# Digital Transformation towards Interoperability

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FAIR **DIGITAL OBJECTS** FORUM
https://fairdo.org/

# Big Challenges

## 1. Stability of Scientific Memory in Digital Times - preventing the Dark Digital Age

- paper, ISBN and copies in national libraries were a promise to society
- need a promise for the persistence of relevant data, code and relations (Scientific Memory) in the Digital Era

## 2. Making Data Management & Processing Efficient and Cost Effective

- we spend about 80 % of time & costs in data projects with data wrangling (**across sectors**)
- in US >500 billion $ per year lost in health sector due to non-FAIR data (WEF Davos)
- 10.000s of tools, 1.000s of repositories, 100s of standards & protocols to cope with and all are different with respect to the way they deal with data – fragmentation and heterogeneity
- as with TCP/IP: looking for a universally accepted & patent-free integration standard that does not hamper dynamic developments and "competition" (Cloud Systems to not address this layer)

## 3. Enabling Semantic Cross-walk (-> Daan)
## 4. Maintaining Data Sovereignty in a Global Integrated Data Space (GIDS)
## 5. Keeping Europe in a Competitive Position in Data Use/Analysis

not explicitly
in my talk

# Phenomena in Data Science

(deep analysis of 75 research infrastructure reports/plans in Spring + Summer 2020)

## FAIRness Paradox

- almost all researchers have heard about FAIR and support the idea

- but daily practices in the lab did hardly change in the last 5 years

- FAIRness shifted to **FAIRness by Publication (FbP)** instead of **FAIRness by Design (FbD)**

## Production Chains

- creating research results includes **chains of specialised actors and labs**

- FAIRness is shifted to the next actor in the chain – finally no one does it

# Phases: where are we?

➢ George Strawn (Internet Pioneer, Advisor to US Administration)
  ➢ 1950s: many computers + many data sets
  ➢ 1990s: one computer + many data sets        (the network is the computer)
  ➢ 2030s: one computer + one data set (will have the Global Integrated Data Space – GIDS)

➢ EOSC/NFDI/EDI/etc. are about building the basis for new types of data/research infrastructures and EU/MS are investing much money! (US may follow in 3 years)

➢ Building efficiently usable infrastructures costs decades!

➢ Thus, we need to anticipate the structures to be established in 10+ years complementing the evolutionary work already being done!

➢ Thus, will EU maintain the current advantage and generalise from our great experience with a decade of piloting with discipline data spaces?

