

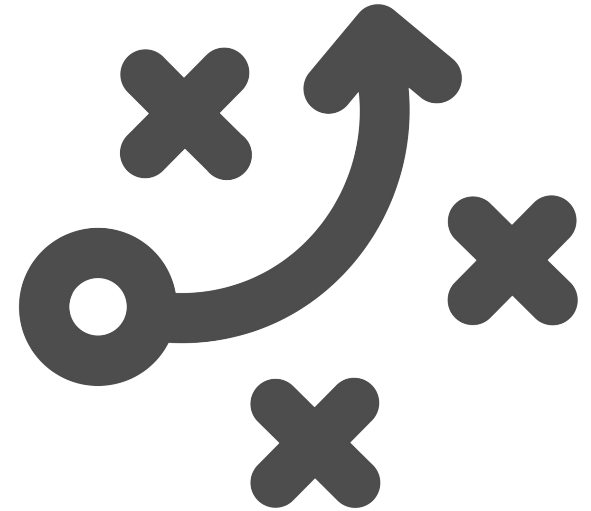
# Project Sustainability and Research Platforms: The Archives Unleashed Project

Nick Ruest (York University)  
Ian Milligan (University of Waterloo)



# Plan for The Talk

- Introduction
- Background
- What we do?
- How much does it cost?
- Discussion



# Background

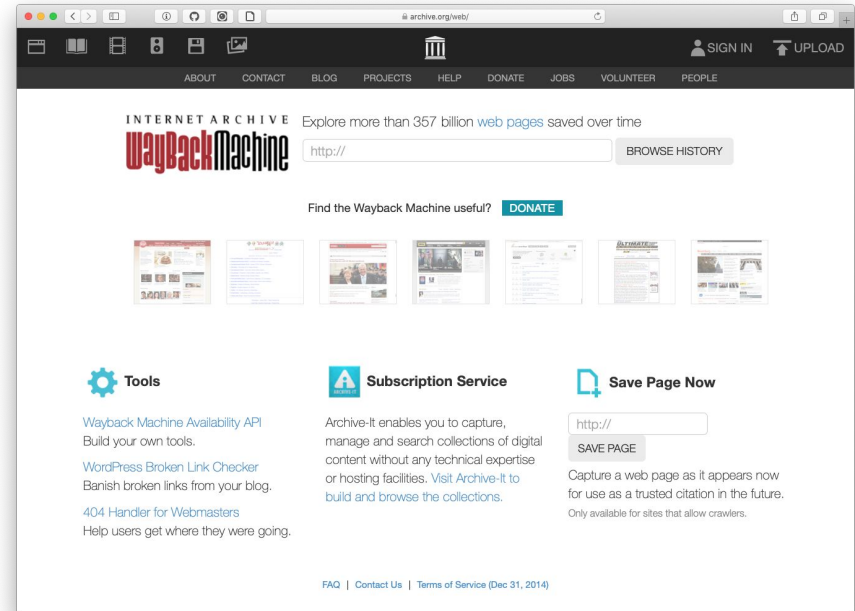


# Why do we care about web archives?

Born-digital sources have the potential to reshape research in the humanities and social sciences;

Research access has lagged (beyond Wayback Machine, analysis ecosystem is mostly command-line-based tools)

As we plan for research access, we need to understand the economics associated with providing this sort of access



# Why do we care about web archives?



# What do we do?



# Archives Unleashed Toolkit

- An open-source platform for analyzing web archives with Apache Spark;
- Scalable
  - Can work on a powerful cluster
  - Can work on a single-node server
  - Can work on a laptop (on MacOS, Linux, or on Windows with a Linux VM)
  - Can work on a Raspberry Pi for all your personal web archiving analysis needs 😊



Using the Toolkit is based on the  
Filter-Analyze-Aggregate-Visualize (FAAV) Cycle

