601.445/601.645
Practical Cryptographic Systems

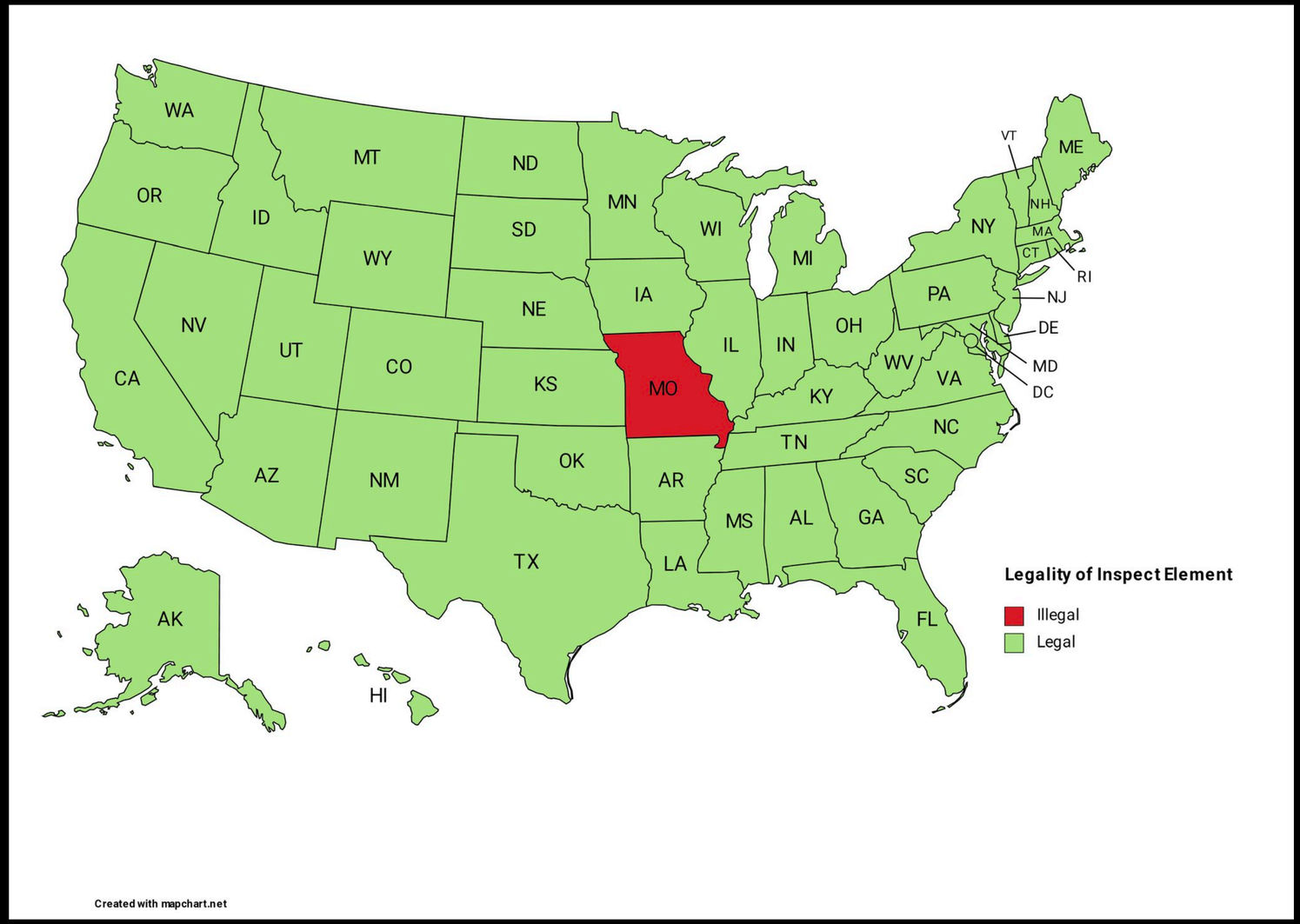
MPC and Private Computation

Instructor: Alishah Chator

Housekeeping

- Assignment 2 due Tuesday 10/26 at 11:59pm
- Weekly HW#3 coming out tonight
- Midterm 11/1
  - Will be covering all lecture and reading material so far

News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NEWS

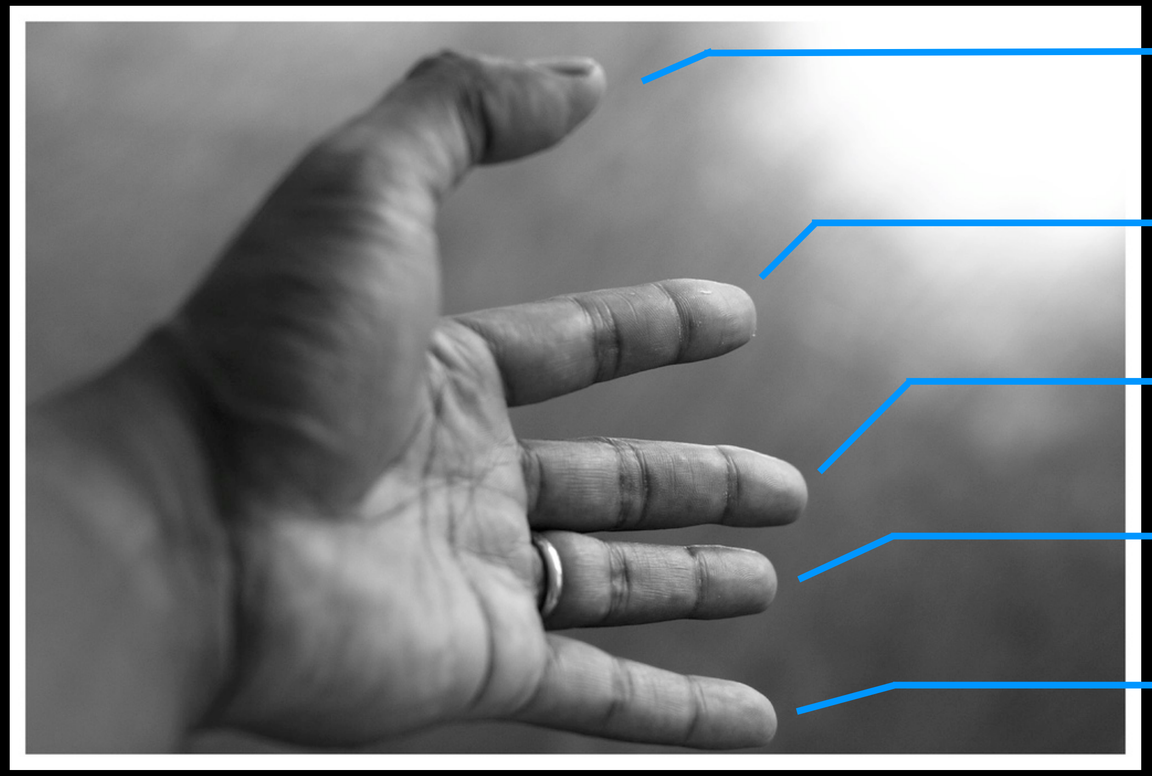
Minneapolis schools are spying on queer students & outing them to teachers and parents

