FOSDEM 2021 Hardware-aided Trusted Computing Devroom

Veracruz

Privacy-preserving collaboration

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Background

We believe that **strong isolation technology** and **remote attestation**:

- Allow the design of novel data-intensive applications with fine-grained access control,
- Allow computations to be safely moved around, without sacrificing privacy or integrity,
- Potentially separate *possession* of data from *control* over that data

Here, **strong isolation** is our term for a range of hardware- and firmware-based isolation mechanisms, aiming to provide strong privacy and integrity guarantees

Veracruz is our vehicle for understanding what these technologies are capable of

The Veracruz framework

A framework for defining flexible and efficient multi-party computations

Veracruz aims to support common use-cases for advanced cryptographic techniques

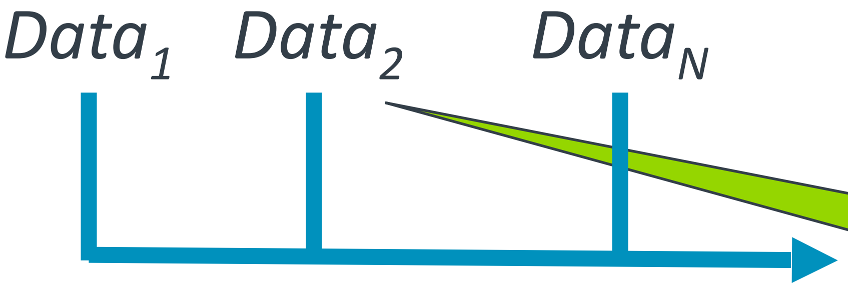
- Techniques like *homomorphic encryption*, *secure-multiparty computations,* and similar

Unlike those techniques, we aim to be:

1. **Efficient**: Be fast enough to execute ”interesting” programs,
2. **Familiar**: Allow programmers to use familiar programming languages and tools,
3. **General**: Seamlessly support a large class of multi-party computations,
4. **Reusable:** Provide a single framework supporting a wide-range of privacy-preserving computations without requiring significant reconfiguration for each task

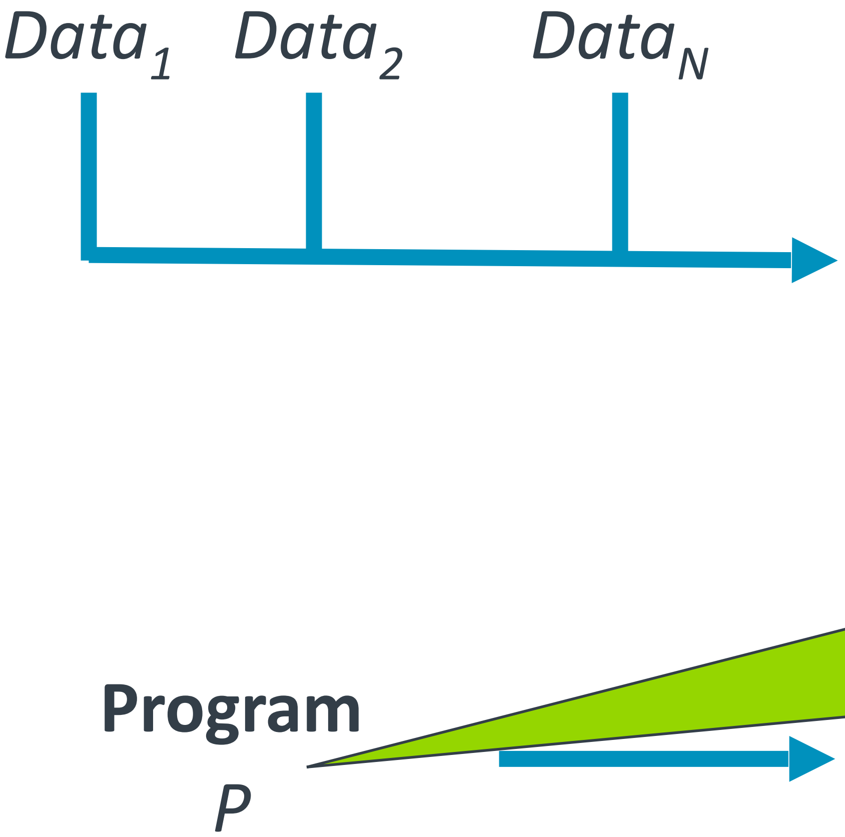
In common with those techniques, we aim to provide a strong **security/privacy guarantee**