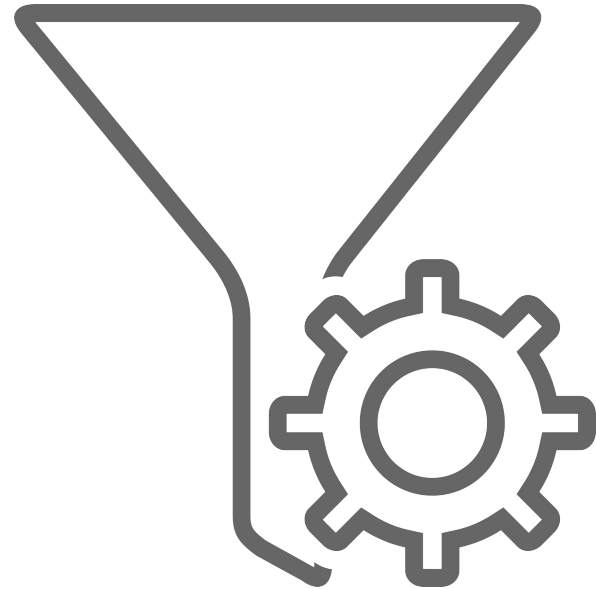




# Filter

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- **Filter down content**
  - Focus on a particular range of crawl dates;
  - Focus on a particular domain;
  - Content-based filter (“global warming”) or those who link to a given site
- Can be nested - i.e. pages from 2012 from liberal.ca that link to conservative.ca and contain the phrase “Keystone XL”



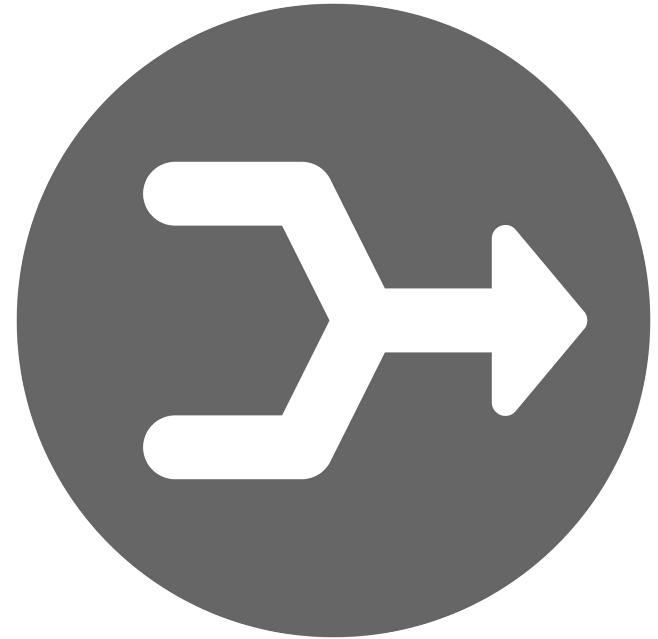
# Analyze

- After filtering, want to perform analysis – extracting information of interest.
- Such as:
  - Links and associated anchor text?
  - Tagging or extracting named entities?
  - Sentiment analysis.
  - Topic modeling.



# Aggregate

- Summarize the output of the analysis from the previous step.
  - Counting
    - How many times is Jack Layton or Barack Obama mentioned?
    - How many links are there from one domain to another?
- Finding maximum (page with most incoming links?)
- Average (average sentiment about “Barack Obama” or “Donald Trump”)



# Visualize

- Output data as a visualization
  - Tables of results
  - External applications (i.e. GEXF files for Gephi)



**Great!**  
**So why doesn't everybody use the Toolkit?!?!**



# Our Cutting Edge Interface

```
1. ssh
fsevent_watch #1 bash #2 ssh #3
our platform... using builtin-java classes where applicable
Setting default log level to "WARN".
To adjust logging level use sc.setLogLevel(newLevel). For SparkR, use setLogLevel(newLevel).
Spark context Web UI available at http://rho.library.yorku.ca:4040
Spark context available as 'sc' (master = local[*], app id = local-1553805629588).
Spark session available as 'spark'.
Welcome to

          Spark
          version 2.3.2

Using Scala version 2.11.8 (Java HotSpot(TM) 64-Bit Server VM, Java 1.8.0_161)
Type in expressions to have them evaluated.
Type :help for more information.

scala> :paste
// Entering paste mode (ctrl-D to finish)

import io.archivesunleashed._
import io.archivesunleashed.matchbox._

RecordLoader.loadArchives("example.arc.gz", sc)
  .keepValidPages()
  .keepDomains(Set("www.archive.org"))
  .map(r => (r.getCrawlDate, r.getDomain, r.getUrl, RemoveHTML(r.getContentString)))
  .saveAsTextFile("plain-text-domain/")
```



## In other words...

---  
We have a wonderful platform that takes WARC files and converts them into formats that are familiar to digital humanists, computational social scientists, systems librarians, digital archivists, and beyond..

.. but you basically need to be a developer to run the simplest of commands (despite ample documentation and outreach... the command line interface is a bridge too far).



