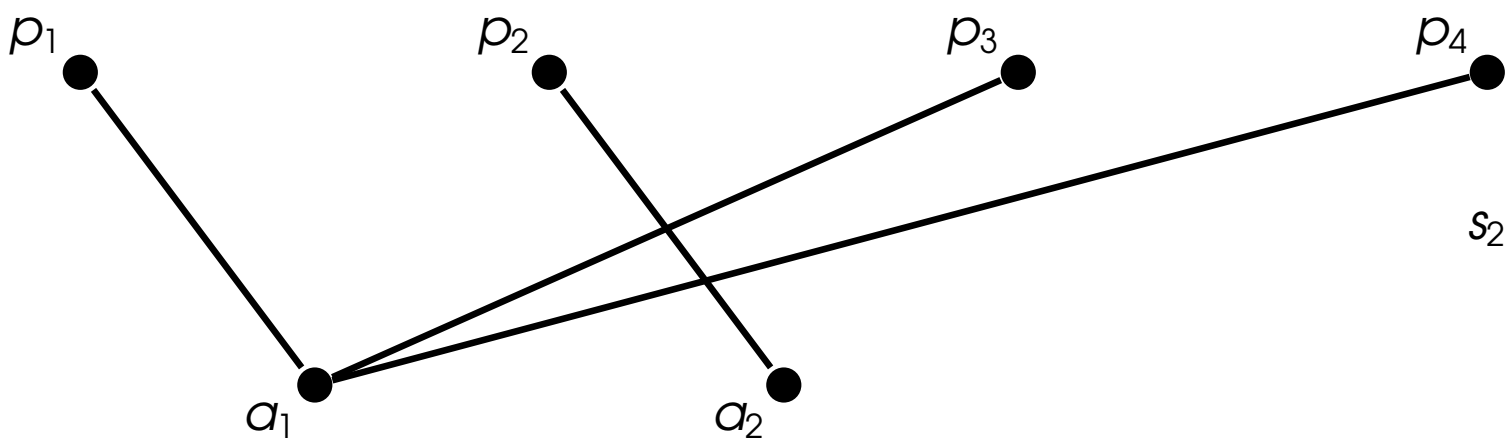

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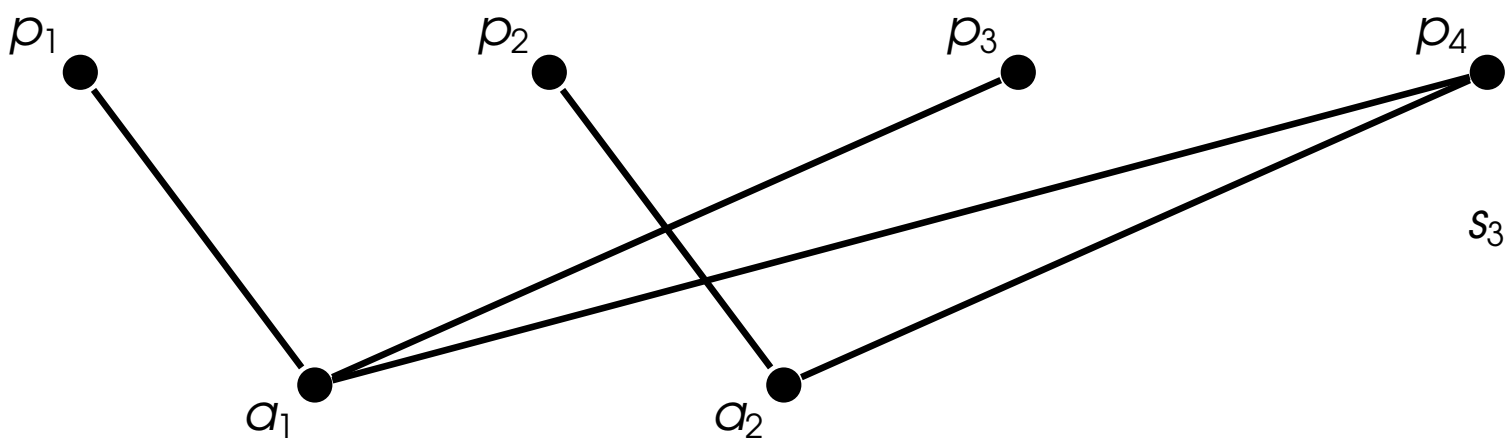