The software has outed one student and also incorrectly notified a transgender teen's parents after they wrote about their past suicidal thoughts.

By LGBTQ Nation Saturday, October 16, 2021

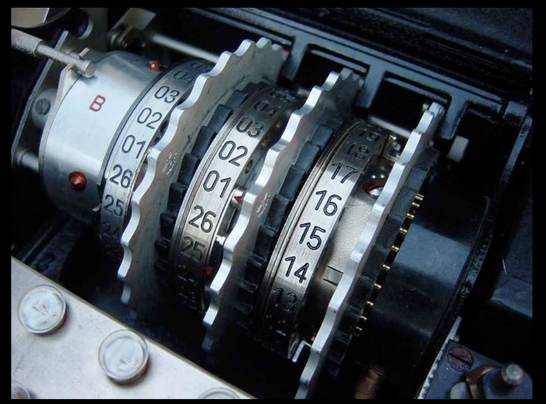
REvil ransomware shuts down again after Tor sites were hijacked

By Lawrence Abrams October 17, 2021 07:19 PM 2



Part 1

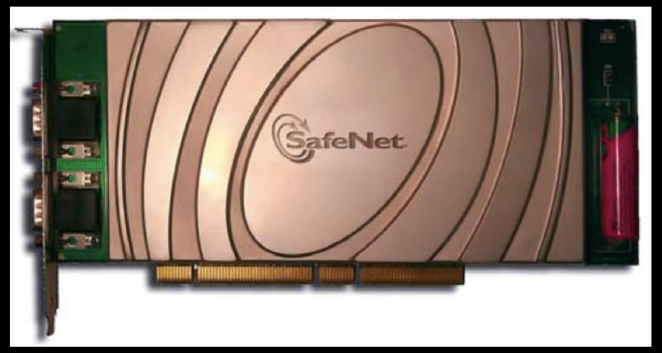
- (Re-)introduction to Crypto... at high speed:
  - Classical cryptography
  - Symmetric-key encryption & block ciphers
  - AES, ChaCha
  - Public-key cryptography
  - Diffie-Hellman, RSA, ECC



Enigma image from Wikipedia, used under GFDL.

Part 2

- Exploiting Software:
  - Crypto vulnerabilities and where they turn up
- Privacy
  - Multi-party Computation
  - Tor and Anonymity
  - Zero Knowledge Proofs



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- **Privacy**
  - **Multi-party Computation**
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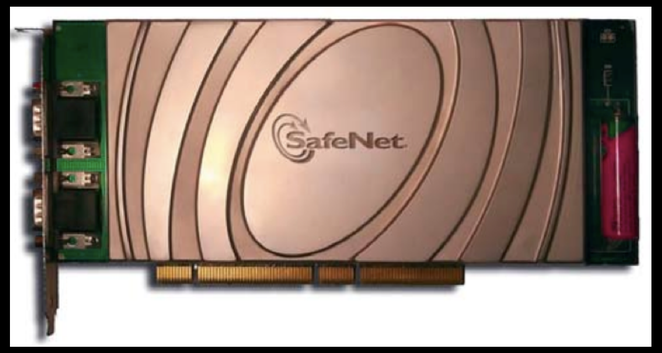

Today

- What is Multiparty Computation?
- How can we build an MPC system

MPC: the Classic Example

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I am the richest person around

MPC: the Classic Example

No, I am the richest!

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What if neither party wants to disclose their net worth?

MPC More concretely

Technology preview: Private contact discovery for Signal

BWWC

BOSTON WOMEN'S WORKFORCE COUNCIL

MPC Formally

- A Multiparty Computation Protocol involves a set of parties $\{A, B, C, \dots\}$, a private input for each party $\{x_A, x_B, x_C, \dots\}$ and some functionality to jointly compute $f(x_A, x_B, x_C, \dots) = y$
  - Each party should learn nothing besides the output y
  - Crucially, that means the input of all other parties should be hidden

