THE OLYMPICS: A LINKED DATA APPLICATION

Brought to you by Wallscope and Oxford Semantic Technologies

WHITE PAPER - OCTOBER 2020

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Wallscope and Oxford Semantic Technologies collaborate on opportunities for the delivery of Wallscope's services and RDFox at Enterprise Scale. Working with an advanced knowledge store creates new possibilities in knowledge extraction, semantic reasoning, data sharing and analytics.

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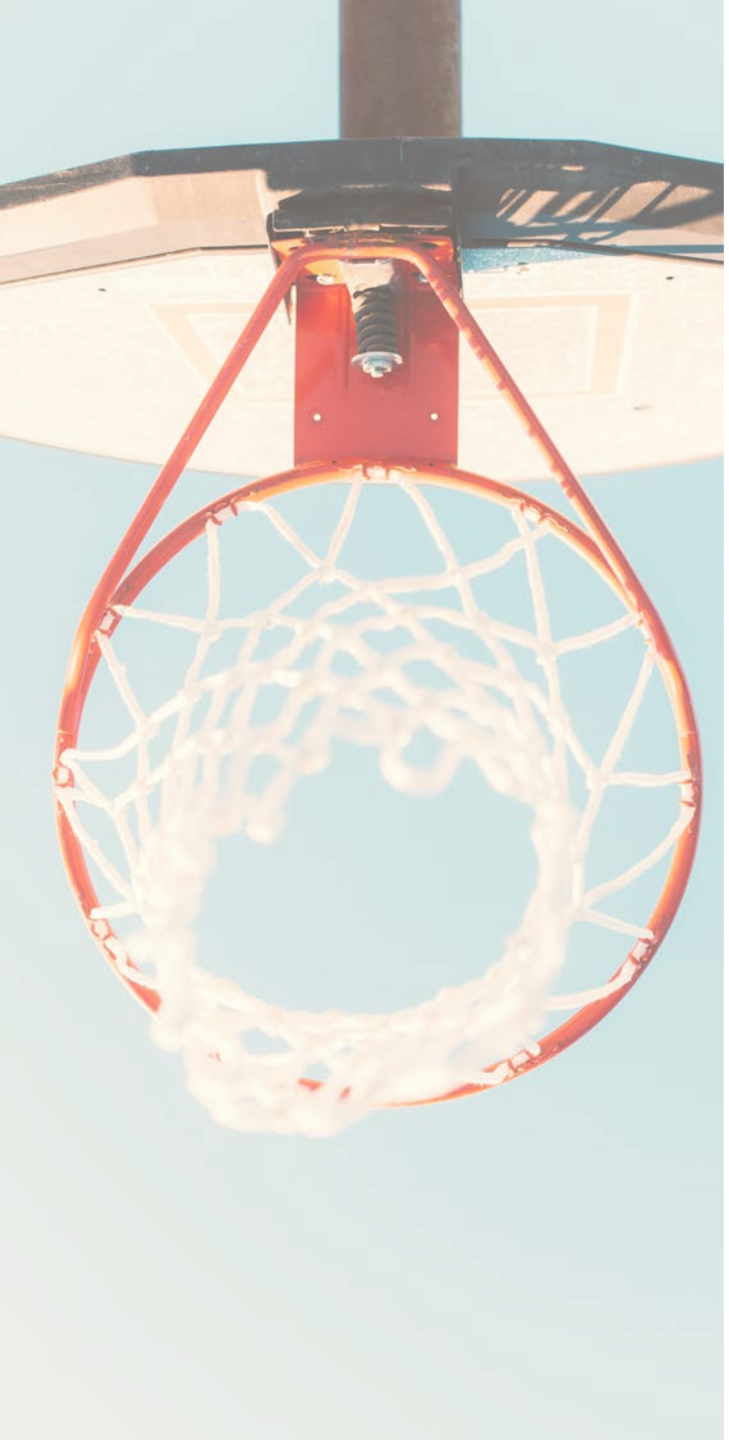

THE EXECUTIVE SUMMARY

- The aim of this joint project was to create a user-friendly linked data application. The application exhibits the integration of the Wallscope Platform and expertise, with RDFox, a knowledge graph and semantic reasoning engine.
- The platform combines three data sources: an Olympic dataset in RDF triples, a tabular dataset and unstructured data in the form of 30,000 Reddit posts. Using unstructured data remains an issue for many businesses, thus this project is indicative of real business challenges.
- To create the application the data was linked, the knowledge graph was restructured, and entities were added, using semantic reasoning. The application's dashboards were then populated with information from the linked data knowledge graph using SPARQL queries. Semantic reasoning simplified this process as the hierarchical system of rules used meant shorter and less complex queries were required.
- The application can operate in real-time; as the user navigates through the platform the dashboard's charts are populated. Additionally, as new information from future Olympic games is generated, the dashboards will be updated with the new information, a result of RDFox's incremental reasoning capabilities.
- Looking forward, Wallscope's experience in designing easy to use and intuitive interfaces for exploring and presenting data, combined with RDFox's features, offers a unique application ahead of future Olympic games and for other linked data applications, including those which require incremental updates.

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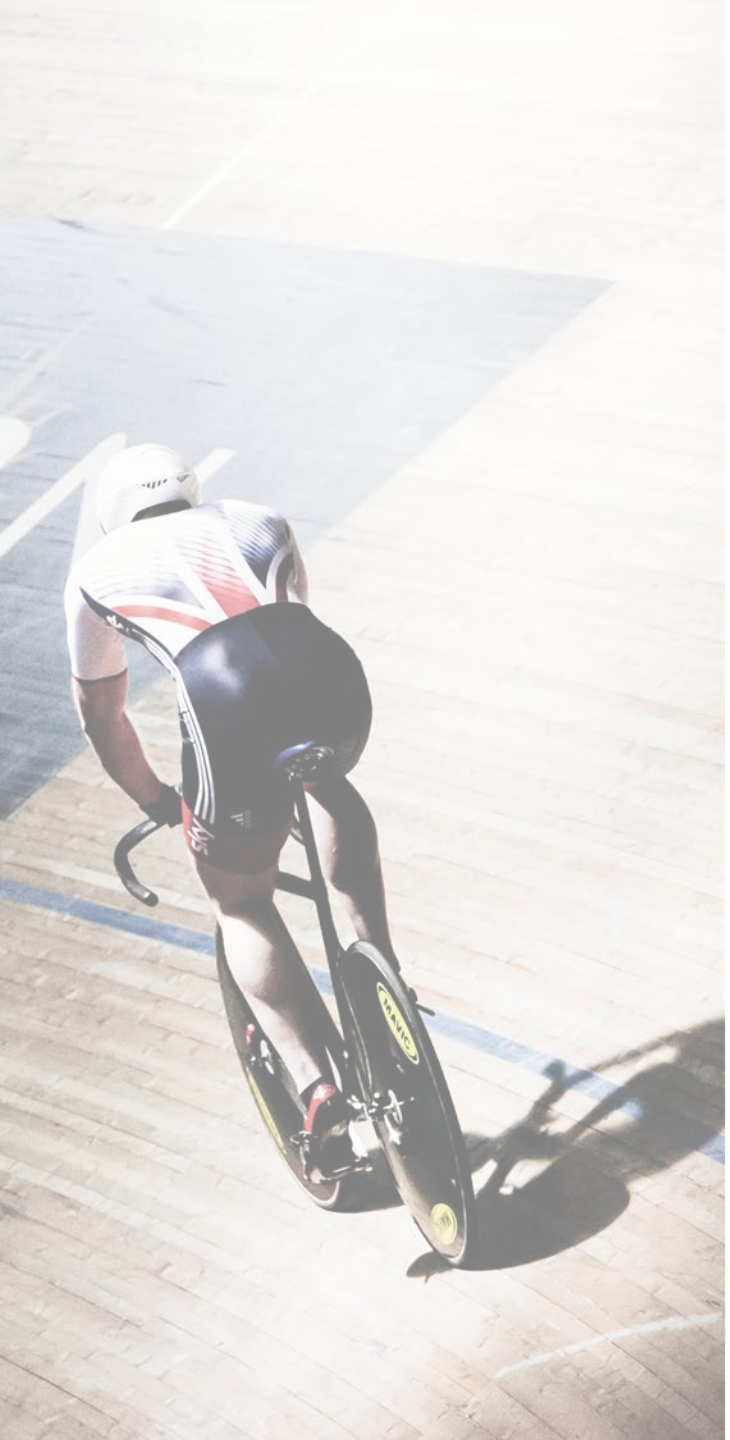