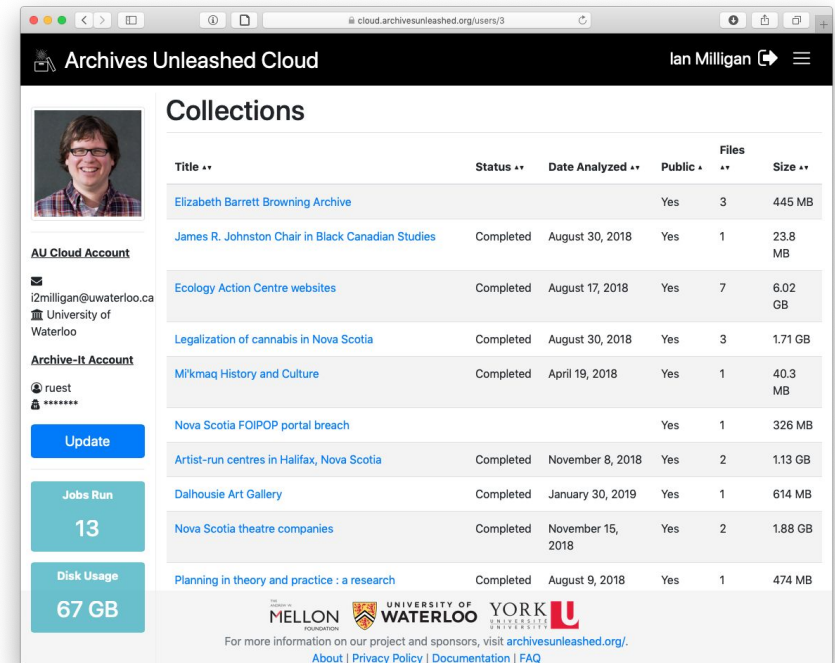
# Enter the Archives Unleashed Cloud





# Archives Unleashed Cloud

- A web-based front end for working with the Archives Unleashed Toolkit;
- Runs on our central servers or you can run one yourself;
- Uses WASAPI – Web Archives Systems API – to transfer data
- Generates a basic set of research derivatives for scholars to work with



The screenshot shows the Archives Unleashed Cloud web interface. The user is logged in as Ian Milligan. The interface displays a profile section for the user, including their email (i2milligan@uwaterloo.ca) and a link to update their profile. Below the profile, there are statistics for 'Jobs Run' (13) and 'Disk Usage' (67 GB). The main section is titled 'Collections' and contains a table with the following data:

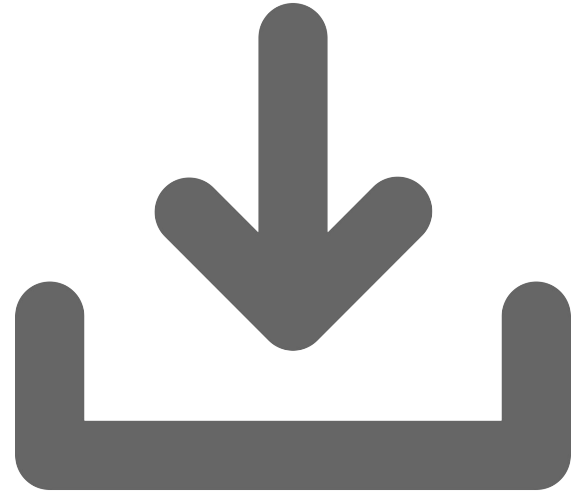
Title	Status	Date Analyzed	Public	Files	Size
<a href="#">Elizabeth Barrett Browning Archive</a>			Yes	3	445 MB
<a href="#">James R. Johnston Chair in Black Canadian Studies</a>	Completed	August 30, 2018	Yes	1	23.8 MB
<a href="#">Ecology Action Centre websites</a>	Completed	August 17, 2018	Yes	7	6.02 GB
<a href="#">Legalization of cannabis in Nova Scotia</a>	Completed	August 30, 2018	Yes	3	1.71 GB
<a href="#">Mi'kmaq History and Culture</a>	Completed	April 19, 2018	Yes	1	40.3 MB
<a href="#">Nova Scotia FOIPOP portal breach</a>			Yes	1	326 MB
<a href="#">Artist-run centres in Halifax, Nova Scotia</a>	Completed	November 8, 2018	Yes	2	1.13 GB
<a href="#">Dalhousie Art Gallery</a>	Completed	January 30, 2019	Yes	1	614 MB
<a href="#">Nova Scotia theatre companies</a>	Completed	November 15, 2018	Yes	2	1.88 GB
<a href="#">Planning in theory and practice : a research</a>	Completed	August 9, 2018	Yes	1	474 MB

At the bottom of the interface, there are logos for the Mellon Foundation, University of Waterloo, and York University, along with a link to visit archivesunleashed.org for more information.

