Engaging Content
Engaging People

Test-driven approach towards GDPR compliance

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European Union
European Regional Development Fund
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Presentation Structure

1. Aims and Goals
2. Use-case: Consent mechanism on a website
3. Information requirements
4. Creating dataset in RDF
5. Some interesting findings
6. GDPR requirements expressed as constraints
7. Testing constraints using SHACL
8. Results of compliance process
9. Discussion
10. Q&A

Domain / Scope

A typical scenario is to start from a process model or workflow of how the service/operations take place, assess it for compliance based on obligations and requirements obtained from interpretation of specific clauses of the law, and tweak it as required based on the outcome to become compliant.

This requires a way to express information about:

1) Process model / Workflow + Provenance Log
2) Constraints / Obligations / Requirements
3) Links to specific aspects of law

Aim – Testing process workflows for compliance

Aim: Test and record compliance information for process workflows

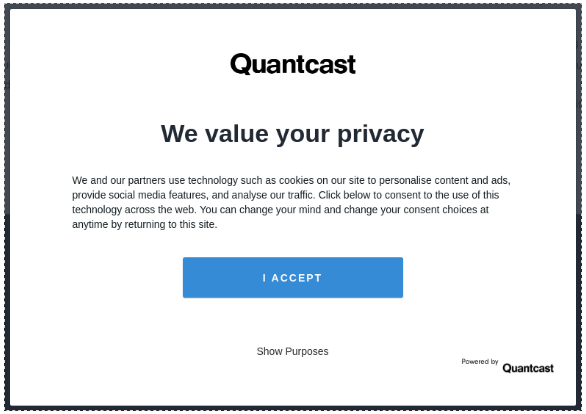
Objective: information (including compliance) can be

1) persisted 2) queried 3) validated 4) linked to legal requirements

We choose Semantic Web because:

a) Linked Data
b) Interoperable Standards (RDF, OWL, SPARQL, SHACL)
c) Creating Knowledge Graph i.e. embedding semantics
d) Extensible based on further use-cases as needed

Use-case: consent mechanism on Quantcast.com



Quantcast

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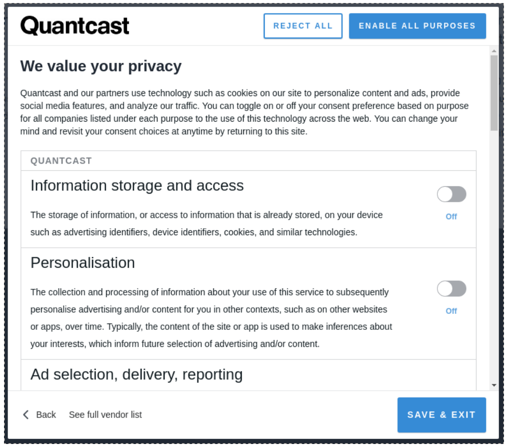

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QUANTCAST

Information storage and access — Off

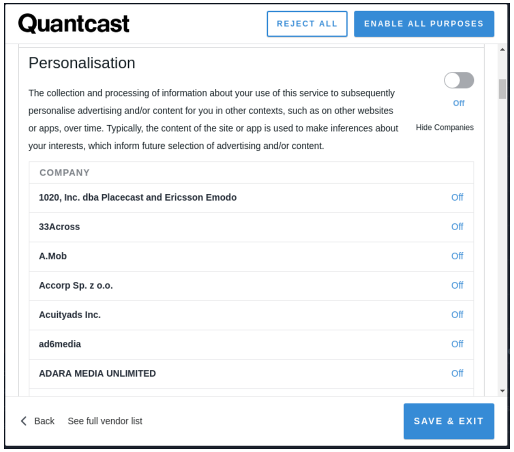
The storage of information, or access to information that is already stored, on your device such as advertising identifiers, device identifiers, cookies, and similar technologies.

Personalisation — Off

The collection and processing of information about your use of this service to subsequently personalise advertising and/or content for you in other contexts, such as on other websites or apps, over time. Typically, the content of the site or app is used to make inferences about your interests, which inform future selection of advertising and/or content.

Ad selection, delivery, reporting

(b)



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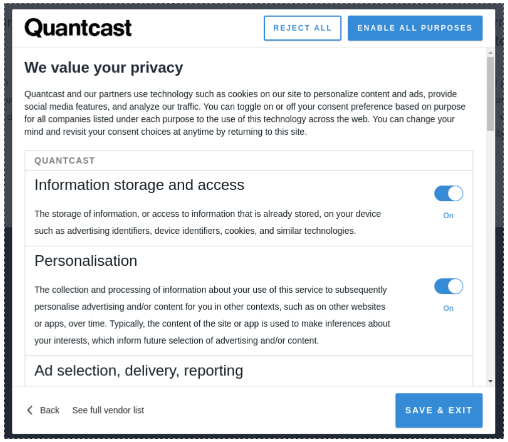
COMPANY	
1020, Inc. dba Placecast and Ericsson Emodo	Off
33Across	Off
A.Mob	Off
Accorp Sp. z o.o.	Off
Acuityads Inc.	Off
ad6media	Off
ADARA MEDIA UNLIMITED	Off

(c)



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Ad selection, delivery, reporting

(d)

Why Quantcast?
- It is one of the largest consent dialogue providers
- Option to change consent

Screenshots show:
(a) first dialogue
(b) second set of options
(c) list of third parties
(d) allows to change consent in subsequent visits

Also investigate:
1. Privacy Policy
2. Subject Access Request
3. Products offered on site

