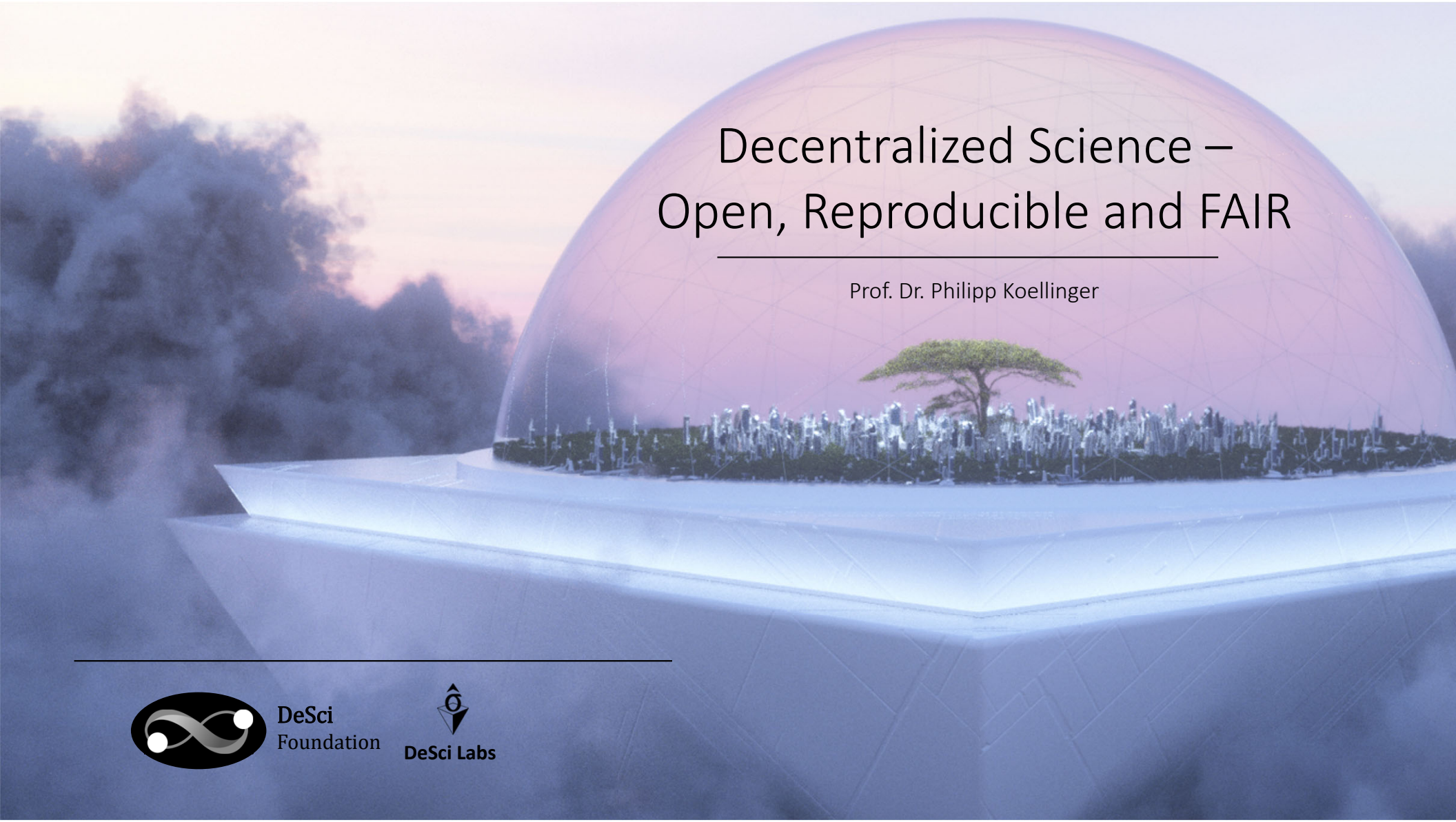


Decentralized Science – Open, Reproducible and FAIR

Prof. Dr. Philipp Koellinger

DeSci Foundation

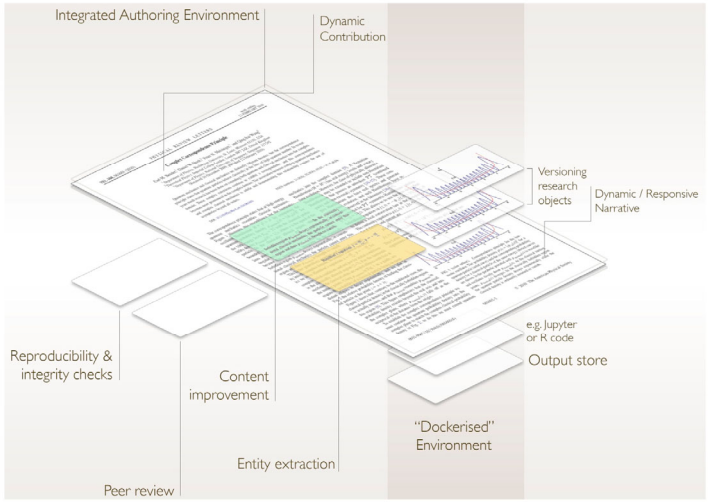
DeSci Labs

The problem

- Outdated, rigid publication infrastructure
- Reproducibility and replicability crisis
  - Decreasing trust in science
- Inaccessible data and code
  - Lost, valuable resources
  - >€10 billion costs due to not having Findable, Accessible, Interoperable & Reusable (FAIR) data
    - European Commission: Cost of not having FAIR data (2018)

The solution

- Interactive and versionable FAIR digital research objects
- Open-state repository
  - No data silos
  - No vendor lock-in
  - Institutional sovereignty
  - Content owned by creators
- Persistent identifiers as irrevocable APIs (DPID.org)
- Pluralistic attestations, e.g.
  - Data & code available
  - Results reproducible
- Affordable data storage
- Fork & merge for composable authorship, e.g.
  - Data stewards
  - Other researchers