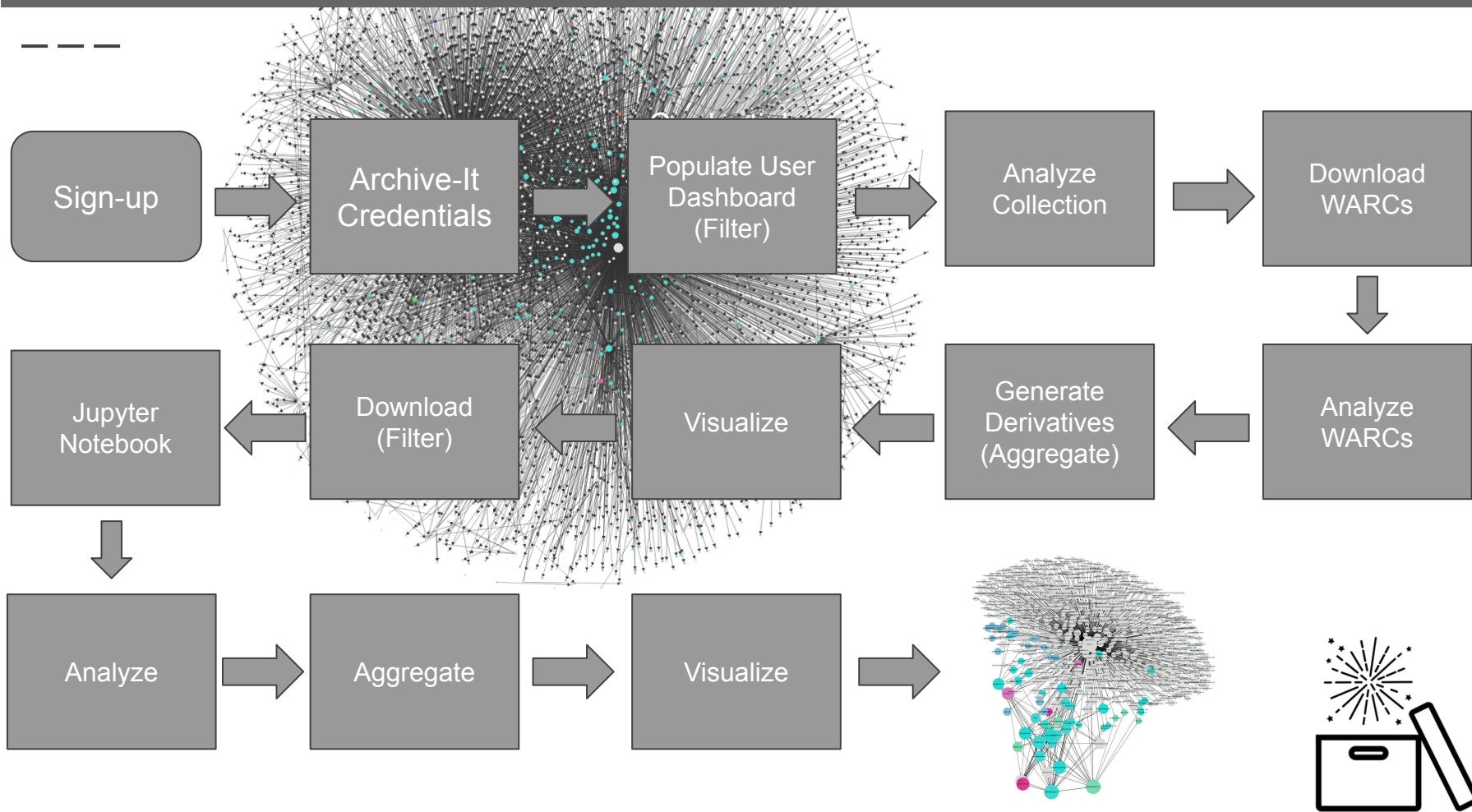


# Archives Unleashed Cloud

- Download options for each collection
  - Full text of a web archive;
  - Full text of the top-ten most popular domains in a web archive;
  - Network diagram with characteristics pre-computed (Gephi);
  - Raw network diagram (origin/destination/weight);
  - Domain frequency statistics

