

Crypto, Cards, and Love

The Paper This Lecture is Based On

Secure Dating with Four or Fewer Cards
(A short note on teaching cryptography)

by
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Alice and Bob: Do They Go on a 2nd Date?

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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.
3. If A-NO then A does not know what B wanted.
4. If B-NO then B does not know what A wanted.

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We need a protocol so that, at the end:

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3. If A-NO then A does not know what B wanted.
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5. Info-Theoretic Security.

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.

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Think Outside the Box Vs Cheating

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

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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 Sol.

The 5-Card Sol. by Boer

1. ♥ is placed on the table face down.

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3. A-YES: place ♣♥ on left, face down.
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2. A and B both have one ♥ and one ♣.
3. A-YES: place ♣♥ on left, face down.
A-NO: place ♥♣ on left, face down.
4. B-YES: place ♥♣ on right, face down.
B-NO: place ♣♥ on right, face down.

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A-NO: place ♥♣ on left, face down.
4. B-YES: place ♥♣ on right, face down.
B-NO: place ♣♥ on right, face down.
5. Not done yet, but let's see what we got.

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3. A-YES: place ♣♥ on left, face down.
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5. Not done yet, but let's see what we got.

A	B	Result
Y	Y	♣♥♥♥♣
Y	N	♣♥♥♣♥
N	Y	♥♣♥♥♣
N	N	♥♣♥♣♥

The 5-Card Sol., cont

The cards are face down.

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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.

The 5-Card Sol., cont

The cards are face down.

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

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Good Idea Randomly shift the cards with wrap-around.

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A	B	Result
Y	Y	♣♥♥♥♣
Y	N	♣♥♥♣♥
N	Y	♥♣♥♥♣
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1. If YY then will have 3 ♥'s in a row. 2nd date!

The 5-Card Sol., cont

A	B	Result
Y	Y	♣♥♥♥♣
Y	N	♣♥♥♣♥
N	Y	♥♣♥♥♣
N	N	♥♣♥♣♥

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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?

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

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

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Yes, there is a 3-card solution.

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Yes, there is a 3-card solution.

Is there a 2-card solution? Vote: Yes, No, Unk?

Can We Get By With Less Cards?

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

Yes, there is a 4-card solution.

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

Yes, there is a 3-card solution.

Is there a 2-card solution? Vote: Yes, No, Unk?

Yes, there is a 2-card solution.

Three Card Sol.

The 3-Card Sol. by Susan Zonghui Li

All cards are face down. The cards have \uparrow or \downarrow .

1. There is an \uparrow card on the table.

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All cards are face down. The cards have \uparrow or \downarrow .

1. There is an \uparrow card on the table.
2. A-YES: place \uparrow on right.
A-NO: place \downarrow on right.

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All cards are face down. The cards have \uparrow or \downarrow .

1. There is an \uparrow card on the table.
2. A-YES: place \uparrow on right.
A-NO: place \downarrow on right.
3. B-YES: place \uparrow on right (of card A put down).
B-NO: place \downarrow on right (of card A put down).

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All cards are face down. The cards have \uparrow or \downarrow .

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4. Not done yet, but let's see what we got.

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3. B-YES: place \uparrow on right (of card A put down).
B-NO: place \downarrow on right (of card A put down).
4. Not done yet, but let's see what we got.

A	B	Result
Y	Y	$\uparrow\uparrow\uparrow$
Y	N	$\uparrow\uparrow\downarrow$
N	Y	$\downarrow\uparrow\uparrow$
N	N	$\downarrow\uparrow\downarrow$

The 3-Card Sol., cont

The cards are face down.

A	B	Result
Y	Y	↑↑↑
Y	N	↑↑↓
N	Y	↓↑↑
N	N	↓↑↓

The 3-Card Sol., cont

The cards are face down.

A	B	Result
Y	Y	↑↑↑
Y	N	↑↑↓
N	Y	↓↑↑
N	N	↓↑↓

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The 3-Card Sol., cont

The cards are face down.

