

# Securing, Authenticating, and Visualizing Data-Links for Manufacturing Enterprises

William Bernstein, Sylvère Kréma, Laetitia Monnier, and Mehdi Shahid  
Systems Integration Division, NIST

## Disclaimer

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# The problem statement

- Digitization of product data comes with data management challenges:
  - Multiple copies of a similar file can exist in different places and be used as a reference/working copy
  - Authentication of digital data is still an issue due to the lack of embedded digital signature implementations
- Visualization of large collections can be challenging:
  - The heterogeneity of the data makes it hard to identify the key concepts that can be queried and made available
  - Finding the right visual representation for the different concepts is key to building a meaningful visual aid

# Expected nature of queries

- **Process:**

- How long did it take to execute process X during the past 10 days?
- How many parts a day are handled during process X?
- Was there a quality improvement between V2 and V1 of process X?

- **Product:**

- What was the assembly structure of Product Y?
- How many parts were affected after changing feature X on product Y?
- Was the new design of Product X actually ready to move to production on November 2, 2018?

- **People:**

- Who inspected the version of part Z that was built on November 2, 2018?
- What was the chain-of-command for Product X through its lifecycle?

## Examples of MBE resources to answer such queries

- **STEP AP242** provides an exchange format for design data including fully characterized Product and Manufacturing Information (PMI).
- **STEP AP238** is a descriptive data representation for machine instructions, providing an additional layer of semantic descriptions compared to traditional G-code.
- **MTConnect** is a read-only communication protocol for capturing execution data from machine tool controllers.
- **Quality Information Framework (QIF)** is a semantically rich data format for representing, exchanging, and storing inspection plans, rules, and results

# Agenda

- Identifying digital resources
- Securing the digital resources
- Exploring visual data types
- Understanding the product data
- A data visualization mapping protocol
- Conclusion

# Identifying digital resources

- Due to the amount of resources generated and constantly manipulated by different actors, it is important to uniquely identify the resources...
- ... in a formal and standardized way
  - Computer interpretable representation
  - Consistent across the enterprise and its collaborators
  - Leveraging existing and proven mechanisms
  - Independent from the physical location

# Identifying digital resources

- Using a Handle System

- A registry of persistent identifiers to digital resources
- Access to the digital resources through metadata about the resources (location, type, ...)

- The Digital Object Identifiers (DOIs) are in the form of a `prefix/suffix`:

- Prefix: identifies the organization registering the DOI – `namespace.organization_ID`
- Suffix: the id of the resource within the organization identified in the prefix

# Identifying digital resources

20.500.11993/NIST.TDH1 NIST SADL

SADL Administrator | admin

Index	Type	Timestamp	Data
1	URL	2017-08-25T17:18:18Z	<a href="https://www.nist.gov/people/thomas-hedberg">https://www.nist.gov/people/thomas-hedberg</a>
2	EMAIL	2017-08-25T17:18:18Z	thomas.hedberg@nist.gov
3	TYPE	2017-08-25T17:18:18Z	physical.person
4	SCHEMA	2017-08-25T17:18:18Z	<a href="http://schema.org/Person">http://schema.org/Person</a>
5	DATE_CREATE	2017-08-25T17:18:18Z	2017-04-27
6	ATTRIBUTE	2017-08-31T03:32:49Z	
7	ATTRIBUTE64	2017-08-29T20:57:37Z	
100	HS_ADMIN	2017-08-25T17:18:18Z	{'index': 200, 'permissions': '111111111111', 'handle': '0.NA/20.500.11993'}
300	HS_PUBKEY	2018-07-31T18:33:31Z	

# Securing the digital resources

- Once the resources are uniquely identified, it is critical to certify/validate their identity
  - Can we trust what we see?
- The Public Key Infrastructure (PKI) offers a mechanism to digitally sign (and “lock”) data (such as a resource identifiers and other metadata)
- This electronic seal cannot be modified and acts as a source of trust

# Securing the digital resources

- Securing and Authentication of Data-Links (SADL)
- SADL is a software that sits on top of Handle registries to build and manage trustworthiness of DOIs
- SADL helps to:
  - Seamlessly and digitally sign DOIs using X.509 certificates
  - Validate the digital signatures to identify trustworthy digital resources
  - Manage users' rights to digitally sign DOIs
  - Enrich the DOIs metadata
  - Navigate through the different digital resources
  - A metadata-based query mechanism