Modeling the data in RDF

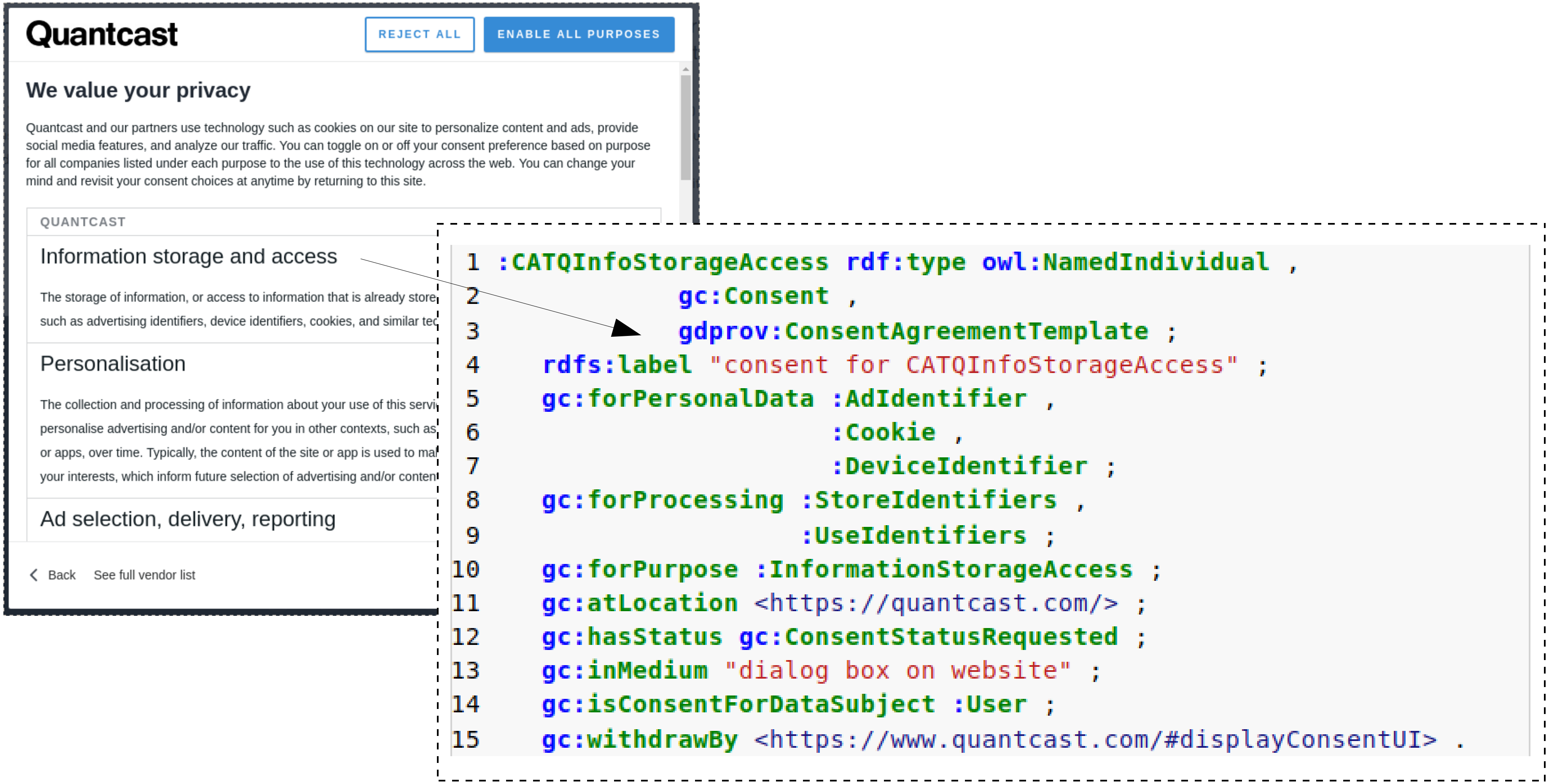
Used vocabularies (also prior work!):

- **GDPRtEXT**: a RDF version of GDPR text, UID for every clause in text, SKOS thesauri of concepts [13] https://w3id.org/GDPRtEXT
- **GDPRov**: extends PROV-O and P-Plan with GDPR specific concept to represent logs and plans/models/templates [16] https://w3id.org/GDPRov
- **Gconsent**: vocabulary for capturing information about consent as per requirements of the GDPR [14] https://w3id.org/GConsent
- SPARQL queries to retrieve information for GDPR compliance [15] https://w3id.org/GDPRep/checklist-demo

Interpret information in the consent dialogue, and also investigate privacy policy and information on the website to get: purpose & categories of processing, personal data categories, legal basis, recipients of data, storage duration

[13] Pandit, H.J. et al.: GConsent - A Consent Ontology based on the GDPR. ESWC 2019
[14] Pandit, H.J. et al.: GDPRtEXT - GDPR as a Linked Data Resource. ESWC 2018
[15] Pandit, H.J. et al.: Queryable Provenance Metadata For GDPR Compliance. SEMANTiCS 2018
[16] Pandit, H.J., Lewis, D.: Modelling Provenance for GDPR Compliance using Linked Open Data Vocabularies. PrivOn (ISWC 2017)

Modeling the data in RDF



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or apps, over time. Typically, the content of the site or app is used to ma
your interests, which inform future selection of advertising and/or conten

Ad selection, delivery, reporting

```
:CATQInfoStorageAccess rdf:type owl:NamedIndividual ,
                        gc:Consent ,
                        gdprov:ConsentAgreementTemplate ;
    rdfs:label "consent for CATQInfoStorageAccess" ;
    gc:forPersonalData :AdIdentifier ,
                       :Cookie ,
                       :DeviceIdentifier ;
    gc:forProcessing :StoreIdentifiers ,
                     :UseIdentifiers ;
    gc:forPurpose :InformationStorageAccess ;
    gc:atLocation <https://quantcast.com/> ;
    gc:hasStatus gc:ConsentStatusRequested ;
    gc:inMedium "dialog box on website" ;
    gc:isConsentForDataSubject :User ;
    gc:withdrawBy <https://www.quantcast.com/#displayConsentUI> .
```

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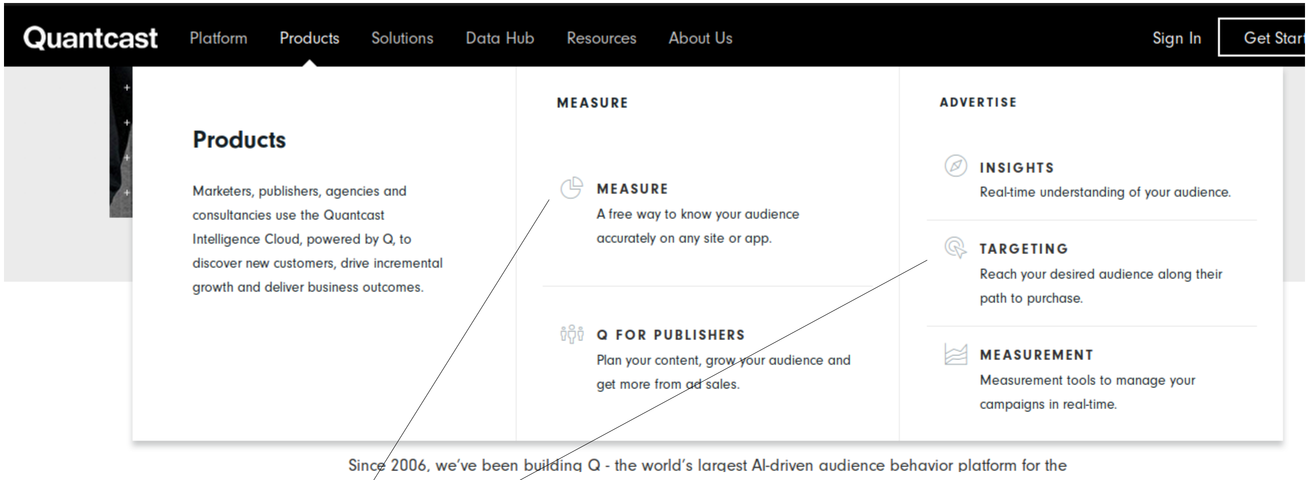
email: pandith@tcd.ie twitter: @coolharsh55
H. J. Pandit, D. O’Sullivan, D. Lewis. SEMANTiCS 2019, Karlsruhe, Germany.

Modeling the data in RDF



Products

Marketers, publishers, agencies and consultancies use the Quantcast Intelligence Cloud, powered by Q, to discover new customers, drive incremental growth and deliver business outcomes.

MEASURE

MEASURE
A free way to know your audience accurately on any site or app.

Q FOR PUBLISHERS
Plan your content, grow your audience and get more from ad sales.

