



Implementing Informed Consent with Knowledge Graphs

ESWC21 PhD Symposium

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With inputs from Anna Fensel

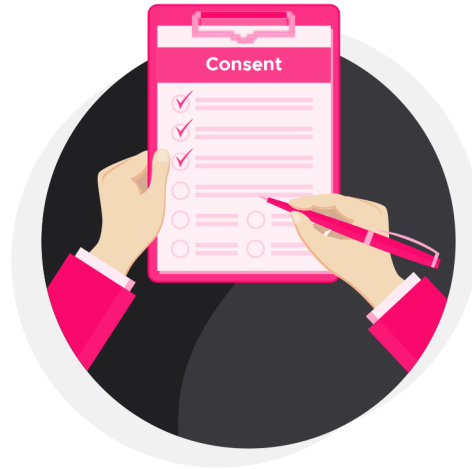
Outline

- 1) Introduction to consent and GDPR
- 2) Consent in smart cities
- 3) Main research questions
- 4) Approach
- 5) Knowledge graphs as a consent solution
- 6) Preliminary results
- 7) Next steps
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Consent

“Any **freely given, specific, informed** and **unambiguous** indication of the data subject’s wishes by which he or she, by a statement or by a clear affirmative action, signifies **agreement to the processing of personal data** relating to him or her”

- Article 4(11) of GDPR



Informed consent

The data subject should know:

- Who is the data controller?
- What kind of data will be used?
- For what purpose is the data required?
- How the data will be used?
- How the data will be processed?
- Where will the data be stored?
- With whom will the data be shared?



2. Consent in smart cities

- In smart cities, one's data is spread across multiple different silos (databases, locations, people) and can be used for different purposes by different entities simultaneously
- Implementing consent should be done in a way that does not disrupt the data flow between those silos, while being compliant with GDPR



This project has received funding
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No 871477, the smashHIT project



Main challenges

- **Responsibilities**

- Who is responsible for what?

- Who records the consent?

- **Storage**

- Where is consent stored?

- What privacy and security mechanisms are in place?

- Who has access to it? Can it be changed without the user's knowledge?

- **Implications of revoking consent**

- How to revoke consent?

- What happens to the data and the processes after consent is revoked?

- **Awareness of what it means to give consent and the implications that follow**

3. Main research questions

RQ1: How to implement informed consent with knowledge graphs in a way that supports its federation across multiple domains?

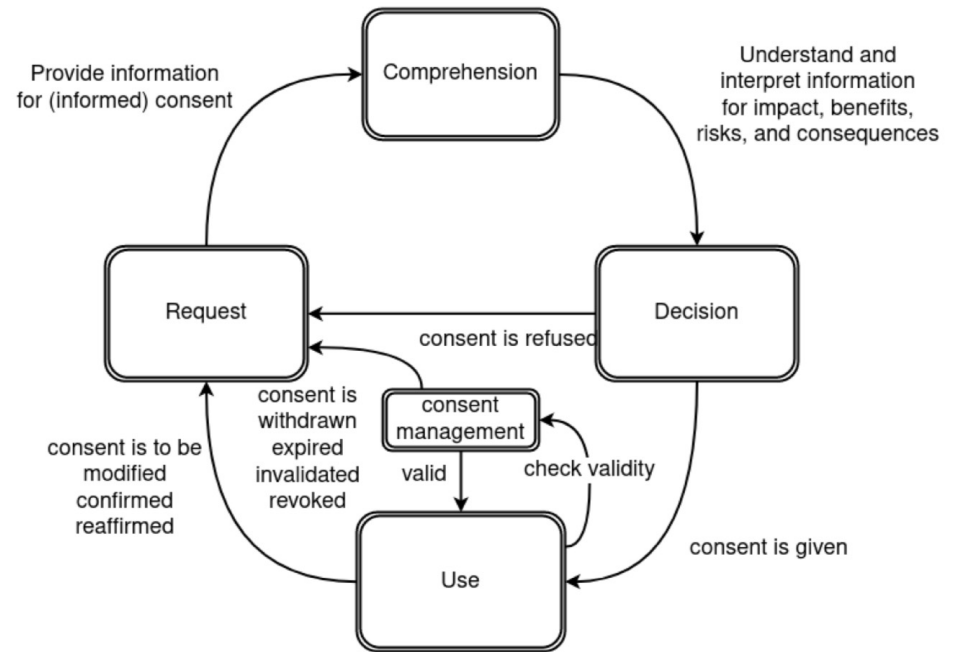
RQ2: Does a visualisation of a knowledge graph help improve one's comprehension of consent?

