Aarhus University
TPMPC 2018 Workshop
Theory & Practice of MPC

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MPyC – Python Package for Secure Multiparty Computation

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SODA
Scalable Oblivious Data Analytics

PRIVBLEDGE

TU/e Technische Universiteit Eindhoven University of Technology

Where innovation starts


Usability

“Love Game” for Alice and Bob

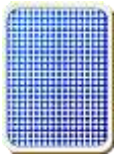
Bert den Boer, Eurocrypt ‘89

Alice’s rule:

for “yes”

for “no”

separator:



Bob’s rule:

for “yes”

for “no”

Suppose Alice thinks “yes”

Suppose Bob thinks “yes”

Alice and Bob make a random cut and open the deck …

Matching without embarrassments

Match!

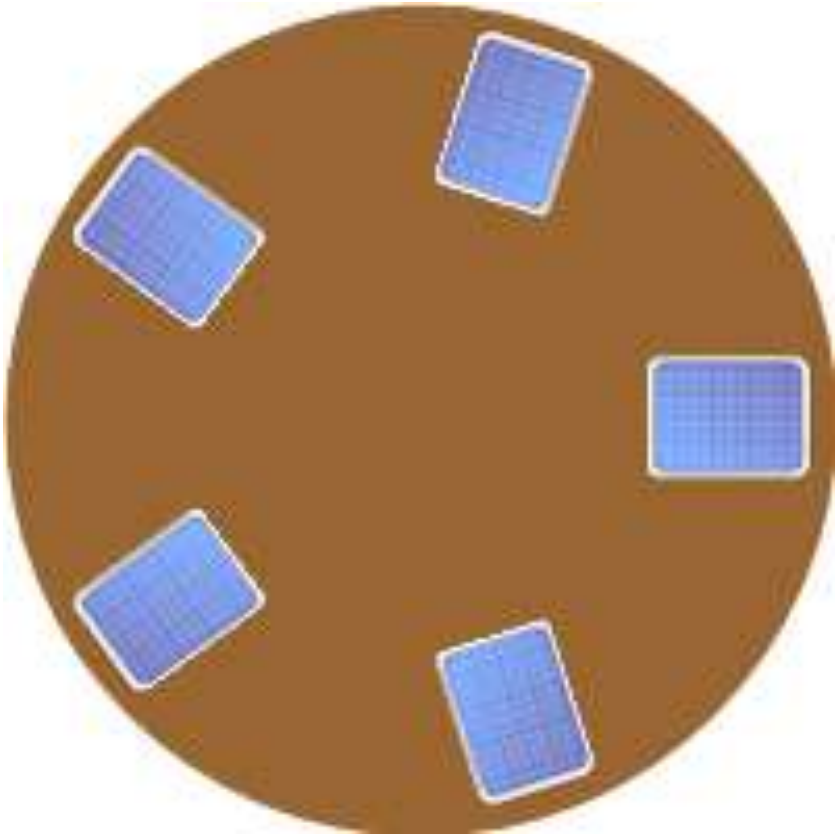
No match

No match

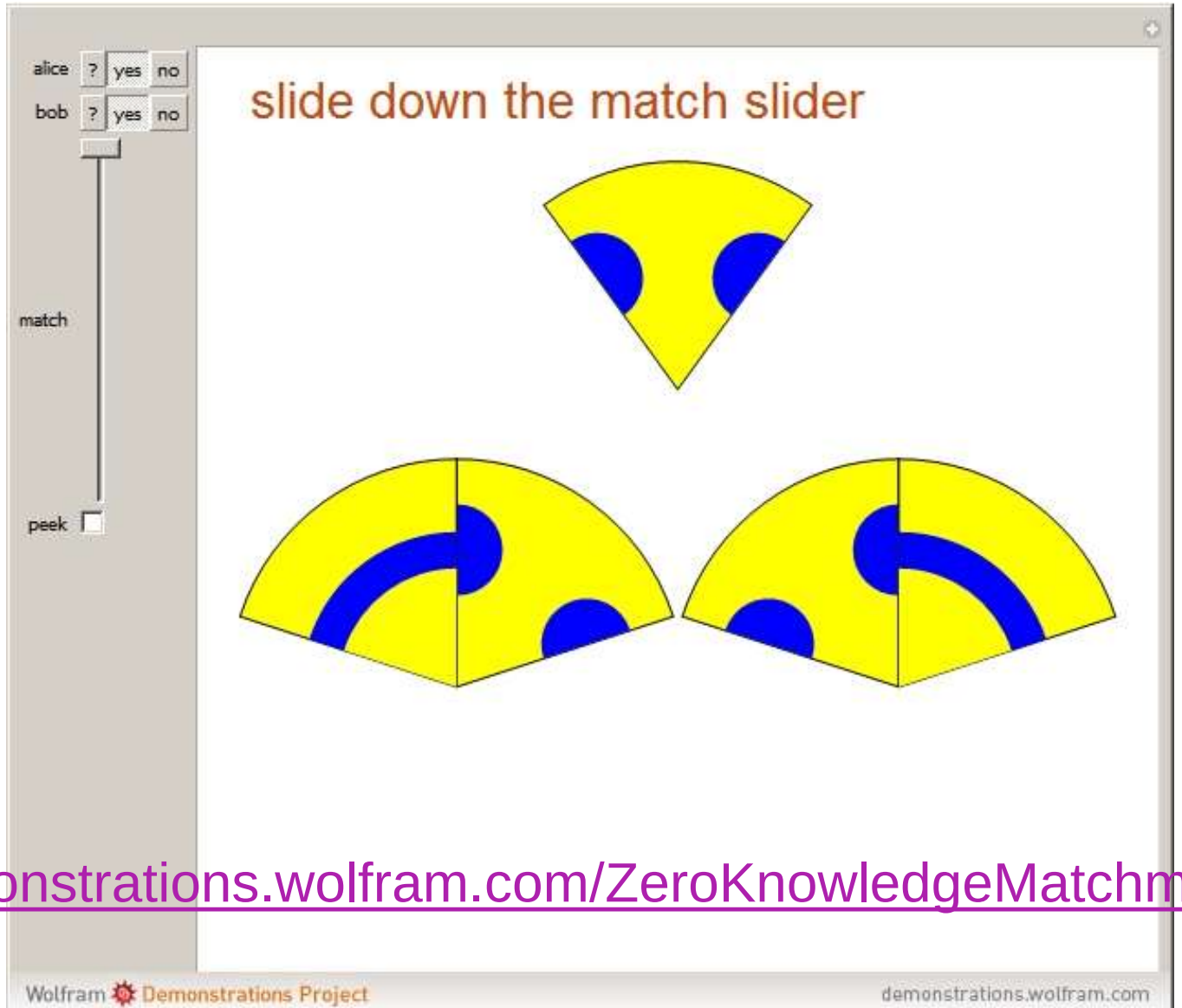
No match

same up to rotation

Random cut of five-card deck



Tom Verhoeff's crypto gadget



demonstrations.wolfram.com/ZeroKnowledgeMatchmaker

MPyC – MPC in Python

Python – widely used programming language

- **platform-independent**
- **high-level, simple and readable**
- **free, open-source, tons of applications**
- **popular for data mining & machine learning**

MPyC – open-source Python package for MPC

- **secure types to operate on secret-shared values**