# Securing the digital resources

- Signing and validating DOIs using X.509 certificates

<input checked="" type="checkbox"/>	Index	Type	Timestamp	Data
<input type="checkbox"/>	1	TYPE	2019-02-27T15:33:31Z	physical.person
<input type="checkbox"/>	2	SCHEMA	2019-02-27T16:23:26Z	http://schema.org/Person
<input type="checkbox"/>	100	HS_ADMIN	2019-02-27T20:42:17Z	{'index': 200, 'permissions': '011111110011', 'handle': 'MNS/ADMIN'}
<input type="checkbox"/>	301	HS_PUBKEY	2019-02-27T15:27:00Z	
<input type="checkbox"/>	401	HS_SIGNATURE	2019-02-28T20:48:54Z	
<input type="checkbox"/>	402	HS_SIGNATURE	2019-03-13T19:22:09Z	
<input type="checkbox"/>	403	HS_SIGNATURE	2019-03-13T19:23:57Z	

Sign Checked Indexes

Signatures' Timeline

Attach JSON

Delete Selected Indexes

# Securing the digital resources

- Managing users' rights to digitally sign DOIs

SADL Administrator (**admin**)

Search...

**Currently Authorized External Handle Servers**

	https://hdl.handle.net/api/handles/ Certificate expired on .	Private Key	Certificate	Authenticate
	http://129.6.225.203:8000/api/handles/ Certificate expired on .	Private Key	Certificate	Authenticate
	http://0.0.0.1:8000/api/handles/ Certificate expired on .	Private Key	Certificate	Authenticate

1 2 3

**Authorize Handle Servers**

Search...