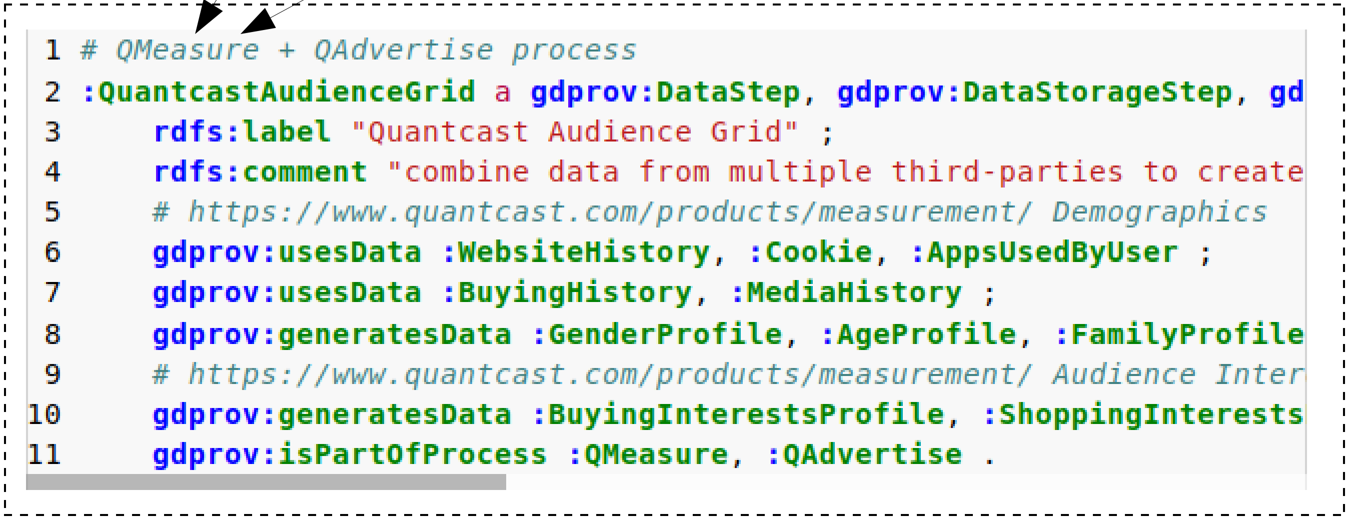
ADVERTISE

INSIGHTS
Real-time understanding of your audience.

TARGETING
Reach your desired audience along their path to purchase.

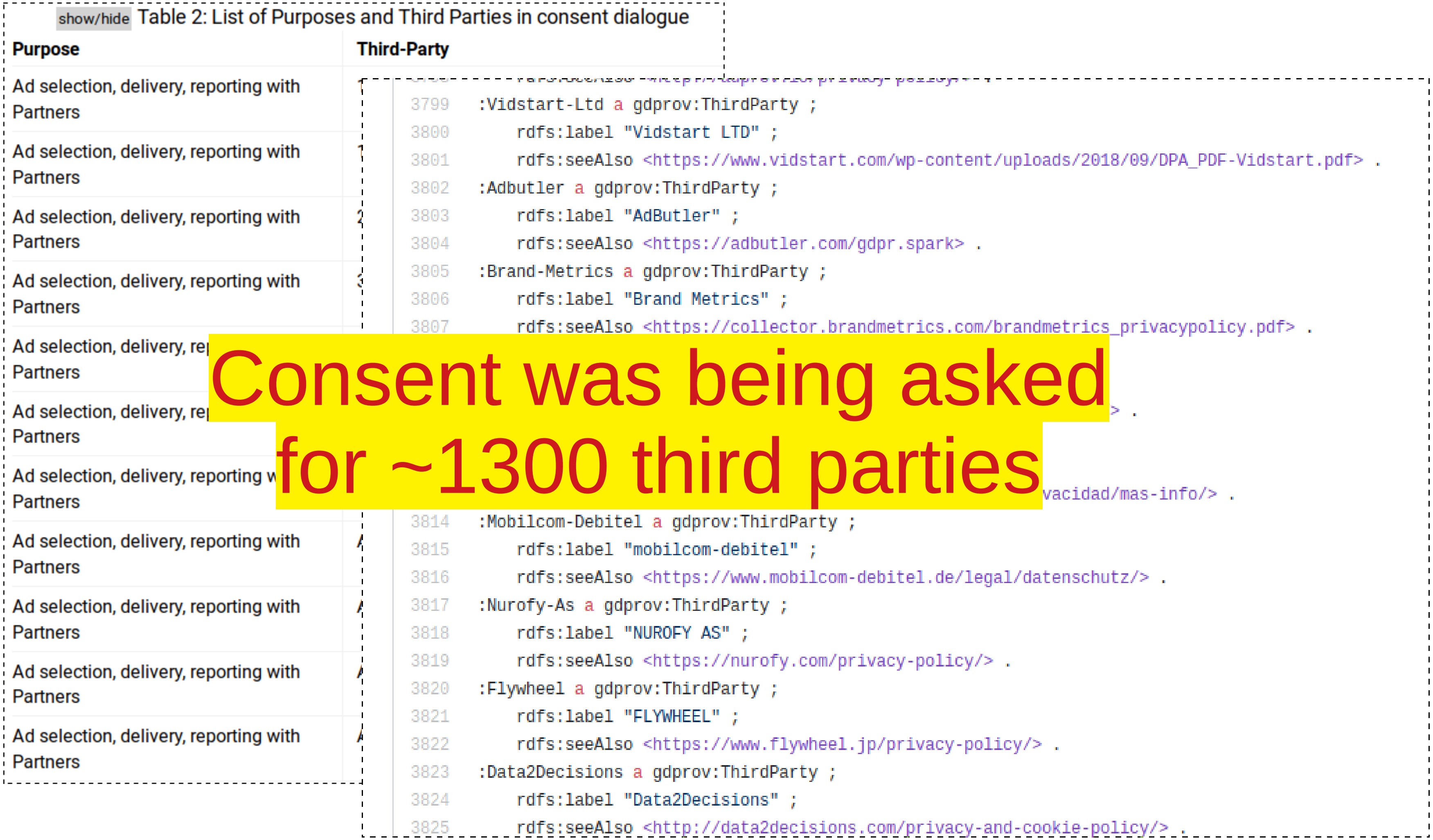
MEASUREMENT
Measurement tools to manage your campaigns in real-time.