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Y	Y	↑↑↑
Y	N	↑↑↓
N	Y	↓↑↑
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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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A	B	Result
Y	Y	↑↑↑
Y	N	↑↑↓
N	Y	↓↑↑
N	N	↓↑↓

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Y	Y	↑↑↑
Y	N	↑↑↓
N	Y	↓↑↑
N	N	↓↑↓

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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!

The 3-Card Sol. by Karun Singh

All cards are face down.

1. The cards ♣♣♥ are on the table.

The 3-Card Sol. by Karun Singh

All cards are face down.

1. The cards ♣♣♥ are on the table.
2. Bob is not in the room.
A-YES: Switch cards 2&3.
A-NO: No switch.

The 3-Card Sol. by Karun Singh

All cards are face down.

1. The cards ♣♣♥ are on the table.
2. Bob is not in the room.
A-YES: Switch cards 2&3.
A-NO: No switch.
3. Alice is not in the room.
B-YES: Switch cards 1 and 2.
B-NO: No switch.

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3. Alice is not in the room.
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B-NO: No switch.
4. Not done yet, but let's see what we got.

A	B	After A	After B
Y	Y		
Y	N		
N	Y		
N	N		

The 3-Card Sol. by Singh, cont

The cards are face down.

A	B	After A	After B
Y	Y	♣♥♣	♥♣♣
Y	N	♣♥♣	♣♥♣
N	Y	♣♣♥	♣♣♥
N	N	♣♣♥	♣♣♥

The 3-Card Sol. by Singh, cont

The cards are face down.

A	B	After A	After B
Y	Y	♣♥♣	♥♣♣
Y	N	♣♥♣	♣♥♣
N	Y	♣♣♥	♣♣♥
N	N	♣♣♥	♣♣♥

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The cards are face down.

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Y	N	♣♥♣	♣♥♣
N	Y	♣♣♥	♣♣♥
N	N	♣♣♥	♣♣♥

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The 3-Card Sol. by Singh, cont

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A	B	After A	After B
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Y	N	♣♥♣	♣♥♣
N	Y	♣♣♥	♣♣♥
N	N	♣♣♥	♣♣♥

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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.

Two Card Sol.

PEZ Dispenser

Question If you know what a PEZ dispenser is raise your hands.

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https://www.google.com/search?q=pez+dispenser&source=lnms&tbm=isch&sa=X&ved=2ahUKEwj4cn4rZv0AhWvg3IEHbt4A64Q_AUoAnoECAEQBA&biw=968&bih=639&dpr=1.5

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Important Looking at PEZ disp one can tell if it is empty or not. But if it is not empty **you cannot tell how many candies are in it.**

A 2-Card Sol. Using a PEZ Dispenser by Jackson Spell

1. Initially there are 2 cards in the PEZ disp (we redesigned them to take cards rather than candies).

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3. B-YES: remove a card. B-NO: do not remove a card.
4. If no cards in the PEZ disp, then 2nd date!
Otherwise no 2nd date!

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1. Initially there are 2 cards in the PEZ disp (we redesigned them to take cards rather than candies).
2. A-YES: remove a card. A-NO: do not remove a card.
3. B-YES: remove a card. B-NO: do not remove a card.
4. If no cards in the PEZ disp, then 2nd date!
Otherwise no 2nd date!

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 Sol. 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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3. A-YES: put transparent card in the box. A-NO: put opaque card in the box.
4. B-YES: put transparent card in the box. B-NO: put opaque card in the box.
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!

Caveat on A 2-Card Sol. Using Light

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

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2. After our first date, Darling and I used the 5-card protocol. We agreed to a second date and are now married 30 years!

More Applications

Secure Multiparty Computation $f(x_1, \dots, x_n)$ 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 $f(x, y) = x \wedge y$ has a secure multiparty computation. There are analogs of what we did that can really be used.

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We showed that $f(x, y) = x \wedge y$ has a secure multiparty computation. There are analogs of what we did that can really be used.

- ▶ 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.

**BILL: STOP
RECORDING**