Computationally binding quantum commitments

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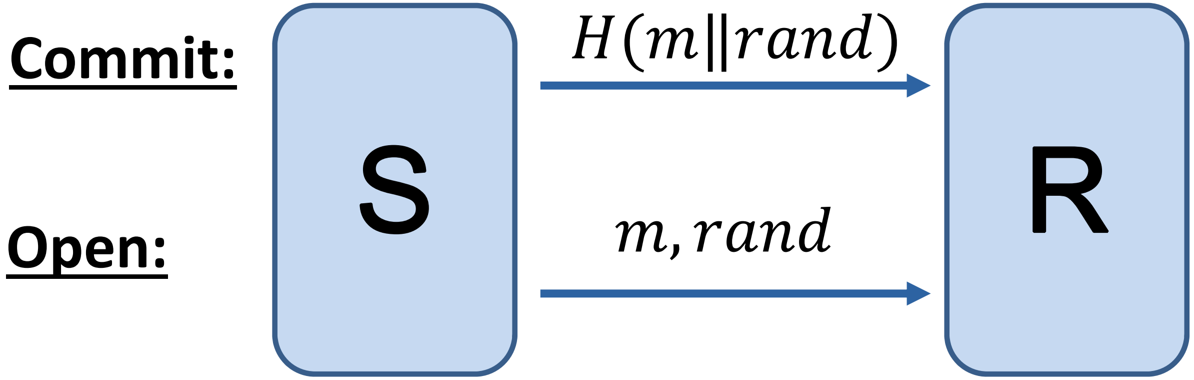
Intro: Commitments

Motivation: Secretly fixing bets



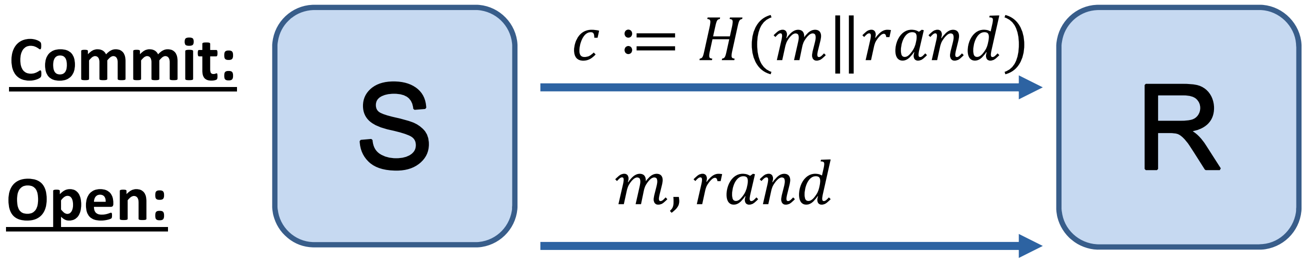
Commit:

Open:

- **Hiding:** Recipient does not learn m
- **Binding:** Sender cannot change his mind

Tricky.
This talk

How to define binding?



Commit:

Open:

S

R

$c := H(m\|rand)$

$m, rand$

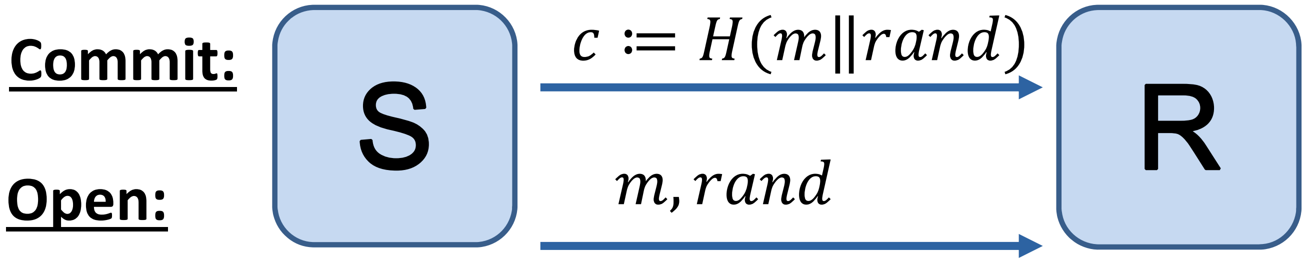
Perfectly binding:

There are no $m \neq m'$

such that $H(m\|rand) = H(m'\|rand')$
for some $rand, rand'$

Problem:
Incompatible with information-theoretical secrecy…

How to define *computational* binding?



