End-User Programmers and their Communities: An Artifact-based Analysis

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Introduction

End User Programmers

People who engage in programming activities to support their hobbies and work.

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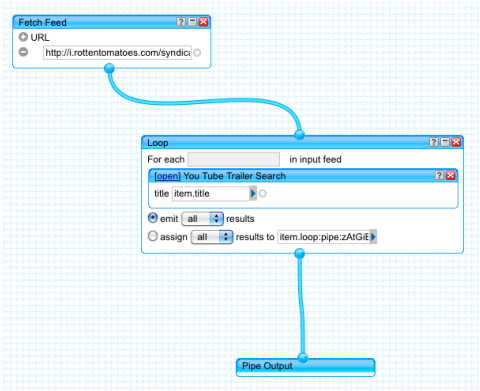
People who engage in programming activities to support their hobbies and work.

	Professionals	**End Users**
Number in U.S.	3 million	13 million
Typical Education	C.S. Degree	Other Degree
Role of Programming	It's their job	It supports their job

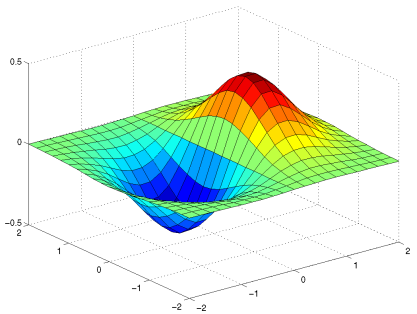
Many Domains and Applications

Web Mashups:



Educational Games:

Scientific Computing:



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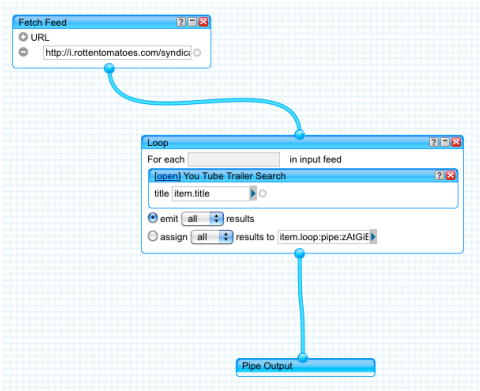

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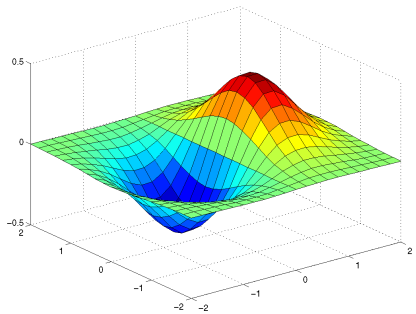

	Yahoo! Pipes	Scratch	MATLAB
# Artifacts	100,000	700,000	13,717
# Participants	90,000	500,000	5,356

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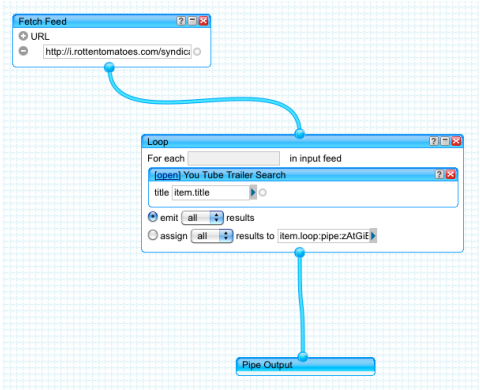

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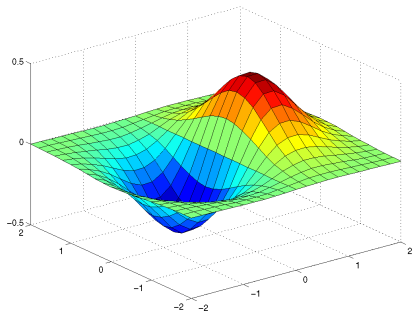

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. . . yet we know little about **how** the repositories are utilized

Empirical Study Details

- **Research Goal**
- Study Context
- Research Questions
- Variables and Metrics
- Methods
- Results

Research Goal

To better understand *end-user programmer* communities

- Learn how communities and artifact repositories evolve
- Uncover needs for support in: development, maintenance, search, program understanding, . . .

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Why Mashup Communities?

Web Mashups

Applications that compose and manipulate existing data sources or services to create new data or service.

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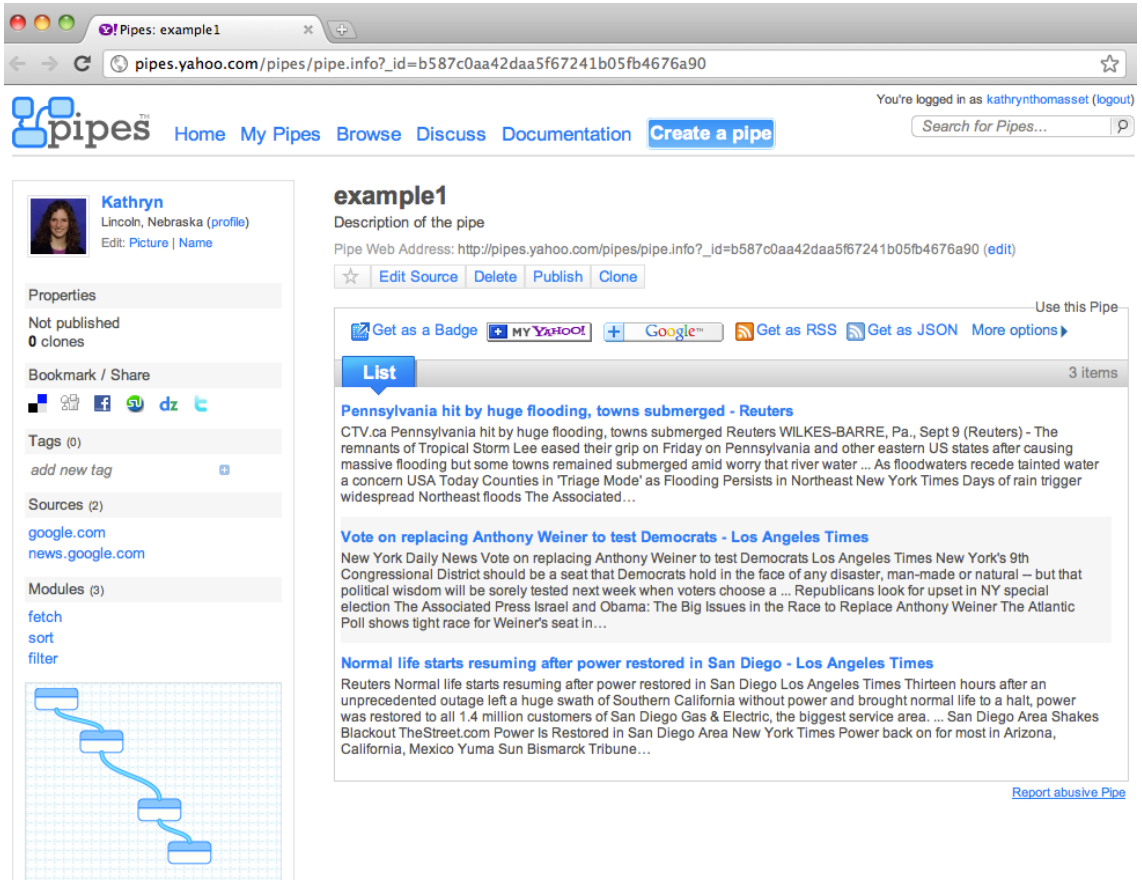

This example mashup fetches and filters news from `news.google.com`

Information page shows the pipe output and descriptive information

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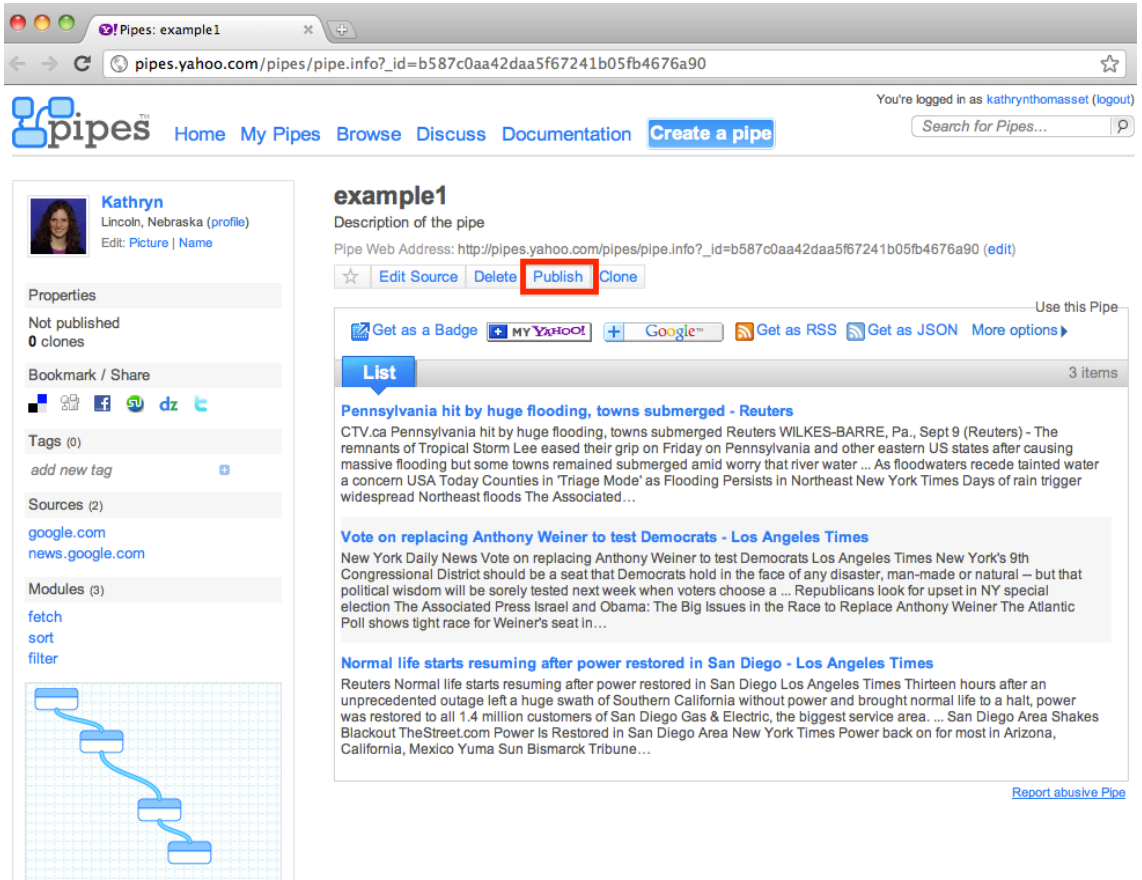

Clicking Publish adds the pipe to the public repository

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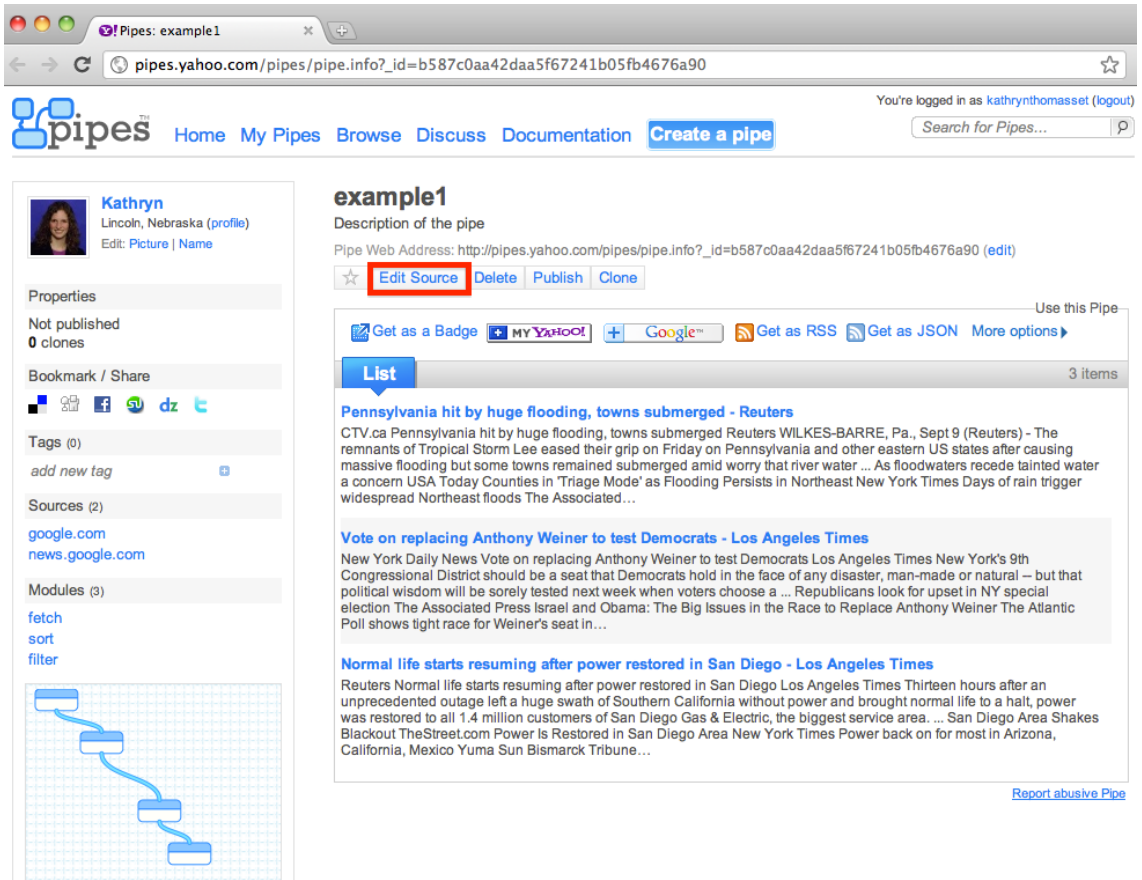

Clicking Edit Source loads the Pipes Editor

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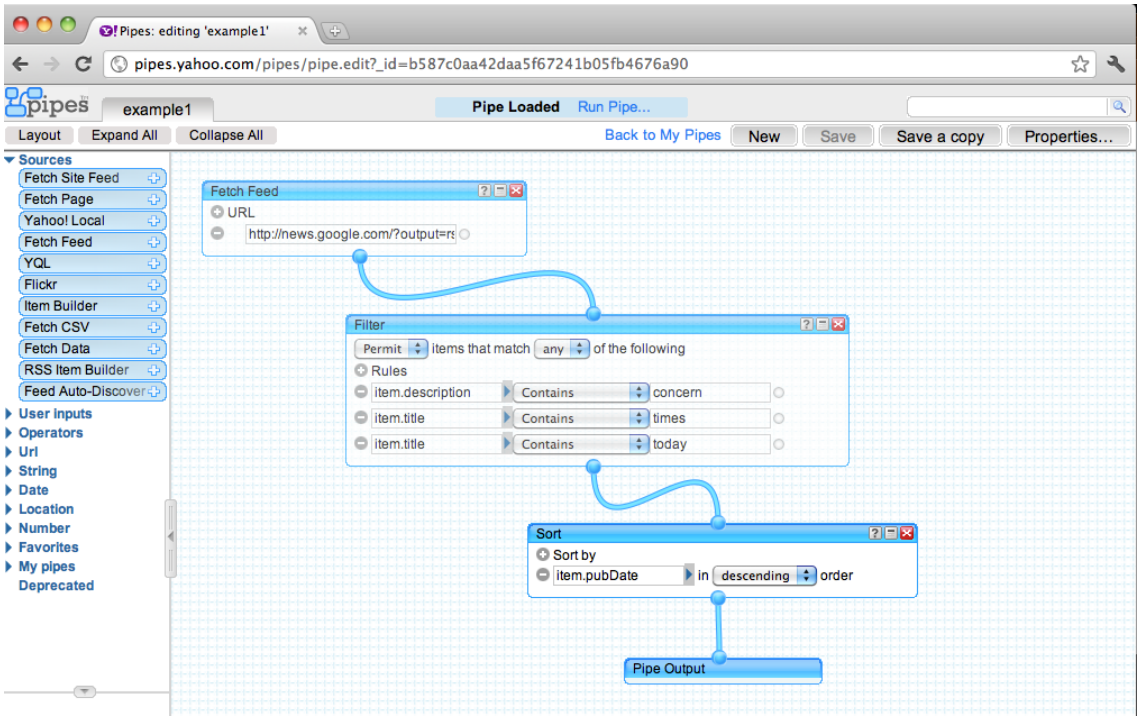

