ETH zürich

ESORICS

Enforcing the GDPR

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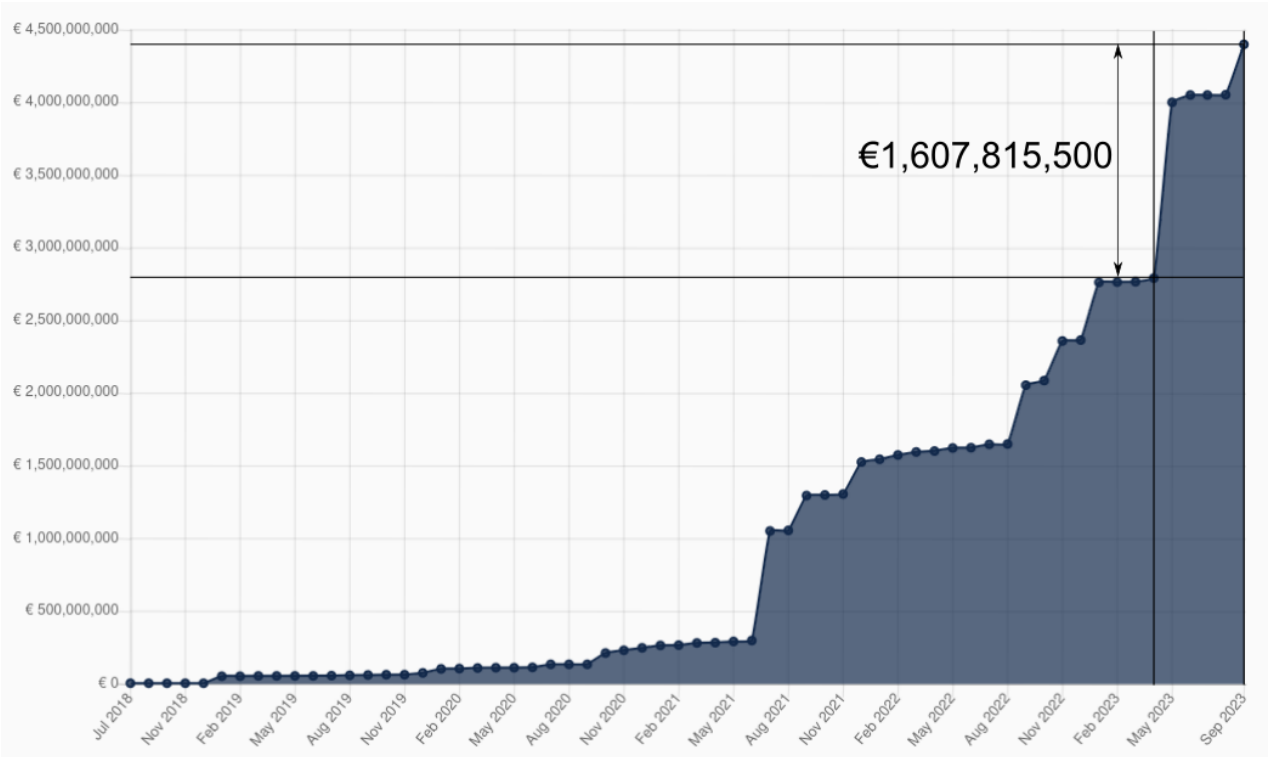
More privacy thanks to the GDPR?

Since the time our paper was written, over €**1.5 billion** in fines have been imposed on entities violating the GDPR.



Source: `www.enforcementtracker.com`

How can we do better?

Be proactive!

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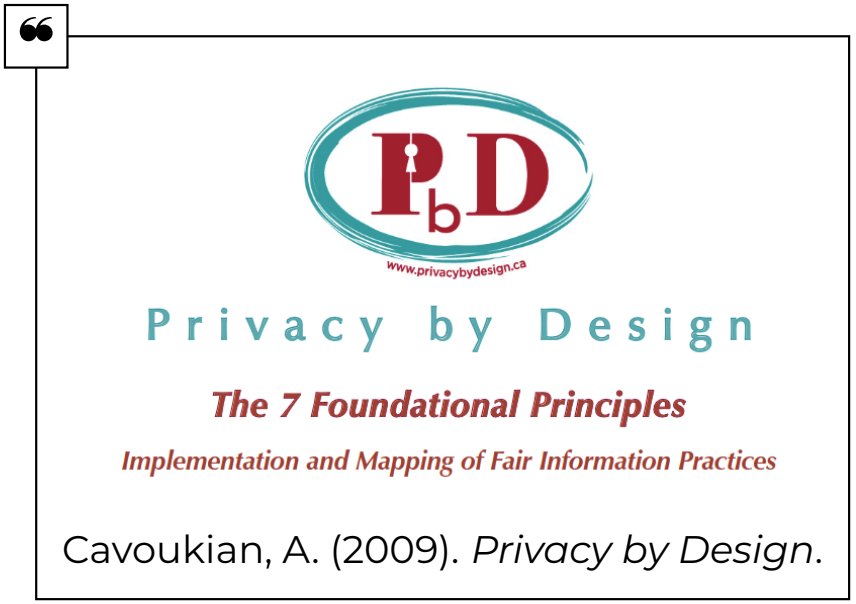

Cavoukian, A. (2009). *Privacy by Design*.

How can we do better?

Be proactive!

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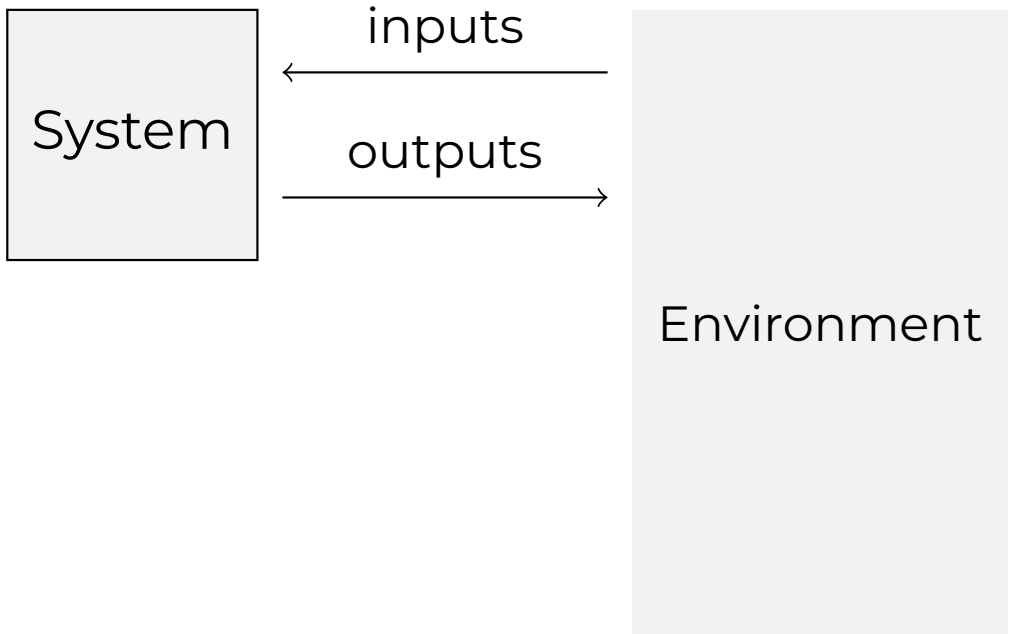
Data protection by design and by default

Taking into account the state of the art, the cost of implementation and the nature, scope, context and purposes of processing [...] ***the controller shall [...] implement appropriate technical and organisational measures [...] in order to meet the requirements of this Regulation*** *and protect the rights of data subjects.*

— GDPR, art. 25(1)

This paper: PbD using Runtime Enforcement



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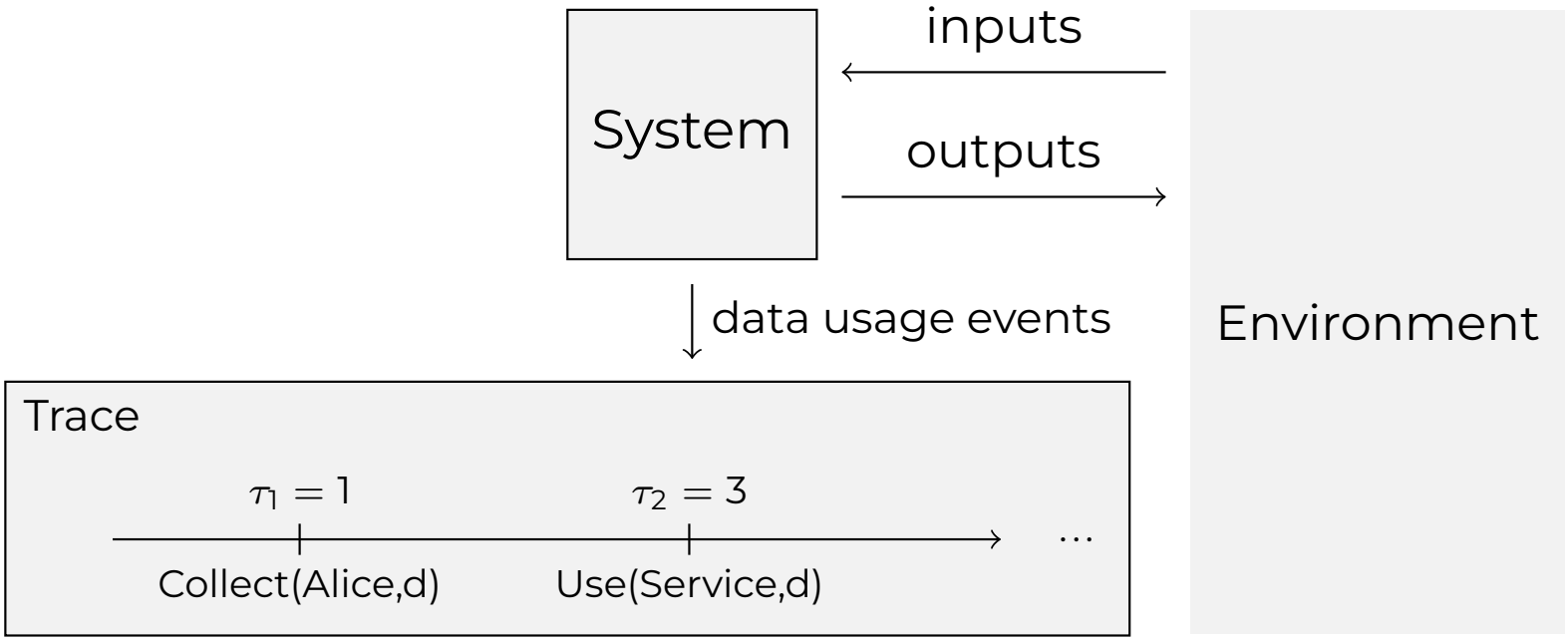