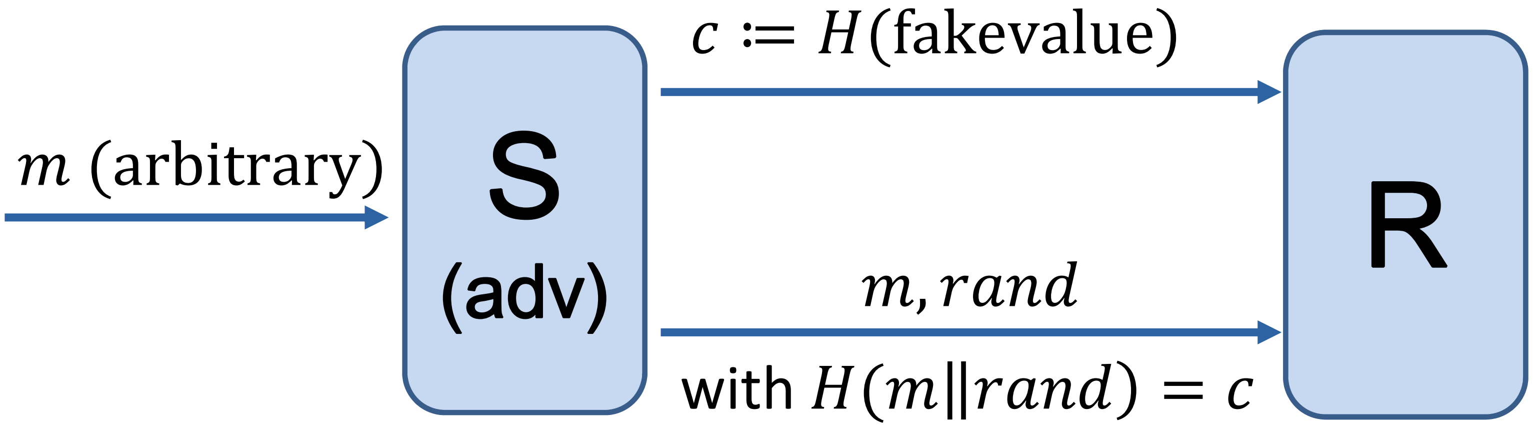
Computationally binding (classical-style):

It is computationally hard to find
$m \neq m'$ and $rand, rand'$
such that $H(m\|rand) = H(m'\|rand')$

Intuition:
Adversary cannot find out how to open two ways.

Classical-style binding: no good!

- There is a commitment scheme such that:



- But still computationally binding (classical-style)
- Reason: Adv can open arbitrarily, but not **at the same time**

[Ambainis, Rosmanis, U 2014; this work]

Computational binding: Next try

Computationally binding (typical Q def):

- Fix malicious poly-time adv S
- Let P_0 be probability that S opens as $m = 0$
- Let P_1 be probability that S opens as $m = 1$
- Then

$$P_0 + P_1 \leq 1 + \text{negligible}$$

Computational binding: Next try

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- Only works for single bit messages
- Unclear what happens if we commit to several messages $m_0, m_1, \ldots, m_n$
- Works bad with rewinding proofs

More definitions

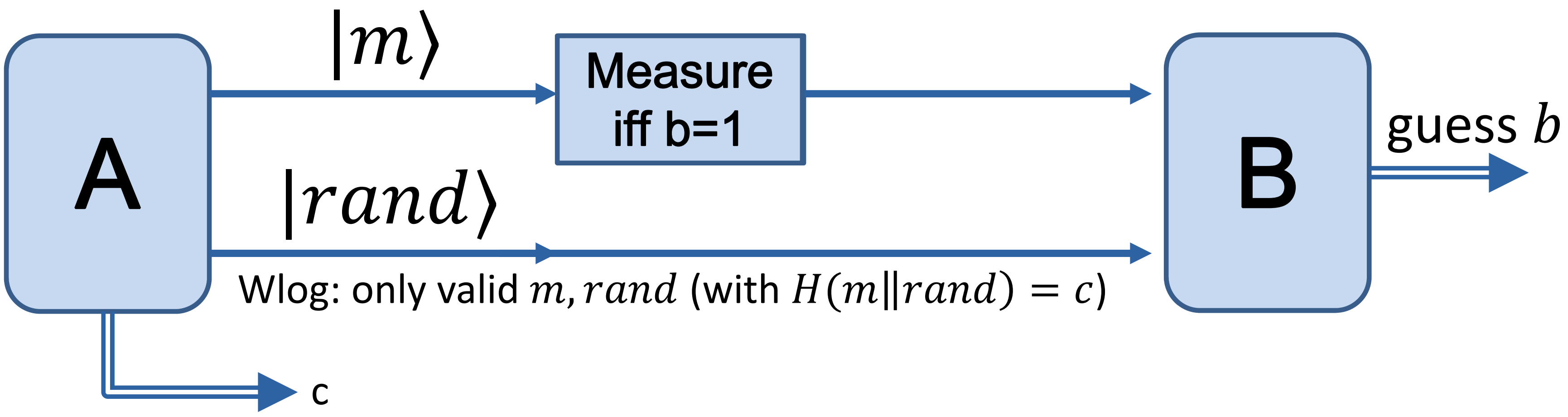
- Crépeau, Dumais, Mayers, Salvail, 2004
  Computational collapse of quantum state with application to oblivious transf
- UC-comm
- Damgård, ffner 2009
  Improving th mmit-and-open (dual-m
- Damgård, Fehr, Salvail, 2004
  Zero-Knowledge Proofs and String Commitments Withstanding Quantum Attacks