MPC: Ideal vs Reality

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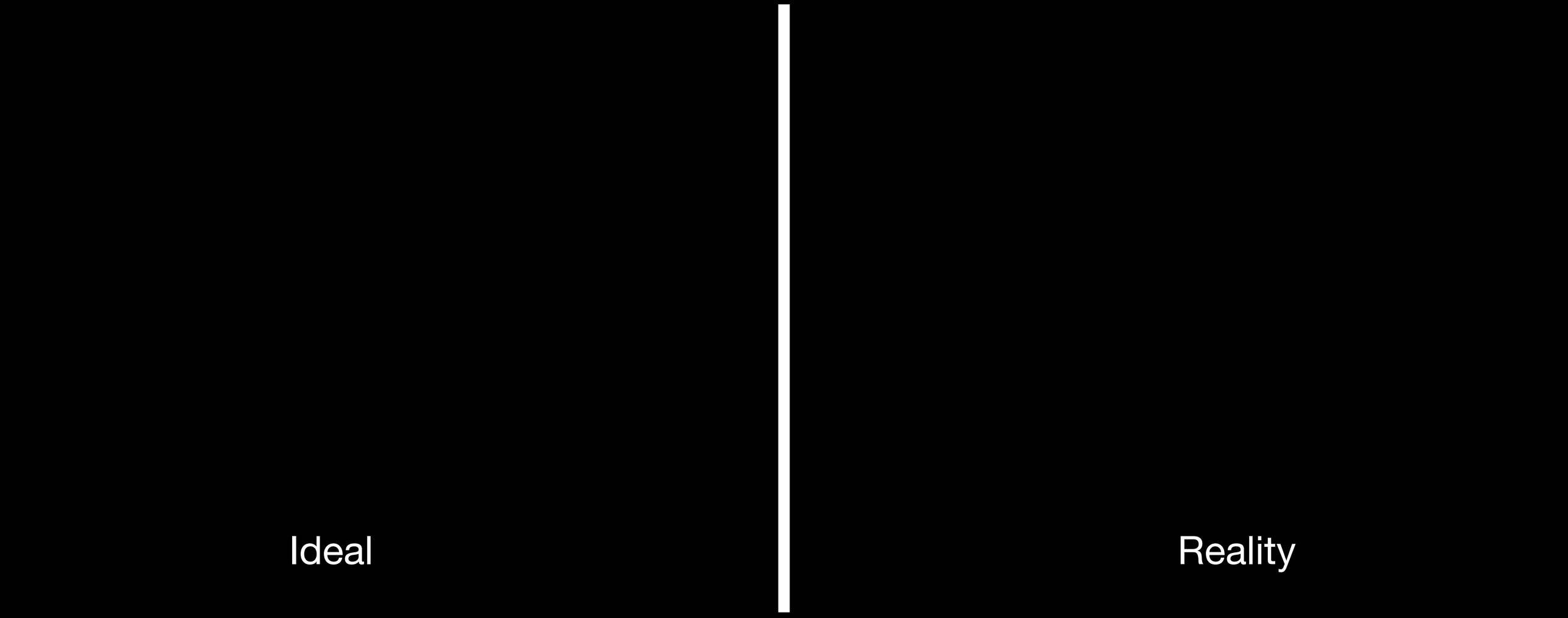
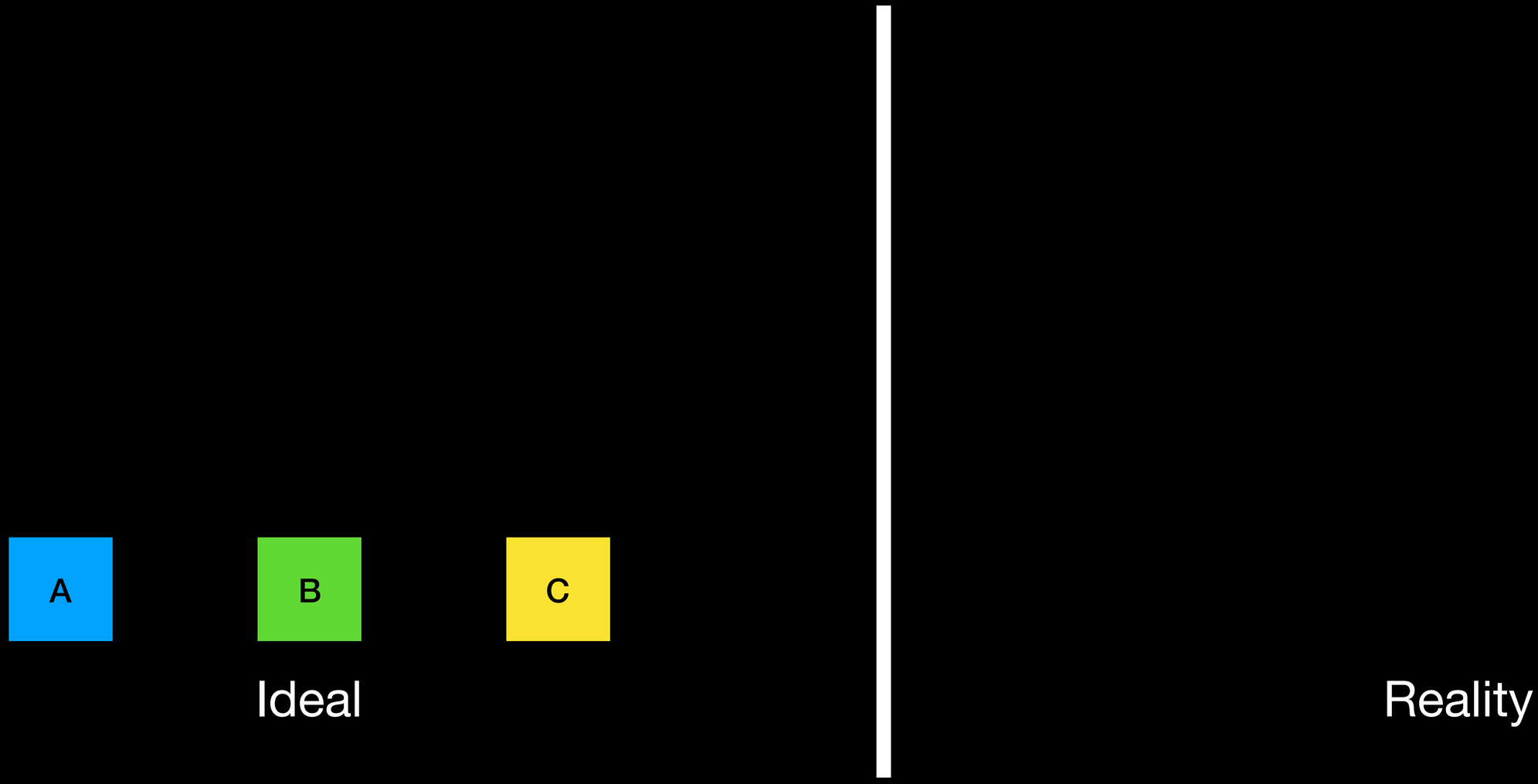