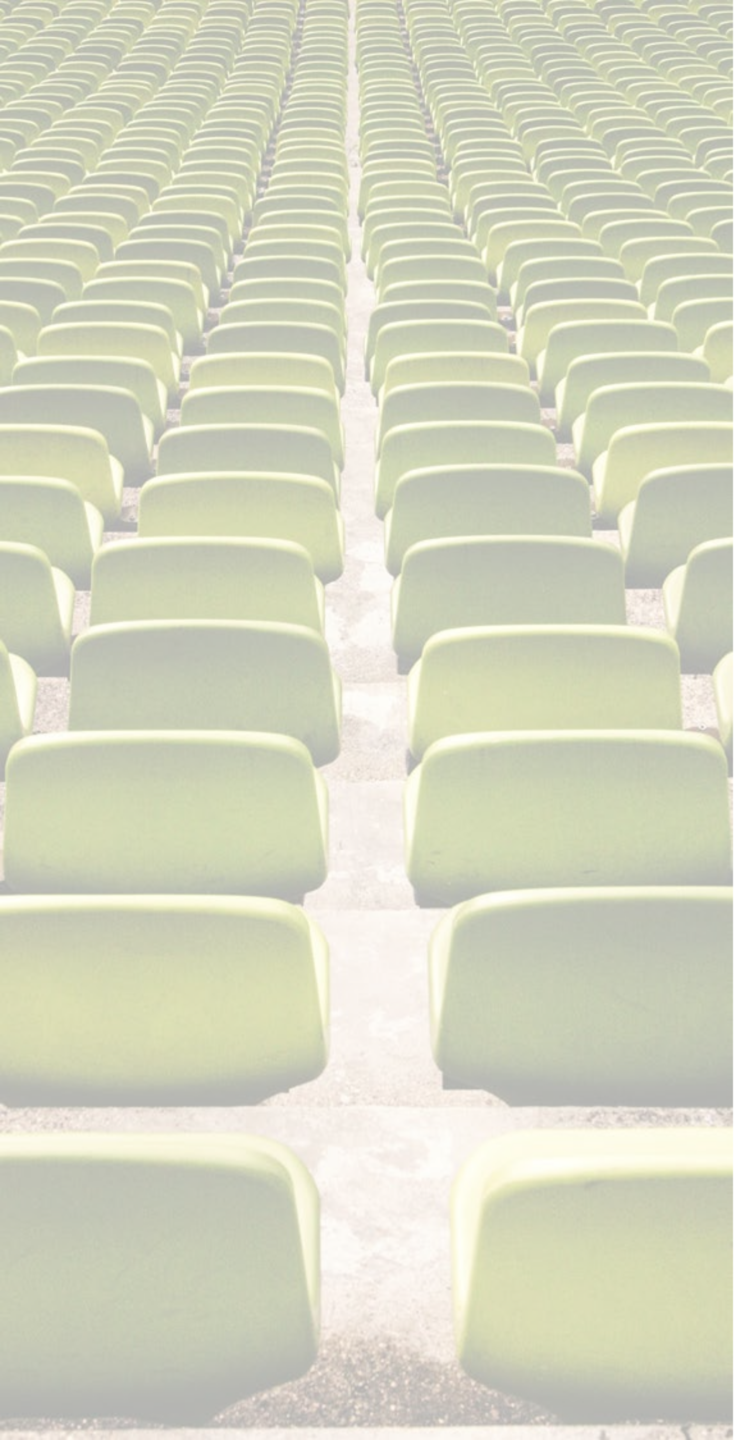
INTRODUCTION

Data management and integration can be a challenge for organisations. Large amounts of data is stored in various formats; for example, documents, financial transactions, social media mentions, staff payroll updates and website traffic tracking data.

Handling all of this data **in real-time** and assimilating it with existing information is a challenge for businesses of every size. Efficiently utilising this unified data in real-time can help businesses across a wide range of industries. For example, it could help the public sector control budget cuts, large businesses retain their staff, and small businesses survive.

Effective linked data applications are a necessity. To demonstrate how this can be achieved, Wallscope and Oxford Semantic Technologies have created an Olympics linked data application. This is done using the Wallscope triplestore agnostic platform and RDFox, a knowledge graph and semantic reasoning engine.

The application is comprised of three dashboard types - athlete, sport and continent view - each of which operate in real-time and will continue to run during the (postponed) Tokyo Olympics.



THE DATA

To imitate the disparity in data sources within organisations, this solution brings together three different data sources. These are:

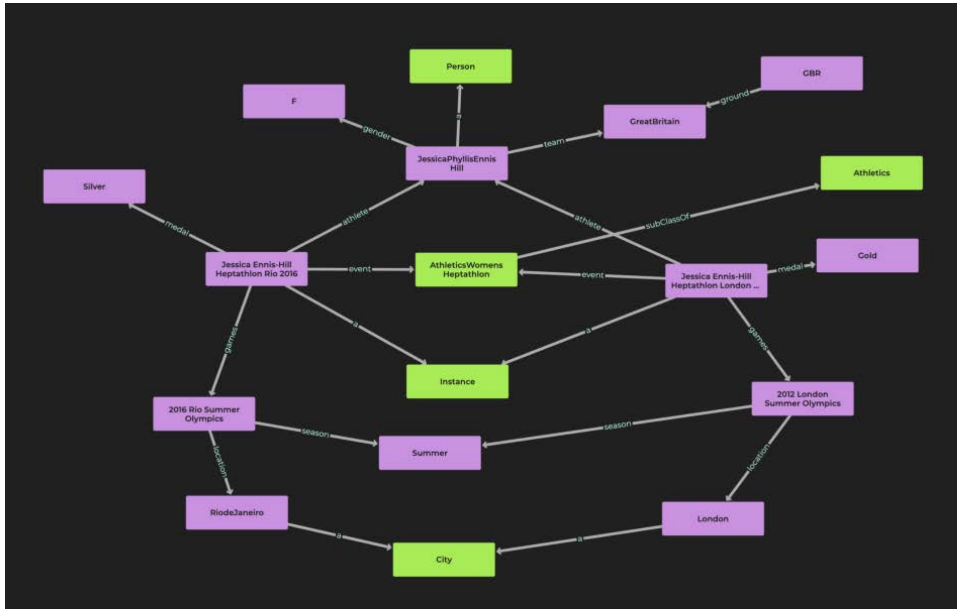
1. **A knowledge graph** about the Olympics (containing 1.8 million triples) created for a tutorial and therefore requiring some refactoring.[1]
2. **A small tabular dataset** that was transformed into linked data.
3. **30,000 Reddit submissions** from the 2012 till the 2018 Olympic games. This is unstructured textual data.

1. Knowledge Graph

The Olympics Knowledge Graph was created for a previous project which explained how to create a knowledge graph from a tabular dataset using OpenRefine.[2] This was originally made using a csv file sourced from Kaggle titled "120 Years of Olympic History".[3] The RDF triples are accessible on Github.[4]

The knowledge graph contains athletes, their attributes including: height, weight, age, sex and team. It also contains the medals they won, including the sport, games and the year they won them. Each team was attached to their National Olympic Committee (NOC) code.[5]

For example, the following image represents the gold medal won by Jessica Ennis-Hill at the London 2012 Olympic games.



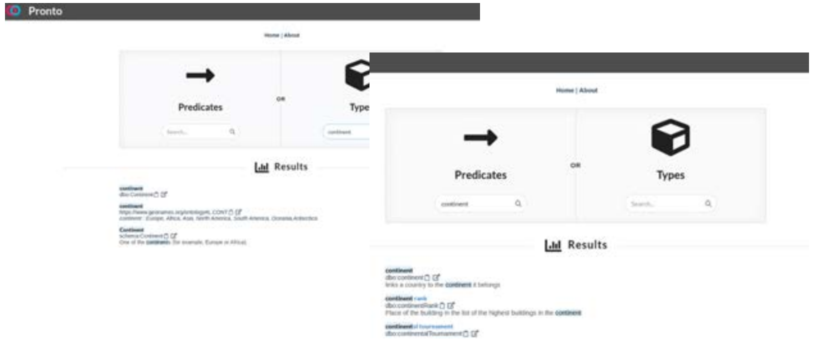
All of these nodes represent entities which have labels and types attached. In some cases (athletes for example), nodes are also attached to literals that are not displayed here.

THE DATA

2. Small Tabular Dataset

The small tabular dataset contained a list of National Olympic Committees (NOC) next to their relevant continents. For transcontinental countries (those with land in more than one continent), the continent in which the majority of their land belongs was chosen. This was transformed into triples using a small script.

To link the NOC to its appropriate continental entity, dbo:continent is used. Next, to indicate that the entity represents a continent, schema:Continent was used as each continent entity's type.



