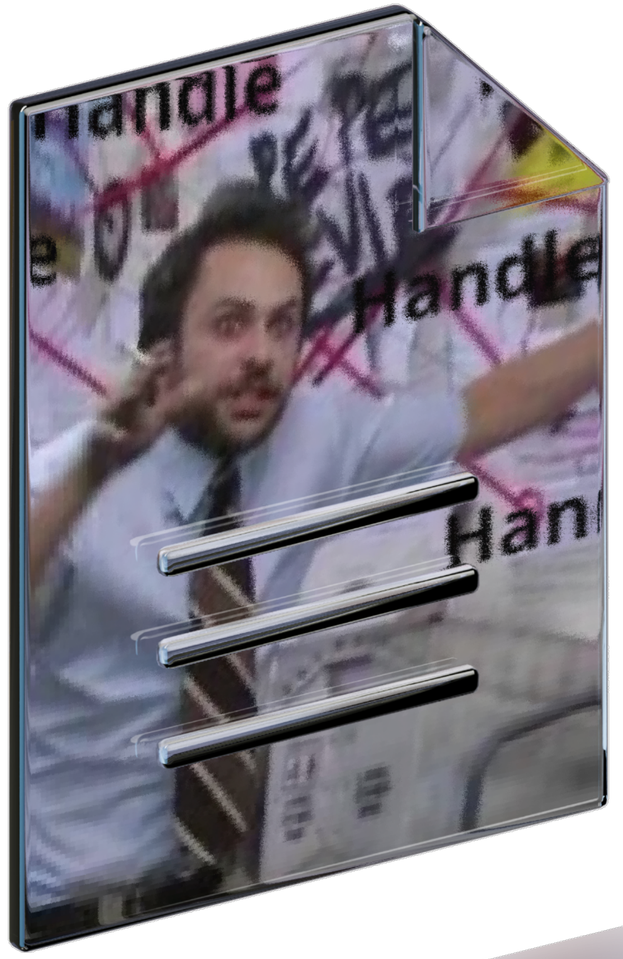
DOI

Beyond the Basics



beyond-the-basics.pdf

Markus Toran — MRMCD 2025 — 13.09.2025 — Darmstadt

DOI: The Basics

- Digital Object Identifier
- Global system for assigning permanent and unique identifiers
- doi:10.1145/322796.322806 or https://doi.org/10.1145/322796.322806
- Metadata associated with a DOI

DOI: The Basics

doi:10.1145/322796.322806

DOI: The Basics

do

06

Users Are Not The Enemy

Why users compromise computer security mechanisms and how to take remedial measures.

Confidentiality is an important aspect of computer security. It depends on authentication mechanisms, such as passwords, to safeguard access to information [9]. Traditionally, authentication procedures are divided into two stages: *identification* (User ID), to identify the user; and *authentication*, to verify that the user is the legitimate owner of the ID. It is the latter stage that requires a secret password. To date, research on password security has focused on designing technical mechanisms to protect

access to systems; the usability of these mecha-

do not have to write them down). The U.S. Fed-

DOI: The Basics

doi:10.1145/322796.322806

DOI: The Basics

doi:10.1145/322796.322806

DOI: The Basics

doi:10.1145/322796.322806

DOIs current scale

- 417,743,323 DOIs
- 173,349 DOI prefixes
- ~ 2B DOI resolutions per month
- ~ 900 resolutions per second on average

DOIs current scale

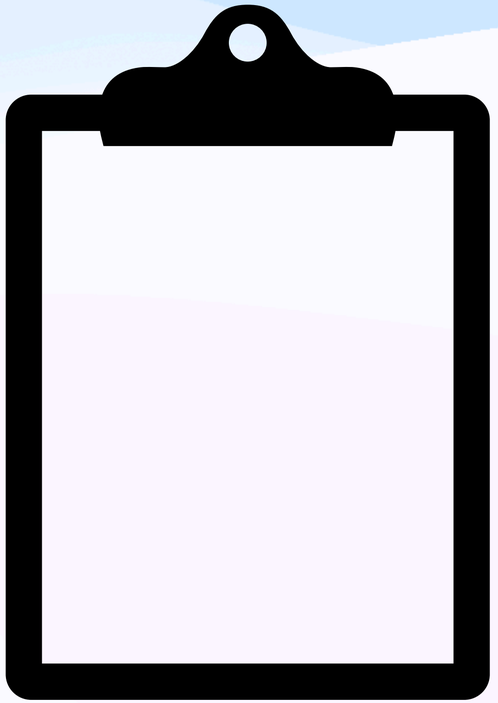
- 417,743,323 DOIs
- 173,349 DOI prefixes
- ~ 2B DOI resolutions per month
- ~ 900 resolutions per second on average
- https://doi.org/api/handles/10.1000/1000
- As of 2025-09-12

It got me thinking…

- But how are DOIs created?
- And how much does production cost?
- Why do they always start with “10.”?
- What software is used to actually achieve the massive scale and handle the high availability requirements?
- What are some unusual or special applications of DOIs?
- How do DOIs relate to others ids?

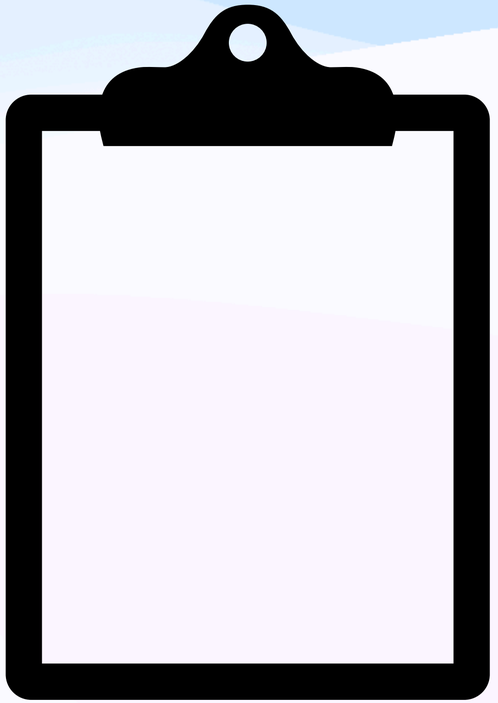
...and reading DOI Specs...

- ISO 26324:2025
- DOI Handbook
- RFC 3650, 3651, 3652
- ITU-T Recommendation X.1255



...and reading DOI Specs...