MPC: Ideal vs Reality



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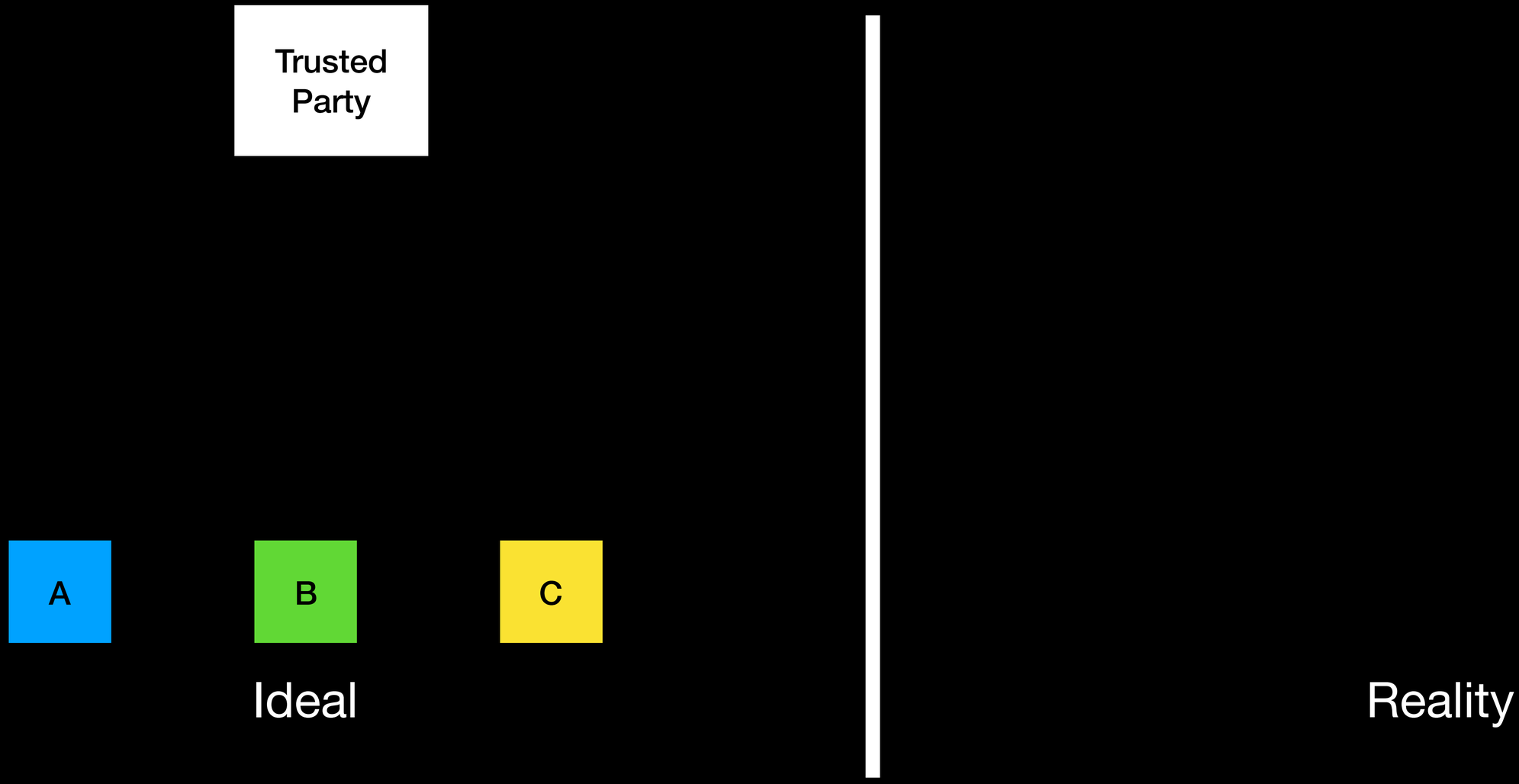

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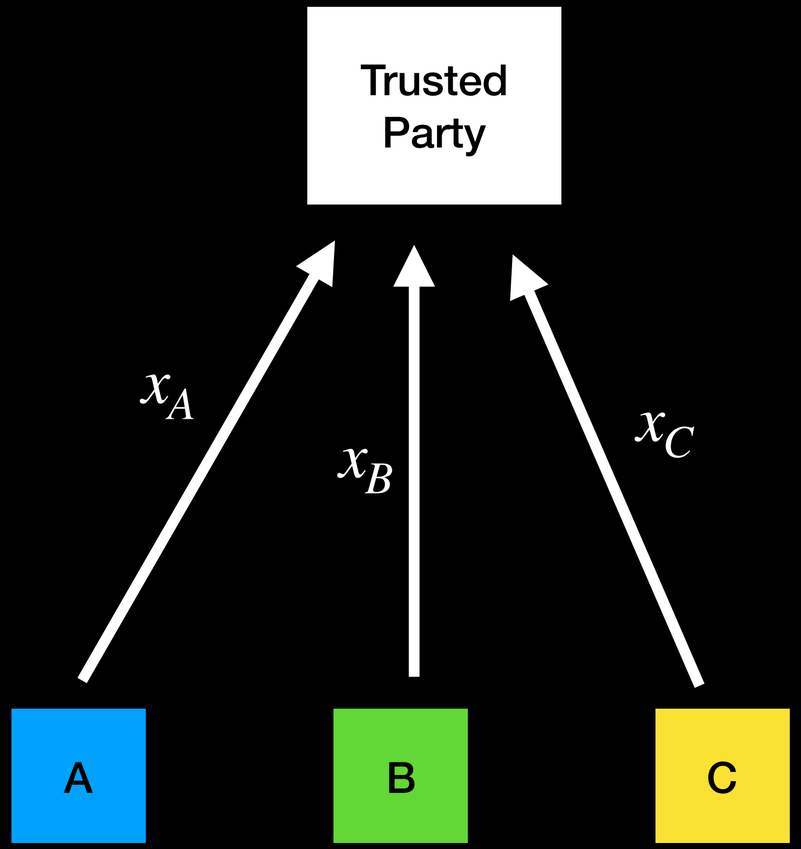