These were found using Wallscope's Pronto tool, which is free and open-source.[6] To give an example, here is Portugal (NOC is "POR") in turtle format:

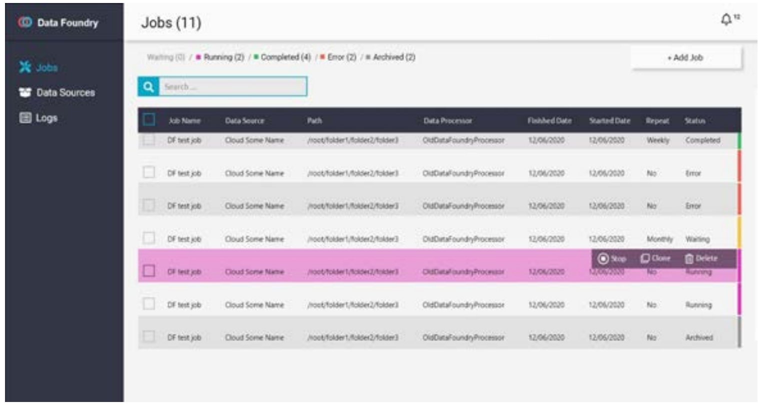
```
@prefix noc: <http://wallscope.co.uk/resource/olympics/NOC/> .
@prefix dbo: <http://dbpedia.org/ontology/> .
@prefix dbr: <http://dbpedia.org/resource/> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix schema: <https://schema.org/> .

noc:POR dbo:continent dbr:Europe .
dbr:Europe a schema:Continent ;
  rdfs:label "Europe"@en .
```

3. Reddit

In order to represent a major challenge that businesses face, this solution includes unstructured text. To do this, Reddit submissions during previous Olympic games (namely: London 2012, Sochi 2014, Rio 2016, and PyeongChang 2018) were downloaded. They were then filtered for relevance, to produce a dataset of 30,000 submissions.

The submissions were then processed using Wallscope's Data Foundry to extract relevant entities, before being transformed into a knowledge graph and mapped to their counterparts in the initial knowledge graph. Data Foundry reads through each Reddit submission and extracts any information that it deems relevant.

The enhanced knowledge graph can then be queried for Reddit submissions relevant to a specific athlete, sport, country and continent.



SEMANTIC REASONING

1. Semantic Reasoning

Semantic Reasoning is the ability to make logical deductions from the information that is explicitly available. In RDFox this is done using rules written in Datalog - a rule language for knowledge representation. Rule languages have been in use since the 1980s in the fields of data management and artificial intelligence. A Datalog rule is a logical implication, where both the "if" part of the implication (the rule body) and the "then" part of the implication (the rule head) consist of a conjunction of conditions. In the context of RDF, a Datalog rule conveys the idea that, from certain combinations of triples in the input RDF graph, we can logically deduce that some other triples must also be part of the graph.

2. RDFox

RDFox is a semantic reasoning engine. It can logically derive new data that follows from the data that is explicitly given and an ontology (given, e.g. as a set of rules or OWL 2 axioms). The knowledge graph containing the three linked data sources was created and stored in RDFox.

Using RDFox has numerous benefits over other knowledge graph solutions. This includes its impressive reasoning capabilities, which can operate incrementally, improving the applications functionality and performance. Similarly, RDFox's speed and accuracy provides additional benefits.[7] Wallscope have optimised the user interface to complement RDFox's capabilities and to ensure it can handle complex calculations, aggregations and queries.

3. Example application

Queries are requests for information to the database made by the user. There are infinite examples of heavy queries over large graphs. For example, if a business had years of financial transactions of varying types (materials, payroll, insurance, etc…) to process and the staff often require a condensed overview of this information - they may request a summary of all material purchases. To achieve this, a lengthy query has to run through all material transactions and run several aggregations to return a full and accurate report. With incremental reasoning capabilities, these calculations can run **as material transactions take place** and integrate this new information into the knowledge graph. As a result, the team can output this report in an instant, making decisions faster, and freeing valuable time.

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USING SEMANTIC REASONING

1. Restructuring the graph

The graph can be restructured using rules. For example, to link an athlete to the games they participated in, the following rule can be used. wso represents: <http://wallscope.co.uk/ontology/Olympics/>

```
[?athlete, wso:athleteInGames, ?games]
:-
[?instance, wso:athlete, ?athlete],
[?instance, wso:games, ?games].
```

When an instance links to both an athlete and an Olympic games (in the original graph), it can be deduced that the athlete in question took part in those games.

The original dataset contained the athletes age when they won a medal. If an athlete won multiple medals, over various years, the dataset contains multiple ages for the athlete. The athletes birth year can be calculated and stored within the graph using rules so that the athletes age during future games is stored within the graph. To do this, the minimum age in the graph for each athlete is determined, and then attached to each athlete:

```
[?ath, wso:minAge, ?min]
:-
AGGREGATE(
  [?ath, foaf:age, ?age]
  ON ?ath BIND MIN(?age) AS ?min ) .
```

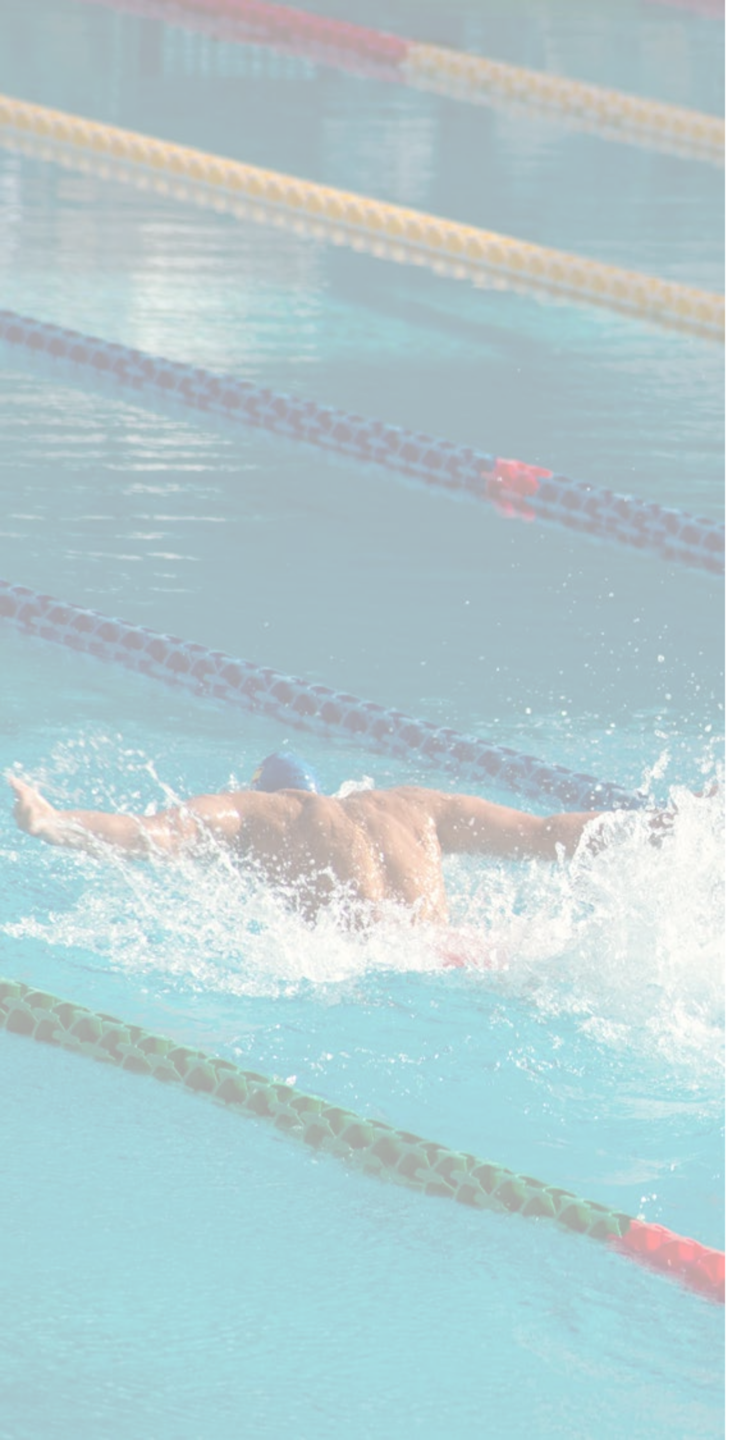
Next, the earliest year that an athlete won a medal is determined and attached to the athlete:

```
[?ath, wso:earliestYear, ?min]
:-
AGGREGATE(
  [?ath, wso:athleteInGames, ?g],
  [?g, dbp:year, ?y]
  ON ?ath BIND MIN(?y) AS ?min ) .
```

To calculate the birth year, the earliest year that an athlete won a medal and their age at the time are used as follows:

```
[?ath, wso:birthYear, ?by]
:-
[?ath, wso:earliestYear, ?ey],
[?ath, wso:minAge, ?age],
BIND(?ey - ?age AS ?by) .
```

The following section provides examples of rules for creating entities within the knowledge graph. The rules used in this application form a hierarchy. This allows information to be efficiently updated at all relevant levels as data is received. Other rules are also used in this application which are not included in this white paper.



