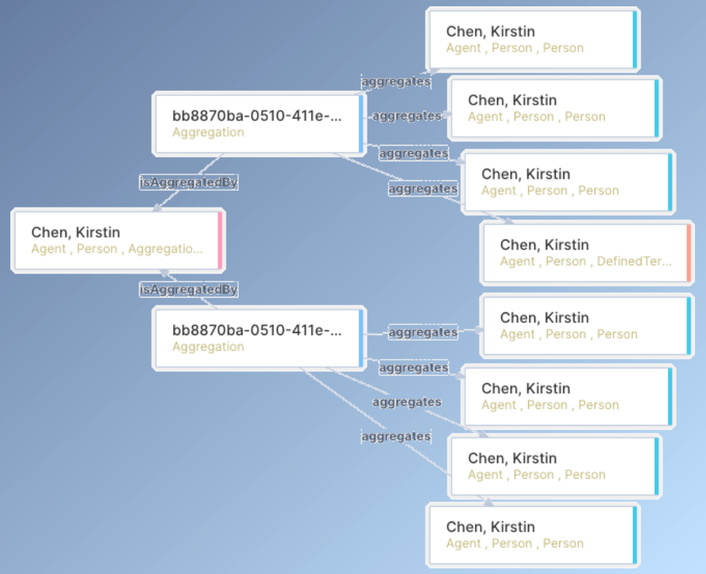
A Semantic Knowledge Graph at National Library Board Singapore



Richard Wallis
Evangelist and Founder
Data Liberate
richard.wallis@dataliberate.com

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BIBFRAME Workshop in Europe 2024
17th September 2024 - Helsinki

Data Liberate

Data Liberate

Independent Consultant, Evangelist & Founder

40+ Years – Computing
30+ Years – Cultural Heritage technology
20+ Years – Semantic Web & Linked Data

W3C Community Groups:

- Bibframe2Schema (Chair) – Standardised conversion path(s)
- Schema Bib Extend (Chair) - Bibliographic data
- Schema Architypes (Chair) - Archives
- Financial Industry Business Ontology – Financial schema.org
- Tourism Structured Web Data (Co-Chair)
- Schema Course Extension
- Schema IoT Community
- Educational & Occupational Credentials in Schema.org

Worked With:

- **Google** – Schema.org vocabulary, site, extensions. documentation and community
- **OCLC** – Global library cooperative
- **FIBO** – Financial Industry Business Ontology Group
- Various Clients – Implementing/understanding Linked Data, Schema.org:
  National Library Board Singapore
  British Library — Stanford University — Europeana

richard.wallis@dataliberate.com — @dataliberate

Agenda for today

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- National Library and their resources

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- Knowledge Graph ambition

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  - User experience enrichment – the sidebar API
  - Data quality enhancement utilizing external authorities

National Library Board Singapore

Public Libraries

Network of 28 Public Libraries, including 2 partner libraries*

Reading Programmes and Initiatives

Programmes and Exhibitions targeted at Singapore communities

*Partner libraries are libraries which are partner owned and
funded but managed by NLB/NLB's subsidiary Libraries and Archives Solutions Pte Ltd. Library@Chinatown and the Lifelong Learning Institute Library are Partner libraries.

National Library

Preserving Singapore's Print and Literary Heritage, and Intellectual memory
Reference Collections
Legal Deposit (including electronic)

National Archives

Transferred from NHB to NLB in Nov 2012

Custodian of Singapore's Collective Memory: Responsible for Collection, Preservation and Management of Singapore's Public and Private Archival Records

Promotes Public Interest in our Nation's History and Heritage

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National Library Board Singapore

Lending Collection

Over 5m
print collection

Over 1.7m
e-books and audio books

78
databases

Over 2.4m
music tracks

Over 7,400
e-newspapers and e-magazines titles

Over 8,000
e-learning courses

Reference Collection

Over 560,000
Singapore & SEA items

Over 147,000
Chinese, Malay & Tamil Languages items

Over 53,000
Arts items

Over 62,000
Social Sciences & Humanities items

Over 39,000
Science & Technology items

Over 19,000
Rare Materials items

Archival Materials

Over 1.14m
Photographs

Over 290,000
Government files & Parliament papers

Over 190,000
Audiovisual & sound recordings

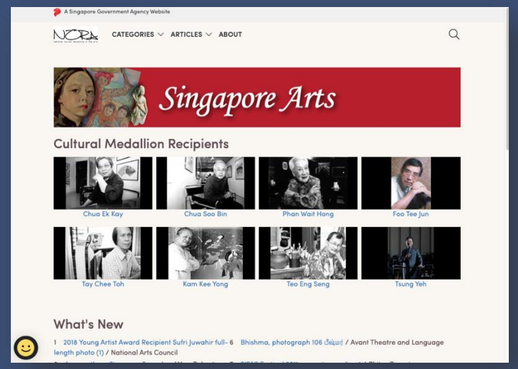
Over 70,000
Maps & building plans

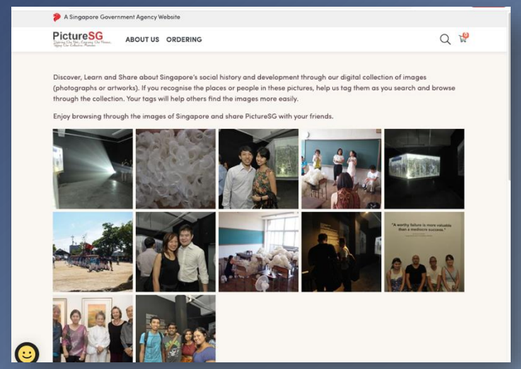
Over 55,000
Speeches & press releases

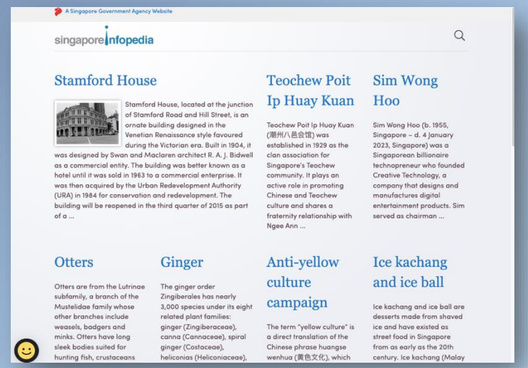
Over 35,000
Oral history interviews

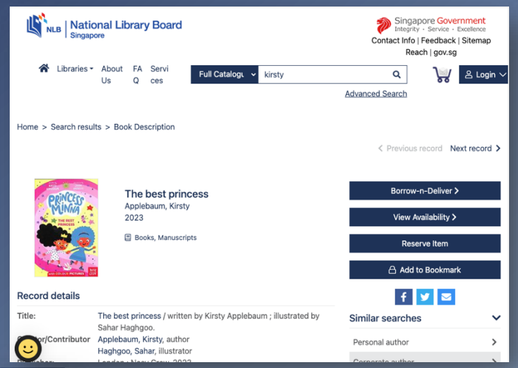
Over 7,000
Posters

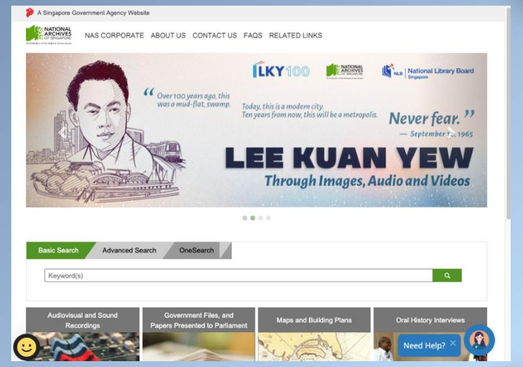
National Library Board Online Services

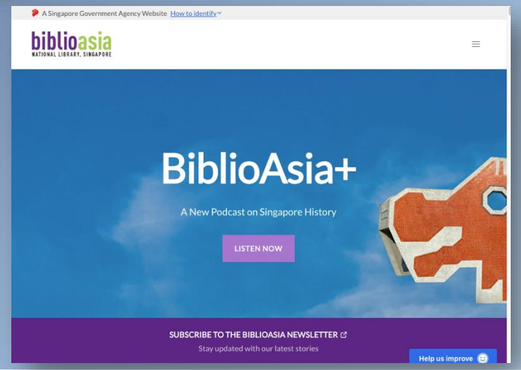


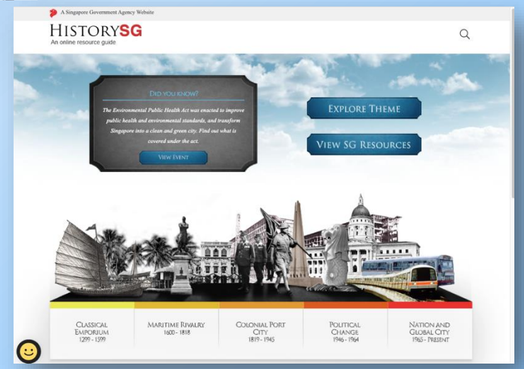












Data Liberate

The Ambition

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- To bring together resources physical and digital
- To bring together diverse systems across the National Library, National Archives, and Public Libraries in a Linked Data Environment
- To provide a staff interface to view and manage all entities, their descriptions and relationships

The Ambition – Technical Challenges

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- An aggregated source of truth

Contract Awarded

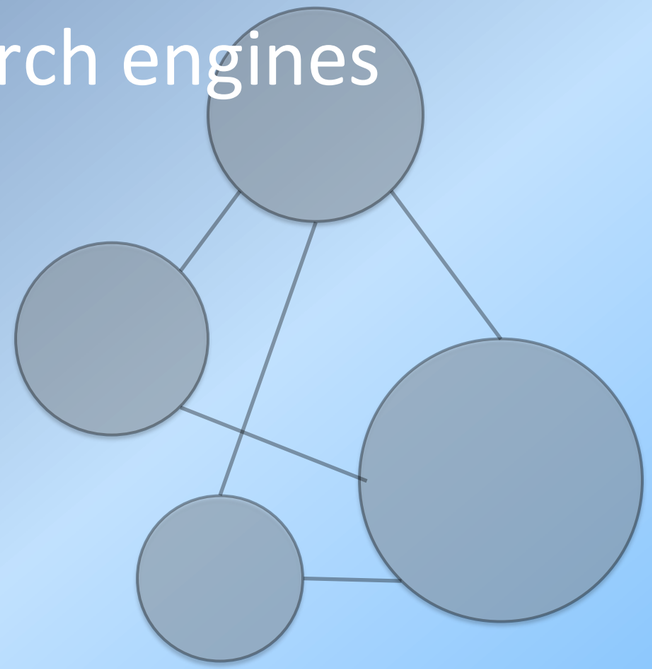
metaphactory platform
Low-code knowledge graph platform
Semantic knowledge modeling
Semantic search & discovery

AWS Partner
Public sector partner
Singapore based

Linked Data, Structured data, Semantic Web, bibliographic meta data, Schema.org and management systems consultant

Basic Data Model

- Linked Data
  - BIBFRAME to capture detail of bibliographic records
  - Schema.org to deliver structured data for search engines



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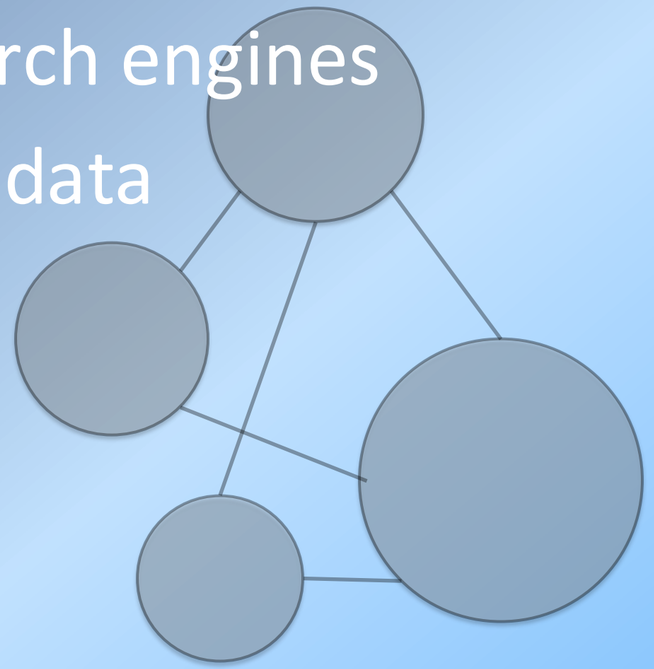

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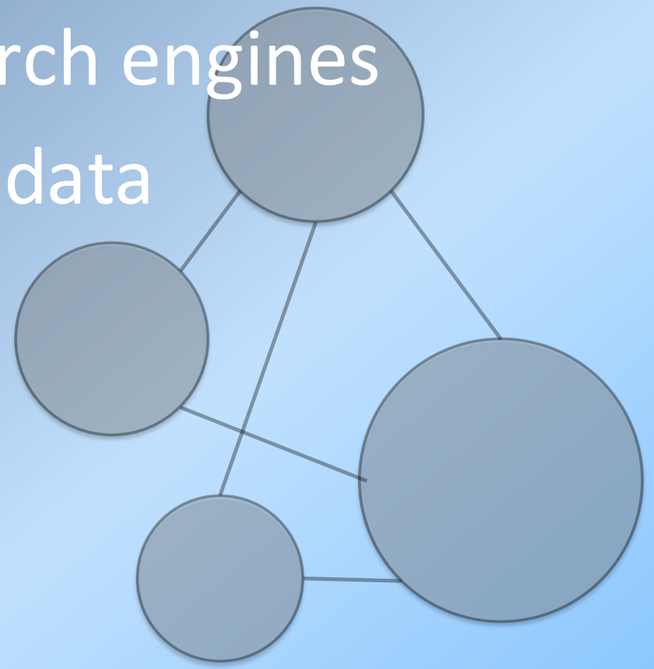

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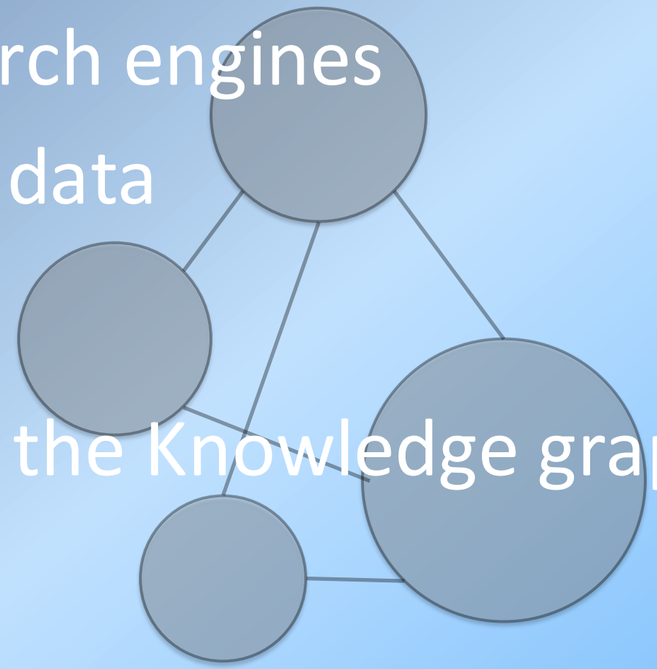

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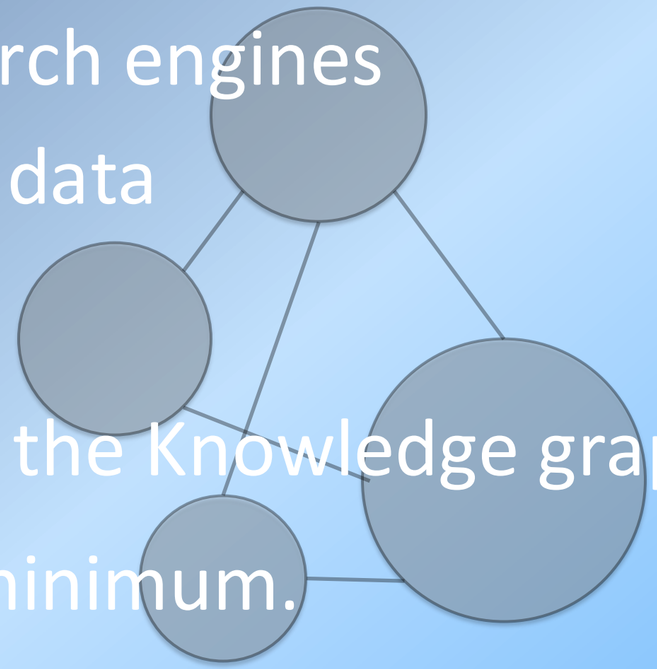
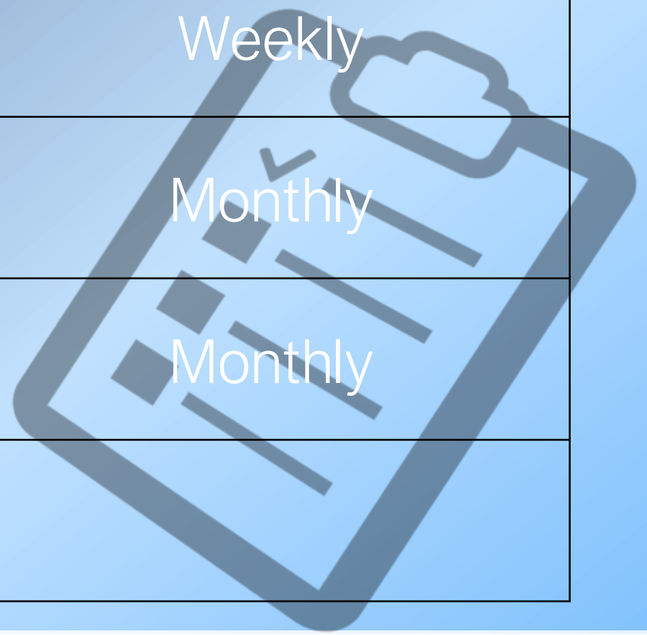
- Schema.org as the ‘lingua franca’ vocabulary of the Knowledge graph
  - All entities described using Schema.org as a minimum.



