

Analyze Decentralized Personal Health Data using Solid, Digital Consent, and Federated Learning

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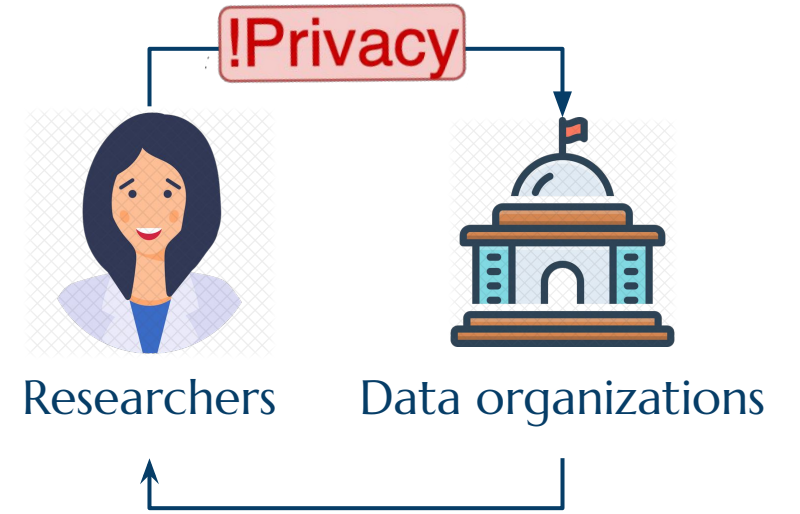
Download date: 13 Dec. 2023



Analyze Decentralized Personal Health Data using Solid, Digital Consent, and Federated Learning

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Institute of Data Science, Maastricht University

Solid Symposium 2023 - Applications for Health Data Management with Solid
31 March 2023





Title and reference

Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) (Text with EEA relevance)

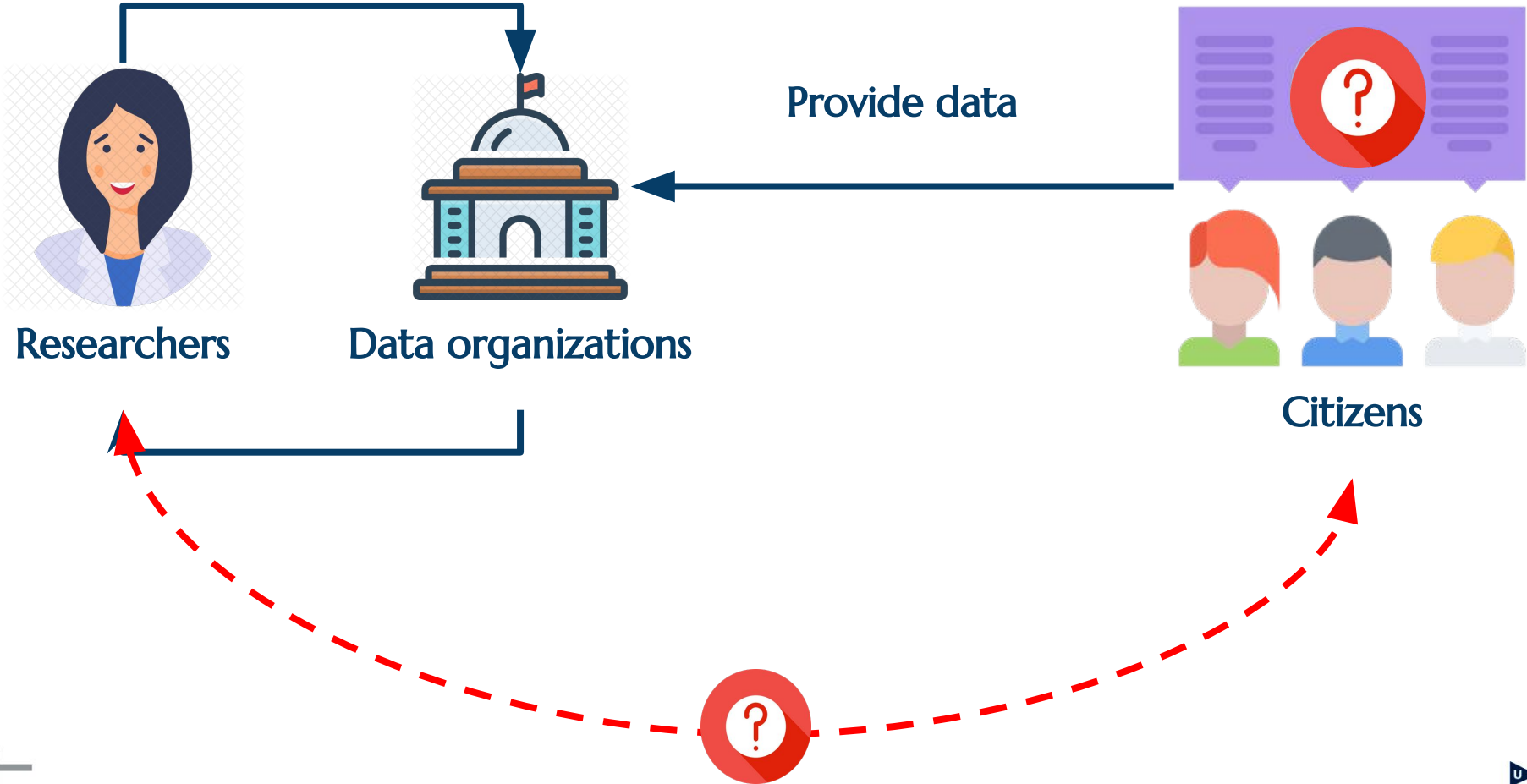
OJ L 119, 4.5.2016, p. 1–88 (BG, ES, CS, DA, DE, ET, EL, EN, FR, GA, HR, IT, LV, LT, HU, MT, NL, PL, PT, RO, SK, SL, FI, SV)

In force: This act has been changed. Current consolidated version: [04/05/2016](#)

ELI: <http://data.europa.eu/eli/reg/2016/679/oj>



A lot work focused on analysing the data controlled by organizations, but what about using data directly controlled by individuals?