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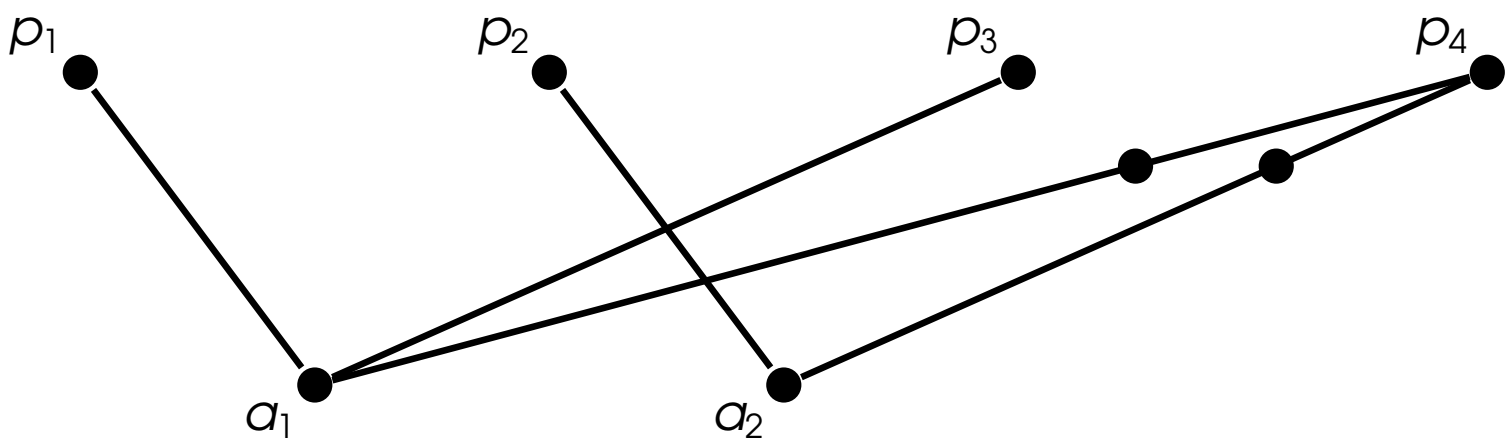

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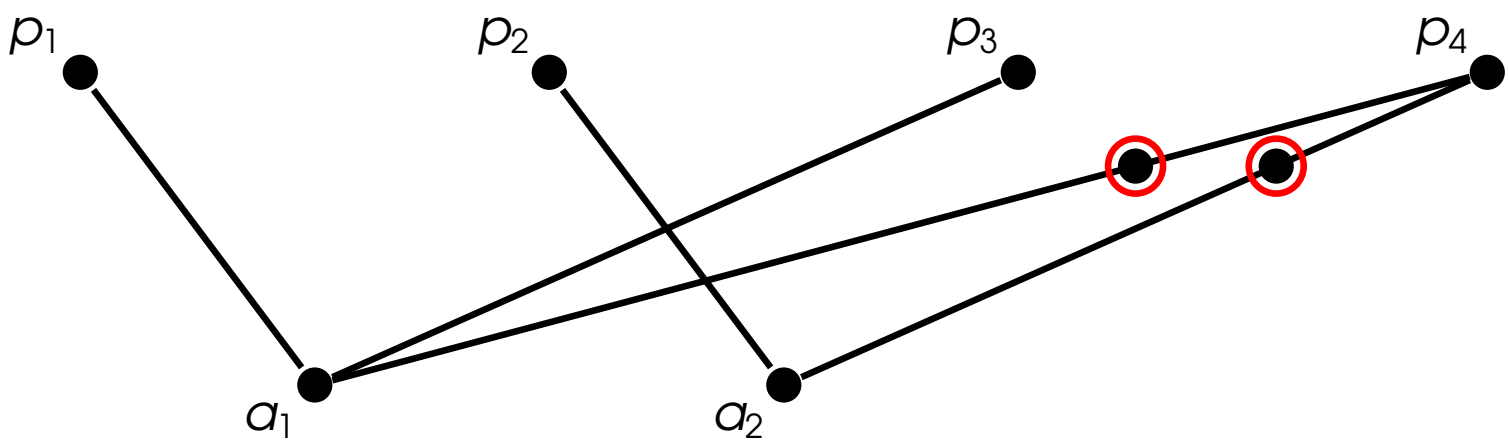