Veracruz from 50,000ft



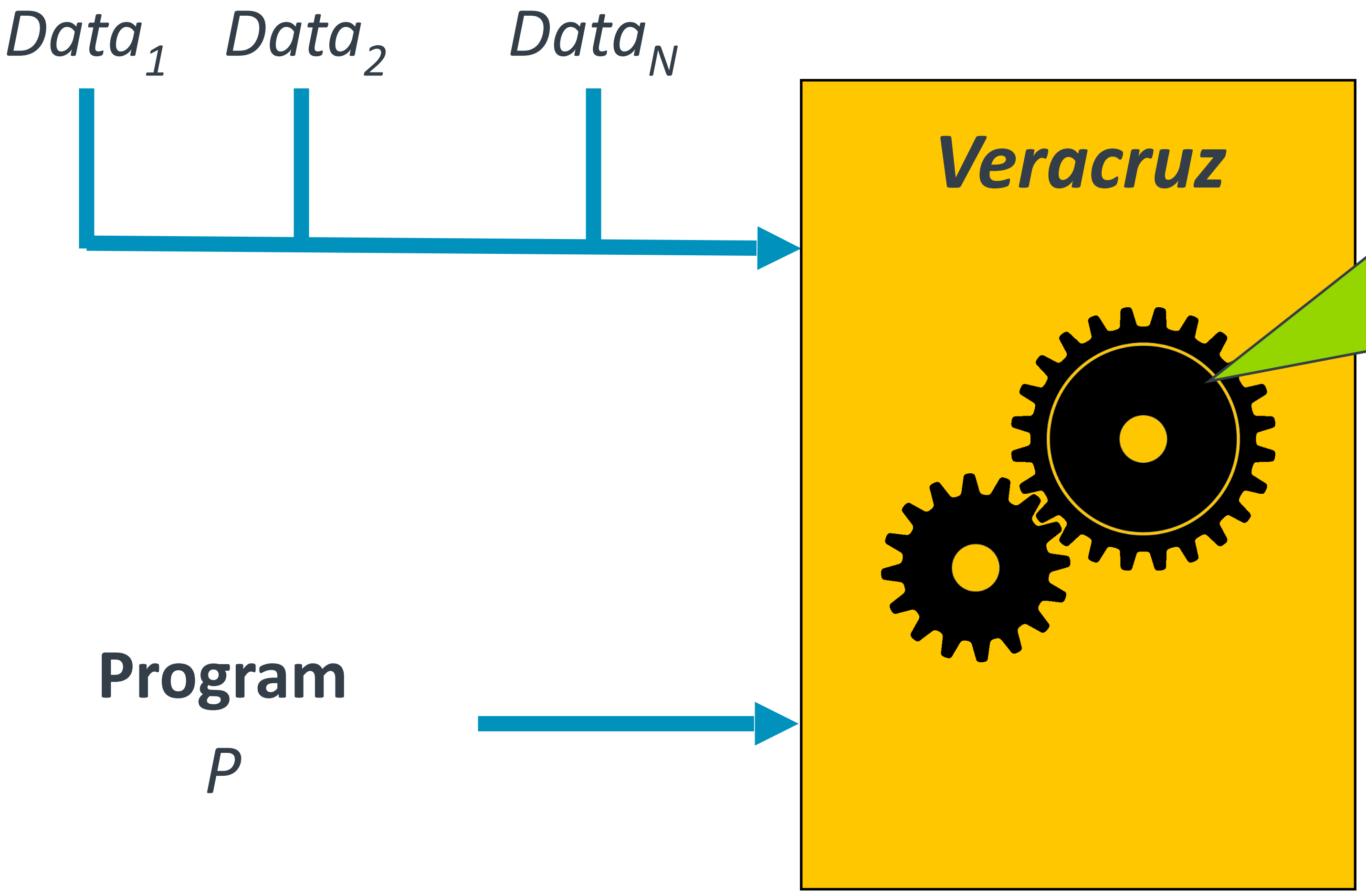
The **data inputs** to Veracruz. Note that these can originate from different agents who are mutually distrusting.

Veracruz from 50,000ft



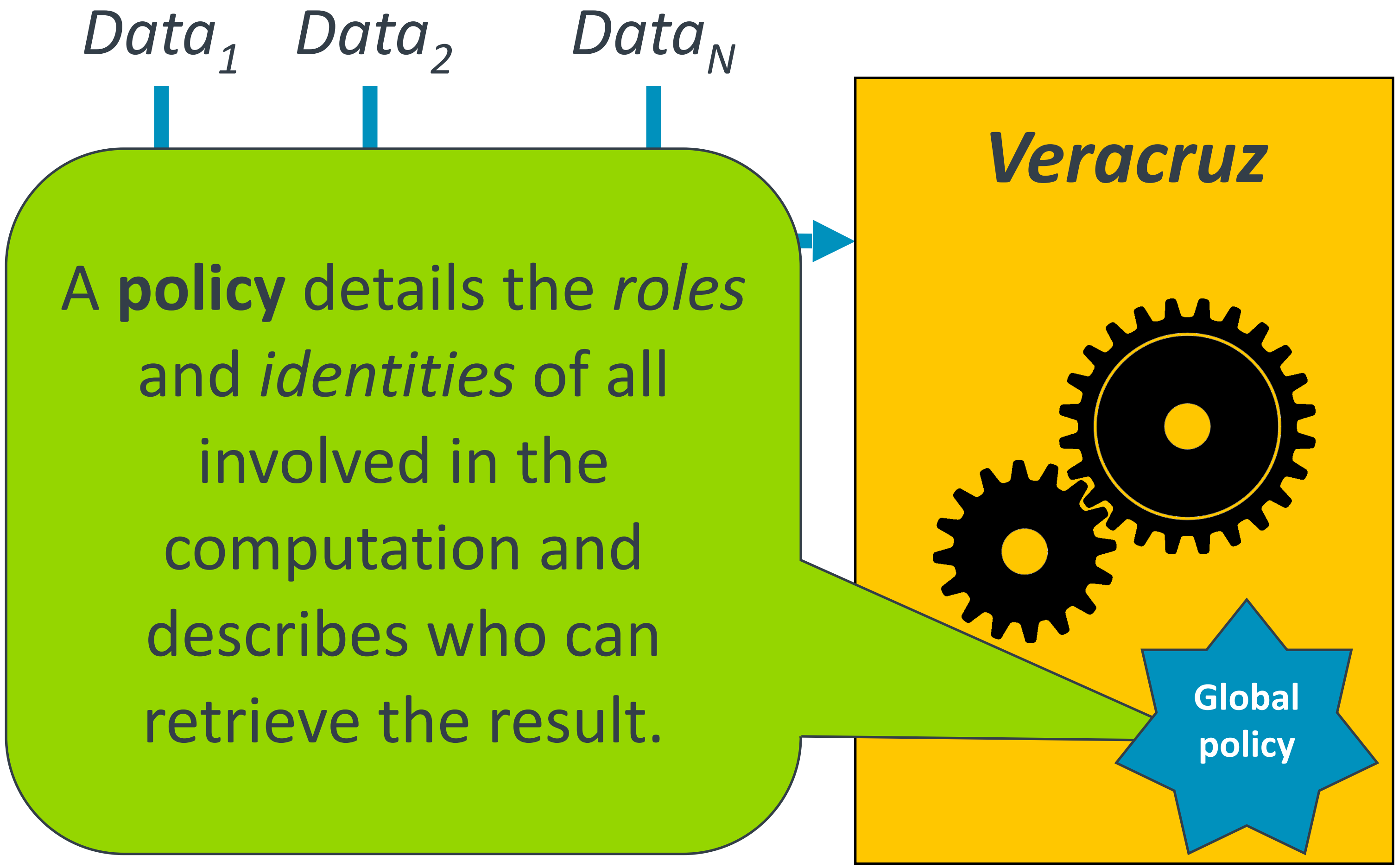
The **program**, which may originate from an agent distinct from those providing the data inputs. In Veracruz, we use *WebAssembly* (WASM) as our executable.