- **passive adversary, honest majority**
- **asynchronous evaluation of underlying protocols**
  - **special coroutines: no explicit callbacks**
- **transparent communication between parties**

VIFF –> TUeVIFF –> MPyC

- VIFF – Virtual Ideal Functionality Framework viff.dk
  - PhD project Martin Geisler, Aarhus University
  - VIFF 1.0 released Dec. 2009 (0.1 released Oct. 2007)
  - contains many fundamental ideas
  - Marcel Keller also made ‘boost’ version

- Tomas Toft introduced VIFF at TUE as a Postdoc
- TUeVIFF – local “fork” at TU Eindhoven
  - developed with my postdocs and PhD students
    - Frank Blom, Niek Bouman, Sebastiaan de Hoogh, Mikkel Krøigaard, Meilof Veeningen, Niels de Vreede
  - also used for assignments and MSc thesis projects

MPC implementation projects @TUE

- **Linear Programming, incl. fixed-point numbers** *Sebastiaan de Hoogh*
- **ID3 decision trees** *Ping Chen, Sebastiaan de Hoogh*
- **Shuffle / QuickSort / ORAM** *Niels de Vreede*
- **DNA sequence alignment** *Sakina Asadova, Meilof Veeningen*
- **Verifiable MPC – Trinocchio, Geppetri, incl. intro of inline-callbacks** *Meilof Veeningen*
- **Linear algebra / ridge analysis** *Frank Blom, Niek Bouman, Niels de Vreede*
- **Convolutional Neural Networks** *Harm Campmans*