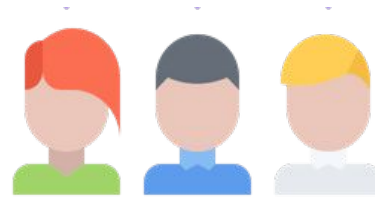


Citizens would like to have more access and control over the data they generate.

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*EU should make major investments in technologies and infrastructures that **enhance data access and use**, while giving us as well as public and private organisations **full control over the data they generate**.*

***Law and technology** should enable us to make available their data for the public interest without any direct reward.*



*We would be willing to **make such data available**, especially for health-related research and for aspects relating to the locality we live in (e.g. mobility, environment).*

*There are **no sufficient tools and mechanisms** for us to 'donate' our data.*

A key challenge

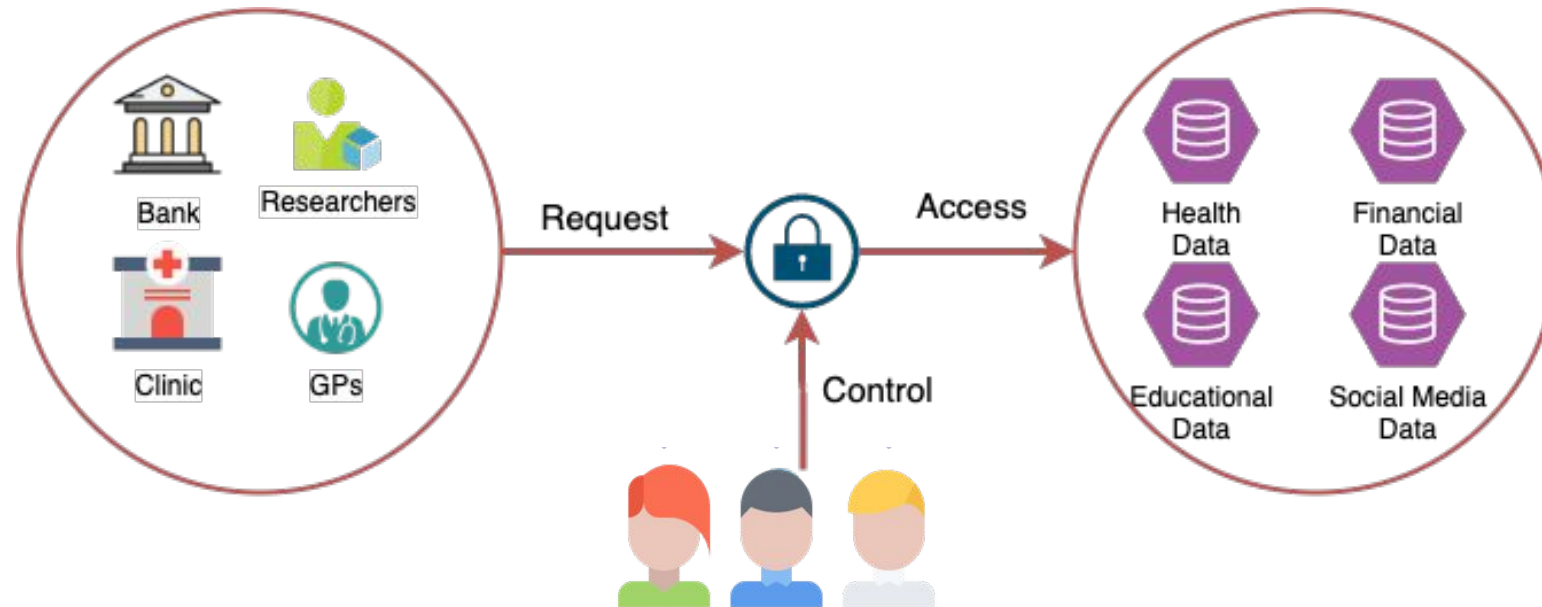
“Individuals value the high level of protection granted by the GDPR and ePrivacy legislation. However, they suffer from the absence of technical tools and standards that make the exercise of their rights simple and not overly burdensome.”

-- European Committee <An European Strategy for Data> 2020



Solutions:

provide individuals **the tools** to decide at a **granular level** what is done with their data using consent management, personal information management, decentralised networking, etc, in order to give greater oversight, transparency, control over their personal data.