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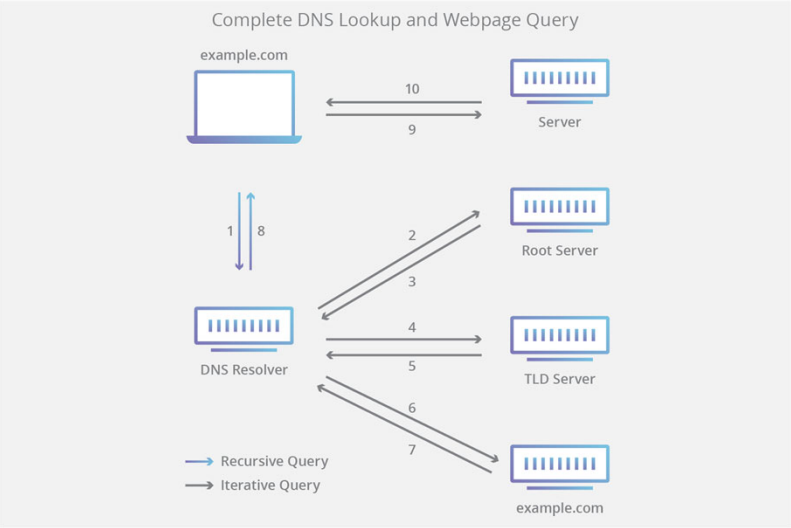
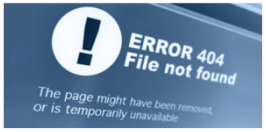
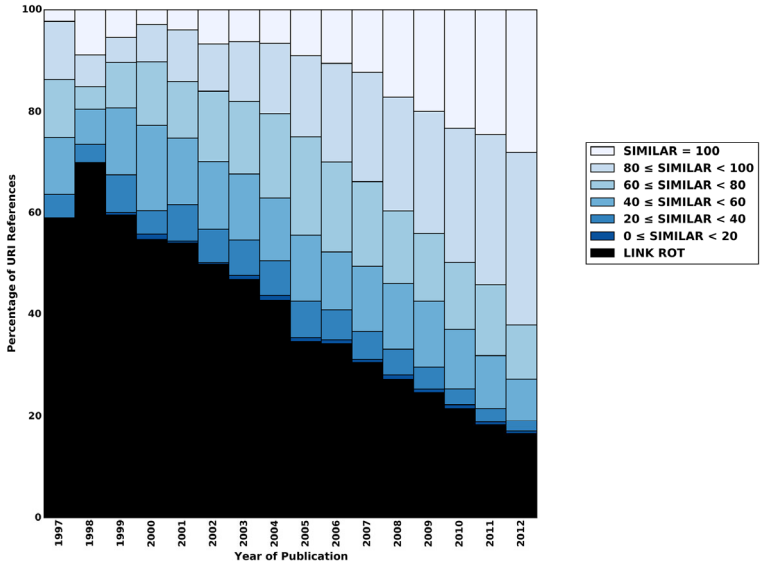
Identifiers in the current Internet – URIs







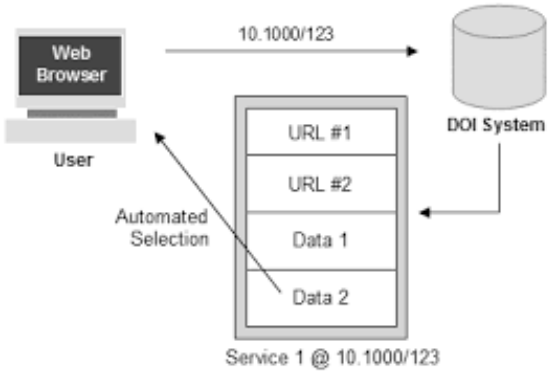
- URLs point to where content is stored, not what the content is
- Link rot (file moved or deleted, 404 error)
- Content drift (content changes over time)
- No version control

- URI citations with link rot or content drift
  by year of publication, Elsevier corpus (Jones et al. 2016)
- A threat to the integrity and value of the scientific record

Sources:

Jones, S.M., et. al. (2016). Scholarly context adrift: Three out of four URI References Lead to Changed Content. *PLoS ONE* 11(12): e0167475.

DOIs are not persistent identifiers



- **DOIs do not correctly resolve to their target resource in ~50% of all cases** (Klein & Balakireva 2020)
- Different results for same DOI depending on request method and network environment
- DOIs are matched to URLs in a database
  → Lots of manual updating work for publishers
- Costly, inefficient system for publishers
- DOIs are neither persistent nor unique identifiers

Sources:
Klein, M., Balakireva, L. (2020). On the Persistence of Persistent Identifiers of the Scholarly Web. In: Hall, M., Merčun, T., Risse, T., Duchateau, F. (eds) *Digital Libraries for Open Knowledge*. TPDL 2020. Lecture Notes in Computer Science, vol. 12246. Springer.