- *How to explain consent to individuals in an understandable way with the help of visualisations?*
- *Can incentives be used to raise one's legal awareness?*

4. Approach

Main idea: Use knowledge graphs to represent consent through its whole life-cycle

- Reuse existing ontologies for:
 - consent:** GConsent [1], CDMM [2], PrOnto [3], BPR4GDPR [4], SPECIAL [5], DUO [6], ICO [7], The Neurona Ontologies [8], OntoPrivacy [9]
 - sensor data:** OntoSensor [6], SDO [7], SSN [8]
 - contracts:** FIBO [9]
 - data sharing:** DSAP [10]
- Combine them in one ontology for consent in smart cities (but not limited to it)
- Use the ontology as the schema for a knowledge graph
- Visualise the ontology via a user interface (UI) (consent request and what happens after it)
- Use incentives to increase legal comprehension and awareness of consent



Consent life-cycle by Kurteva et al. [15]

5. Knowledge graphs as a consent solution

Benefits of knowledge graphs related, but not limited, to consent:

Transparency (data is in both human-readable and machine-readable formats)

Traceability (one can reuse ontologies for provenance, events, time to timestamp data)

Knowledge discovery (discover patterns, inconsistencies, security and privacy issues)

Reasoning (GDPR compliance checking)

Understanding connections between data (e.g. how a third-party gained access to specific user data)

Common understanding across all silos

5.1. Existing semantic models for consent

Several ontologies exist: GConsent [1], CDMM [2], PrOnto [3], BPR4GDPR [4], SPECIAL-K [5], DUO [6], ICO[7], The Neurona Ontologies [8], OntoPrivacy [9]

Common limitations:

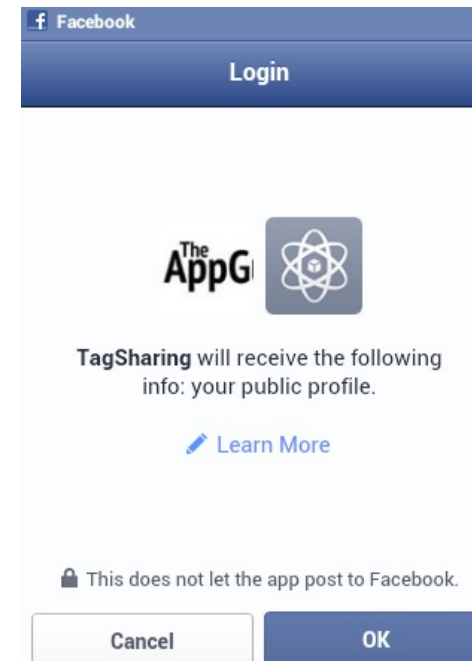
- Too general (do not model use cases such as consent in smart city)
- Built for a specific use case
- Representing only consent (no specific information about the data or the processes)
- Do not model consent state changes (e.g. revocation)
- Not open-access

Survey paper:

A. Kurteva, T. Raj Chhetri, H. J. Pandit, A. Fensel, Consent Through the Lens of Semantics: State of the Art Survey and Best Practices, Semantic Web journal, IOS Press, June 2021.

5.2. Issues when visualising consent to users

- Information overload
- Privacy policy written in technical and legal jargon
- Not compliant with GDPR
- Consent information is not visible:
 - Why is data required?
 - How data is processed?
 - Where data is stored?
- Users are unaware of *“the right to be forgotten”*[5]



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Place

The Data is processed at the Data Controller's operating offices and in any other places where the parties involved with the processing are located. For further information, please contact the Data Controller.