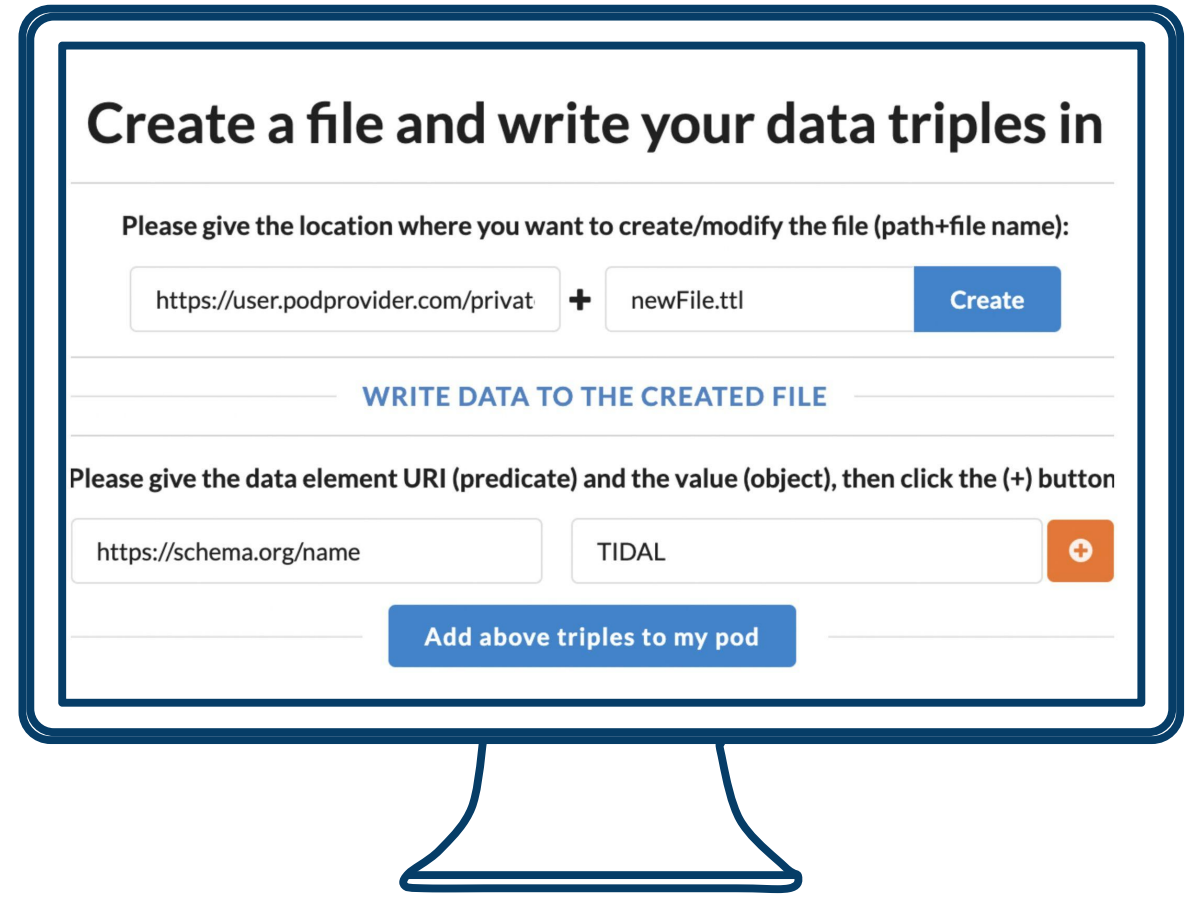
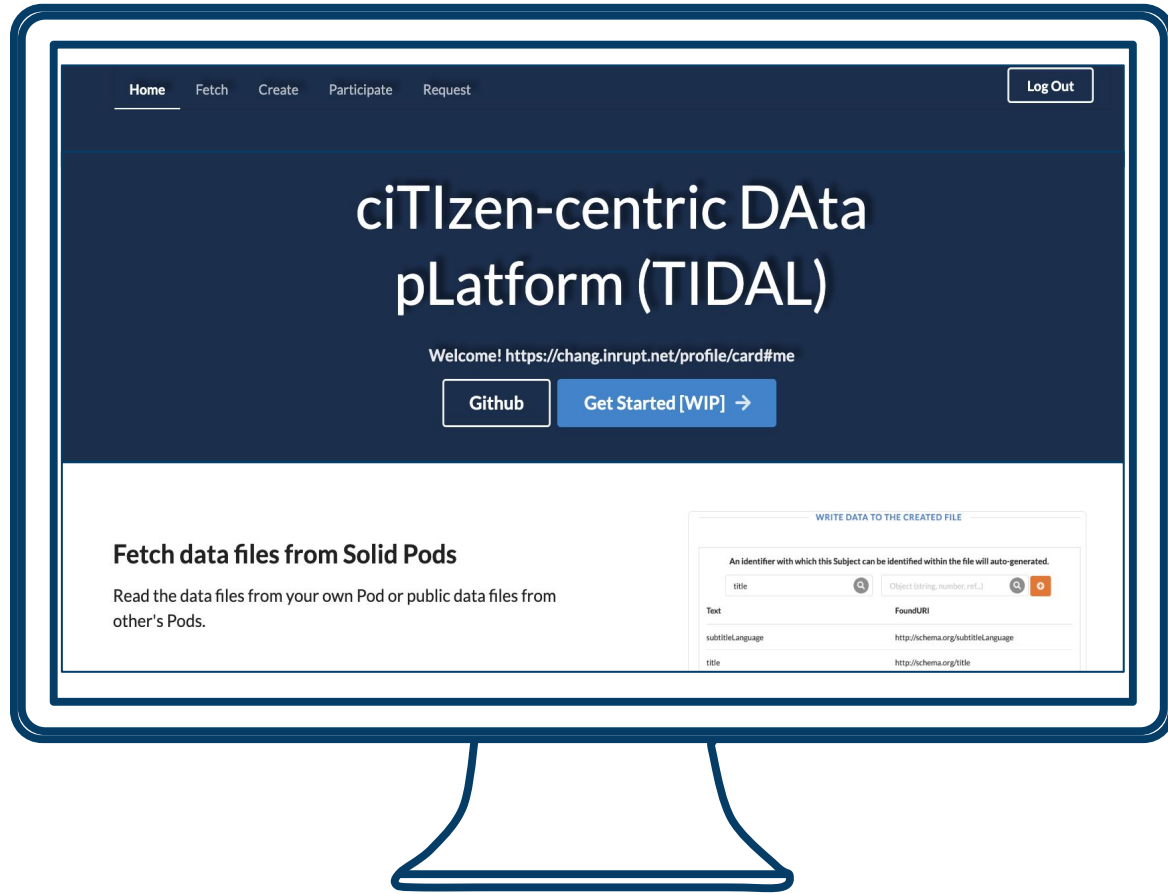
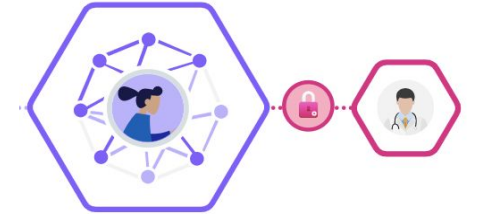


ciTizen-centric DAta pLatform (TIDAL)