Ideal

Reality

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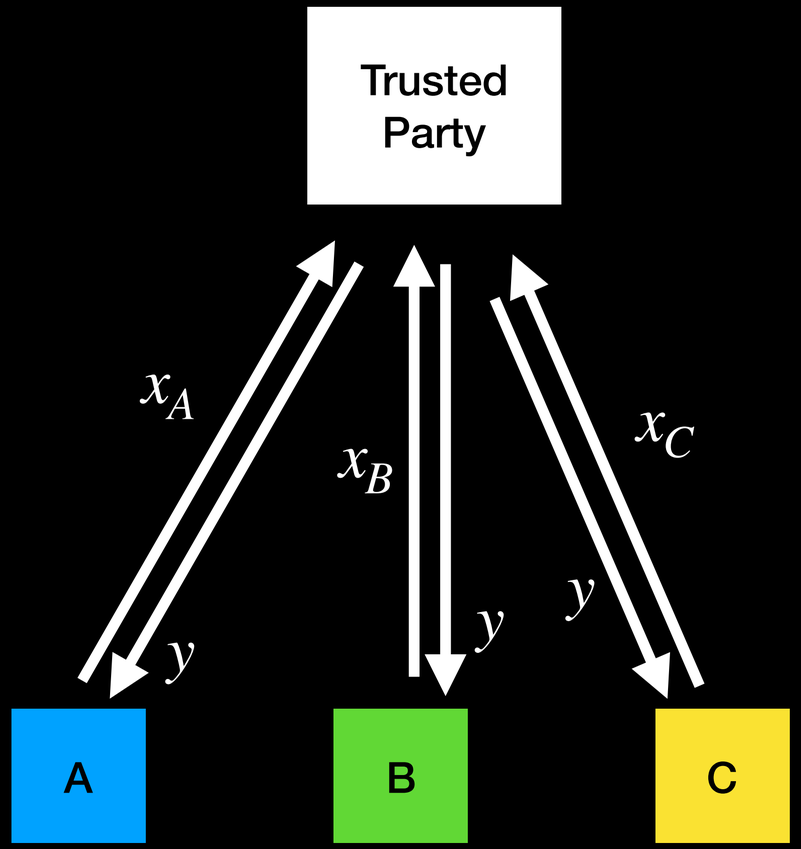

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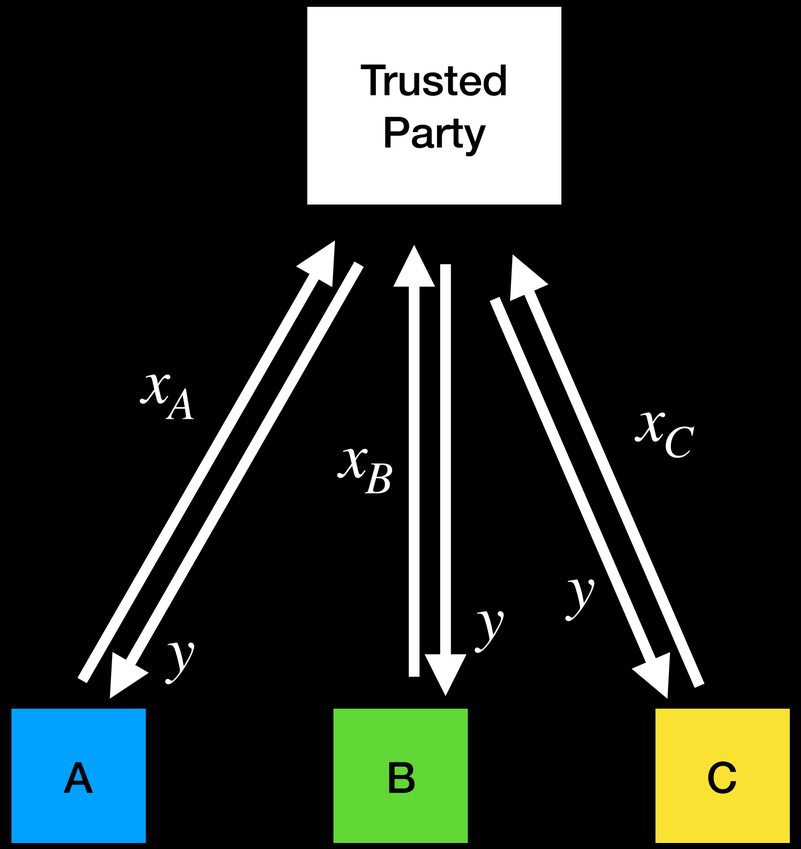

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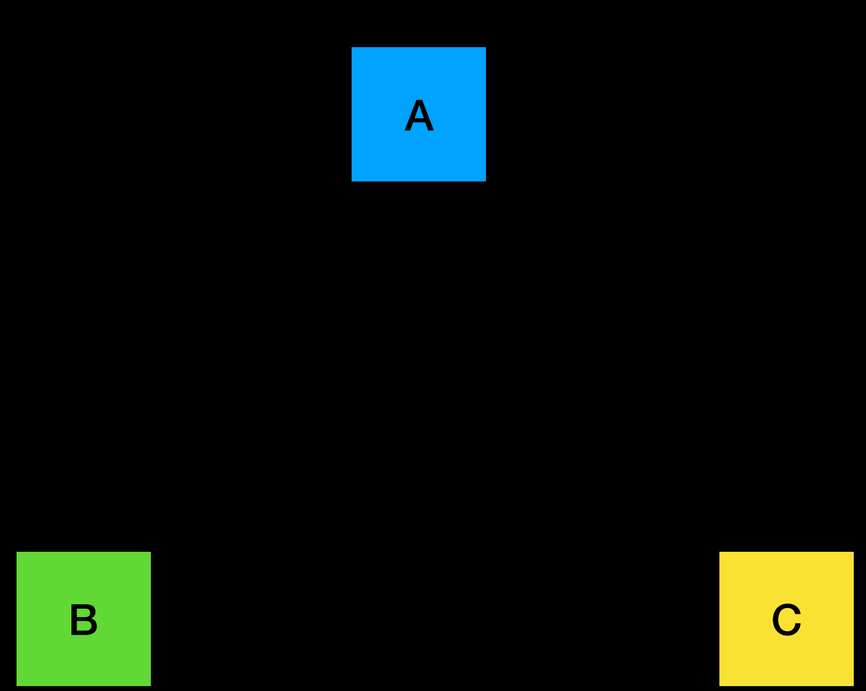