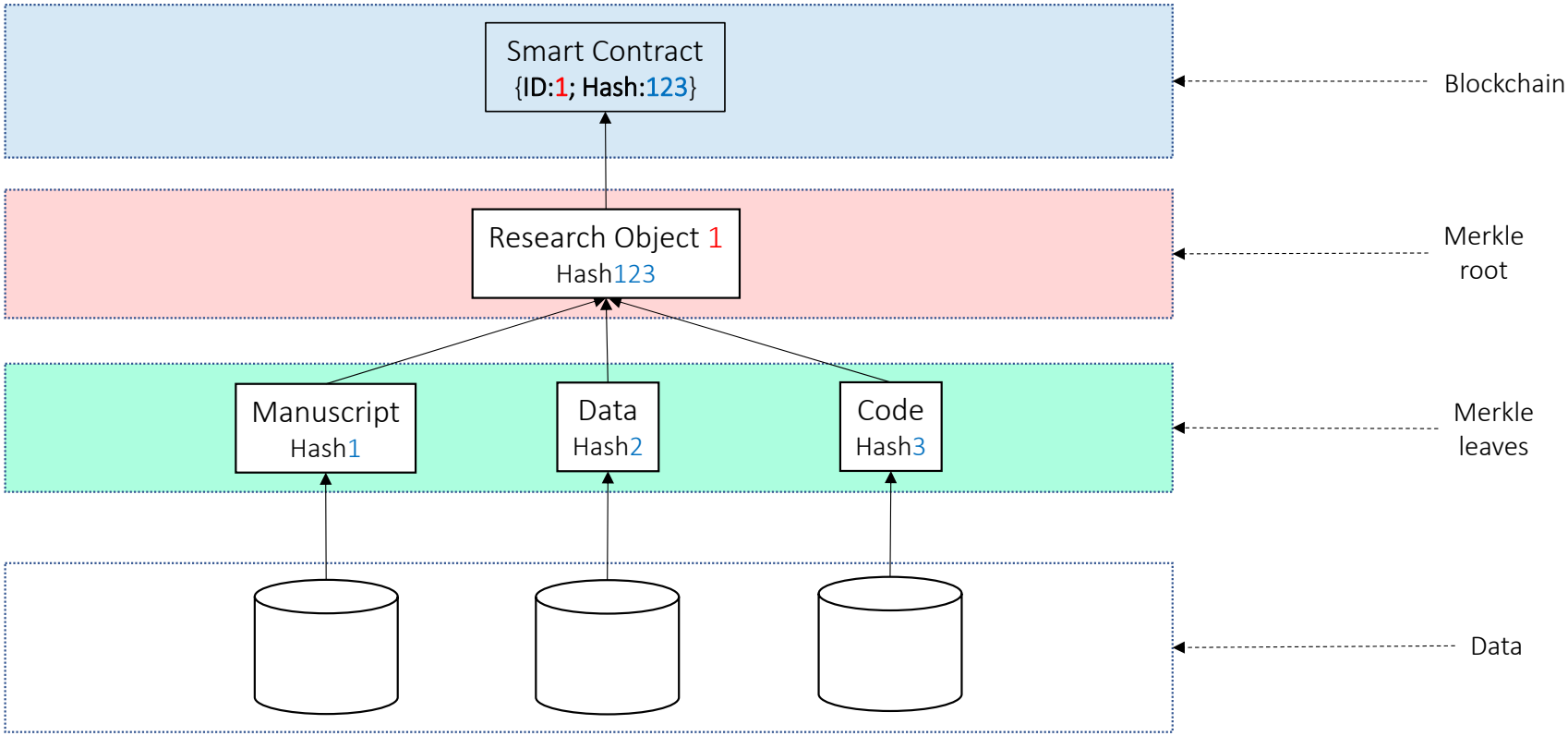
Decentralized content addressing based on hashes

- A cryptographic hash function converts a string of arbitrary length into string of fixed length
  - One-way mathematical function
    - E.g., the SHA-256 algorithm creates a 64 hexadecimal string for any input
  - Changing *anything* in the input (i.e. a word, pixel, comma) will yield a different hash
  - Hashes are *unique*
    - E.g., SHA-256 allows creating 10^{77} different hashes – billions of times more than the number of atoms on Earth
  - For example, SHA-256 hashes:
    - "PSV will win the Champions League 2024" → c554644c23a1ebdcf29f9c7af8492fac3a9964b0fbd0231f66a469580d09cfc9
    - "Feyenoord will win the Champions League 2024" → 24e4996dc8601efcd676e8f94fd312776c3f648cfd0d30a380121e240660ec5e

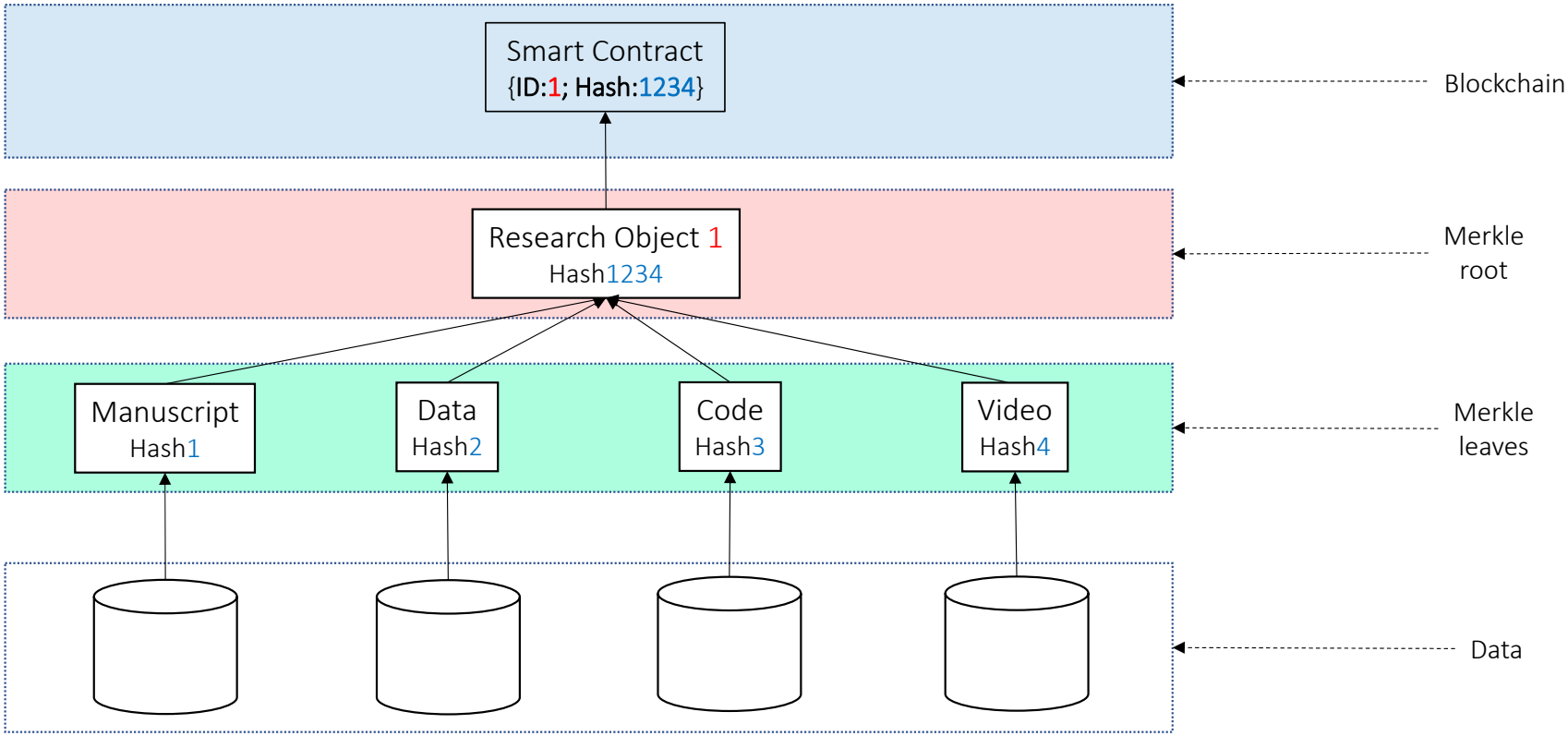
- Content-addressed storage is immune to content drift and link rot!
  - Interplanetary File System (https://ipfs.tech/)