- Visual mashup creation environment
- Within a browser
- Drag and drop interface

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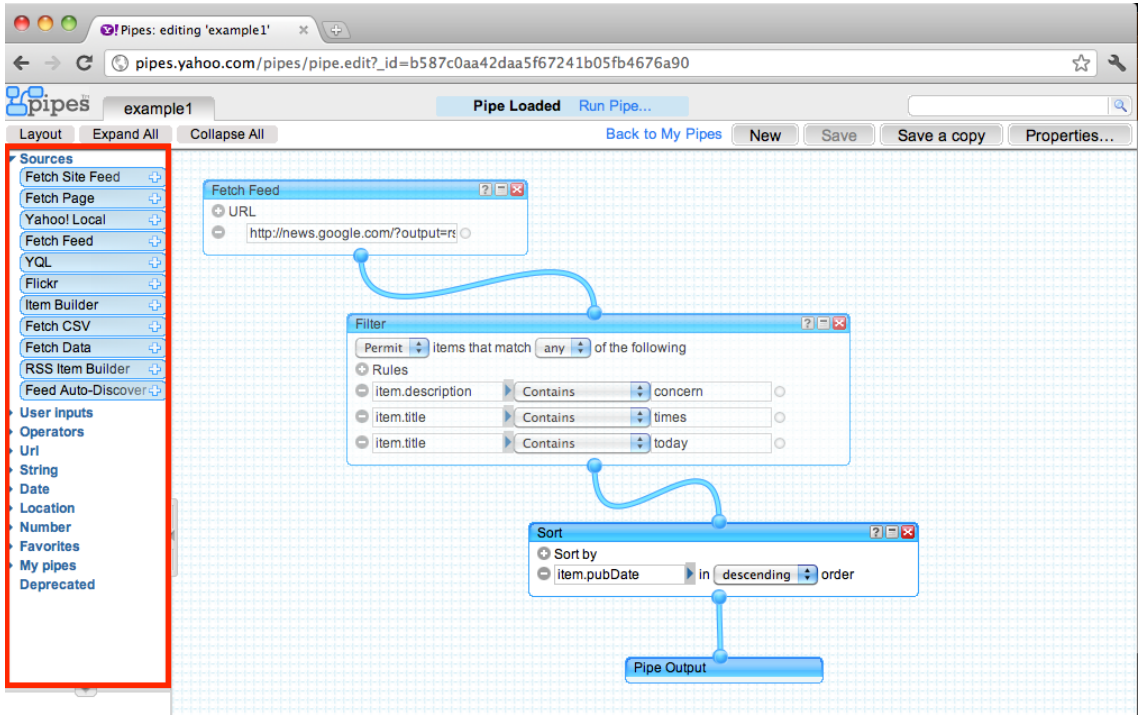

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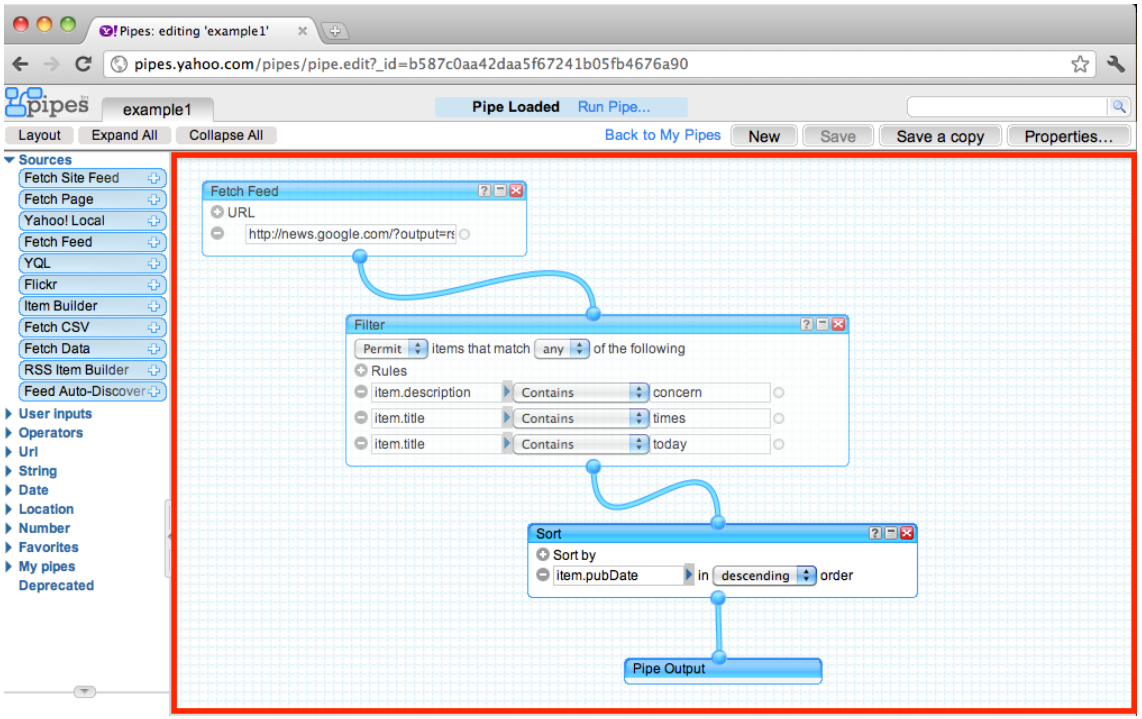

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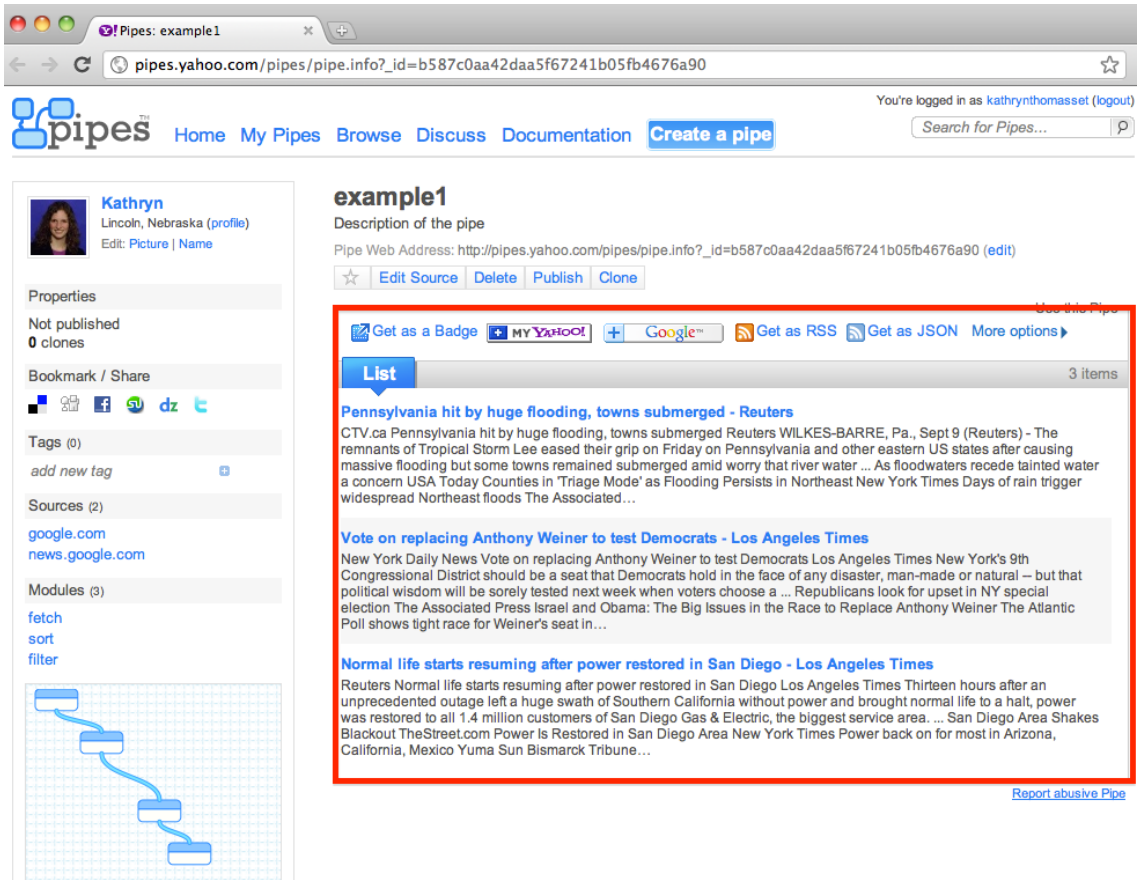

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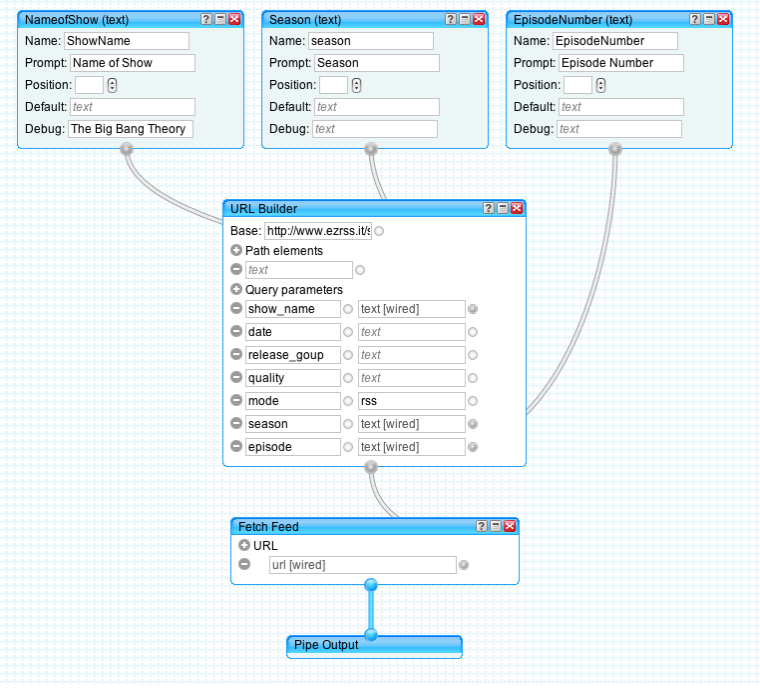
Study Details

Concept to Capture	Variable
artifact sharing/impact	popularity
abstraction	configurability
complexity	size
overlap of artifacts in repository	diversity

Study Details

Variables: size, configurability, popularity, diversity

Pipe Source



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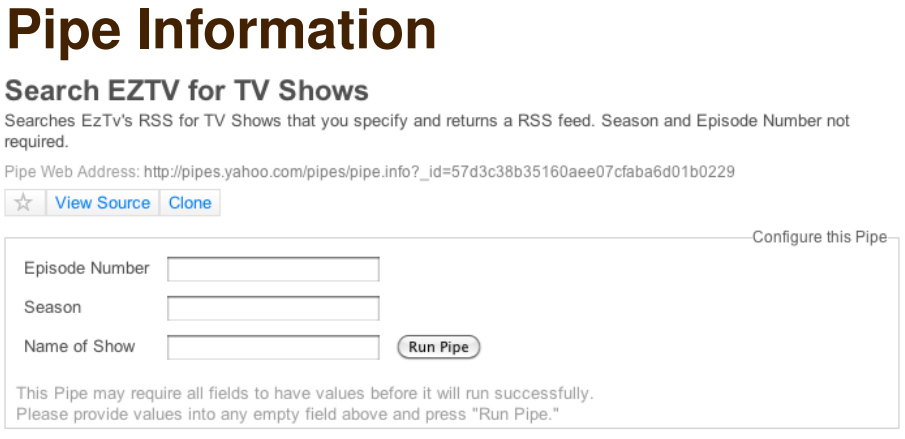

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Pipe Source

6 modules

Significance: Size is related to complexity

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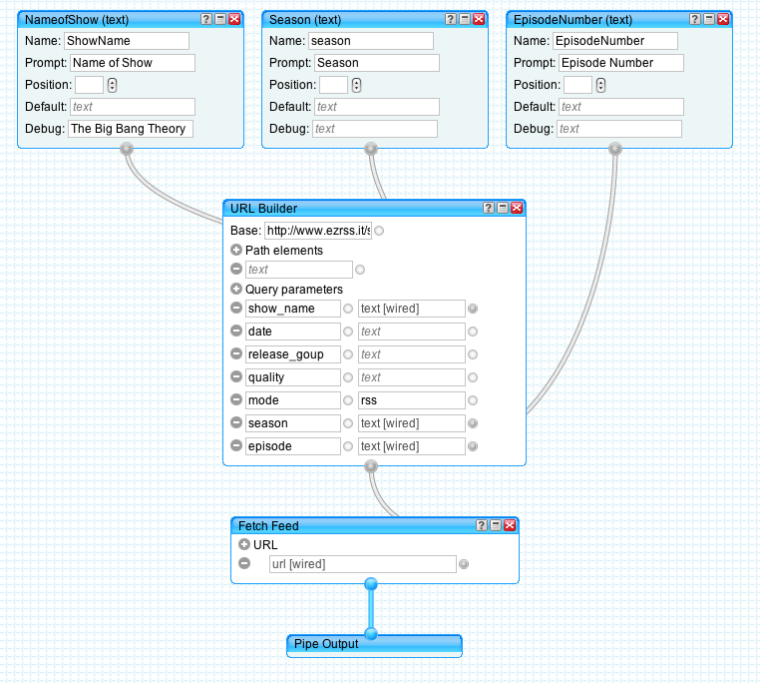

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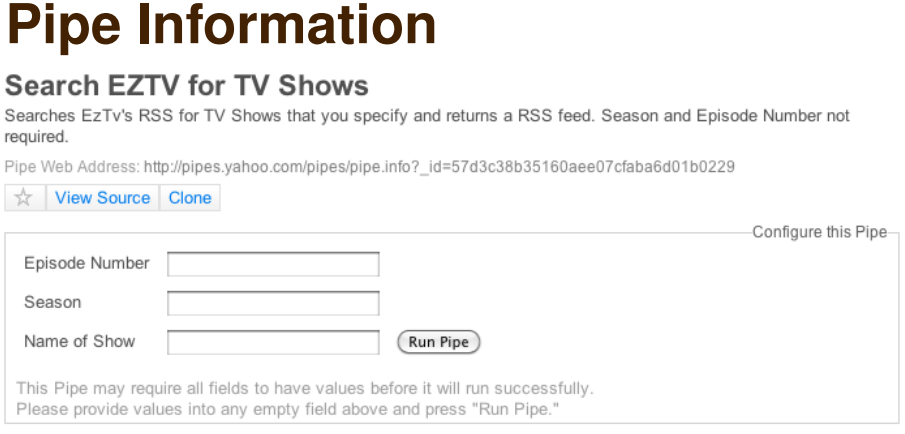