# From Connecting to the Internet towards Connecting to the Global Interoperable Data Space

**Dream in 1970ies**

**Dream in 2020ies**
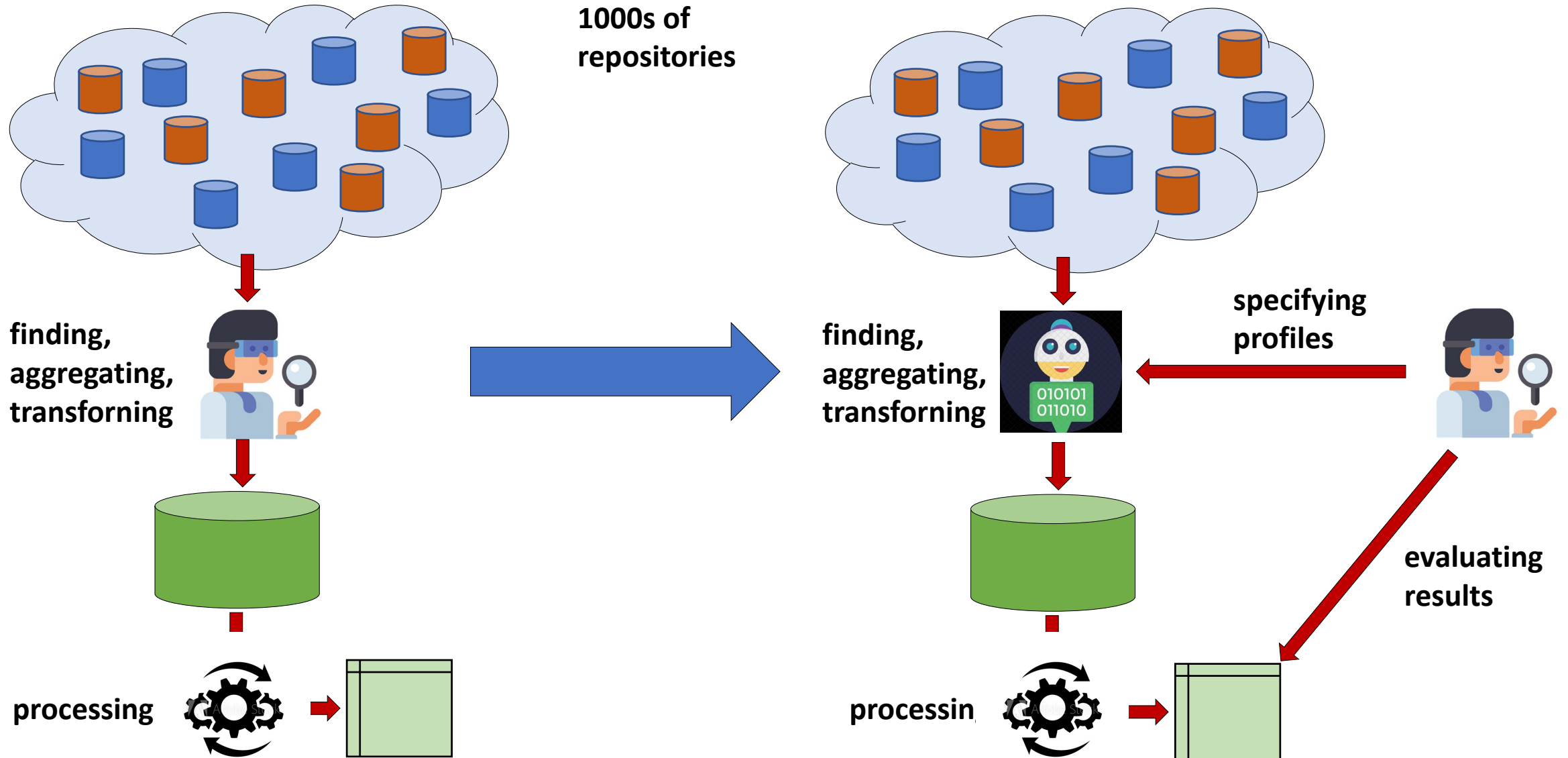


a user simply plugs-in a computer and is part of the Internet

a community simply plugs-in a repository and is part of the GIDs

# Change of Researchers' Role
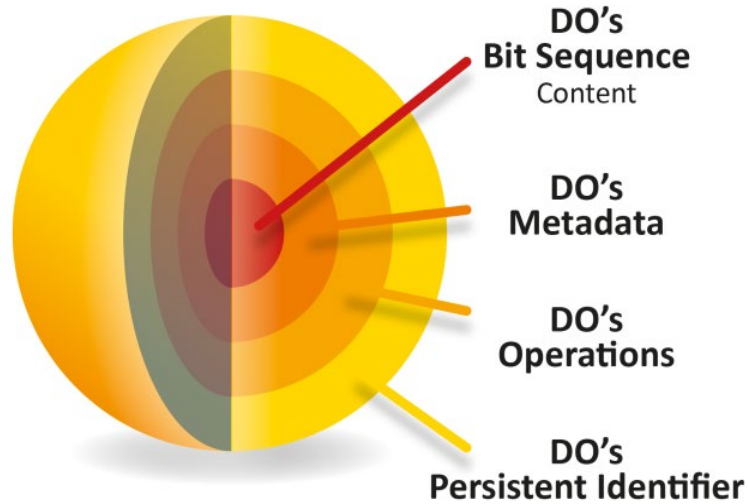
# What does „plugging-into GIDS" mean?

- need to have an entity clearly identifiable, self-contained and traceable
- need to have an entity that binds all relevant information persistently (type, metadata, rights, licenses, etc.) for reuse
- a repository is added to the GIDS: it offers its holding (data, all metadata) to all interested crawlers by a DO Interface Protocol to update collections, registries & portals automatically
- a user adds data to a repository: the repository updates its offers enabling crawlers to harvest
- managing trust relationships will be a challenge – PIDs help

# FAIR Digital Objects – just in time



DO's
**Bit Sequence**
Content

DO's
**Metadata**

DO's
**Operations**

DO's
**Persistent Identifier**

## FAIR Digital Objects (FDO)

- are atomic and self-standing by bundling all relevant information to process digital concent (FAIR, machine actionable)

- have a Globally Unique, Persistent and Resolvable Identifier (-> Maggie)

- Identifier System (Handles/DOIs) is globally administered, distributed, secure, redundant, free of patents and is owned by the Swiss non-profit DONA Foundation

- DOIP acts as TCP/IP: helps reducing complexity to 1*N in a complex, heterogeneous and fragmented landscape

## FDO characteristics

- abstraction (any content)
- persistent binding
- encapsulation
- a single protocol needed (DOIP)



Adapter

**DOIP Domain**

Adapter

Adapter
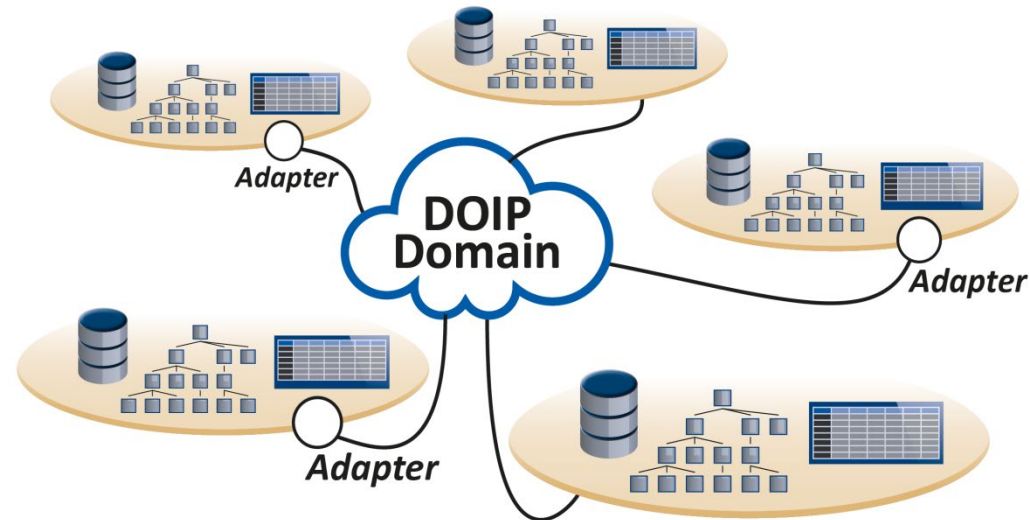
# Are FAIR Digital Objects FAIR?

Typical Canonical FDO Example: FDO with metadata and two bit-sequences, themselves being FDOs.
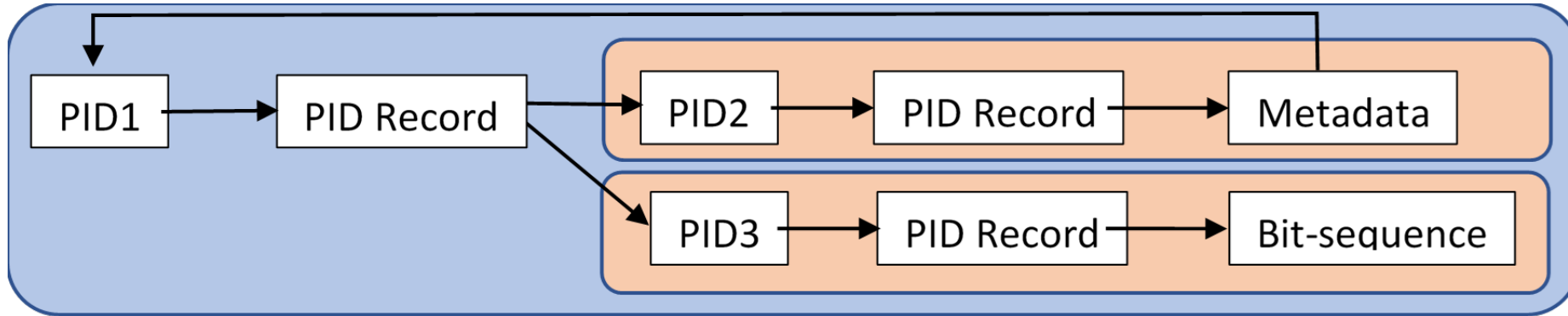


