Crypto, Cards, and Love
Secure Dating with Four or Fewer Cards
(A short note on teaching cryptography)

by
Antonio Marcedone,
Zikai Wen,
Elaine Shi.
Alice and Bob: Do They Go on a 2nd Date?

1. Alice and Bob go on a date.

If both want a 2nd date, both know it.
If either does not want a 2nd date, both know it.
If A-NO then A does not know what B wanted.
If B-NO then B does not know what A wanted.

Info-Theoretic Security.
Alice and Bob: Do They Go on a 2nd Date?

1. Alice and Bob go on a date.
2. Alice thinks either
   ▶ I want to date Bob again, or
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3. Bob thinks either
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We need a protocol so that, at the end:
1. If both want a 2nd date, both know it.
2. If either does not want a 2nd date, both know it.
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Alice and Bob have a deck of cards. Each card has a ♥ or a ♣ on it. They can use this.
Think About How They Would Do This

Alice and Bob have a deck of cards. Each card has a ♥ or a ♣ on it. They can use this.

Think about how they can do this.
Think Outside the Box Vs Cheating

We will present several protocols for Alice and Bob to do this.
Think Outside the Box Vs Cheating

We will present several protocols for Alice and Bob to do this

For some you will say

That's Cheating
Think Outside the Box Vs Cheating

We will present several protocols for Alice and Bob to do this

For some you will say

That's Cheating

I will respond

I’m thinking outside the box
Five Card Solution
The 5-Card Solution by Boer

All cards are put on the table face-down.

1. ♠ is placed on the table.
The 5-Card Solution by Boer

All cards are put on the table face-down.

1. ♠️ is placed on the table.

2. A and B both have one ♠️ and one ♣️.
The 5-Card Solution by Boer

All cards are put on the table face-down.

1. ♠ is placed on the table.
2. A and B both have one ♥ and one ♠.
All cards are put on the table face-down.

1. ♥ is placed on the table.
2. A and B both have one ♥ and one ♥.
The 5-Card Solution by Boer

All cards are put on the table face-down.

1. ♡ is placed on the table.
2. A and B both have one ♡ and one ♠.
5. Not done yet, but let’s see what we got.
All cards are put on the table face-down.

1. ♥ is placed on the table.
2. A and B both have one ♥ and one ♣.
5. Not done yet, but let’s see what we got.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>Y</td>
<td>♣♥♥♥♥♣</td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td>♣♥♥♣♥</td>
</tr>
<tr>
<td>N</td>
<td>Y</td>
<td>♥♠♥♥♣</td>
</tr>
<tr>
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</tr>
</tbody>
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The cards are face down.

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<tr>
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<tr>
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**Bad Idea** Reveal all the cards. If do this then in YN, NY, NN cases the N-person knows what the other one did.
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</tr>
<tr>
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<td>Y</td>
<td>♥️♦️♥️♥️♠️</td>
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How to finish this protocol so that it works. Ideas?
The 5-Card Solution, cont

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1. If YY then will have 3 ♥’s in a row. 2nd date!
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How to finish this protocol so that it works. Ideas?

**Good Idea** Randomly shift the cards with wrap-around.

1. If YY then will have 3 ♥’s in a row. 2nd date!
2. YN, NY, NN are all a cyclic shift away from each other. No 3-in-row. An N-person has no idea which case they are in. No 2nd date!
Can We Get By With Less Cards?

Is there a 4-card solution? Vote: Yes, No, Unk?

Yes, there is a 4-card solution. A byte complicated.

Is there a 3-card solution? Vote: Yes, No, Unk?

Yes, but...

Two solutions.

One We will use cards with ↓ or ↑ on them.

Two We will have Alice leave the room and come back.
Can We Get By With Less Cards?

Is there a 4-card solution? Vote: Yes, No, Unk? **Yes**, there is a 4-card solution. A byte complicated.
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Yes, but. . . . Two solutions.
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Three Card Solutions
All cards are face down.

1. There is an ↑ card on the table.
All cards are face down.

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1. There is an ↑ card on the table.
3. B-YES: place ↑ on right (of card A put down). B-NO: place ↓ on right (of card A put down).
All cards are face down.