USING SEMANTIC REASONING

2. **Designing new entities**

The following rule creates Participation (?part) entities which are similar to instances in the original graph but less convoluted for further extensions and rule building.

```
[?part, a, wso:Participation],
[?part, wso:hasAthlete, ?ath],
[?part, wso:hasGames, ?g],
[?part, wso:hasYear, ?y],
[?part, wso:hasAthleteAge, ?age],
[?part, wso:hasCountry, ?ctry]
:-
[?ath, wso:athleteInGames, ?g],
[?ath, wso:birthYear, ?by],
[?ath, wso:hasCountry, ?ctry],
[?ath, foaf:age, ?age],
[?g, dbp:year, ?y],
FILTER( ?age + ?by = ?y),
BIND(IRI( CONCAT(STR(wsr:), "participation/",
  REPLACE(STR(?ath), STR(wsr:),""), "_",
  REPLACE(STR(?g), STR(wsr:),""))) AS ?part ) .
```

To illustrate an extension to this participation entity, the number of medals an athlete wins can be linked to their participation at an Olympic games:

```
[?part, wso:medalsAtGames, ?ct]
:-
AGGREGATE(
  [?part, wso:hasInstance, ?inst],
  [?inst, wso:medal, ?med]
  ON ?part
  BIND COUNT(?med) AS ?ct ) .
```

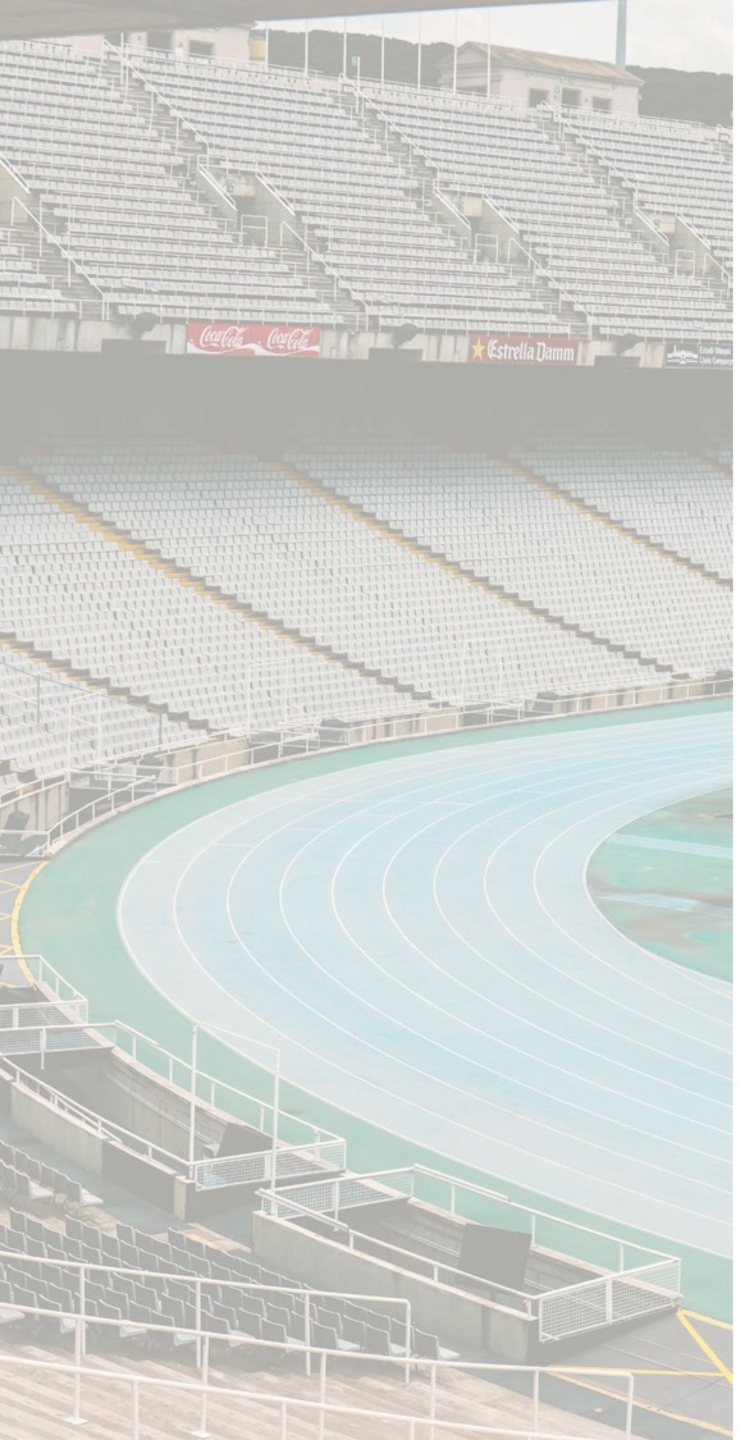
To illustrate the development of further rules using participation entities, an athlete can be linked to the total number of medals they have ever won at the Olympics:

```
[?ath, wso:totalMedalCount, ?mc]
:-
AGGREGATE(
  [?part, wso:hasAthlete, ?ath],
  [?part, wso:medalsAtGames, ?meds]
  ON ?ath
  BIND SUM(?meds) AS ?mc
) .

[?ath, wso:totalMedalCount, 0]
:-
[?ath, a, foaf:Person],
NOT EXIST ?meds, ?part IN (
  [?part, wso:hasAthlete, ?ath],
  [?part, wso:medalsAtGames, ?meds] ) .
```

Athletes are either connected to their wso:totalMedalCount (if they have won a medal), or to a wso:totalMedalCount of zero (if they have not ever won a medal). Developing this even further, the birth years calculated earlier can be linked to the average wso:totalMedalCount of all athletes born in that year:

```
[?year, wso:yearHasAverageMedals, ?avg]
:-
AGGREGATE(
  [?ath, wso:birthYear, ?year],
  [?ath, wso:totalMedalCount, ?tot]
  ON ?year BIND AVG(?tot) AS ?avg
) .
```

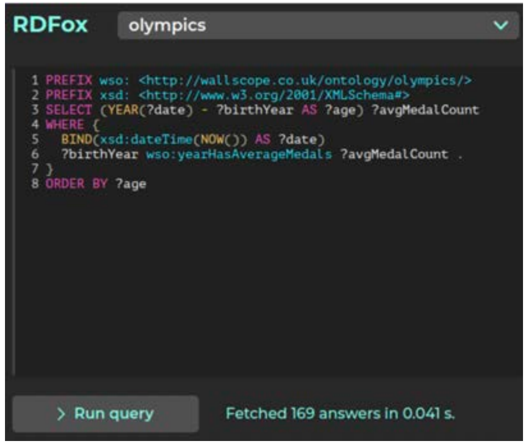


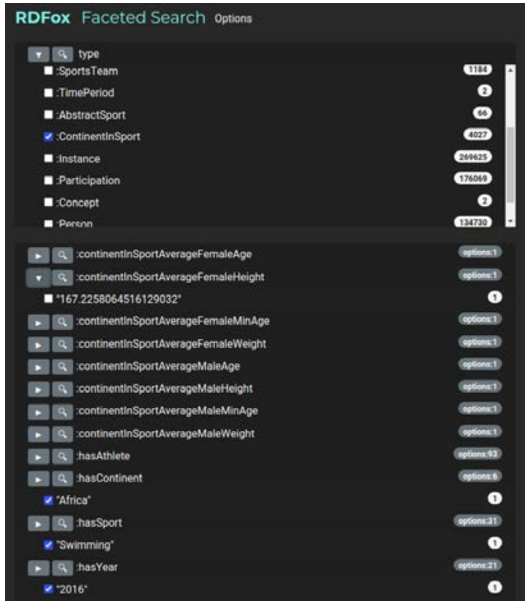
QUERYING THE KNOWLEDGE GRAPH

1. Populating the user interface - Athlete view

The next step is to populate the charts on the application's dashboard. This is done with SPARQL queries.