Data Data Data!

Data Source	Source Records	Entity Count	Update Frequency
ILS	1.4m	7.9m	Daily
CMS	82k	228k	Weekly
NAS	1.6m	6.7m	Monthly
TTE	3k	317k	Monthly
	3.1m	15.15m	



Data Ingest Pipelines

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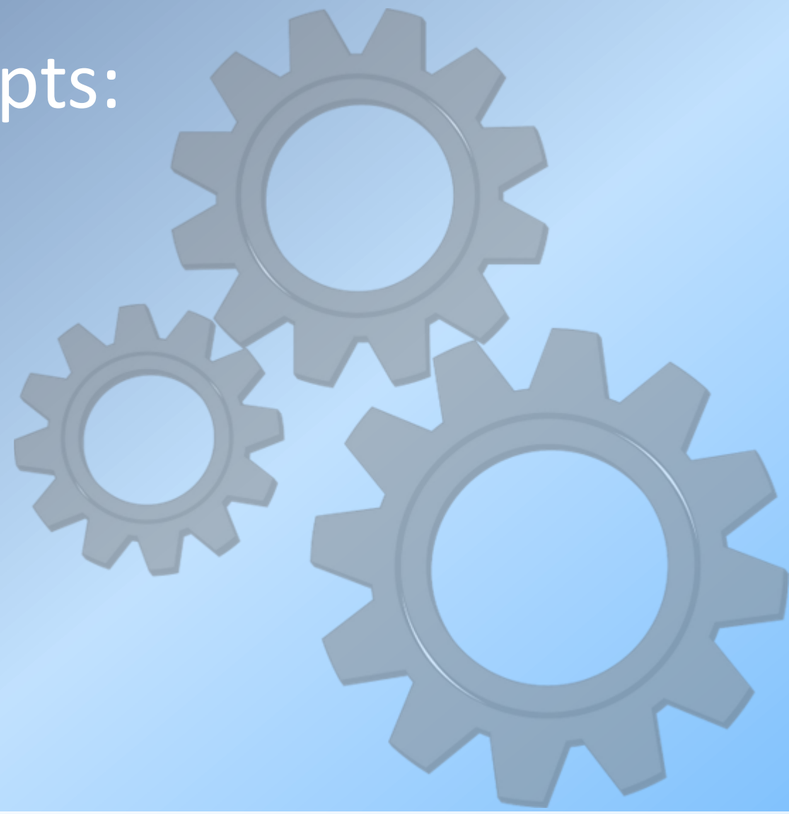

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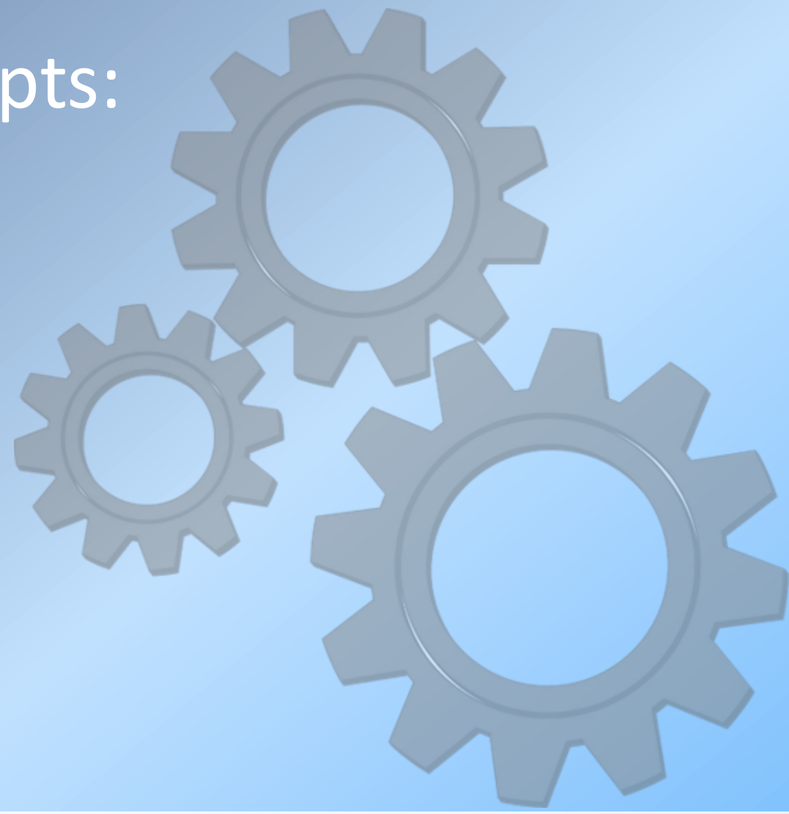

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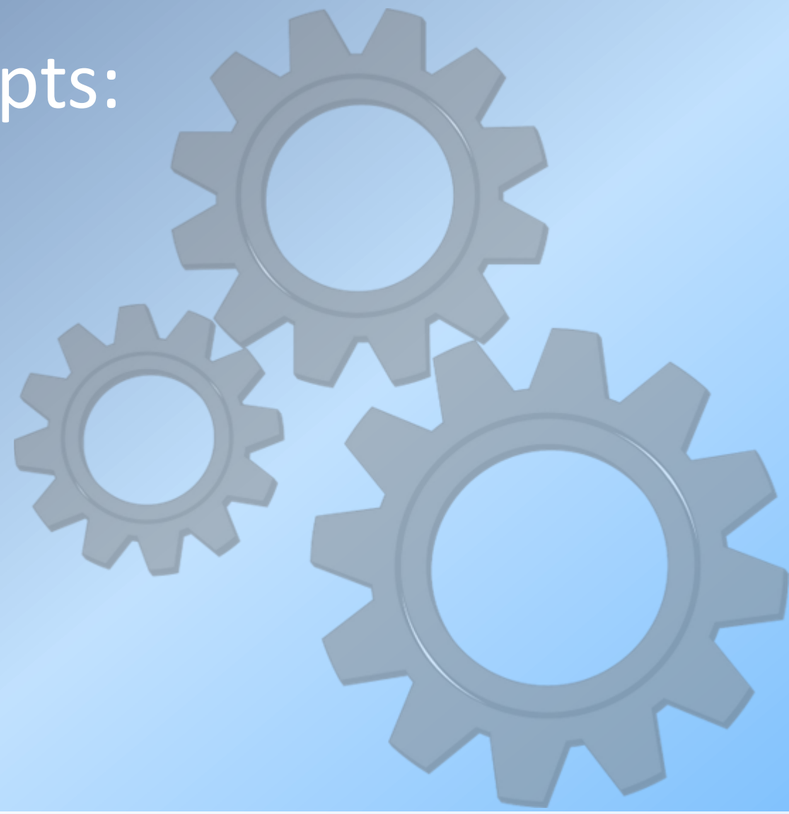

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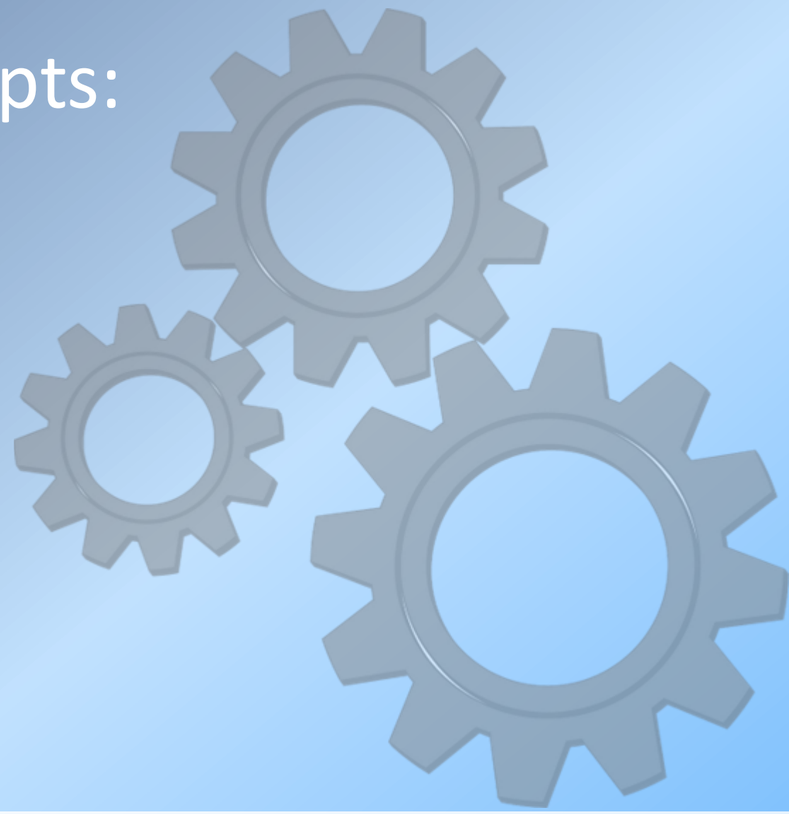

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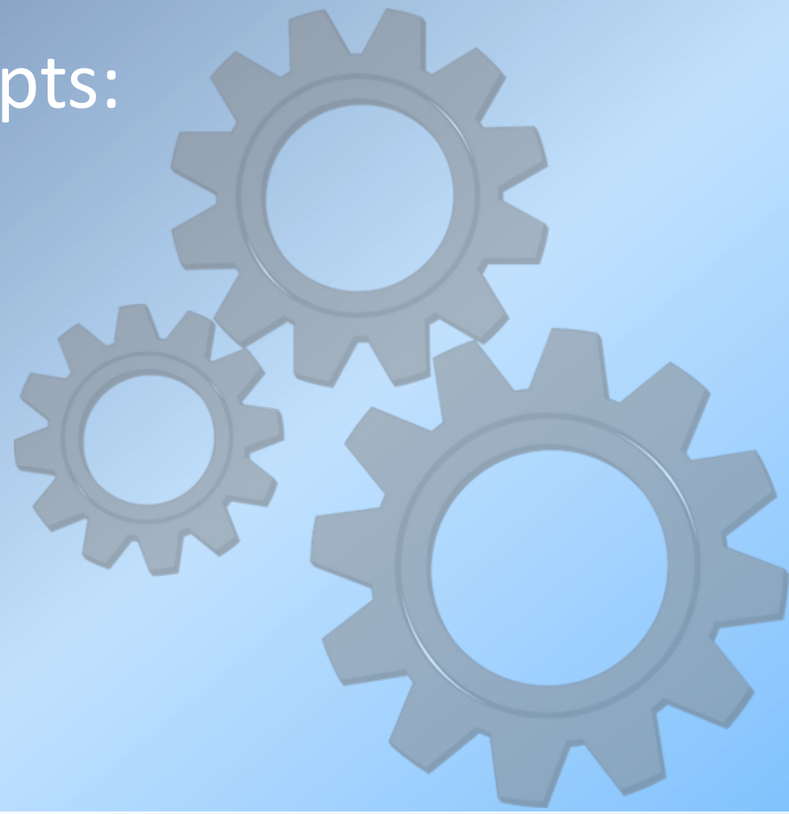
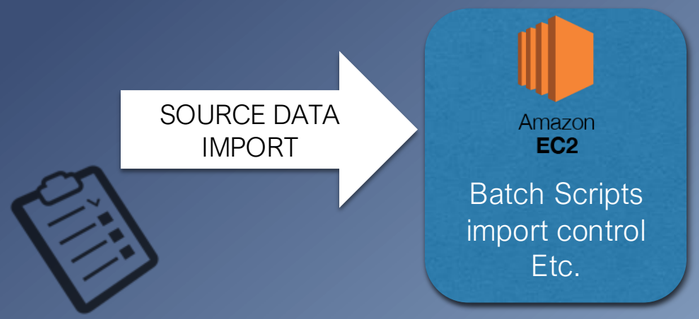


Technical Architecture (simplified)

Hosted on Amazon Web Services



Data Liberate

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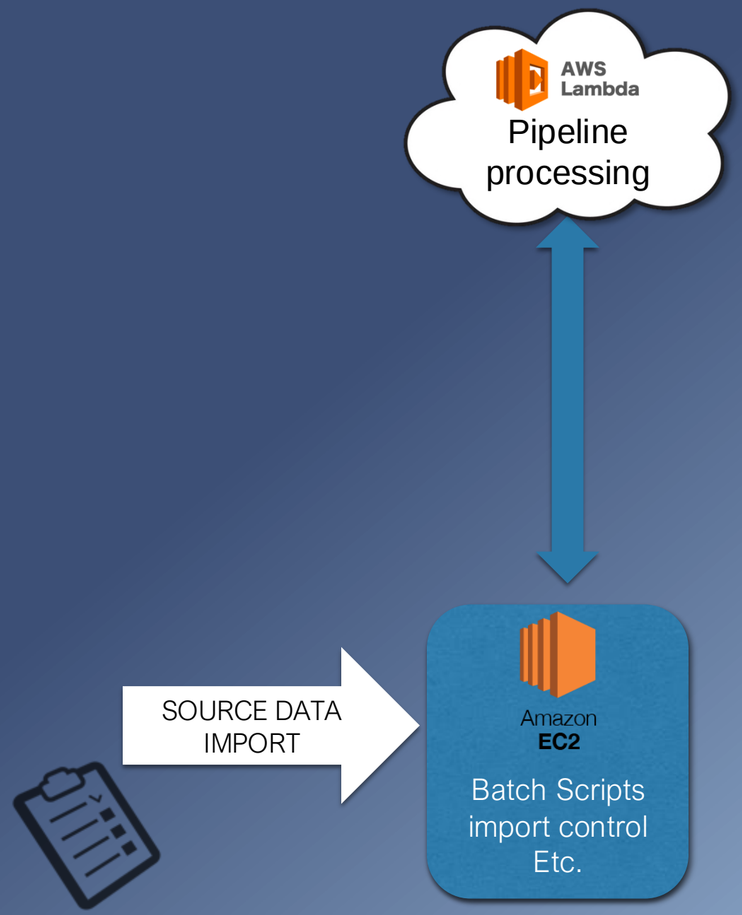