Retention time

The Data is kept for the time necessary to provide the service requested by the User, or stated by the purposes outlined in this document, and the User can always request that the Data Controller suspend or remove the data.

The use of the collected Data

“Google Maps” Would Like to Use Your Current Location

Don't Allow

OK

6. Preliminary results of this research

Defined the concept of a **campaign** (according to the CampaNeo² and smashHit³ projects)

Campaign: a specific request for data sharing made from a company to the end user.



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Sample campaign

- The Tyrolean government wants to examine which roads of Innsbruck are heavily used in order to determine if further investment is needed.
- A campaign called "Roads of Innsbruck" is created and posted on the CampaNeo² platform.

Data of interest:

- GPS data from car drivers in the area of Innsbruck and up to 15 km away.
- The data will be stored anonymously in a central database in Kufstein owned by the government itself.
- Upon user consent data will be shared with STI Innsbruck for running a research on car traffic at various time of the day.

6.1 Current state of the ontology

Reuse existing ontologies for:

Consent: GConsent [1], CDMM [2], PrOnto [3]...

Sensor data: OntoSensor [10], SDO [11], SSN [12]

Contracts: FIBO [13]

Data sharing: DSAP [14]

Defined data processing

Defined consent revocation

Metrics

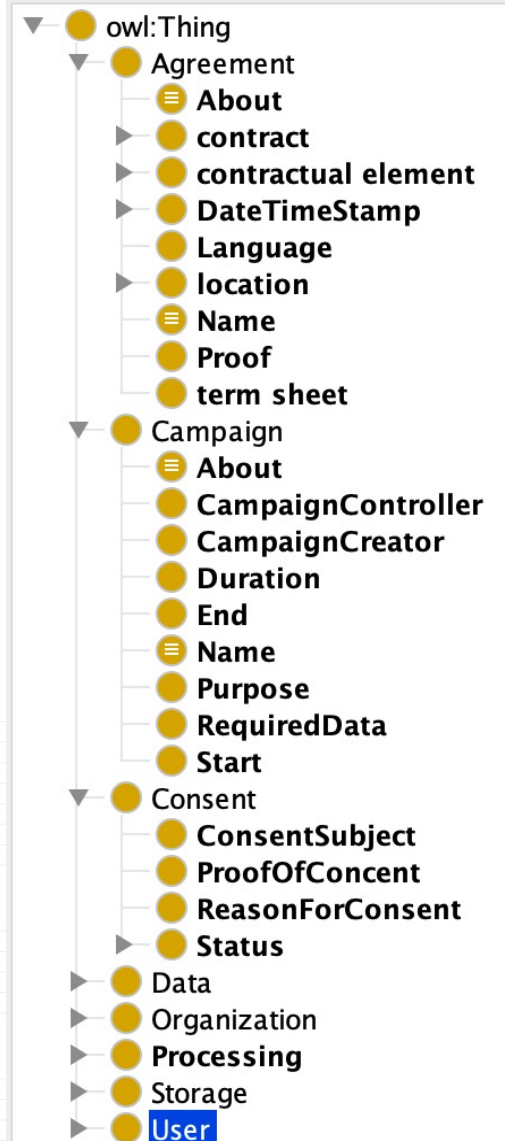
Axiom	696
Logical axiom count	290
Declaration axioms count	224
Class count	166
Object property count	42
Data property count	8
Individual count	0
Annotation Property count	12

Class axioms

SubClassOf	171
EquivalentClasses	1
DisjointClasses	3
GCI count	0
Hidden GCI Count	2

Object property axioms

SubObjectPropertyOf	24
EquivalentObjectProperties	0
InverseObjectProperties	0
DisjointObjectProperties	0
FunctionalObjectProperty	0
InverseFunctionalObjectProperty	0