Sources:
https://xorbin.com/tools/sha256-hash-calculator

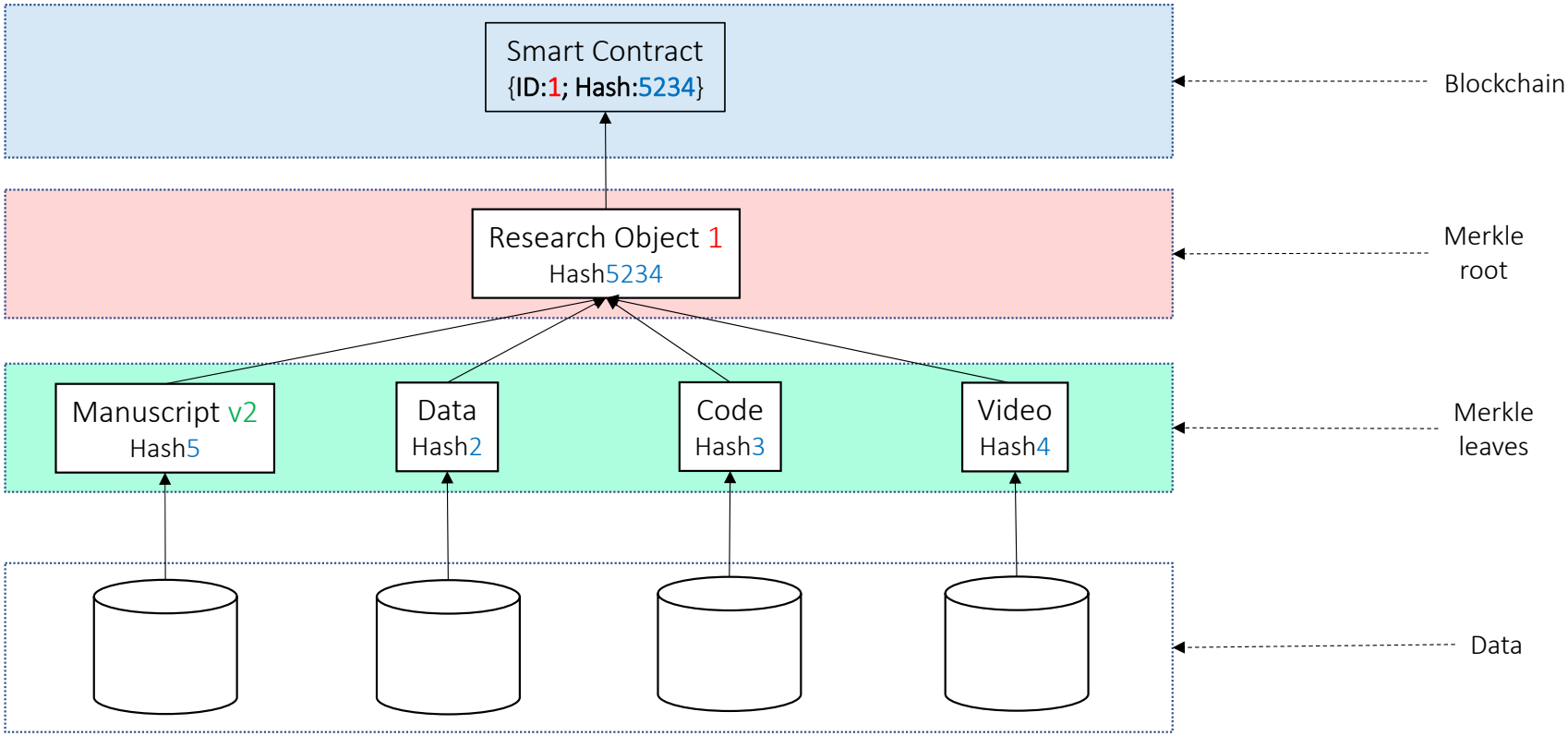
DeSci Nodes: Research objects with hash-PIDs, indexed on a blockchain