| PID needs to resolve in predictable resolution result according to a registered profile | Handle/DOI ok | URL? |
|---|---|---|
| Attributes in PID record need to be defined & registered & thus machine actionable | DTR ok | URL? |
| Attributes that include references to MD and Bit-Sequences to be machine actionable | DTR ok | URL? |
| Metadata to be accessible, interpretable (mostly not machine actionable) | ESFRIs ok | ESFRIs ok |
| Metadata elements that refer to FDO need to be machine actionable | ? | ? |
| Bit-Sequences need to be accessible, interpretable (compliant with Type) | in general ok | in general ok |

Making metadata provided by communities FAIR will be the challenge.

# A Domain of FAIR Digital Objects
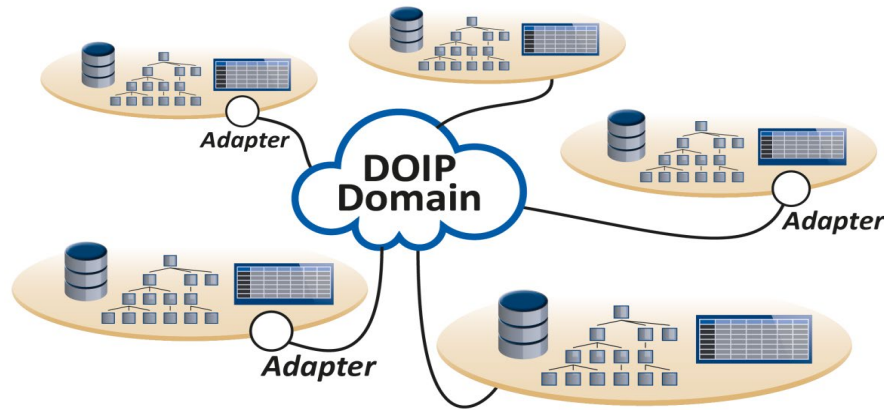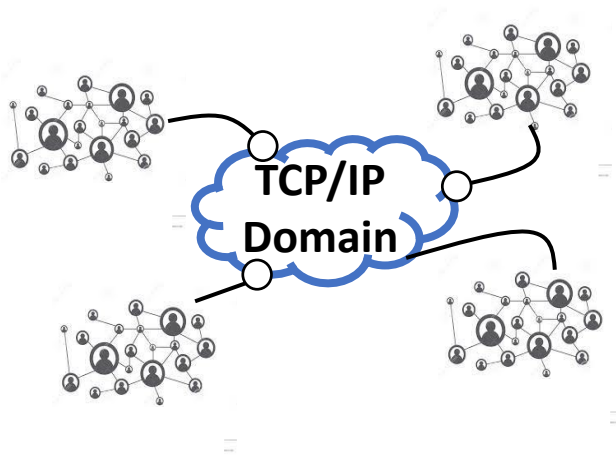


|  | Internet | Integrated Data Space |
|---|---|---|
| challenge | creating an integrated computer network | creating an integrated global data space |
| heterogenity | 100s of networks | 100s of standards, 1000s of repositories, 10000s of tools |
| differences | mode, packaging | data organisation and modelling |
| basic protocol | TCP/IP | DOIP |
| rights | no patents, no commerce | no patents, no commerce |
| achievements | complexity reduction, start of innovation | complexity reduction, start of innovation |
| key | broad social agreement | broad social agreement (?) |

# What is the state of FDO work?

- a clear specification called **FDO Framework**

- this is currently turned into technical specs allowing to develop **validators** in 2021 and to enable a "**plug-in" domain**

- a **DO Interface Protocol (DOIP)** specification, a software implementation and a reference repository (server)

- a variety of initiatives (ESFRIs, US, etc.) working on **implementations** and **demonstrators**

- **FDO Forum** is an independent initiative led by international experts which will be turned into a non-profit organisation (must be similar to Internet Society to prevent take-overs)

- FDO Forum will closely collaborate with RDA, CODATA, WDS, GOFAIR, EOSC

# What about community uptake?

quite a number of communities and data centers are testing and piloting with aspects of the FDO concept – some we even don't know

- DISSCO, CLARIN, ICOS, material science, climate modelling, health, social science, biophysics,

- KIT, GWDG, CSC, SDSC, IU, CAS, NIST, GOFAIR, DTL, GESIS,

Trends in Climate Modelling Research (WCDC)

- CMIP 6 to include PIDs (Handles, DOIs) and FDO aspects

- increasingly more automatic workflows for data management & processing (Open Science by Design, reproducibility, etc.)

- from 30 CWFR abstracts for Data Intelligence Journal 8 from environmental sciences

250 experts on our email list, but still a small group of experts

# Recommendations

- Need to anticipate requirements for next decades and invent suitable structures.

- Need to capitalise on more than a decade of experience in infrastructure building and dare to abstract from SILO approaches to generic solutions.

- Decisive is not **where** we will store digital objects (clouds) but **how** (FDO) to prevent dark digital age, improve FAIRness, drastically improve efficiency and build-in security, to support tracking, validation etc. and to foster sovereignty & trust

- Need a system of persistent registries and services (PIDs, Types, Mappings, Provenance, etc.) and clarify responsibilities

- **It's time to invest in large testbeds and reference architectures**

- Of course: invest in training young experts (courses, hackathons, etc.)