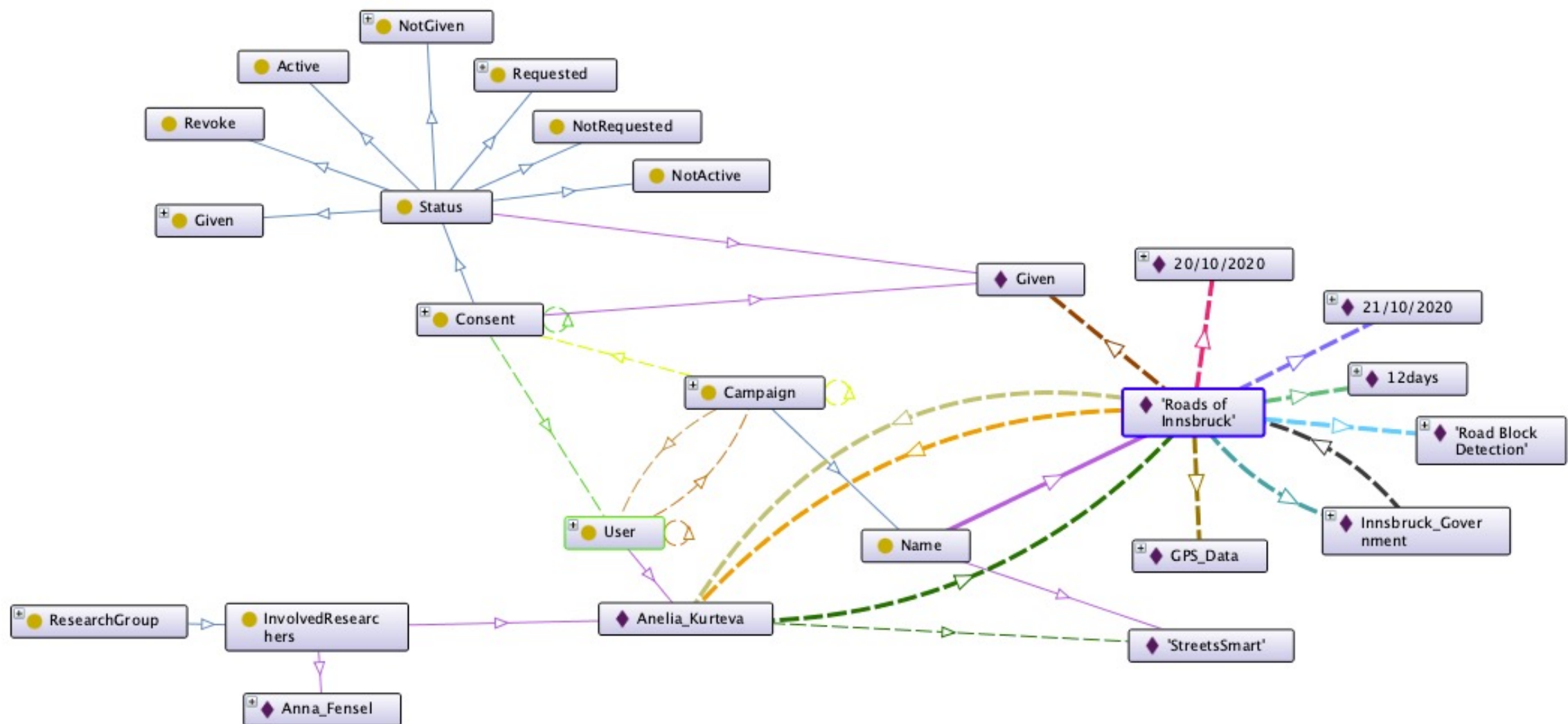


Figure 1. High-level overview of the consent ontology

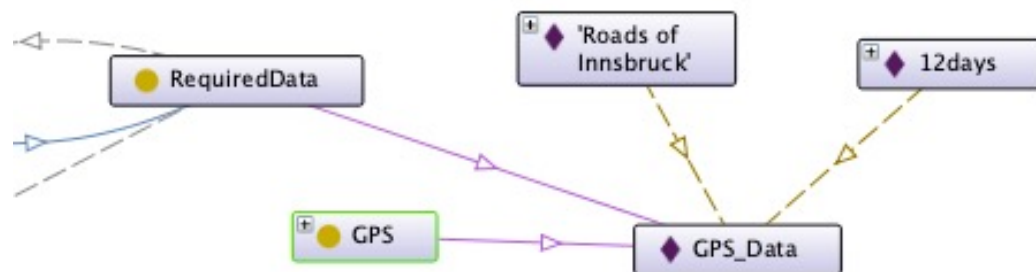


Fig 3. Required Data

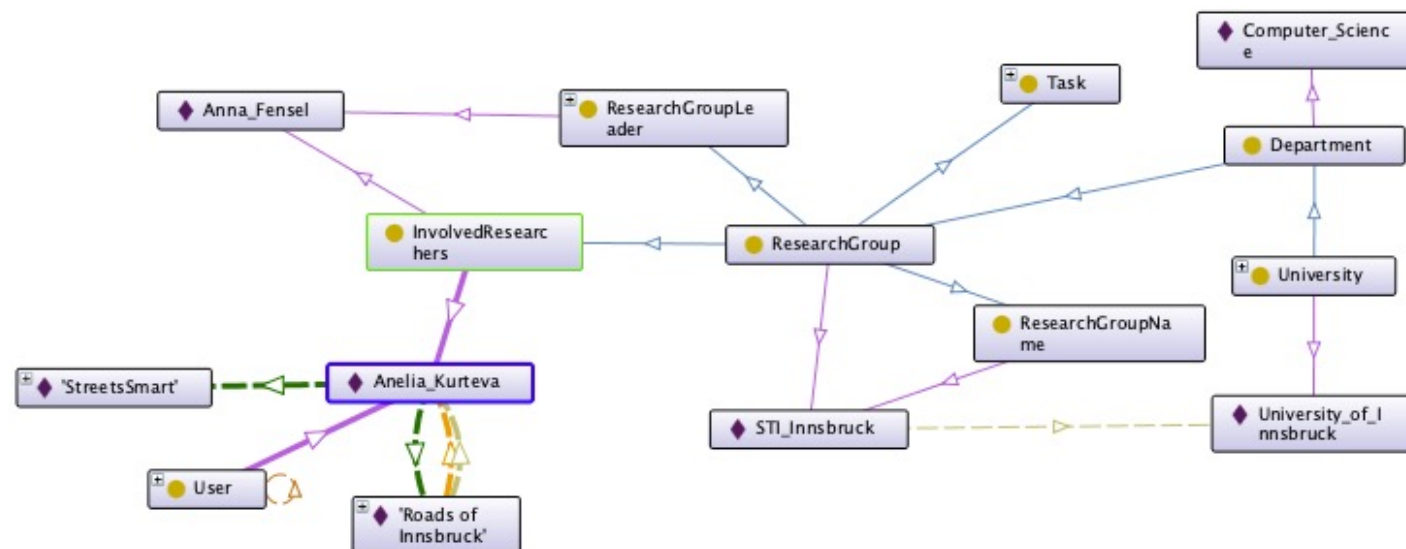


Fig 4. Involved users

6.2 Consent solicitation UI

- Developed with Flutter³
 - Google's new UI toolkit
 - Cross-platform software development
- Follows the consent ontology
- Represents campaigns and allows users to manage their consent (e.g. grant, revoke consent)
- Designed for use in a vehicle (on a tablet or phone)