On the 'athlete view' there is a histogram which displays the average number of medals athlete's have won, bucketed by athlete's age. The athlete birth year rule simplifies the query significantly, to the following:





For the parallel coordinates plot, a slightly larger query is needed using some of the additional rules.[8] These rules form another hierarchy which aggregates athlete statistics by sex, sport, continent, and year. This design allows the more dynamic charts to be populated very quickly, as the dropdown options are used.

The following query calculates and returns the global average weight, height, and age of all Olympic athletes recorded. By switching the ?continent or ?sportvariables to a fixed entity (see in query comments), more specific aggregates are returned to the user. Sex can be easily aggregated within the query, so this is not done with rules.

```
PREFIX wso: <http://wallscope.co.uk/ontology/olympics/>
PREFIX wSport: <http://wallscope.co.uk/resource/olympics/sport/>
PREFIX dbr: <http://dbpedia.org/resource/>

SELECT
  (((AVG(?mWeight) + AVG(?fWeight))/2) AS ?avgWeight)
  (((AVG(?mHeight) + AVG(?fHeight))/2) AS ?avgHeight)
  (((AVG(?mAge) + AVG(?fAge))/2) AS ?avgAge)

WHERE {
  ?cis wso:continentInSportAverageMaleWeight ?mWeight ;
       wso:continentInSportAverageMaleHeight ?mHeight ;
       wso:continentInSportAverageMaleAge ?mAge ;
       wso:continentInSportAverageFemaleWeight ?fWeight ;
       wso:continentInSportAverageFemaleHeight ?fHeight ;
       wso:continentInSportAverageFemaleAge ?fAge ;
       wso:hasContinent ?continent ;
       wso:hasSport ?sport .

  # When user selects "Africa", ?continent is set to dbr:Africa.
  # When user selects "Swimming", ?sport is set to wSport:Swimming.
}
```

QUERYING THE KNOWLEDGE GRAPH

2. Populating the user interface – Sport view

In the 'sport' view, the top athletes are reported, ordered by total medal count. The rule which attaches athletes directly to the number of Olympic medals they have won in their career is helpful here. This can be used to calculate top athletes, such as, the best male swimmers:

RDFox olympics

```
PREFIX wso: <http://wallscope.co.uk/ontology/olympics/>
PREFIX wSex: <http://wallscope.co.uk/resource/olympics/gender/>
PREFIX wSport: <http://wallscope.co.uk/resource/olympics/sport/>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

SELECT DISTINCT ?name ?mc
WHERE {
  ?instance wso:event ?event ;
            wso:athlete ?athlete .

  ?event rdfs:subClassOf wSport:Swimming . # Swimming for example.

  ?athlete foaf:gender wSex:M ; # Switch "M" to "F" for female.
           wso:totalMedalCount ?mc ;
           rdfs:label ?name .
}
ORDER BY DESC(?mc)
LIMIT 5
```

> Run query   Fetched 5 answers in 0.121 s.

name	mc
Michael Fred Phelps, II	28
Aleksandr Vladimirovich Popov	11
Matthew Nicholas "Matt" Biondi	11
Mark Andrew Spitz	11
Gary Wayne Hall, Jr.	10

3. Populating the user interface – News

Wallscope's platform was used to process the 30,000 Reddit posts and create a knowledge graph of the submissions and their content. This was then mapped to the core knowledge graph, so that related 'news' could be retrieved.

To demonstrate the speed of RDFox, each time you open a page of the demonstration a series of queries are run which populate the news column. The first query returns all of the Reddit submissions that match a given text, for example, all submissions which mention **Michael Phelps**.

Next, a query retrieves all other information related to Michael Phelps from the dataset, before the final query filters the submissions (for relevance, e.g. athletes, sports, continents) and maps the related entities to the core knowledge graph.

The result is that when the page for Michael Phelps opens, the news column quickly displays submissions relating him to swimming.

August 2016
"Michael Phelps Wins Gold in Men's Swimming 200M Butterfly | Olympics 201...\n"

Michael Fred Phelps, II   Swimming

HICCUP

To allow public data access without compromising security, Wallscope's Platform provides a data access management layer called HiCCUP, that allows fine grained control over the data that can be accessed within the knowledge graph. The knowledge graph is available as an API that can be consumed from different applications. Wallscope is preparing HiCCUP for external release. The following sections provide information on HiCCUP.

1. Why HiCCUP?

HiCCUP (Highly Componentised Connection Unification Platform) was built out of frustration over the lack of tools which support Linked Data scientists. Since Wallscope's inception, work with Linked Data and RDF has involved repetitive tasks across projects. As a result, the Wallscope team have turned these tedious tasks into a software package which aids the development of Linked Data applications internally.

2. What does HiCCUP do?

HiCCUP processes data as a pipeline. Currently it accepts raw text, files or RDF data as inputs. It operates over HTTP and allows the configuration of routine Linked Data conversion and expansion tasks, and dynamically generates a REST API endpoint. The pipeline is created through the configuration and ordering of components (plugins).

For example, a plugin allows us to send a SPARQL query to an RDF triplestore. This can be as simple as:

- Given an input triple: *dbr:Bob_Marley rdf:type foaf:Person* . Query DBPedia and return more information about this person

HiCCUP can be configured to grab the subject of the RDF triple and substitute a variable in a SPARQL query, and then configure triple patterns that each component should match. Essentially, the endpoint can react to the triples in the following format: *?s rdf:type foaf:Person*

Extra components can be added into the pipeline, such as: *?s rdf:type dbo:Musician* and return the Musicians instrument.

In theory this can be done through a single SPARQL query. However, through Wallscope's experience it can be a lot faster, especially when communicating with remote endpoints, to send multiple queries. Additionally, if a caching layer is introduced, some of these queries may never even hit the remote triplestore.

There are also more complex use cases, such as the recent addition of a JSON API adapter. One can query JSON API's and through configuration, transform the response object into RDF triples. Using the Bob Marley example, one could query his birthplace and from that connect to a weather API to get the real-time weather in Jamaica.

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HICCUP

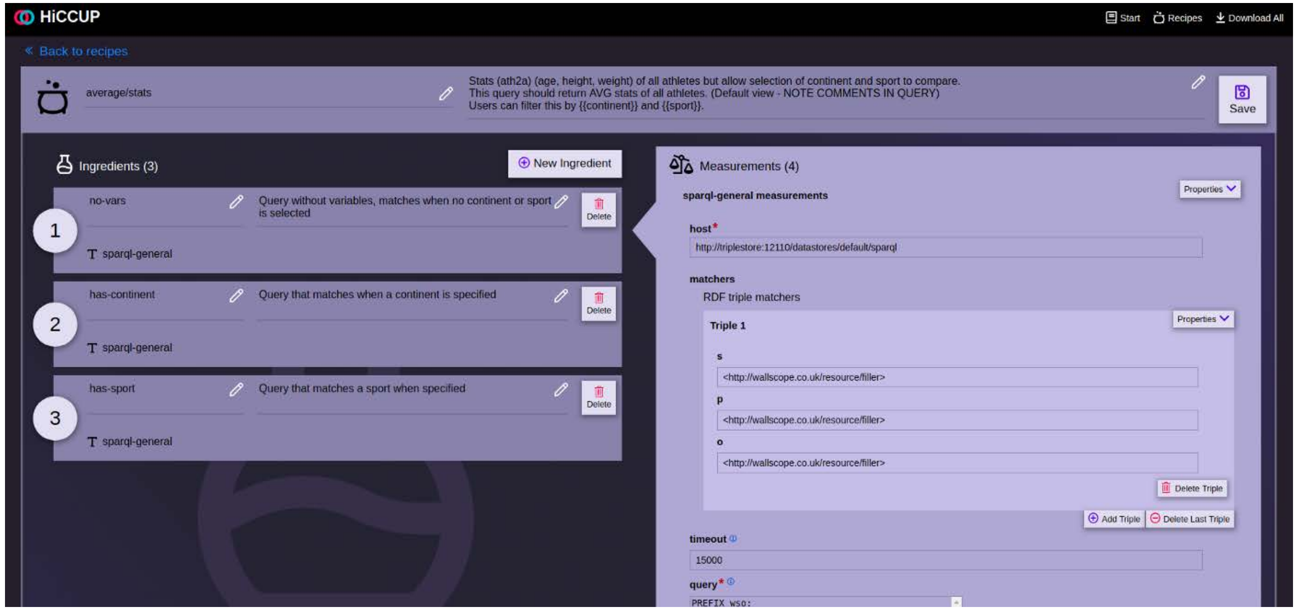
3. HiCCUP for the Olympics

Specifically in the context of the Olympics joint solution, HiCCUP turns a set of variable templated queries into a REST API, which provides the benefits of:

- Preventing the SPARQL endpoint from being publicly available
- Making the queries cacheable
- Removing the need to write a custom backend with the business logic, since HiCCUP handles all the queries and provides an endpoint and even methods for filtering

4. Other use cases

Wallscope have used HiCCUP as the RDF "glue" across the majority of their projects. Especially since the introduction of the JSON adapter, this layer of compatibility enables Wallscope to use data tools that were not specifically built for Linked Data and which are not accustomed to RDF. An additional benefit is the usability by those who are unaccustomed to RDF. For example, machine learning engineers produce a model that can be used in production through a JSON API and use the HiCCUP adapter.