8



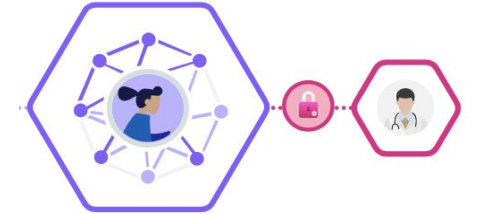
Based on Solid (SOcial Linked Data) to store and structure personal data, and give individual control access to their fine-grained personal data



ciTizen-centric DAta pLatform (TIDAL)



Based on Solid (SOcial Linked Data) to store and structure personal data, and give individual control access to their fine-grained personal data



Integrating Data Privacy Vocabulary to structure personal data requests as digital consents

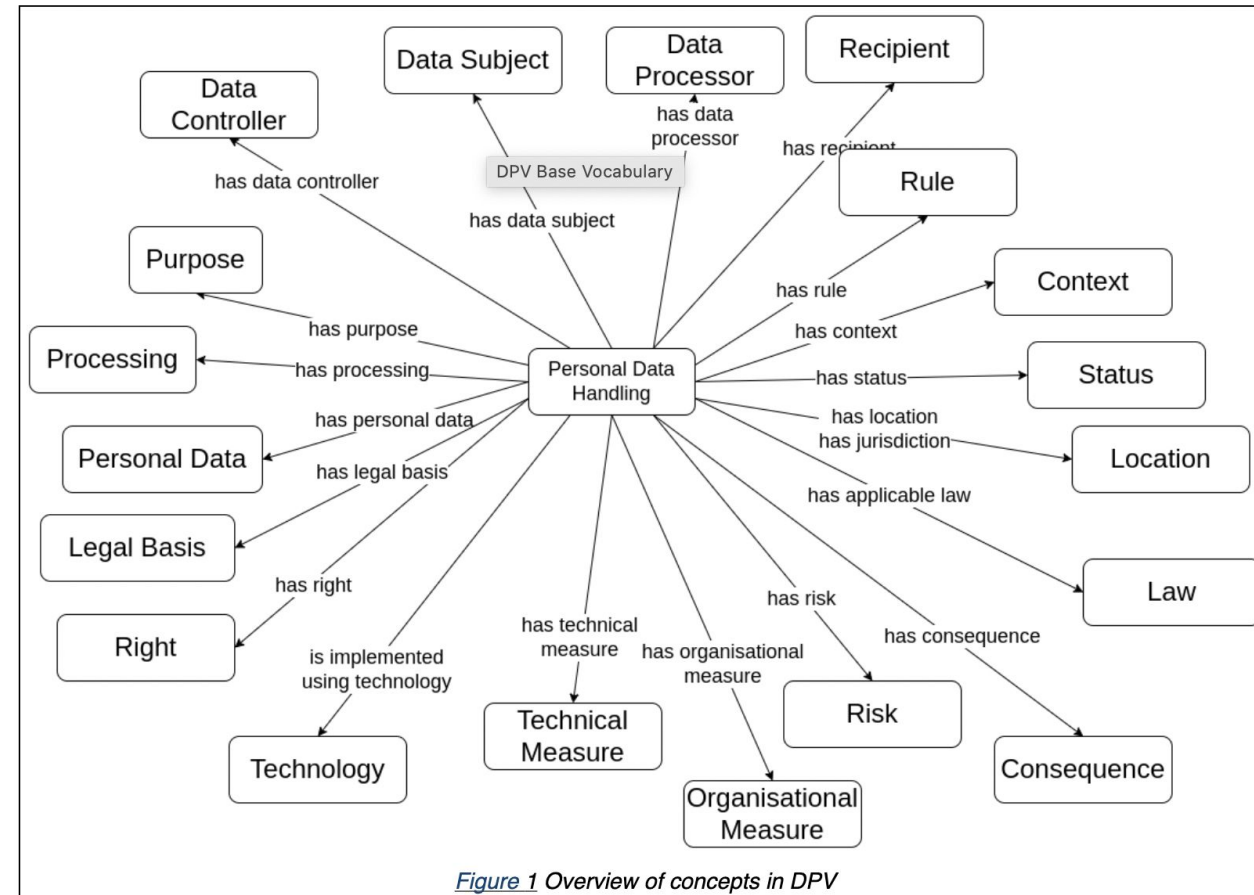


Figure 1 Overview of concepts in DPV

ciTizen-centric DAta pLatform (TIDAL)

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```
@prefix : <https://exampleparticipant.solidprovider.com/profile/card#>.
@prefix SNOMEDCT: <http://purl.bioontology.org/ontology/SNOMEDCT/>.