- ISO 26324:2025
- DOI Handbook
- ~~RFC 3650, 3651, 3652~~
- ~~ITU-T Recommendation X.1255~~
- DO-IRP(v3)
- DOIP(v2)



Achieving the Scale

Achieving the Scale

Achieving the Scale

Achieving the Scale

Achieving the Scale

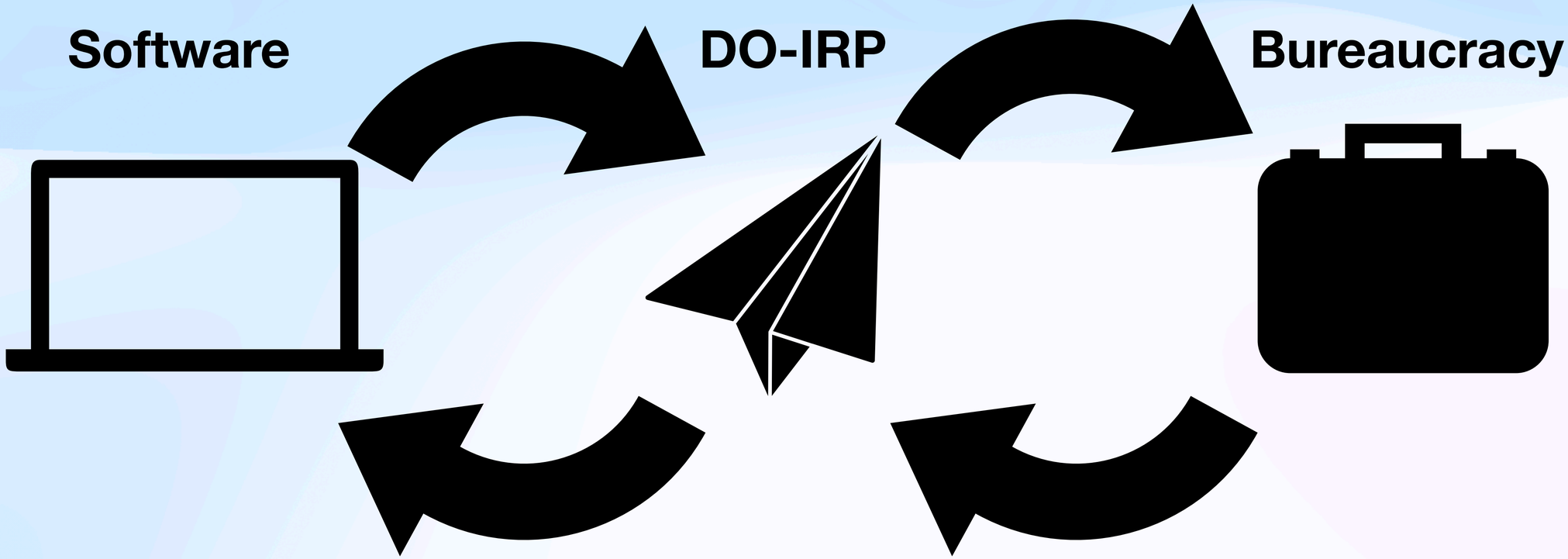
Achieving the Scale

Software

DO-IRP

Bureaucracy

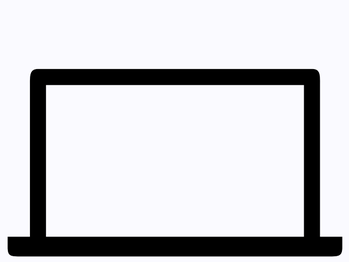
Achieving the Scale

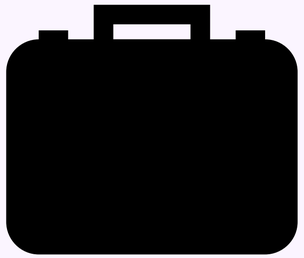


Handle System

- Foundation for DOI
- DOIs are Handles
- Provides resolution protocol to resolve DOI to URL
- “10” prefix within Handle System is assigned to DOI
- There are other prefixes

[3, 4]





Handle System

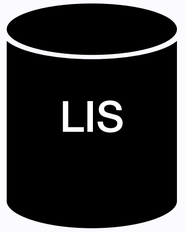
- Development started in the 1990s
- Bob Kahn (TCP/IP)
- Handle System associates Handles (identifiers) with records
- Multiple standard record types
- Citation Metadata is not stored in the Handle System

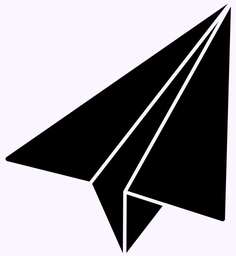
[5, 6]

Resolving a Handle

doi:10.1145/322796.322806

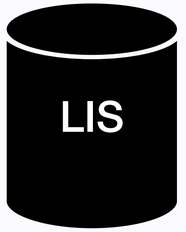
Resolving a Handle



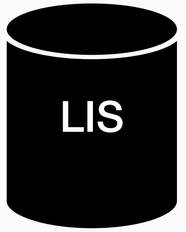


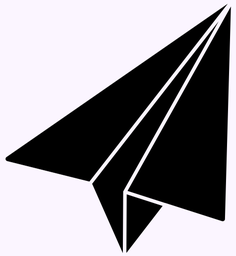
Resolving a Handle

?