- Help enthusiastic young people to build smart services (portals, specific mappings, etc.)
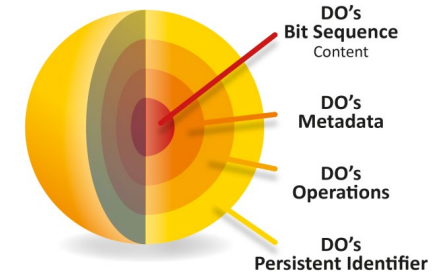
# Thanks so far.

➢ Wittenburg & Strawn: **Common Patterns in Revolutionising Infrastructures & Data**;
http://doi.org/10.23728/b2share.4e8ac36c0dd343da81fd9e83e72805a0

➢ de Smedt, Koureas & Wittenburg: **Analysis of Scientific Practice towards FAIR Digital Objects**;
http://doi.org/10.23728/b2share.e14269d07ce84027a7f79ee06b994ef9

➢ **FDO Framework**: https://github.com/GEDE-RDA-Europe/GEDE/tree/master/FAIR%20Digital%20Objects/FDOF

➢ **Paris Workshop**:  https://github.com/GEDE-RDA-Europe/GEDE/tree/master/FAIR%20Digital%20Objects/Paris-FDO-workshop

➢ Jeffery, et.al.: **Not Ready for Convergence in Data Infrastructures;** *Data Intelligence* (2021) 3 (1): 116–135,
https://doi.org/10.1162/dint_a_00084

➢ **DOIP V2.0:** https://www.dona.net/specsandsoftware
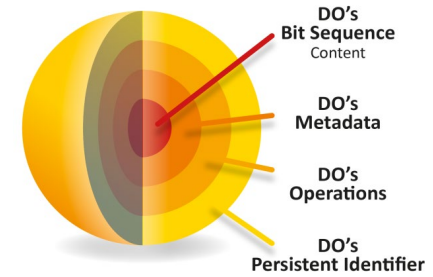
# Demonstrators

Purpose:
➢ demonstrate that FDOs are useful and that DOIP is operational and reduces complexity
➢ show that FDOs are ready for building larger reference implementations

Contributors:
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# Three demonstrators

KIT Karlsruhe:

- new FDO, FAIR Handle generation, validation, dissemination, search support

U Indiana:

- scientific workflow with systematic Handle generation, DOIP usage, tracking

GWDG – CSC – CNRI (US):
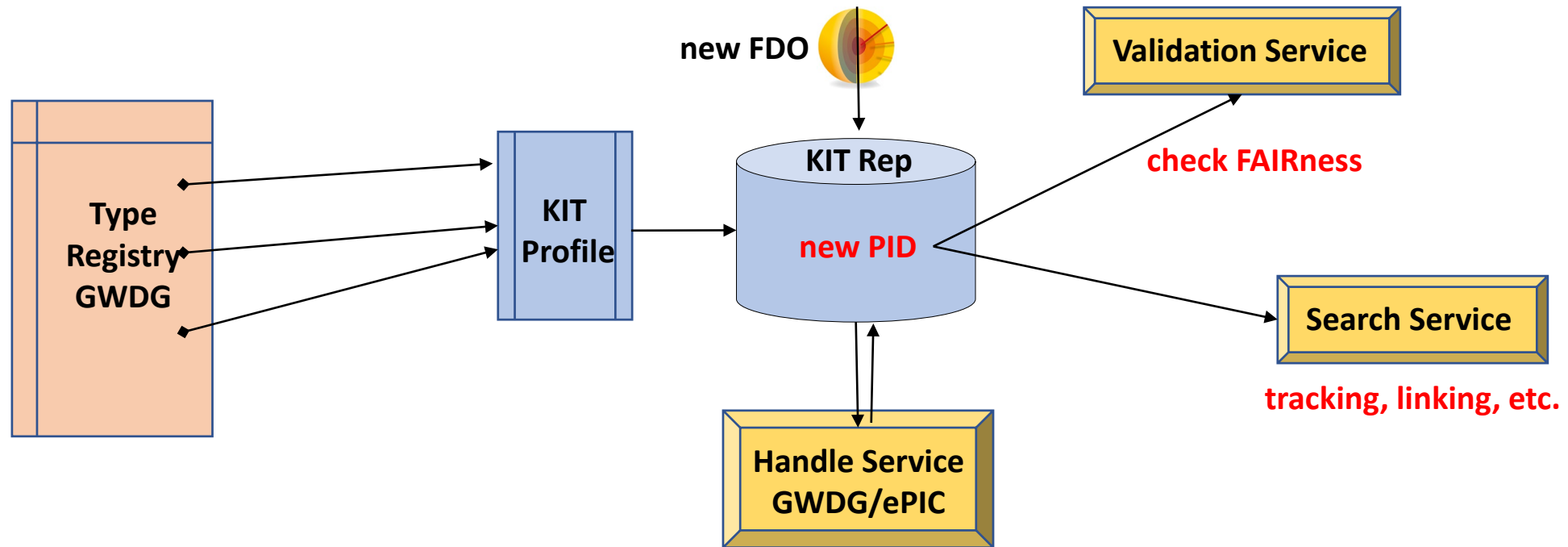
- exchange (F)DOs, FAIR Handle generation, DO search

# KIT Demo

- A PID is created according to a profile with machine actionable attributes, it is automatically validated, distributed and a search can be executed

- This is part of the KIT work for the Helmholtz Society

- next step to make use of DOIP exchange between different repositories and thus to unify. Validated and machine actionable (FAIR) PIDs are crucial.

- Participants: KIT, GWDG (PID Service, Type Registry Service)

# KIT Demonstrator



new FDO

Validation Service

check FAIRness

KIT Rep

new PID

Type
Registry
GWDG

KIT
Profile

Search Service

tracking, linking, etc.