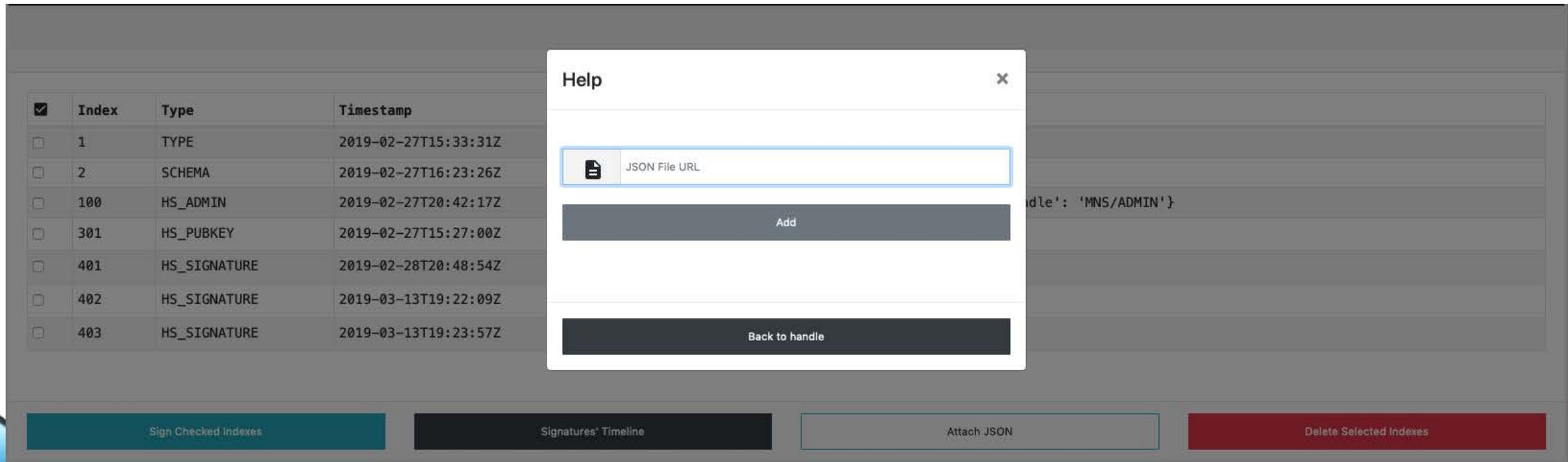
**Authorize External Handle Servers**

	https://hdl.handle.net/api/handles/ Handle Server <b>authorized</b> by user: <b>admin</b> .	Unauthorize
	http://129.6.225.203:8000/api/handles/ Handle Server <b>authorized</b> by user: <b>admin</b> .	Unauthorize
	http://0.0.0.1:8000/api/handles/ Handle Server <b>authorized</b> by user: <b>admin</b> .	Unauthorize
	http://0.0.0.2:8000/api/handles/ Handle Server <b>authorized</b> by user: <b>admin</b> .	Unauthorize

1 2

# Securing the digital resources

- Enriching the DOIs metadata

A screenshot of a web application interface for managing digital resources. A table lists various indexes with their types and timestamps. A 'Help' dialog box is open in the foreground, showing a text input field for a 'JSON File URL' and buttons for 'Add' and 'Back to handle'. At the bottom of the interface, there are four buttons: 'Sign Checked Indexes', 'Signatures' Timeline', 'Attach JSON', and 'Delete Selected Indexes'.

<input checked="" type="checkbox"/>	Index	Type	Timestamp
<input type="checkbox"/>	1	TYPE	2019-02-27T15:33:31Z
<input type="checkbox"/>	2	SCHEMA	2019-02-27T16:23:26Z
<input type="checkbox"/>	100	HS_ADMIN	2019-02-27T20:42:17Z
<input type="checkbox"/>	301	HS_PUBKEY	2019-02-27T15:27:00Z
<input type="checkbox"/>	401	HS_SIGNATURE	2019-02-28T20:48:54Z
<input type="checkbox"/>	402	HS_SIGNATURE	2019-03-13T19:22:09Z
<input type="checkbox"/>	403	HS_SIGNATURE	2019-03-13T19:23:57Z

Help dialog box content:

JSON File URL

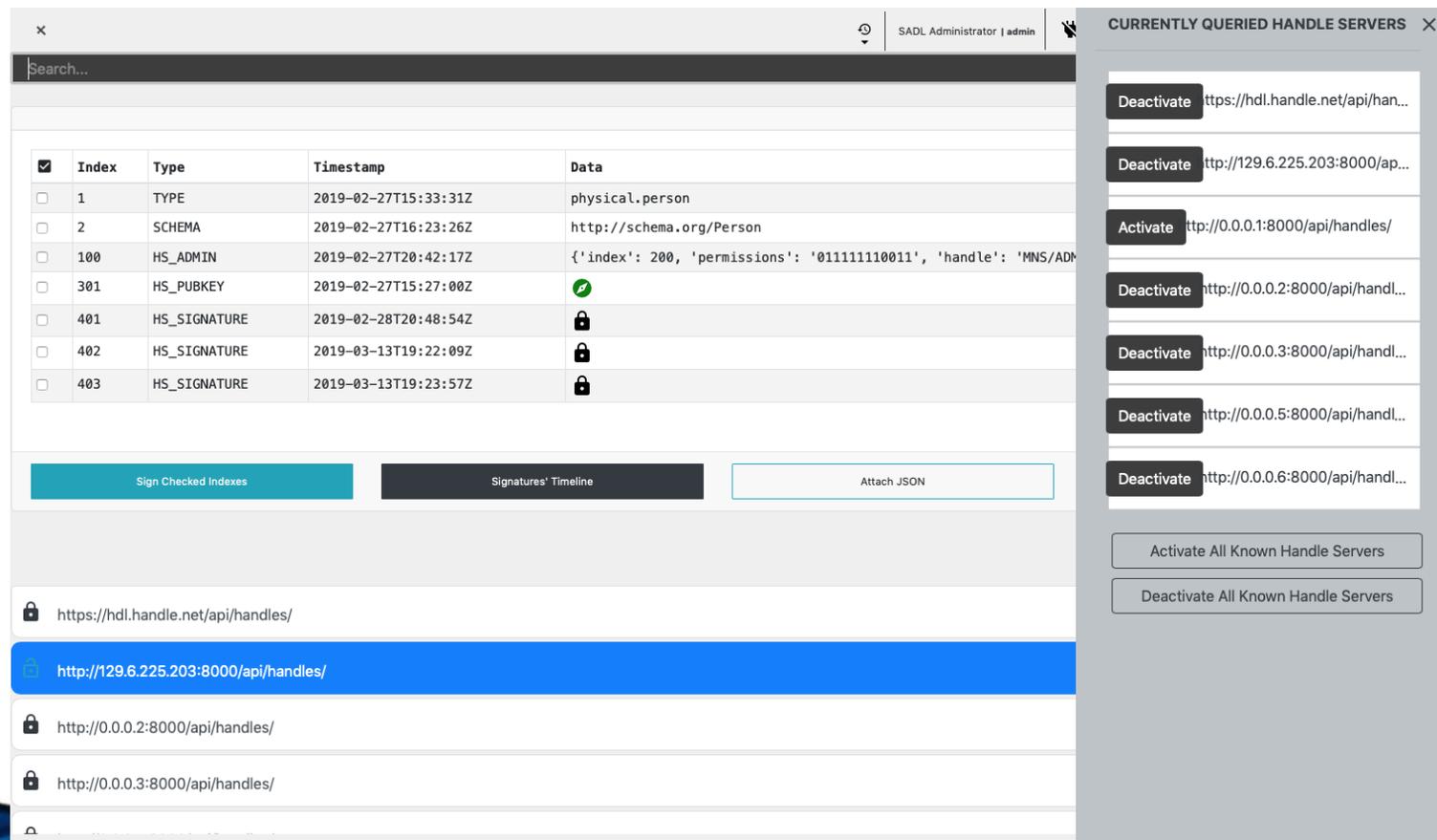
Add

Back to handle

Buttons at the bottom: Sign Checked Indexes, Signatures' Timeline, Attach JSON, Delete Selected Indexes

# Securing the digital resources

- Navigate and query through the different digital resources



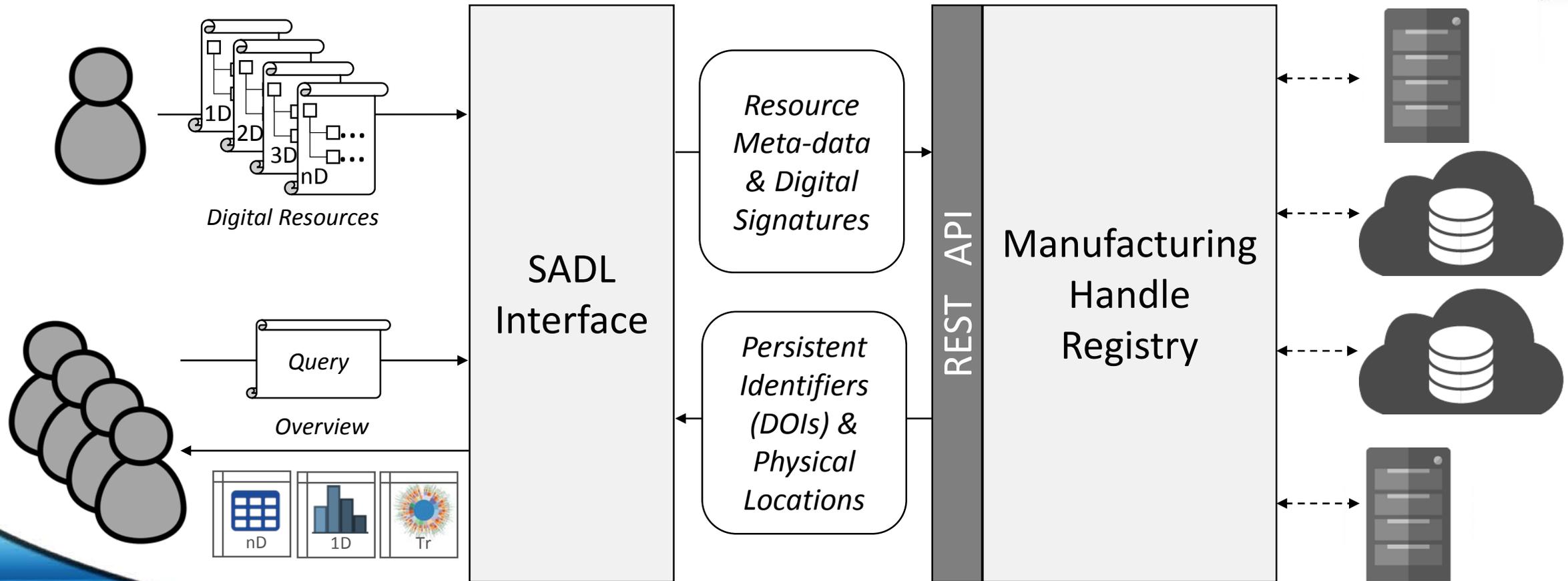
The screenshot displays the SADL Administrator interface. The main area shows a table of handle servers with the following data:

<input checked="" type="checkbox"/>	Index	Type	Timestamp	Data
<input type="checkbox"/>	1	TYPE	2019-02-27T15:33:31Z	physical.person
<input type="checkbox"/>	2	SCHEMA	2019-02-27T16:23:26Z	http://schema.org/Person
<input type="checkbox"/>	100	HS_ADMIN	2019-02-27T20:42:17Z	{'index': 200, 'permissions': '011111110011', 'handle': 'MNS/ADM
<input type="checkbox"/>	301	HS_PUBKEY	2019-02-27T15:27:00Z	✔
<input type="checkbox"/>	401	HS_SIGNATURE	2019-02-28T20:48:54Z	🔒
<input type="checkbox"/>	402	HS_SIGNATURE	2019-03-13T19:22:09Z	🔒
<input type="checkbox"/>	403	HS_SIGNATURE	2019-03-13T19:23:57Z	🔒

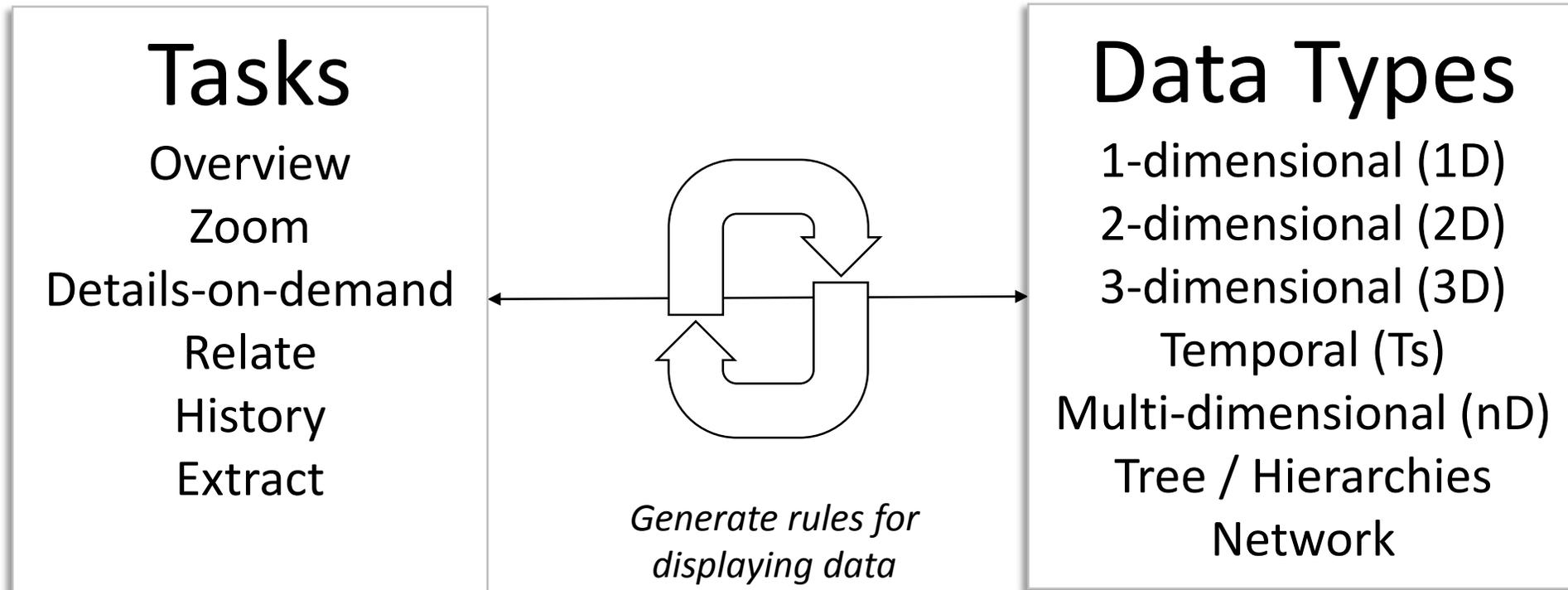
Below the table are buttons for "Sign Checked Indexes", "Signatures' Timeline", and "Attach JSON".