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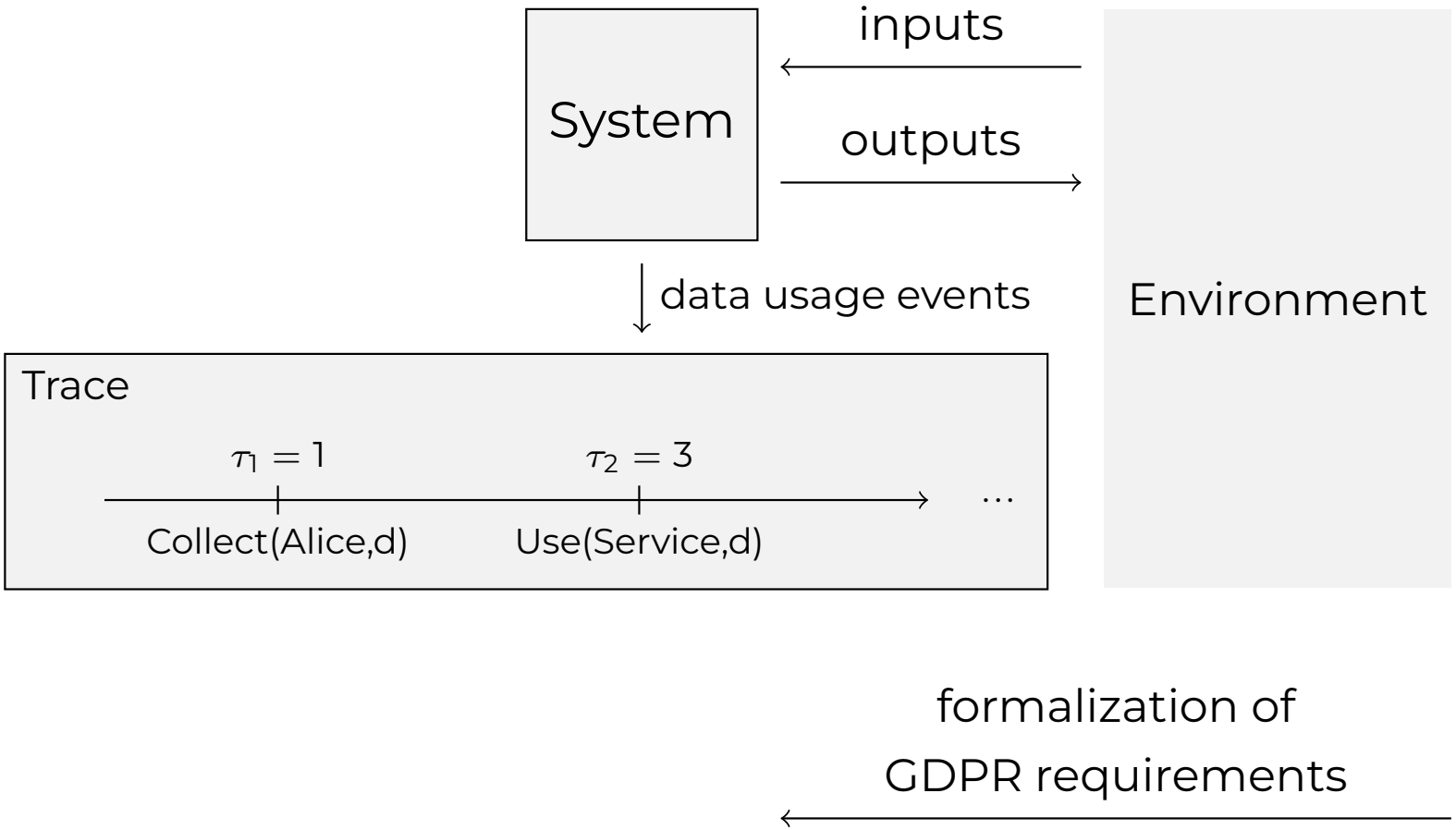

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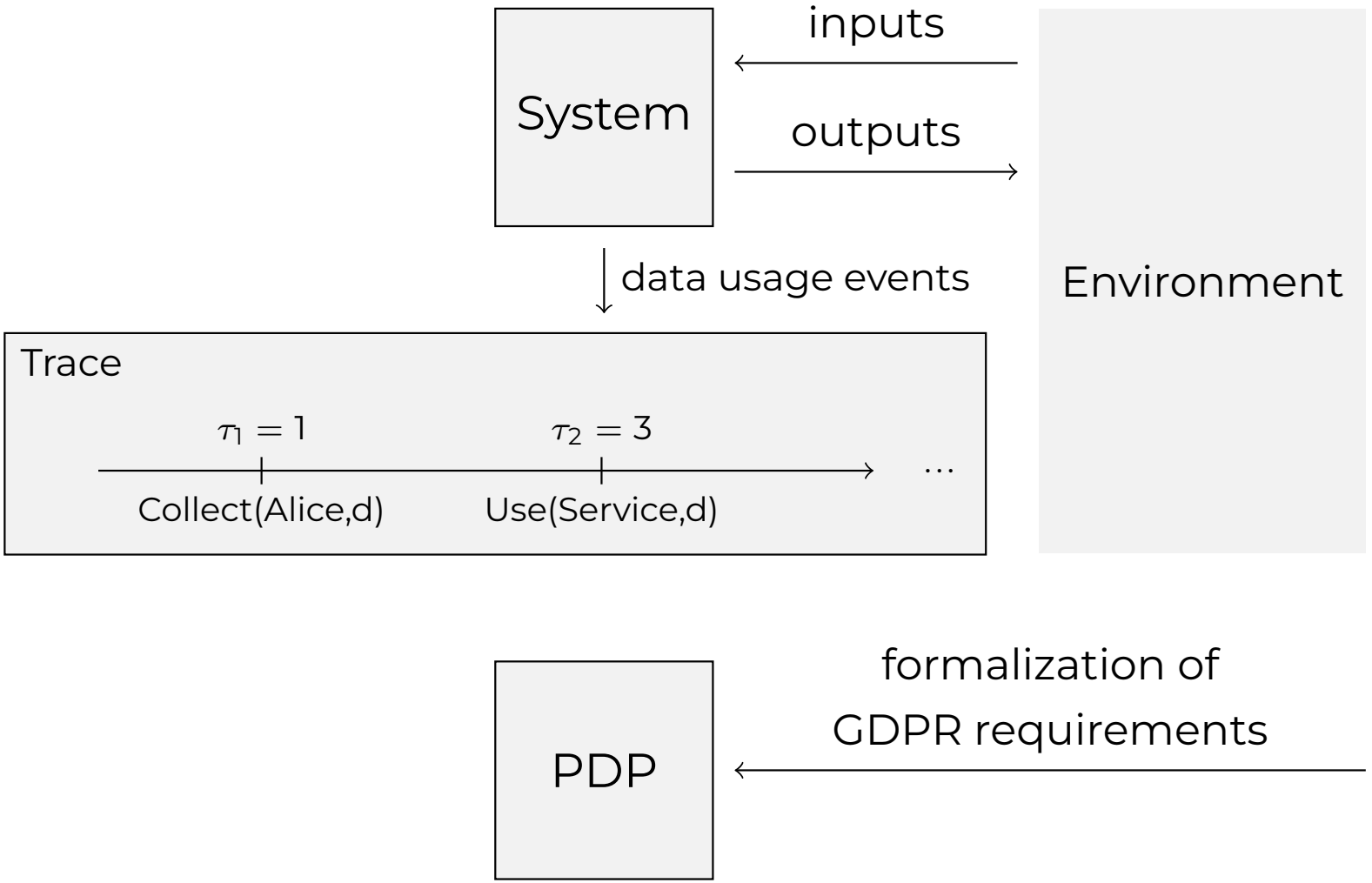

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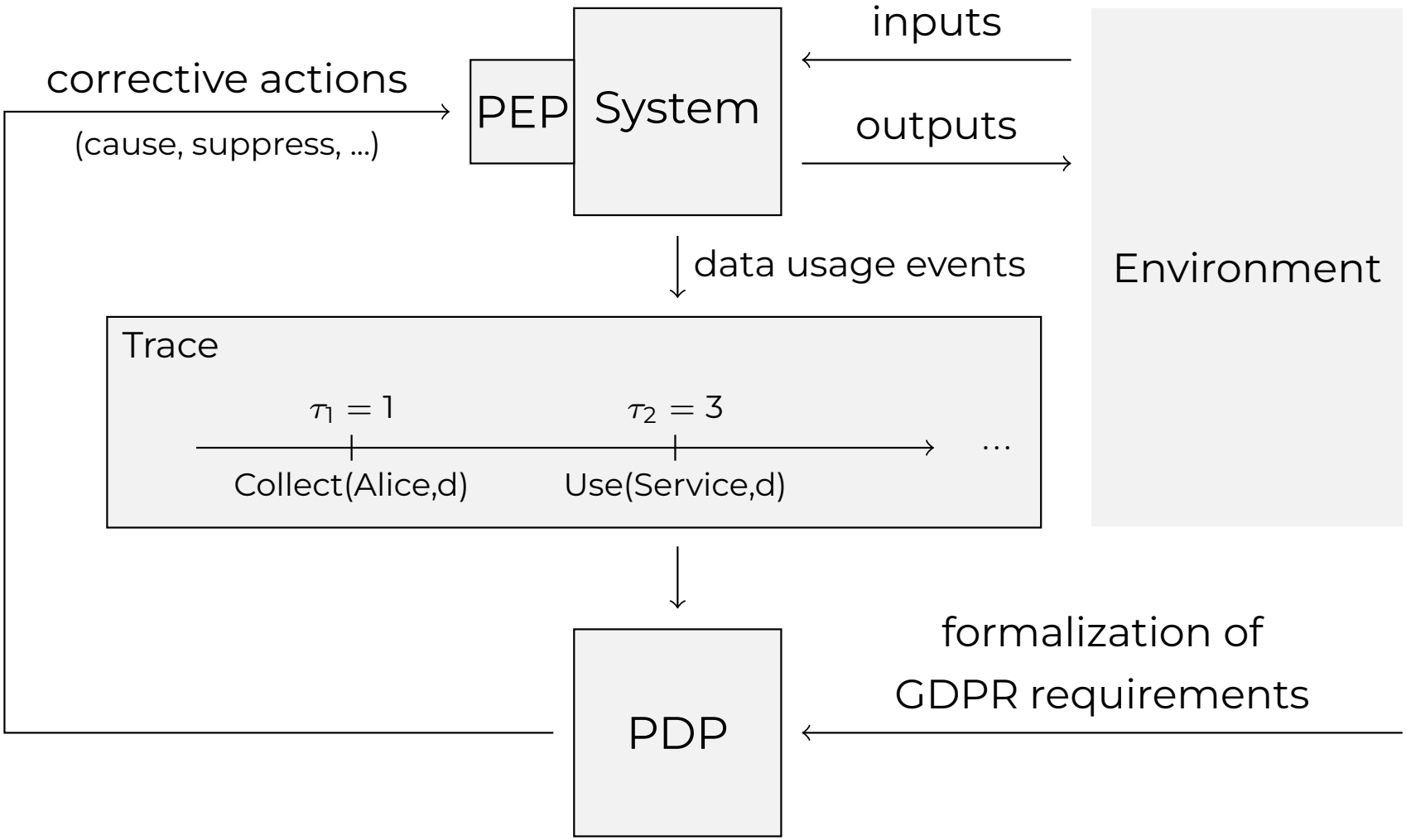