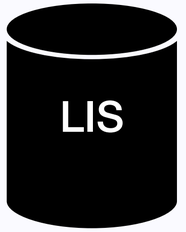


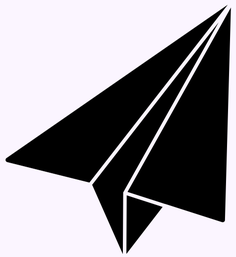
Resolving a Handle



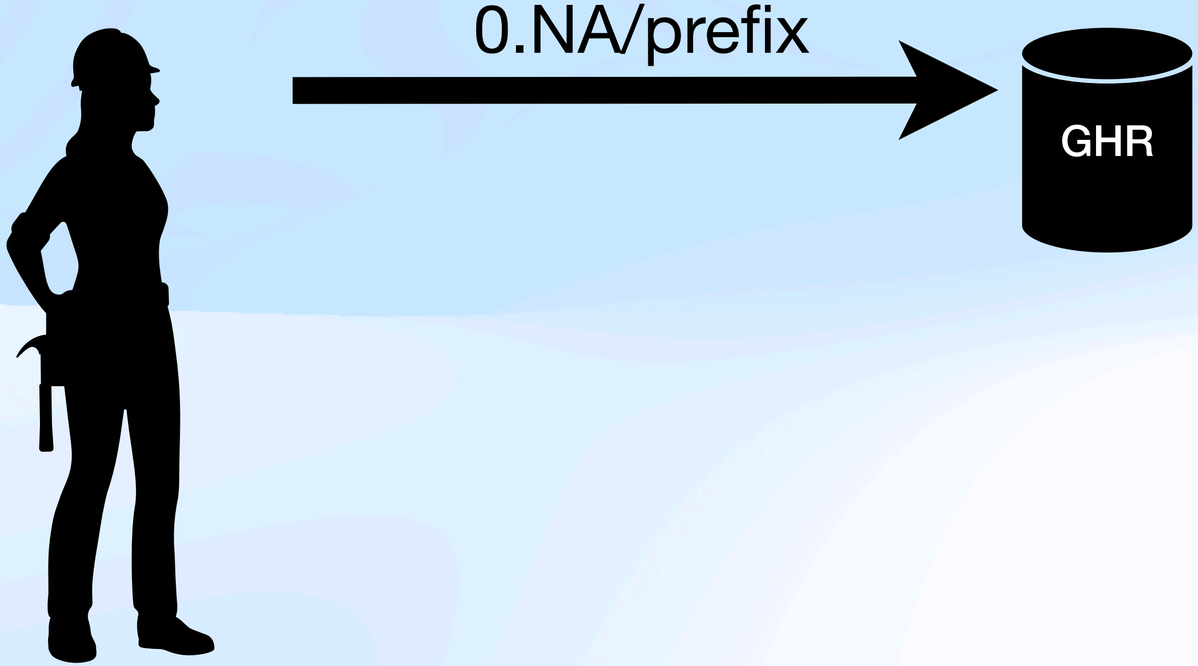


Resolving a Handle

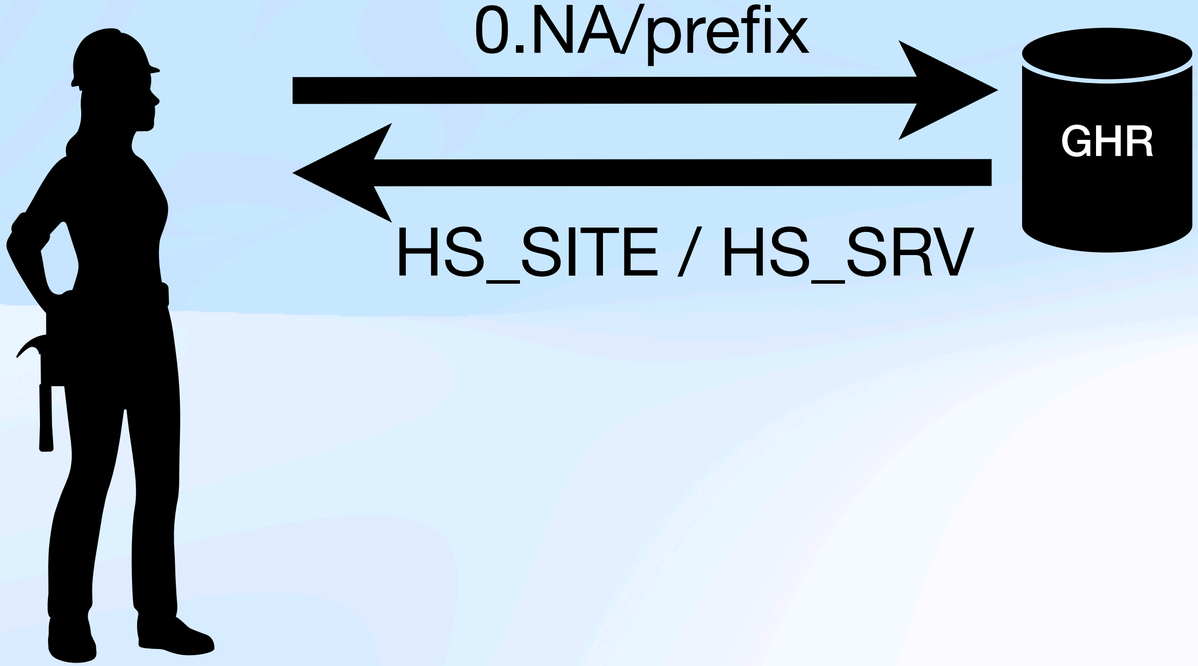




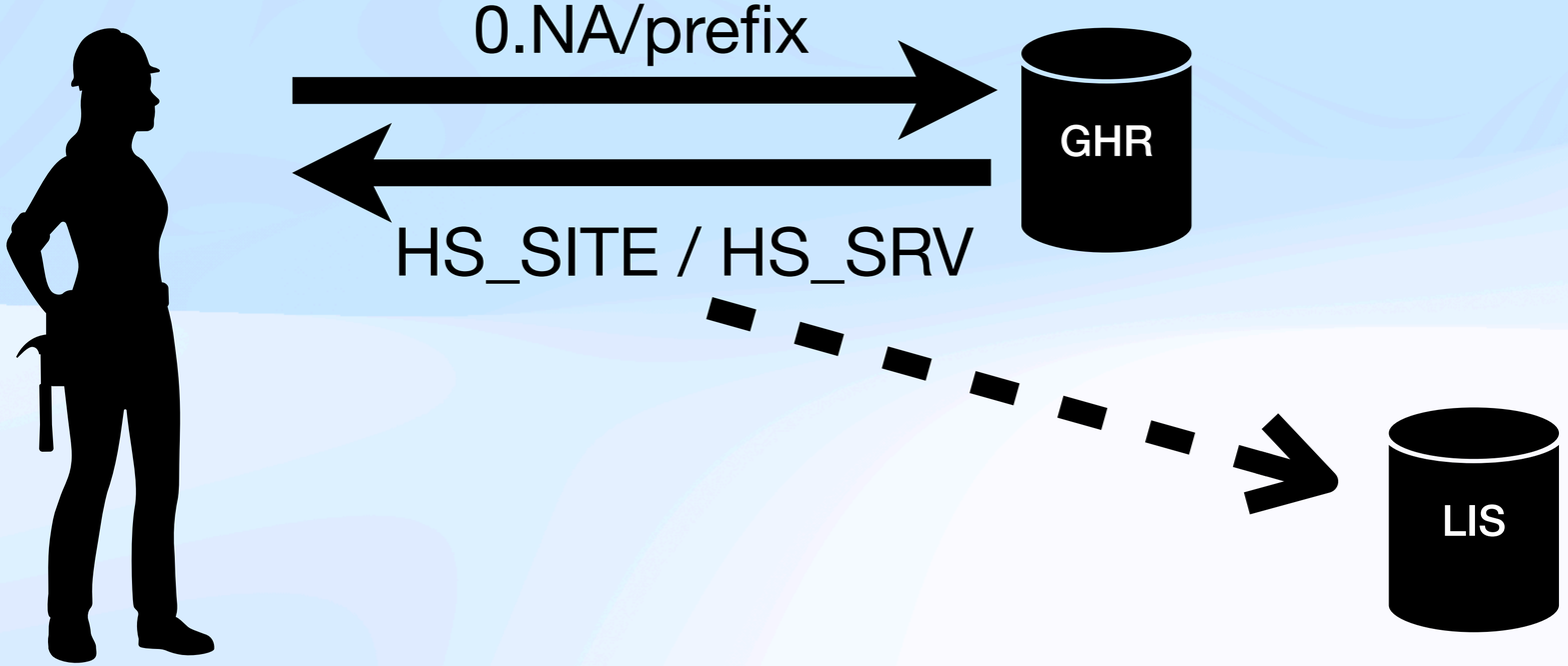
Resolving a Handle



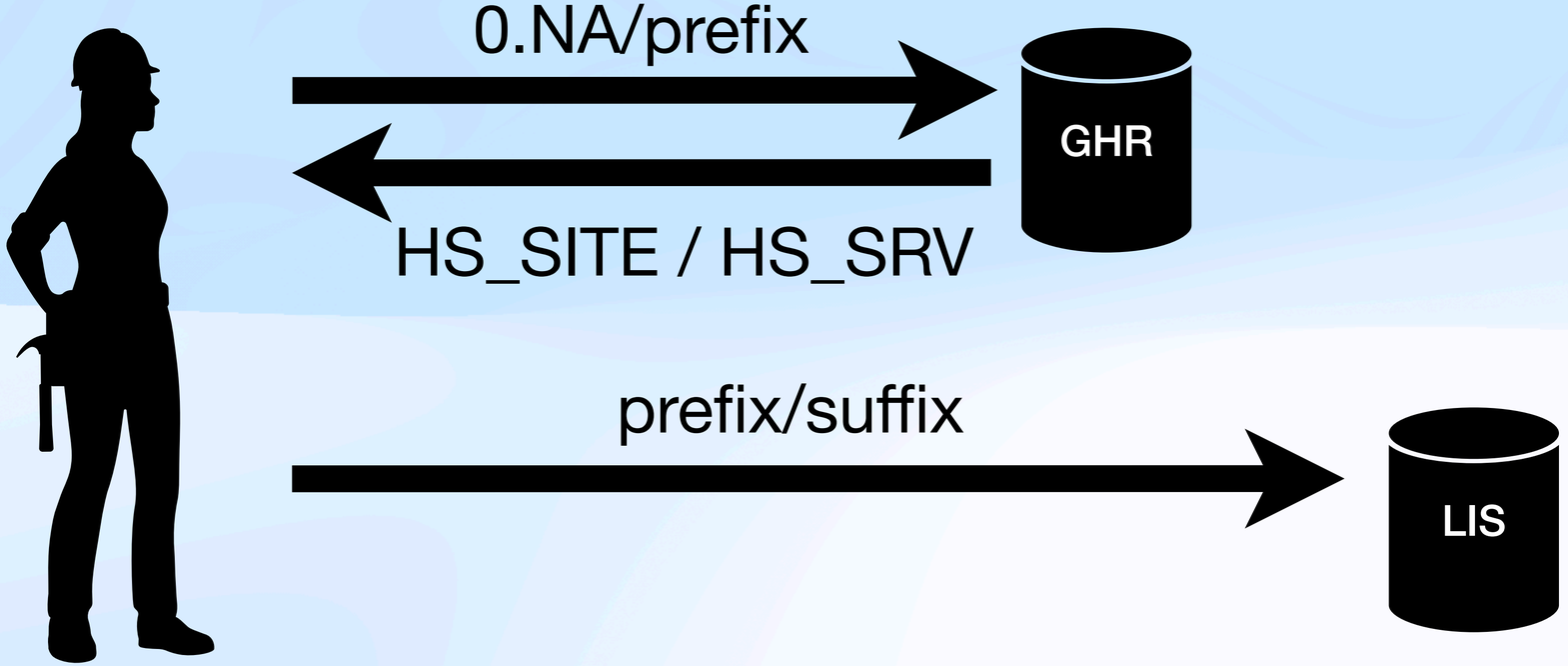
Resolving a Handle



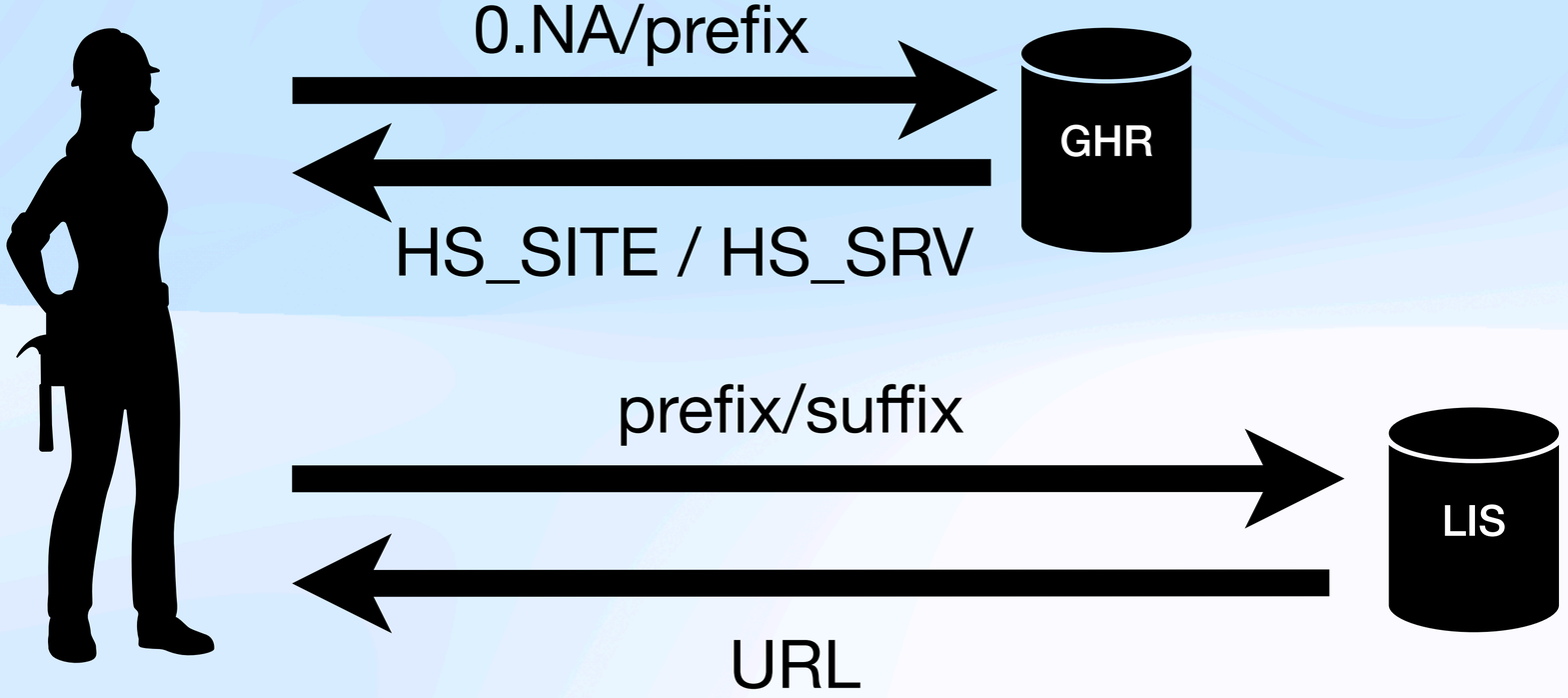
Resolving a Handle



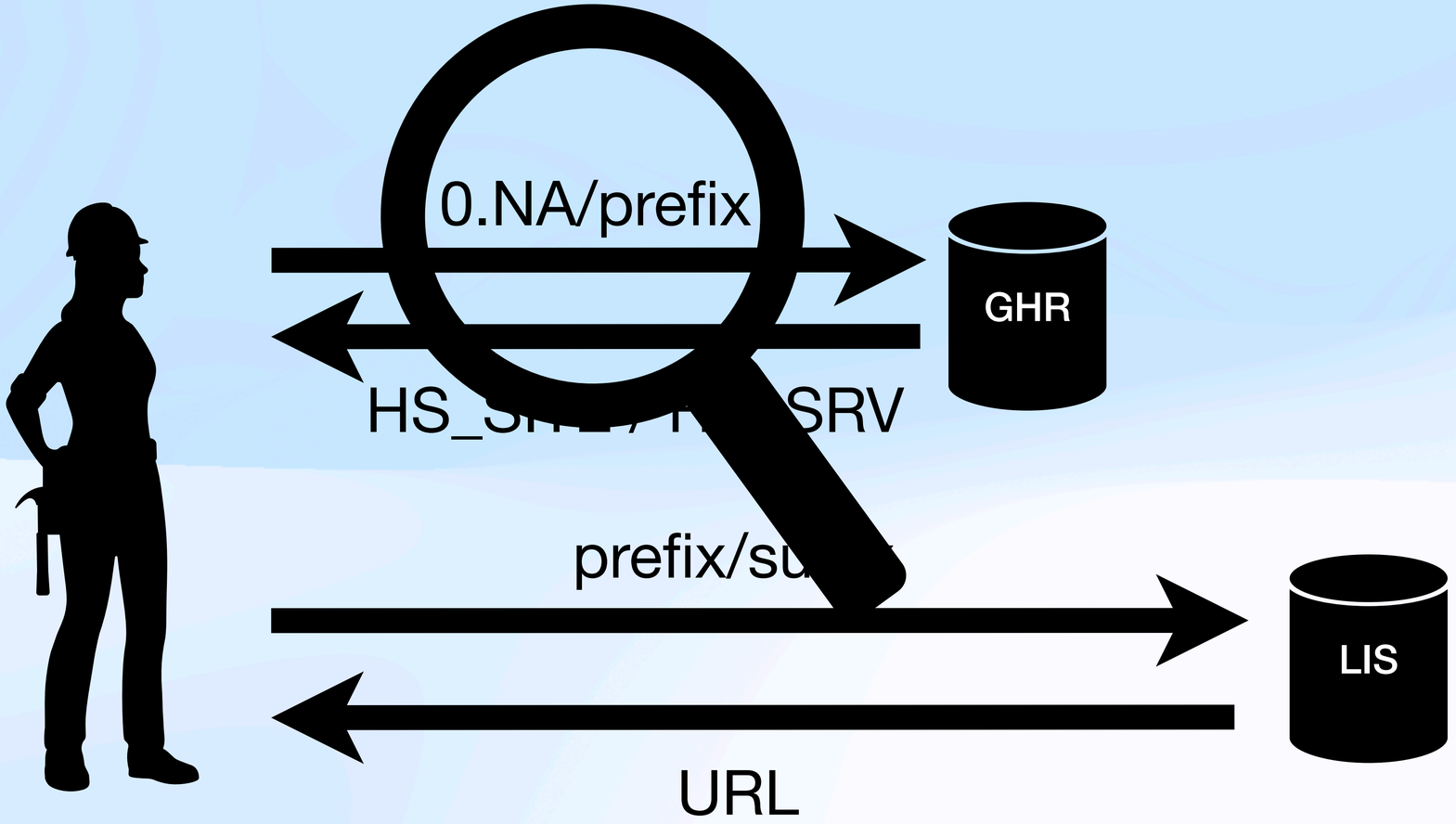
Resolving a Handle



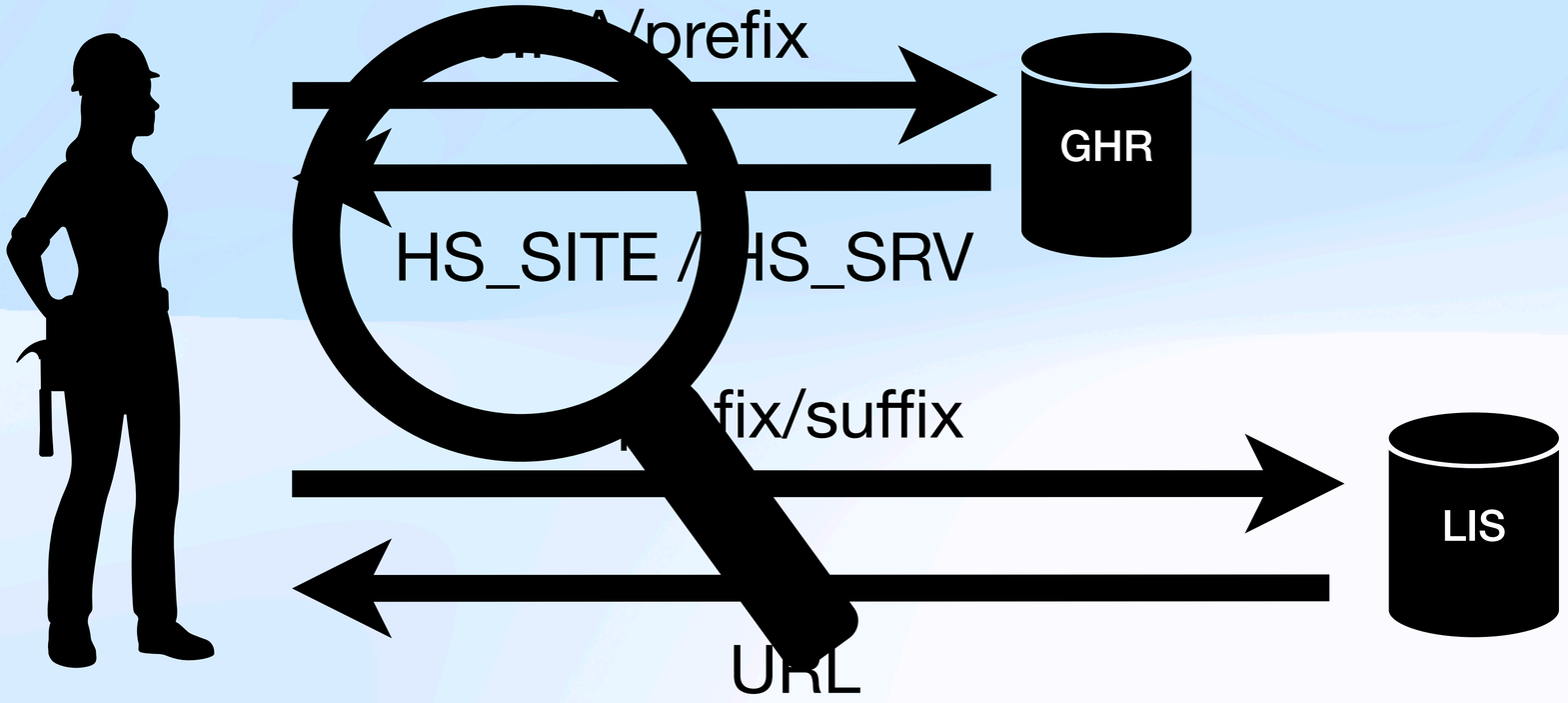
Resolving a Handle



Resolving a Handle

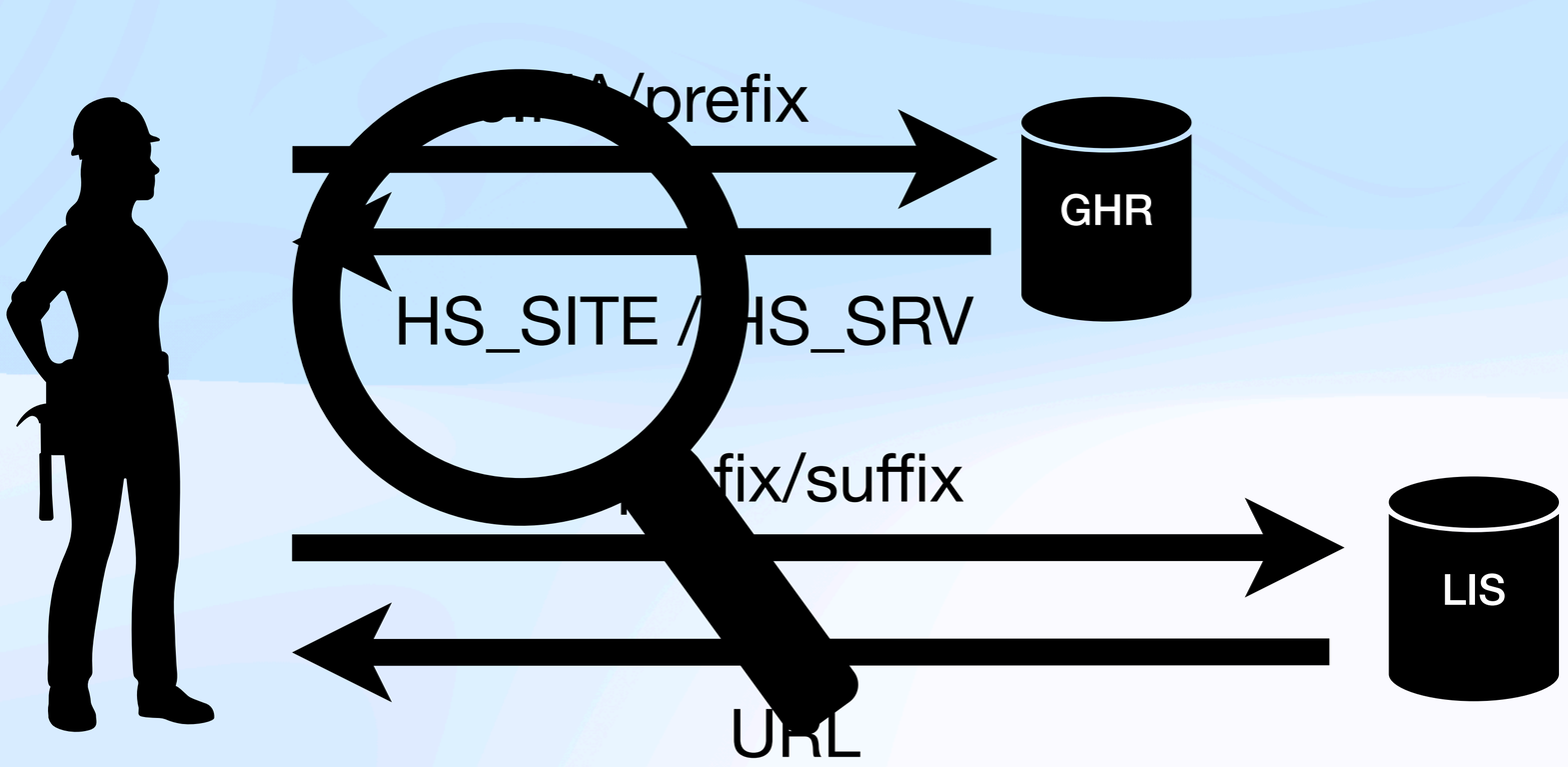


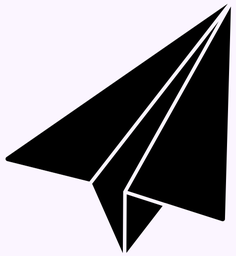