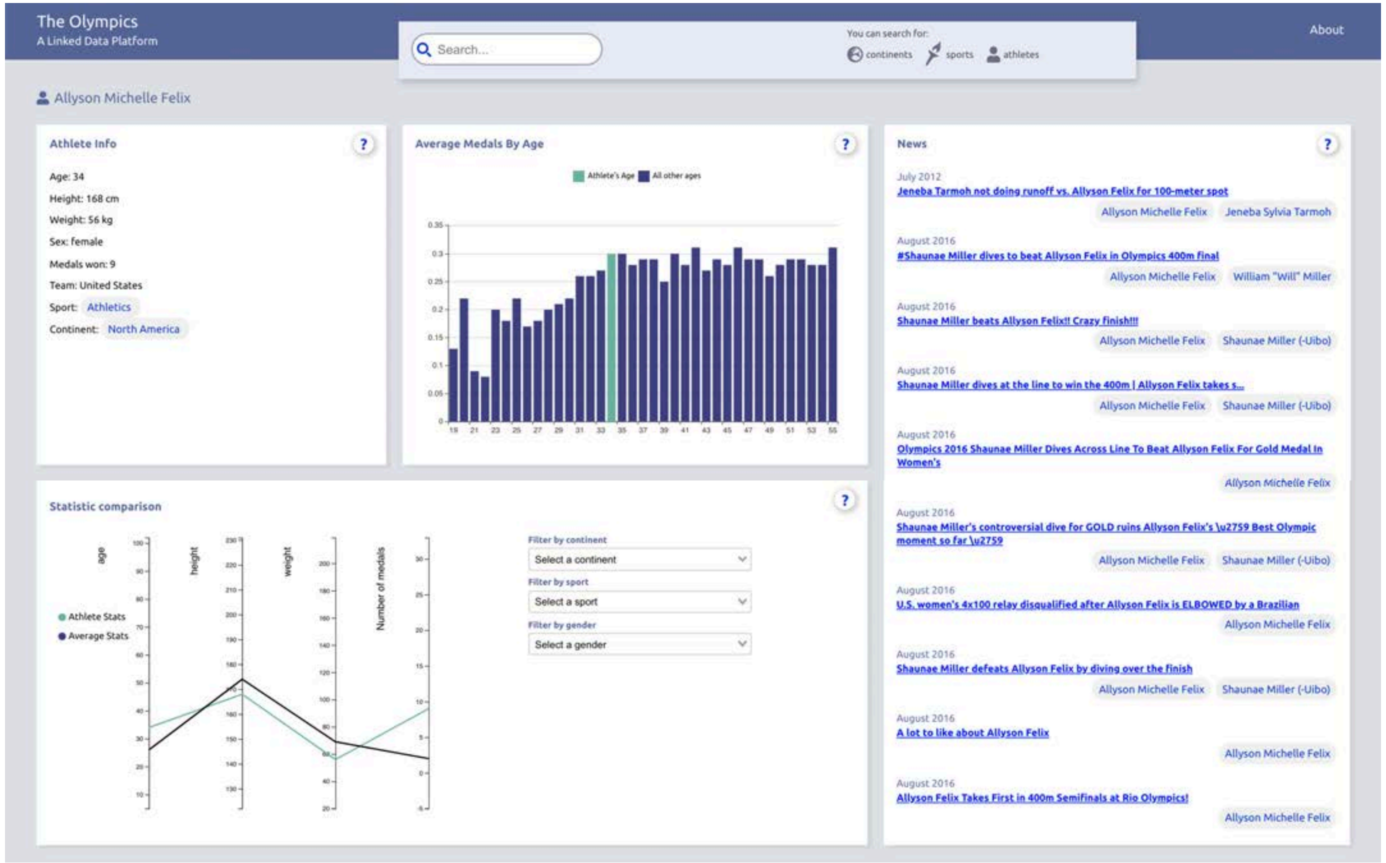


THE DASHBOARD

The dashboard was created by the Wallscope team and has three views – athlete, sport and continent. There is a link to the live demonstration on page 22.

To demonstrate the speed of the application, the results are not cached. This means that as the user roams through the interface all updates and charts are populated at runtime and as the user filters.

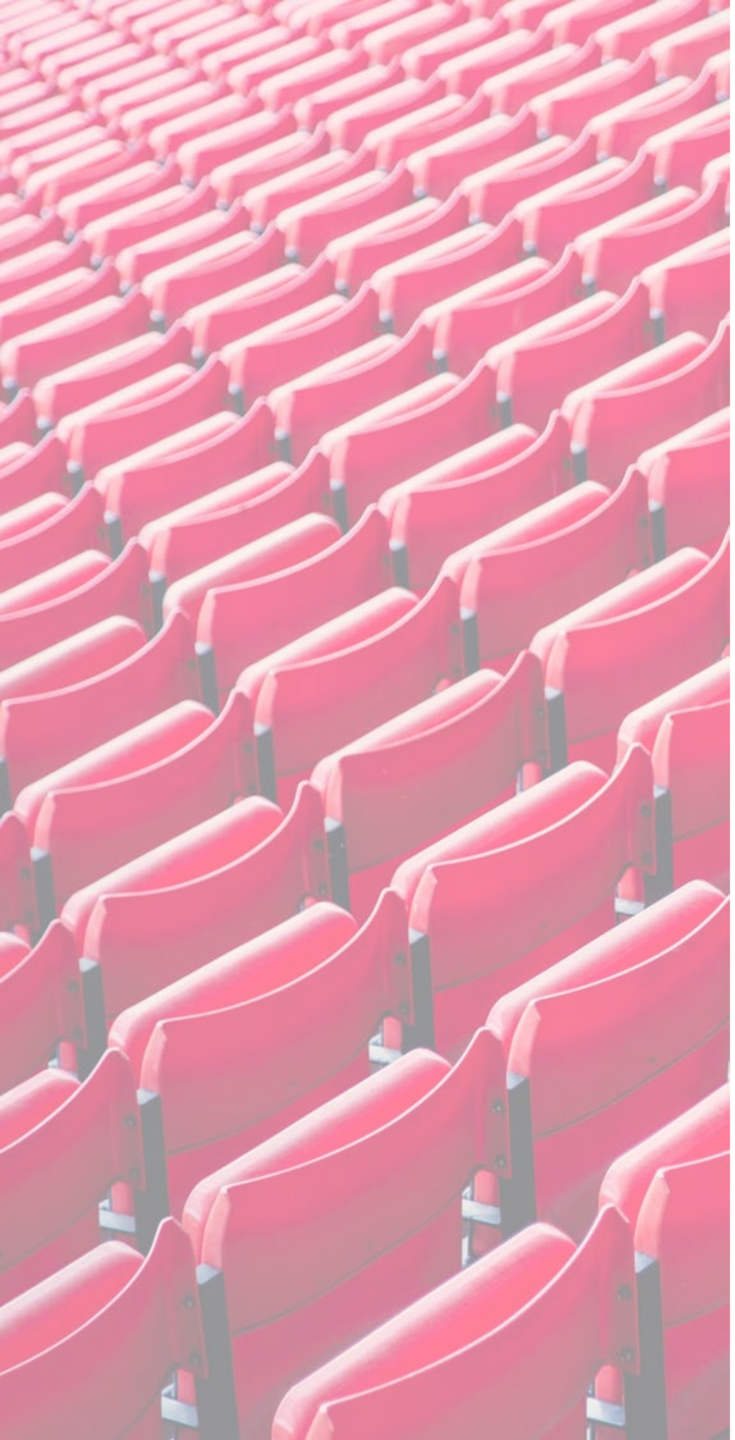
There are info buttons (?) explaining what is being shown and what is happening behind the scenes.



1. **Athlete View**

The athlete view contains information on the athlete, personalised charts, and related Reddit posts. By clicking on ‘Gymnastics’ or ‘North America’ in the ‘Athlete info’ box, the user can navigate to the sport or continent view.