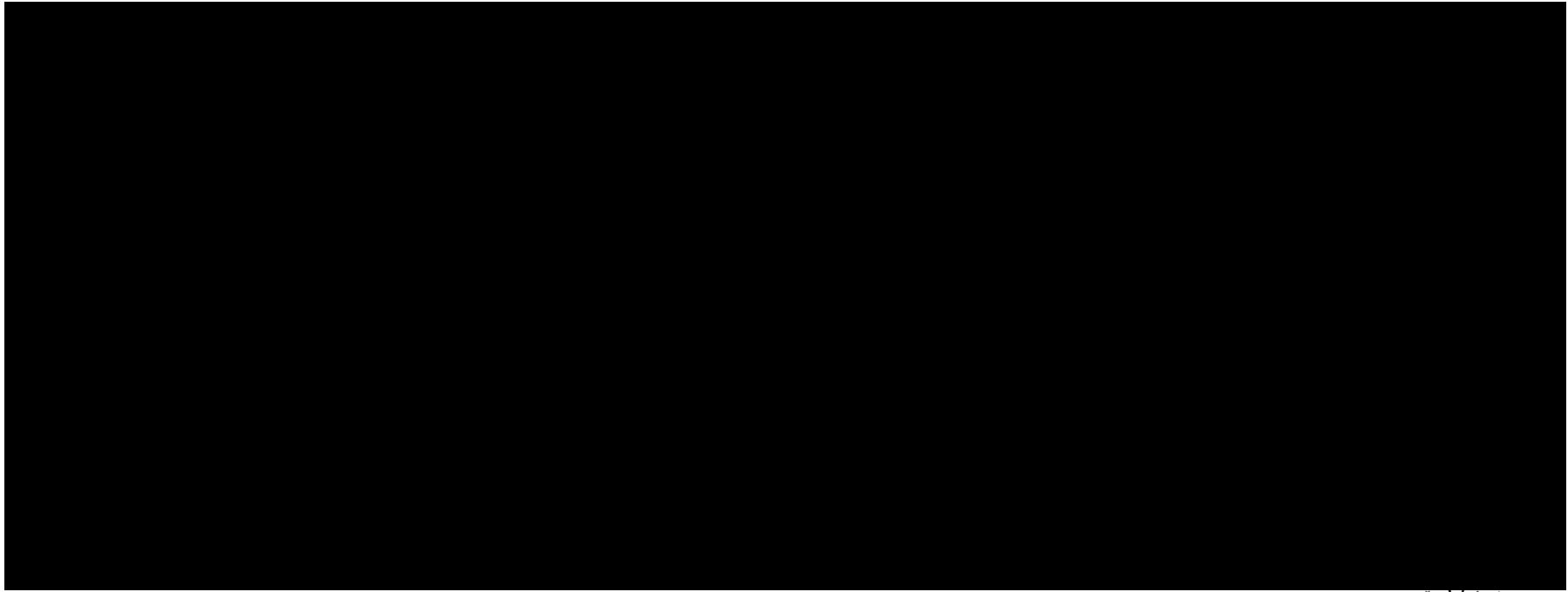


# How it works



# Archives Unleashed Cloud

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Cool.  
How much does it cost?  
(...to process WARC files in the “CLOUD”)



# US\$7 per TB

— — —  
The TL;DR



# What do we mean by the “Cloud”?

We conduct our work on the **Compute Canada Cloud**, which is an **OpenStack** instance supported by a research grant.

As OpenStack is a popular open-source cloud platform, our findings should be generalizable.

We translated all of our compute time into **Amazon Web Services** costs as it is the most popular commercial provider.

compute | calcul  
canada | canada





# What are we performing “analysis” with?

## Analysis using the **Archives Unleashed Toolkit** or **AUT**

**AUT** is a Scala domain-specific language on top of the Apache Spark platform

```
Welcome to
Spark version 2.3.0

Using Scala version 2.11.8 (Java HotSpot(TM) 64-Bit Server VM, Java 1.8.0_161)
Type in expressions to have them evaluated.
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scala> :paste
// Entering paste mode (ctrl-D to finish)

import io.archivesunleashed._
import io.archivesunleashed.matchbox._

val r = RecordLoader.loadArchives("example.arc.gz", sc)
  .keepValidPages()
  .map(r => ExtractDomain(r.getUrl))
  .countItems()
  .take(10)
```