This paper: Runtime Enforcement of the GDPR

Challenges

Contributions

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Challenges

SPECIFY legal requirements

Contributions

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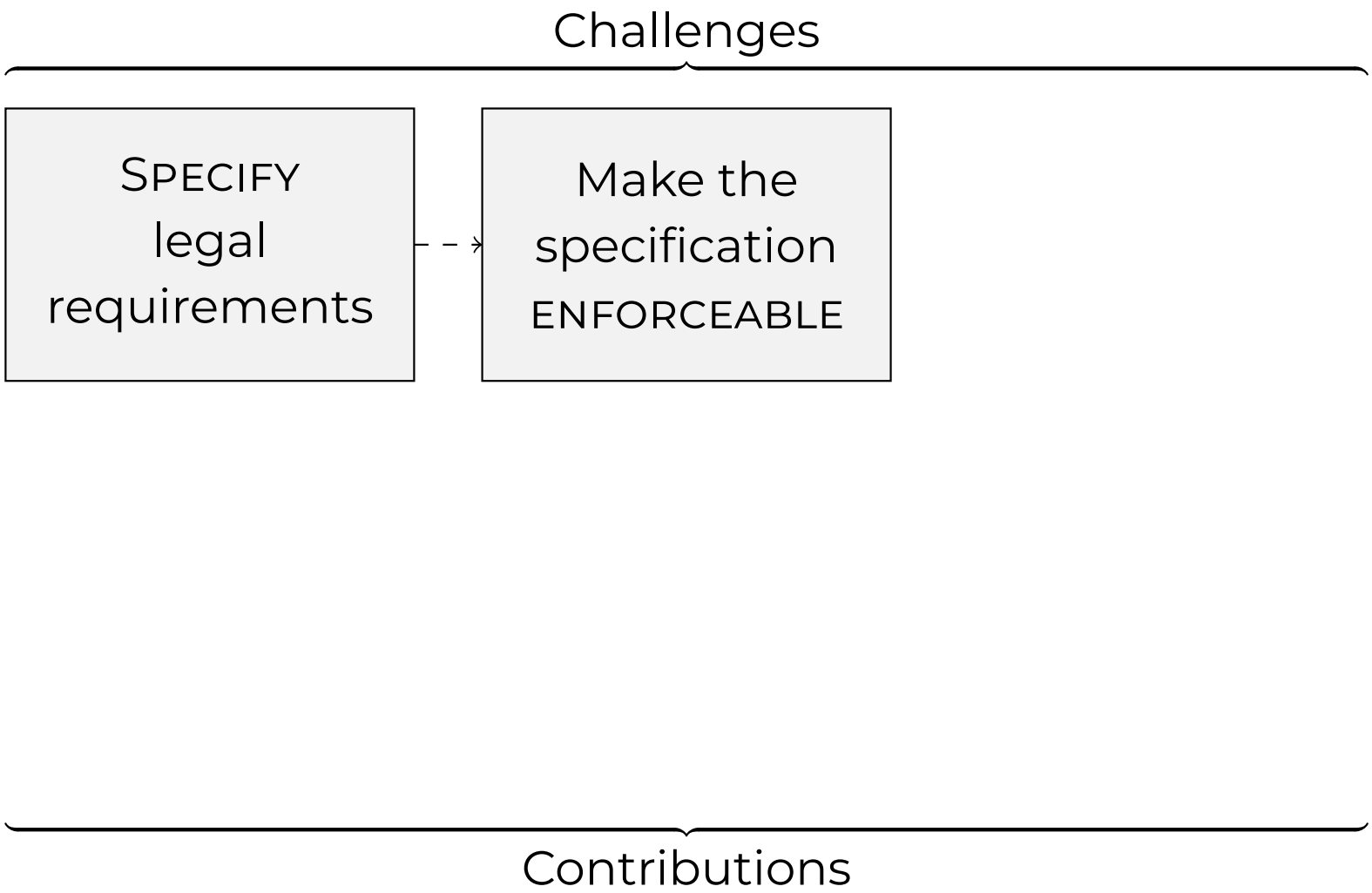

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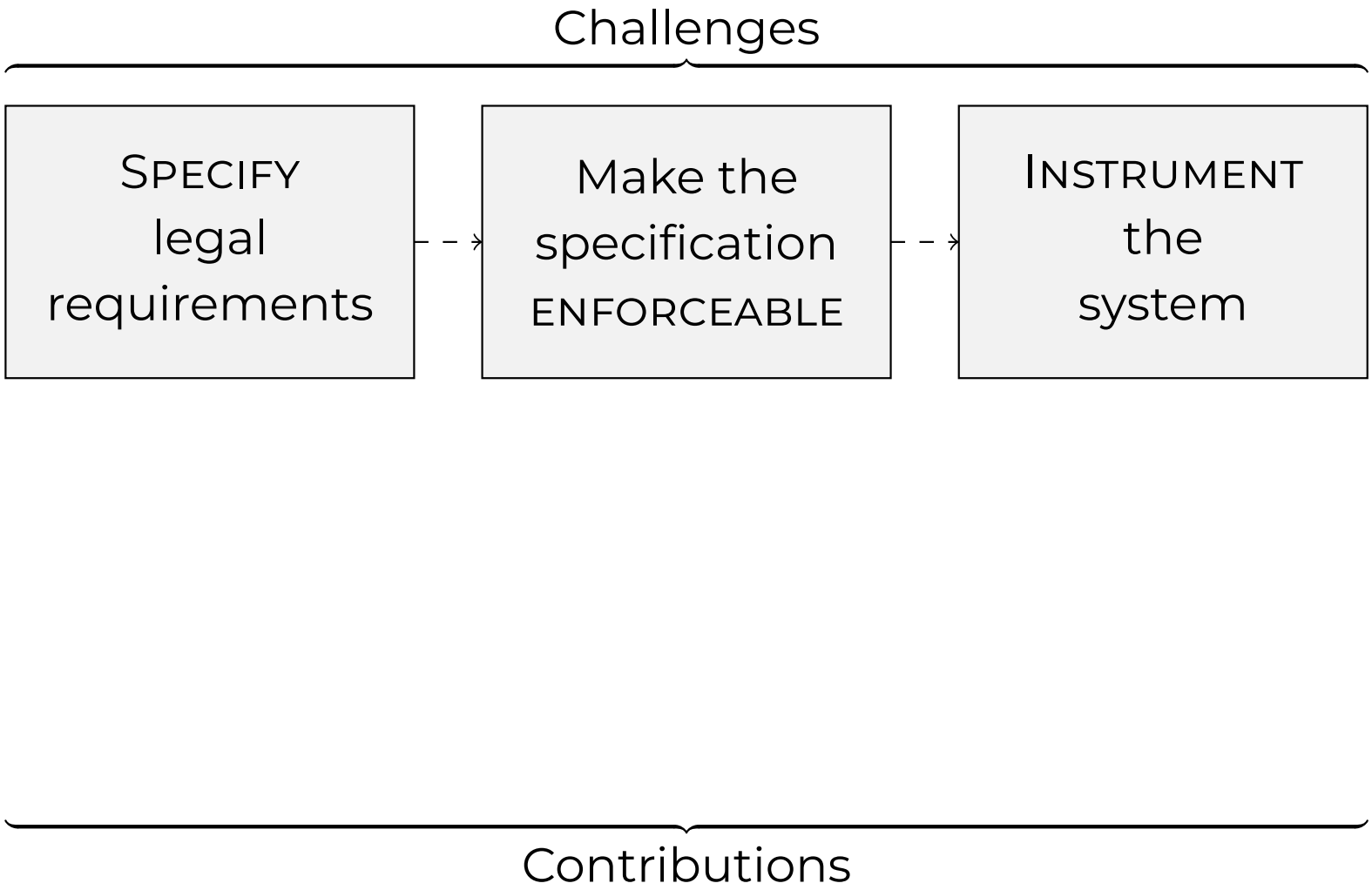