Adding a new component to the research object

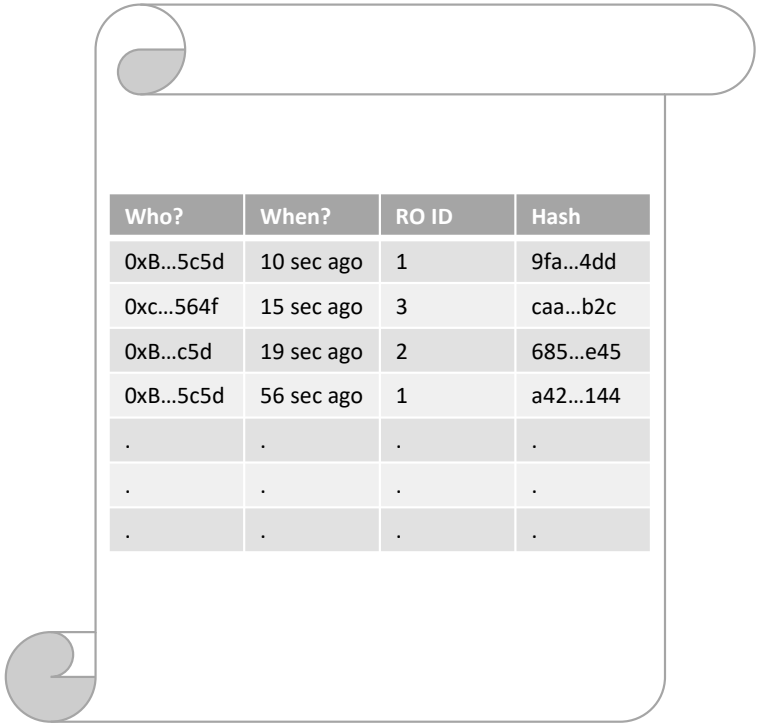


Updating a component of the research object



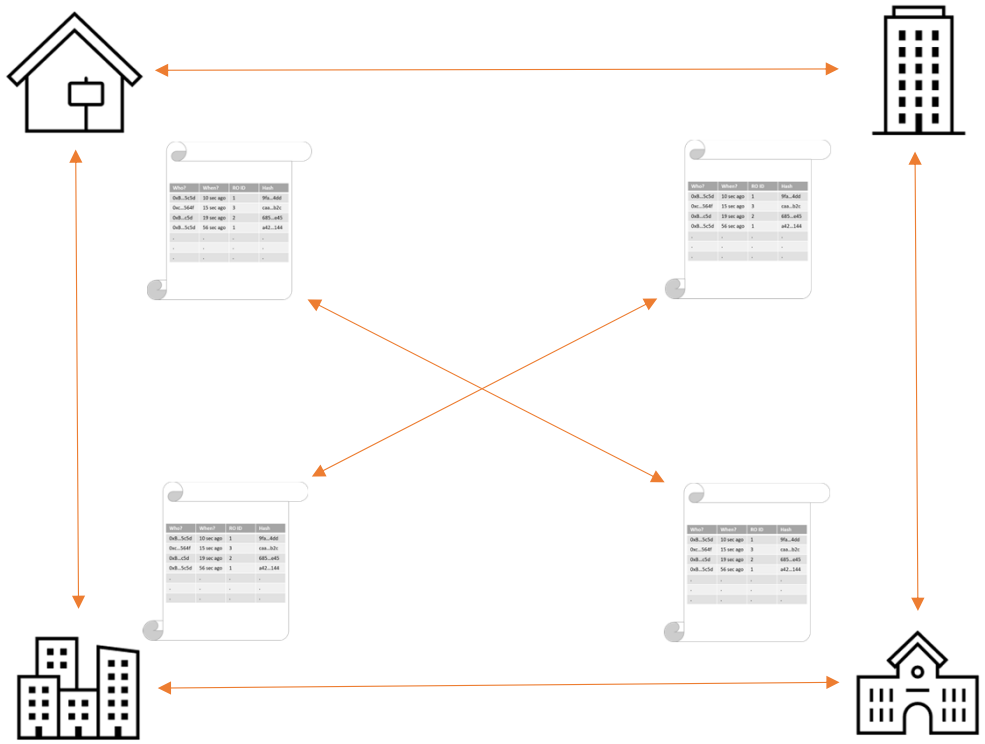
→ The decentralized web allows us to upgrade the scientific record from static manuscripts *without* persistent IDs *or* version control to rich, dynamic, interoperable research objects *with* persistent IDs *and* version control!

Provenance: A public ledger of research objects…



Who?	When?	RO ID	Hash
0xB…5c5d	10 sec ago	1	9fa…4dd
0xc…564f	15 sec ago	3	caa…b2c
0xB…c5d	19 sec ago	2	685…e45
0xB…5c5d	56 sec ago	1	a42…144
.	.	.	.
.	.	.	.
.	.	.	.

…distributed across many servers



DeSci protocol

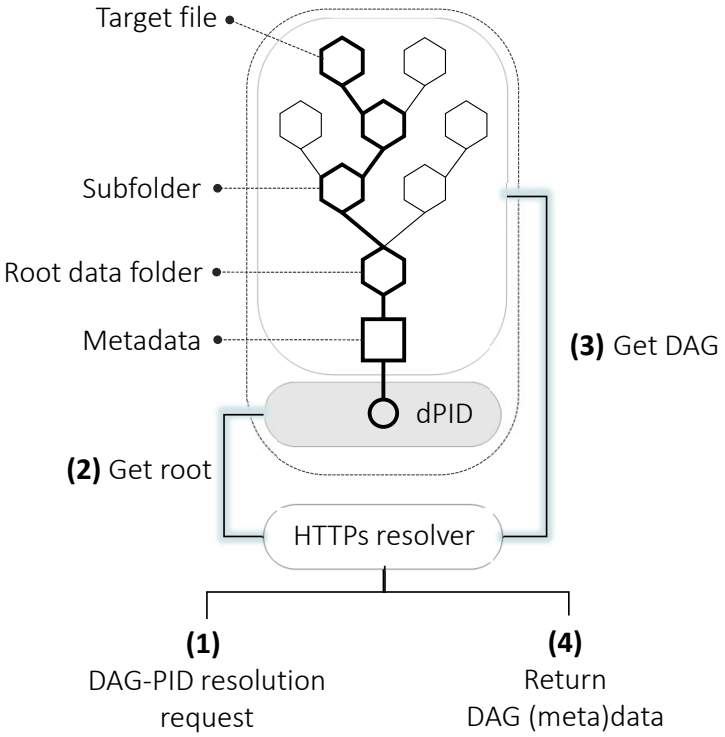
…resolution to (meta)data over HTTP

RESOLVER/[UUID or short PID]/[ROOT_HASH or version]/[Component ID]/[JSON_PATH][optional method suffix]

COMPACT PID TO DATA: dpid.org/42/1/2/1

COMPACT PID TO METADATA: dpid.org/42/1/2/1?jsonld

Open state resolution to (meta)data
Over HTTP gateway



Open state read and write
(Irrevocable API)