Resolving a Handle



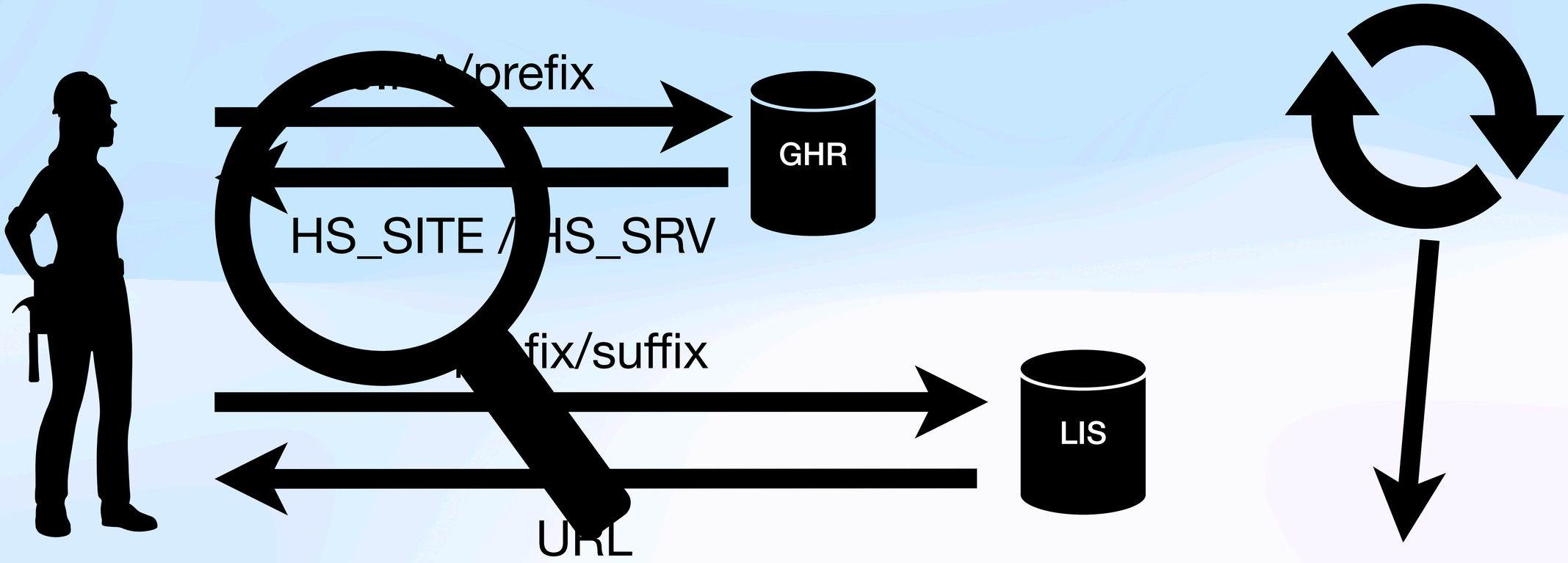
Res

Resolving a Handle





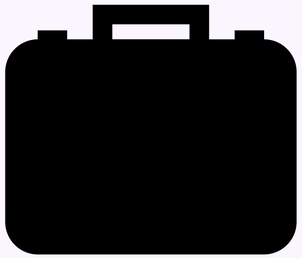
Resolving a Handle



DOI Stakeholders

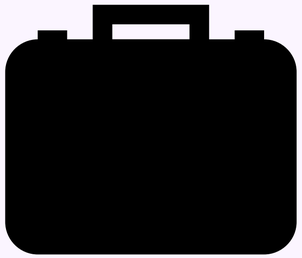
- International DOI Foundation (IDF)
  - Lead the DOI
  - Owns DOI Trademark
- 12 Registration Authorities (RA)
  - Crossref is the largest, DataCite also important
  - Provide LIS
  - https://www.doi.org/the-community/existing-registration-agencies/
- Assigners

[7]



Handle System Stakeholders

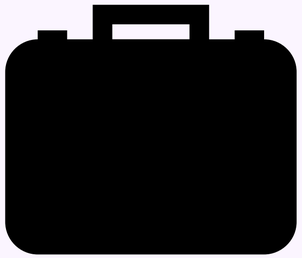
- DONA
  - International Foundation founded 2014
- 9 Multi-Primary Administrators