3 modules

Significance: Configurability is related to abstraction and language mastery

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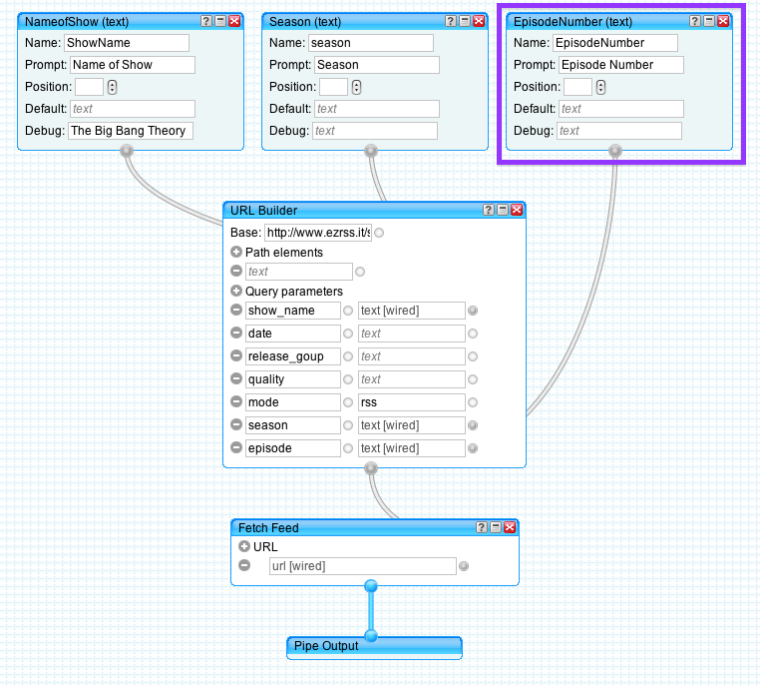

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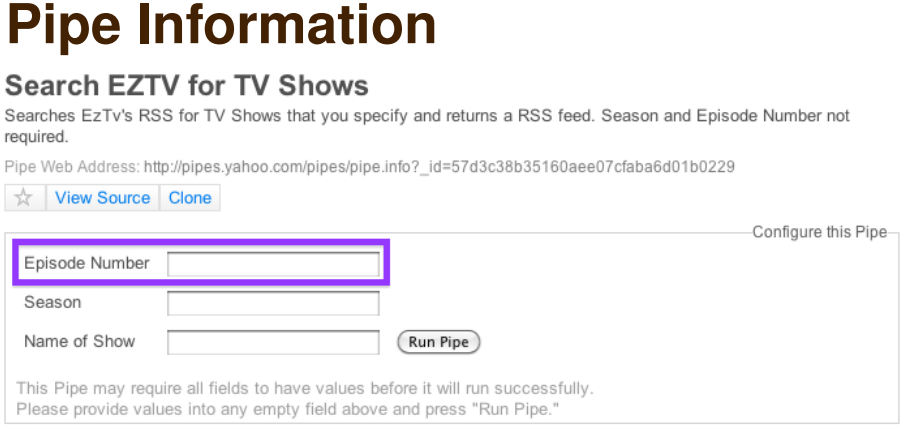

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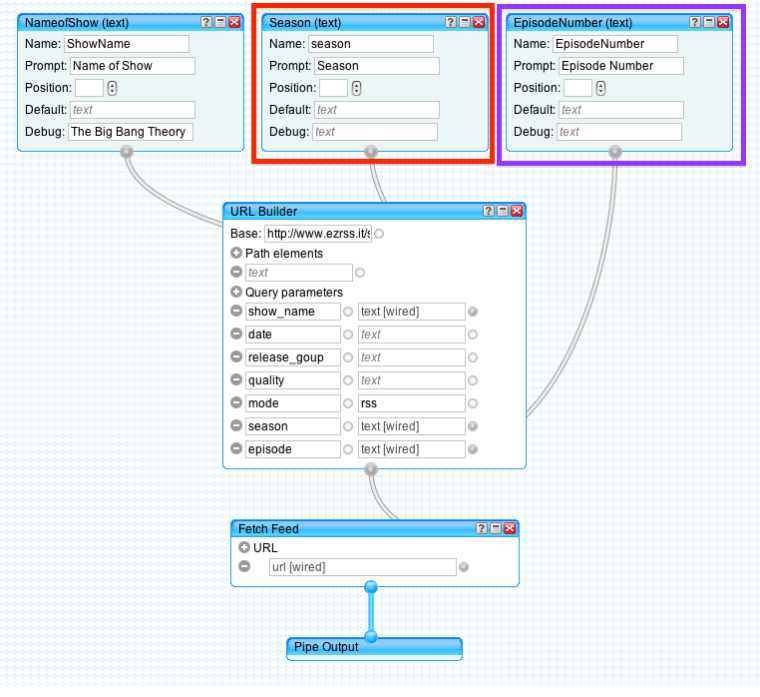

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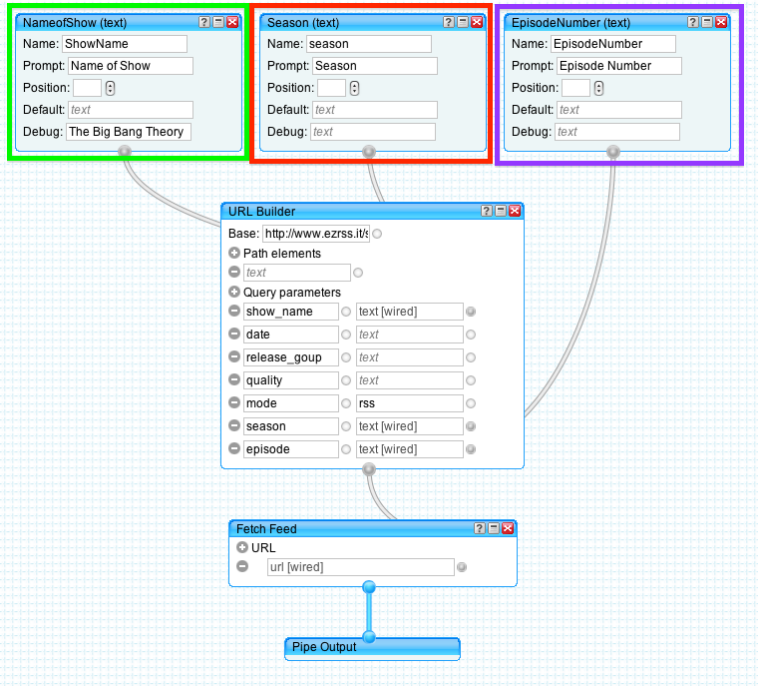

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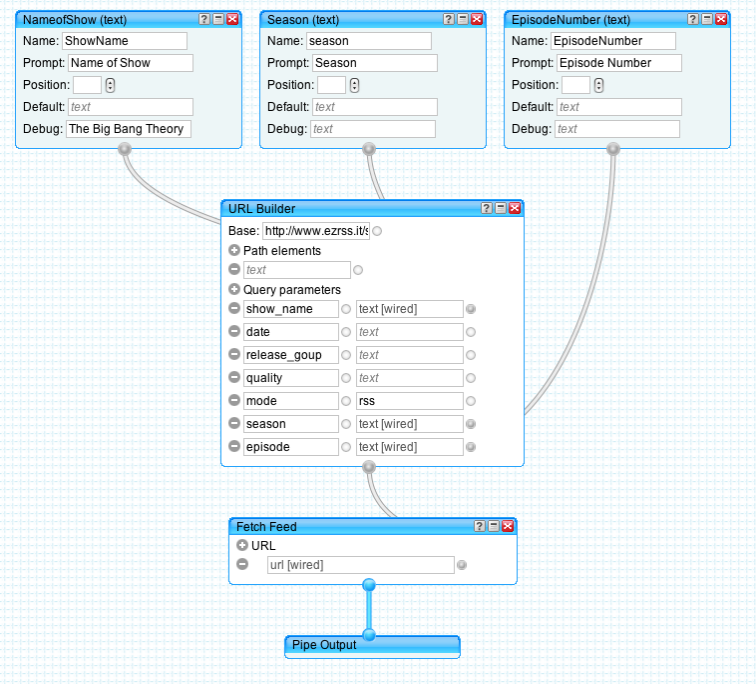

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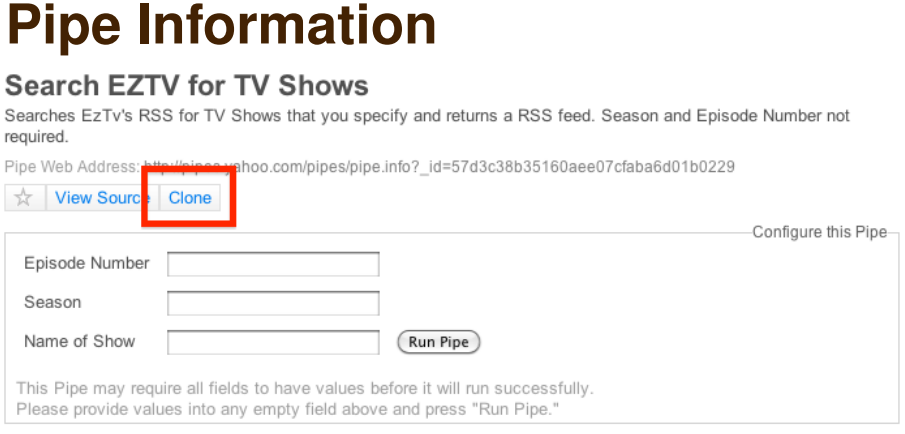

190 clones

Significance: Popularity is related to impact on community

Study Details

Variables: size, configurability, popularity, **diversity**

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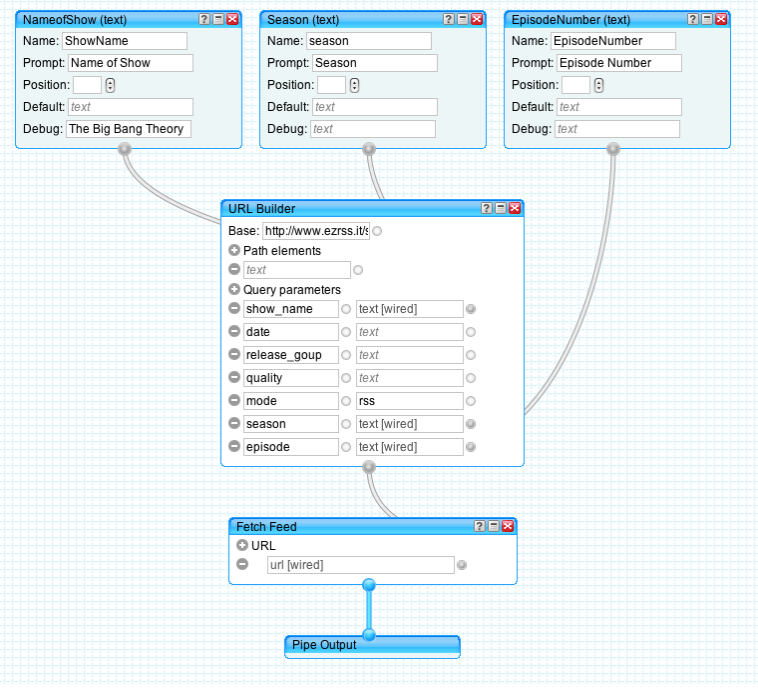

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3 Same structure
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Significance: Diversity is related to contribution novelty

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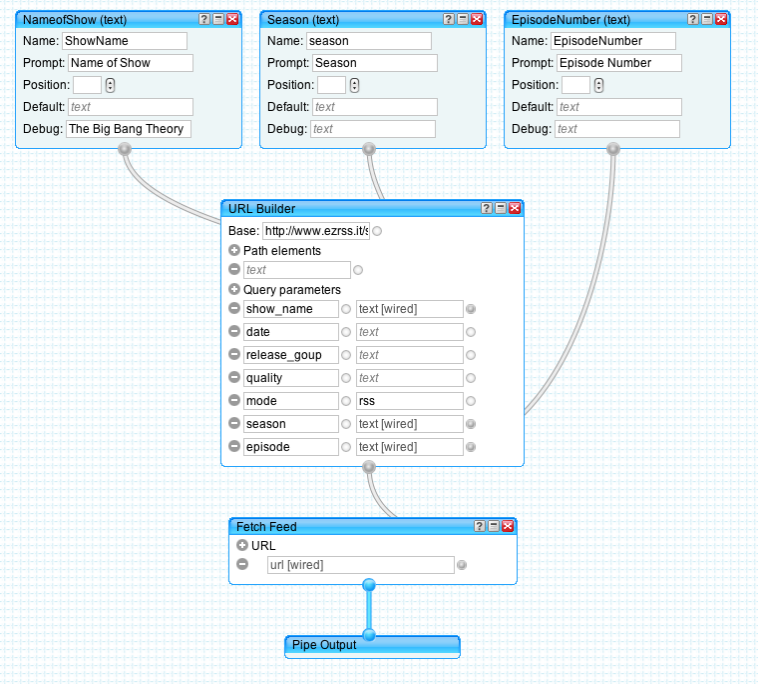

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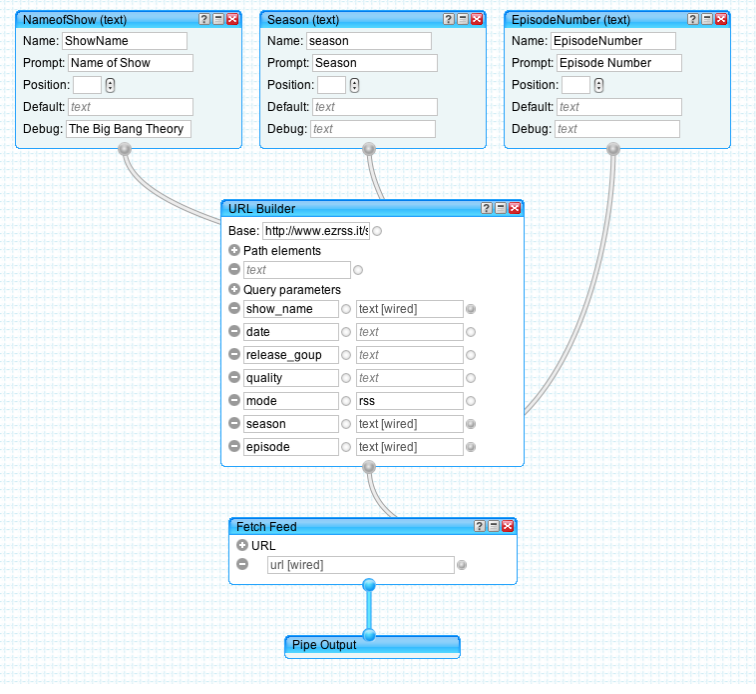