Handle Service
GWDG/ePIC

# U Indiana Demo

- U Indiana is working on a variety of testbeds
- Workflow testbed based on a VRE supporting Handles and DOIP
  - Raw data –> data preparation SW -> Intermediate data -> data analysis -> data products
  - PIDs for workflow, data & software
  - at all stages PIDs are being assigned for tracing and provenance tracking
  - all stages well-documented

- Material Science Repository Integration
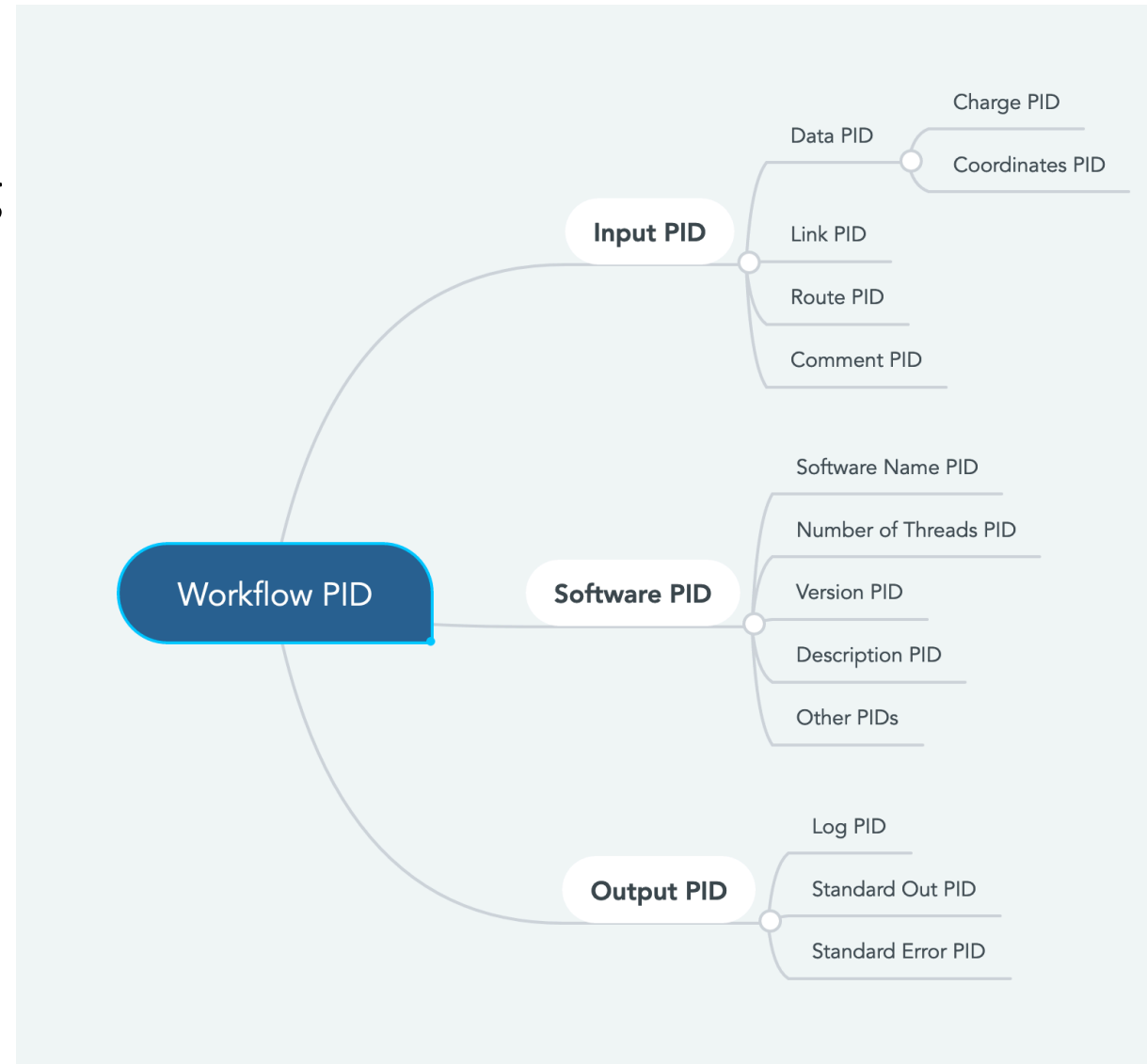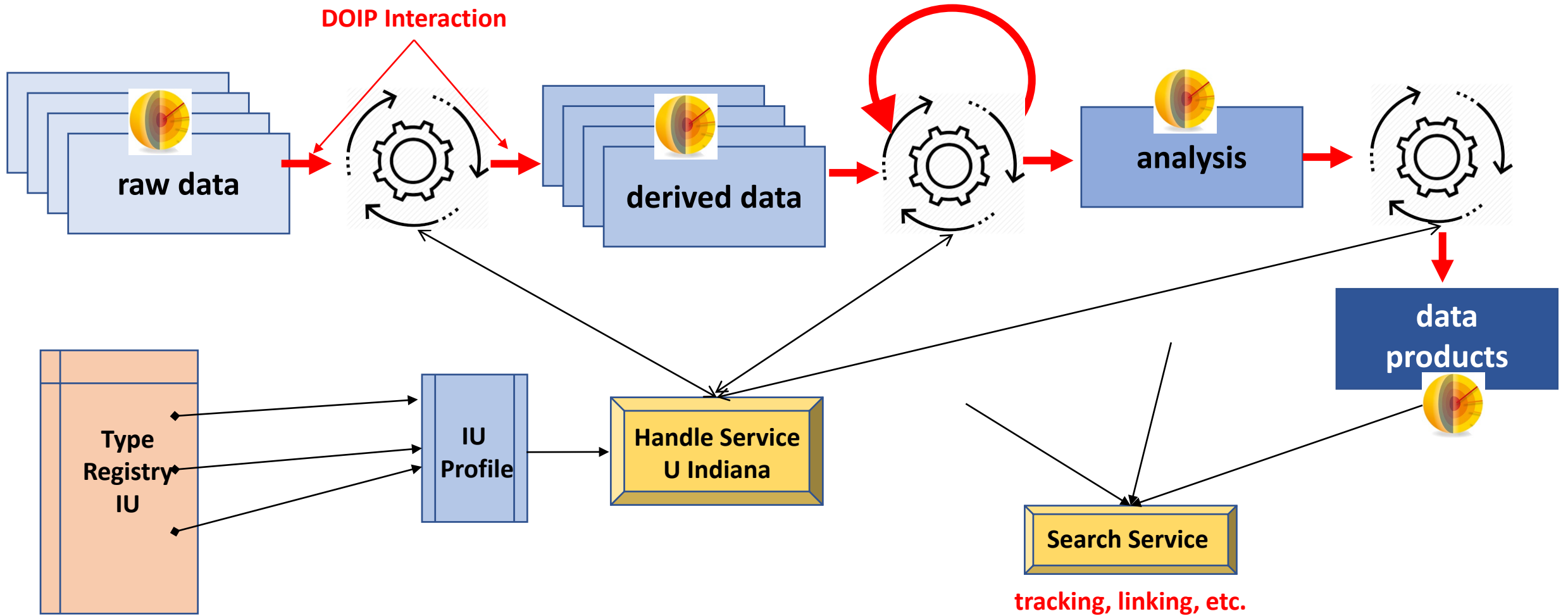
# B2SHARE – CNRI Integration Testbed