Veracruz from 50,000ft



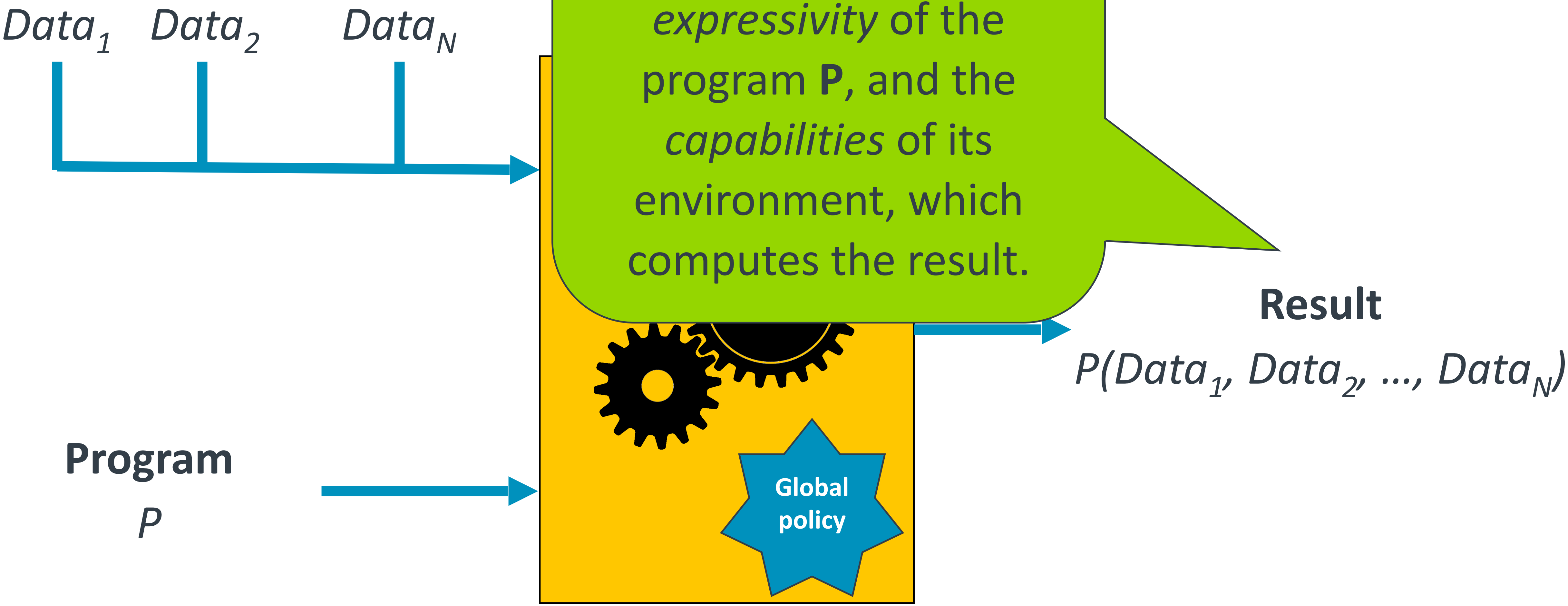
Program and data are provisioned securely into Veracruz, running on a **host**, which computes a result by applying the program to the data.