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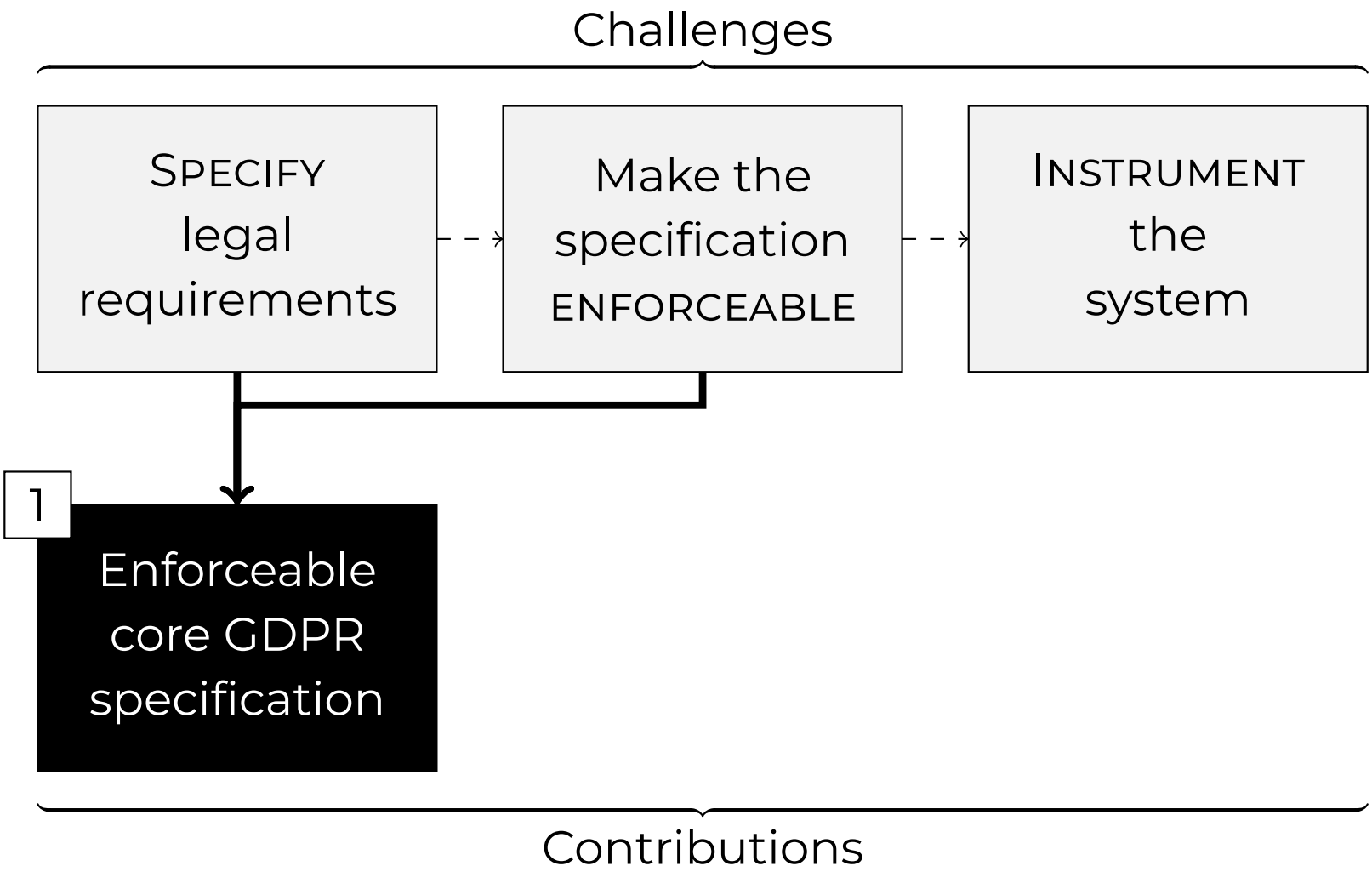

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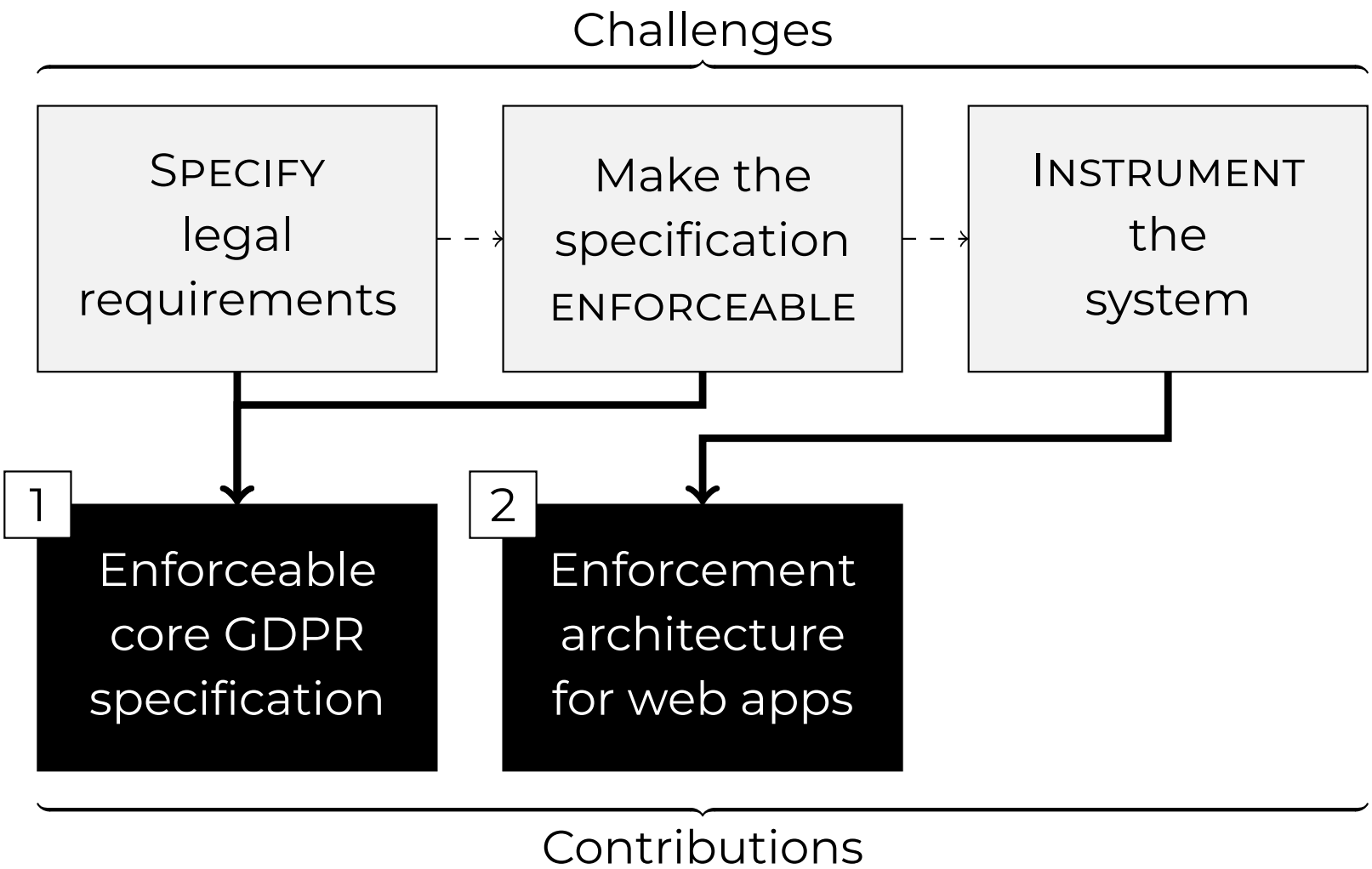

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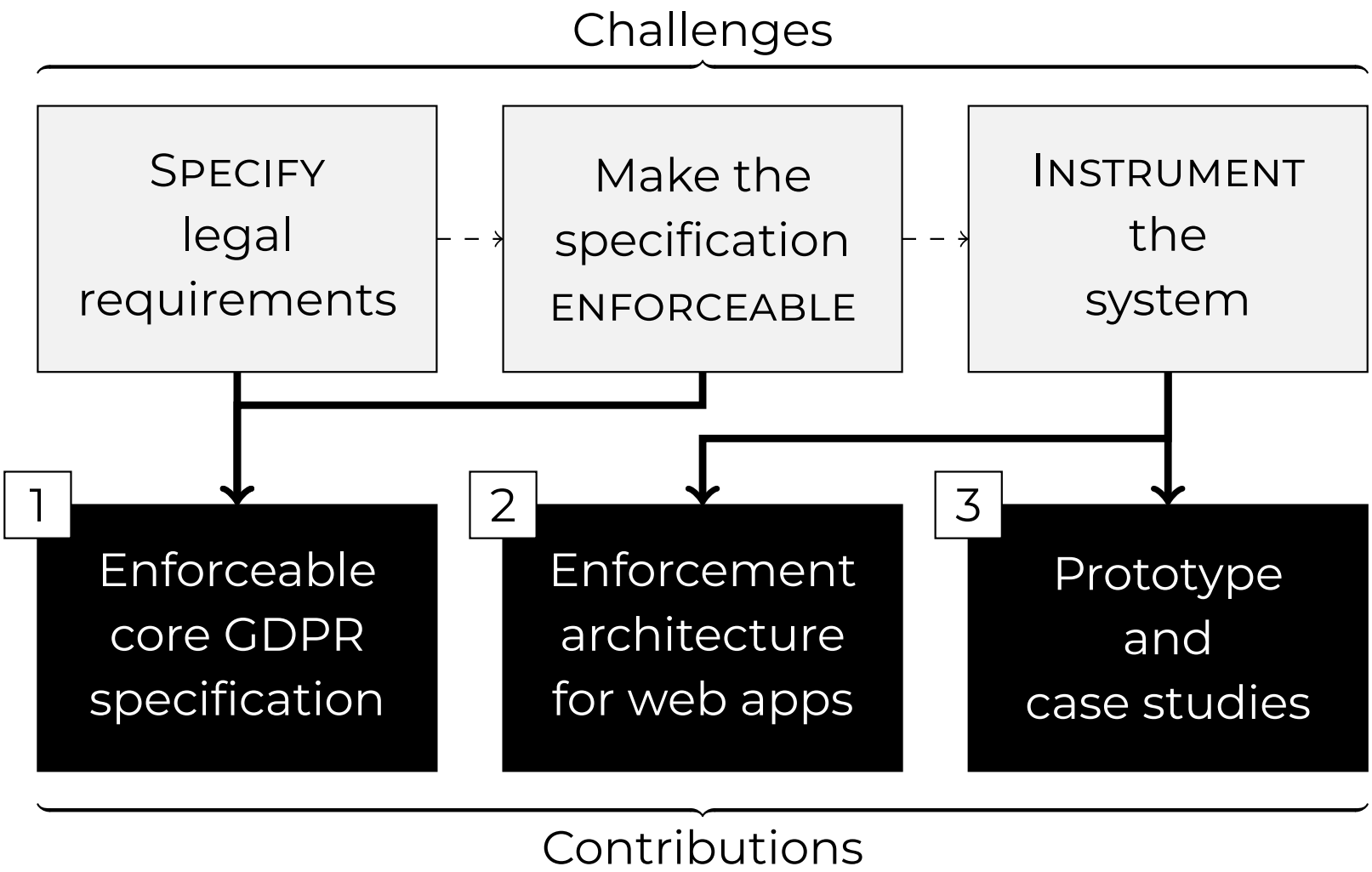