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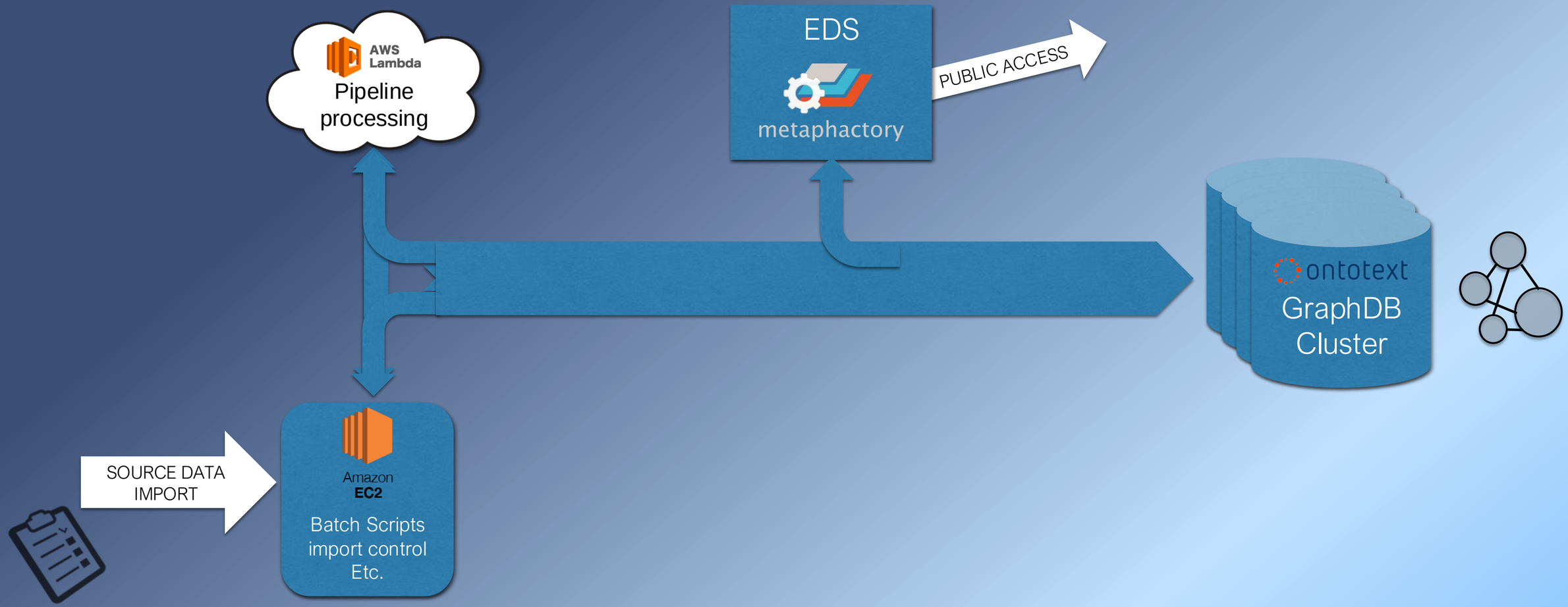

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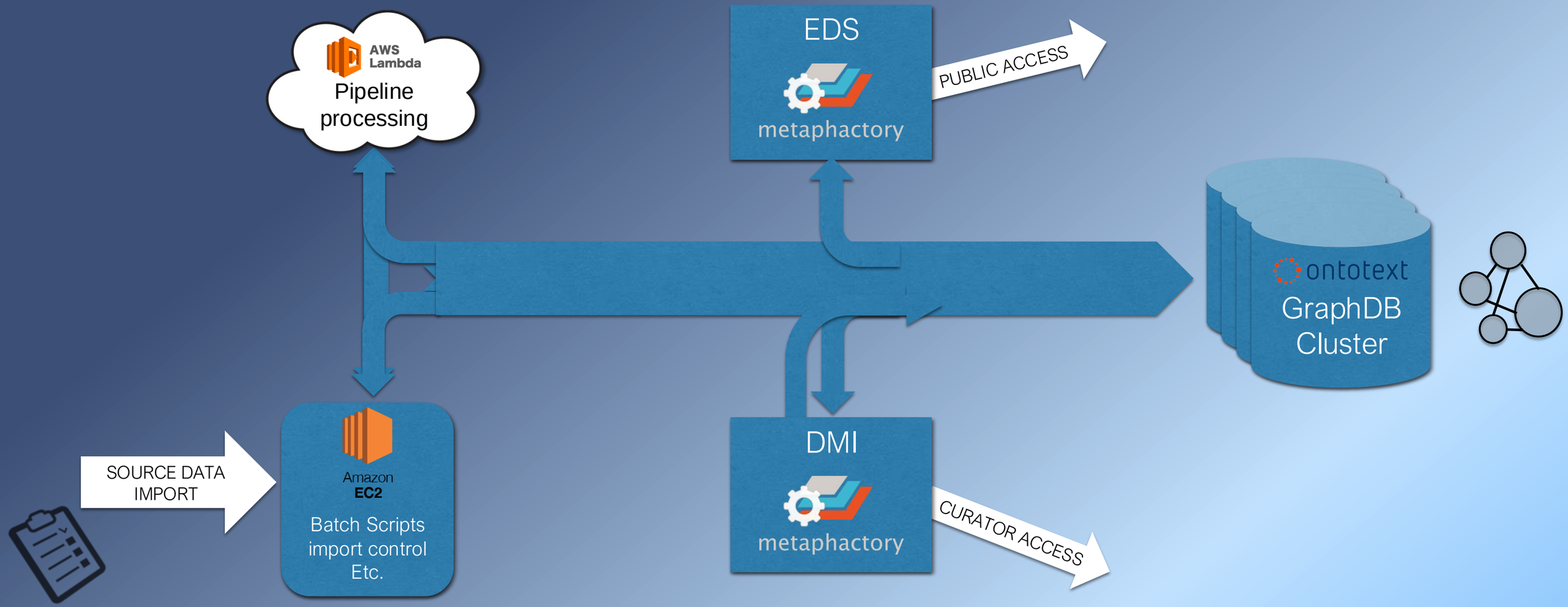

Data Liberate

A need for entity reconciliation …..

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    - 21 CMS, 1 NAS, 66 ILS, 1 TTE

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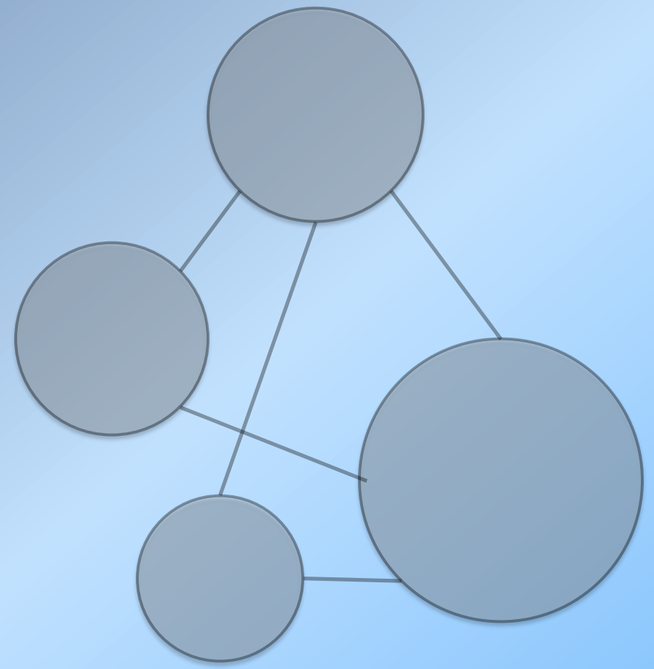
    - 21 CMS, 1 NAS, 66 ILS, 1 TTE
- Users only want 1 of each!

Adaptive Data Model Concepts

- **Source entitles**
  - Individual representation of source data



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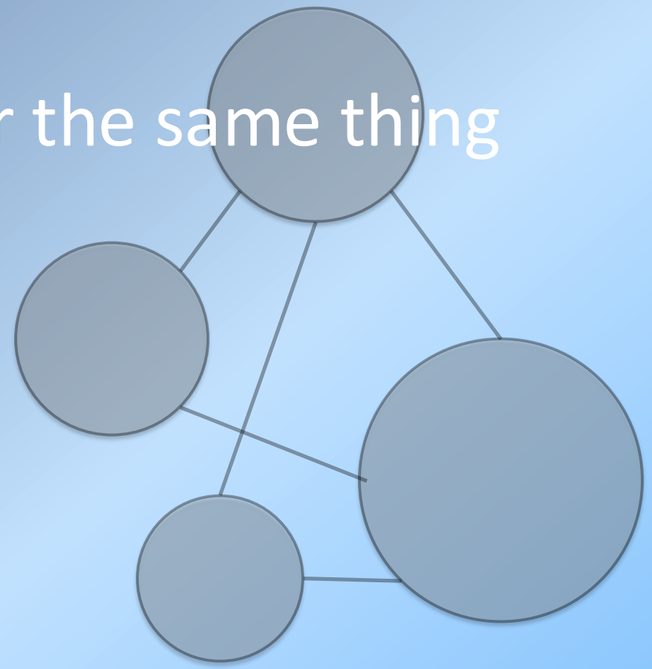

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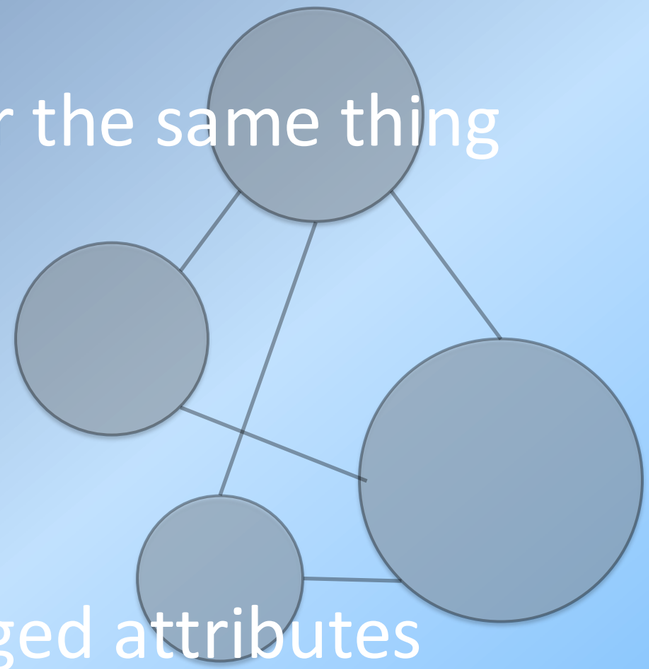
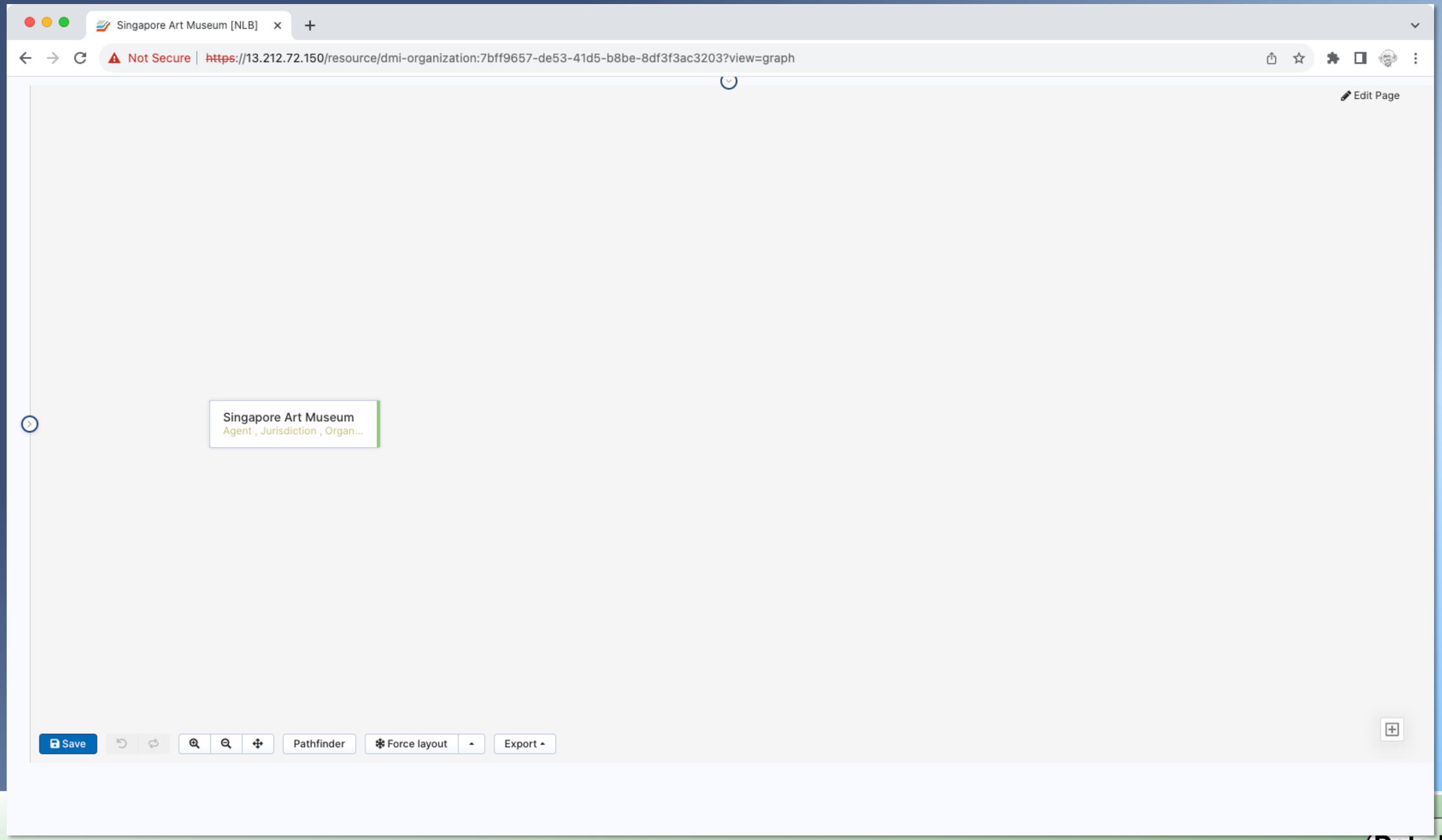
- **Primary Entities**
  - Searchable by users
  - Displayable to users
  - Consolidation of aggregated source data & managed attributes