Veracruz from 50,000ft



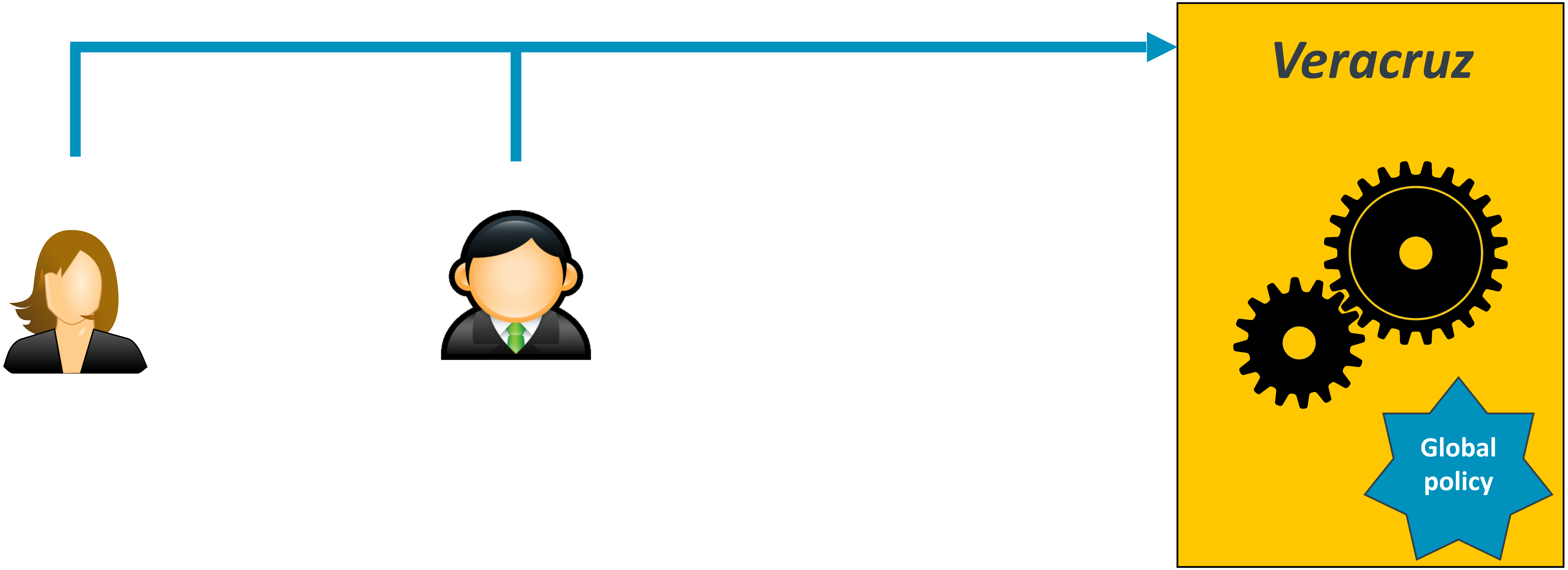
A **policy** details the *roles* and *identities* of all involved in the computation and describes who can retrieve the result.

Veracruz from 50,000ft



To maintain secrecy we need to control the *expressivity* of the program **P**, and the *capabilities* of its environment, which computes the result.

Use-case: privacy-preserving machine learning



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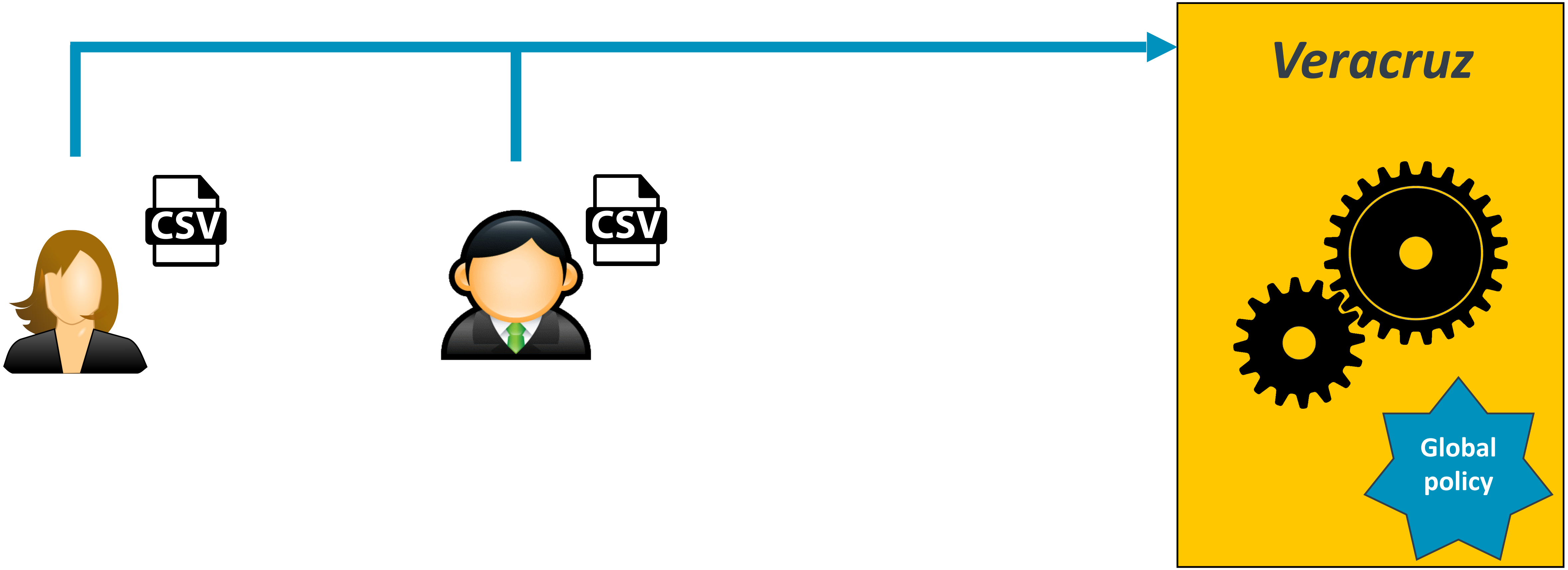