1

Enforceable core GDPR specification

Previous work: Monitorable GDPR specification

> | Article | MFOTL Formula |
> |---|---|
> | 5(1)(c)
Data minimisation | collect (*data*, *dataid*, *dsid*) IMPLIES
EVENTUALLY use(*data*, *dataid*, *dsid*) |
> | 5(1)(e)
Storage limitation | collect (*data*, *dataid*, *dsid*) IMPLIES
EVENTUALLY delete(*data*, *dataid*, *dsid*) |
> | 6(1)
Lawful processing | use(*data*, *dataid*, *dsid*) IMPLIES ONCE
(ds_consent(*dsid*, *data*) OR legal_grounds(*dsid*, *data*)) |
> | 7(3)
Consent | use(*data*, *dataid*, *dsid*) IMPLIES
(ONCE legal_grounds(*dsid*, *data*)) OR
(NOT ds_revoke(*dsid*, *data*) SINCE ds_consent(*dsid*, *data*)) |
>
> Arfelt, E. et al. (2019). Monitoring the GDPR. *ESORICS'19*.

- Focuses on a simple specification of **data subject rights**
- Uses **Metric First-Order Temporal Logic** (MFOTL)
- **Monitors** traces for GDPR violations

Previous work: MFOTL enforcement

Algorithm 1. Function enf

function $\mathsf{enf}(\varphi, \sigma, v)$
  if $\varphi = r(t_1, \ldots, t_n), r \in \mathsf{Sup}$ **then**
    return $(\{(r, (v(t_1), \ldots, v(t_n)))\}, \emptyset)$
  else if $\varphi = \neg r(t_1, \ldots, t_n), r \in \mathsf{Cau}$ **then**
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  else if $\varphi = \varphi_1 \wedge \varphi_2$ **then**
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  $(D^-, D^+) \leftarrow (\emptyset, \emptyset)$
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Hublet, F. et al. (2022). Real-time Policy Enforcement with Metric First-Order Temporal Logic. *ESORICS'22*.

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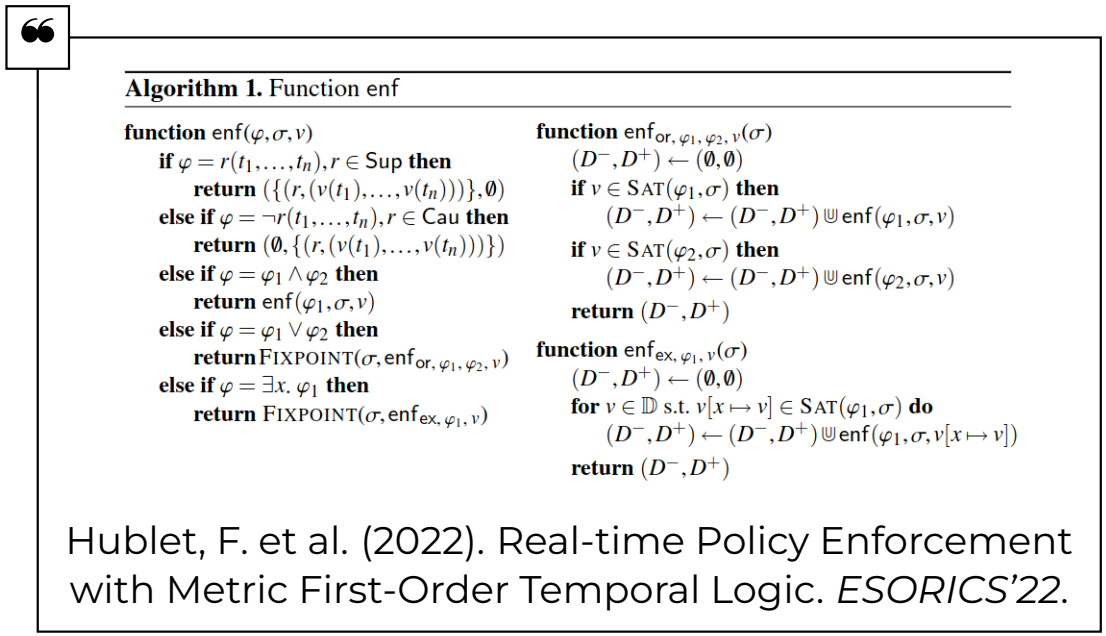

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- Supports **suppressable** and **causable** events

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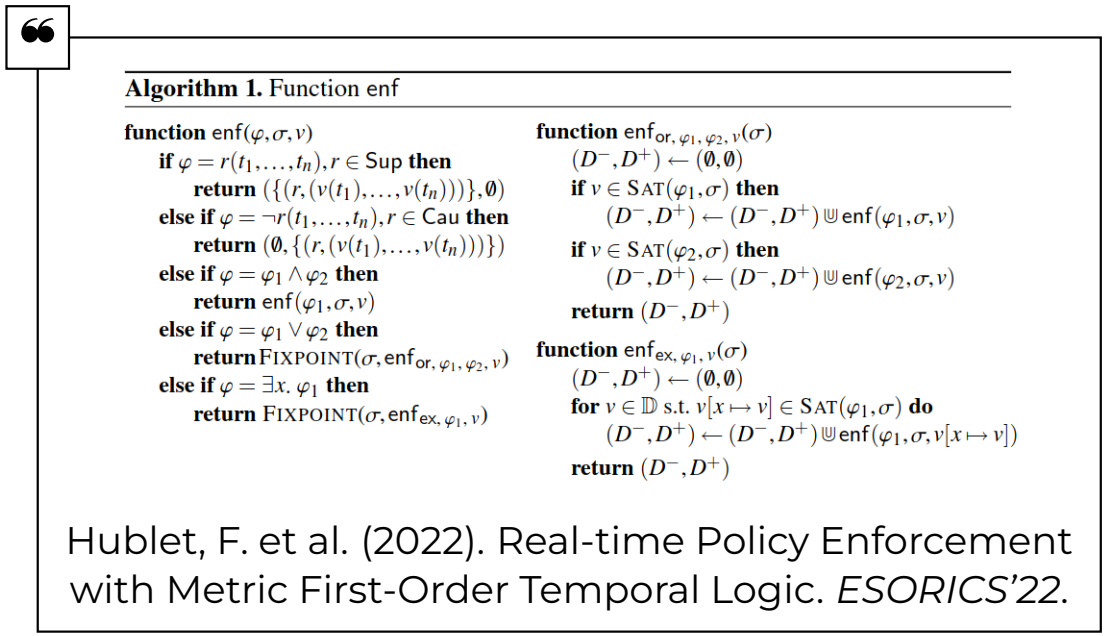

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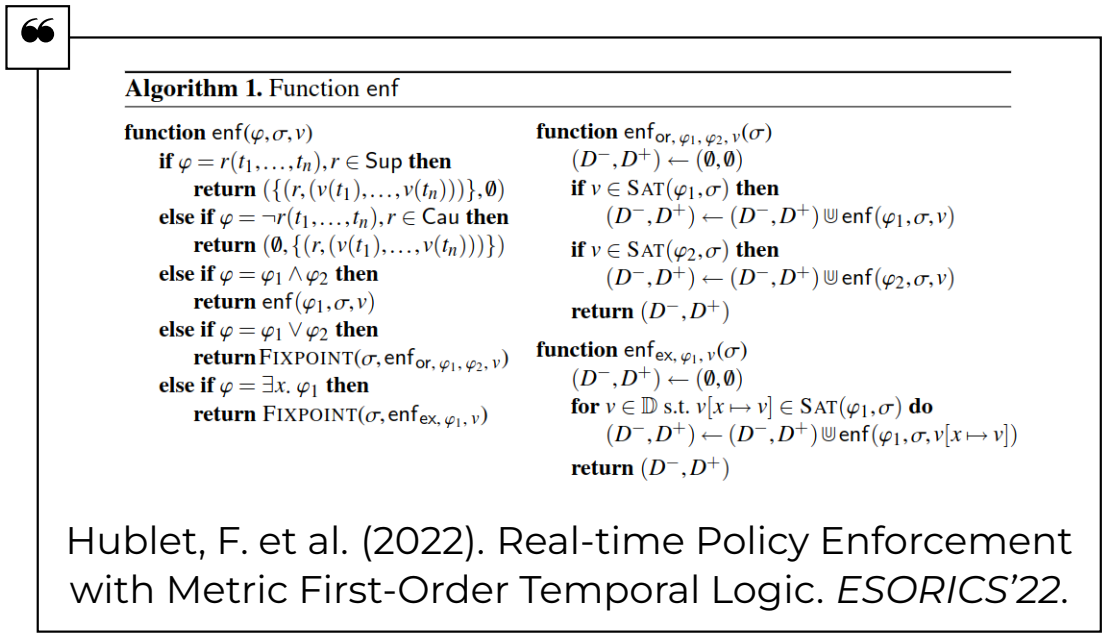