  - IDF (10)
  - CRNI (20)
  - GWDG (21)



Handle System Stakeholders

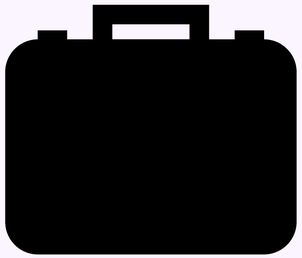
- DONA
  - International Foundation founded 2014
- 9 Multi-Primary Administrators
  - IDF (10)
  - CRNI (20)
  - GWDG (21)
  - Corporation for National Research Initiatives
  - Original initiative behind the Handle System
  - Develop the handle.net Software

[8]



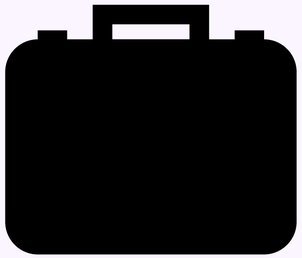
Handle System Stakeholders

- DONA
  - International Foundation founded 2014
- 9 Multi-Primary Administrators
  - IDF (10)
  - CRNI (20)
  - GWDG (21)



Assignment of DOIs

- Assigners obtain a DOI prefix (10.XXXX)
- DOI suffix is decided for publication
- RA stores and serves DOIs
- Assigners don't run the software themselves,
  a RA does it for them (and they pay for it)



Handle.NET Software

- Java implementation of Handle System server
- Backend for administering Handles and Prefixes
- 62854 LOC 461 Files
- Builtin replication
- Database scale is limited, DOI uses a custom implementation

[9]

Handle.Net®

Resolve a Handle and View the Values

The web form below will enable you to resolve individual handles and view their associated values. It uses a proxy server, which understands both the Handle protocol and HTTP protocol.