Since 2006, we've been building Q - the world's largest AI-driven audience behavior platform for the



```
# QMeasure + QAdvertise process
:QuantcastAudienceGrid a gdprov:DataStep, gdprov:DataStorageStep, gd
    rdfs:label "Quantcast Audience Grid" ;
    rdfs:comment "combine data from multiple third-parties to create
    # https://www.quantcast.com/products/measurement/ Demographics
    gdprov:usesData :WebsiteHistory, :Cookie, :AppsUsedByUser ;
    gdprov:usesData :BuyingHistory, :MediaHistory ;
    gdprov:generatesData :GenderProfile, :AgeProfile, :FamilyProfile
    # https://www.quantcast.com/products/measurement/ Audience Inter
    gdprov:generatesData :BuyingInterestsProfile, :ShoppingInterests
    gdprov:isPartOfProcess :QMeasure, :QAdvertise .
```

Interesting finding



show/hide Table 2: List of Purposes and Third Parties in consent dialogue

Purpose	Third-Party
Ad selection, delivery, reporting with Partners	1
Ad selection, delivery, reporting with Partners	1
Ad selection, delivery, reporting with Partners	2
Ad selection, delivery, reporting with Partners	3
Ad selection, delivery, rep Partners	
Ad selection, delivery, rep Partners	
Ad selection, delivery, reporting w Partners	
Ad selection, delivery, reporting with Partners	A
Ad selection, delivery, reporting with Partners	A
Ad selection, delivery, reporting with Partners	A
Ad selection, delivery, reporting with Partners	A

```
:Vidstart-Ltd a gdprov:ThirdParty ;
    rdfs:label "Vidstart LTD" ;
    rdfs:seeAlso <https://www.vidstart.com/wp-content/uploads/2018/09/DPA_PDF-Vidstart.pdf> .
:Adbutler a gdprov:ThirdParty ;
    rdfs:label "AdButler" ;
    rdfs:seeAlso <https://adbutler.com/gdpr.spark> .
:Brand-Metrics a gdprov:ThirdParty ;
    rdfs:label "Brand Metrics" ;
    rdfs:seeAlso <https://collector.brandmetrics.com/brandmetrics_privacypolicy.pdf> .
> .
vacidad/mas-info/> .
:Mobilcom-Debitel a gdprov:ThirdParty ;
    rdfs:label "mobilcom-debitel" ;
    rdfs:seeAlso <https://www.mobilcom-debitel.de/legal/datenschutz/> .
:Nurofy-As a gdprov:ThirdParty ;
    rdfs:label "NUROFY AS" ;
    rdfs:seeAlso <https://nurofy.com/privacy-policy/> .
:Flywheel a gdprov:ThirdParty ;
    rdfs:label "FLYWHEEL" ;
    rdfs:seeAlso <https://www.flywheel.jp/privacy-policy/> .
:Data2Decisions a gdprov:ThirdParty ;
    rdfs:label "Data2Decisions" ;
    rdfs:seeAlso <http://data2decisions.com/privacy-and-cookie-policy/> .
```

Consent was being asked for ~1300 third parties

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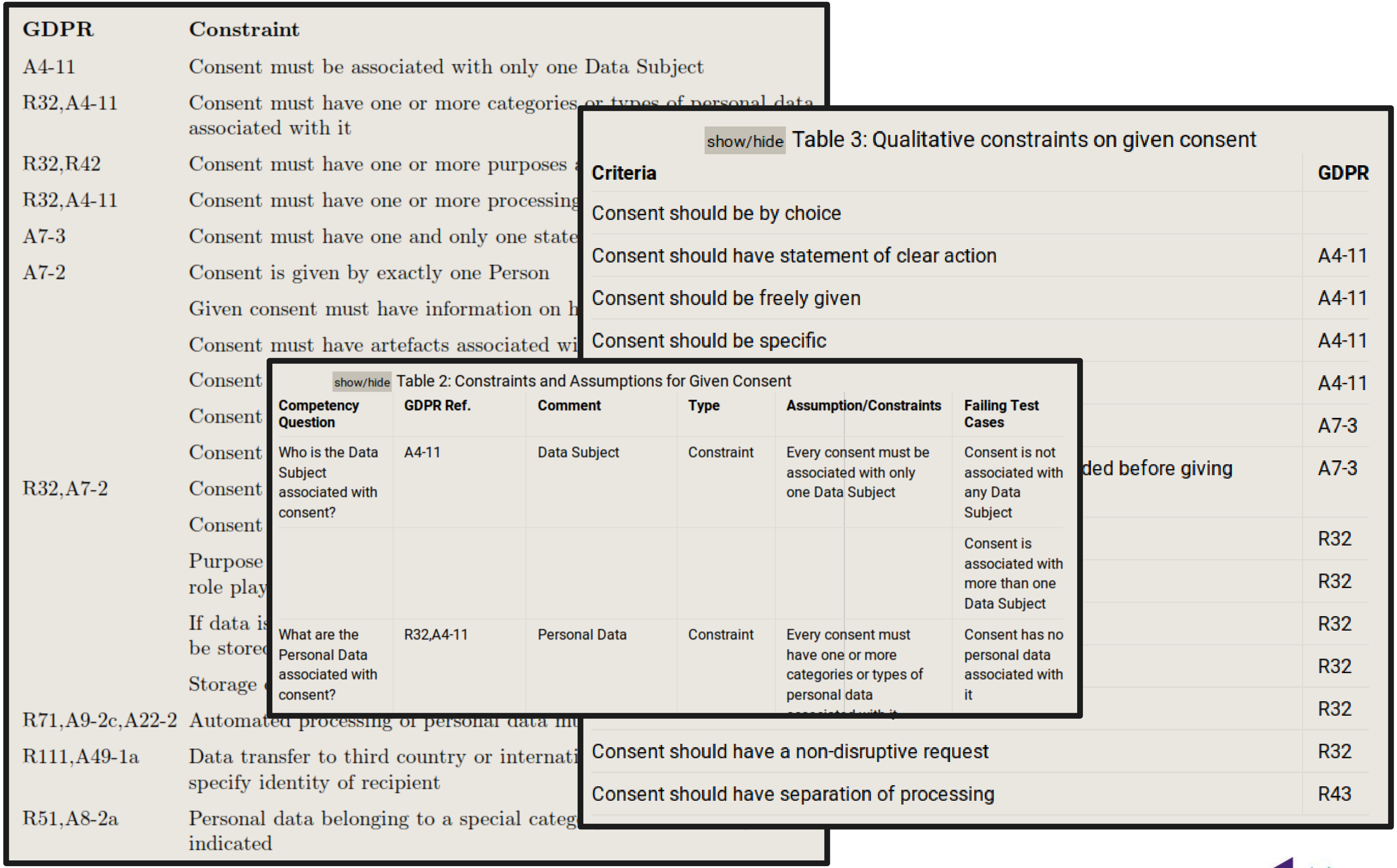
H. J. Pandit, D. O’Sullivan, D. Lewis. SEMANTiCS 2019, Karlsruhe, Germany.