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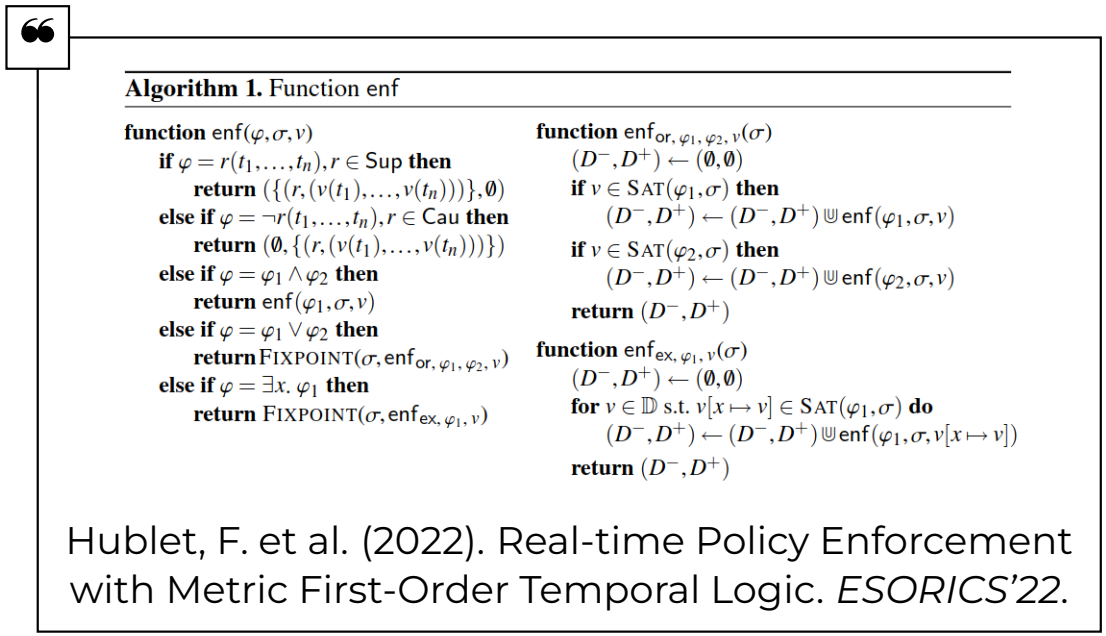

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- Supports **suppressable** and **causable** events
- Characterizes an **enforceable fragment** of MFOTL
- Provides a PDP (**EnfPoly** tool)
- Two main inputs: **signature** + **MFOTL formula**

GDPR signature for enforcement

Event	Description	Type
	The data subject *ds*:	
`DSConsent`(*ds*, *prp*, *d*)	gives consent to use data *d* for purpose *prp*	
`DSRevoke`(*ds*, *prp*, *d*)	revokes consent given to use data *d* for purpose *prp*	
...	...	...
`DSErase`(*ds*, *d*)	requests erasure of data *d*	
...	...	...
	The application:	
`Collect`(*ds*, *d*)	collects data *d* of data subject *ds*	
`Use`(*prp*, *d*)	uses data *d* for purpose *prp*	Ⓢ
...	...	...
`Erase`(*d*)	erases data *d*	Ⓒ
...	...	...
`LegalGround`(*grd*, *d*)	application claims legal ground *grd* for using data *d*	

Ⓒ = Causable; Ⓢ = Suppressable; unmarked events are only-observable

Formalization of core GDPR requirements

We cover 6 core requirements / data subject rights:

- Purpose-based usage
- Right to access
- Right to rectification
- Right to erasure
- Right to restriction
- Right to object

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Core GDPR requirements using MFOTL

Example: **Purpose-based usage**

$$\alpha \,\hat{\mathsf{S}}\, \beta := \alpha \,\mathsf{S}\, (\alpha \wedge \beta)$$

$$\varphi_{\mathrm{Purp}} = \exists prp, d, ds.\ \texttt{Use}(prp, d) \wedge \blacklozenge\, \texttt{Collect}(ds, d)$$
$$\wedge \neg((\neg \texttt{DSRevoke}(ds, prp, d)\ \hat{\mathsf{S}}\ \texttt{DSConsent}(ds, prp, d))$$
$$\vee\ (\exists grd.\ \blacklozenge\, \texttt{LegalGround}(grd, d)))$$

Purpose-based usage is violated when

Core GDPR requirements using MFOTL

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Purpose-based usage is violated when some data *d* is used for purpose *prp*

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Purpose-based usage is violated when some data *d* is used for purpose *prp*, data *d* **was** collected from data subject *ds* and neither

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Purpose-based usage is violated when some data *d* is used for purpose *prp*, data *d* **was** collected from data subject *ds* and neither the data subject *ds* has given (and since then not revoked) consent to process data *d* for purpose *prp*

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Purpose-based usage is violated when some data *d* is used for purpose *prp*, data *d* **was** collected from data subject *ds* and neither the data subject *ds* has given (and since then not revoked) consent to process data *d* for purpose *prp* nor has the application claimed some legal ground *grd* to use data *d*.

Core GDPR requirements using MFOTL

Example: **Purpose-based usage**

$$\alpha \,\hat{\mathsf{S}}\, \beta := \alpha \,\mathsf{S}\, (\alpha \wedge \beta)$$

$$\begin{aligned}\varphi_{\mathrm{Purp}} = \exists \mathit{prp}, \mathit{d}, \mathit{ds}.\ &\texttt{Use}(\mathit{prp}, \mathit{d}) \wedge \blacklozenge\, \texttt{Collect}(\mathit{ds}, \mathit{d}) \\ &\wedge \neg((\neg \texttt{DSRevoke}(\mathit{ds}, \mathit{prp}, \mathit{d}) \,\hat{\mathsf{S}}\, \texttt{DSConsent}(\mathit{ds}, \mathit{prp}, \mathit{d})) \\ &\quad \vee (\exists \mathit{grd}.\ \blacklozenge\, \texttt{LegalGround}(\mathit{grd}, \mathit{d})))\end{aligned}$$

Purpose-based usage is violated when some data *d* is used for purpose *prp*, data *d* **was** collected from data subject *ds* and neither the data subject *ds* has given (and since then not revoked) consent to process data *d* for purpose *prp* nor has the application claimed some legal ground *grd* to use data *d*.

Core GDPR requirements using MFOTL (II)

Example: **Right to erasure**

$$\varphi_{\text{Erasure}} = \exists ds, ut.\ \texttt{DSErase}(ds, d) \wedge \blacklozenge\, \texttt{Collect}(ds, d) \wedge \neg \texttt{Erase}(d)$$

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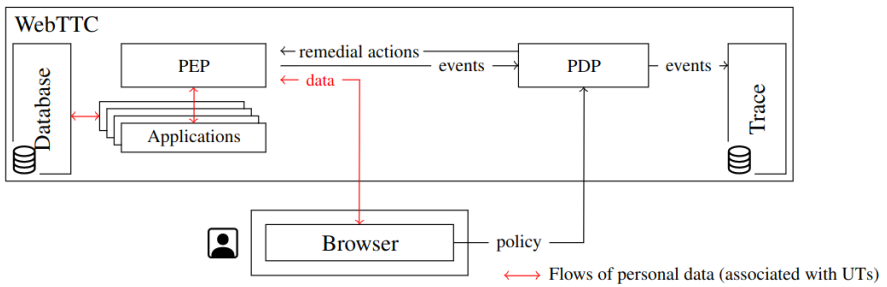
Enforceability

- Our formalization is **enforceable**, being in the enforceable fragment from Hublet et al. (2022)
- Enforcement through suppression / causation
  - Purpose based-usage: suppression of `Use`
  - Right to erasure: causation of `Erase`

2

Enforcement architecture for web apps

Previous work: WebTTC



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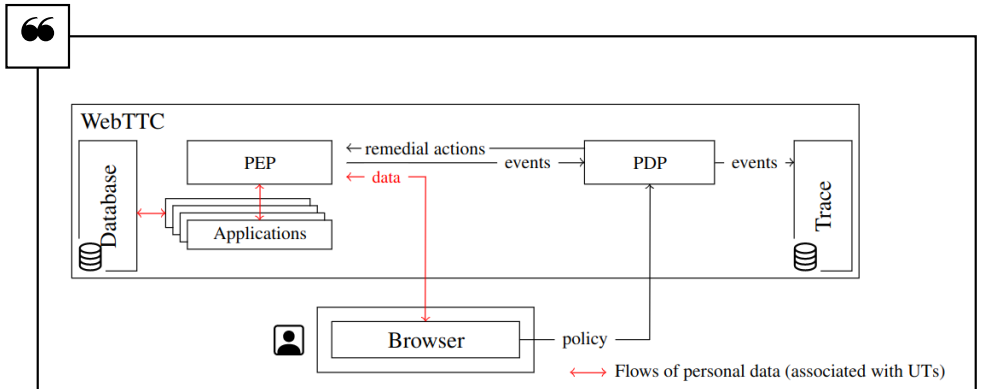

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- Enforces **MFOTL privacy policies** in web applications by observing the following events:

Event	Description	Type
$\texttt{In}(u, d)$	Data subject *ds* inputs a value with UT *d*	
$\texttt{Out}(u, prp, d)$	Value with UT *d* is output to data subject *ds* for purpose *prp*	Ⓢ
$\texttt{Itf}(d, o)$	Input with UT *d* interferes with output *o*	

Ⓢ = Suppressable; unmarked events are only-observable

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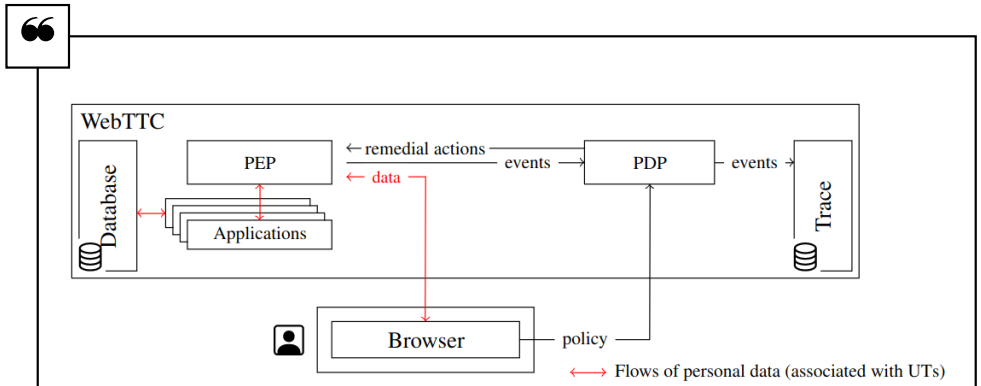

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- **Python-like language** with dynamic Information Flow Control