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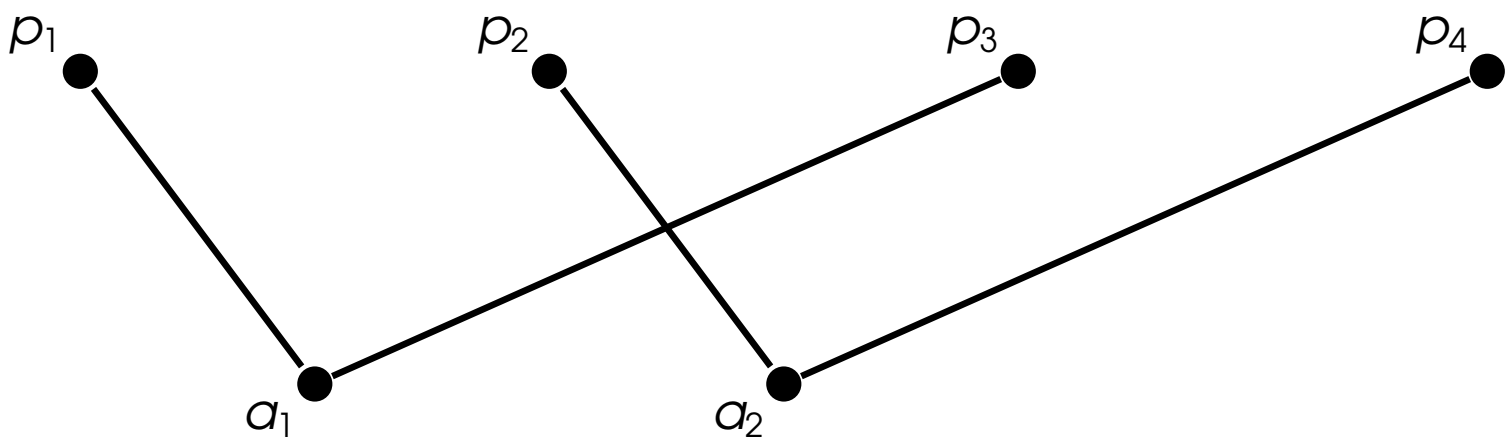