The ‘statistical comparison’ parallel coordinates plot allows the current athlete to be compared to the average Olympian. For example, one could compare Allyson Michelle Felix with Male Basketball players from Oceania.



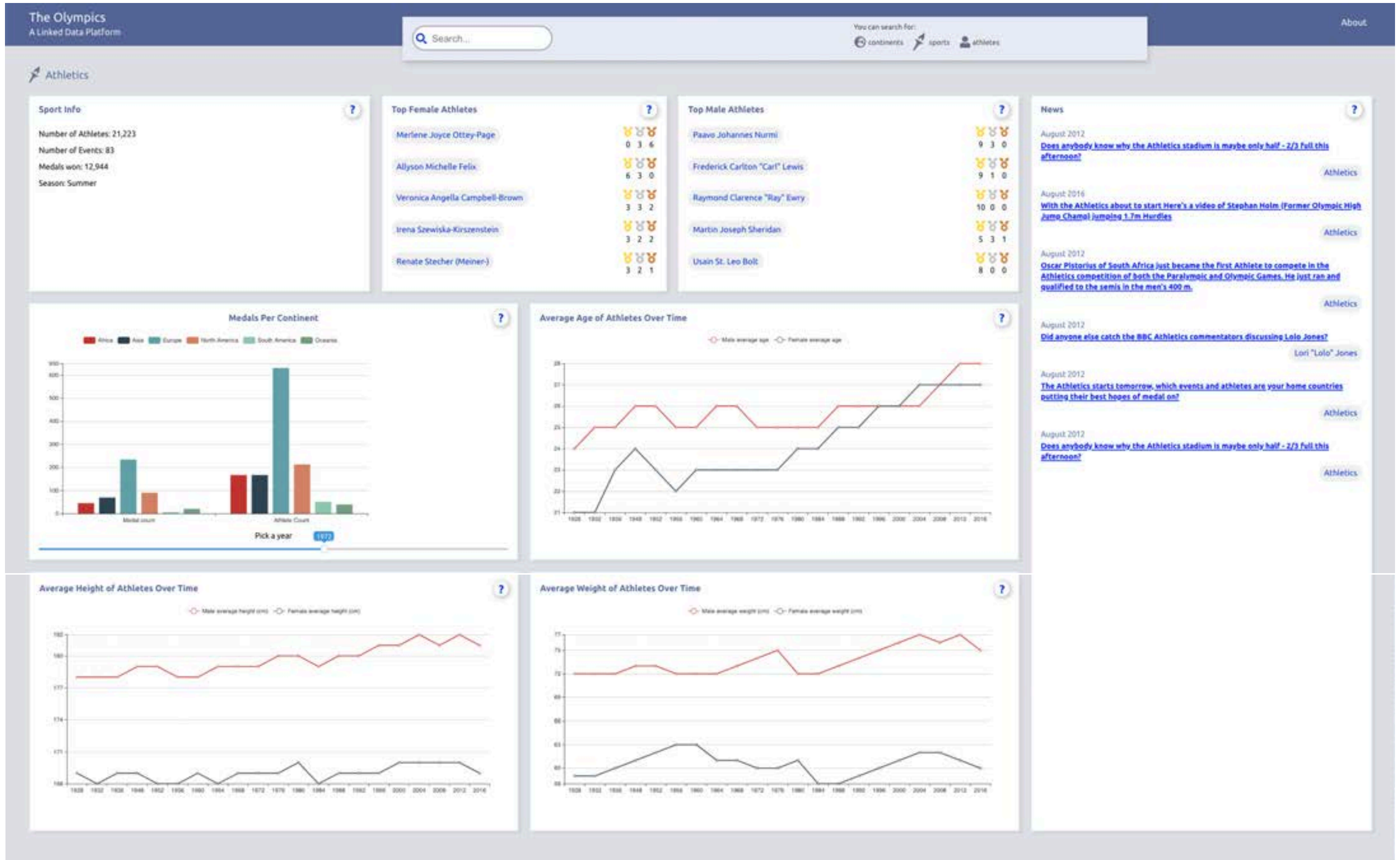
THE DASHBOARD

2. Sport View

The sport view contains information on the average height, weight and age of athletes competing in a specific sport.

There is a '*medals per continent*' chart which is populated by the year 'slider' and a list of the top athletes by medal counts for the selected sport.

Each dashboard has a news view which is populated at runtime with the most relevant Reddit posts associated with the sport in question. By clicking on the title, the original Reddit post can be opened.

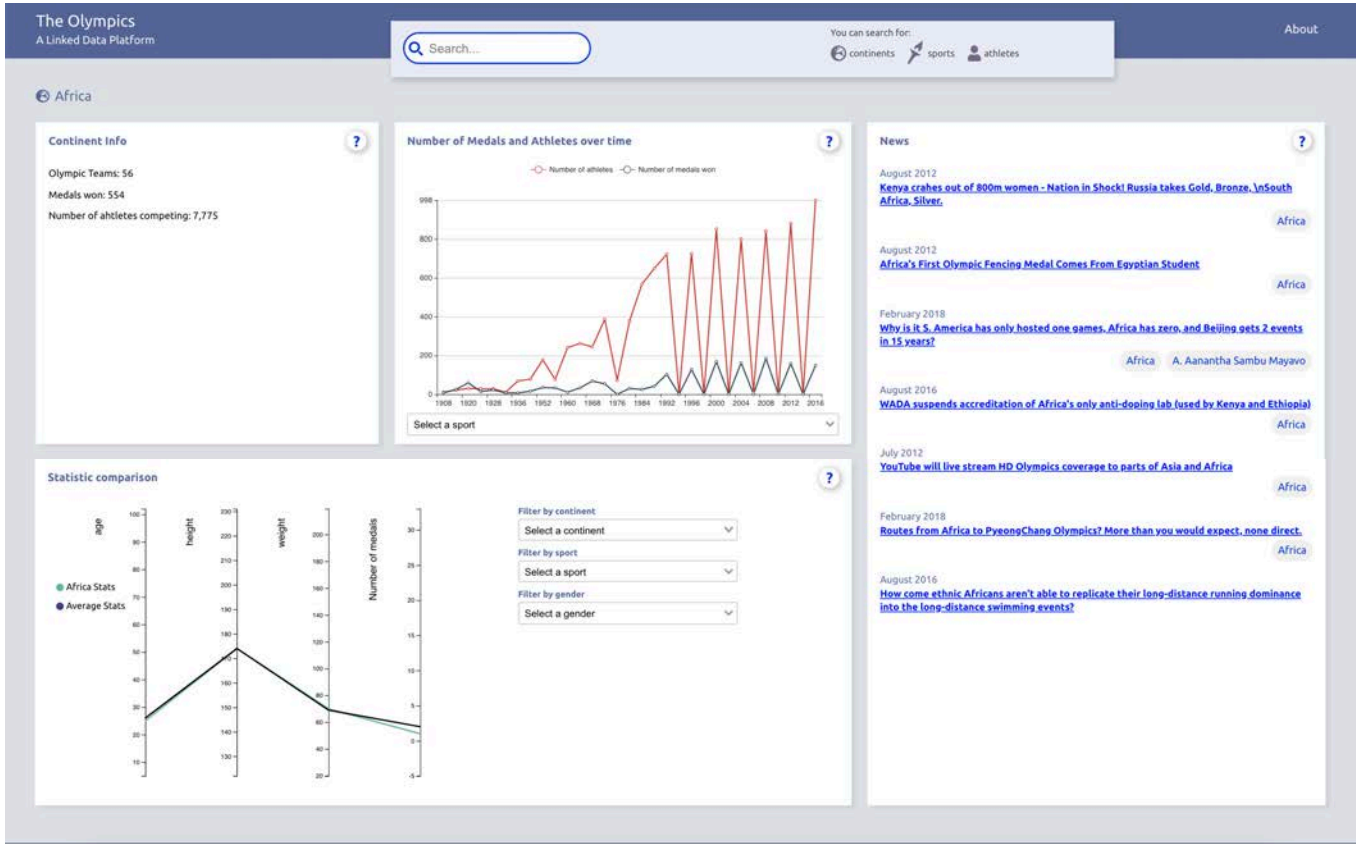


THE DASHBOARD

3. Continent View

Similarly to the other views, the continent view contains information on each continent in general, a ‘*statistical comparison*’, and a ‘*news*’ panel.

This example shows Africa. The sharp peaks and troughs in the diagram for ‘*number of meals and athletes over time*’ is due to the two different types of games. The summer and winter Olympics occur every four years but are staggered, alternating every two years (summer in 2012, winter in 2014). African athletes rarely compete at the winter Olympics (5 at Sochi 2014), hence the vastly different numbers of athletes every two years.