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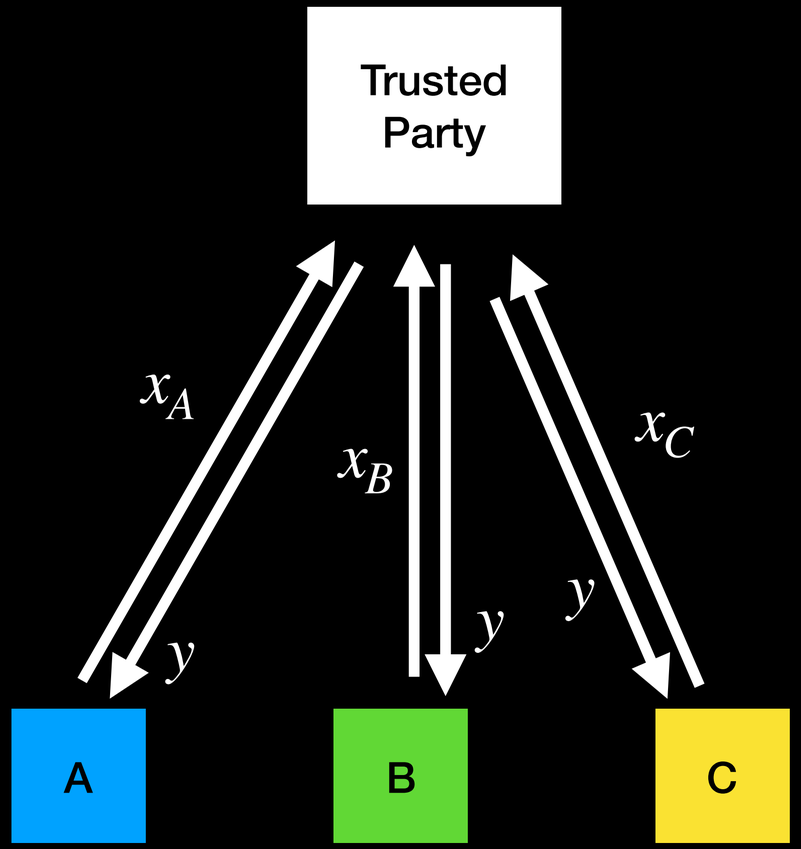

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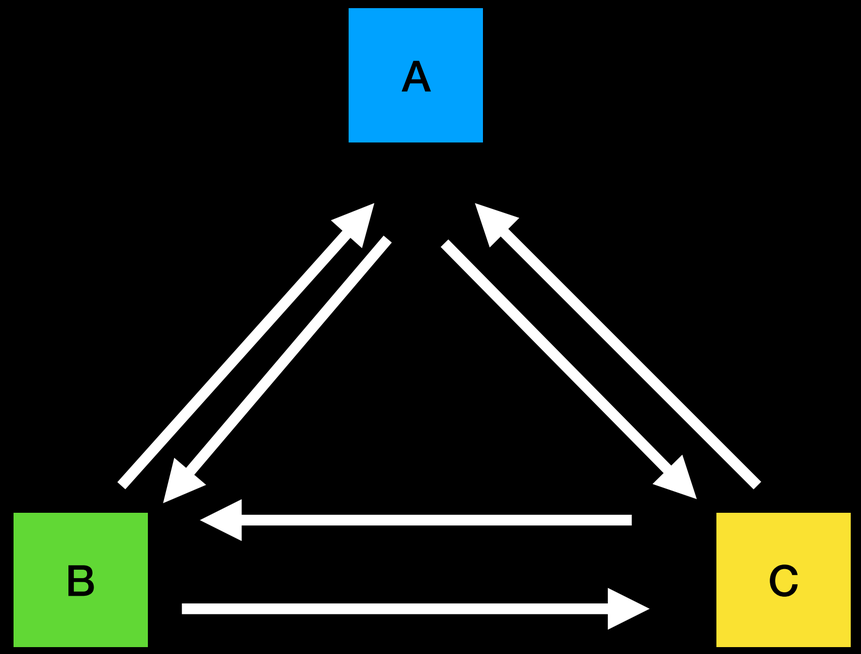