DeSci protocol

…resolution to (meta)data over HTTP

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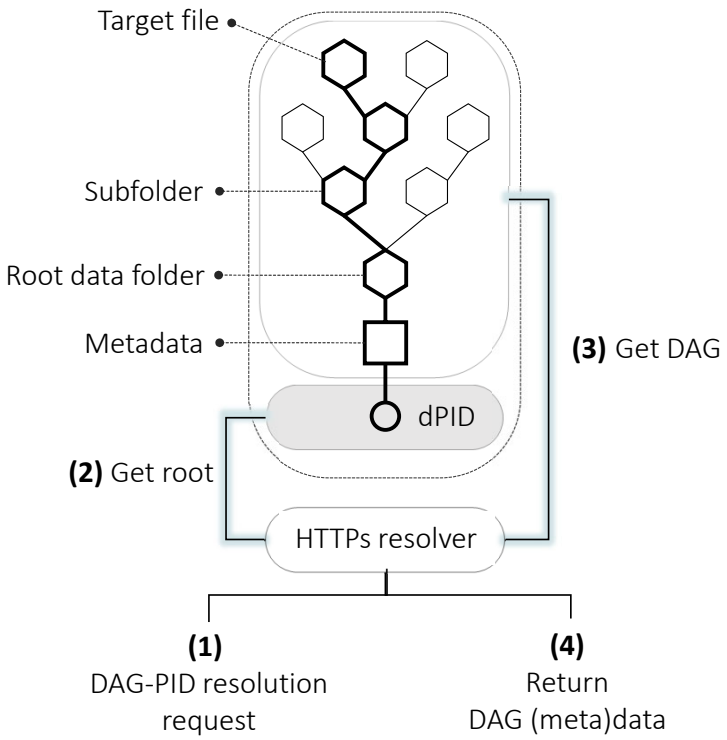
COMPACT PID TO DATA: dpid.org/42/1/2/1

COMPACT PID TO METADATA: dpid.org/42/1/2/1?jsonld

…as addresses for edge compute jobs

```
bacalhau docker run \
-v PID #PID of the digital object
-- magick mogrify -resize 100x100 -quality 100 #program to execute
```

Open state resolution to (meta)data
Over HTTP gateway



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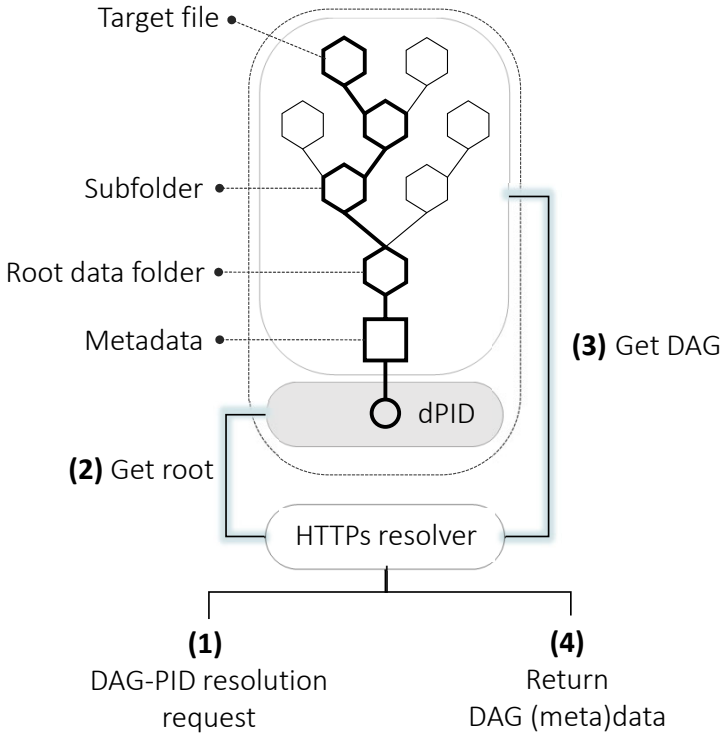
bacalhau docker run \
-v PID #PID of the digital object
-- magick mogrify -resize 100x100 -quality 100 #program to execute
```

…as importable resources

```
Import desci as desci

with desci.fetch
      import ("42/v1/data/measurement.csv") #import from PID
```

Open state resolution to (meta)data Over HTTP gateway



Open state read and write (Irrevocable API)

DeSci protocol

…resolution to (meta)data over HTTP

RESOLVER/[UUID or short PID]/[ROOT_HASH or version]/[Component ID]/[JSON_PATH][optional method suffix]

COMPACT PID TO DATA: dpid.org/42/1/2/1

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…as addresses for edge compute jobs

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```
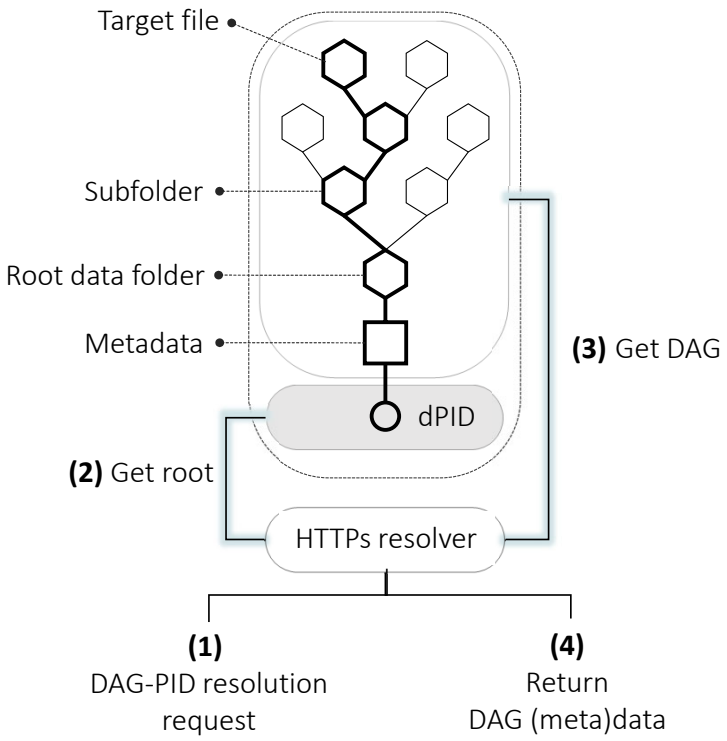

…as importable resources

```
Import desci as desci

with desci.fetch
      import ("42/v1/data/measurement.csv") #import from PID
```

…as targets for attestations