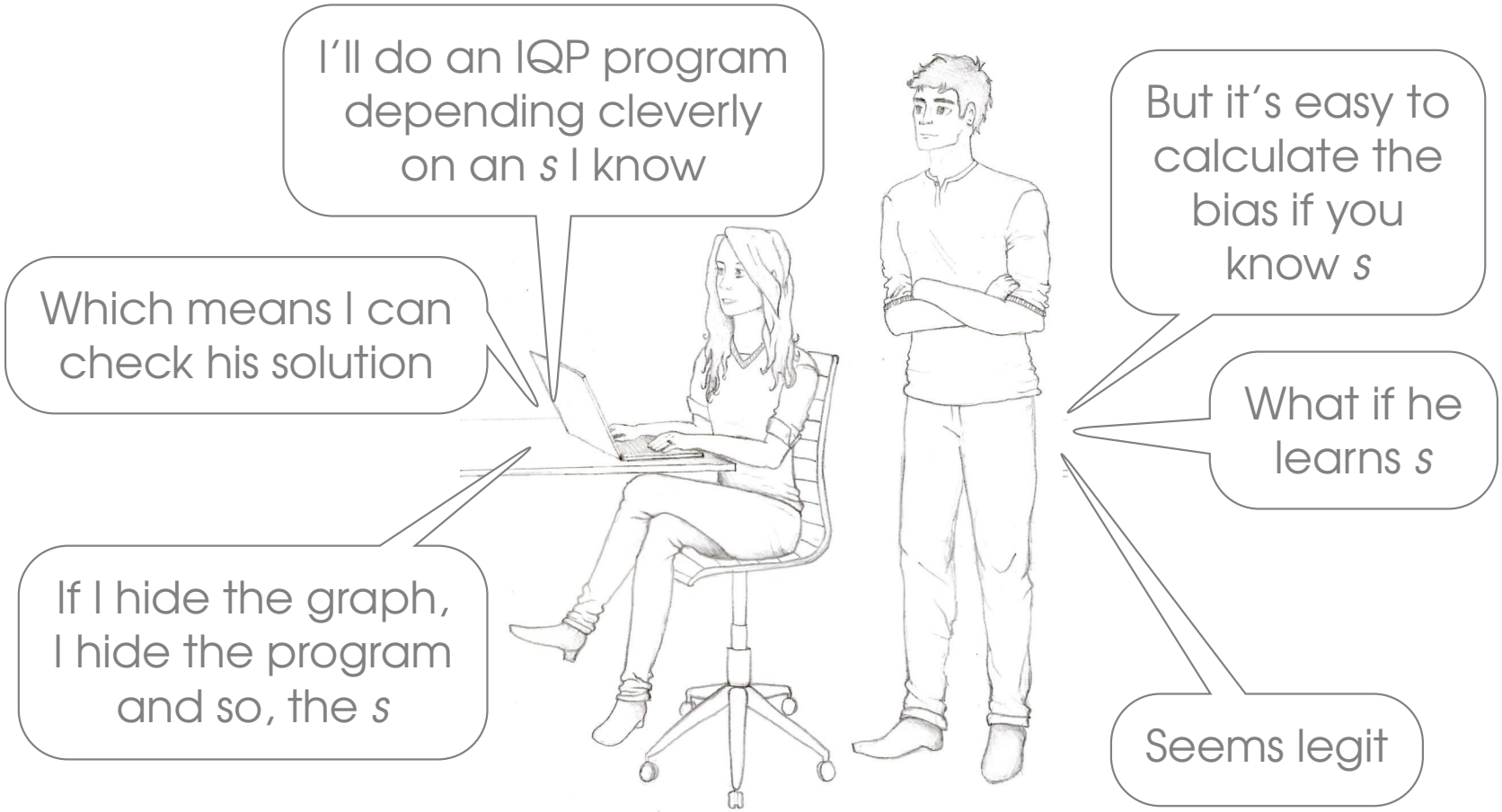
I'll do an IQP program depending cleverly on an s I know
But it's easy to calculate the bias if you know s
Which means I can check his solution
What if he learns s
If I hide the graph, I hide the program and so, the s
Seems legit

Three conditions for a successful hypothesis test:

- The Server must complete a hard IQP computations
  - Computation bias is calculated for is hard
- The Client knows a secret allowing them to check the outcome
  - The Client knows the direction s
- The Server hides the secret something
  - Using blind IQP


Thank you for listening
Any questions?

Bibliography

(FK) - Joseph F. Fitzsimons and Elham Kashefi, *Unconditionally Verifiable Blind Quantum Computation*, arXiv preprint arXiv:1203.5217 (2012).
(SB) - Dan Shepherd and Michael J. Bremner, *Temporally Unstructured Quantum Computation*, Proc. R. Soc. A 465, 1413–1439 (2009).
(V) - Dunjko, Vedran, et al, *Composable security of delegated quantum computation*, International Conference on the Theory and Application of Cryptology and Information Security. Springer Berlin Heidelberg (2014).

Thanks to:

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