Consent requirements from GDPR



GDPR	Constraint
A4-11	Consent must be associated with only one Data Subject
R32,A4-11	Consent must have one or more categories or types of personal data associated with it
R32,R42	Consent must have one or more purposes a
R32,A4-11	Consent must have one or more processing
A7-3	Consent must have one and only one state
A7-2	Consent is given by exactly one Person
	Given consent must have information on h
	Consent must have artefacts associated wi
	Consent
	Consent
	Consent
R32,A7-2	Consent
	Consent
	Purpose role play
	If data is be stored
	Storage
R71,A9-2c,A22-2	Automated processing of personal data in
R111,A49-1a	Data transfer to third country or internati specify identity of recipient
R51,A8-2a	Personal data belonging to a special categ indicated

show/hide Table 3: Qualitative constraints on given consent

Criteria	GDPR
Consent should be by choice	
Consent should have statement of clear action	A4-11
Consent should be freely given	A4-11
Consent should be specific	A4-11
	A4-11
	A7-3
ded before giving	A7-3
	R32
	R32
	R32
	R32
	R32
Consent should have a non-disruptive request	R32
Consent should have separation of processing	R43

show/hide Table 2: Constraints and Assumptions for Given Consent

Competency Question	GDPR Ref.	Comment	Type	Assumption/Constraints	Failing Test Cases
Who is the Data Subject associated with consent?	A4-11	Data Subject	Constraint	Every consent must be associated with only one Data Subject	Consent is not associated with any Data Subject
					Consent is associated with more than one Data Subject
What are the Personal Data associated with consent?	R32,A4-11	Personal Data	Constraint	Every consent must have one or more categories or types of personal data associated with it	Consent has no personal data associated with it

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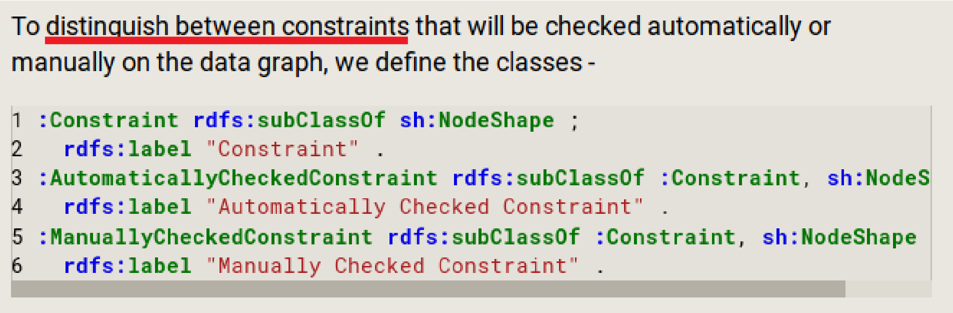
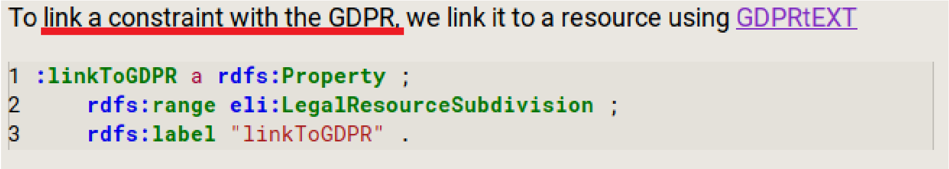
SHACL to validate constraints



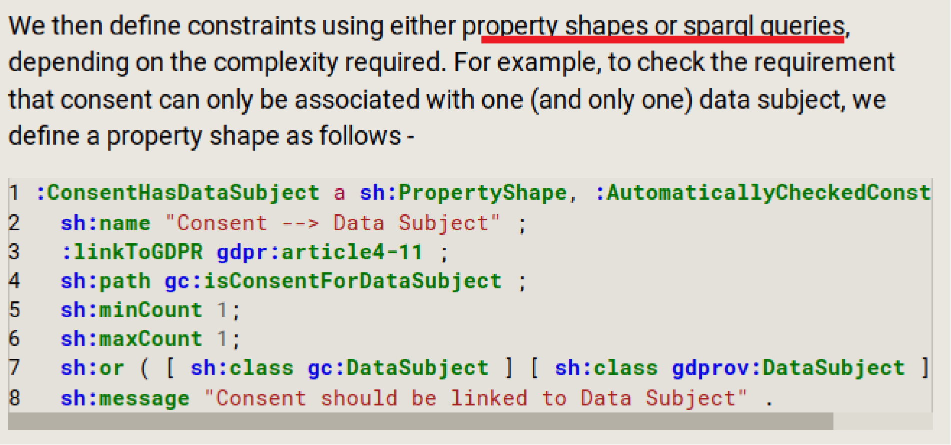
To distinguish between constraints that will be checked automatically or manually on the data graph, we define the classes -

```
:Constraint rdfs:subClassOf sh:NodeShape ;
  rdfs:label "Constraint" .
:AutomaticallyCheckedConstraint rdfs:subClassOf :Constraint, sh:NodeS
  rdfs:label "Automatically Checked Constraint" .
:ManuallyCheckedConstraint rdfs:subClassOf :Constraint, sh:NodeShape
  rdfs:label "Manually Checked Constraint" .
```



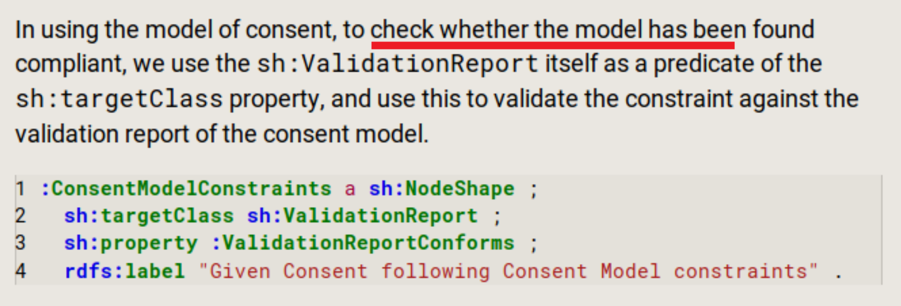
To link a constraint with the GDPR, we link it to a resource using GDPRtEXT

```
:linkToGDPR a rdfs:Property ;
    rdfs:range eli:LegalResourceSubdivision ;
    rdfs:label "linkToGDPR" .
```



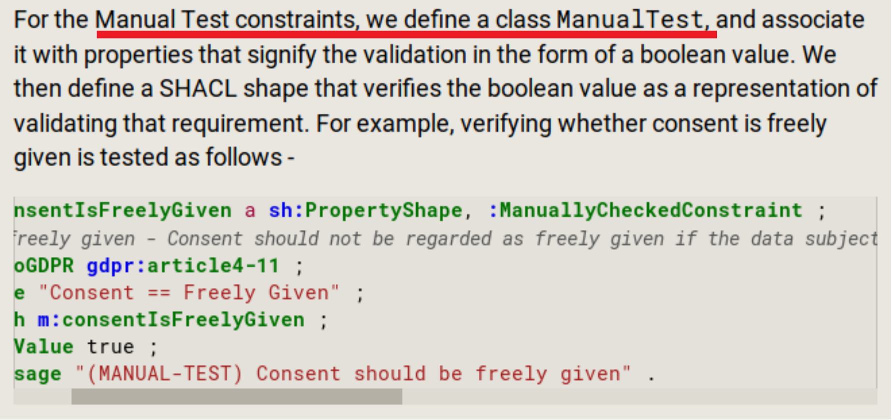
We then define constraints using either property shapes or sparql queries, depending on the complexity required. For example, to check the requirement that consent can only be associated with one (and only one) data subject, we define a property shape as follows -

```
:ConsentHasDataSubject a sh:PropertyShape, :AutomaticallyCheckedConst
  sh:name "Consent --> Data Subject" ;
  :linkToGDPR gdpr:article4-11 ;
  sh:path gc:isConsentForDataSubject ;
  sh:minCount 1;
  sh:maxCount 1;
  sh:or ( [ sh:class gc:DataSubject ] [ sh:class gdprov:DataSubject ]
  sh:message "Consent should be linked to Data Subject" .
```