None work well with rewinding proofs

(and other problems)

Towards our def

- Reformulating perfect binding:

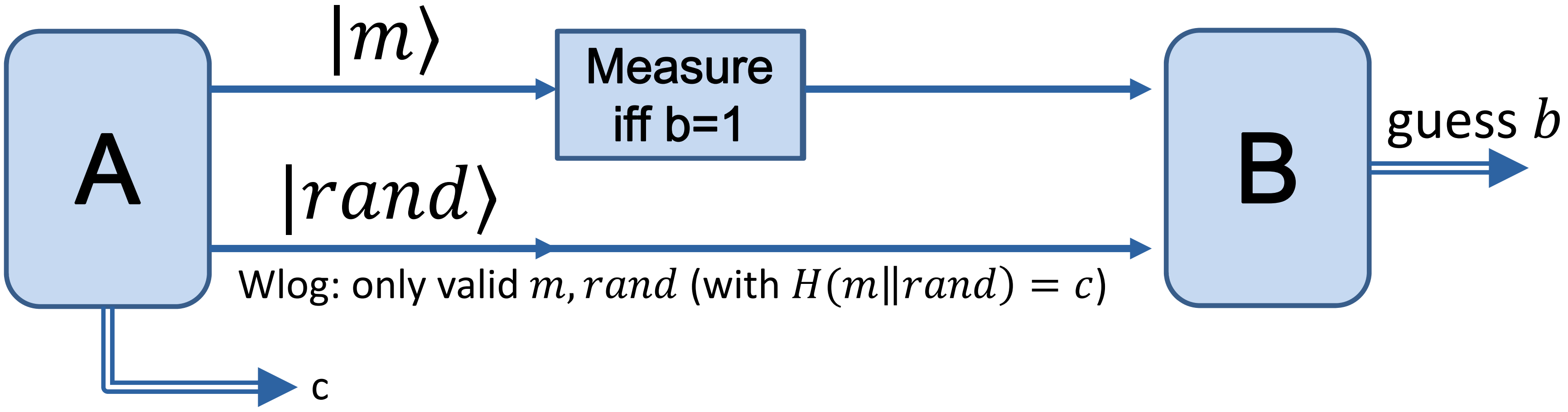


Wlog: only valid $m, rand$ (with $H(m\|rand) = c$)

- Perfect binding **iff** no superposition in $|m\rangle$ register
- Perfect binding **iff** measurement has no effect
- Perfect binding **iff** B cannot guess b (better than ½)

Collapse binding (new def)

Perfect binding **iff** B cannot guess b (better than ½)



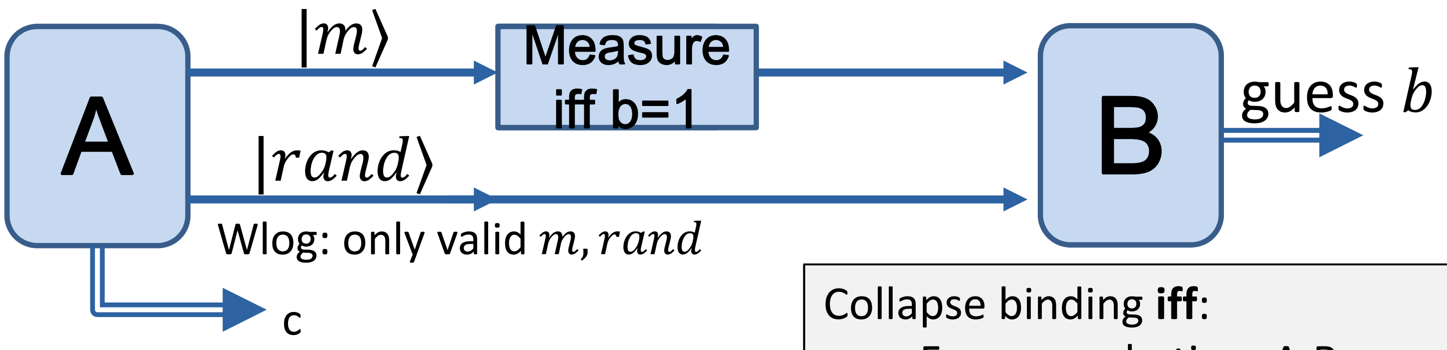
Wlog: only valid $m, rand$ (with $H(m\|rand) = c$)

"Collapse binding" **iff**:

For any poly-time A,B,

B cannot guess b (better than ${}^1/_2$ + negligible)

Facts about new def



Wlog: only valid $m, rand$

Collapse binding **iff**:

For any poly-time A,B,

B cannot guess b (better than $^1/_2 +$ negligible)

- Works well with rewinding
  - We analyzed arguments of knowledge
- Multi-bit m, composes in parallel
- For random oracle H, natural constructions work

Open problems

- Relationship between the definitions
- Constructions without random oracle
  - We have sketches
- Analyse protocols based on collapse-binding commitments
  - Done: Arguments of knowledge
  - Open: OT protocol, e.g., [BBCS91]

I thank for your attention

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