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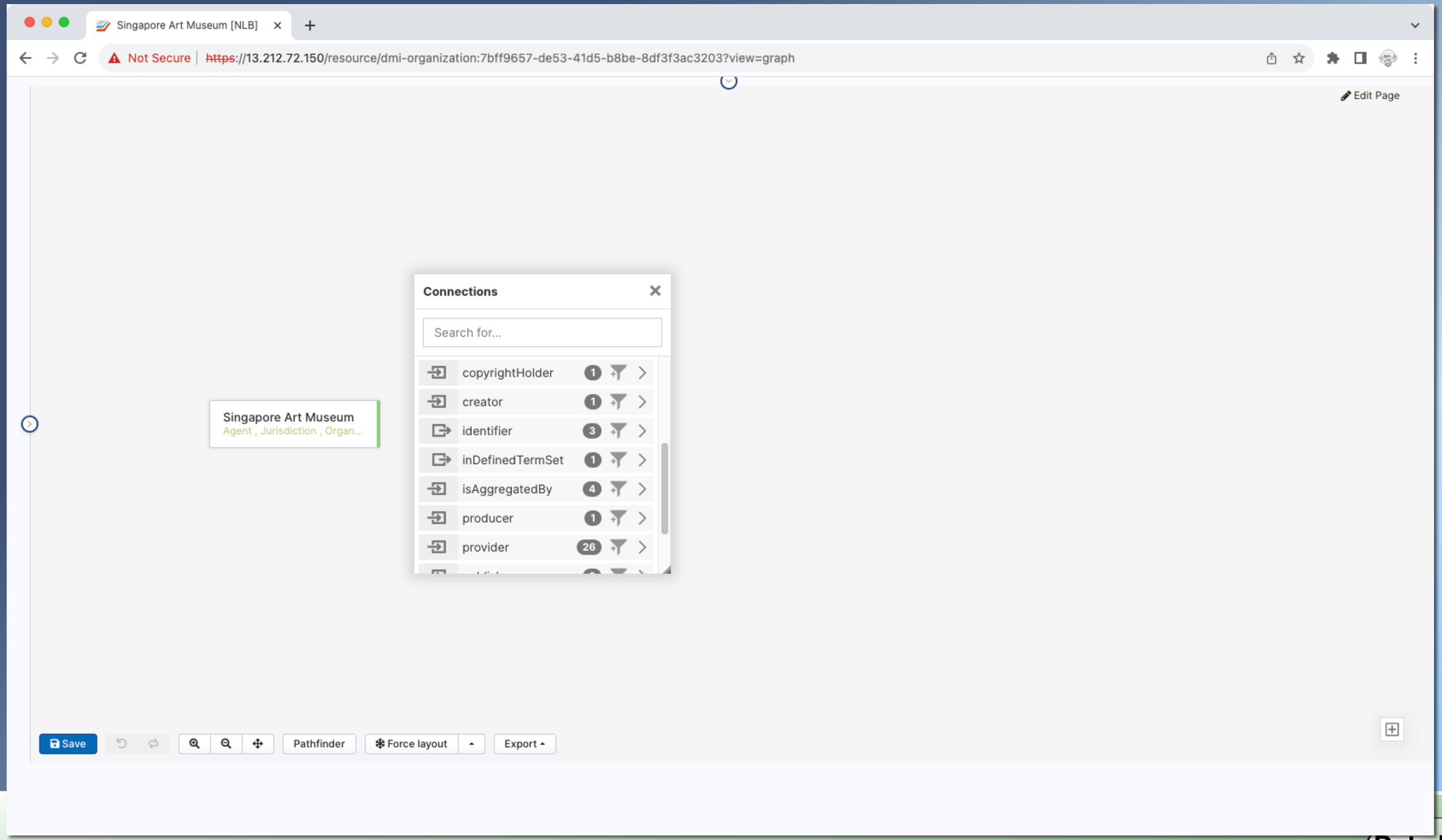
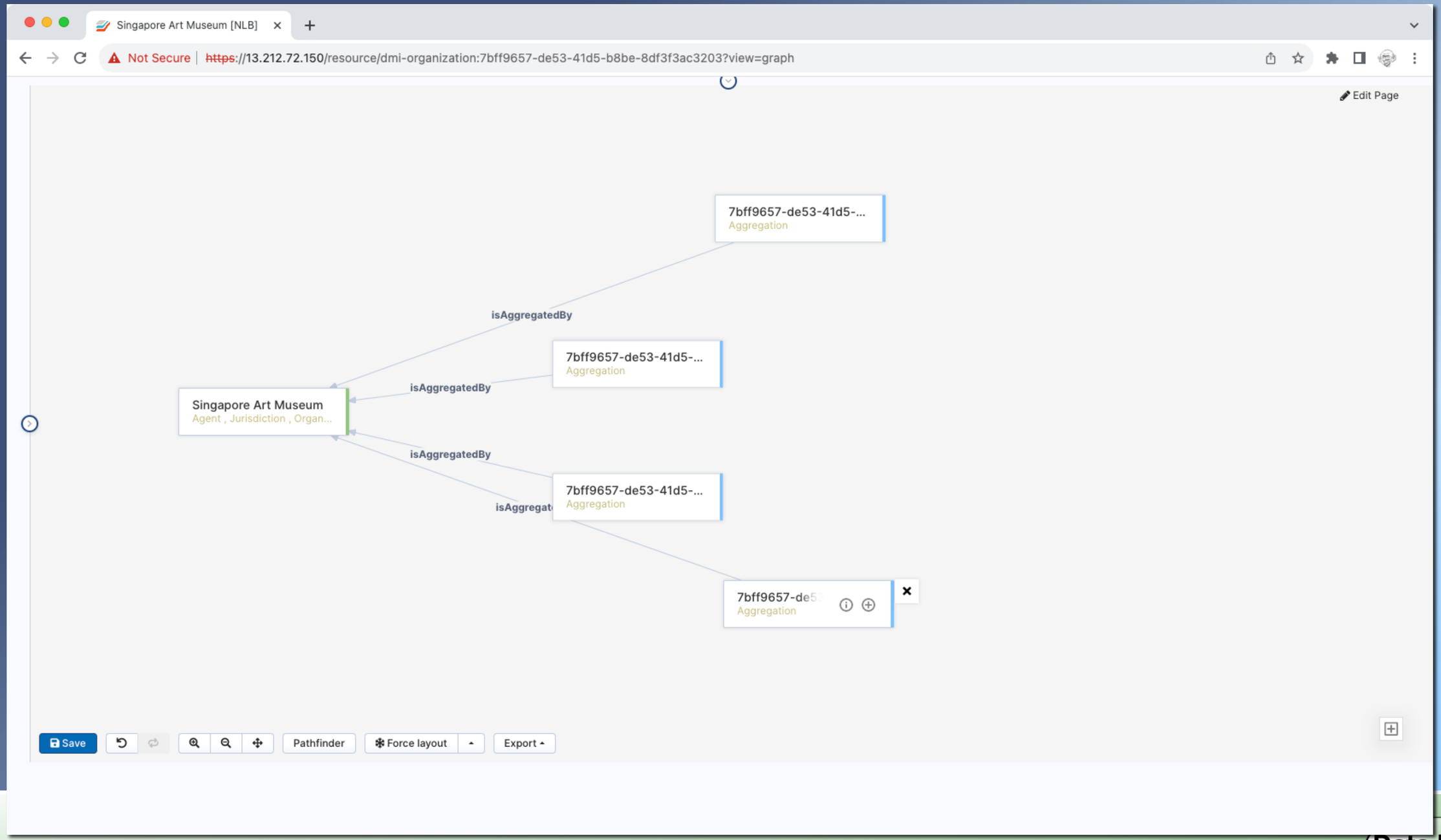

Singapore Art Museum [NLB]
Not Secure
https://13.212.72.150/resource/dmi-organization:7bff9657-de53-41d5-b8be-8df3f3ac3203?view=graph
Edit Page
Singapore Art Museum
Agent , Jurisdiction , Organ...
Connections
Search for...
copyrightHolder 1
creator 1
identifier 3
inDefinedTermSet 1
isAggregatedBy 4
producer 1
provider 26
Save
Pathfinder
Force layout
Export



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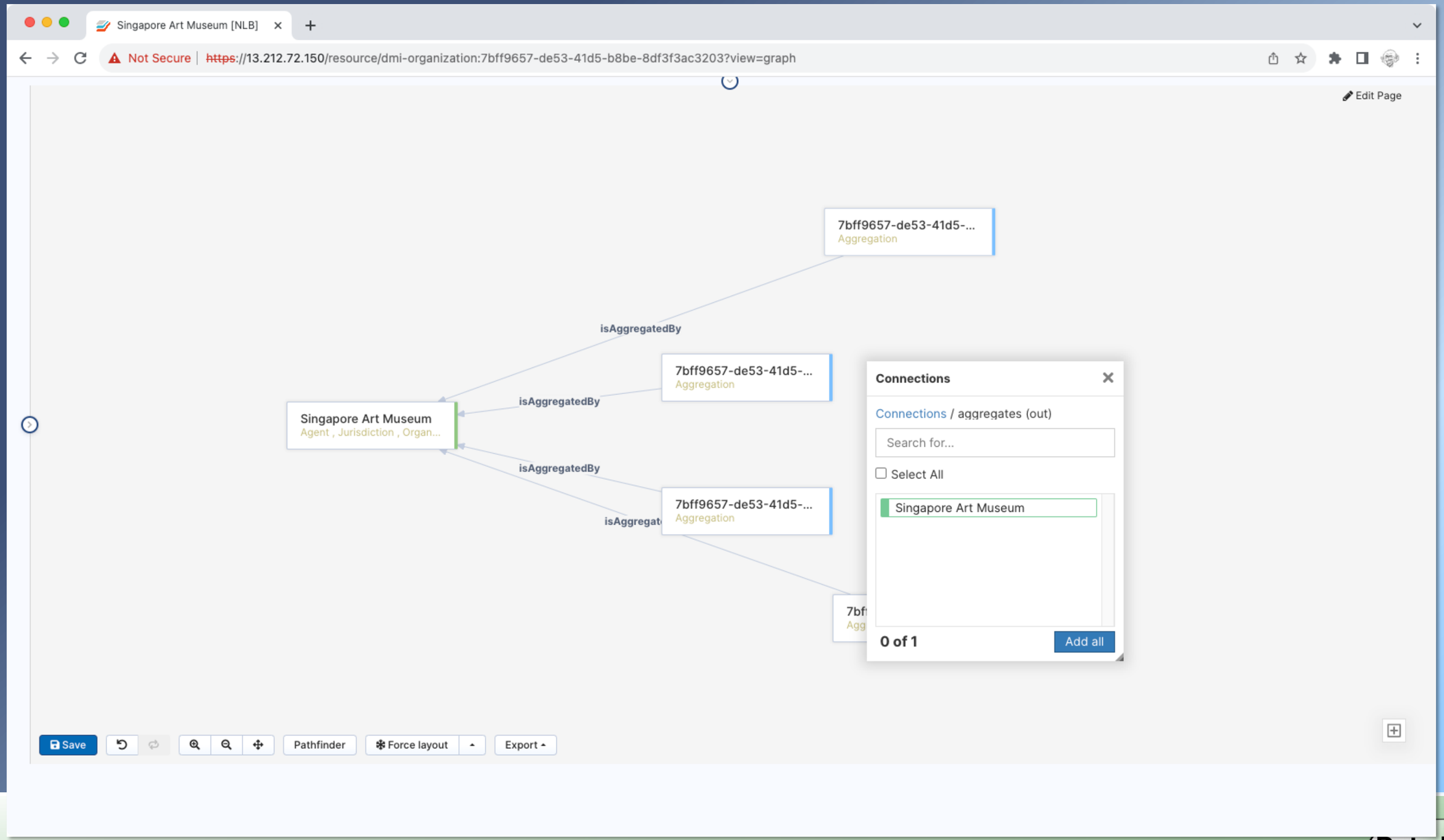

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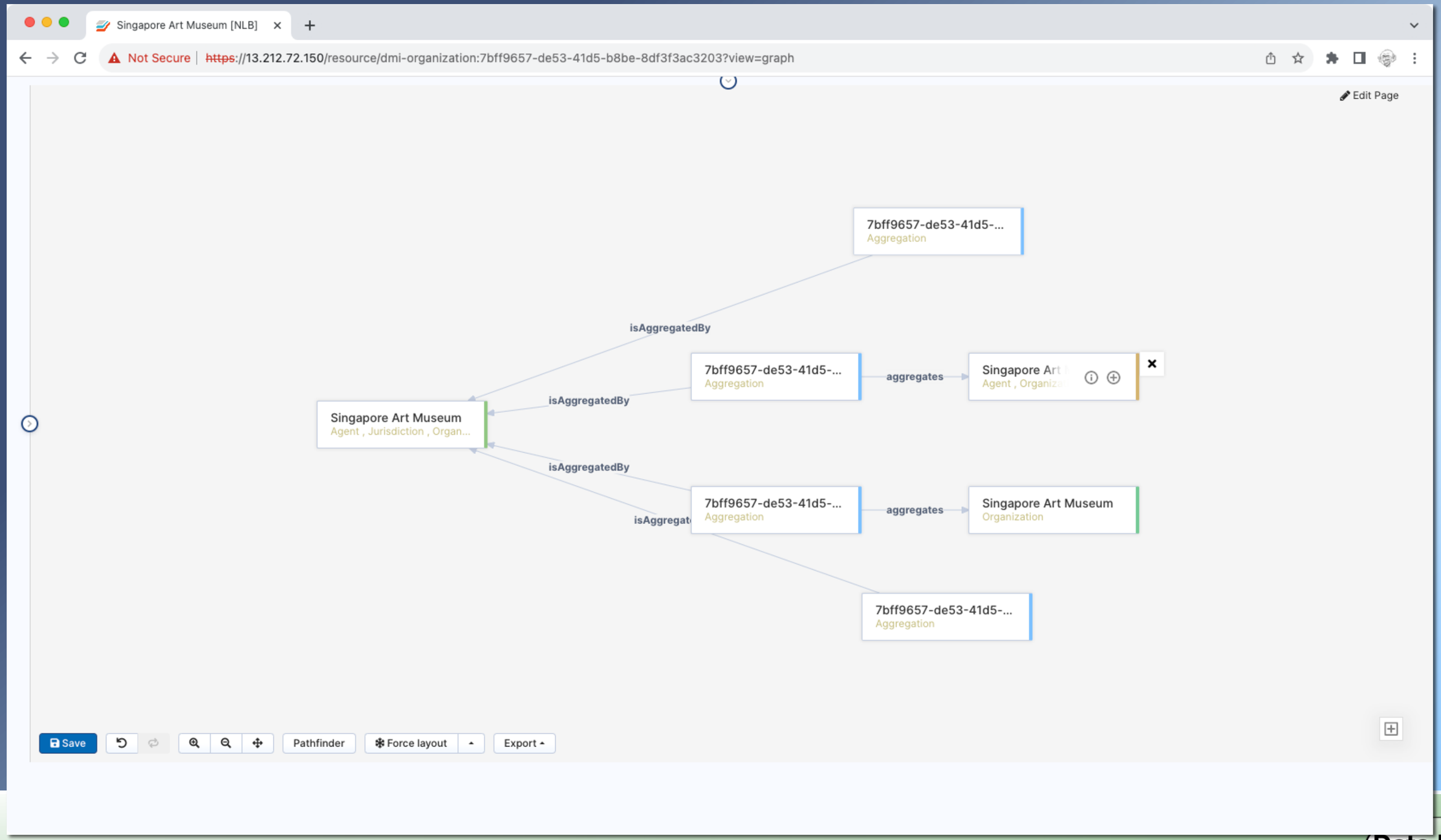

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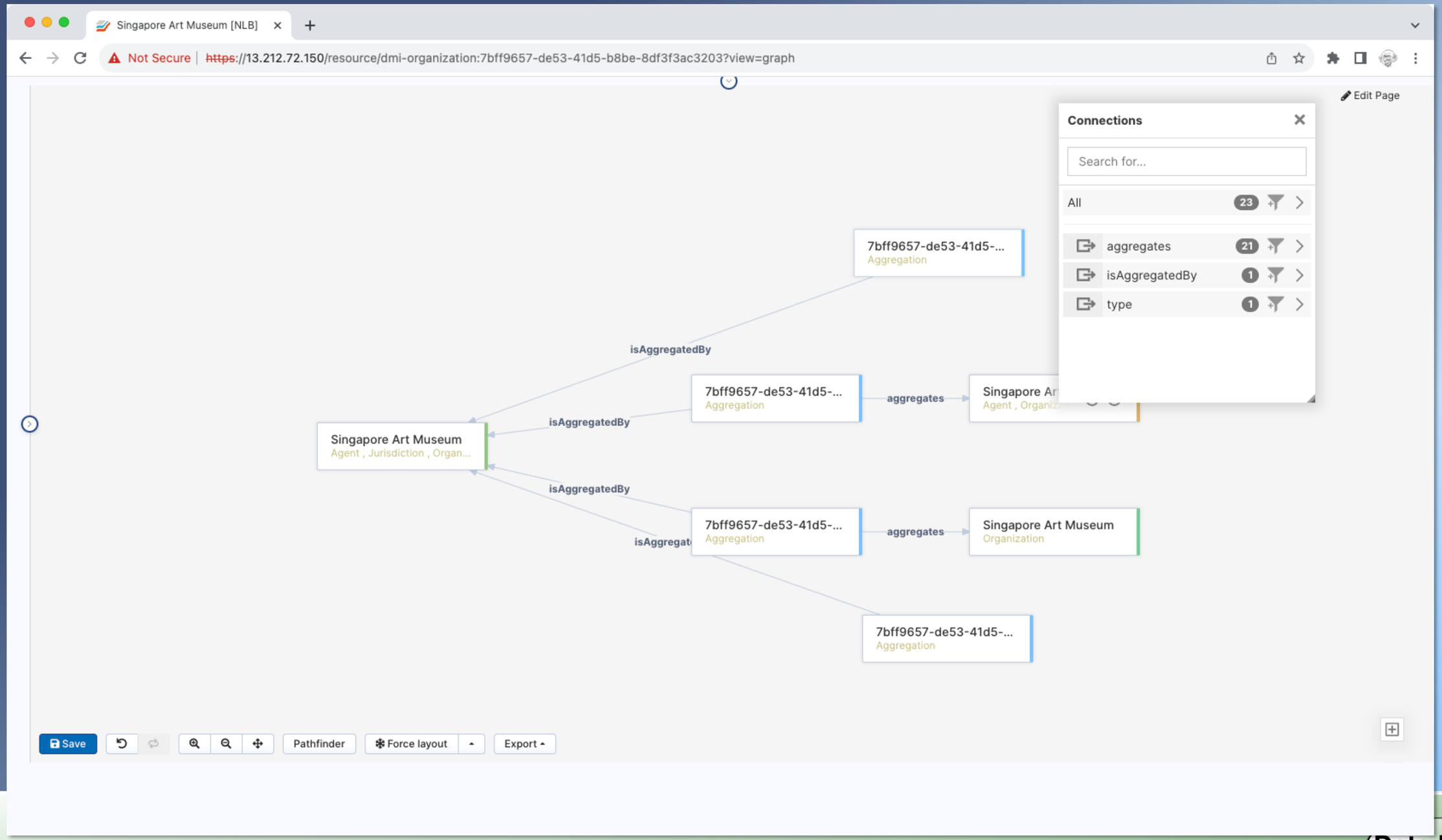