In using the model of consent, to check whether the model has been found compliant, we use the sh:ValidationReport itself as a predicate of the sh:targetClass property, and use this to validate the constraint against the validation report of the consent model.

```
:ConsentModelConstraints a sh:NodeShape ;
  sh:targetClass sh:ValidationReport ;
  sh:property :ValidationReportConforms ;
  rdfs:label "Given Consent following Consent Model constraints" .
```



For the Manual Test constraints, we define a class ManualTest, and associate it with properties that signify the validation in the form of a boolean value. We then define a SHACL shape that verifies the boolean value as a representation of validating that requirement. For example, verifying whether consent is freely given is tested as follows -

```
nsentIsFreelyGiven a sh:PropertyShape, :ManuallyCheckedConstraint ;
reely given - Consent should not be regarded as freely given if the data subject
oGDPR gdpr:article4-11 ;
e "Consent == Freely Given" ;
h m:consentIsFreelyGiven ;
Value true ;
sage "(MANUAL-TEST) Consent should be freely given" .
```

Categories of constraints

We divide the constraints into 3 parts as follows:

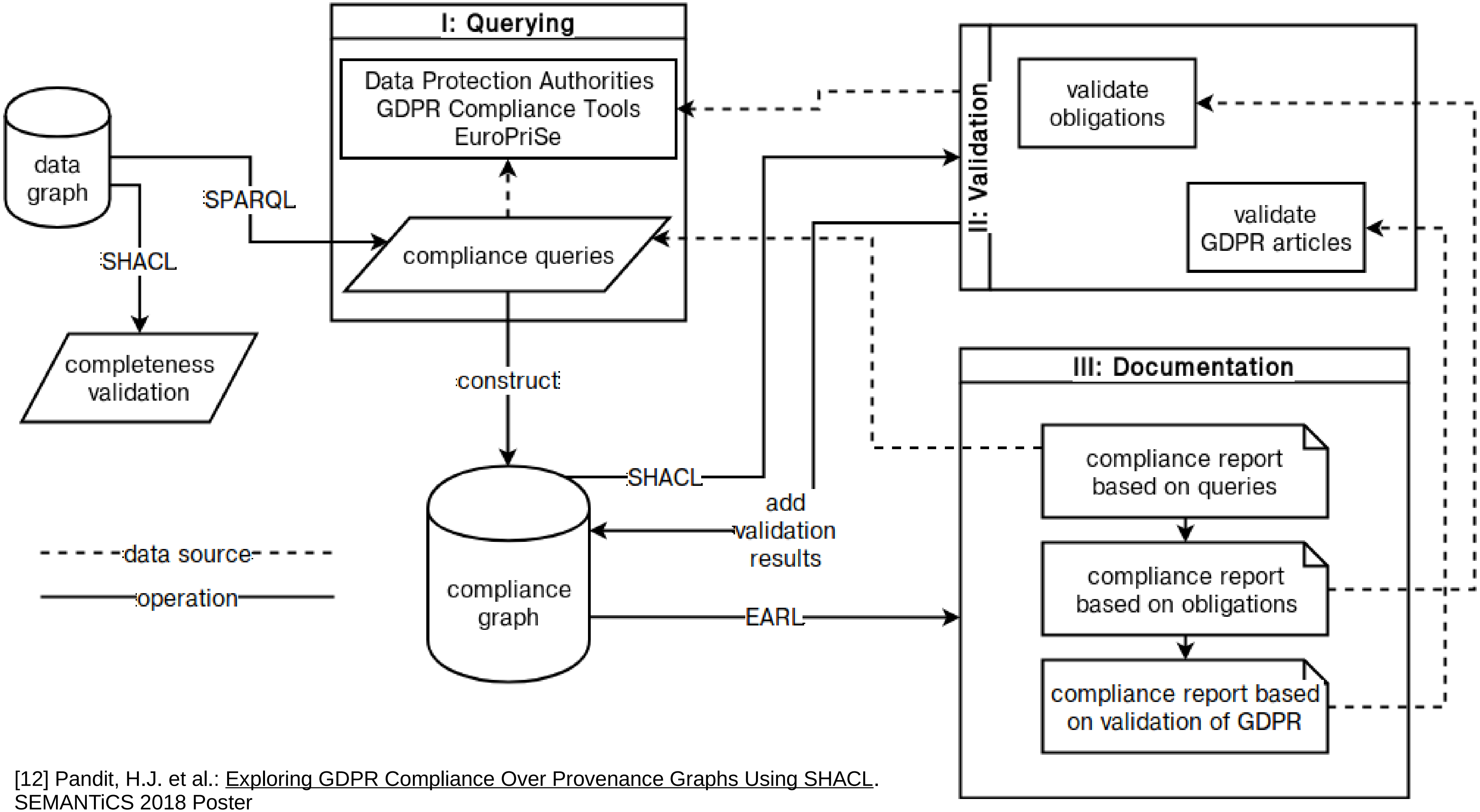
Part A: constraints related to the model of the system
Part B: constraints related to instances of given consent
Part C: common constraints in model + constraints unique for each instances

Part A test requirements such as the presence of DPO and procedures to handle the various rights.

Part B checks requirements directly associated with an instance of given consent. These constraints have to be tested for every instance of given consent.

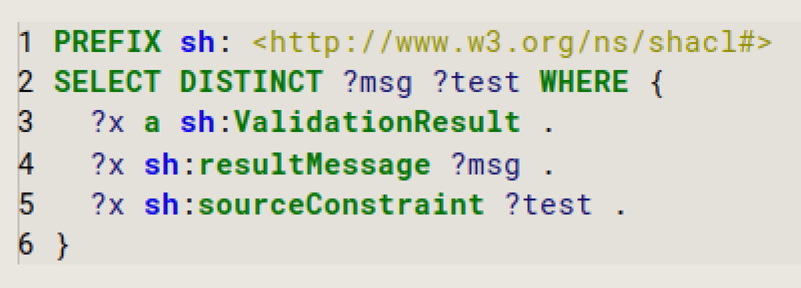
Part C splits the requirements (from Part B) into two parts - one common to all consent and validated against a 'model' or 'template' of consent, and the other validated against the instance of given consent. As most constraints are abstracted away to the model and only need to be checked once, this makes the validation of given consent more efficient.