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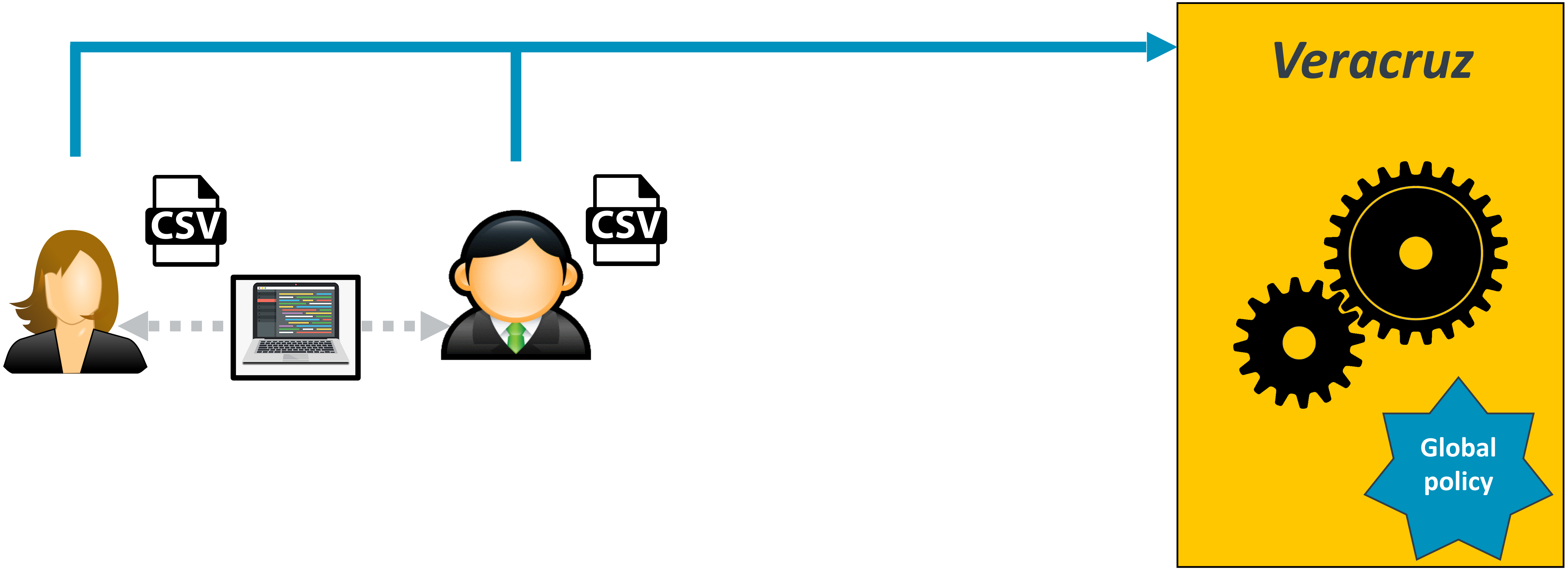