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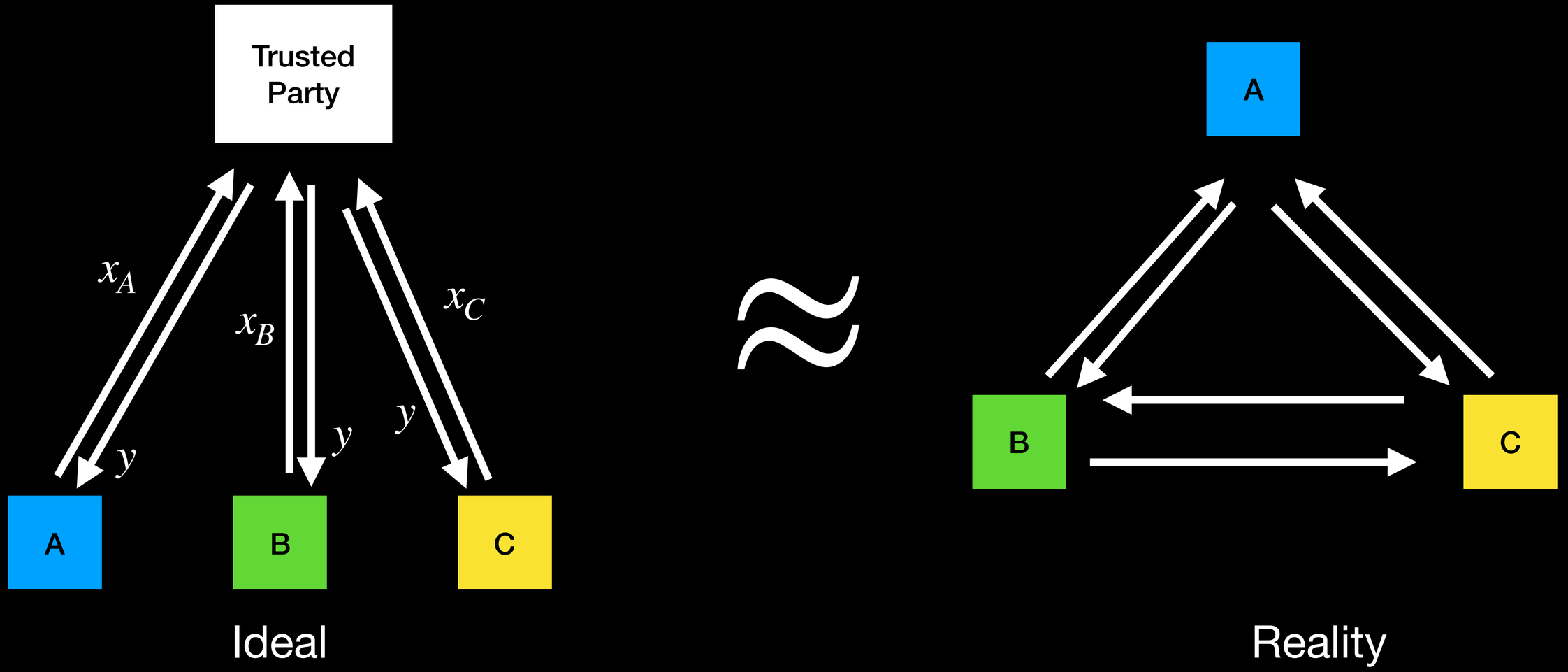
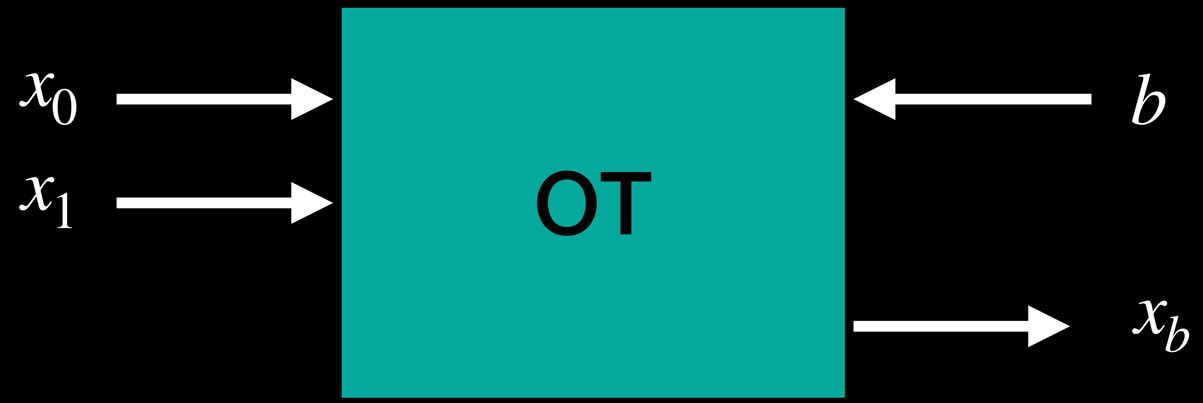