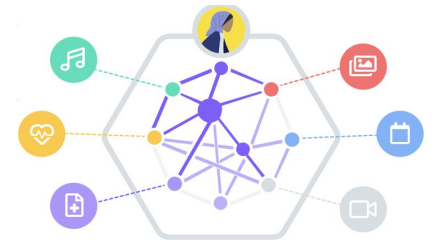
:me a SNOMEDCT:116154003; # Patient
    SNOMEDCT:397669002 "27"^^xsd:int; # Age
    SNOMEDCT:50373000 "165"^^xsd:int; # Height
    SNOMEDCT:726527001 "55"^^xsd:int; # Weight
    SNOMEDCT:263495000 SNOMEDCT:248152002; # Gender, Female
    SNOMEDCT:271649006 "110"; # Systolic blood pressure
    SNOMEDCT:271650006 "90"; # Diastolic blood pressure
    SNOMEDCT:405751000 SNOMEDCT:44054006. # Type 2 diabetes
```

try

Listing 4: An example of the RDF data file in a participant's Solid pod.



Formulating personal data and data request into RDF format with integration of vocabulary services and standards



ciTizen-centric DAta pLatform (TIDAL)

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Based on Solid (SOcial Linked Data) to store and structure personal data, and give individual control access to their fine-grained personal data



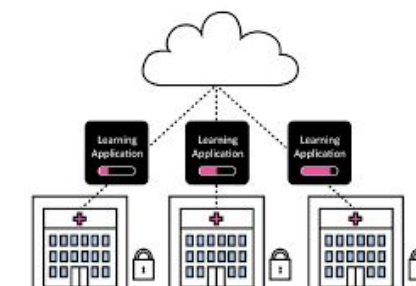
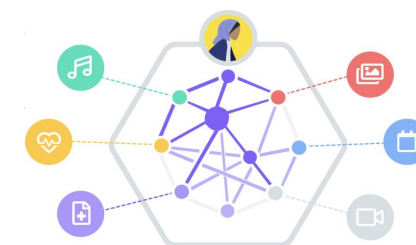
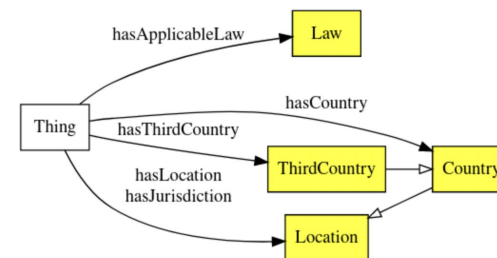
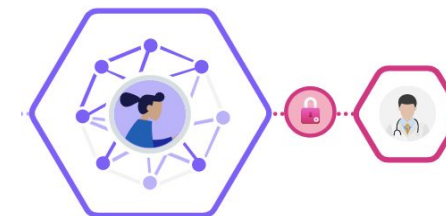
Integrating Data Privacy Vocabulary to structure personal data requests as digital consents to meet the requirements of GDPR



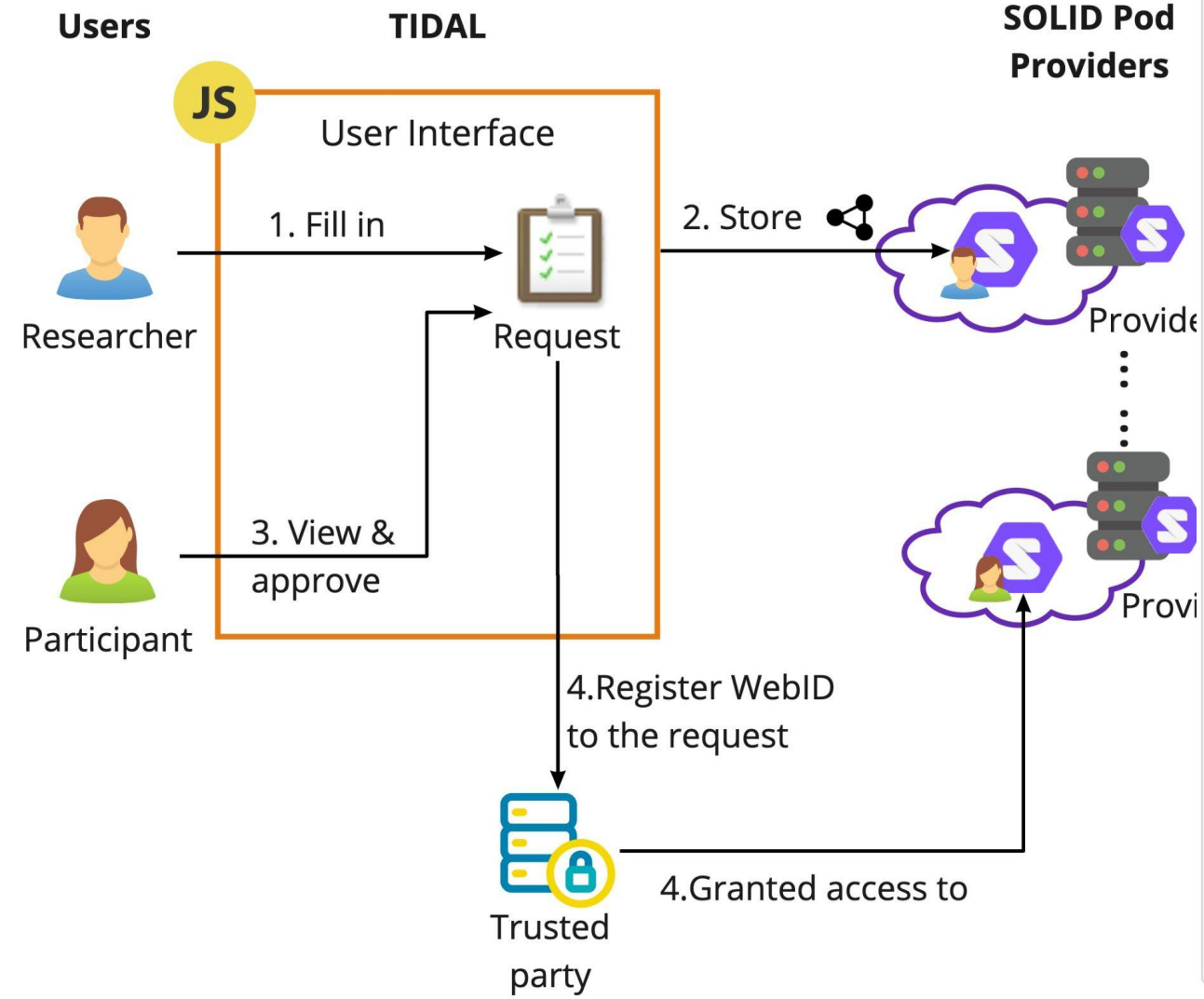
Formulating personal data and data request into RDF format with integration of vocabulary services and standards



Integrating federated learning (Personal Health Train) using the parameters promised in the data request and only the results are sent to the researchers



TIDAL framework - Data request



Please Note: This request form is structured using the [Data Privacy Vocabulary \(DPV\)](#). DPV provides terms (classes and properties) to describe and represent information related to processing of personal data based on established requirements such as GDPR.

Purpose of your research ⓘ *

Research and Development ✕

Description of your purpose: ⓘ

Learn association between diabetes status and dietary pattern Recommender

Personal data categories ⓘ *

Medical Health [Special] (hysical Health, Mental Health, DNA Code, Disability, Health History) ✕

Demographic (Physical Trait, Income Bracket, Geographic) ✕

Data elements (URI) ⓘ *

diagnosis +

Consent Duration (Days) *

90	NCIT	Diagnosis http://ncicb.nci.nih.gov/xml/owl/EVS/Thesaurus.owl#C15220 The investigation, analysis and recognition of the presence and nature of disease, condition, or injury from expressed signs and symptoms; also, the scientific determination of any kind; the concise results of such an investigation.
100	PREMEDONTO	Diagnosis http://purl.obolibrary.org/obo/NCIT_C15220 The investigation, analysis and recognition of the presence and nature of disease, condition, or injury from expressed signs and symptoms; also, the scientific determination of any kind; the concise results of such an investigation.

Data Processing Category ⓘ *

> Analyse ✕

	CRISP	diagnosis http://purl.bioontology.org/ontology/CSP/4000-0159 general term for detecting and classifying diseases.
	IOBC	Diagnosis http://purl.jp/bio/4/id/200906001611549035

Analysis Model *

Linear Regression

Consequences of data processing and impact of your research:

Help diabetes patients understand the impact of their diet pattern

Publish

Searching terms from BioPortal ontologies

TIDAL framework - Data request and consent

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```
@prefix : <http://exampleresearcher.solidprovider.com/public/request.ttl#>.
@prefix schema: <https://schema.org/>.
@prefix exre: <http://exampleresearcher.solidprovider.com/profile/card#>.
@prefix dpv: <http://w3id.org/dpv#>.
@prefix dpvvpd: <http://w3id.org/dpv/dpv-pd#>.
@prefix dpvtech: <http://w3id.org/dpv/dpv-tech#>.
@prefix SNOMEDCT: <http://purl.bioontology.org/ontology/SNOMEDCT/>.

:161964062096710764675982245664
  a schema:AskAction, dpv:PersonalDataHandling;
  dpv:hasLegalBasis dpv:Consent;
  rdfs:label "Learn association between diabetes status and dietary pattern";
  schema:collectionSize 32;
  schema:creator exre:me;
  schema:DataFeedItem SNOMEDCT:10396001, SNOMEDCT:230125005, SNOMEDCT:56718006, SNOMEDCT:73211009;
  schema:dateCreated "2021-01-18T00:00:00Z"^^XML:dateTime;
  dpvtech:isImplementedUsingTechnology dpvtech:LinearRegression;
  dpv:hasImpact "Help diabetes patients understand the impact of their diet pattern";
  dpv:hasContext SNOMEDCT;
  dpv:hasDataController exre:me;
  dpv:hasExpiryTime "2021-12-31T00:00:00Z"^^XML:dateTime;
  dpvvpd:hasPersonalData dpvvpd:Health;
  dpv:hasProcessing dpv:Analyse;
  dpv:hasPurpose dpv:ResearchAndDevelopment.
```