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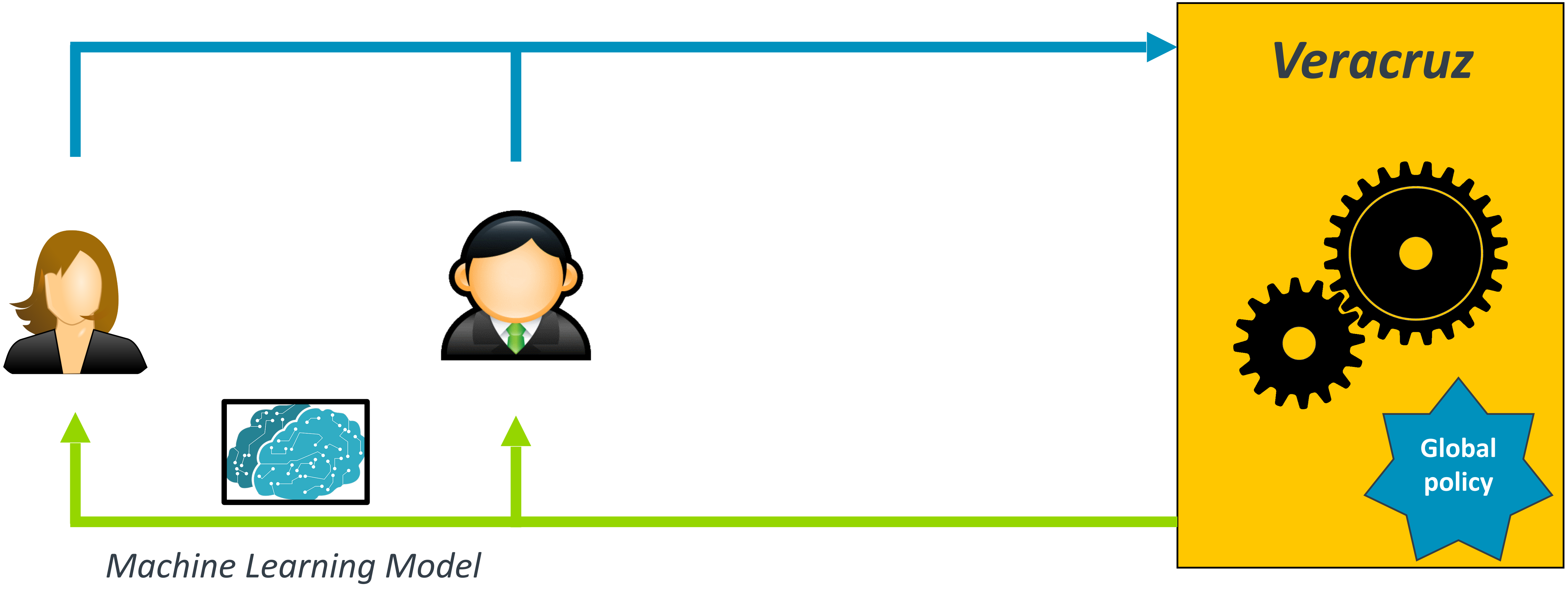
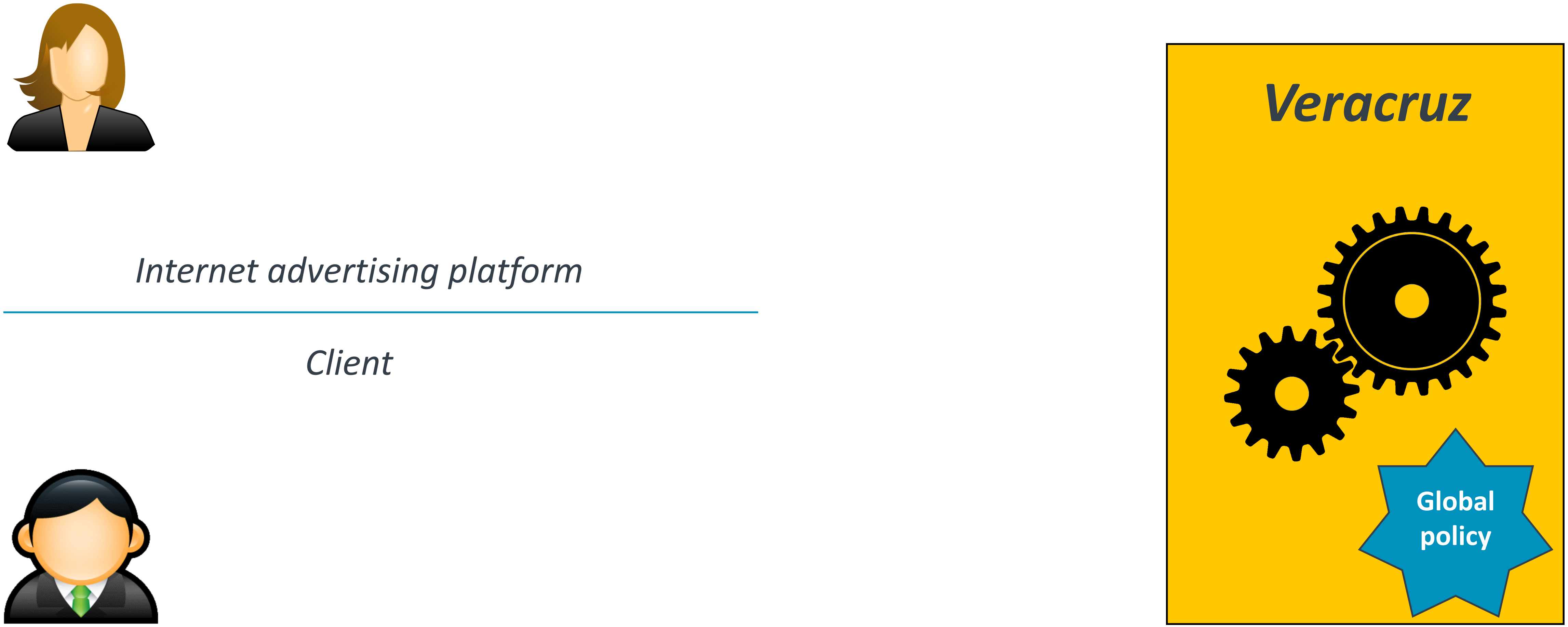