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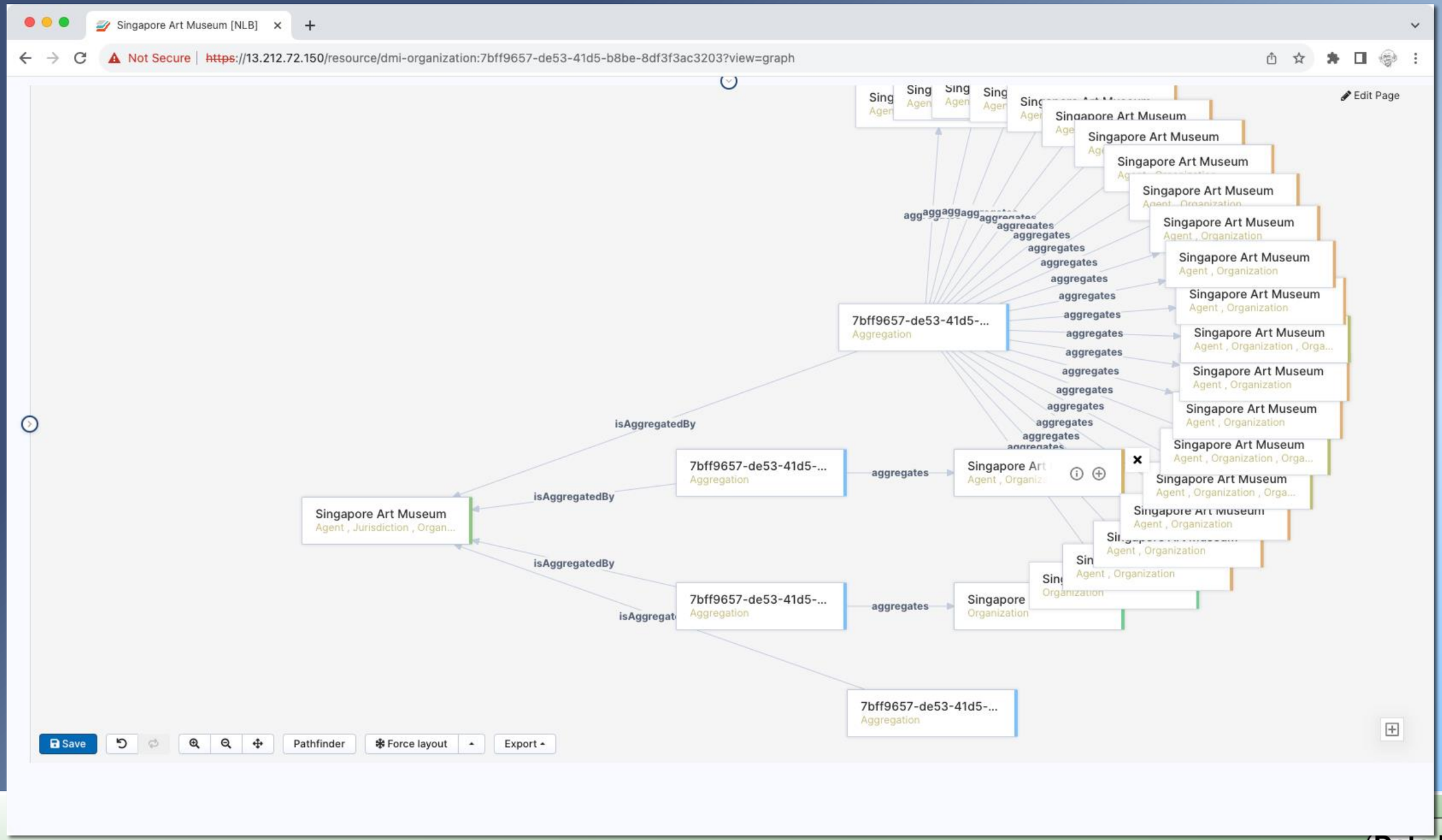
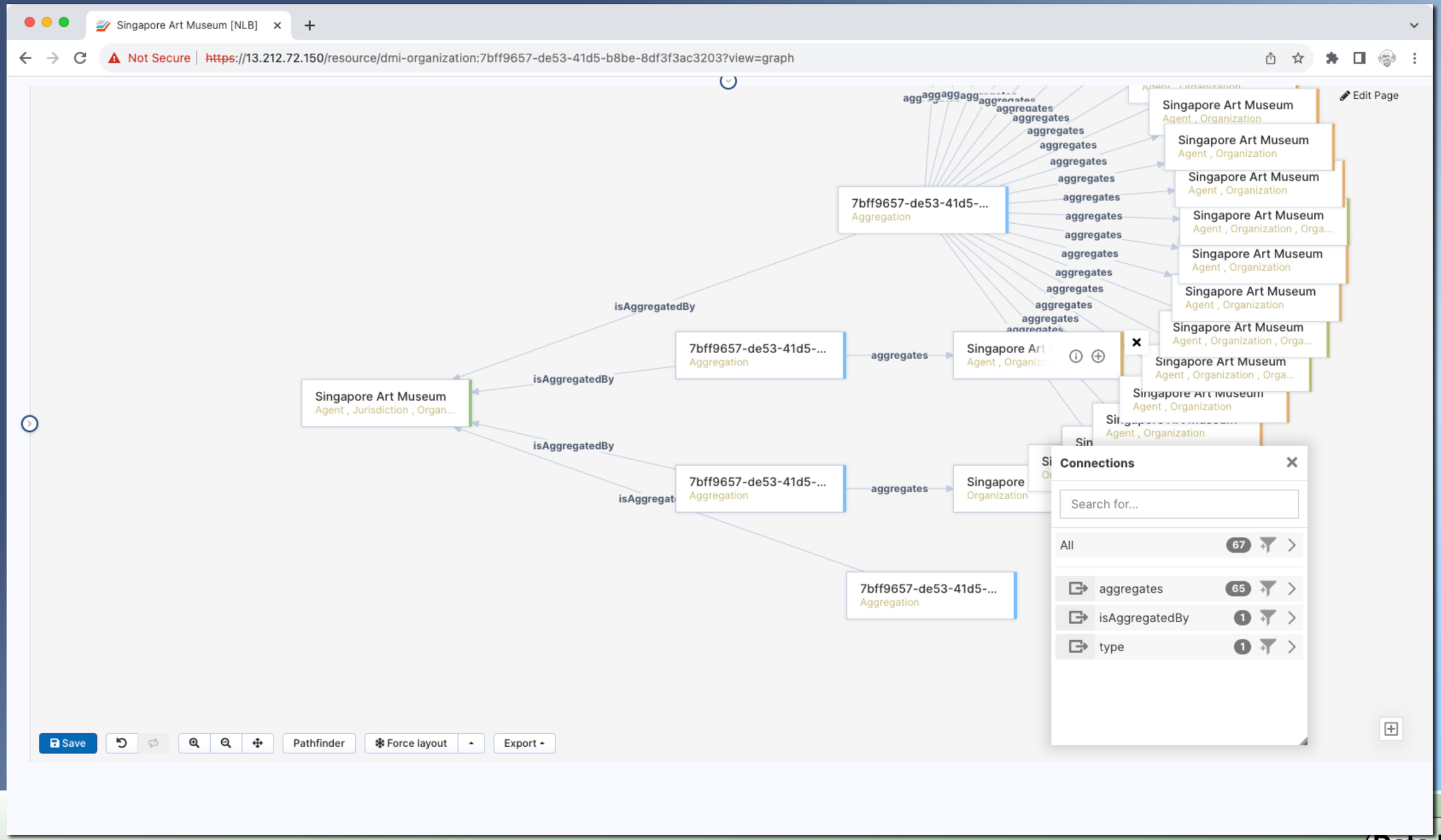


Data Liberate



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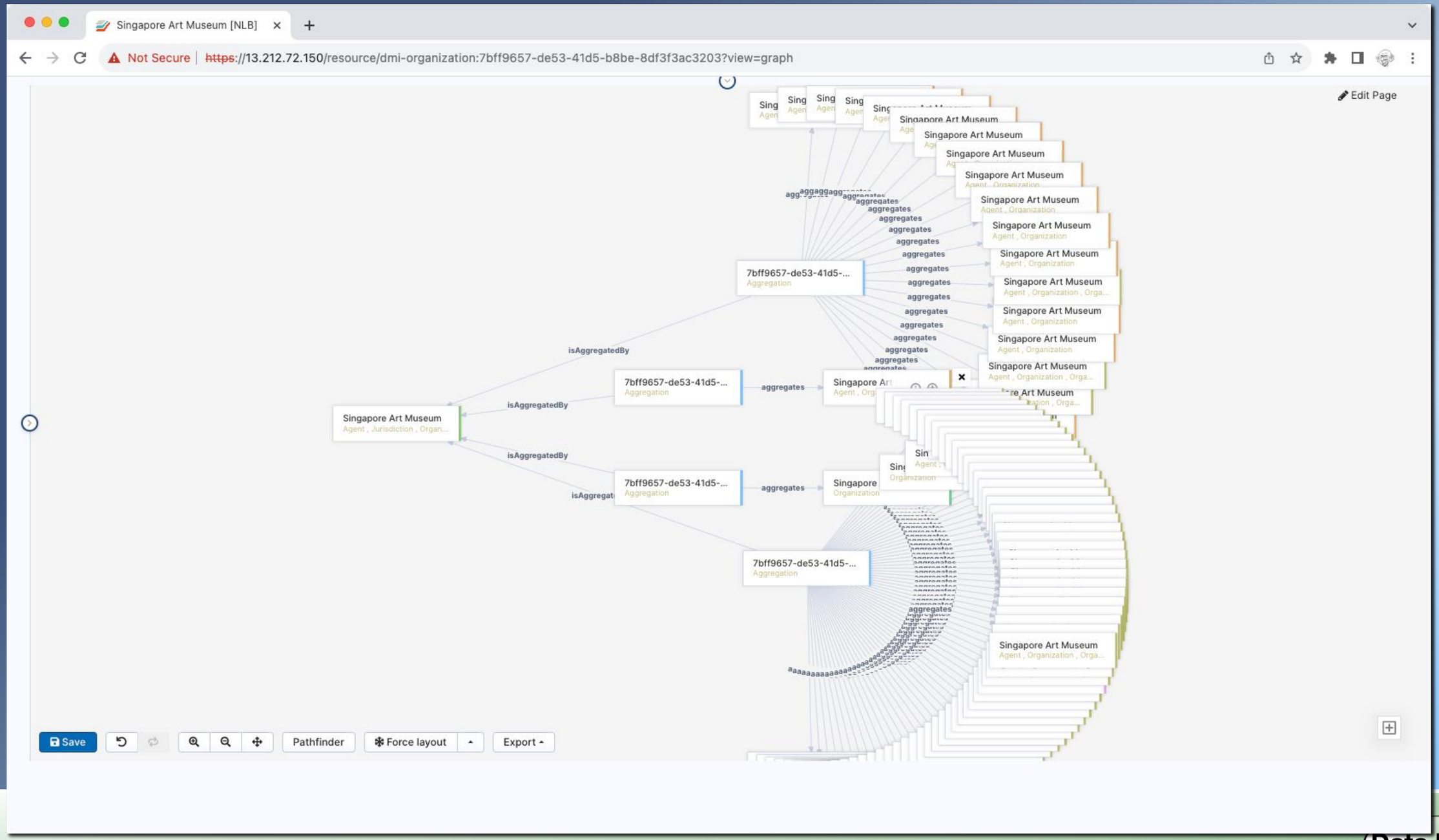
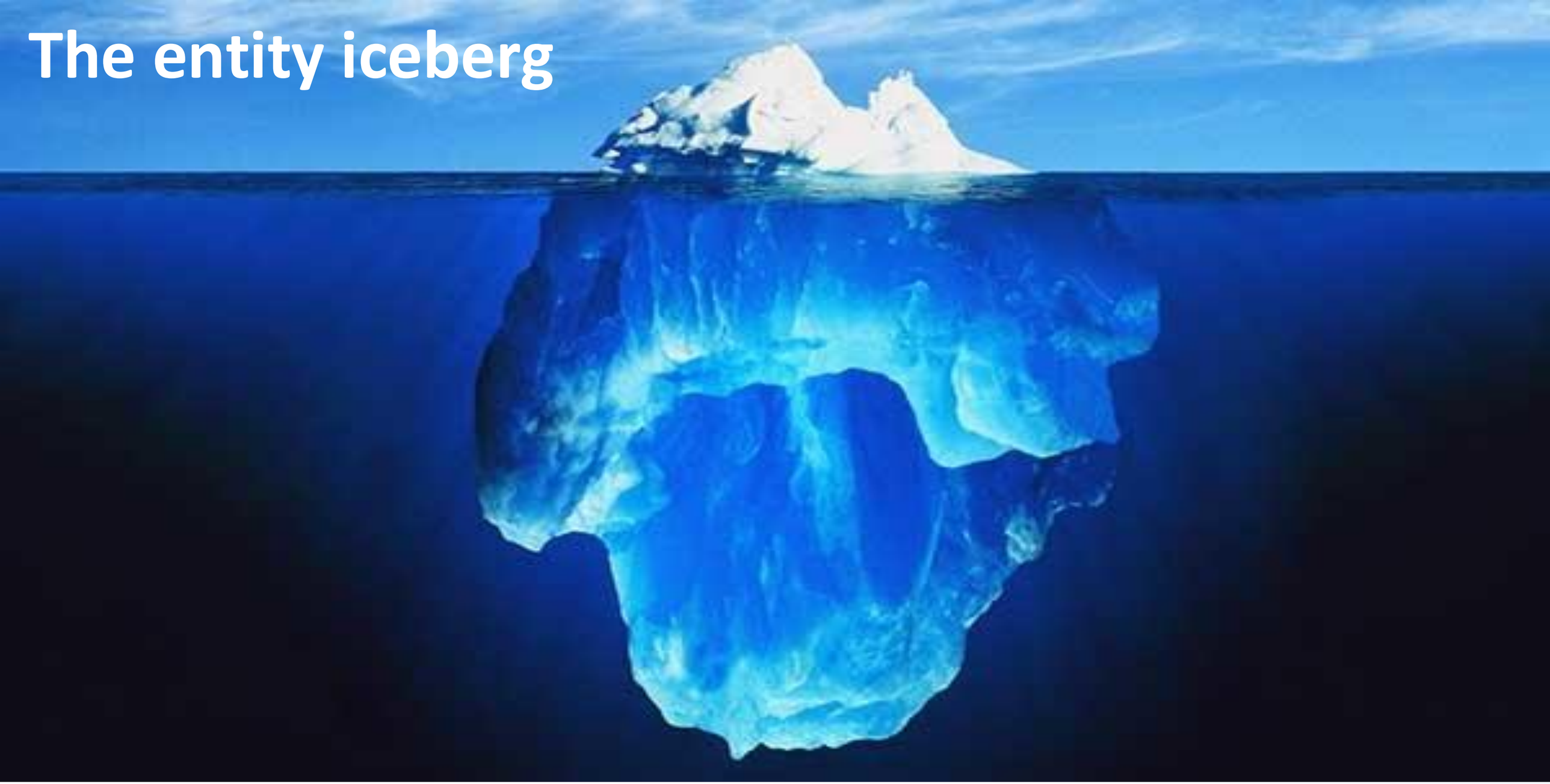