TIDAL framework - Data request and consent

Home Fetch Create **Participate** Request

Log Out

All ongoing data requests



Viewing

View the published data requests from researchers.



Period

Enter the specific end date for using your data.



Respond

Click decline or approve to the data request.

CommercialInterest

ResearchAndDevelopment

Security

Researcher A

Institute A



Class of purpose: [CommercialInterest](#)
Purpose: How XXX health app can help patient with obesity to have healthier lifestyle.
Personal Data Category: [HealthRecord](#)
Data Processing Category: [Analyse](#)
Requested data:
[Weight change](#)
[Running](#)
[Body mass index](#)
End date: 2021-09-15T00:00:00Z
Instances: 300
Analysis: Linear Regression

Withdrawal Date: dd/mm/yyyy

Data Recipient:

Decline

Approve

Researcher B

Institute B



Class of purpose: [ResearchAndDevelopment](#)
Purpose: Learn association between diabetes status and dietary pattern
Personal Data Category: [Health](#)
Data Processing Category: [Analyse](#)
Requested data:
[Hyperlipoproteinemia diet](#)
[Diabetes mellitus](#)
End date: 2021-08-01T00:00:00Z
Instances: 32
Analysis: Linear Regression
Consequence of data process: Help diabetes patients understand the impact of their diet pattern

Requested data is not detected in your pod!

Send a message to the researcher.