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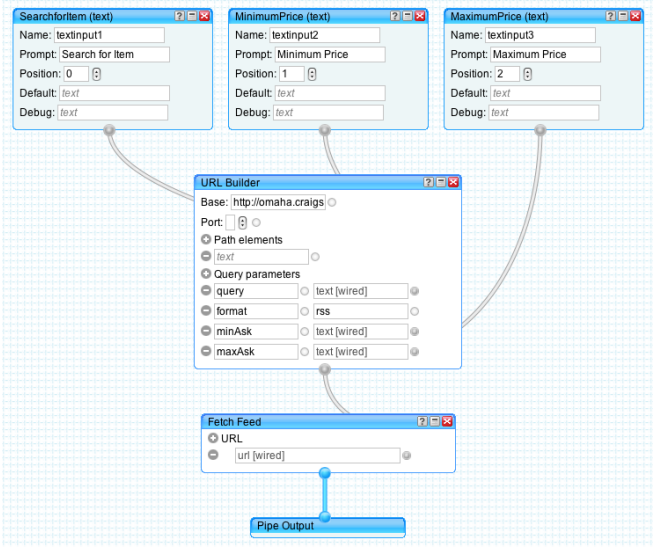

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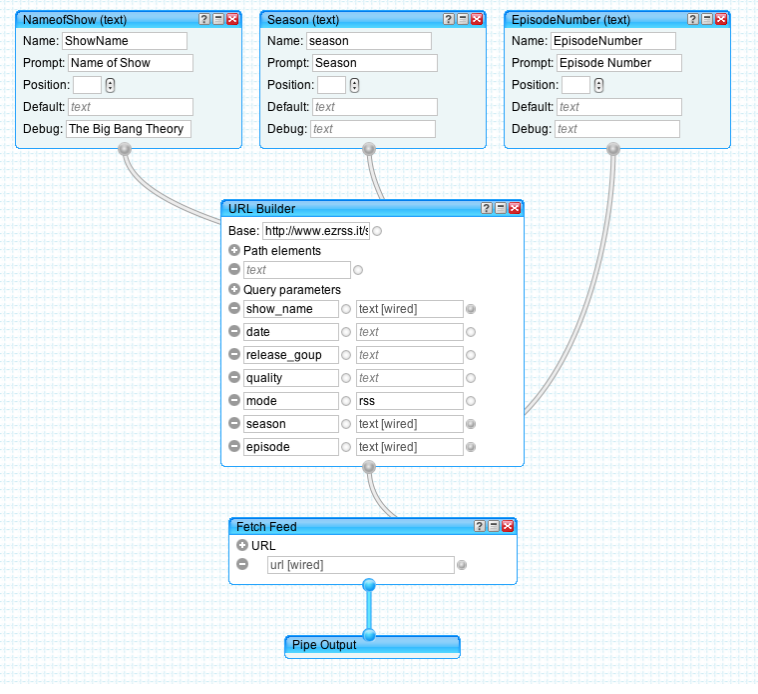

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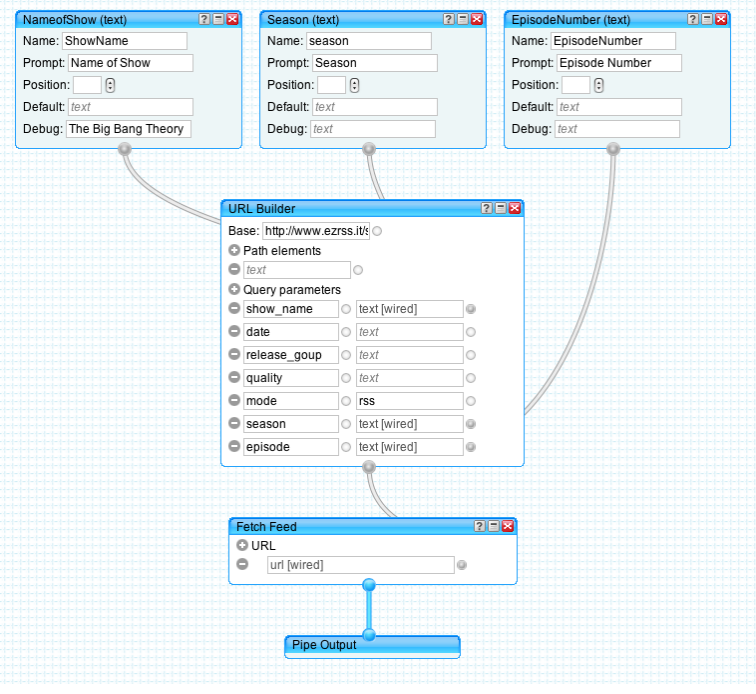

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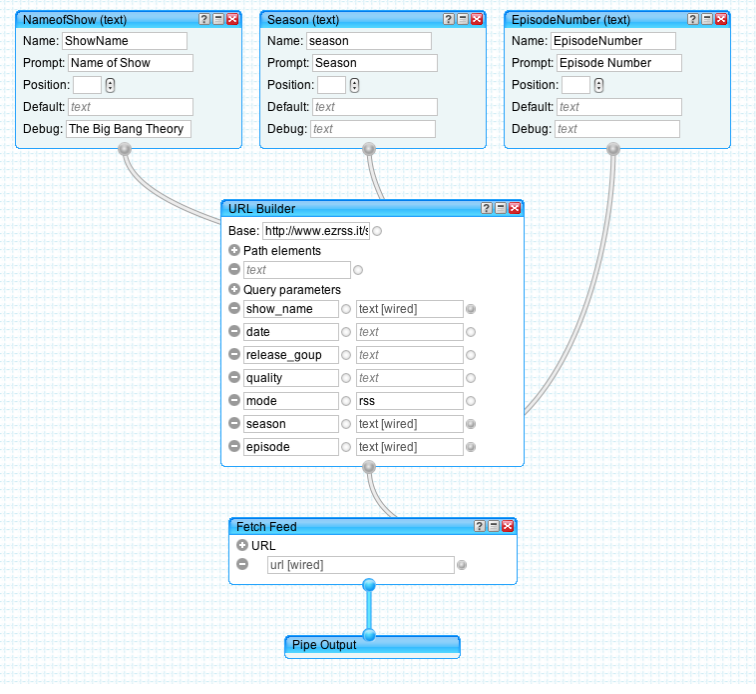

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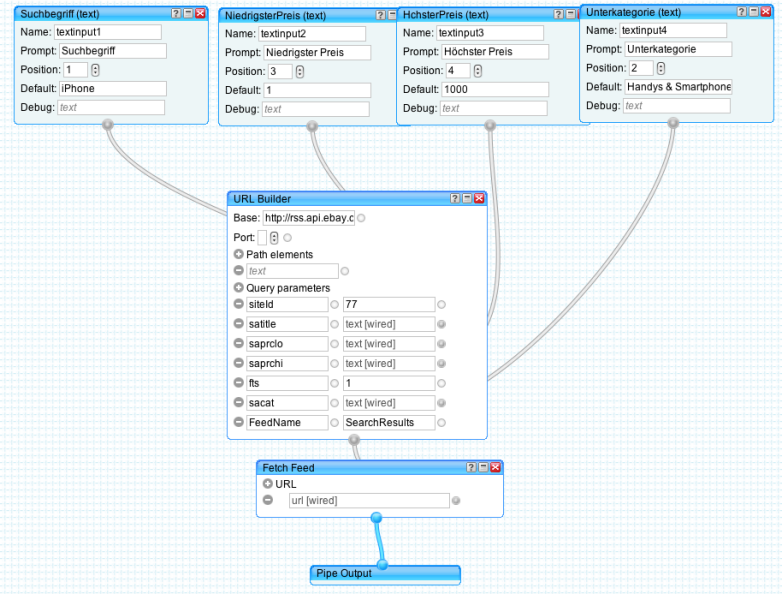

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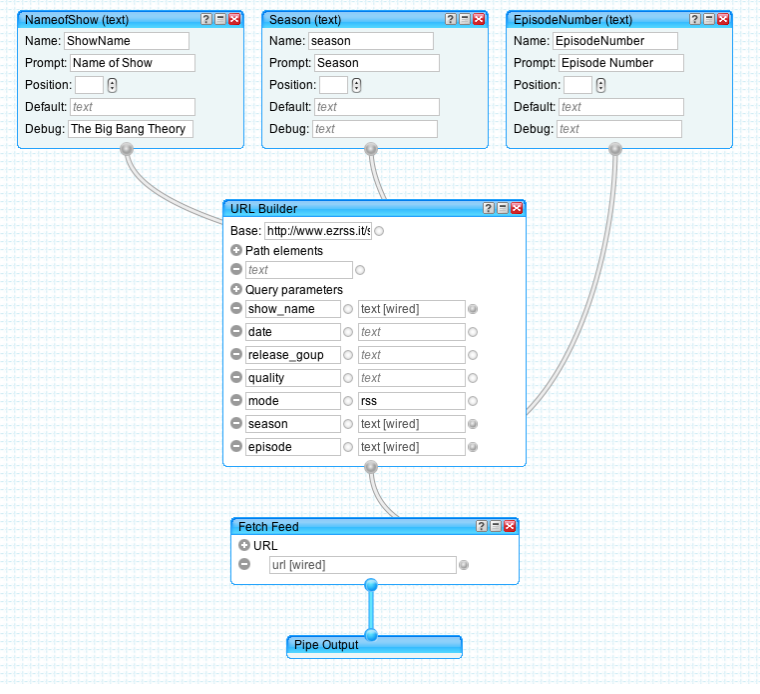

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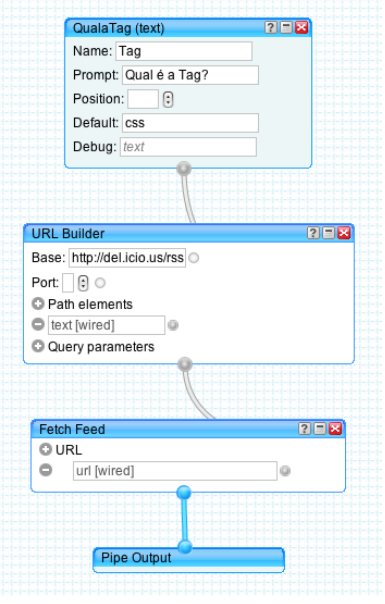

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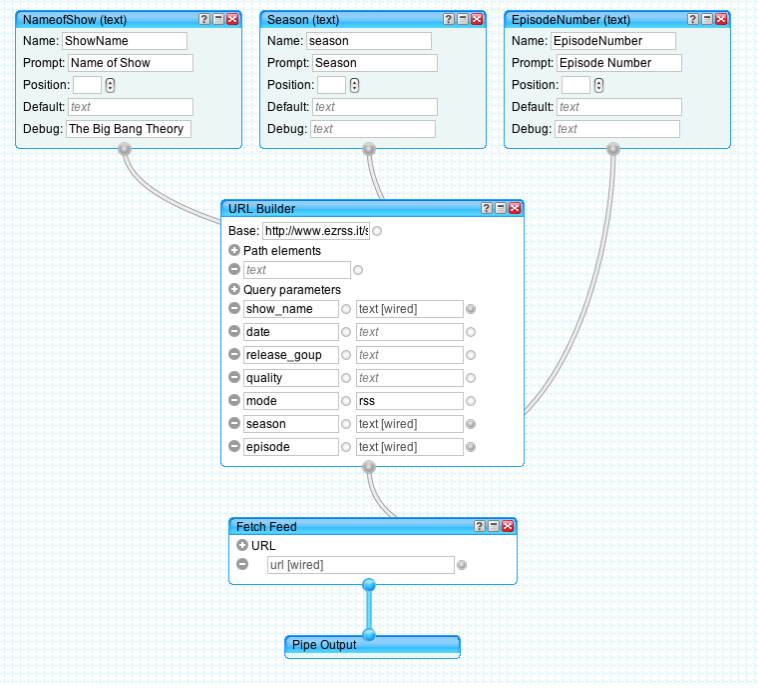

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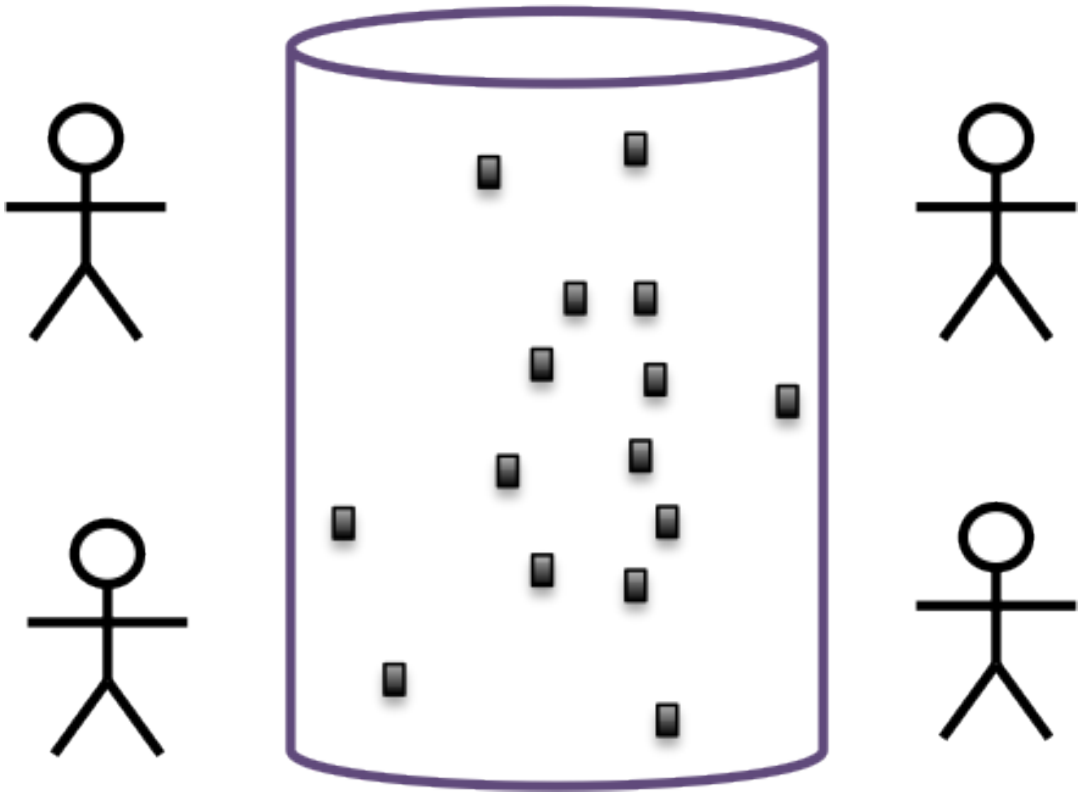