Data Liberate

The entity iceberg



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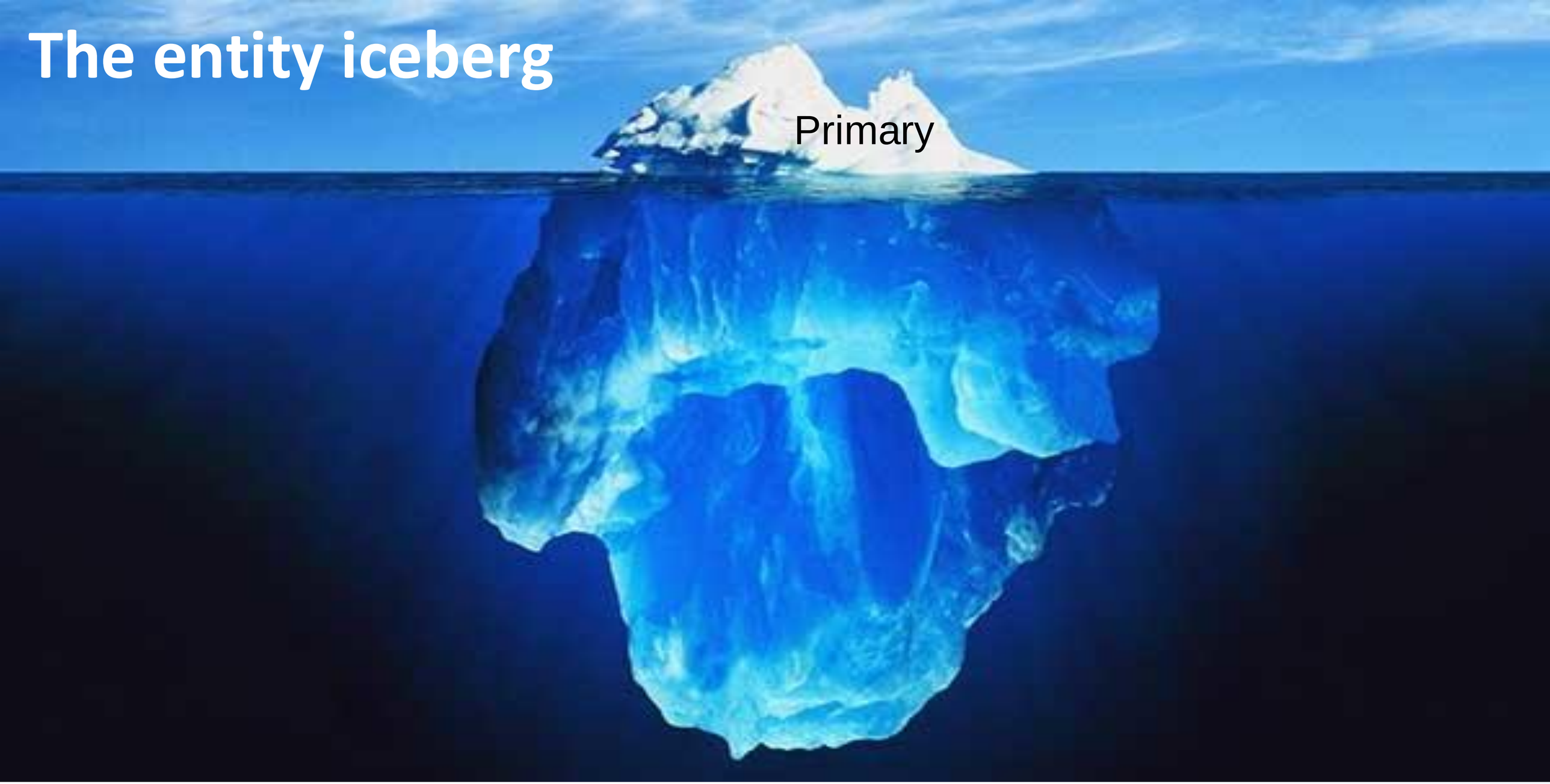

The entity iceberg

Primary

Discovery

Data Liberate

The entity iceberg

Primary

Aggregation

Discovery

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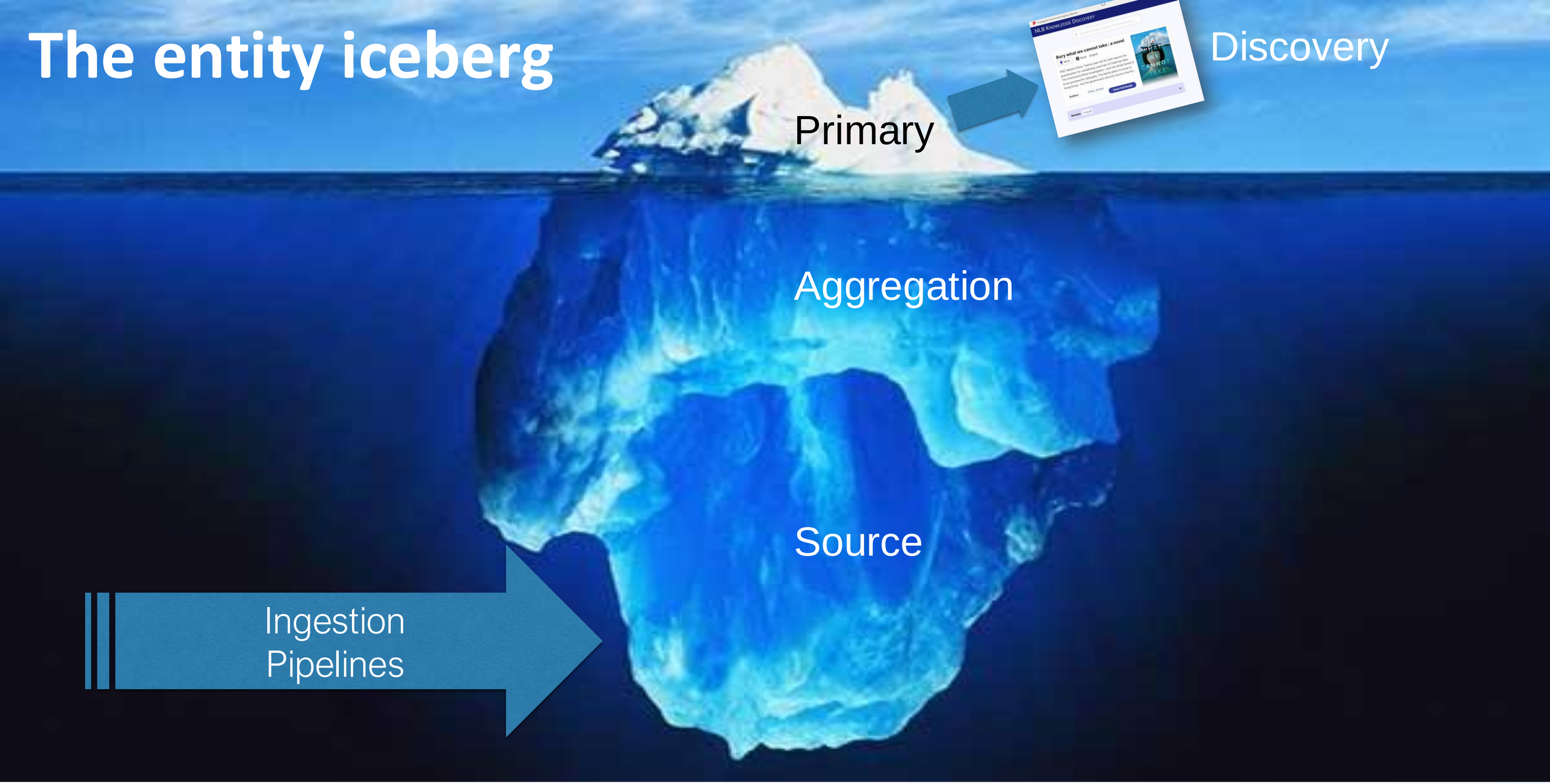
The entity iceberg



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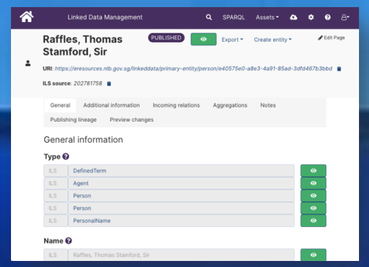
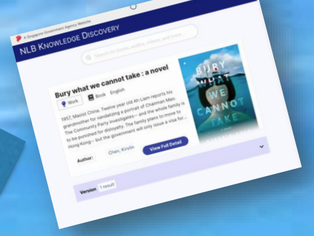


Management

Primary



Discovery

Aggregation

Source

Ingestion Pipelines

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The NLB Knowledge Graph

- 666M Triples

The NLB Knowledge Graph

- 666M Triples
- 10M Source Entities

The NLB Knowledge Graph

- 666M Triples
- 10M Source Entities
- 5.8M Primary Entities

The NLB Knowledge Graph

- 666M Triples
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  - Aggregation of source derived entities

The NLB Knowledge Graph

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- 10M Source Entities
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  - Searchable

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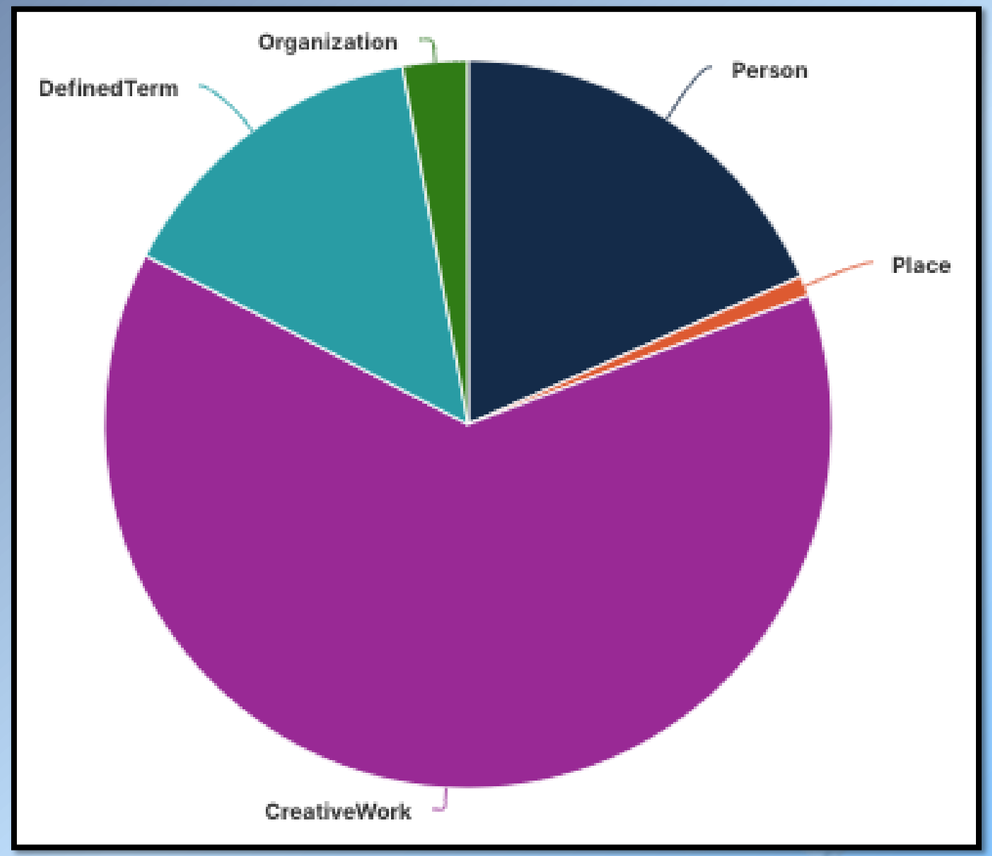

Data Liberate

NLB Linked Data Management System (LDMS)

- Powered by the Knowledge Graph

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- Powered by the Knowledge Graph
- Updated daily

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- Delivering Linked Data benefits back into the organization

Building on the Knowledge Graph
Entity Data Service

- Open Linked Data interface

Building on the Knowledge Graph
Entity Data Service

- Open Linked Data interface
- Dereferencing entity URIs

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- Content negotiation for RDF/XML / JSON-LD / Turtle / N-Triples

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- Embedded Schema.org
- Enhanced navigation

https://eresources.preprod.nlb.gov.sg/linkeddata/resource/dmi-topic:014f60e7-33cf-433a-8c82-61950300551f

ENTITY DATA SERVICE

Search for entities

Lee, Kuan Yew, 1923-2015

Person **Prime ministers**

The first Prime Minister of Singapore (1959-1990), he is recognized as the nation's founding father. He was Senior Minister (1990-2004); Minister Mentor (2004-2011); Member of Parliament for Tanjong Pagar (1955-1991) and Tanjong Pagar GRC (1991-2015). He co-founded the People's Action Party (PAP) in 1954 and was its Secretary-General between 1954 and 1992. He passed away at 3.18 am on 23 Mar 2015. National mourning from 23 Mar to 29 Mar 2015 was declared, culminating in a State Funeral Service on 29 Mar 2015.

URI: https://eresources.nlb.gov.sg/linkeddata/primary-entity/topic/014f60e7-33cf-433a-8c82-61950300551f

Also known as:
Li, Guangyao, 1923-2015
Lī, Kūan Yū, 1923-2015
Yi, K'wan Yu, 1923-2015
Yew, Lee Kuan, 1923-2015
Lī Kuvān Iyū, 1923-2015
Lee, Harry, 1923-2015
李光耀, 1923-2015
1923-2015 ,לי יו, קואן
Li, Kuang-yao, 1923-2015
Yū, Lī Kūan, 1923-2015
Lý, Quang Diệu, 1923-2015

Birth place: Singapore

Birth date: 1923-09-16

Death date: 2015-03-23

Spouse: Kwa, Geok Choo, 1920-2010

Children:
Lee, Hsien Loong
Lee, Wei Ling
Lee, Hsien Yang

Parent:
Lee, Chin Koon
Lee, Chin Koon, Mrs.

External Links 4 results

- Library of Congress - Linked Data Service
- VIAF - Virtual International Authority File
- VIAF - Virtual International Authority File
- Wikidata

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Lee, Wei Ling
Lee, Hsien Yang

Parent: Lee, Chin Koon
Lee, Chin Koon, Mrs.

Related: Lee, Freddy Thiam Yew
Lee, Hoon Leong
Lee, Suet Fern
Ho, Ching
Lee, Choo Neo
Lee, Kim Yew
Lee, Suan Yew

Nationality: Singaporean

Awards: Order of the Companions of Honour (1970)
Bintang Republik Indonesia Adi Pradana
First Class Order of the Rising Sun, Japan (1967)
The Most Esteemed Family Order, DK, Brunei [The Darja Kerabat Laila Utama]
Freedom of the City of London
G.C.M.G. (1972)
The Most Honourable Order of the Crown of Johore, First Class
Grand Cordon of the Order of the Paulownia Flowers, Japan (2015)

Alumni: Fitzwilliam College
Raffles College
Raffles Institution (Singapore)
Choon Guan School
Telok Kurau English School

Affiliation: People's Action Party (Singapore)
Malayan Forum (Great Britain)

Works by Lee, Kuan Yew, 1923-2015 24 items

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Works About Lee, Kuan Yew, 1923-2015 250 items

Download source data: RDF/XML Turtle JSON-LD N-Triples

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National Library Board

COMING SOON

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Building on the Knowledge Graph
Enriching the User Journey

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- Systems are often silos

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- Systems are often silos
- User search and navigation constrained to the data in the silo

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- Plugged into user interface
- Powered by a JavaScript **Sidebar API**

right of the statue. Title devised by Library staff.