Researcher C

Institute B



Class of purpose: [Security](#)
Purpose: Improve the security of health data storage and sharing
Personal Data Category: [HealthRecord](#)
Data Processing Category: [Profiling](#)
[PseudoAnonymise](#)
Requested data:
[Blood pressure](#)
[Heart rate](#)
[Plasma glucose](#)
End date: 2022-01-01T00:00:00Z
Instances: 265
Analysis: Linear Regression

Requested data is not detected in your pod!

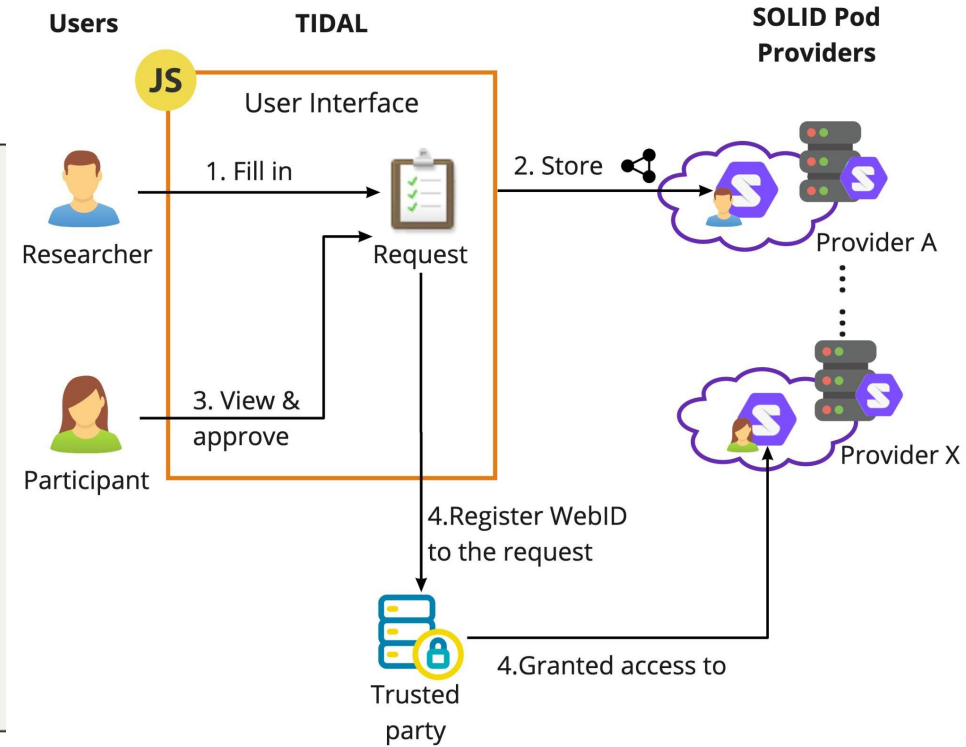
Send a message to the researcher.

TIDAL framework - Data request and consent

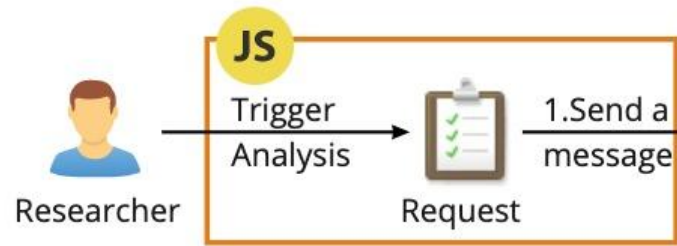
```
@prefix : <http://exampleParticipant.solidProvider.com/private/participation#>.
@prefix part: <https://exampleparticipant.solidprovider.com/profile/card#>.
@prefix req: <https://exampleresearcher.solidprovider.com/public/request.ttl#>.
@prefix extp: <http://exampltrustedparty.solidprovider.net/profile/card#>
@prefix app: <https://examplesolidapp.com/

:16197041266295299657542155198
  a schema:JoinAction, dpv:Consent;
  schema:dateCreated "2021-02-18T00:00:00Z"^^XML:dateTime;
  dpv:DataSubject part:me;
  dpv:hasConsentNotice req:161964062096710764675982245664;
  dpv:hasExpiry schema:false;
  dpv:hasExpiryTime "2021-12-31T00:00:00Z"^^XML:dateTime;
  dpv:hasProvisionMethod app:participate;
  dpv:hasProvisionTime "2021-02-18T00:00:00Z"^^XML:dateTime;
  dpv:hasWithdrawalTime "2021-09-18T00:00:00Z"^^XML:dateTime;
  dpv:hasRecipient extp:me.
```

Listing 2: An example of generated participation statements in a RDF format in the participant's Solid pod.



TIDAL framework - Data Analysis



Chang Sun
Institute of Data Science

Purpose: InruptUser64VarTest
Requested data:
<http://dbpedia.org/ontology/income>
<http://xmlns.com/foaf/0.1/age>
<http://schema.org/height>
<http://schema.org/weight>
<http://purl.bioontology.org/ontology/SNOMEDCT/4085780>
... .. 59 more data elements
End date: 2021-11-24T00:00:00Z
Instances: 128
Analysis: Linear Regression

Data collection progress - 0%

Stop collection Trigger analysis

Chang Sun
Institute of Data Science

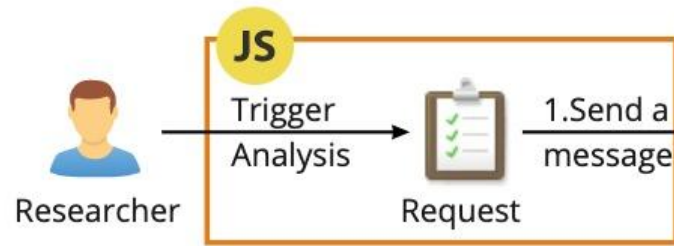
Purpose: TestUser4VarTest
Requested data:
<http://solidtest.org/variable/100001>
<http://solidtest.org/variable/100002>
<http://solidtest.org/variable/100003>
<http://solidtest.org/variable/100004>
End date: 2022-01-01T00:00:00Z
Instances: 128
Analysis: Linear Regression