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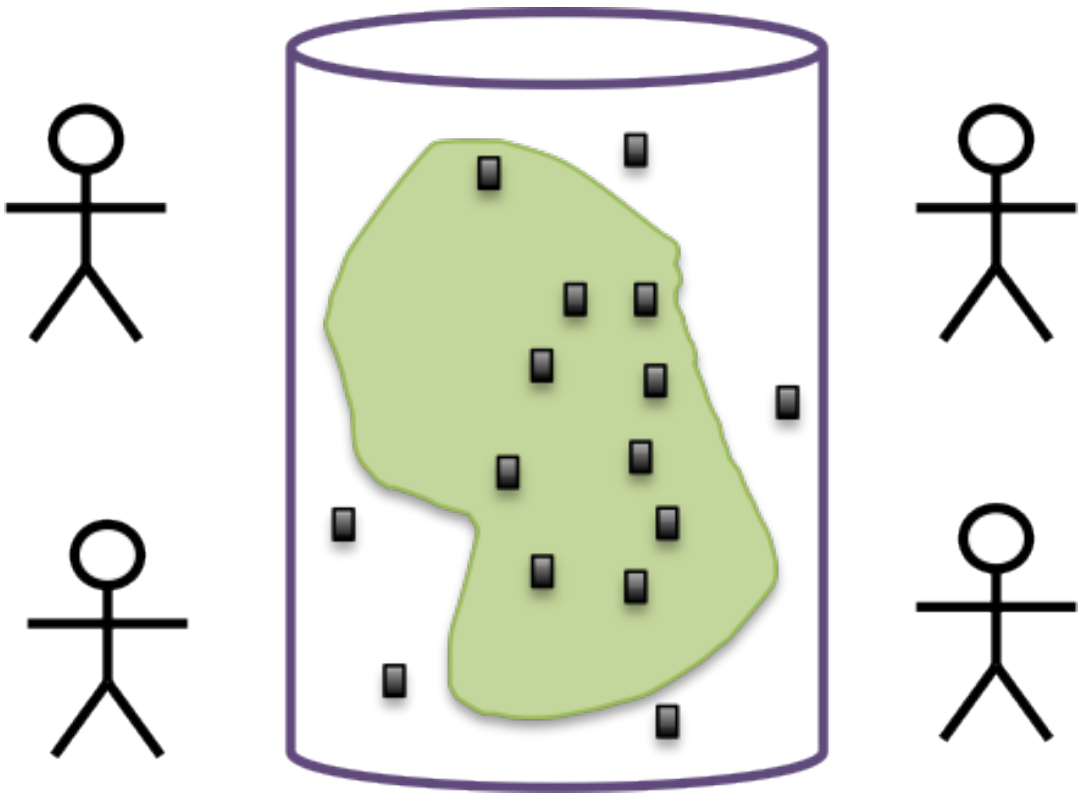
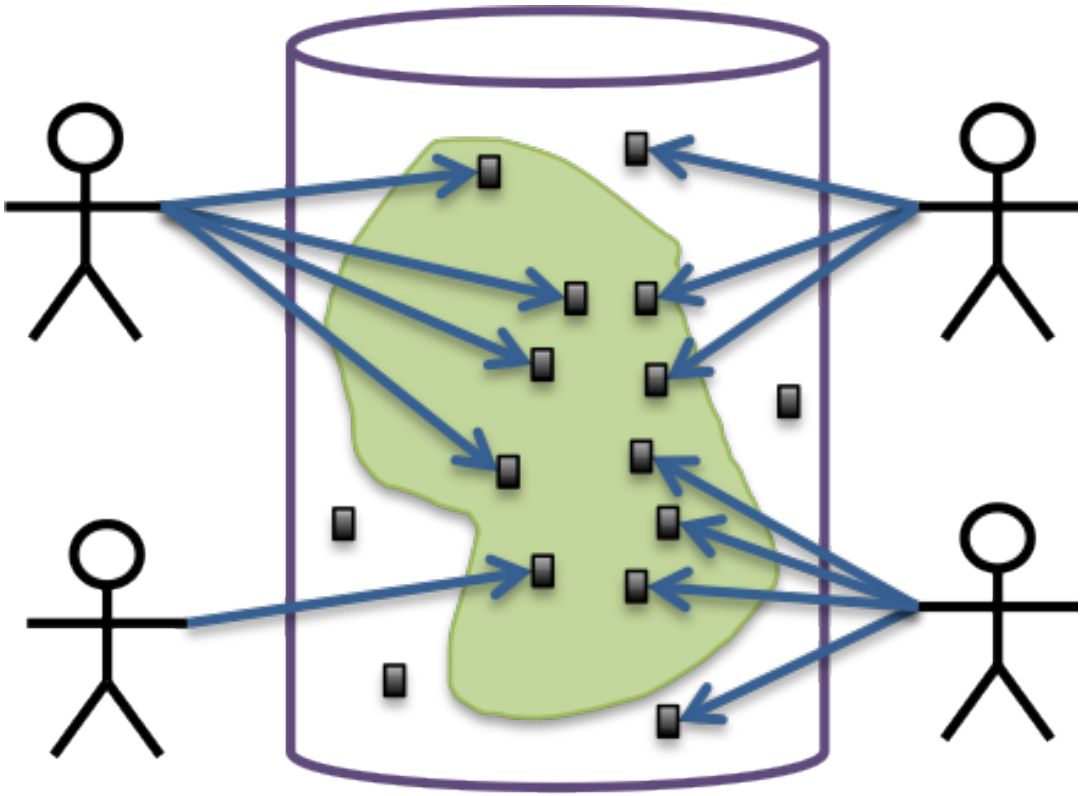


Artifacts: 32,887

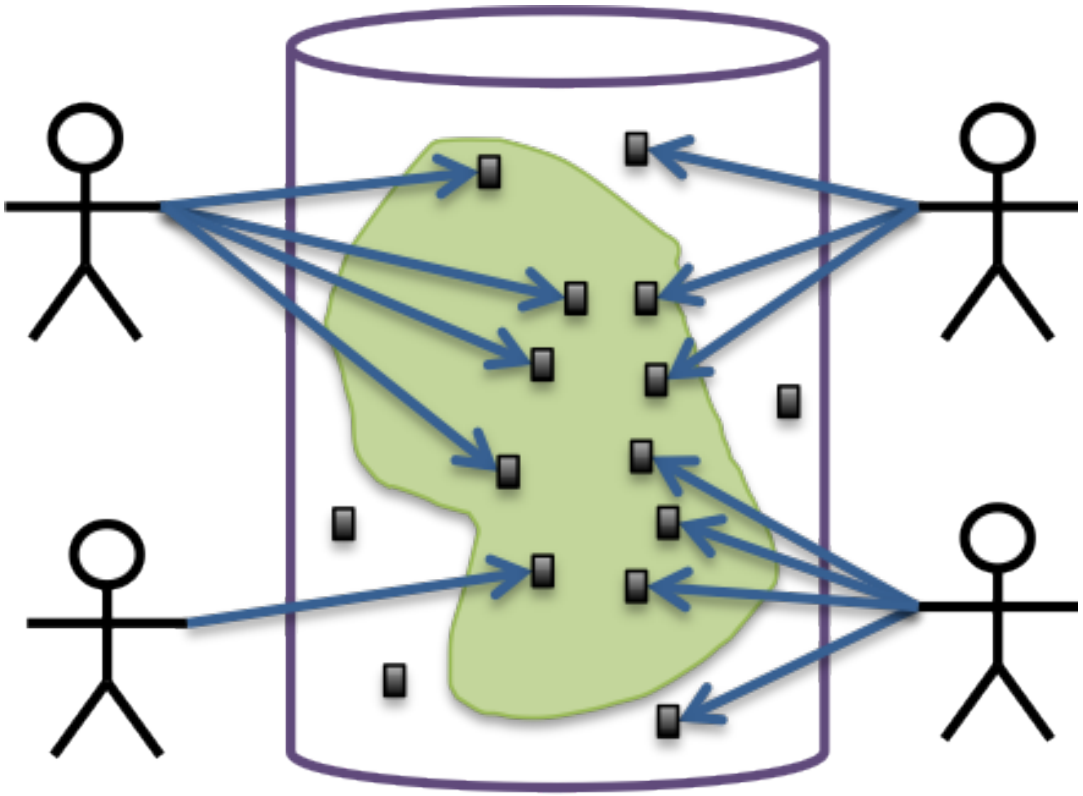
Data Collection



Artifacts: 32,887

Authors: 20,313

Data Collection



Artifacts: 32,887

Authors: 20,313

Threats: public repository offers limited visibility (internal); sampling bias (external); generalizability to other domains (external)

Empirical Study Details

Goal: To better understand *end-user programmer* communities

- Research Goal
- Study Context
- Research Questions
- Variables and Metrics
- Methods
- **Results**

Research Questions

RQ1: What are the characteristics of Yahoo! Pipes community?

1a,b: author attrition and author contributions

1c: artifact sharing, abstraction, complexity, and degree of overlap among pipes in the repository

RQ1: Characteristics of Yahoo! Pipes Community

Summary

Metric	Average
Size	8.20 modules per pipe
Configurability	0.65 modules per pipe
Popularity	5.67 clones per pipe
Diversity	3.62 cluster level

RQ1: Characteristics of Yahoo! Pipes Community

Summary

Metric	Average
Size	8.20 modules per pipe
Configurability	**0.65 modules per pipe**
Popularity	5.67 clones per pipe
Diversity	3.62 cluster level

34% of pipes are configurable

RQ1: Characteristics of Yahoo! Pipes Community

Summary

Metric	Average
Size	8.20 modules per pipe
Configurability	0.65 modules per pipe
Popularity	**5.67 clones per pipe**
Diversity	3.62 cluster level

54% of pipes have been cloned

RQ1: Characteristics of Yahoo! Pipes Community

Summary

Metric	Average
Size	8.20 modules per pipe
Configurability	0.65 modules per pipe
Popularity	5.67 clones per pipe
Diversity	**3.62 cluster level**

5% of pipes are exact duplicates, yet 46% have a match if field values are relaxed

RQ1: Characteristics of Yahoo! Pipes Community

Take Aways:

- There is a lot of reuse of shared pipes
- Participants often submit pipes that are highly similar to other pipes in the repository

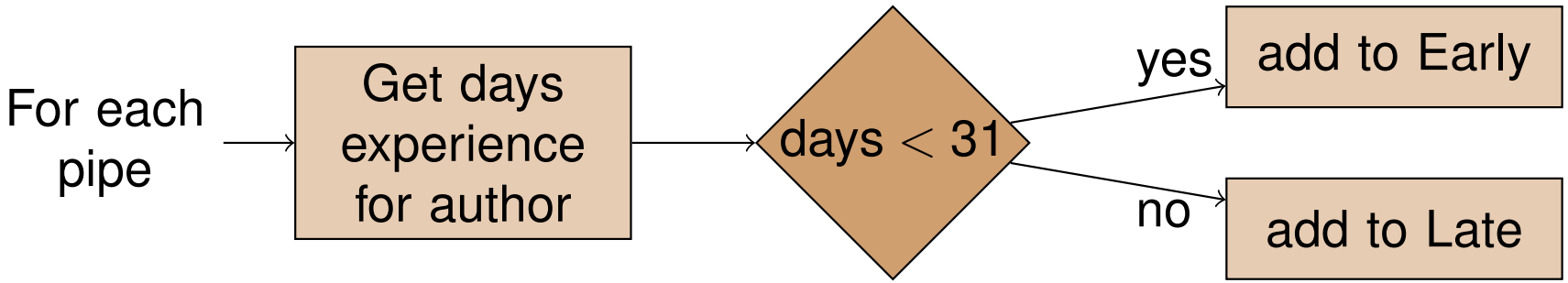
Research Questions

RQ2: How do pipe attributes change as authors gain experience?

- 2a: measures experience in terms of time
- 2b: measures experience in terms of total contributions

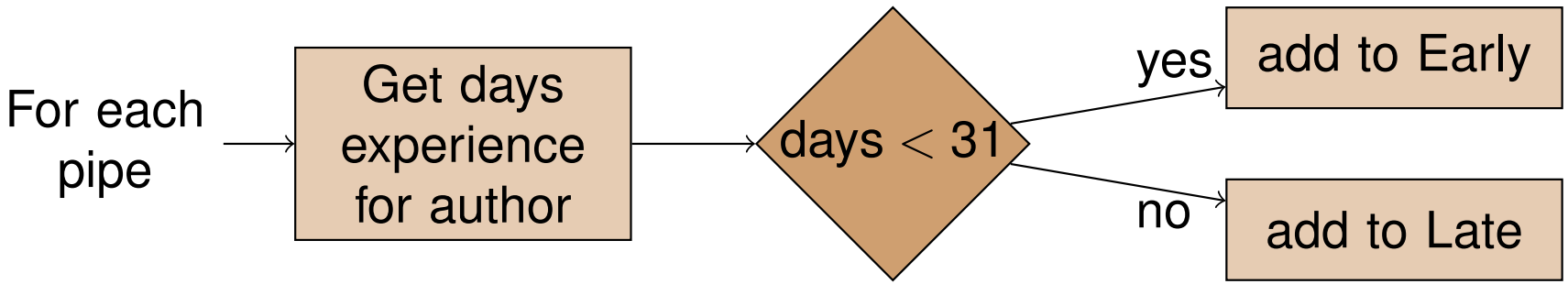
RQ2: Analysis of artifacts as authors gain experience

Comparisons based on experience (time)



RQ2: Analysis of artifacts as authors gain experience

Comparisons based on experience (time)



Characteristic	μ_{early}	μ_{late}
# of Pipes	27,555	5,332
Diversity***	3.519	4.126
Popularity***	4.984	9.254
Configurability***	0.614	0.838
Size***	7.919	9.587

$H_0 : \mu_{early} > \mu_{late}$
$H_a : \mu_{early} \leq \mu_{late}$

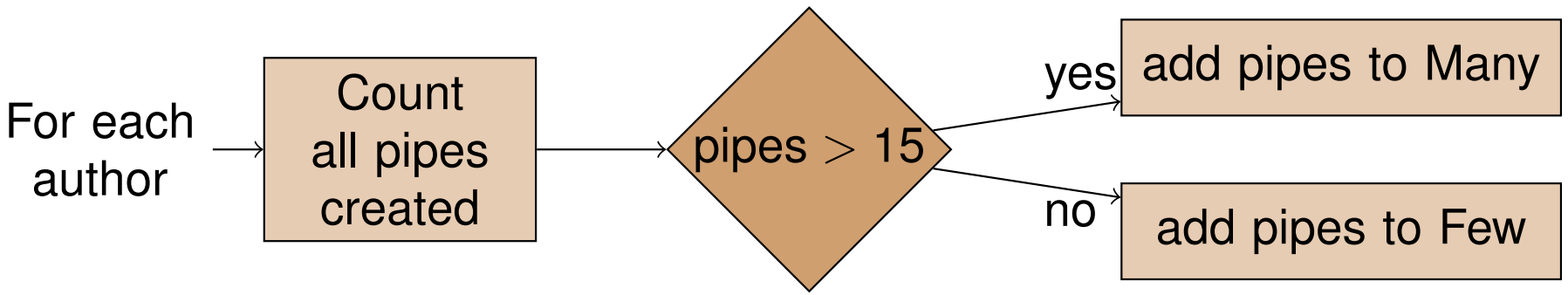
Signif. codes:
*** 0.001 ** 0.01

RQ2: Analysis of artifacts as authors gain experience

Take Away: More experience results in pipes that are larger, more popular, more configurable, and more diverse

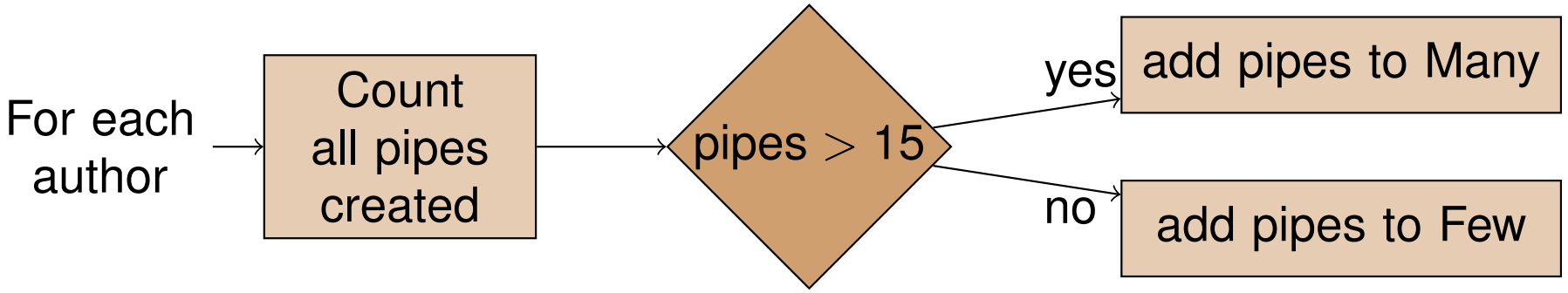
RQ2: Analysis of artifacts as authors gain experience

Comparisons based on contributions



RQ2: Analysis of artifacts as authors gain experience

Comparisons based on contributions



Characteristic	μ_{few}	μ_{many}
# of Pipes	30,503	2,384
Diversity	3.639	3.355
Popularity***	4.302	23.250
Configurability***	0.644	0.729
Size**	8.194	8.136

$H_0 : \mu_{few} > \mu_{many}$
$H_a : \mu_{few} \leq \mu_{many}$

Signif. codes:
*** 0.001 ** 0.01

RQ2: Analysis of artifacts as authors gain experience

Take Away: The most prolific authors create pipes that are larger, more popular, and more configurable

. . . what about diversity?