01 / 01

Stamford Raffles landed in Singapore on 28 January 1819. Travelling on the *Indiana* with a squadron that included the schooner *Enterprise*, he anchored at St John's Island at 4.00 pm on 28 January 1819 and met with Temenggong Abdul Rahman.[1] The site on the Singapore mainland where Raffles landed is today marked with the statue of Raffles, which is located by the Singapore River behind Parliament House.[2]

The event

According to a 13 February 1819 letter written by Raffles, a delegation from Singapore boarded the *Indiana* on 28 January, enquiring about his intentions. Raffles consulted them, asking if the Dutch had authority over the main island, and noted that only the Temenggong held fort there. Later that same evening, Raffles and William Farquhar went ashore and visited the Temenggong.[3] They returned the next morning on the 29th, planted the Union Jack, and continued their discussions with the Temenggong.[4] Raffles named his landing location South Point.[5]

The Temenggong, a vassal of Sultan Hussein, was consulted and a provisional treaty was agreed upon. Thereafter, the British flag was planted upon Singapore shores, troops were dispatched and instructions left for a fort to be built at what is now known as Fort Canning Hill. Sultan Hussein (Tunku Long) arrived on 1 February, whereupon the trio agreed on a treaty on 6 February. Raffles departed Singapore on 7 February, leaving Farquhar in charge of the inchoate settlement.[6]

Timeline

19 Jan 1819: Raffles leaves Penang aboard the *Indiana*, under the command of Captain James Pearl, to establish a new settlement south of Malacca.[7]
27 Jan 1819: The *Indiana* rendezvous with the *Discover* and the *Investigator* with Farquhar on board, surveying the possibility of the Karimun islands as new British sites. After discussion, they decide against it and head towards Singapore.[8]
28 Jan 1819: The *Indiana* and *Enterprise* anchor at St John's Island. Raffles and Farquhar meet the Temenggong.[9]
30 Jan 1819: A draft agreement is penned between the Temenggong and the British, and the Union Jack is raised with little ceremony.[10]
1 Feb 1819: Sultan Hussein (Tunku Long) arrives from Riau.[11]
6 Feb 1819: The Singapore Treaty is signed between Raffles, the Sultan and the Temenggong, with commanders from the accompanying seven ships witnessing the event. Farquhar is appointed Resident and Commandant under the authority of Raffles, the Lieutenant-Governor of Bencoolen. The Union Jack is officially raised. This date is recognised as the official founding of Singapore.[12] Controversy has arisen, however, from Raffles's mistake in recording the date of his first landing as 29 February 1819, in his "Statement of the Services of Sir Stamford Raffles" – a date that does not exist because 1819 was not a leap year.[13]

Variant interpretations

Wah Hakim's interpretation

Wah Hakim, a 15-year-old eye-witness to the events, testified that in the morning, Raffles arrived in the company of Farquhar who wore a helmet, and a Sepoy who carried a musket. They were entertained with fruits, including rambutans, at the Temenggong's home, leaving at about 4.00 pm that afternoon.[14] The British then left, returning 12 days later, but they remained by the shore, living in makeshift attap huts. Tunku Long was found fishing in the Straits of Rhio by two princes, Raja Ombong, the former's kinsman, and Enche Wan Abdullah, both of whom were paid 500 pounds for their effort. Upon his arrival, the Tunku conducted negotiations with Raffles at the Temenggong's residence first, and later at Raffles's, which was located in Padang Senar.[15]

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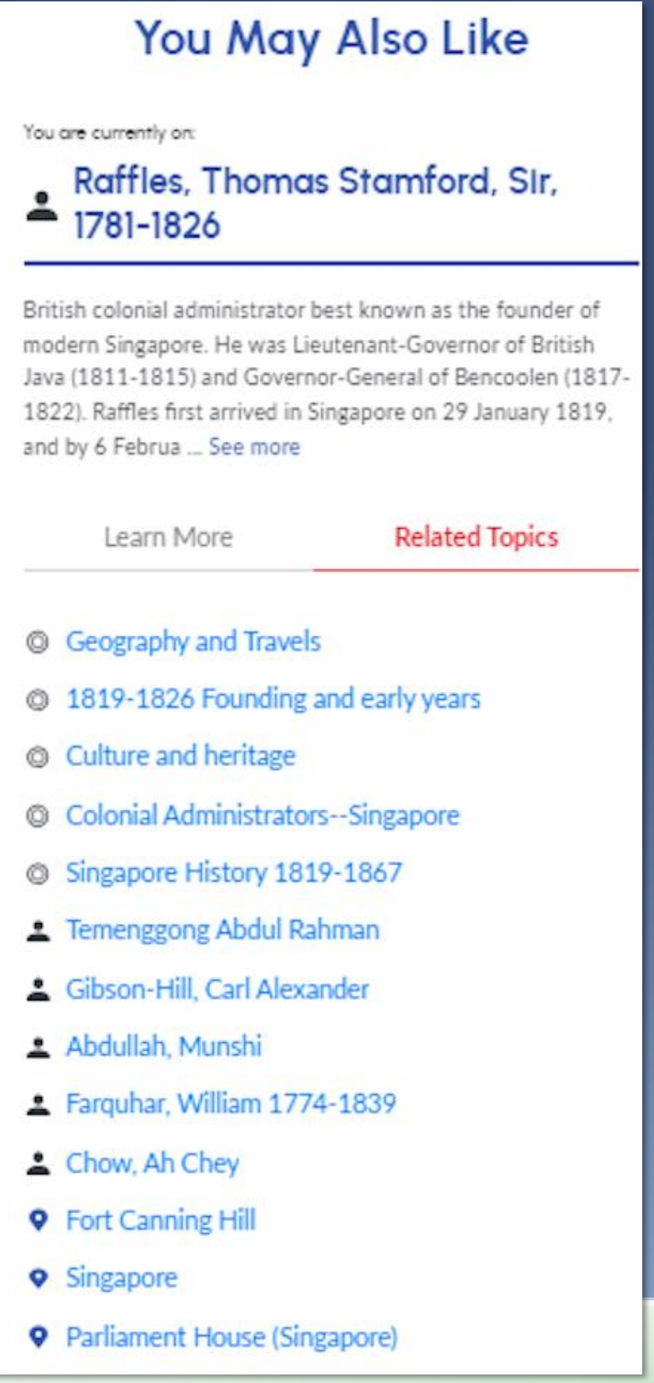
Use of the JavaScript **Sidebar API**



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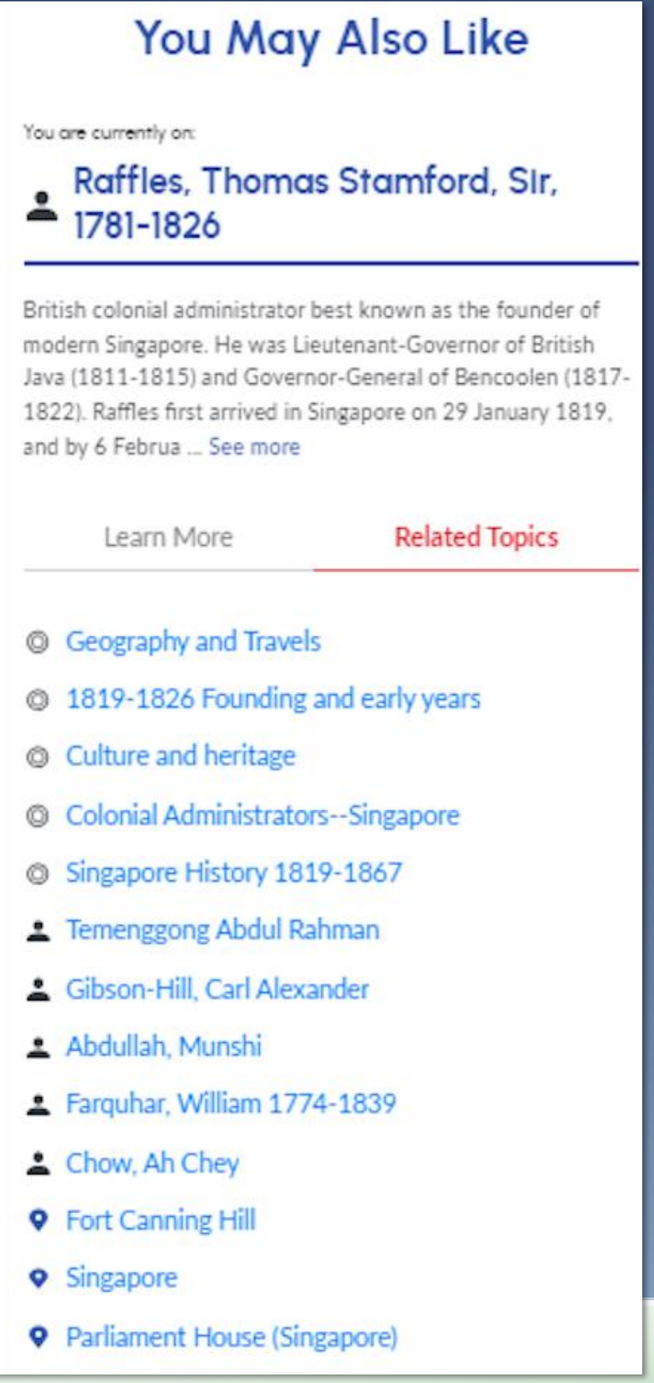

Use of the JavaScript **Sidebar API**

→ API call to KG – article ID passed as parameter

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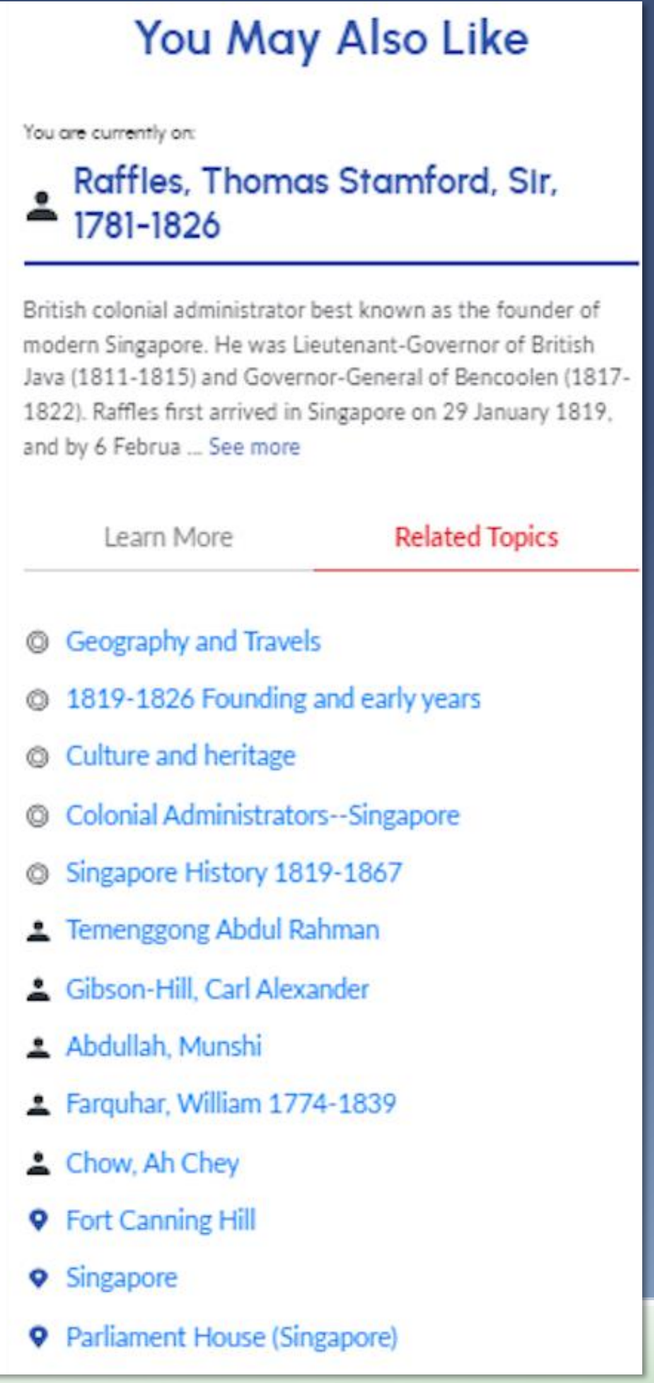

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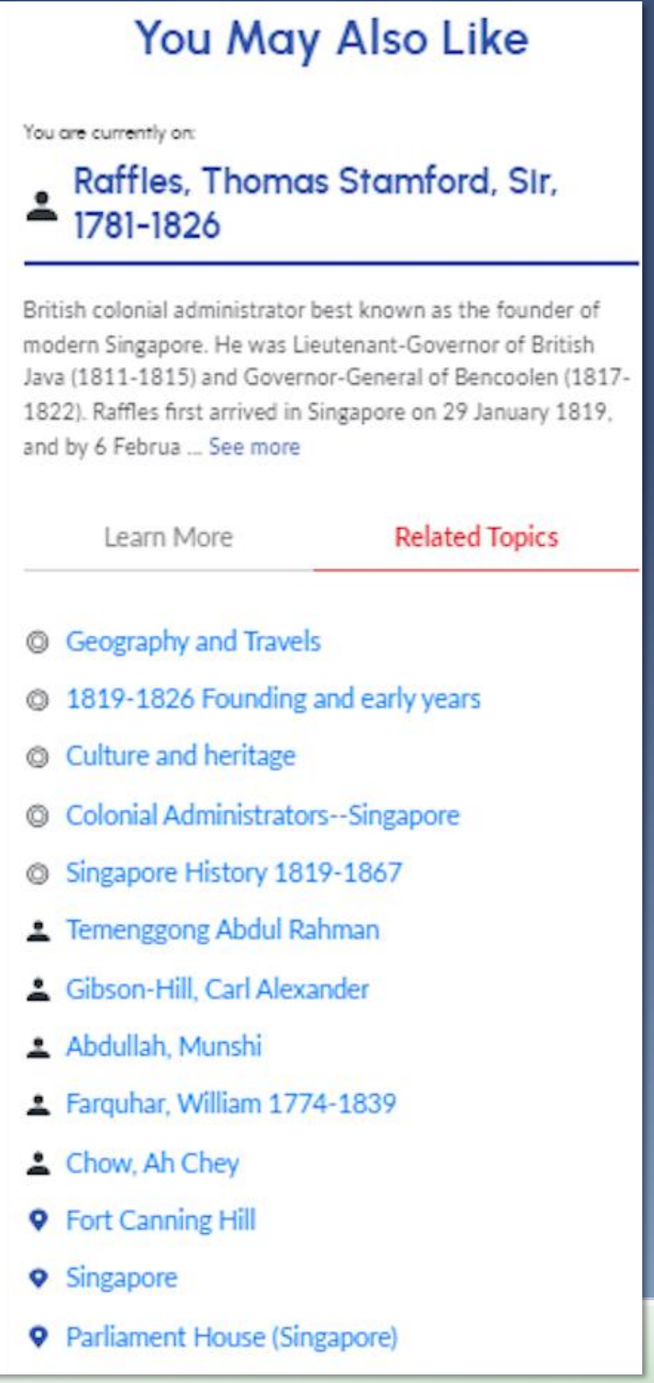