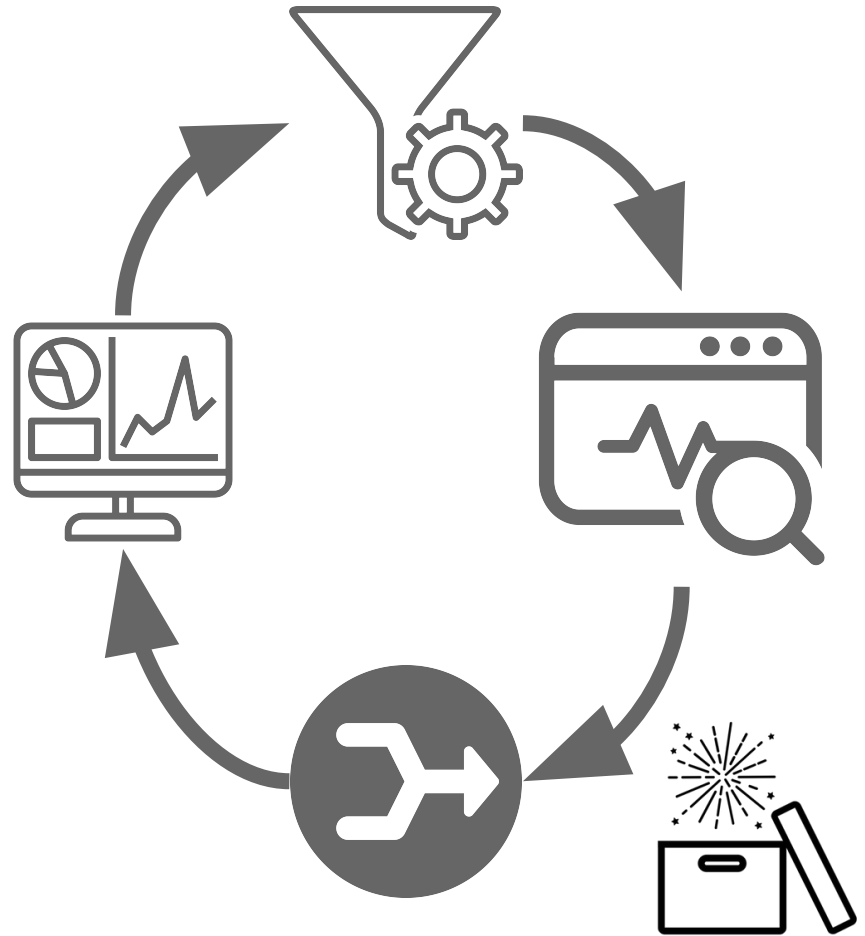


# What do we mean by “Analysis”?

The **Filter - Analyze - Aggregate - Visualize (FAAV)** Cycle

**Common analytics task:** crawl statistics to visualizing web graphs to exploring text at scale

Informed by extensive hands-on collaboration

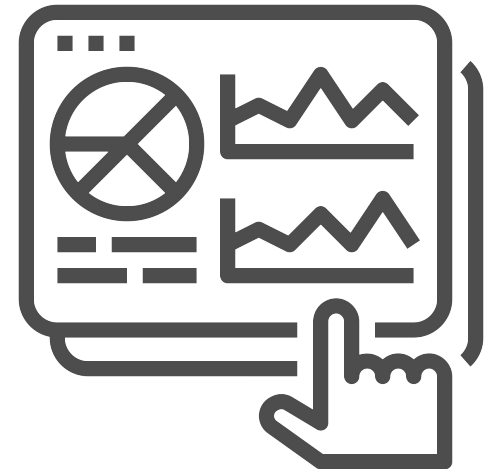


# What do we mean by “Analysis”?

**Extract all URLs** to compute the frequency of domains appearing in a given collection (domain distribution);

**Extract all plain text** from all pages, along with metadata such as crawl date, domain name, and URL (full text); and

**Extract all hyperlinks** to create a domain-to-domain network graph (webgraph);



# The Experiment

We decided to use a **16 core, 64GB memory virtual machine**

Powerful, but struck the balance between expensive and power

Why not a cluster?



# The Experiment

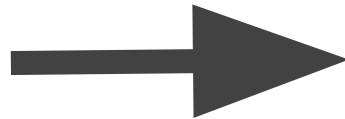
Analysis based on analyzing the cost of processing **48 Archive-It collections** from six Canadian universities (Toronto, Victoria, Simon Fraser University, Manitoba, Dalhousie, and Winnipeg).