Compliance testing [12]



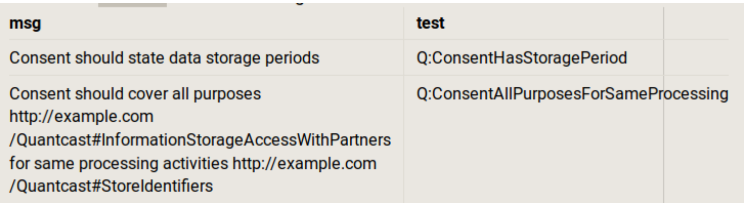
[12] Pandit, H.J. et al.: Exploring GDPR Compliance Over Provenance Graphs Using SHACL. SEMANTiCS 2018 Poster

SPARQL queries for Compliance results



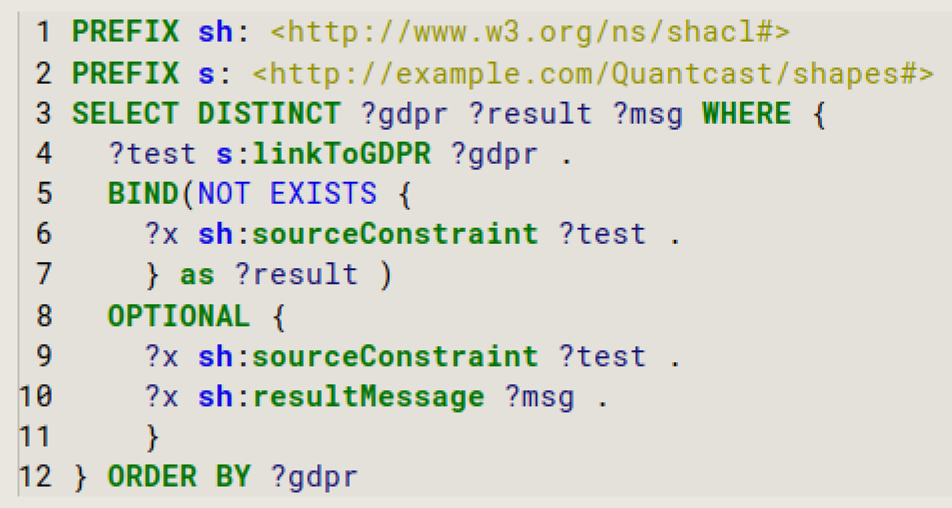
```
PREFIX sh: <http://www.w3.org/ns/shacl#>
SELECT DISTINCT ?msg ?test WHERE {
  ?x a sh:ValidationResult .
  ?x sh:resultMessage ?msg .
  ?x sh:sourceConstraint ?test .
}
```

SPARQL query for retrieving test messages as actionable items



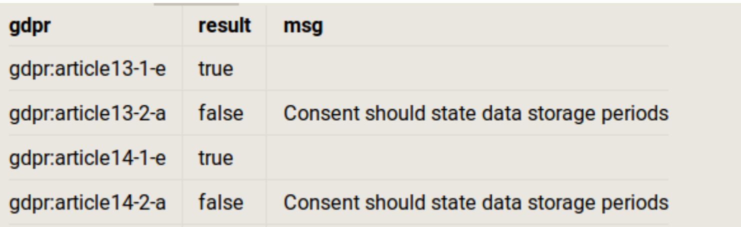
msg	test
Consent should state data storage periods	Q:ConsentHasStoragePeriod
Consent should cover all purposes http://example.com /Quantcast#InformationStorageAccessWithPartners for same processing activities http://example.com /Quantcast#StoreIdentifiers	Q:ConsentAllPurposesForSameProcessing

Messages from tests as actionable items



```
PREFIX sh: <http://www.w3.org/ns/shacl#>
PREFIX s: <http://example.com/Quantcast/shapes#>
SELECT DISTINCT ?gdpr ?result ?msg WHERE {
  ?test s:linkToGDPR ?gdpr .
  BIND(NOT EXISTS {
    ?x sh:sourceConstraint ?test .
    } as ?result )
  OPTIONAL {
    ?x sh:sourceConstraint ?test .
    ?x sh:resultMessage ?msg .
    }
} ORDER BY ?gdpr
```

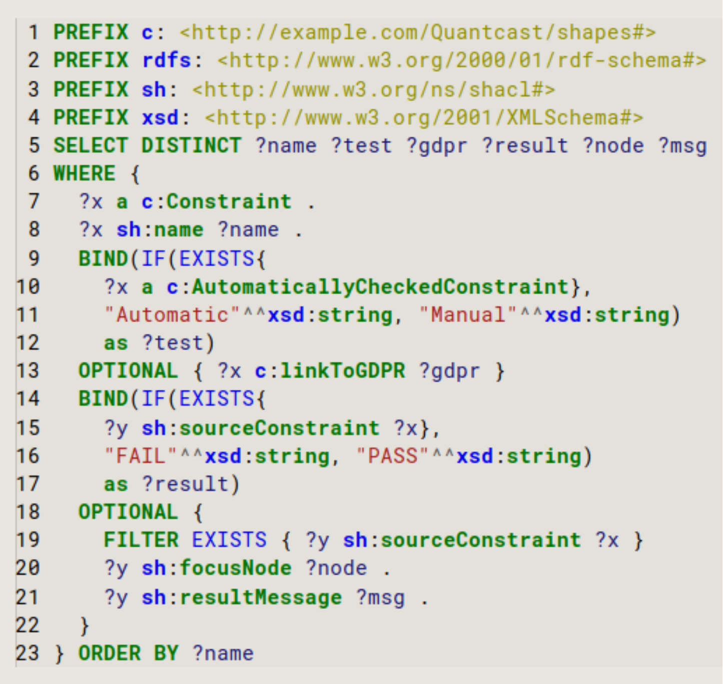
SPARQL query to retrieve GDPR articles and their test results



gdpr	result	msg
gdpr:article13-1-e	true	
gdpr:article13-2-a	false	Consent should state data storage periods
gdpr:article14-1-e	true	
gdpr:article14-2-a	false	Consent should state data storage periods