Use-case: privacy-preserving set-sum computation



Internet advertising platform

Client

Use-case: privacy-preserving set-sum computation

Internet advertising platform

Client

A45B3201:	£4.99
E3332110:	£34.23
01224573:	£17.50
…	

Veracruz
Global policy

Use-case: privacy-preserving set-sum computation

```
A45B3201
B8920345
45398A21
…
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Internet advertising platform

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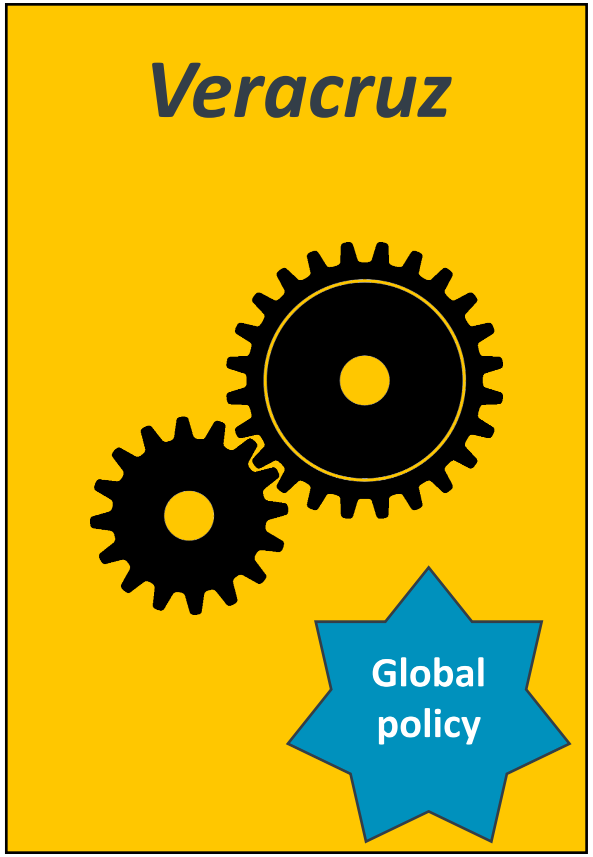

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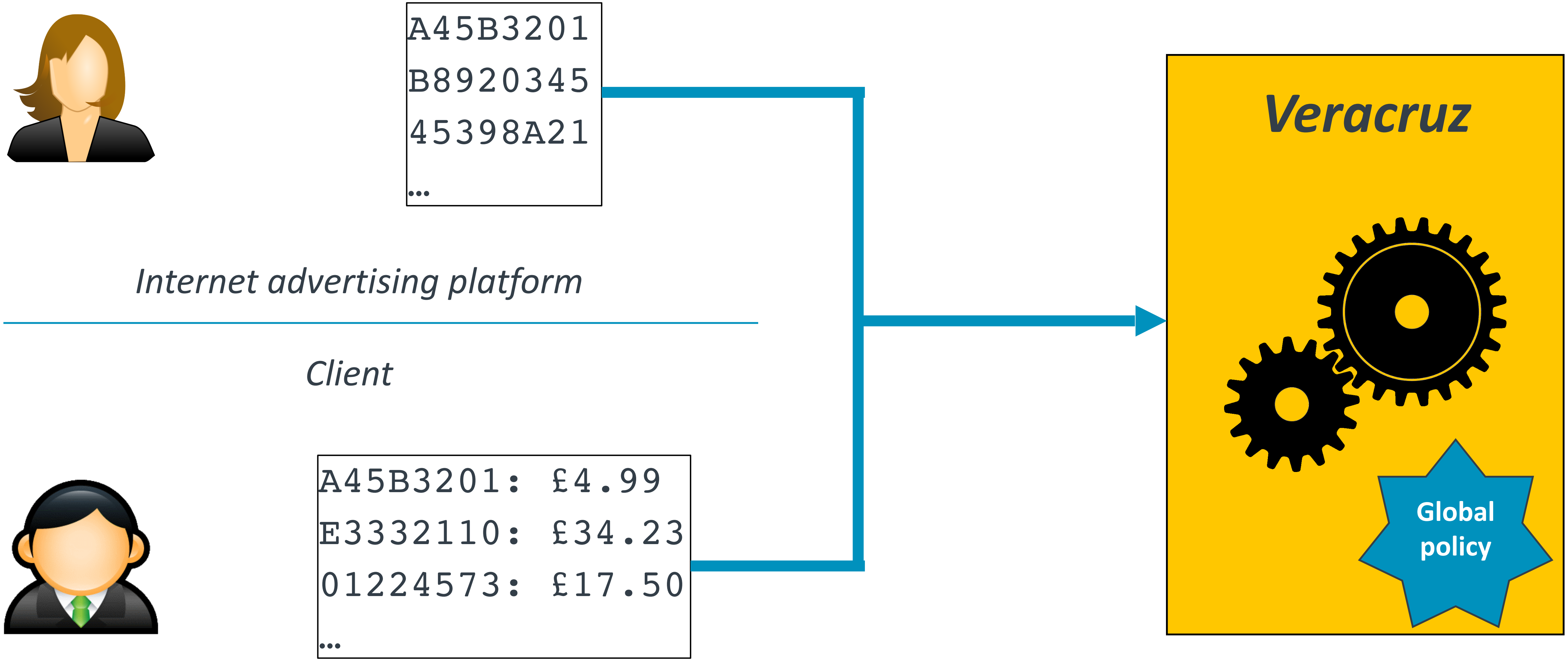

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Veracruz

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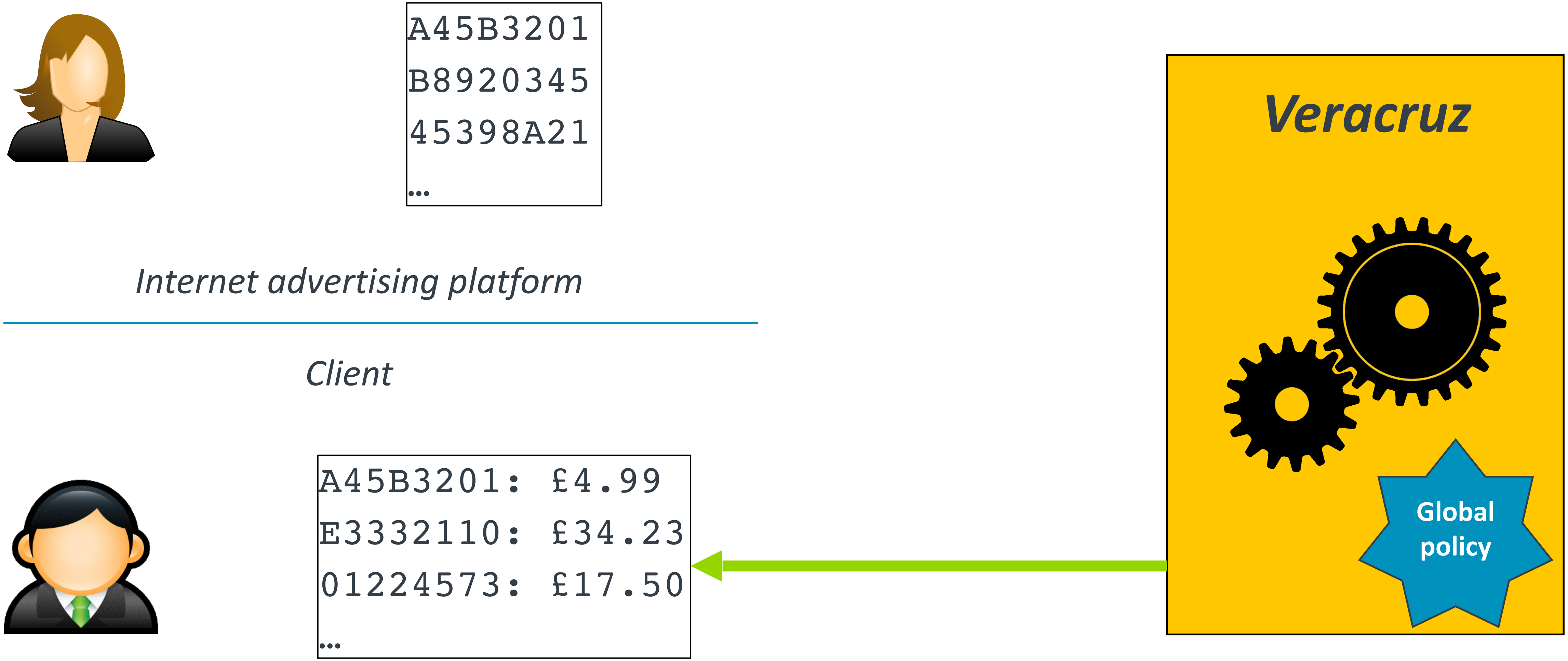

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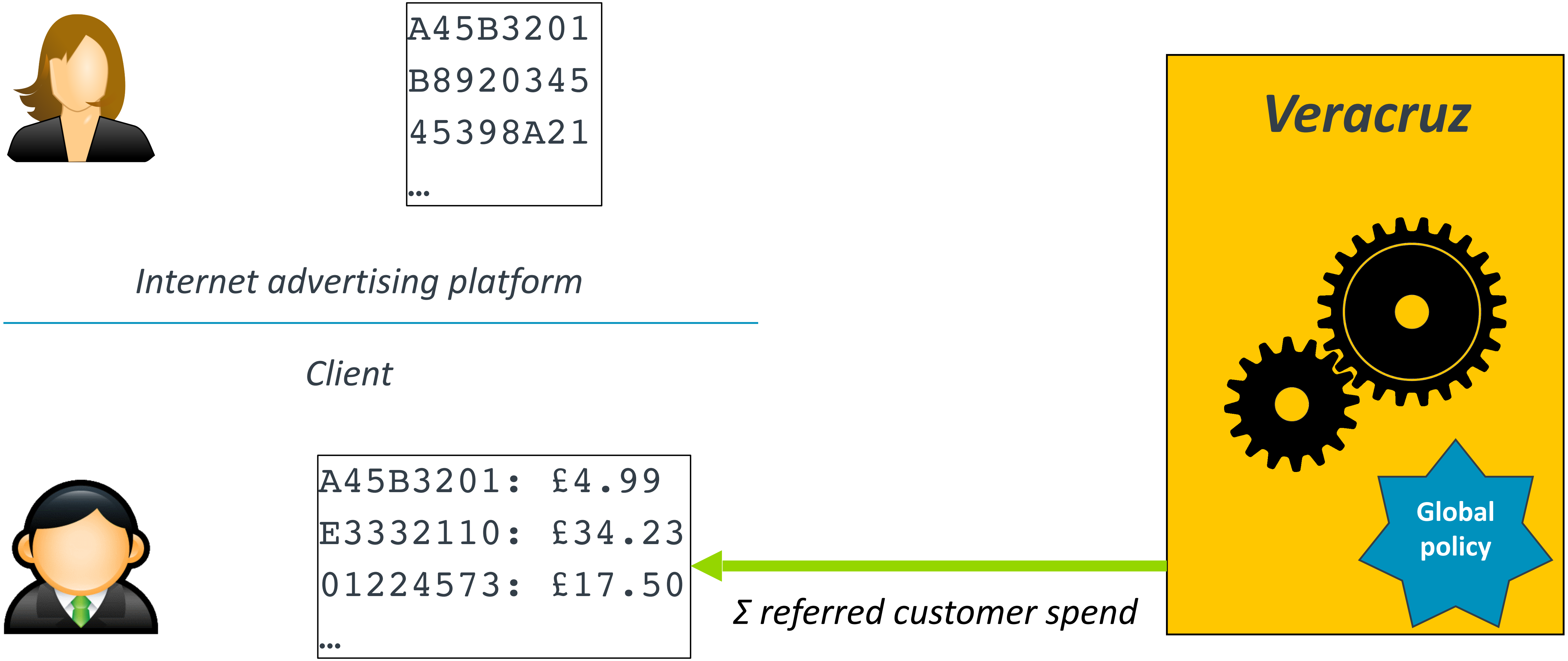

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Internet advertising platform

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Σ referred customer spend

…and many more potential use-cases

1. IP protection,
2. Privacy-preserving surveys/auctions/elections,
3. Privacy-preserving distributed compute: map-reduce/grid computing *a la* SETI@home,
4. Private search/fuzzy matching,
5. Provenance tracking for data,
6. Verifiable computation,
7. N-way secret sharing,
8. Fair exchange of documents,
9. Zero-knowledge proof of knowledge,
10. Delegating computations from weak devices to untrusted servers,

…ad infinitum

Abstracting over isolates

Veracruz supports *multiple* different isolation technologies at present:

- **Arm TrustZone** trusted applications,
- **Intel SGX** secure enclaves,
- The high-assurance **seL4 microkernel**,
- **AWS Nitro Enclaves**, …and maybe more in the future,