If you type a handle into the text box, and that handle has a URL associated with it as one of its values, the proxy server will instruct your browser to display the location of that URL. If you select "Don't Redirect to URLs", the proxy will display the handle record.

The Handle proxy server uses caching to speed handle resolution. If you check "Authoritative Query", the proxy will bypass the cache, go directly to the responsible handle server, and then refresh the cache with the data for that handle.

Simply appending a handle to the URL http://hdl.handle.net/ and giving the string to a browser as a location will also resolve that handle. The proxy also supports a REST API, returning handle records in JSON format. Further documentation is available here.

Handle: 10.1145/322796.322806

- [ ] Authoritative Query
- [x] Don't Redirect to URLs
- [ ] Don't Follow Aliases

Submit

Handle Proxy Server Documentation
Handle.net Web Site

Handle.Net®

Handle Values for: 10.1145/322796.322806

Index	Type	Timestamp	Data
1	**URL**	2020-09-10 09:26:49Z	https://dl.acm.org/doi/10.1145/322796.322806
700050	**700050**	2022-12-31 18:51:52Z	20221231102404002 80
100	**HS_ADMIN**	2016-12-06 19:31:22Z	handle=0.na/10.1145; index=200; [delete hdl,read val,modify val,del val,add val,modify admin,del admin,add admin,list]

Handle Proxy Server Documentation
Handle.net Web Site

Please contact hdladmin@cnri.reston.va.us for your handle questions and comments.

Technicals of Handle.NET Software

- Ports: 2641 tcp / udp, 8000 http
- Public Key Infrastructure
  - RSA, DSA Signatures and JWT
  - Root of Trust: 0.0/0.0
  - HTTPS certificates are often invalid w.r.t. Web PKI
- Responses may be signed

DOI extends the Handle System

- DOIs are stored at multiple RAs
- DOIs can exist without the IDF
- Standardization to improve consistency
- Support
- Improve interoperability

[3]

Metadata Resolution

- Citation metadata is a service offered by RAs
- Potentially as a value added service
- Rest API or GraphQL
  - https://api.crossref.org/swagger-ui/index.html
  - https://support.datacite.org/reference/introduction

Crossref

- Largest RA
- How do they host such a large instance?

Crossref

- Largest RA
- How do they host such a large instance?
  - Recently moved to the Cloud
  - Expect up to five times higher costs (up to 2 Million USD yearly)
  - Migration from Oracle to Postgres
  - Clustered

Crossref

- Membership based organization
- Regularly provide reports
- DOI crawling (found 3% link rot) [12]
- Participation Report [13]
- Public data file (March 2025 ~200 GB) [14]
- Provide Tooling (Console, Manifold) and Documentation [15]

Economics of DOI

- RAs charge per DOI, with bulk discounts and additional base fees
- Crossref:
  - One-off registration fee (~1 USD)
  - Membership fee (275 - 50k USD)
- Datacite:
  - Membership fee (2k EUR) + Organization Fee (500 EUR) + Service Fee
  - Tiered per DOI Volume
  - DOI Registration fee 0.80 EUR per DOI in lowest tier

DOI and HTTP

- doi.org/ or hdl.handle.net/ …
- Proxy servers, act as DO-IRP client
- Offer REST API

ShortDOI

- Shortener for DOIs -> 10/aabbe
- Run by IDF
- Not actually a DOI, but a Handle and respected by the DOI resolver
- Implemented as an Alias

- https://shortdoi.org/

DOI to OID

- Object Identifier for Assigners
- Prefix the DOI prefix with 1.3.6.1.4.1.37476.9003.3.
- -> 1.3.6.1.4.1.37476.9003.3.10.1109

- Offered by viathinksoft
- https://hosted.oidplus.com/viathinksoft/?goto=oid%3A1.3.6.1.4.1.37476.9003.3

RFC to DOI

- RFC Editor has obtained DOI prefix 10.17487 from Crossref
- DOIs are assigned to RFCs according to RFC7669
- Thus: 10.17487/rfc7669

RFC to DOI

- RFC Editor has obtained DOI prefix 10.17487 from Crossref
- DOIs are assigned to RFCs according to RFC7669
- Thus: 10.17487/rfc7669
- Also:
  - This RFC is in the IAB Stream
  - The IAB predecessor was founded by Vint Cerf, the other creator behind TCP/IP

DOI and Bookland

- ISBN is embedded within GS1
- ISBN-10 was converted to ISBN-13 by prefixing 978
- Within GS1 978 and 979 are assigned to Bookland
- ISBN: 978-12345-99990
- ISBN-A: 10.978.12345/99990
- Must be assigned by DOI RA, DOI RA must be a ISBN RA

DOI for Blogposts

- Rogue Scholar offers assigning DOIs to blogposts
- Blog must be science related
- Achive and searchable
- Registration form
- https://rogue-scholar.org/

Entertainment ID Registry Association (EIDR)

- Assign DOIs for entertainment media...
- Barbie (2023): 10.5240/18DD-1046-583F-9F4A-BE2A-B
- Mr Robot S4: 10.5240/D831-F02C-58BD-F0B2-0209-A
- Warner Bros: 10.5237/A929-C667
- Lowest Tier (<100M US): 6k USD membership fee
- https://www.eidr.org/

Human & Digital (HAND)

- ... go even further
- DOIs of Actors
  - Bruce Willis: 10.23/AA6A-2FE6-172A-207C-2F26
- DOIs of fictional characters
  - Bruce Wayne: 10.23/D353-C028-36C7-429A-8AC2
- https://handidentity.com/

DOI-like Strings and Fake DOIs

- Bogus Organisation posing as legit DOI Agencies
- Creating something that looks like DOIs, but it’s not actually part of the system

- ACM uses DOI-like string 10.5555\... for imported publications
- 10.5555 is Crossrefs testing prefix

Going Further and Tools

- Crossref Engineering: https://crossref.gitlab.io/engineering/
- Crossref Blog: https://www.crossref.org/blog/
- Run Handle.NET Software in you Homelab
- https://search.crossref.org/
- https://www.dona.net/prefix/resolve
- https://hdl.handle.net/
- https://doi.org/doiRA/
- https://api.crossref.org/swagger-ui/index.html
- https://doi.org/ra/
- https://rogue-scholar.org/

Thank you!

Questions?