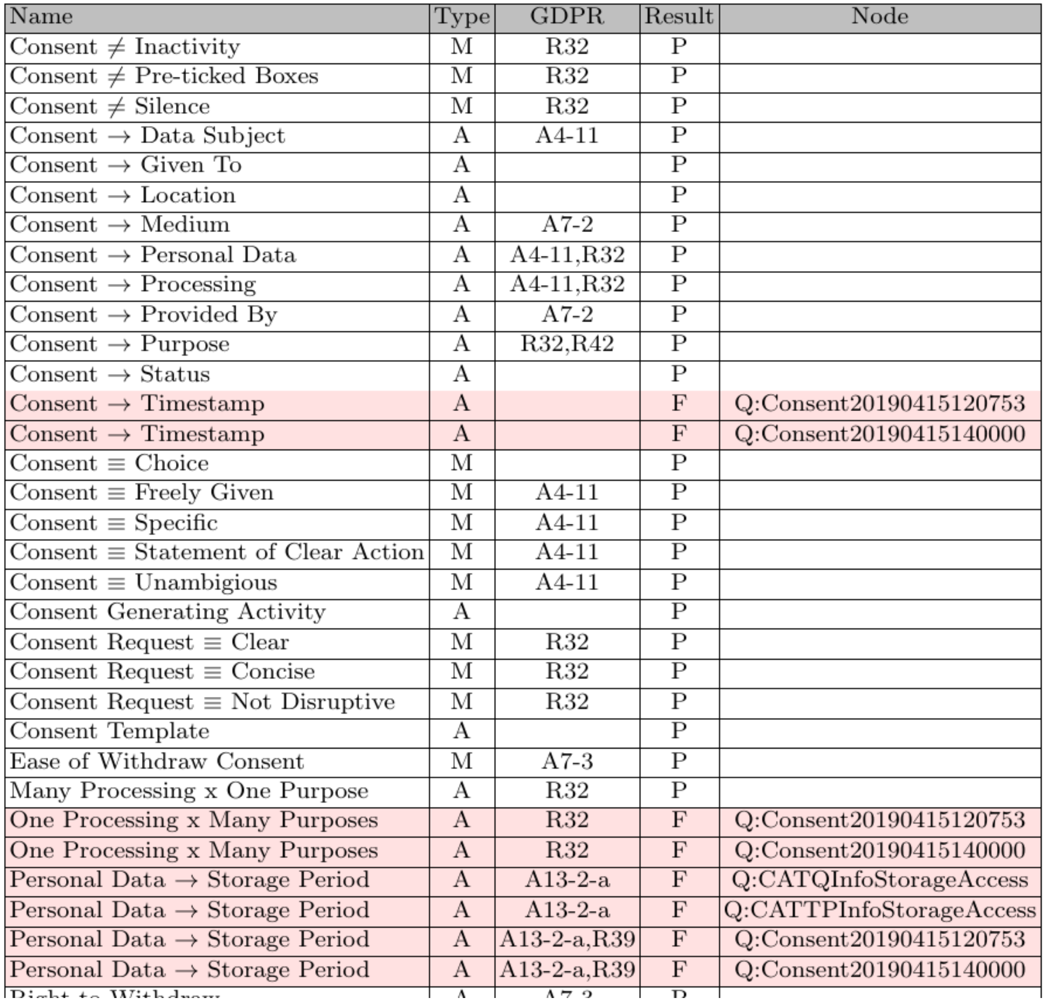
GDPR articles and their test results

Generating Compliance Report



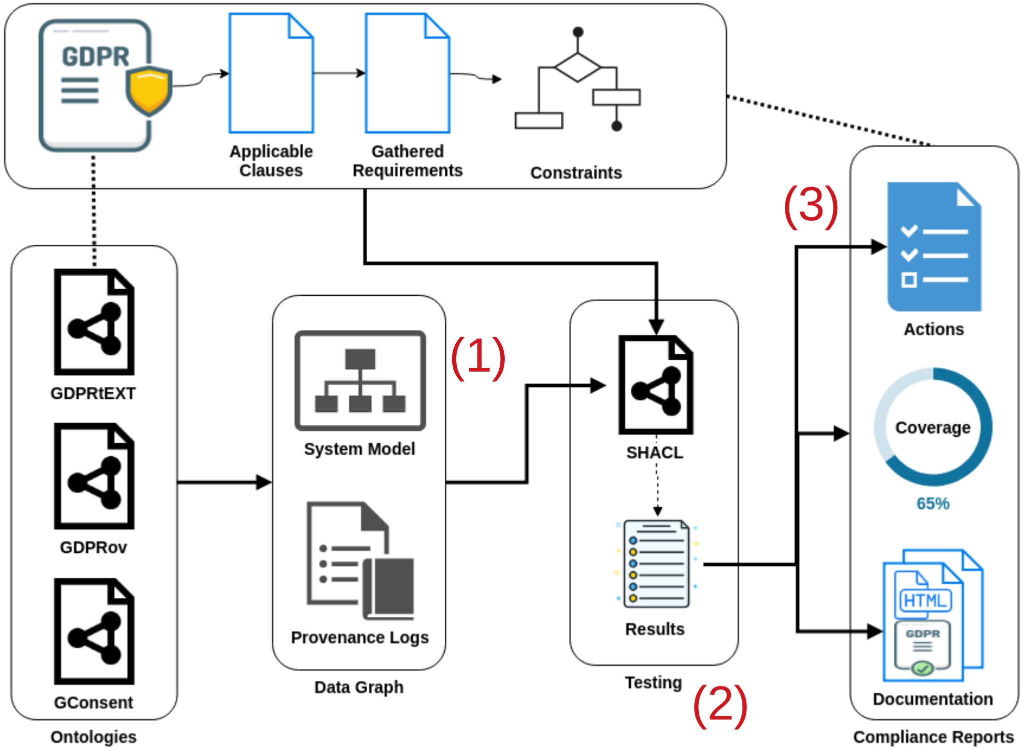
```
PREFIX c: <http://example.com/Quantcast/shapes#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX sh: <http://www.w3.org/ns/shacl#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
SELECT DISTINCT ?name ?test ?gdpr ?result ?node ?msg
WHERE {
  ?x a c:Constraint .
  ?x sh:name ?name .
  BIND(IF(EXISTS{
    ?x a c:AutomaticallyCheckedConstraint},
    "Automatic"^^xsd:string, "Manual"^^xsd:string)
    as ?test)
  OPTIONAL { ?x c:linkToGDPR ?gdpr }
  BIND(IF(EXISTS{
    ?y sh:sourceConstraint ?x},
    "FAIL"^^xsd:string, "PASS"^^xsd:string)
    as ?result)
  OPTIONAL {
    FILTER EXISTS { ?y sh:sourceConstraint ?x }
    ?y sh:focusNode ?node .
    ?y sh:resultMessage ?msg .
  }
} ORDER BY ?name
```

SPARQL query and results to generate a report showing constraints, validation results, and link to GDPR



Name	Type	GDPR	Result	Node
Consent ≠ Inactivity	M	R32	P	
Consent ≠ Pre-ticked Boxes	M	R32	P	
Consent ≠ Silence	M	R32	P	
Consent → Data Subject	A	A4-11	P	
Consent → Given To	A		P	
Consent → Location	A		P	
Consent → Medium	A	A7-2	P	
Consent → Personal Data	A	A4-11,R32	P	
Consent → Processing	A	A4-11,R32	P	
Consent → Provided By	A	A7-2	P	
Consent → Purpose	A	R32,R42	P	
Consent → Status	A		P	
Consent → Timestamp	A		F	Q:Consent20190415120753
Consent → Timestamp	A		F	Q:Consent20190415140000
Consent ≡ Choice	M		P	
Consent ≡ Freely Given	M	A4-11	P	
Consent ≡ Specific	M	A4-11	P	
Consent ≡ Statement of Clear Action	M	A4-11	P	
Consent ≡ Unambigious	M	A4-11	P	
Consent Generating Activity	A		P	
Consent Request ≡ Clear	M	R32	P	
Consent Request ≡ Concise	M	R32	P	
Consent Request ≡ Not Disruptive	M	R32	P	
Consent Template	A		P	
Ease of Withdraw Consent	M	A7-3	P	
Many Processing x One Purpose	A	R32	P	
One Processing x Many Purposes	A	R32	F	Q:Consent20190415120753
One Processing x Many Purposes	A	R32	F	Q:Consent20190415140000
Personal Data → Storage Period	A	A13-2-a	F	Q:CATQInfoStorageAccess
Personal Data → Storage Period	A	A13-2-a	F	Q:CATTPInfoStorageAccess
Personal Data → Storage Period	A	A13-2-a,R39	F	Q:Consent20190415120753
Personal Data → Storage Period	A	A13-2-a,R39	F	Q:Consent20190415140000
Right to Withdraw	A	A7-3	P	

Conclusion



(1) Testing a model of a system is more efficient than testing individual instances of processing logs

(2) Persisting results with semantics enables recording and querying compliance information as data

(3) Knowledge can be used to enable systemic information regarding actions for compliance, coverage, and automation in generation of documentation

Engaging Content
Engaging People

~ end of presentation ~

Test-driven approach towards GDPR compliance

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