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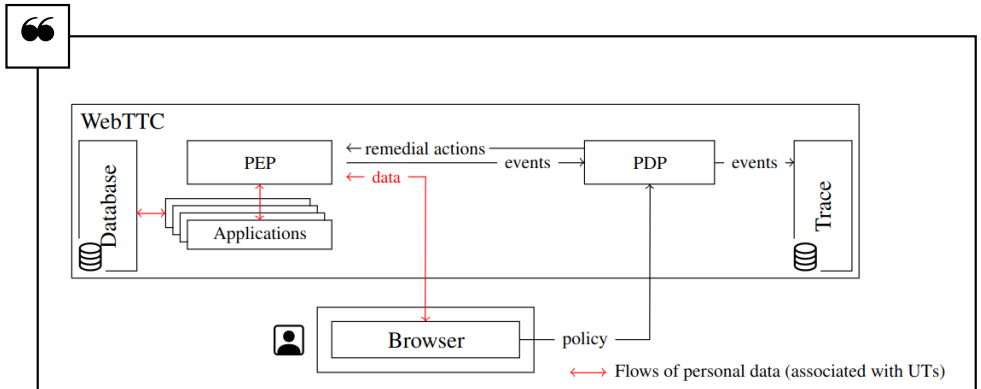

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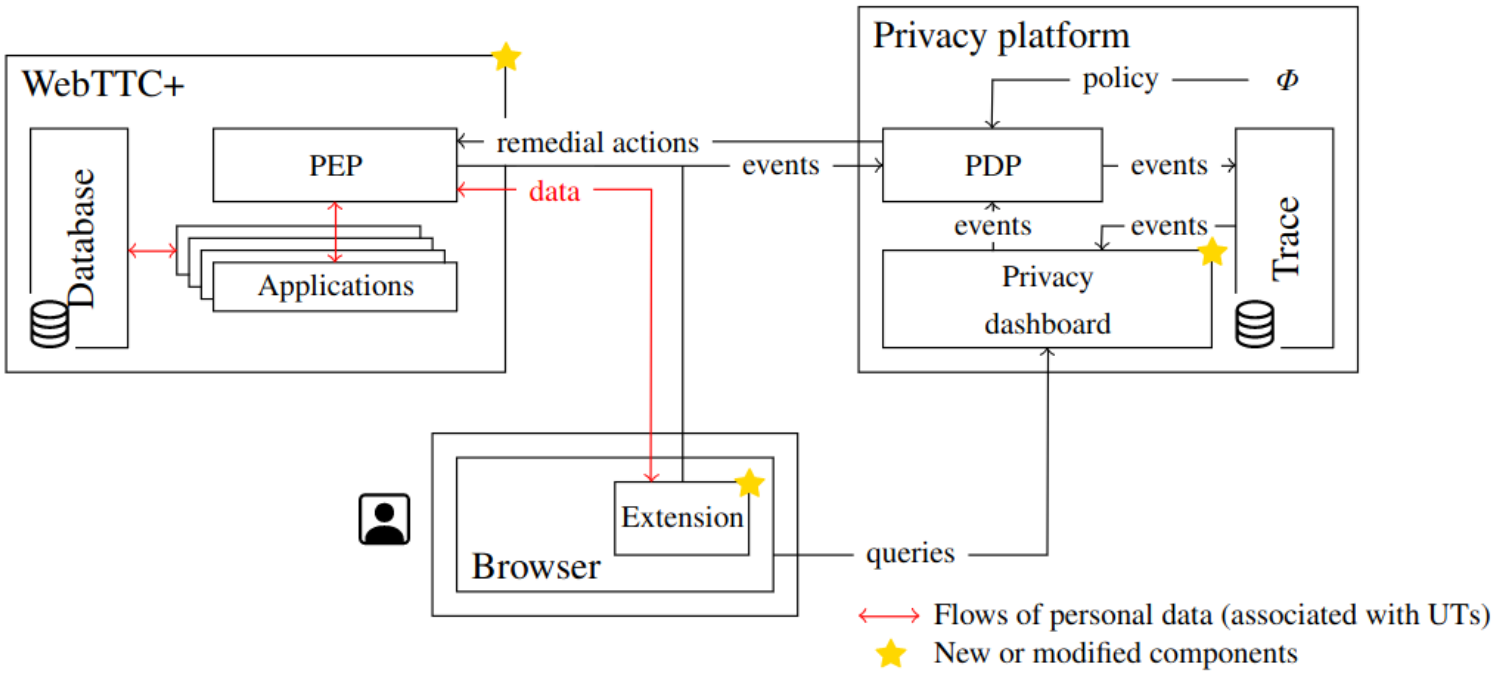
- **Python-like language** with dynamic Information Flow Control
- Associates **unique taints** (UTs) to inputs and propagates them

Our enforcement architecture: WebTTC+

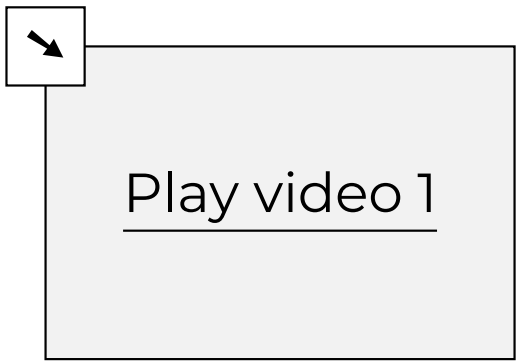


Instrumentation

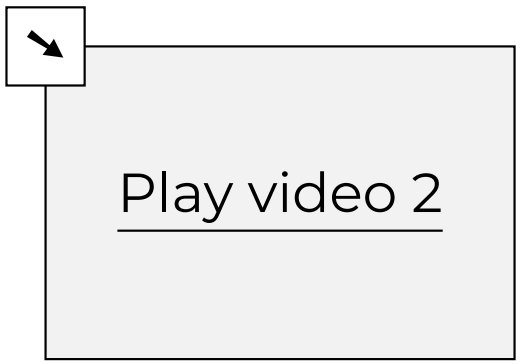
- Events are emitted at input or output time, on user request (`DS`...) or on PDP request (causable events)

Event	Type	When emitted?	By...
`DSConsent`(ds, prp, d)		Input time / on user request	Extension / Dashboard
`DSRevoke`(ds, prp, d)		On user request	Dashboard
`DSErase`(ds, d)		On user request	Dashboard
`Collect`(ds, d, sp)		Input time	Extension
`Use`(prp, d)	Ⓢ	Output time	PEP
`Erase`(d)	Ⓒ	On enforcer request	PEP

Instrumentation: input time



Instrumentation: user requests



3

Prototype and case studies

Prototype

Includes:

- WebTTC+
- Privacy platform including EnfPoly wrapper
- PoC browser extension
- EnfPoly (Hublet et al. 2022)

$\sim$ 3k lines of code on top of WebTTC and EnfPoly

Evaluation

We ported three applications from previous work (Wang et al. 2019, Yang et al. 2016).

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RQ3: What share of the GDPRs provisions does our implementation effectively enforce?

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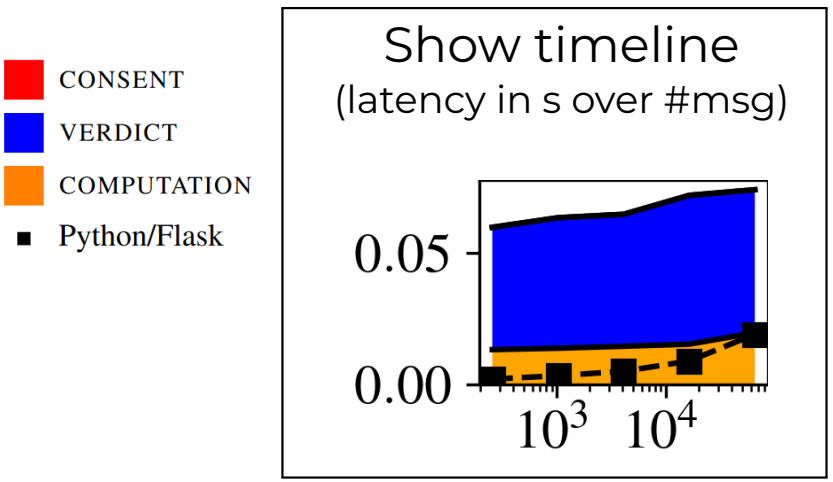

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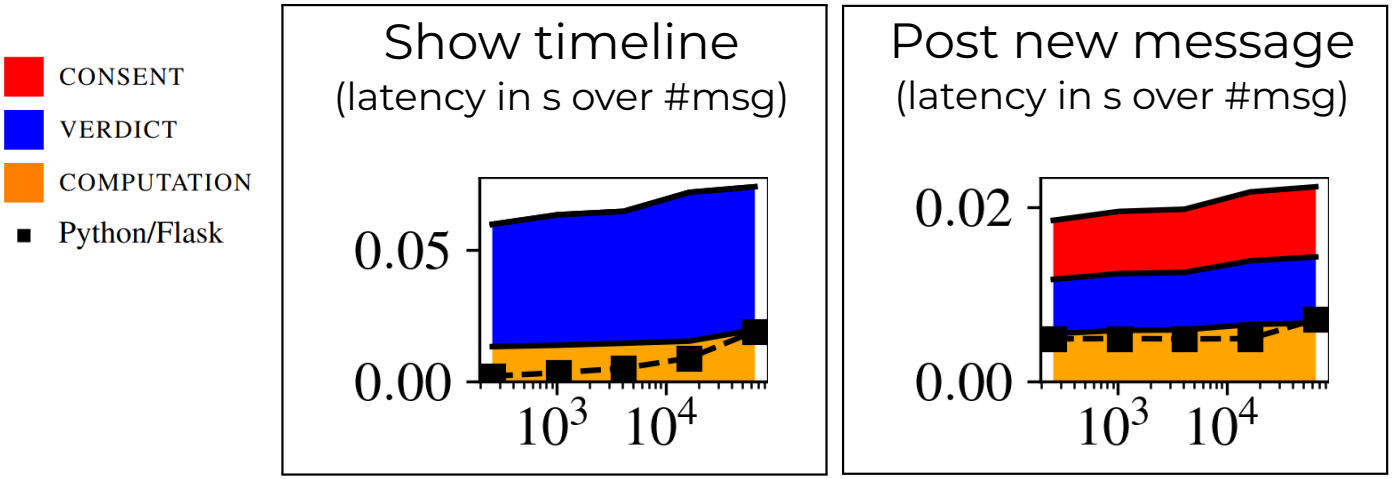