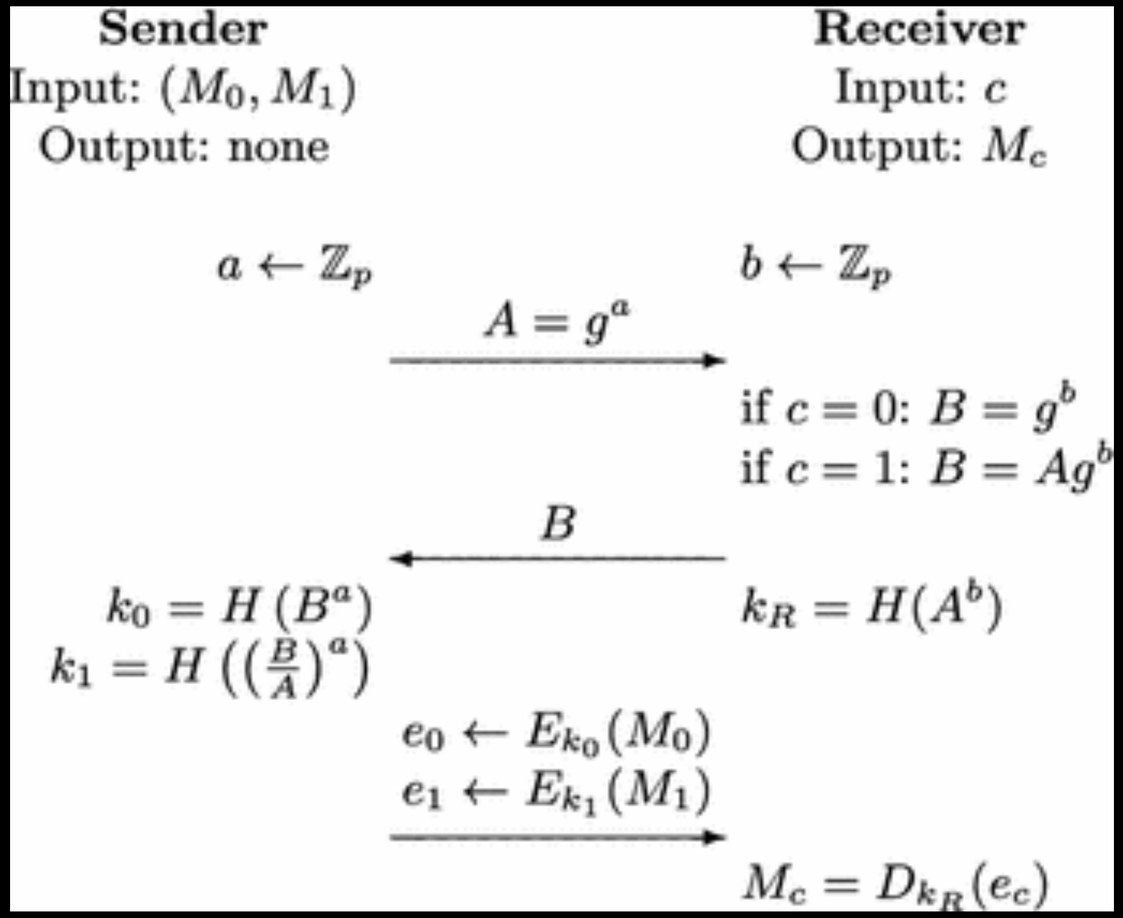
Building Block

- Consider a simple protocol for retrieving one of two values from a party

1-out-of-2 Oblivious Transfer



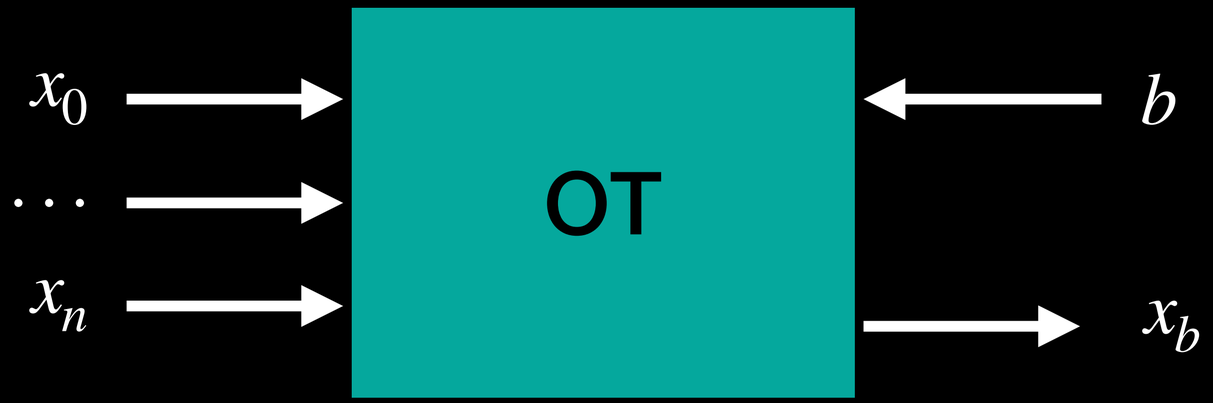
Oblivious Transfer



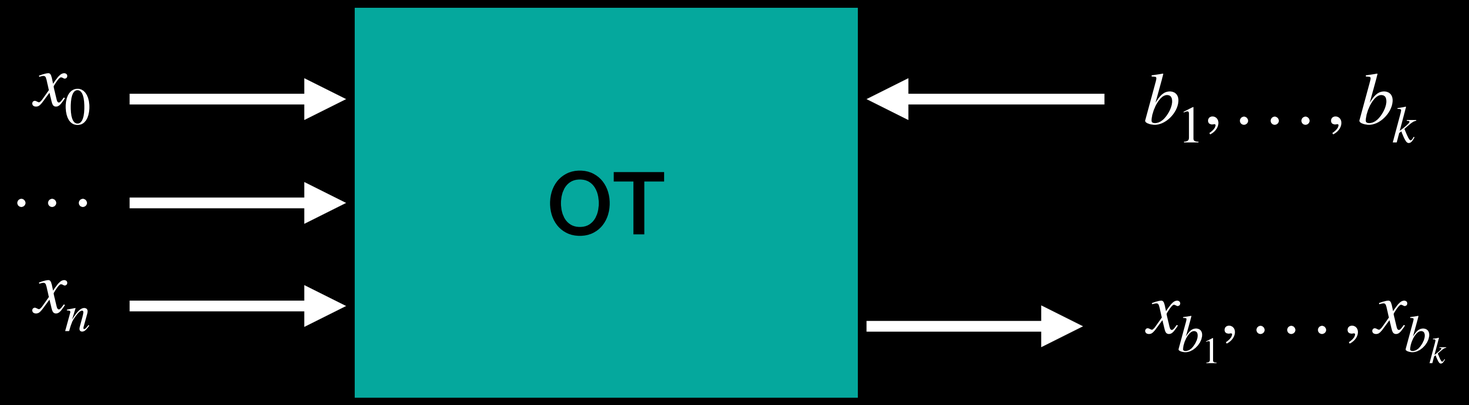
Oblivious Transfer and MPC

- Oblivious Transfer is complete for MPC!
- Note: the protocol we showed is only **semi-honest secure**: It only is secure against an adversary that may try to learn additional information but otherwise follows the protocol
  - Stronger security is possible but difficult so we will focus on semi-honest for now
- We saw 1-out-of-2 OT but we could also have 1-out-of-n OT or k-out-of-n OT

1-out-of-n Oblivious Transfer



k-out-of-n Oblivious Transfer



Private Information Retrieval (PIR)

- Goal: Query a server’s database without:
  - The server learning which entry was looked up
  - The client learning other entries of the database

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- Goal: Query a server's database without:
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- How might we do this naively?
- Can we use OT to build this?