Data collection progress - 100%

Stop collection Trigger analysis

TIDAL framework - Data Analysis

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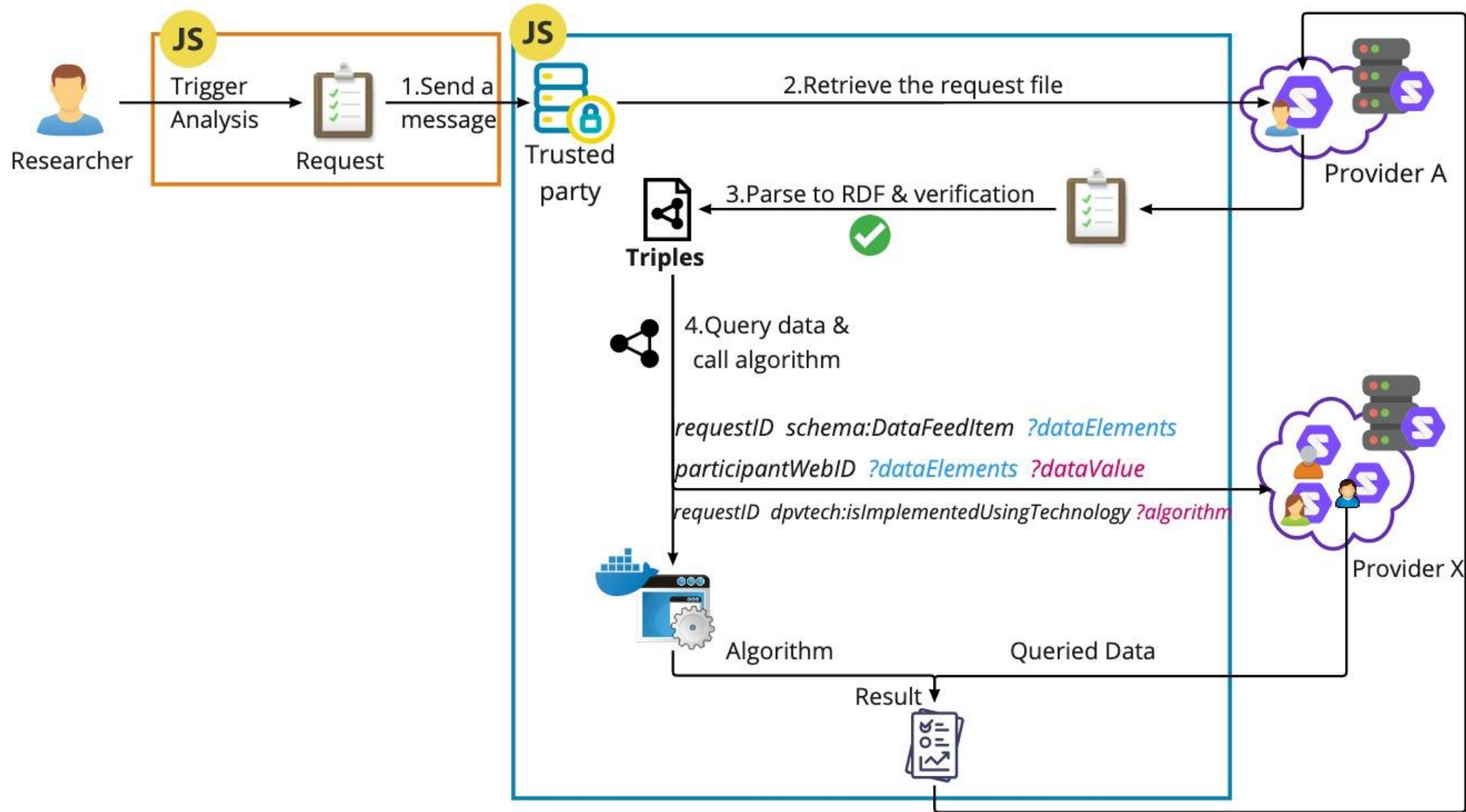


```
@prefix : <http://examplertrustedparty.solidprovider.net/inbox/triggermessage#>.
@prefix req: <http://examplerresearcher.solidprovider.com/public/request.ttl#>.
@prefix exre: <http://examplerresearcher.solidprovider.com/profile/card#>.

:160622932739325095672093710975
  schema:actionStatus schema:ActivateAction;
  schema:creator exre:me;
  schema:dateCreated "2021-04-20T09:37:57.499Z"^^XML:dateTime;
  schema:target req:161964062096710764675982245664.
```

Listing 3: An example of generated trigger message (Activate Action) sent by the researcher.

TIDAL framework - Data Analysis



- Individuals data will be read only when the analysis gets executed.
- The analysis can only be triggered by the data requester under conditions (have enough participants, in the valid period, for the indicated purpose, etc)
- Individuals can revoke the permission anytime.
- Individuals can change the data values at any moment (even after giving researchers permission, when the experiments are being conducted)
- (Future work) Individuals will be able to indicate their preference to which data requests they want to receive.
- and more...

Paper: ciTizen-centric DATA pLatform (TIDAL): Sharing Distributed Personal Data in a Privacy-Preserving Manner for Health Research

Open Source tool and code: <https://github.com/sunchang0124/TIDAL>

Web application is live →

Demo Youtube Video:



Contact:

- chang.sun@maastrichtuniversity.nl
- www.linkedin.com/in/chang-sun-maastricht/