A variety of **sizes** – smallest at 1.2GB was Victoria's academic calendar; largest at 4.3TB was Canadian Government Information Collection

Size	Count
$\geq 1 \text{ GB}, < 10 \text{ GB}$	10
$\geq 10 \text{ GB}, < 100 \text{ GB}$	18
$\geq 100 \text{ GB}, < 1 \text{ TB}$	15
$\geq 1 \text{ TB}$	5
Total	48

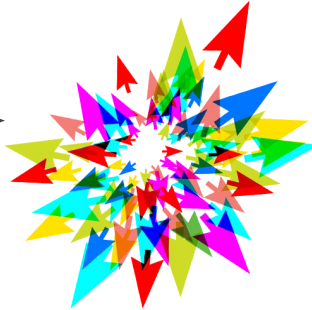


# The Experiment (Workflow)



WASAPI

compute | calcul  
canada | canada



ANALYSIS

```
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val r = RecordLoader.loadArchives("example.arc.gz", sc)
.keepValidPages()
.map(r => ExtractDomain(r.geturl))
.countItems()
.take(10)
```



# Findings

We then took all the times for each job (**Domain, Full Text, Webgraph**) and found processing time per GB in seconds.

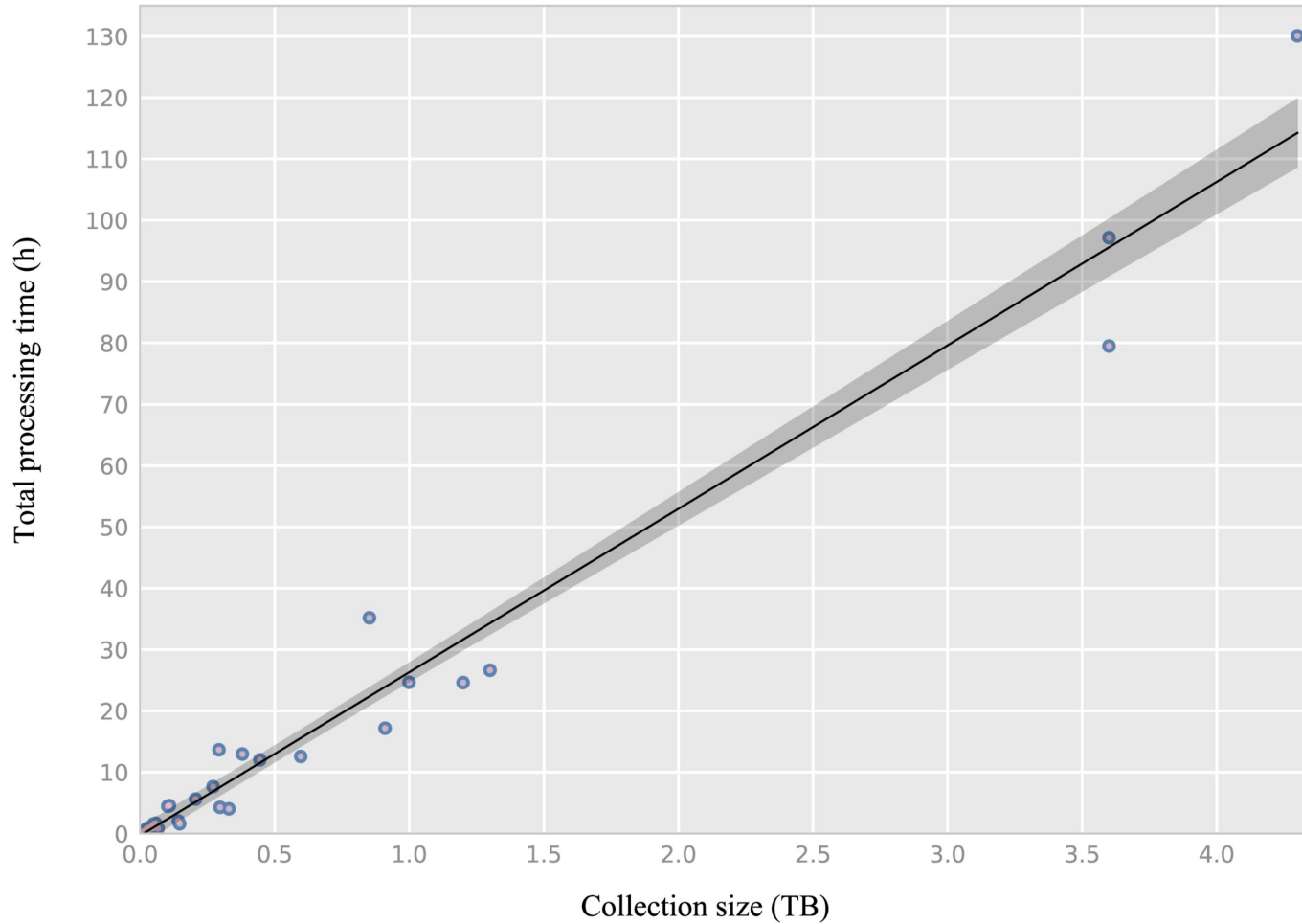
Webgraph is most computationally intensive, but not too much so.