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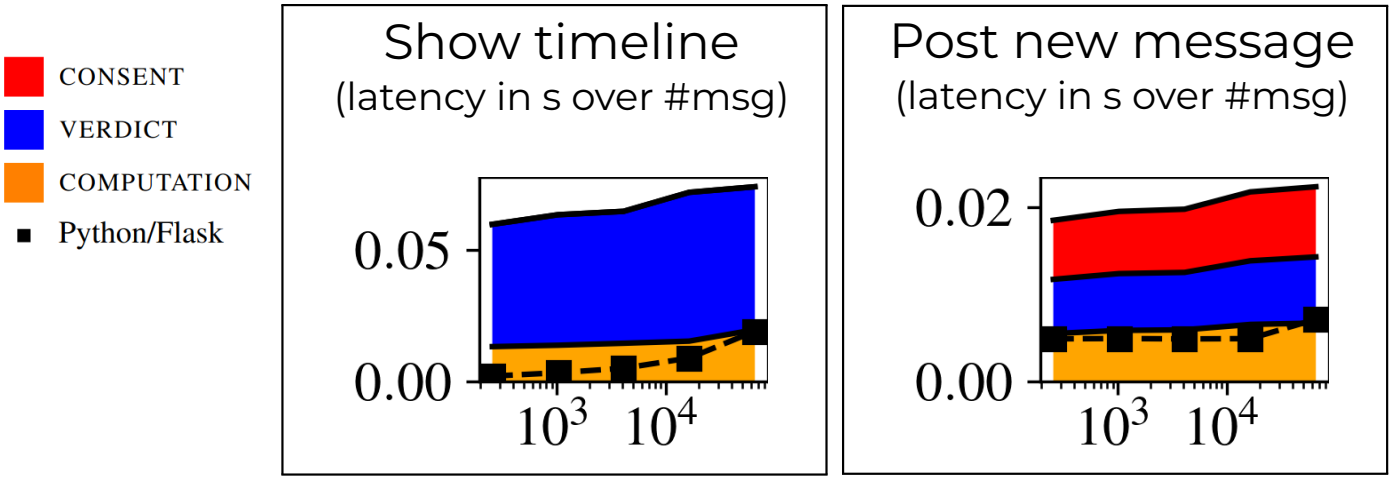

RQ3: About 2/3 of the fines imposed until May 2023 are related to at least one of the articles addressed by our approach

Conclusion and future work

- First work to provide an enforceable specification + enforcement architecture for a core of the GDPR

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Contributions

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Contributions

Enforceable core GDPR specification	Enforcement architecture for web apps	Prototype and case studies

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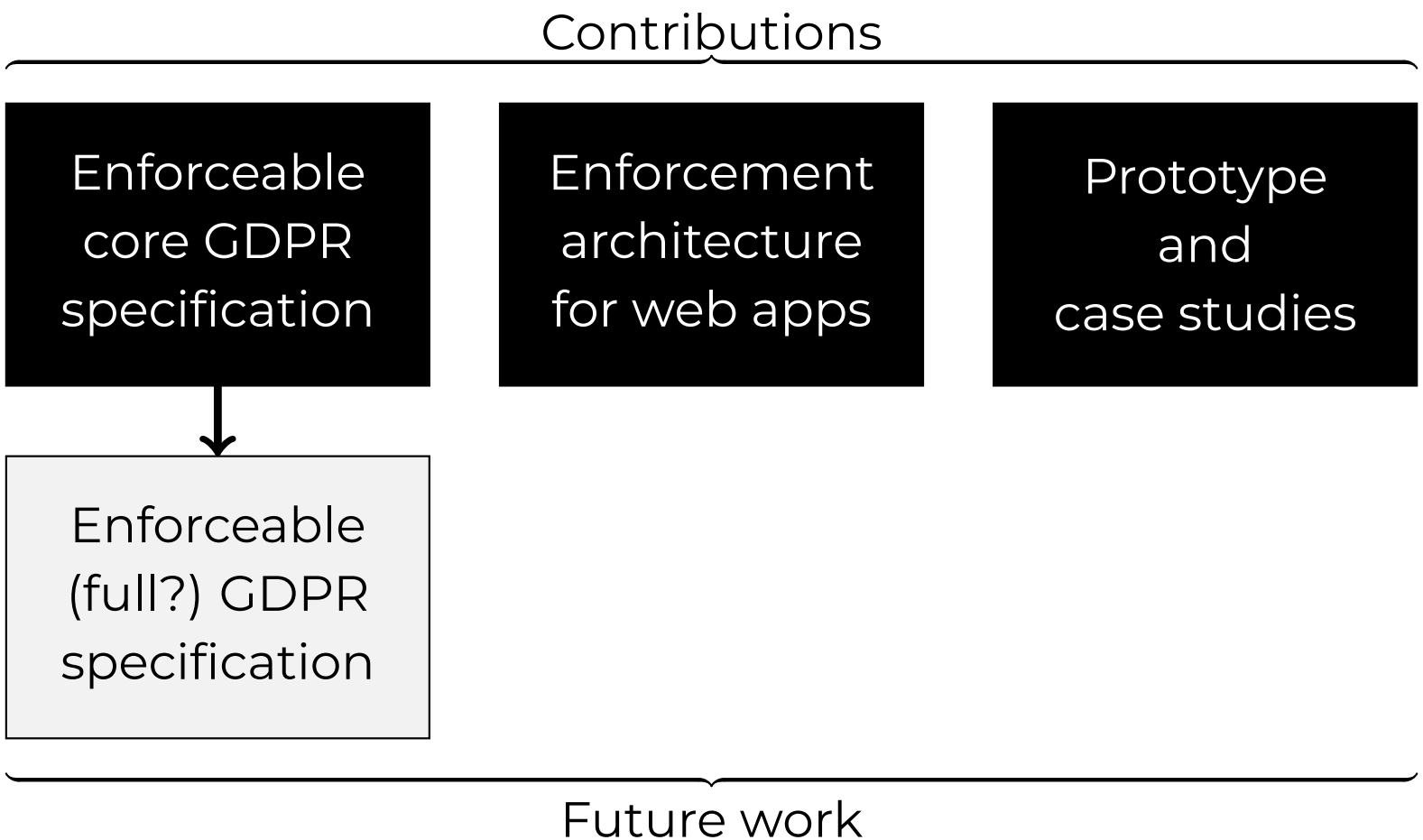

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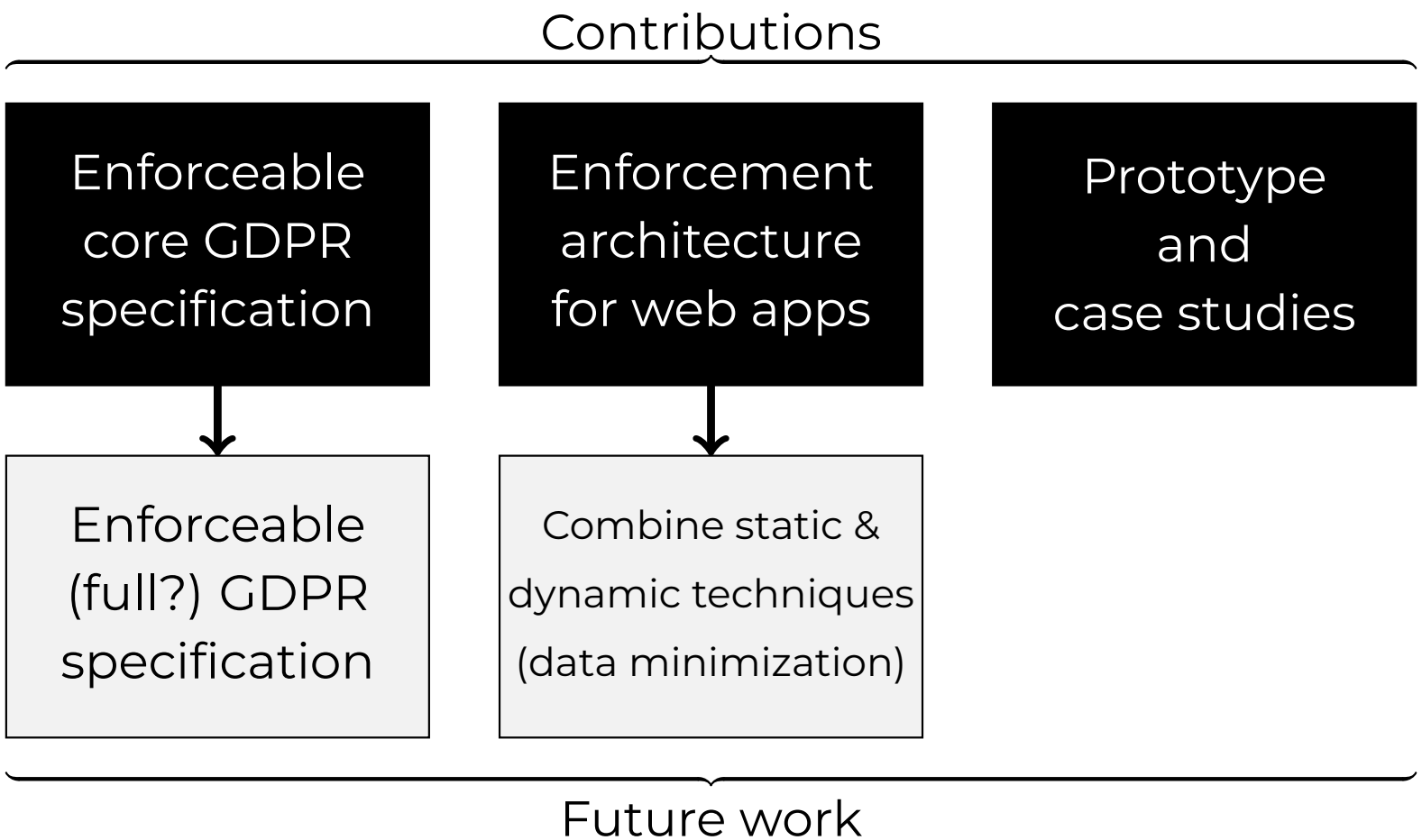

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