```
structAttestation{

// Generate a PID for the attestation
bytes32 uid
```

Open state resolution to (meta)data Over HTTP gateway



Open state read and write (Irrevocable API)

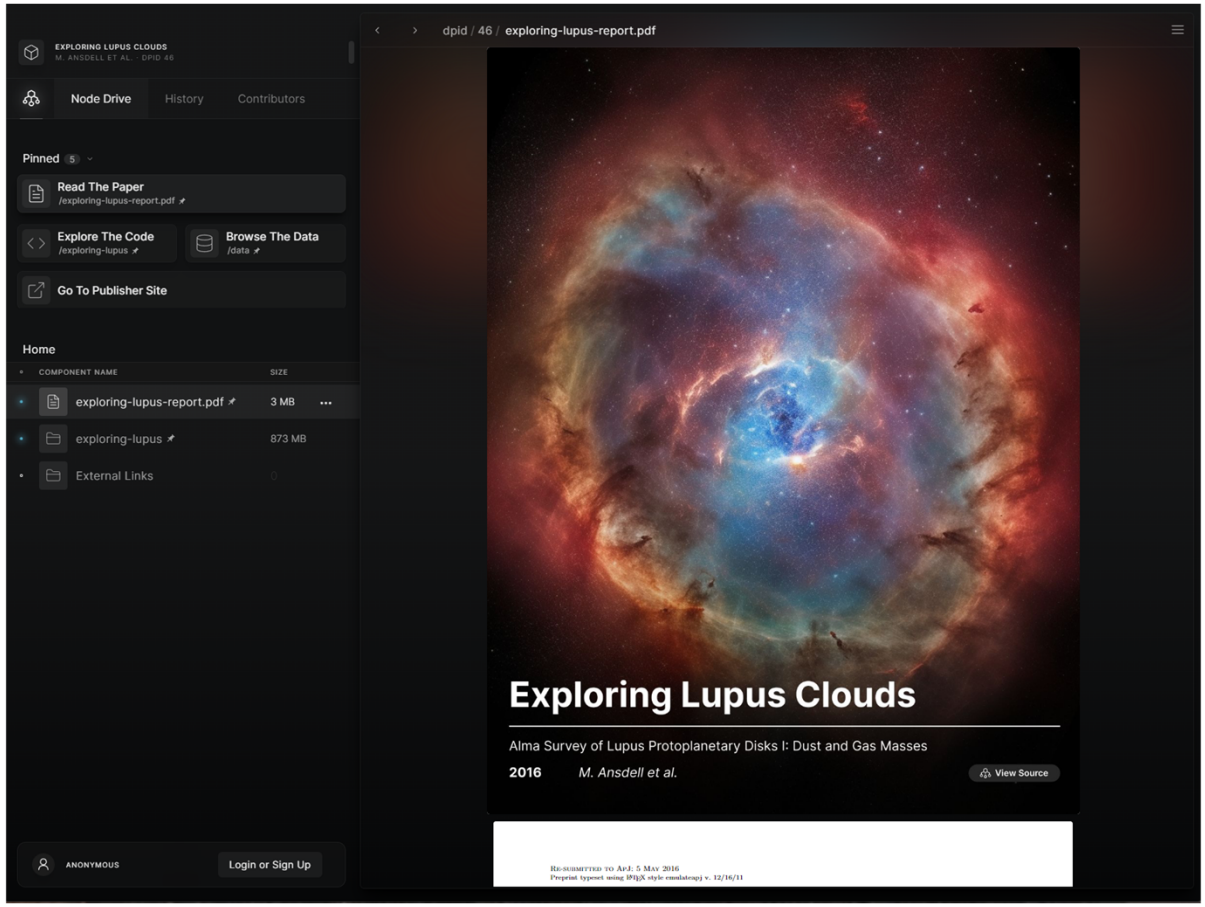
DeSci Nodes application

- Currently in open beta testing
  - Create and share an interactive, versionable FAIR digital research object
  - Enable reproducibility
  - DPID Fetch (import data and code directly into your local environment)
  - Compute over data with Bacalhau (https://www.bacalhau.org/)
  - Free (up to 50GB)

- Major upgrade release in November
  - Improved user experience
  - No wallet needed
  - ORCID integration
  - New website

- Next year and beyond
  - Attestations & commentaries
  - Text-editor integration
  - Fork & merge
  - In-browser compute
  - Automatic meta-data suggestions (e.g. authors and affiliations, keywords for each file)
  - Affordable, flexible data storage
  - Targeted solutions for publishers, academic societies, universities, and funding agencies

DeSci Nodes demo



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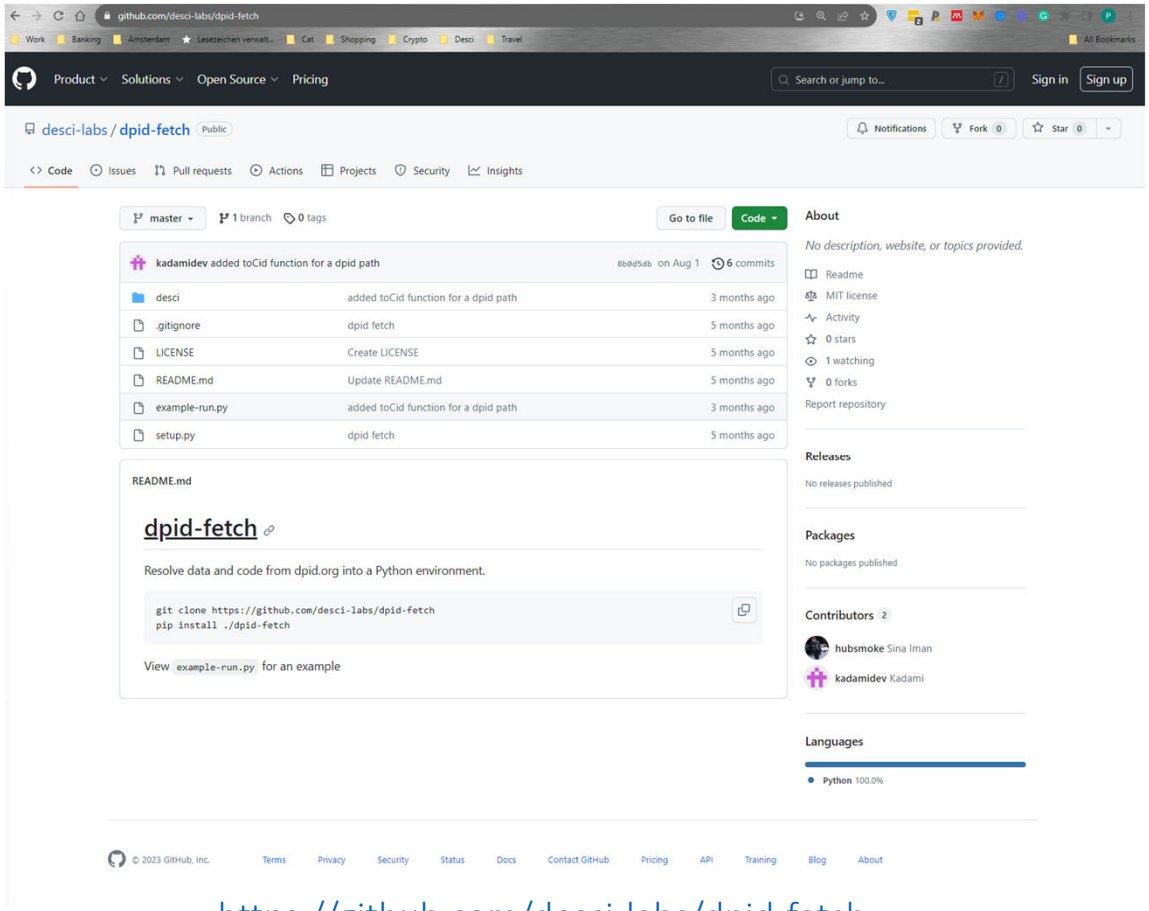
DPID Fetch



https://github.com/desci-labs/dpid-fetch

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Recommendations