**Processing times drop as size increases**, as startup costs are amortized.

Derivative	all	L	M	S
domain distribution	32	25	27	36
full text	34	28	35	34
webgraph	36	34	36	36
total	102	87	98	106

**Figure:** Processing times per GB in seconds





Scatter plot between collection size and total processing time, **illustrating a linear relationship**





# Findings

Derivative files are **much smaller**

Researcher can usually work with these derivative files on their own systems in a way they could not work with their WARC

Derivative	all	L	M	S
domain distribution (KB)	0.95	0.51	0.98	1.01
full text (MB)	78.5	97.6	102.1	62.4
webgraph (KB)	76.9	85.8	122.6	50.9

**Figure:** Derivative sizes per GB



So we know the times to compute these derivatives. Show me the money!



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Derivative	all	L	M	S
domain distribution	\$6.51	\$4.67	\$5.05	\$7.63
full text	\$6.73	\$5.24	\$6.65	\$7.04
webgraph	\$7.19	\$6.46	\$6.82	\$7.52

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total	\$20.43	\$16.37	\$18.52	\$22.19
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Processing cost per TB in US \$



# Cost of a WARC

C5.4xlarge (16 core, 68 GB memory) is \$0.68/hour in US East (Ohio)

The previous results show a **macro-average**

The bottom line: US\$7/TB for a typical analytics operation such as generating **domain frequency** reports, extracting **full text of a collection**, or extracting the link-to-link **webgraph** of hyperlinks.



# Cost of a WARC

This is **cost-competitive**

Google BigQuery costs US\$5 per TB – *but* is SQL based and prices on uncompressed size whereas our calculations were on compressed WARCs (which are roughly 60% the size of uncompressed WARCs)

Archives Unleashed is price competitive with commercial services, albeit without any profit margin.



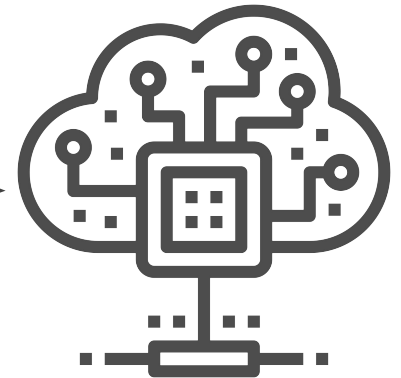
# Proposed Workflow



Cheaper download server  
(ex. t3.medium)



Expensive processing server  
(ex. c5.4xlarge)

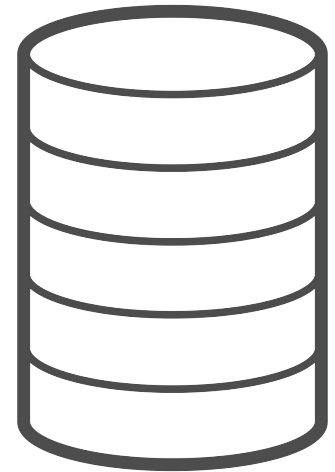


## Limitations: Storage

We did not include **storage** in this discussion. 1TB of data costs US\$23 per month. Our preferred workflow would be to transfer WARC<sub>s</sub>, analyze, and then delete them quickly.

At 30 MB/s data transfer speed, transferring a TB costs US\$0.40; less than the per-day cost of S3 data storage

**As long as the preservation copy is secure, the “processing copy” can be created and deleted on a whim**



# Limitations: People





# Discussion/Conclusions



**We share the beginnings of an economic analysis and believe the costs to be quite affordable; whether institutions or individual scholars find these costs palatable remains to be seen.**



# GIVE ME STATS

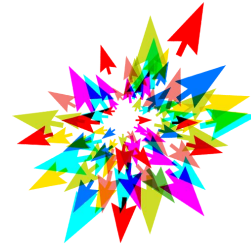
- 4,865 jobs run
- 187T analysed
- 12,987h, 8m, 18s (540+ days)
- 590h, 31m, 49s (24 days)
- 164 users
- 930 collections, 1,235,263 files
- Dataset citations?



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