representing different points on a *continuum of paranoia*

Veracruz provides abstractions over isolate technologies, with:

- A single, portable programming model based on **WebAssembly,**
- A unified attestation mechanism, based on **Arm's PSA Attestation** protocol, which hides platform-specific attestation protocols from clients

A few future directions

- Support for streaming computations
- Adoption of a subset of WASI as our ABI
- Multi-isolate use-cases, e.g. privacy-preserving grid-compute, or map-reduce
- Dynamic checking of the runtime behaviour of the program
- Supporting more isolation technologies

Conclusions

Veracruz is a research project exploring how strong isolation technology and remote attestation can influence the design of novel, data-intensive distributed systems

Veracruz allows users to easily design and deploy collaborative, privacy-preserving computations using a range of software and hardware isolation mechanisms and WASM:

- Arm TrustZone trusted applications,
- Intel SGX enclaves,
- The seL4 high-assurance hypervisor,
- AWS Nitro Enclaves.

Veracruz has many potential applications, which we are only just beginning to explore!

Get involved

Veracruz is (provisionally) adopted as a project by the *Confidential Compute Consortium*, and all of our development is now out in the open, on Github:

https://github.com/veracruz-project/veracruz

We are interested in attracting collaborators to help us drive the project forward. If you're interested in getting involved, e-mail any of the team members or get in touch via Github!

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Thank You

Danke

Merci

谢谢

ありがとう

Gracias

Kiitos

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