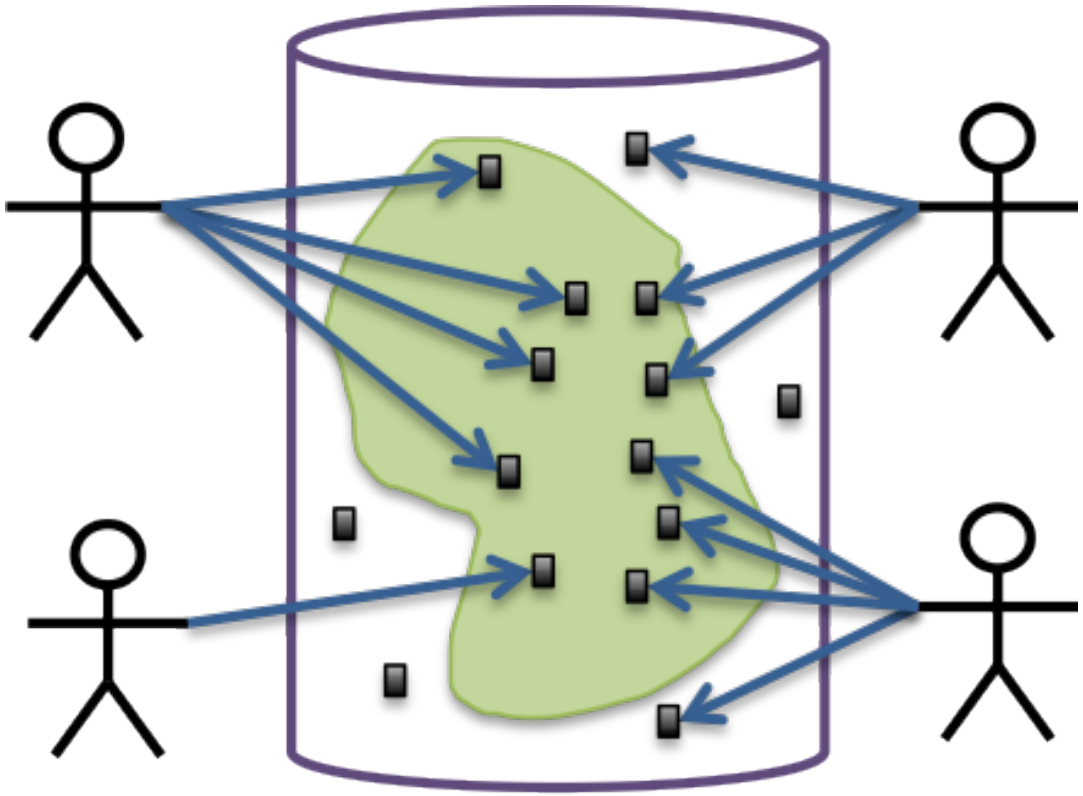
Research Questions

RQ3: What are the characteristics of most prolific authors?

- 3a: author activities
- 3b: author skills
- 3c: awareness of the community

RQ3: Characteristics of most prolific authors

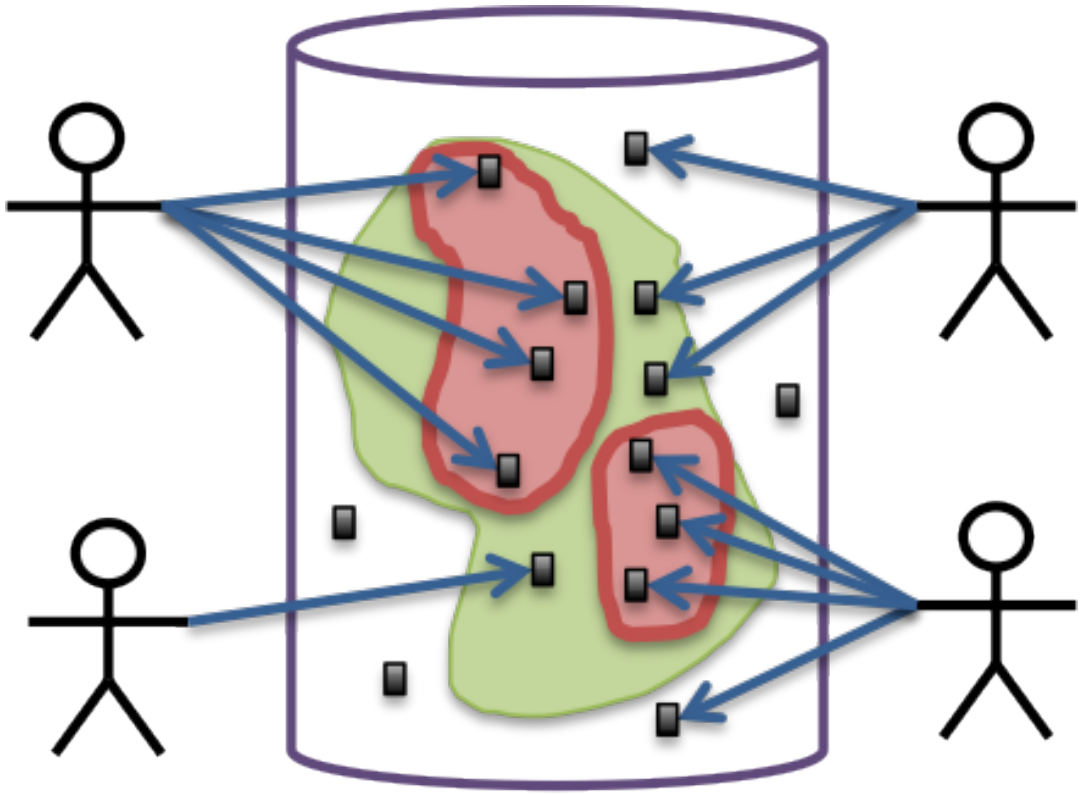
Study Set-up



Authors: 20,313

RQ3: Characteristics of most prolific authors

Study Set-up

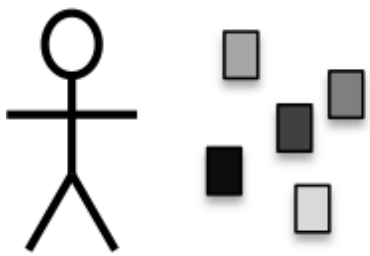


Authors: 20,313

Prolific Authors: 81

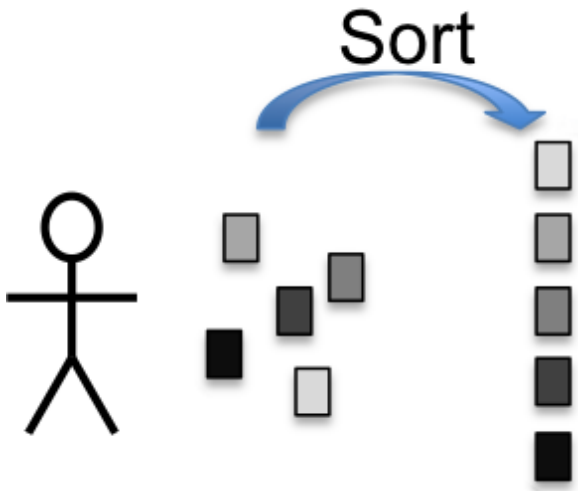
RQ3: Characteristics of most prolific authors

Rolling Cluster Analysis



RQ3: Characteristics of most prolific authors

Rolling Cluster Analysis

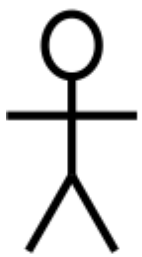


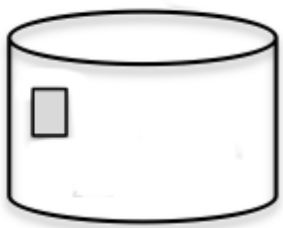
RQ3: Characteristics of most prolific authors

Rolling Cluster Analysis

RQ3: Characteristics of most prolific authors

Rolling Cluster Analysis





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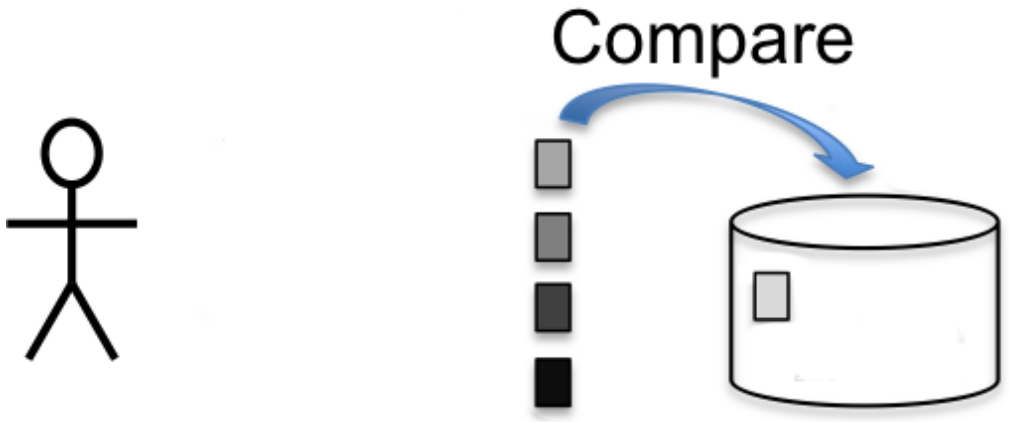

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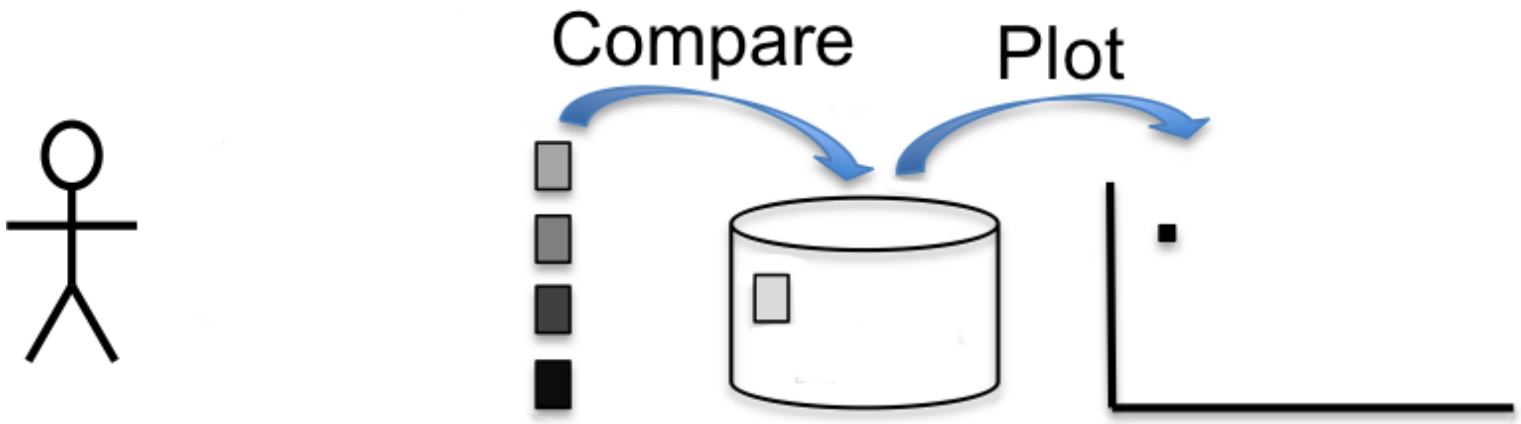

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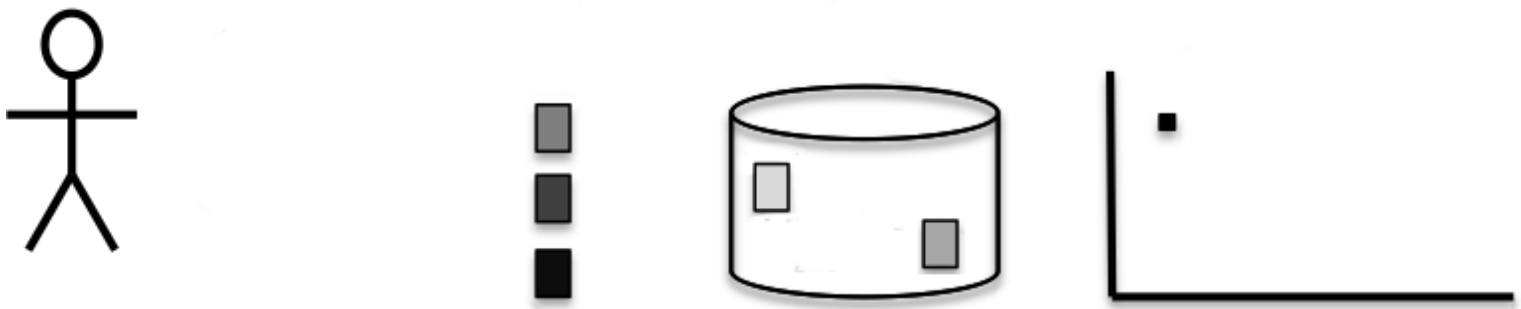