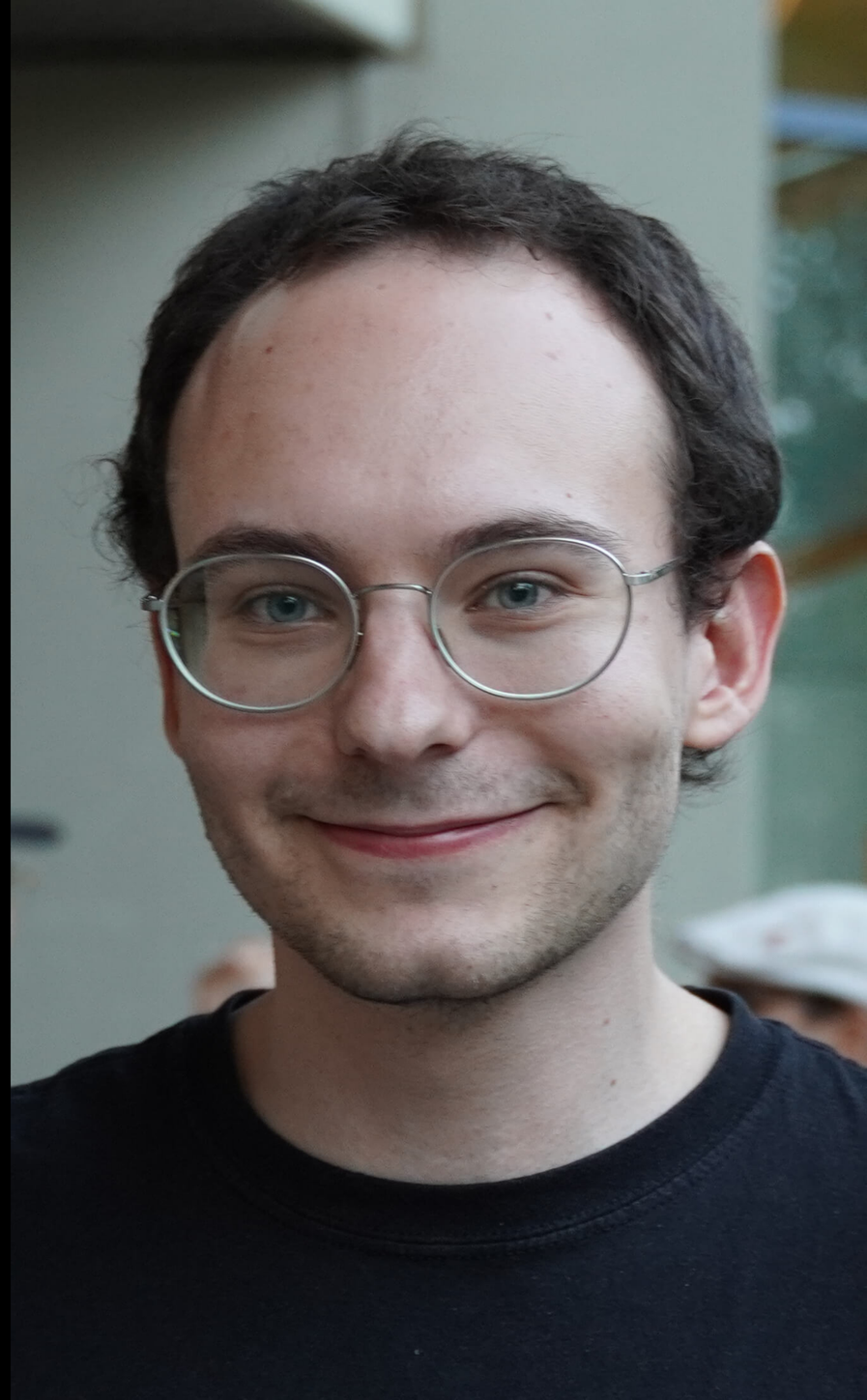
Markus Toran

DECT: 4499

@m4s:t3n.tech

talk-doi@toranm.me

toranm.me



Thank you!

Questions?

Wanna watch me resolve a DOI per hand?

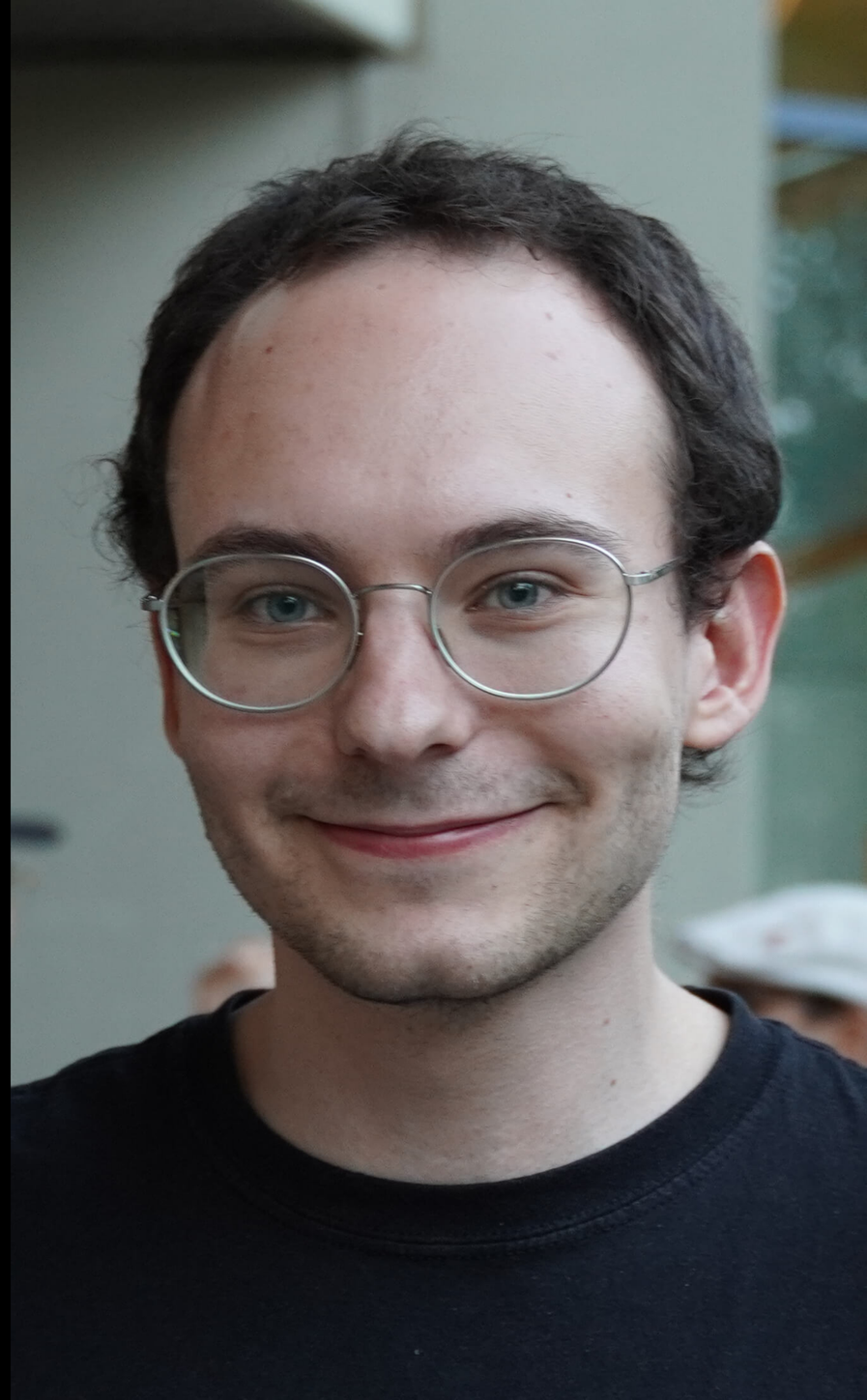
Markus Toran

DECT: 4499

@m4s:t3n.tech

talk-doi@toranm.me

toranm.me



Sources

rx.mt/talk/doi