MPyC main features

- ***m*-party computation, up to *t* passive corruptions**
  - ***m* ≥ *1* and *0* ≤ *t* ≤ *(m-1)/2***
  - ***m = 1, t = 0: normal computation***
  - ***m > 1, t = 0: parallel computation***

- **Secure types: secint, secfxp, secfld**
  - **overloaded operators +, -, *, / , ==, <**
  - **input/output methods**
  - **hides (pseudorandom) secret-sharing**

- **Asynchronous computation via MPyC coroutines**
  - **no explicit callbacks at all – not go to “callback hell”**
  - **natural control flow**

MPyC coroutines

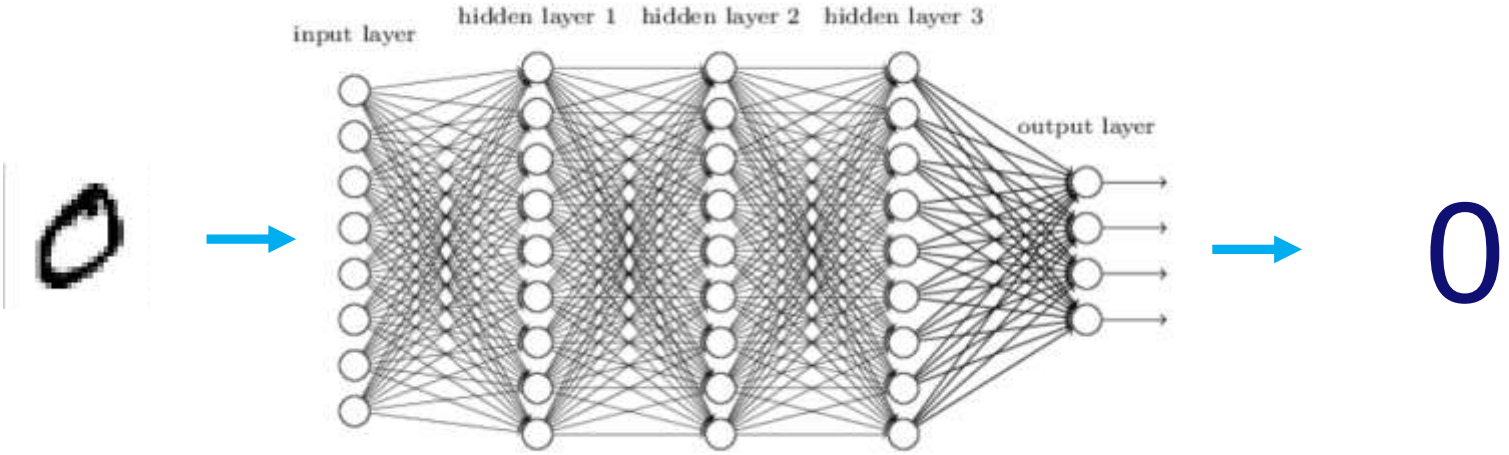
- Python coroutine uses async/await syntax, like in many other programming languages
- MPyC coroutine: special kind of Python coroutine

```
@mpc.coroutine                                  # MPyC decorator
async def mul(a, b) -> secint:                  # MPyC return type
    a, b = await gather_shares(a, b)            # suspends execution
    c = reshare(a * b)                          # asynchronous call
    return c
```

- Call to async mul() returns immediately with secint object containing empty placeholder.
- Evaluation of expression (s*t) + (u*v) * (w+x) * y * z:
  - first creates tree with empty placeholders
  - then starts filling in these placeholders

Demos at github.com/lschoe/mpyc

- **Secure sorting**
  - **from sorting networks**
- **Secret Santa**
  - **random permutation without fixed-points**
- **Convolutional neural network for MNIST dataset**
  - **recognizing hand-written digits 0,1,2,..,9**



Conclusion

- **MPyC: standard Python**
- **Small footprint: easier verification of framework**
- **Balance usability and efficiency for**
  - **rapid prototyping, executable specification**
  - **educational purposes, e.g.,**
    - **teaching secure/oblivious programming**
    - **explaining how MPC works – look inside MPyC**
- **Some next steps:**
  - **secure numpy arrays**
  - **transparent secret indexing**
- **See** github.com/lschoe/mpyc

H2020 EU-projects

soda-project.eu

priviledge-project.eu

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