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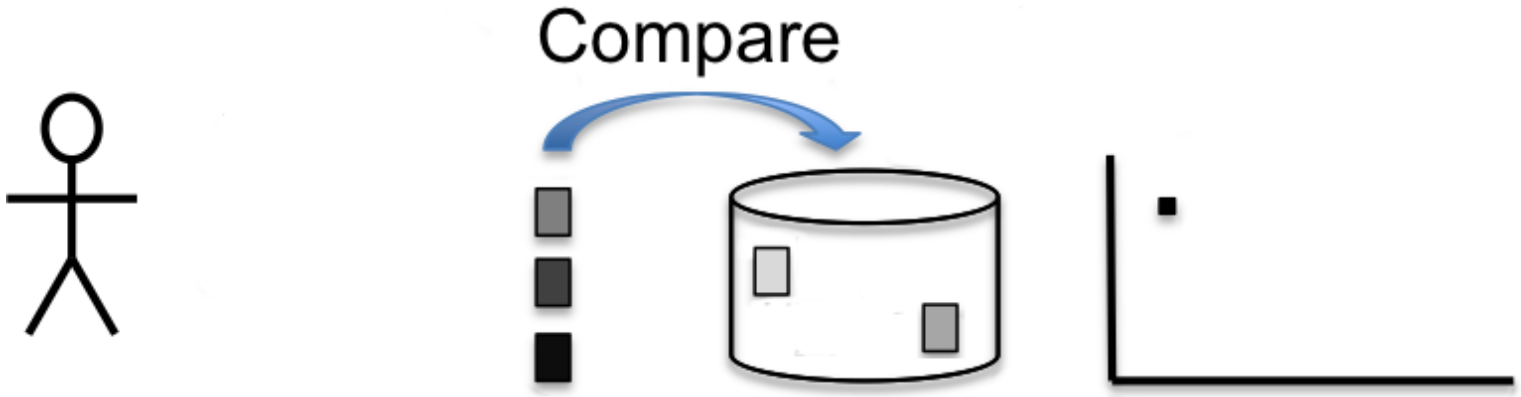

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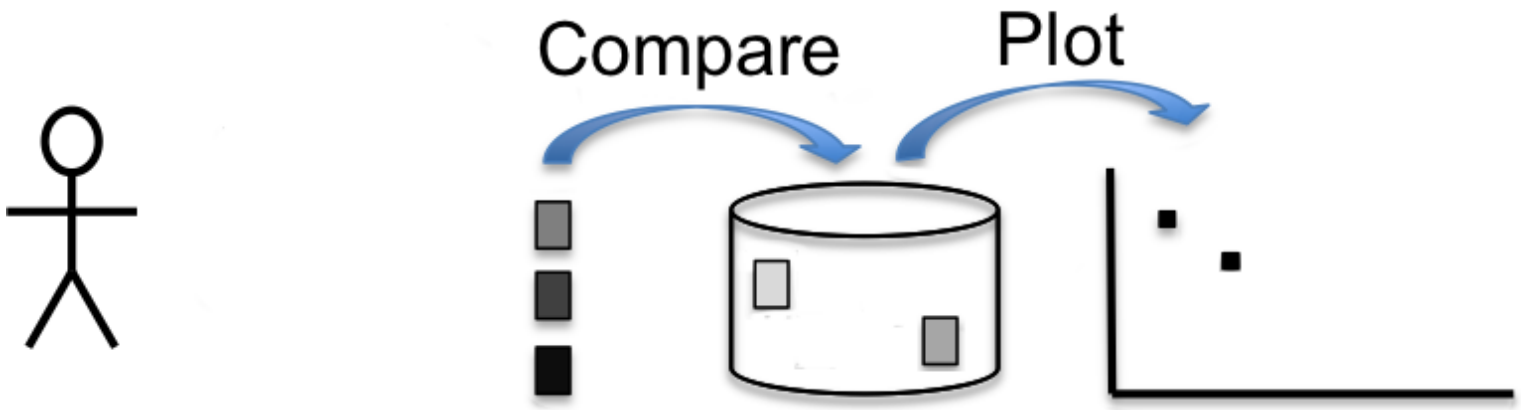

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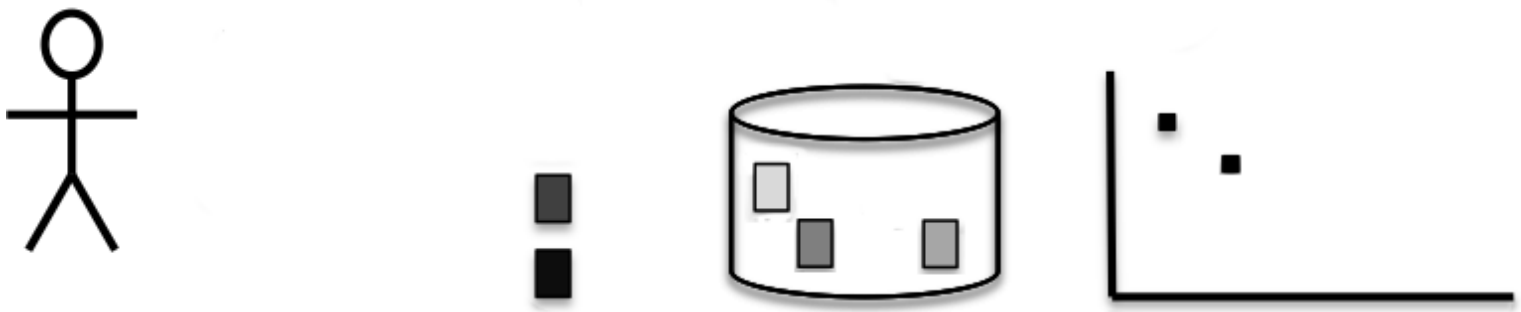

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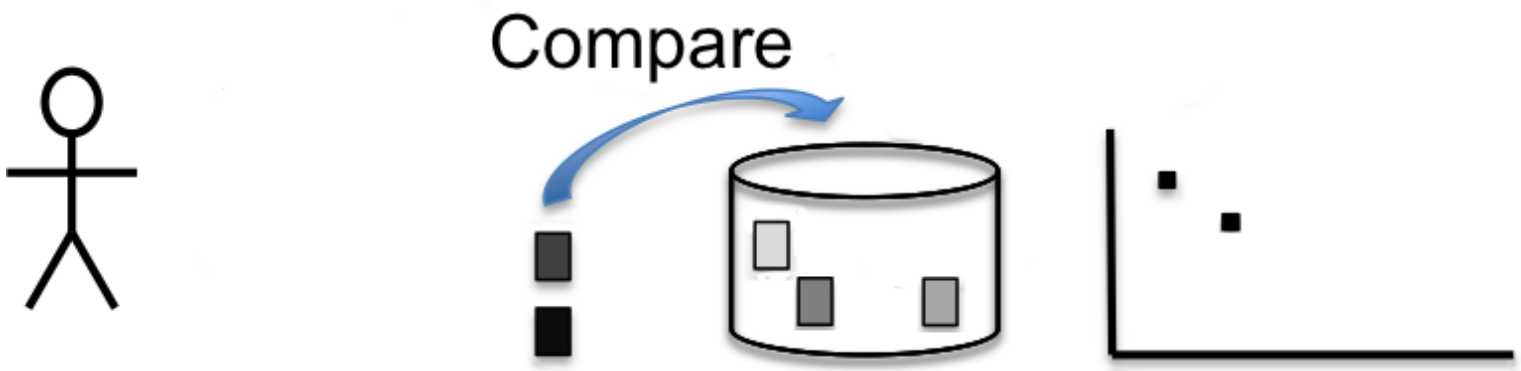

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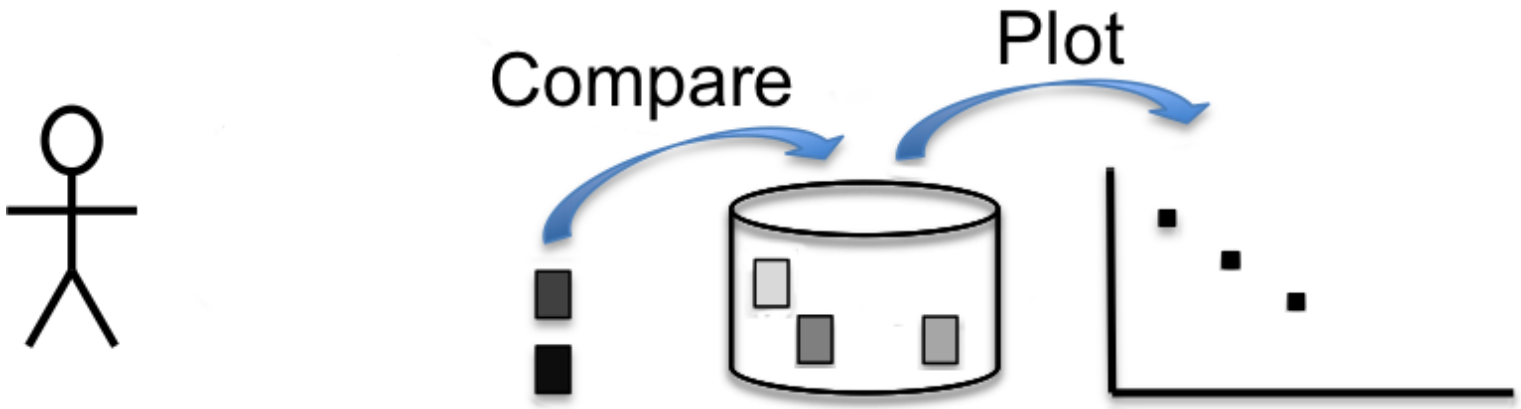

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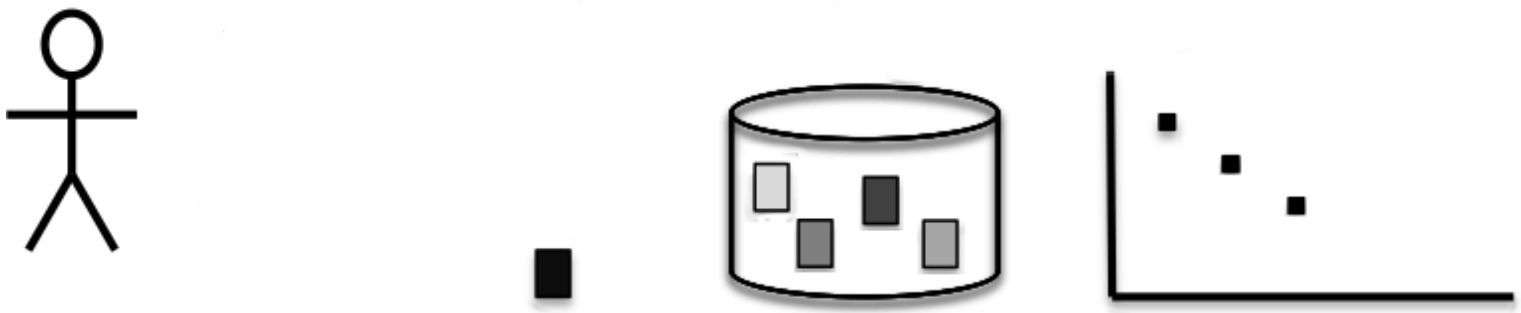

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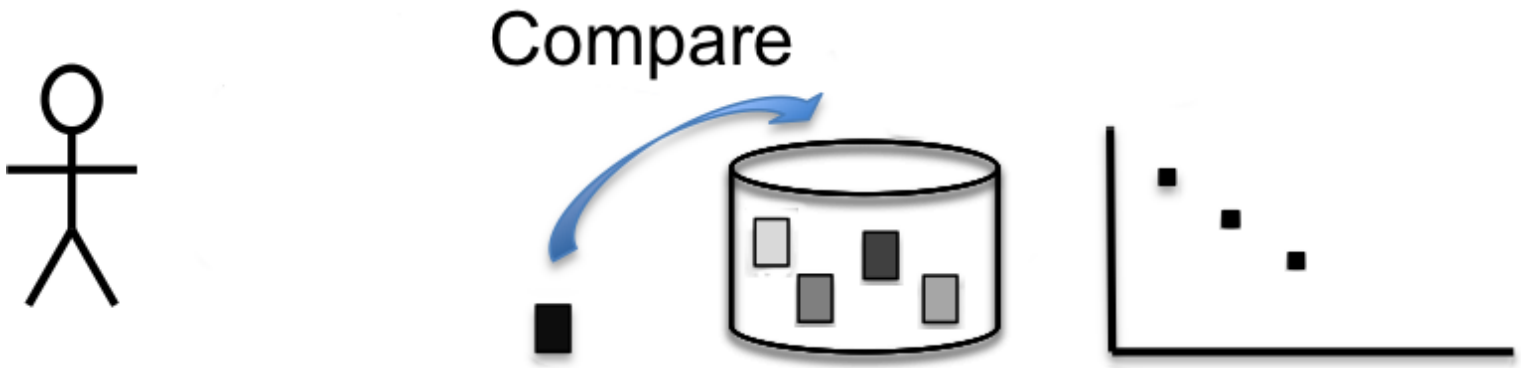

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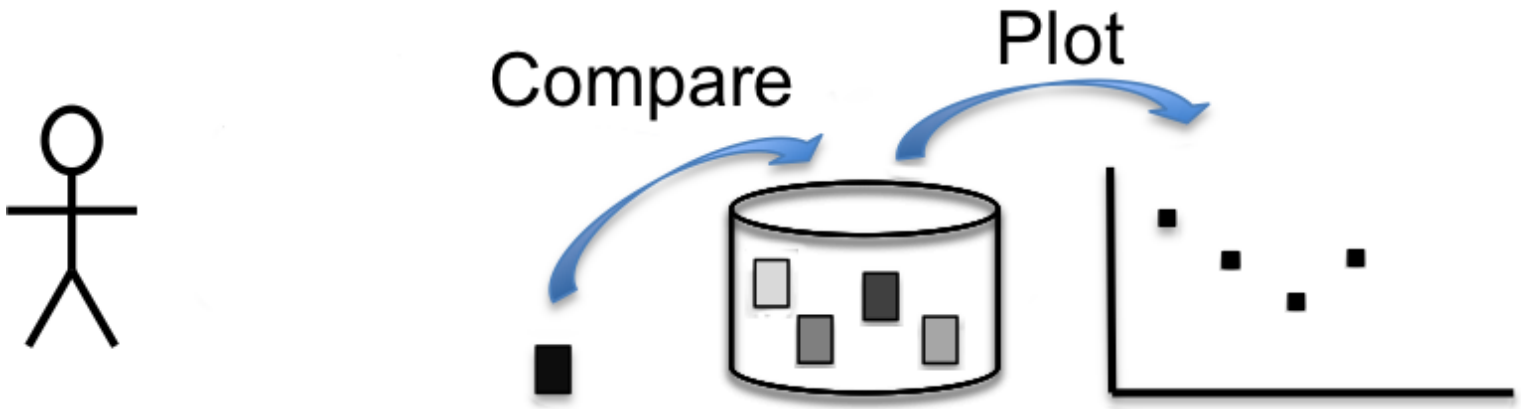