1. There is an ↑ card on the table.
3. B-YES: place ↑ on right (of card A put down). B-NO: place ↓ on right (of card A put down).
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</tr>
<tr>
<td>Y</td>
<td>N</td>
<td>↑↑↓</td>
</tr>
<tr>
<td>N</td>
<td>Y</td>
<td>↓↑↑</td>
</tr>
<tr>
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### The 3-Card Solution, cont

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<tbody>
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<td>↑↑↑</td>
</tr>
<tr>
<td>Y</td>
<td>N</td>
<td>↑↑↓</td>
</tr>
<tr>
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How to finish this protocol so that it works. Ideas?
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**Good Idea** Randomly shuffle and turn the deck around a random number of times.
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How to finish this protocol so that it works. Ideas?

**Good Idea** Randomly shuffle and turn the deck around a random number of times.

1. If YY then will have 3 in same dir 2nd date!
The 3-Card Solution, cont

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How to finish this protocol so that it works. Ideas?

**Good Idea** Randomly shuffle and turn the deck around a random number of times.
1. If YY then will have 3 in same dir 2nd date!
2. YN, NY, NN will have 2 in one dir, 1 in other. No 2nd date!
All cards are face down.

1. The cards ♠♠♥ are on the table.
The 3-Card Solution by Karun Singh

All cards are face down.

1. The cards ♠♠♥ are on the table.
2. Bob is not in the room.
All cards are face down.

1. The cards ♣♣❤️ are on the table.
2. Bob is not in the room.
3. Alice is not in the room.
   B-YES: Switch cards 1 and 2. B-NO: No switch.
The 3-Card Solution by Karun Singh

All cards are face down.

1. The cards ♠♣♥ are on the table.
2. Bob is not in the room.
3. Alice is not in the room.
   B-YES: Switch cards 1 and 2. B-NO: No switch.
4. Not done yet, but let’s see what we got.

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<tr>
<th></th>
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<th>After A</th>
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<tbody>
<tr>
<td>Y</td>
<td>Y</td>
<td>♠♥♣♣</td>
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<tr>
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<td>N</td>
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<td>♣️♠️♥️</td>
<td>♣️♠️♥️</td>
</tr>
<tr>
<td>N</td>
<td>N</td>
<td>♣️♠️♥️</td>
<td>♣️♠️♥️</td>
</tr>
</tbody>
</table>

**Bad Idea** Reveal all the cards. If do this then in YN, NY, NN cases the N-person knows what the other one did.

How to finish this protocol so that it works. Ideas?

Just reveal the first card:
- If it’s ♥️ then 2nd date!
- If not then no 2nd date!

**Security** Might be a HW.
Can We Get By With Less Cards?

Is there a 2-card solution? Vote: Yes, No, Unk?
Can We Get By With Less Cards?

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*Yes*, but.... Two solutions.
Can We Get By With Less Cards?

Is there a 2-card solution? Vote: Yes, No, Unk?
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Yes, but we use a PEZ dispenser.
Can We Get By With Less Cards?

Is there a 2-card solution? Vote: Yes, No, Unk?
Yes, but.... Two solutions.

Yes, but we use a PEZ dispenser.

Yes, but we use light and optics.
Two Card Solutions
A 2-Card Solution Using a PEZ Dispenser
by Jackson Spell

**Question** If you know what a PEZ dispenser is raise your hands.
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An N-player only knows that there is 1 or 2 cards in the dispenser, but does not know which. So does not know what the other player thought.
A 2-Card Solution Using Light by Rena Yang

1. Both players have a transparent and an opaque card.
2. There is a box with slots in it for cards. One cannot tell if there are already some cards in the box. One can shine a light through one end of the box.
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5. Shine light. If goes through then A and B both put in transparent, 2nd date! If not then at least one put in an opaque card. No 2nd date!
Actually needs four cards since
- Alice has a transparent and an opaque card.
- Bob has a transparent and an opaque card.
Depends on if you count cards-used, which is 2, or cards needed which is 4.
Applications

1. E-harmony is thinking of incorporating the 5-card protocol into their software.
2. After our first date, Darling and I used the 5-card protocol. We agreed to a second date and are now married 29 years!
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Secure Multiparty Computation $f(x_1, \ldots, x_n)$ is a function. $A_i$ has $x_i$. They want to compute it so that at the end they all know the answer but NOTHING more (except what they can conclude from their $x_i$ and the answer).
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We showed that $f(x, y) = x \land y$ has a secure multiparty computation using cards and other means. These other means have real analogs in computers.

▶ Auctions—players know who won, but not what others bid. Was used for real in Denmark (see Wikipedia page on Secure Multiparty Computation).

▶ Voting—players know who won, but not what others voted. I've heard this is actually used but have not been able to track down a source.
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