USING THE DASHBOARD FOR ANALYSIS

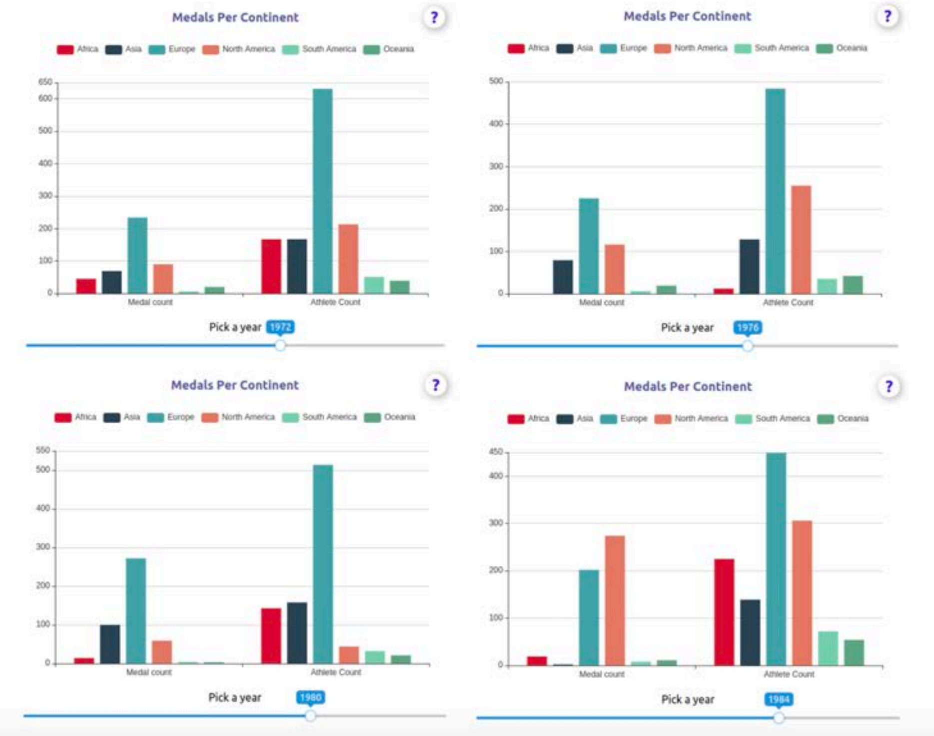
During the development of this application an anomaly was identified in the '*medals per continent*' between 1972 and 1984.

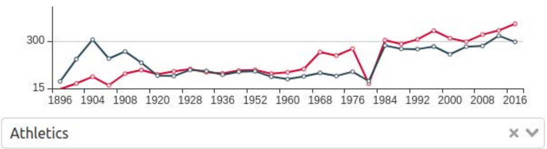
In the 1976 games Africa disappears from the chart, and North America disappears during the 1980 games. Additionally, on the continent view, there is a dip in the number of athletes during these years for both continents reflecting this omittance from the medals per continent chart.

Further research indicates that during the 1976 games, African countries boycotted the Olympics for allowing New Zealand to participate. Since 1964 South Africa had been banned from the Olympics for refusing to condemn apartheid. New Zealand's rugby team's tour of South Africa sparked the boycott.[9]

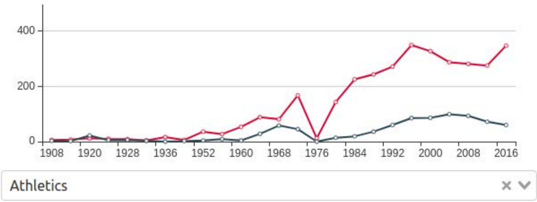
Additionally, the drop in North American athletes at the 1980 games was also due to a boycott. The games were held in Moscow, Russia. The United States boycotted the games in protest of the Soviet invasion of Afghanistan.[10]

This indicates the ability to use linked data applications to identify patterns and anomalies.





North American continent view, number of North American athletes competing in athletics



African continent view, number of African athletes competing in athletics

LOOKING AHEAD

This white paper has demonstrated how Wallscope's platform and RDFox were used to create a real-time, responsive, linked data application. To do this, a user interface was designed and three disparate data sources were enhanced and integrated. Semantic reasoning was used to improve dashboard functionality and performance, and the charts were populated with SPARQL queries.

Integrating and managing large quantities of heterogenous data is a crucial challenge for many organisations. In order to gain insights and business value from their data, organisations need linked data applications for real-time information. Using a linked data application can help uncover unknown relationships between data points or even data anomalies. Effective linked data applications are a necessity for modern businesses.

This application demonstrates the efficient and intuitive pairing of Wallscope's platform and expertise, with RDFox, for the production of linked data applications. By combining technical experience and proficient software, new possibilities for knowledge extraction, semantic reasoning, data sharing and analytics are possible.

For more information on acquiring Wallscope's services or using RDFox, see page 21 for contact details.

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WALLSCOPE

At Wallscope we believe that knowledge should be accessible to all. Our aim is to empower organisations to navigate and link ever-increasing volumes of information, and to present this in an understandable and engaging way.

Wallscope's products and services use semantic web techniques and linked data principles to improve the search and discovery of information. We are committed to using open source technologies and adhering to data standards.

By linking and analysing data across different systems, data stores and file types, our innovative tools allow for collaboration across organisational and technological boundaries.

Wallscope was founded in 2014 by David Eccles and Ian Allaway to exploit the founders' interests in the areas of knowledge extraction, visualisation and communication, through the use of digital tools and the technologies associated with the internet.

Wallscope

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OXFORD SEMANTIC TECHNOLOGIES

Oxford Semantic Technologies develop RDFox, the first market-ready high-performance knowledge graph database designed from the ground up with semantic reasoning in mind.

Oxford Semantic Technologies was founded in 2017 as a spin-out of the University of Oxford with a mission to bring cutting-edge research in semantic web technologies to industry.

The team started working on RDFox in 2011 in the Computer Science Department of the University of Oxford, with the conviction that flexible and high-performance reasoning was a possibility for data extensive applications without jeopardising the correctness of the results.

Patented modern computing techniques underpin RDFox's ability to deliver responses to complex queries on the fly. This has unlocked a new wave of enterprise applications for prestigious partners.

The principal shareholders are the Founders, the University of Oxford, Oxford Sciences Innovation and Samsung Ventures.

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Email: info@oxfordsemantic.tech

Medium: https://medium.com/oxford-semantic-technologies

Twitter: @oxfordsemantic

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LIVE DEMO & SUPPORT MATERIALS

To view the live demonstration and navigate through the dashboards use the following link:

https://wallscope.rdfox.tech/#/athlete/AllysonMichelleFelix

To read the blog visit:

https://medium.com/wallscope/the-olympics-how-to-build-a-linked-data-application-f6f844b3a19c?source=friends_link&sk=0ca1ee3e1396c846e7fef59dcd20410e

Additional Resources by the Authors:

All Articles by Angus Addlesee (Wallscope)
https://medium.com/wallscope/all-articles-by-angus-addlesee-organised-by-topic-updated-9549fa2c5156

All Resources by Oxford Semantic Technologies
https://medium.com/oxford-semantic-technologies/all-articles-by-oxford-semantic-technologies-7b7085c34ef9?source=friends_link&sk=fd4d6f27dadc19277d70e46fffa3b0cb

Semantic Reasoning Resources:

Full documentation of Reasoning in RDFox:
https://docs.oxfordsemantic.tech/reasoning-in-rdfox.html

Datalog Basics and RDFox:
https://medium.com/oxford-semantic-technologies/datalog-basics-and-rdfox-942768327604?source=friends_link&sk=c3e9e83e002e31ea6ba937548e98442d

SPARQL Resources:

Constructing Basic SPARQL queries:
https://medium.com/wallscope/constructing-sparql-queries-ca63b8b9ac02

Construction More Advanced SPARQL Queries
https://medium.com/wallscope/constructing-more-advanced-sparql-queries-72d5ade1eedc

SPARQL Basics and RDFox
https://medium.com/oxford-semantic-technologies/sparql-basics-and-rdfox-684056664e2d

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[7] A Comparison of Linked Data Triplestores: A New Contender https://medium.com/wallscope/comparison-of-linked-data-triplestores-a-new-contender-c62ae04901d3

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[9] African Countries Boycott the Olympics - 1976 http://news.bbc.co.uk/onthisday/hi/dates/stories/july/17/newsid_3555000/3555450.stm

[10] America boycott Russian Olympics - 1980 https://en.wikipedia.org/wiki/1980_Summer_Olympics_boycott

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