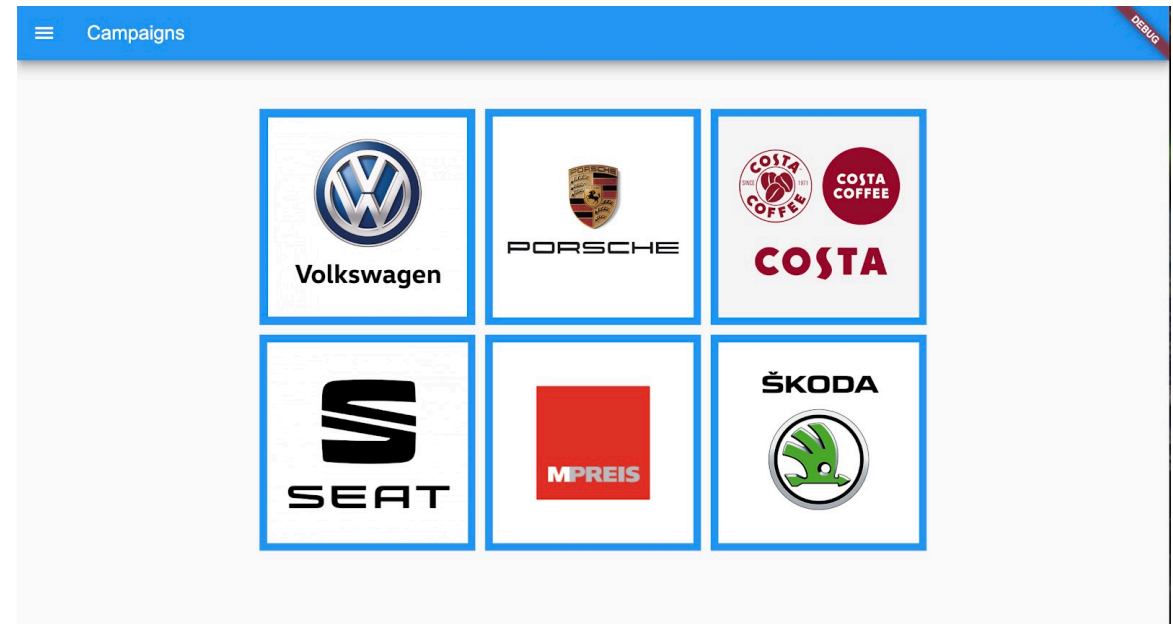


Fig. 5 Campaign visualisation UI

Campaign Details


 Volkswagen https://www.volkswagenag.com	Company:	Volkswagen
	Campaign:	Roads of Innsbruck
	Collected Data:	GPS, Speed, Acceleration, Tire pressure, ABS, ESP
	Start Date:	10/01/2020
	End Date:	12/10/2020
		<input checked="" type="checkbox"/> <input type="checkbox"/>

Fig. 6 Campaign visualisation UI (campaign details)

Do you agree to share the following data?

GPS	<input checked="" type="checkbox"/>
ABS	<input type="checkbox"/>
Tire Pressure	<input checked="" type="checkbox"/>
Speed	<input checked="" type="checkbox"/>
EPS	<input type="checkbox"/>
<input checked="" type="button" value="I Agree"/> <input type="button" value="Disagree"/>	

Fig. 7 User consent preferences

6.3 Consent visualisation (data sharing)

- Visualisation of what happens after consent is given
- Uses a knowledge graph as a main source of information
- D3.js visualisation library

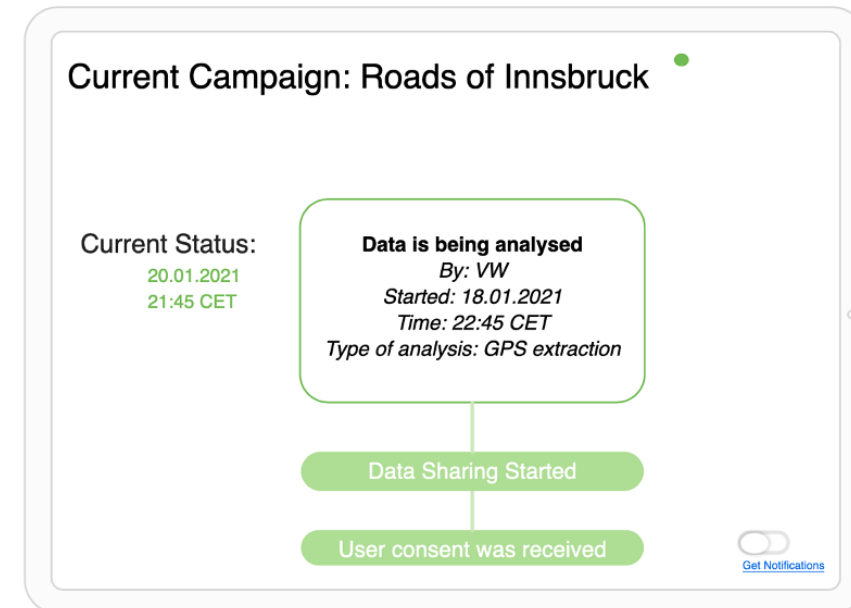


Fig. 8 Detailed campaign view

Details:

C. Bless, L. Dötlinger, M. Kaltschmid, M. Reiter, A. Kurteva, A. J. Roa-Valverde, A. Fensel, *Raising Awareness of Data Sharing Consent Through Knowledge Graph Visualisation*, SEMANTiCs, June 2021.

A. Kurteva, H. De Ribaupierre, *Interface to Query and Visualise Definitions from a Knowledge Base*, International Conference on Web Engineering (ICWE 2021), May 2021.

7. Next steps

- Extend the knowledge graph with more concepts and instances
- Implement the visualisation of what happens after consent is given (Fig. 8)
- Select and implement an incentive (e.g gamification)
- Testing

8. Evaluation (in progress)

Ontology/Knowledge Graph

- Testing with use-case specific competency questions (as SPARQL queries)
- Comparison of the evaluation (of the ontology expressivity) with existing ontologies such as GConsent
- Review of the results with legal and use-case experts
- Integration with services from the smashHit³ Automatic Contracting Tool
- Truthfulness testing with tools such as OntoManager [11]; quality testing with ODEval [12]; SHACL⁴ validation

Consent Visualisations (Consent Solicitation UI and Data Sharing)

- Usability and design surveys with users
- Consent comprehension survey in the form of a test (similar to CoRe [13] and CURE's [14] evaluation)
- User motivation survey (testing the effectiveness of the incentives)



9. Research contribution

- A **knowledge graph** model for consent implementation in smart cities in compliance with GDPR
- Achieving **process transparency of data sharing** with knowledge graphs
- A **new approach (based on incentives)** to raise awareness about the **implications of giving and revoking consent** for data sharing and GDPR



Thank you!

Questions?

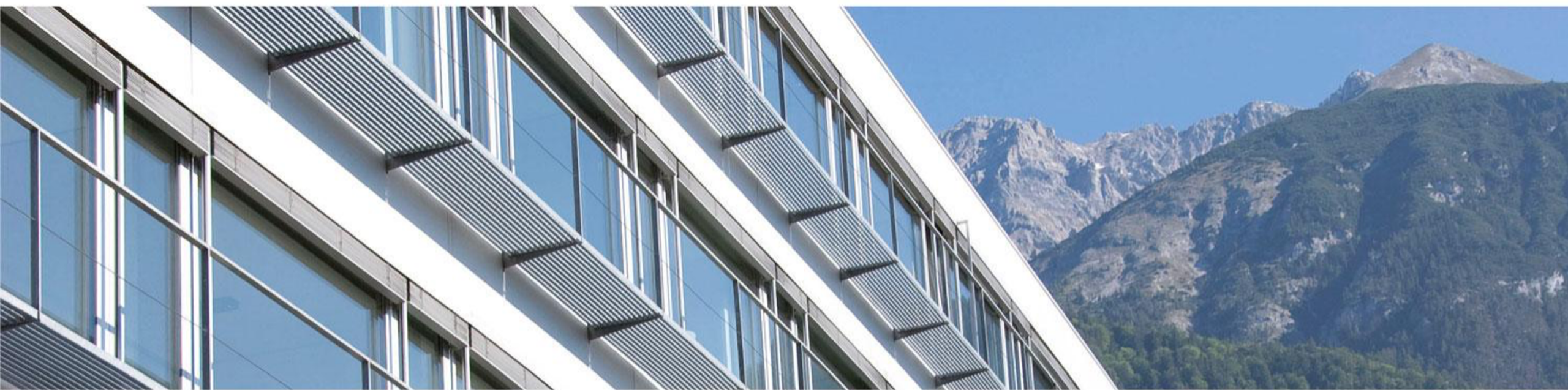


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