Classical proofs of quantum knowledge

INTRODUCTION

A *proof of knowledge* allows a *prover* machine to prove to a less knowledgeable or less powerful *verifier* that it 'knows' or 'possesses' some piece of secret information (for example, the password to an account). In this work, we study the setting where the **verifier is entirely classical,** but the **prover is quantum**, and where the **'secret information' (witness) is a quantum state.**

A NEW DEFINITION

The usual formulation of a proof of classical knowledge has already been translated into the quantum setting in prior work. However, this usual formulation, where the knowledge extractor is required to use the prover as a black box, is inadequate in the setting with which we are concerned, because the **black-box extractor** would be in the position of trying to **reconstruct a quantum state from the prover's purely classical output**, which may be as hard as state tomography. **A new definition** is therefore required, and our first contribution is to provide a workable definition for our setting with a **non-black-box extractor** that is **allowed to access the prover's circuit and internal state.** We state our definition for several settings in which it may be useful.

SIMPLE PROPERTIES

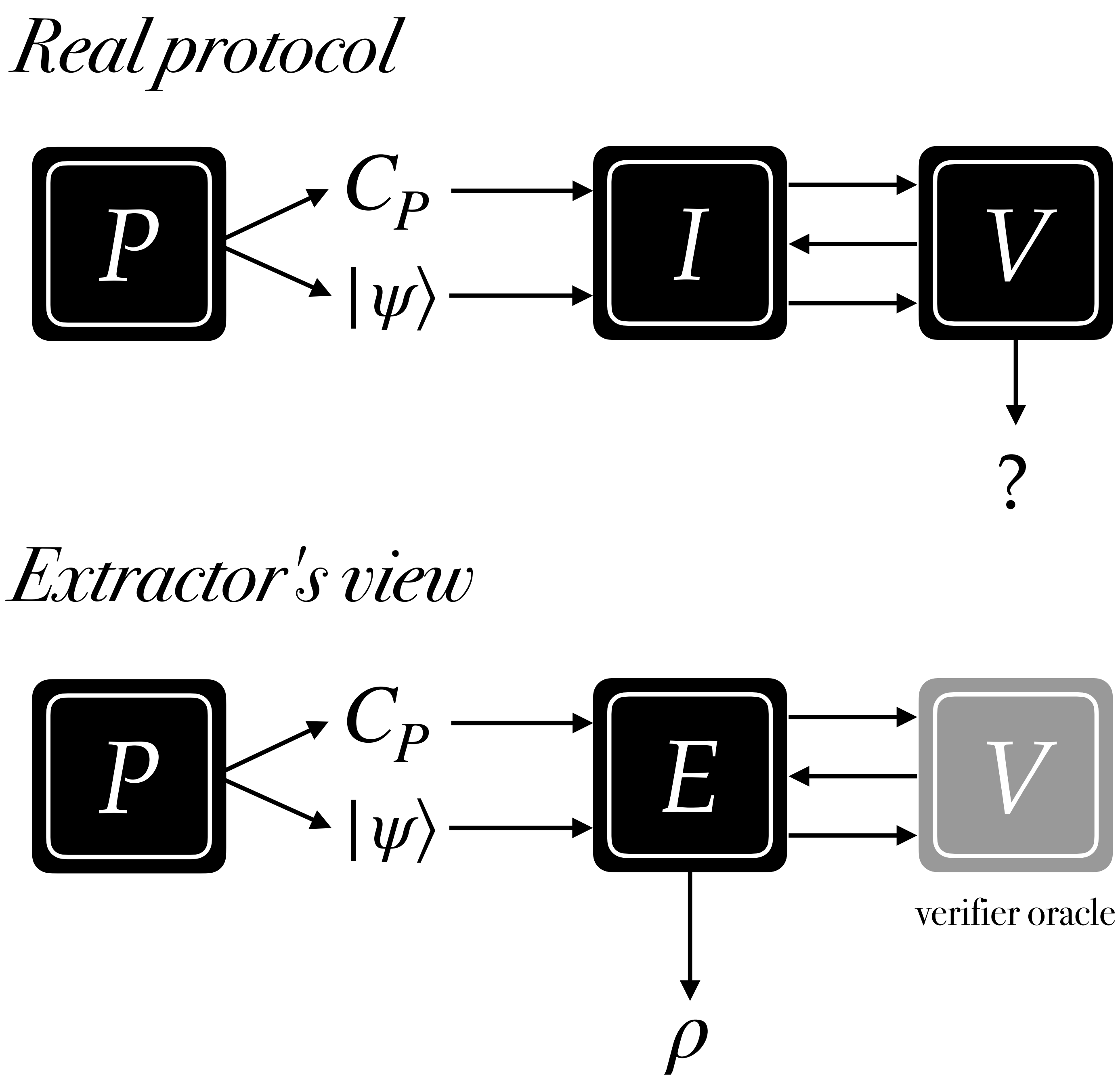
One of the ways the new definition may prove useful is that it might provide a framework which can be studied fruitfully independently of specific protocols that instantiate it. We prove two examples of simple properties which the new definition has, including that **nondestructive classical proofs of quantum knowledge are impossible**, and that **proofs of knowledge for hard-to-clone states can be used as (destructive) quantum money verification protocols.**

EXAMPLE INSTANTIATIONS

We prove, using techniques based on nonlocal games, that two **simple protocols inspired by classical private-key quantum money schemes** are classical proofs of quantum knowledge under our definition. We also show that the **classical verification protocol for QMA problem instances introduced by Mahadev** in 2018 is a classical *argument* of quantum knowledge under our definition.

FIGURE 1

A schematic illustrating our definition of a classical proof of quantum knowledge.



Thomas Vidick
& Tina Zhang