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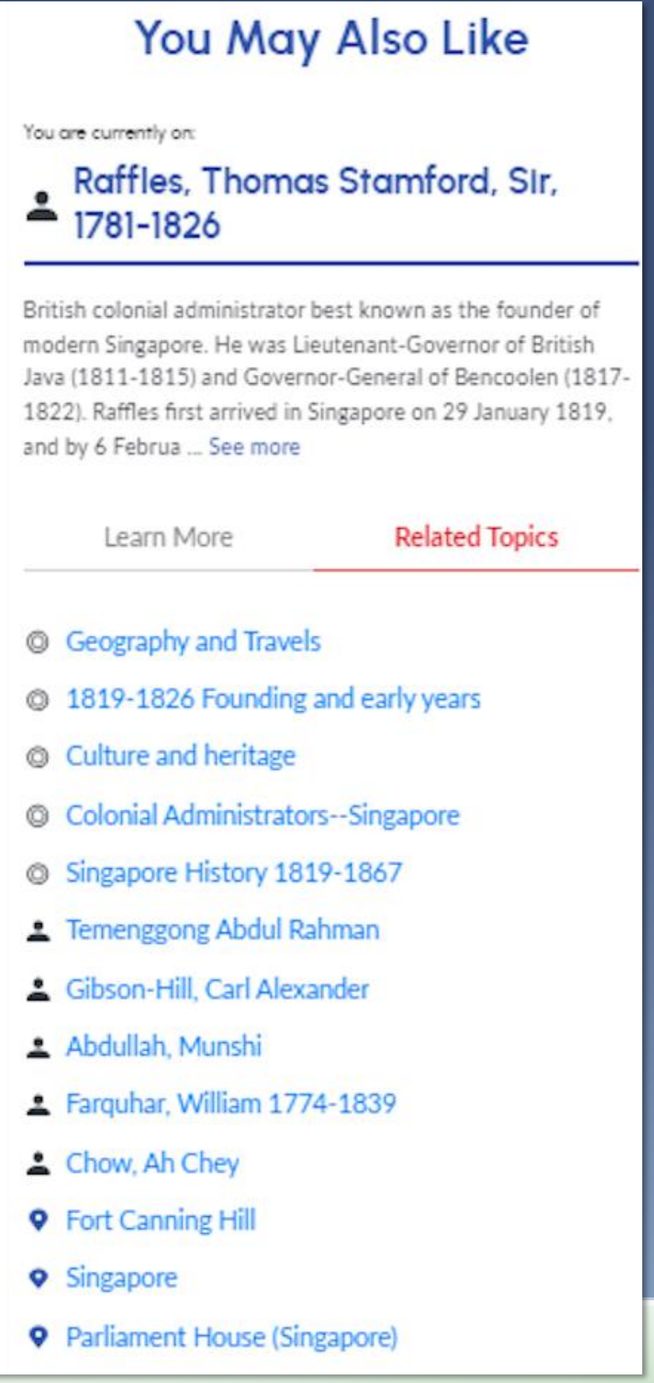

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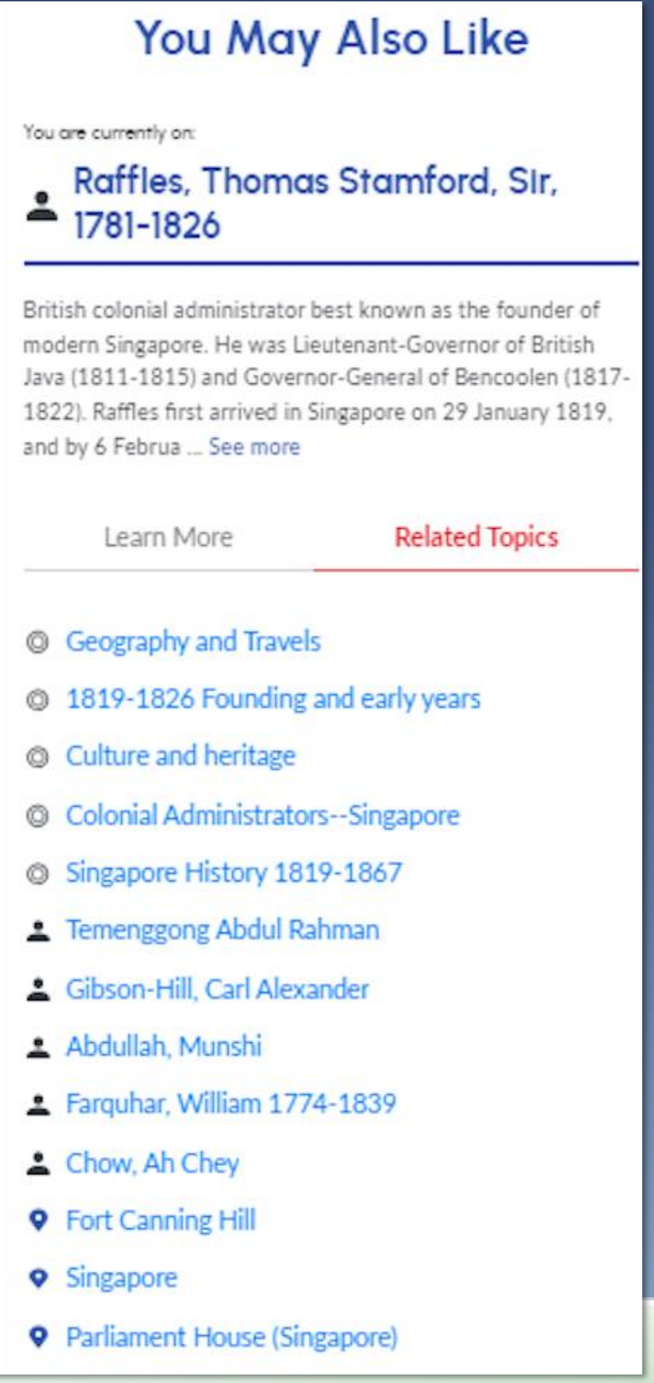

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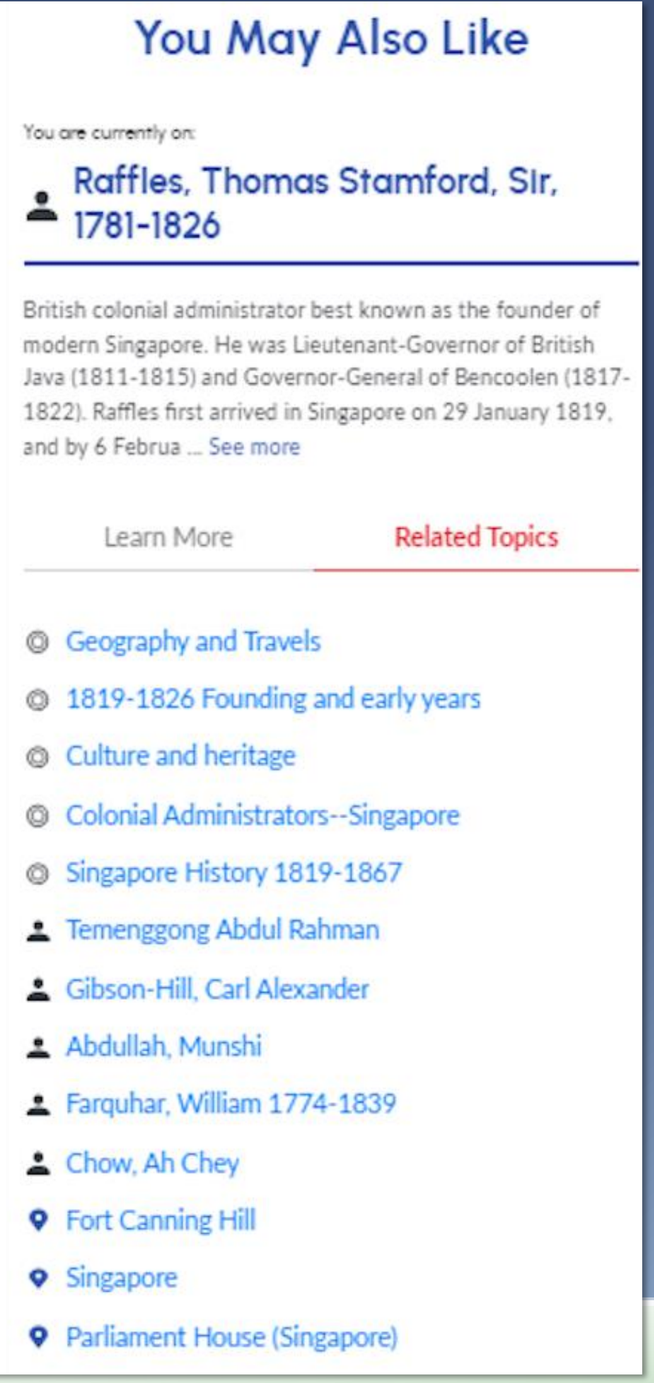
Data Liberate



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KG Quality Enhancement from Authorities
LCNAF URI Ingestion

- For Person / Organization entities with LCNAF URIs

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- Created via the marc2bibframe2 scripts - from `$0` subfield

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  eg. `700$a` **+** `700$d`

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- LCNAF values take precedence in primary entity consolidation

Quality Enrichment from Authorities
LCNAF URI Ingestion

MARC XML:

```
        <marc:datafield tag="700" ind1="1" ind2=" ">
            <marc:subfield code="a"><![CDATA[Khoo, Eric,]]></marc:subfield>
            <marc:subfield code="d"><![CDATA[1965-]]></marc:subfield>
            <marc:subfield code="0"><![CDATA[http://id.loc.gov/authorities/names/no2003076369]]></marc:subfield>
```

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            <marc:subfield code="a"><![CDATA[Khoo, Eric,]]></marc:subfield>
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Bibframe RDF:

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          <bf:Agent rdf:about="http://id.loc.gov/authorities/names/no2003076369">
            <rdf:type rdf:resource="http://id.loc.gov/ontologies/bibframe/Person"/>
            <bflc:name00MatchKey>Khoo, Eric, 1965-</bflc:name00MatchKey>
            <bflc:name00MarcKey>7001 $aKhoo, Eric,$d1965-$0http://id.loc.gov/authorities/names/no2003076369$0http://viaf.org/viaf/48921439</bflc:name00MarcKe
            <rdfs:label>Khoo, Eric, 1965-</rdfs:label>
            <bf:identifiedBy>
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Data Liberate

Quality Enrichment from Authorities
LCNAF URI Ingestion

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```

Entity result in Knowledge Graph

rdfs:label	"Khoo, Eric 1965-"
rdfs:label	"Khoo, Eric, 1965-"
rdfs:label	"Khoo, Eric, 1965- 1965-"

Which is correct?

Data Liberate

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Entity result in Knowledge Graph	
rdfs:label	"Khoo, Eric 1965-"
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Which is correct?

The Library of Congress > Linked Data Service > LC Name Authority File (LCNAF)

Khoo, Eric, 1965-

Data Liberate

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LCNAF URI Ingestion

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Entity result in Knowledge Graph

rdfs:label	"Khoo, Eric 1965-"
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The Library of Congress > Linked Data Service > LC Name Authority File (LCNAF)

Khoo, Eric, 1965-

Ingest from LCNAF and give precedence in consolidation

Data Liberate

Quality Enhancement from Authorities
LCNAF Person & Organization Name Matching

- For all Person and Organization primary entities

Quality Enhancement from Authorities
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- Perform a string-matching LCNAF lookup for `schema:name` **values**

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  - Add to list of match candidates

Quality Enhancement from Authorities
LCNAF Person & Organization Name Matching

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- Perform a string-matching LCNAF lookup for `schema:name` values
- Automatic background process
- If exact match
  - Ingest LCNAF entity – takes precedence in consolidation
- If close match
  - Add to list of match candidates
  - [Human] curator either accepts as a match or not

Quality Enrichment from Authorities
LCNAF Person & Organization Name Matching

External lookups validation for Persons | External lookups validation for Organisations

Refresh list

Quick search ...

Filter columns

337 entries

LDMS Record	LDMS Record Origin	LCNAF Proposed match	Action	Status
Chen, Wenxi, 1906-1991 • **rdf:type :** schema:Person • **schema:name :** Chen, Wen Hsi • **schema:name :** Chen, Wenxi, 1906-1991 • **schema:name :** Chen Wen Hsi • **schema:name :** Chen, Wenxi, 1906- • **schema:birthDate :** 1906 • **schema:birthDate :** 1906-09-09 • Show more...	Singapore	Chen, Wenxi, 1906-1991 • **rdf:type :** mads:PersonalName • **mads:authoritativeLabel :** Chen, Wenxi, 1906-1991 • **mads:birthDate :** (edtf) 1906-09-09 • Show more...	✔ Make ExactMatch ✔✔ Make ExactMatch & Publish ✖ Discard CloseMatch	CloseMatch for review. Last status update : 2024-06-05 21:45
Kenny, the Fish, 1965- • **rdf:type :** schema:Person • **schema:name :** Yap, Kenny Kim Lee • **schema:name :** Kenny, the Fish, 1965- • **schema:name :** Kenny Yap Kim Lee • **schema:birthDate :** 1965 • Show more...	Singapore	Kenny, the Fish, 1965- • **rdf:type :** mads:PersonalName • **mads:authoritativeLabel :** Kenny, the Fish, 1965- • **mads:birthDate :** 1965 • Show more...	✔ Make ExactMatch ✔✔ Make ExactMatch & Publish ✖ Discard CloseMatch	CloseMatch for review. Last status update : 2024-06-05 21:45
Koh, Tommy T. B. (Tommy Thong Bee), 1937- • **rdf:type :** schema:Person • **schema:name :** Koh, Tommy • **schema:name :** Koh, Tommy T. B. (Tommy Thong Bee), 1937- • **schema:name :** Tommy Koh • **schema:birthDate :** 1937-11-12 • Show more...	Singapore	Koh, Tommy T. B. (Tommy Thong Bee), 1937- • **rdf:type :** mads:PersonalName • **mads:authoritativeLabel :** Koh, Tommy T. B. (Tommy Thong Bee), 1937- • **mads:birthDate :** (edtf) 1937-11-12 • Show more...	✔ Make ExactMatch ✔✔ Make ExactMatch & Publish ✖ Discard CloseMatch	CloseMatch for review. Last status update : 2024-06-05 21:45
Abdul Rahman • **rdf:type :** schema:Person • **schema:name :** Abdul Rahman, Tunku, Putra Al-Haj, 1903-1990 • **schema:name :** Abdul Rahman	Other	Abdul Rahman, Tunku, Putra Al-Haj, 1903-1990 • **rdf:type :** mads:PersonalName • **mads:authoritativeLabel :** Abdul Rahman, Tunku, Putra Al-Haj, 1903-1990 • **mads:birthDate :** 1903	✔ Make ExactMatch ✔✔ Make ExactMatch & Publish	CloseMatch for review. Last status update : 2022-10-05 04:24

Quality Enrichment from Authorities
LCNAF Person & Organization Name Matching

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NLB Linked Data Management System (LDMS)

- 2 years in development

metaphacts KEWMANN Data Liberate

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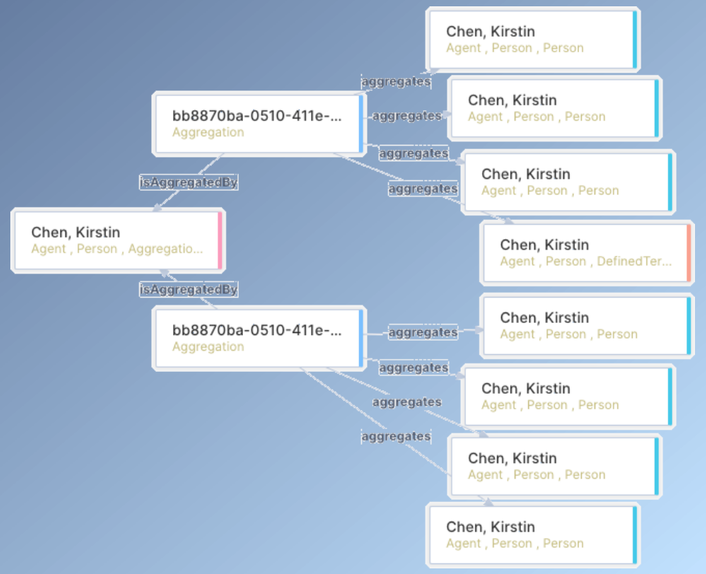
  - Part of Open Linked Data Cloud – via Entity Data Service
  - Enriching user journeys on non-linked data systems – via sidebar API

A Semantic Knowledge Graph at National Library Board Singapore



Richard Wallis
Evangelist and Founder
Data Liberate
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BIBFRAME Workshop in Europe 2024
17th September 2024 - Helsinki

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