- Intention is to integrate B2SHARE (EUDAT) with CNRI repository via DOIP

- CNRI developed a proxy (one week analysing and programing)

- Proxy allows to connect all B2SHARE instances (GWDG, CSC, FZ Jülich, U Helsinki, etc.)
  - usual operations: „copy" FDO, copy bit-sequence, move FDO, delete bit-sequence

- next steps
  - nice Virtual Environment (GWDG) to be finished
  - transformation to full FDOs
  - connection of San Diego SC repository, automatic execution of docker image
  - integration of other repositories
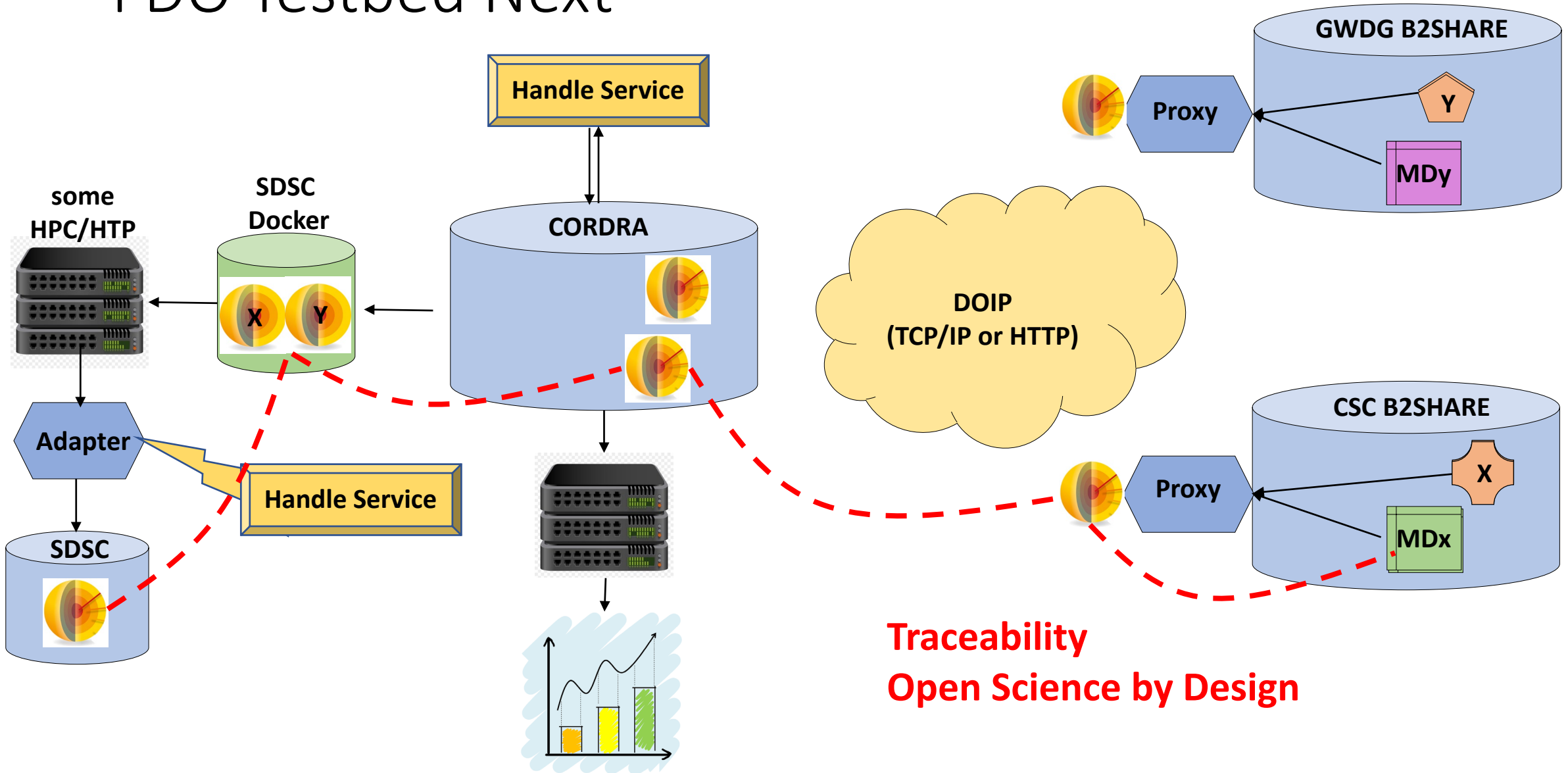
- participants: CNRI, GWDG, CSC, SDSC
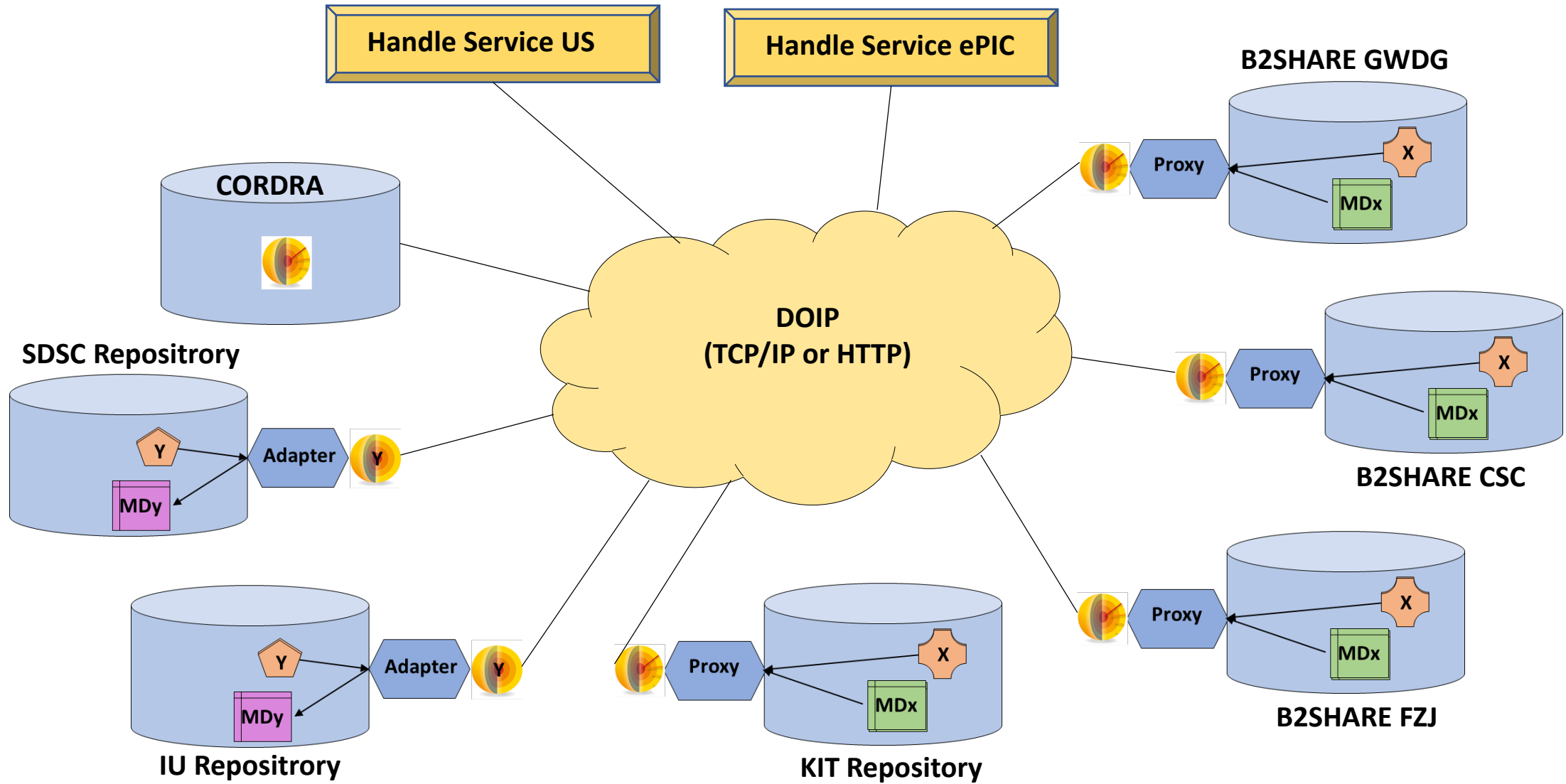
# FDO Testbed
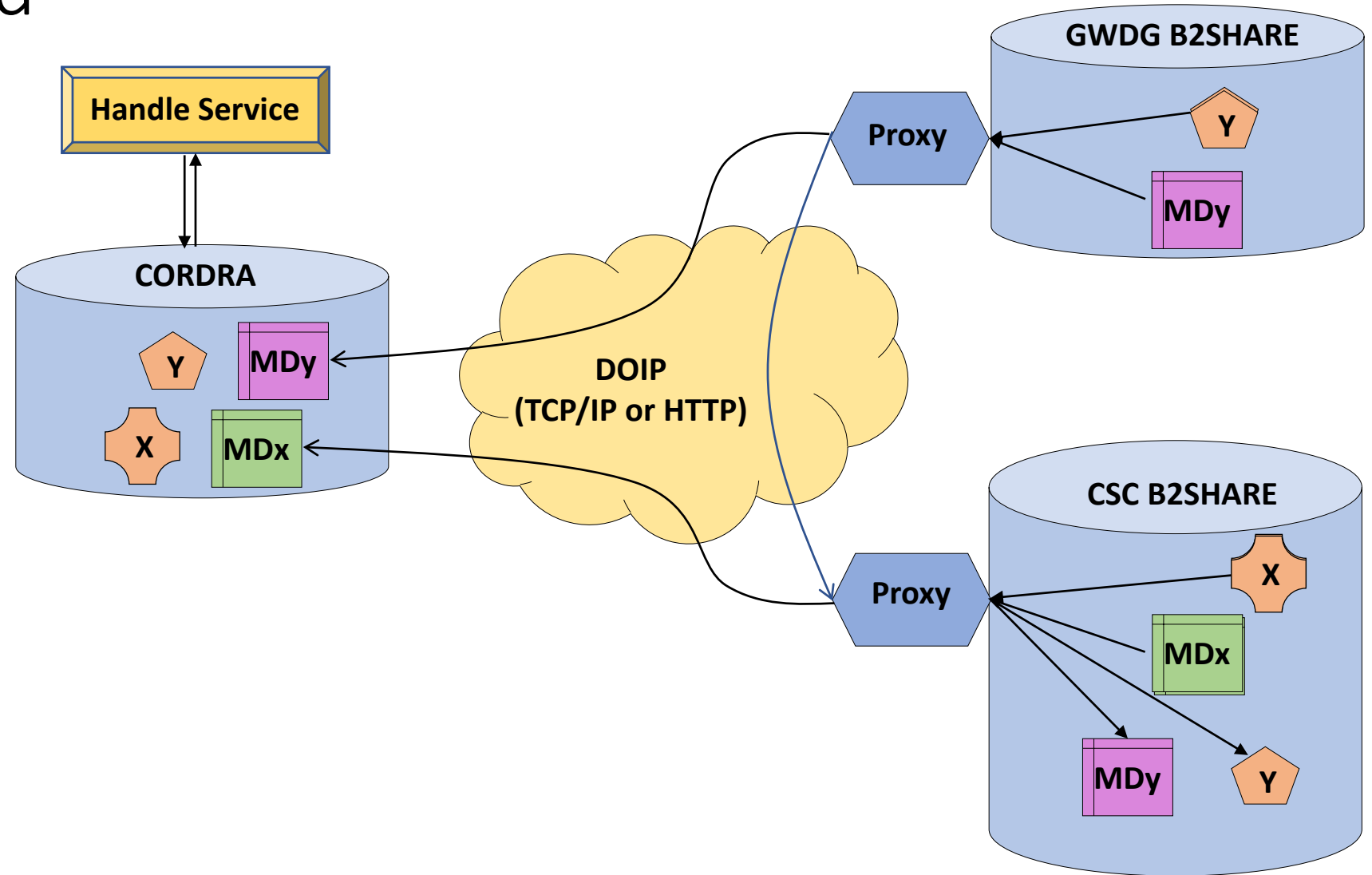
# FDO Testbed Next
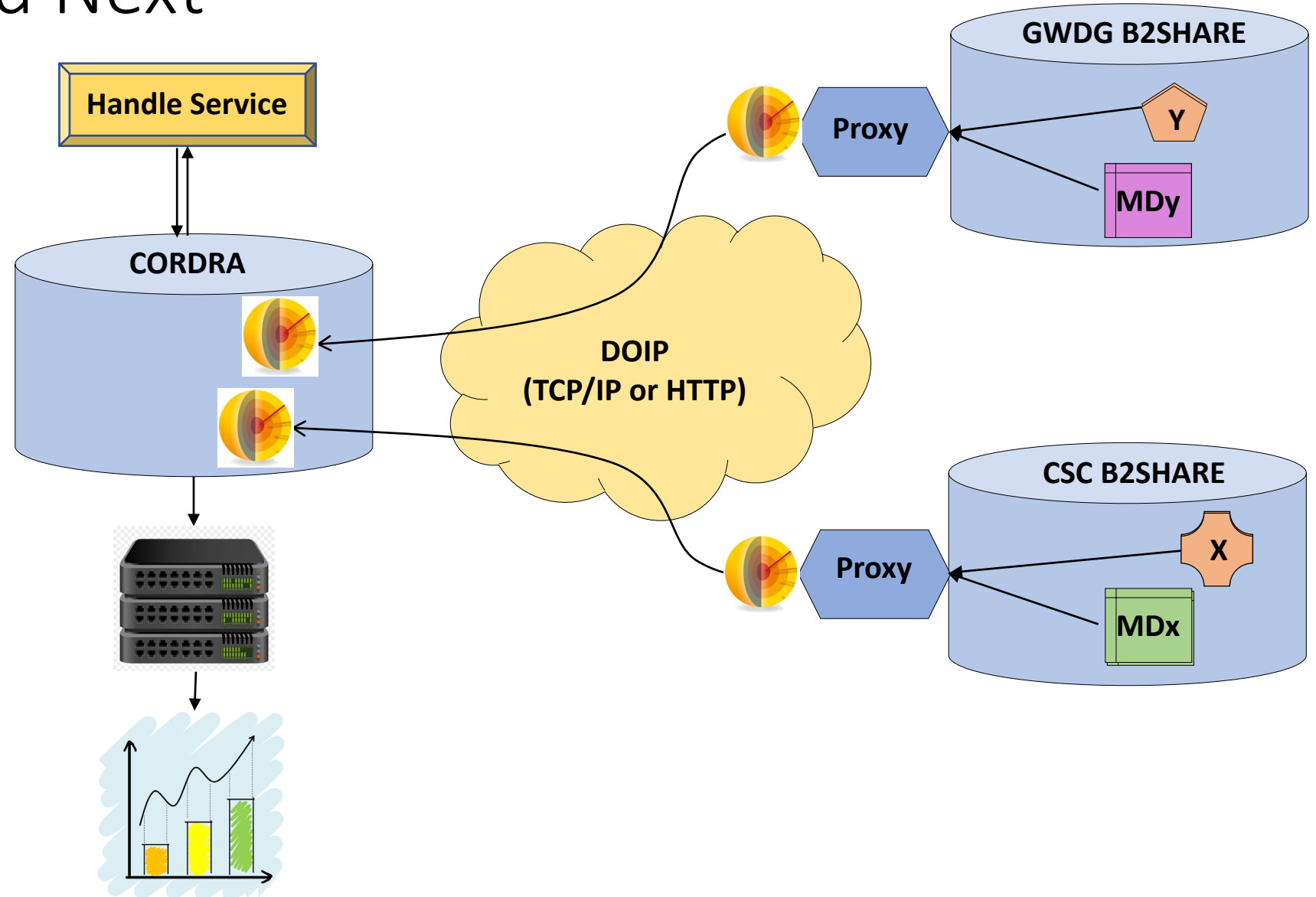
FDO Testbed Next

# FDO Testbed Next

# Demo Video Kit

# Demo Video U Indiana
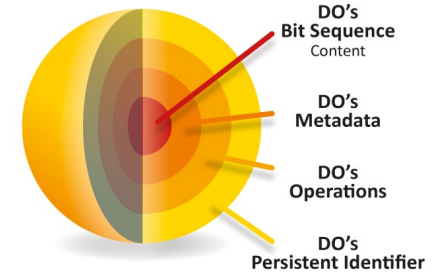
# Demo Video FDO Testbed

# Resumee

- a variety of piloting projects in addition to massive Handle/DOI usage (-> Maggie)
- with relatively small effort (1 week) one can create an FDO adapter/proxy (if developer is professional)
- all kinds of repositories (different data organisations & models) can be connected to DOIP network reducing complexity to N*1
- FDOs are FAIR compliant if community metadata is made FAIR compliant
- „encapsulation" by specifying the FDO Type – Operation relationship

- **biggest problem for our demonstrator: access to developers**
- **urgent: connect these partial demonstrators together (incrementally growing testbed)**

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Thanks for the attention.