The sidebar, titled "CURRENTLY QUERIED HANDLE SERVERS", lists several servers with "Deactivate" buttons. At the bottom of the sidebar are buttons for "Activate All Known Handle Servers" and "Deactivate All Known Handle Servers".

# Vision of the SADL Interface and User Interactions



# Designing visualizations through Shneiderman's task by data type taxonomy



# Examples of how MBE resources relate to data types



Data Type	Explanation	MBE Examples
1-dimensional	Linear data types, such as text with only strings	STEP AP242 Rules and Requirements
2-dimensional	Planar or map data, such as floorplans	Factory Layouts, CMSD files
3-dimensional	Real world objects, CAD models	STEP AP242 & STEP AP238 Geometry
Multi-dimensional	Relational databases with many attributes	QIF inspection results
Temporal	Time series data, such as historical trends	MTConnect streams & AP238 Plans
Tree	Hierarchies with items relating to a parent item	MTConnect Device models
Network	Items linked to an arbitrary number of other items	STEP AP242 Assembly Structure

# Classifying STEP AP242, STEP AP238, MTConnect and QIF

Representation	Business Function	Concept Description	Data Types						
			1D	2D	3D	nD	Ts	Tr	Nk
STEP 242 (as-designed)	Specification, Breakdown & Configuration	Assembly Structure						●	●
		Transformations, Geometry, & Coordinate System		●	●				
.....									
STEP 238 (as-planned)	Model-Based Manufacturing Process	Generic Toolpaths		●	●				
		Parameters (feeds, speeds, etc.)	●						
.....									
MTConnect (as-executed)	Historical Machine Operations	Samples					●		
		Conditions	●						
.....									
QIF (as-inspected)	Model-Based Definition	Computer-aided design (CAD) data			●			●	
		Product manufacturing information (PMI) data				●			
.....									

Progress of the table can be accessed here: <https://goo.gl/Zbkqmb>.

# Addressing questions through data acquisition

	Question	Representation(s)	Key concept(s)	Shneiderman's Data Type
Process	Execution time of Process X?	MTConnect	Events	Tree
	# Parts handled by Process X?	MTConnect	Part Count, Samples	1-dimensional
	Did quality improve?	MTConnect, QIF	Events, Measurements data	1-dimensional
Part	Assembly structure of Part Y?	AP242	Assembly structure	Tree
	Effect of change of Feature X?	AP242	Assembly structure	Tree / 1-dimensional
	Product X ready for production?	AP242	Meta-data entered at SADL*	Tree
People	Who inspected Part Z?	AP242, QIF	General Management Information	1-dimensional
	Approval of Product X?	AP242	Meta-data entered at SADL*	Temporal / Tree

\*Not part of the standard representation itself. The digital signatures would be appended to the digital resource once the user enters the information in the SADL Interface.

## Moving Forward

- Testing: Gathering a large amount of resources in the SADL + registry will allow for scalability and usability testing.
- Implementation: Once the data types of the MBE resources are fully classified, we will test automatic generation of visualization through the task by data type matching.

Questions? Comments? Objections (☺)?

William Bernstein ([william.bernstein@nist.gov](mailto:william.bernstein@nist.gov))

Sylvere Krime ([sylvere.krime@nist.gov](mailto:sylvere.krime@nist.gov))

Laetitia Monnier ([laetitia.monnier@nist.gov](mailto:laetitia.monnier@nist.gov))

Mehdi Shahid ([mehdi.shahid@nist.gov](mailto:mehdi.shahid@nist.gov))