- Try to use open-source stats software and data formats (e.g. R, Jupyter, Python)
- One code file for each key result (e.g. figure, table)
  - Use DPIDs from the Nodes application to address data files
  - Annotate your code
- Make use of versionability, e.g.
  - Start with analysis plan
  - Add data and code
  - Add manuscript and connect results to data & code
- Check Dryad recommendations for sharing human subject data
  - https://datadryad.org/docs/HumanSubjectsData.pdf
- Check out DeSci Nodes user documentation
  - https://docs.desci.com/using-nodes/getting-started

Call to action

- Participate in a meta-science field experiment!
  - Does fully reproducible research have a better chance of getting published?
  - Rewards for participants
  - Reach out to me
- Try out Nodes and make your work reproducible!
  - Any feedback and suggestions are VERY welcome
  - Reach out to me or use the “Feedback” button in the app
- Ask the DeSci Labs team for help to create reproducible research!
  - Reach out to me

Prof. Dr. Philipp Koellinger

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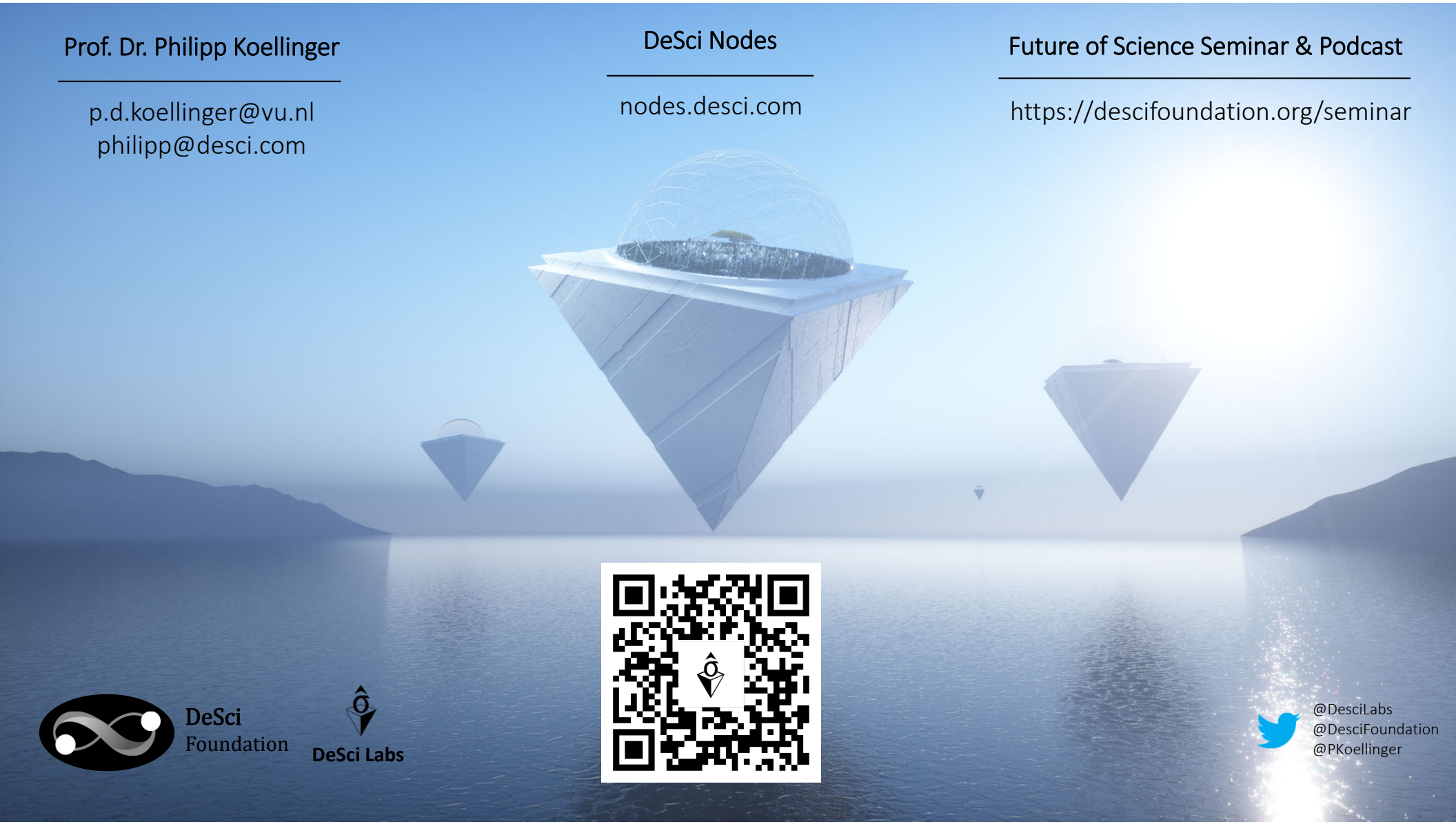
philipp@desci.com

DeSci Nodes

nodes.desci.com

Future of Science Seminar & Podcast

https://descifoundation.org/seminar



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