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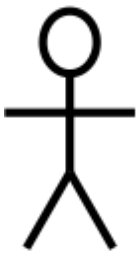
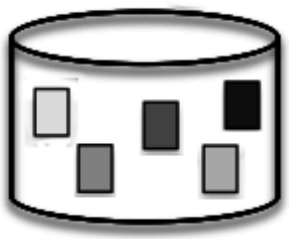
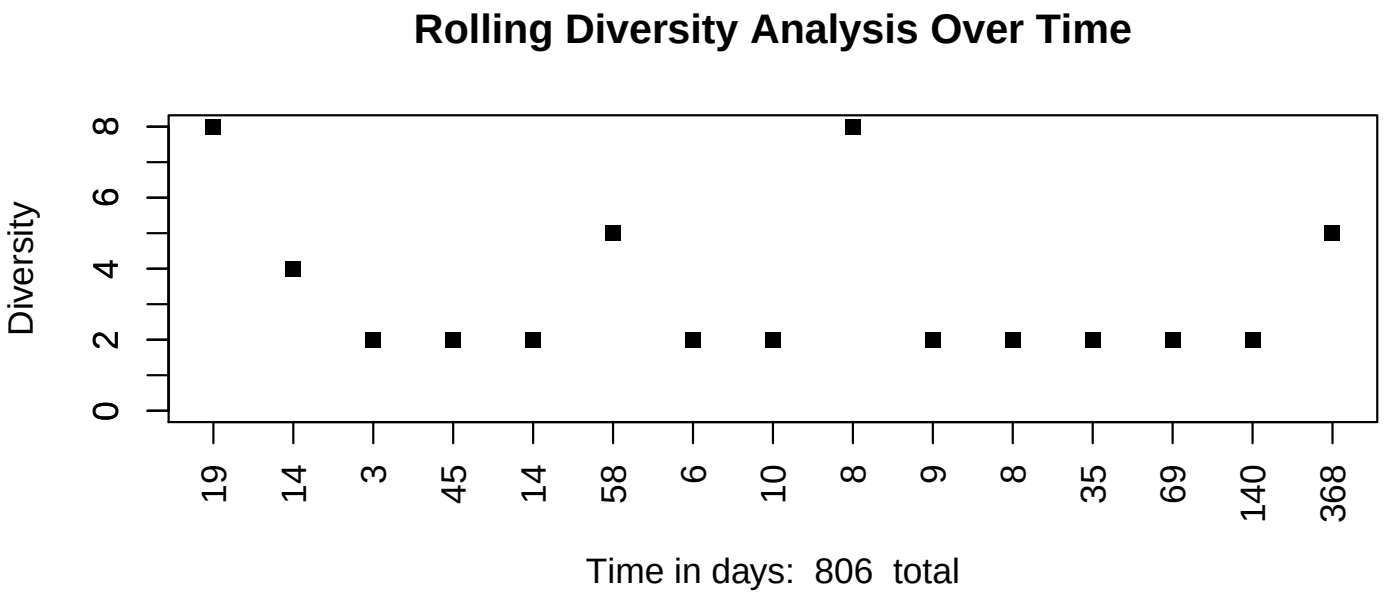




RQ3: Characteristics of most prolific authors

Author Activities



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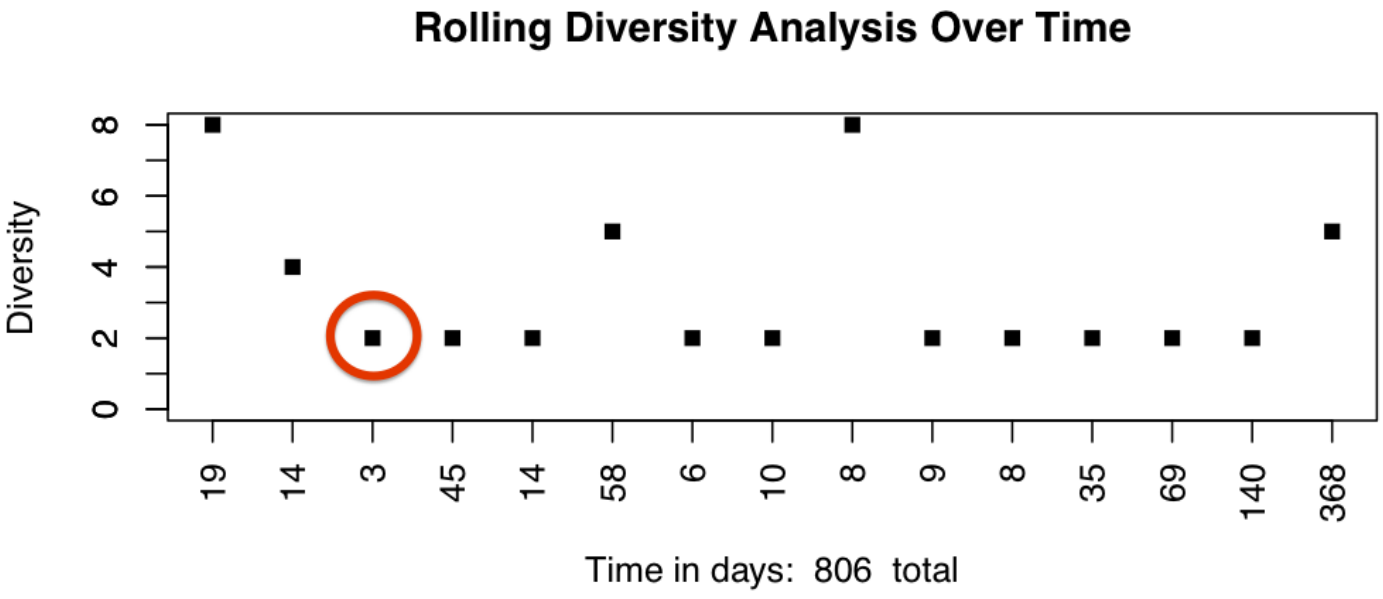


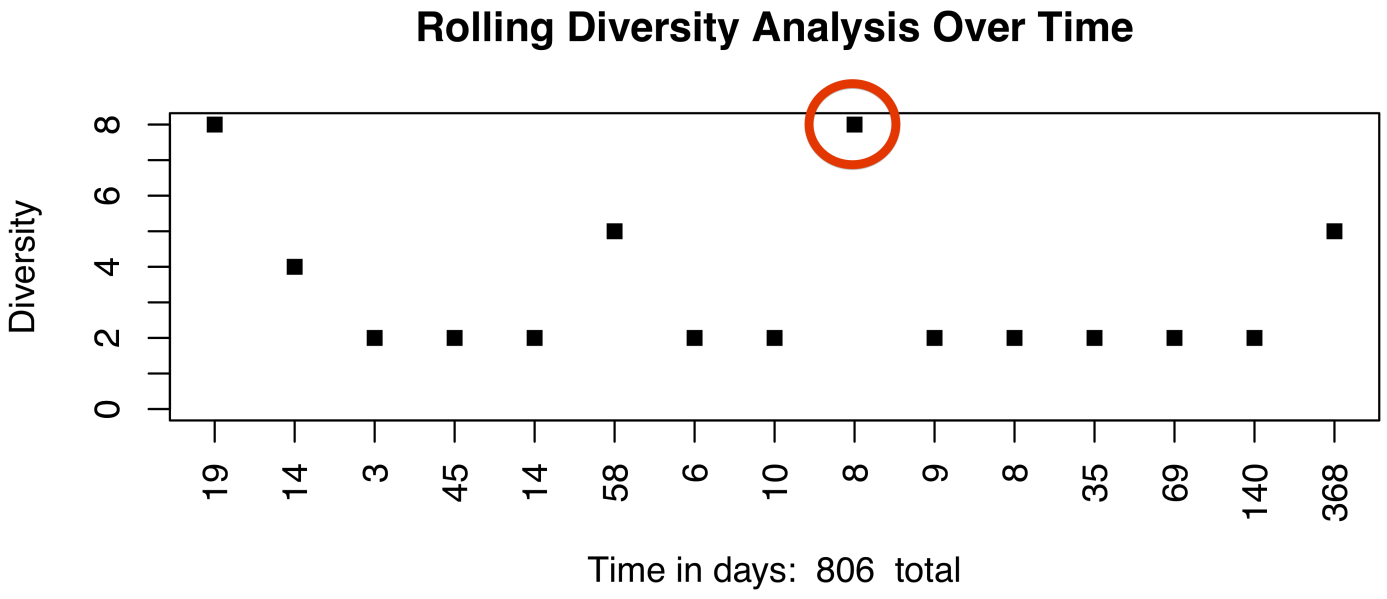
Level 2: Same structure and field counts; relax field values

43% of pipes submitted by prolific authors represent tweaks

For Example: Change a URL, filter criterion, sort order, . . .

RQ3: Characteristics of most prolific authors

Author Activities

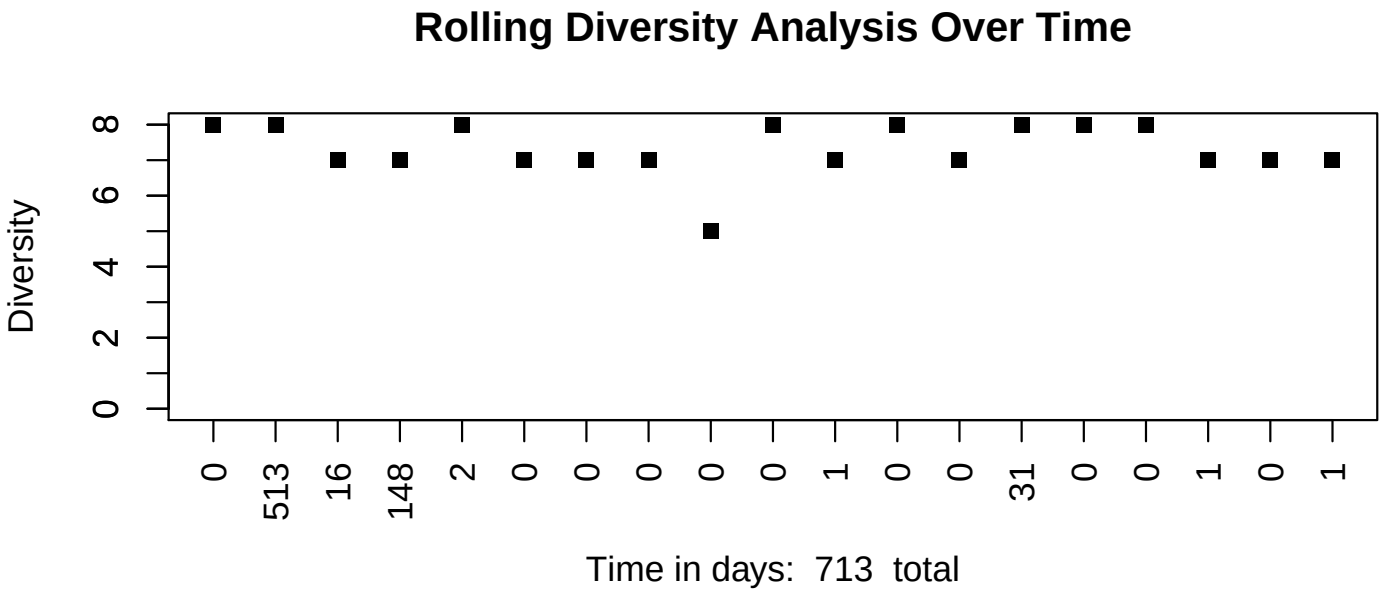


Level 8: No structural similarities

43% of pipes submitted by prolific authors represent tweaks
52% of pipes submitted by prolific authors represent new initiatives

RQ3: Characteristics of most prolific authors

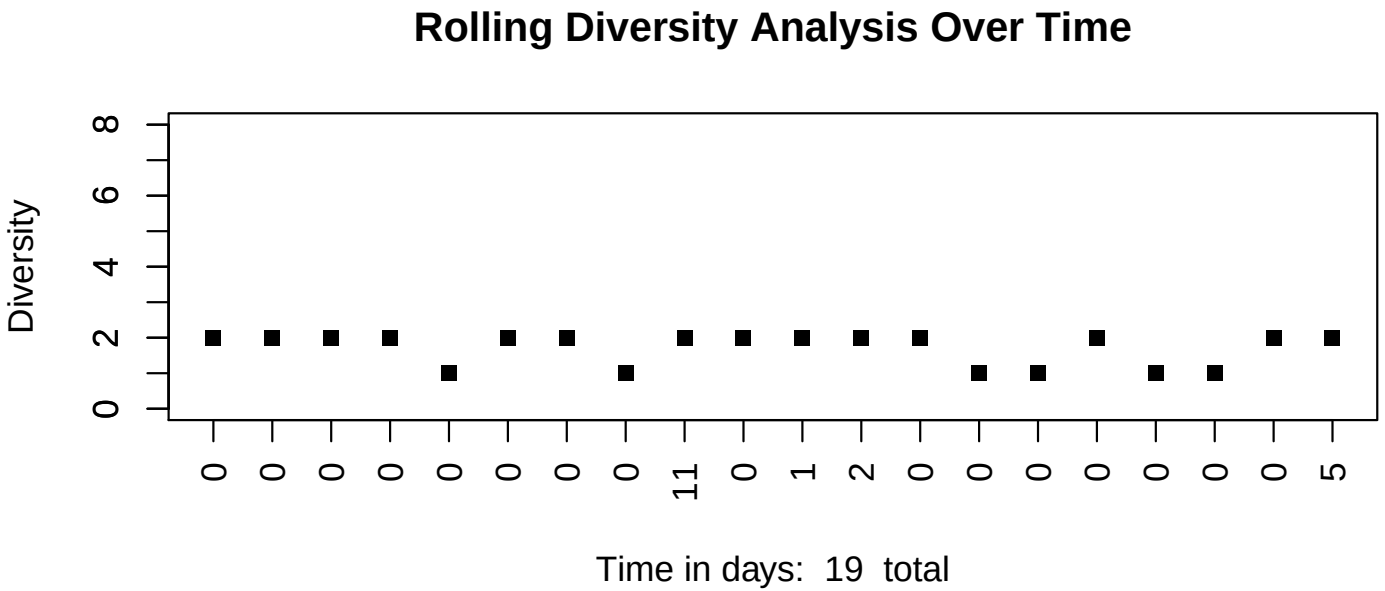
Author Activities



56% of prolific authors consistently submit new initiatives

RQ3: Characteristics of most prolific authors

Author Activities



27% of prolific authors consistently submit tweaks

RQ3: Characteristics of most prolific authors

Take Away #1: 1/2 of participants submit pipes that are novel to their previous contributions

Take Away #2: 1/4 of participants submit pipes that are tweaks of their other pipes

The *real* take away

End-user programmer communities may need . . .

- moderators.
  - → Repository is cluttered with highly similar artifacts (RQ1)

The *real* take away

End-user programmer communities may need . . .

- moderators.
  - → Repository is cluttered with highly similar artifacts (RQ1)
- more sophisticated repository search.
  - → Many pipes are very structurally similar to other pipes in the repository (RQ1)
  - → Early authors create less diverse pipes than later authors (RQ2)

The *real* take away

End-user programmer communities may need . . .

- moderators.
  - → Repository is cluttered with highly similar artifacts (RQ1)
- more sophisticated repository search.
  - → Many pipes are very structurally similar to other pipes in the repository (RQ1)
  - → Early authors create less diverse pipes than later authors (RQ2)
- artifact development support.
  - → Tweaks represent missed opportunities for parameterization (RQ3)
  - → Many shared pipes are tweaks on previously-committed pipes by the same author (RQ3)

Threats to Validity

- Internal
  - → History (the pipes were sampled at different times)
  - → Selection (the repository only provides public pipes)
- Construct
  - → Interaction of different factors
  - → Mono-method bias on diversity (only consider structural diversity, not semantic)
- External
  - → Generalizability (only studied one community)
  - → Sampling bias (could not control search results when sampling)

Conclusion

- Authors utilize the repository in different ways
- As authors gain experience in the environment, they tend to make more valuable contributions to the repository
- There is a need for better support to help end-user programmer communities continue to progress and grow
- To generalize the results, we are interested in extending the metrics to other languages and repositories

To facilitate replication, the data used in this analysis is available:
`http://cse.unl.edu/~kstolee/esem2011/artifacts.html`

Backup

Future Work

Extend this study to other end-user programming communities.
Metric considerations:

Size: requires some measure of program size and/or complexity

Configurability: requires some notion of abstraction or measure of configuration

Popularity: requires some notion of clones, copies, favorites, etc. to indicate community approval

Diversity: For structured languages, this metric can be adapted by mapping fields and modules to the language-specific structures

RQ1: Characteristics of Yahoo! Pipes Community

RQ1a: Attrition of contributors

82% of the 20,313 authors were active for only one day

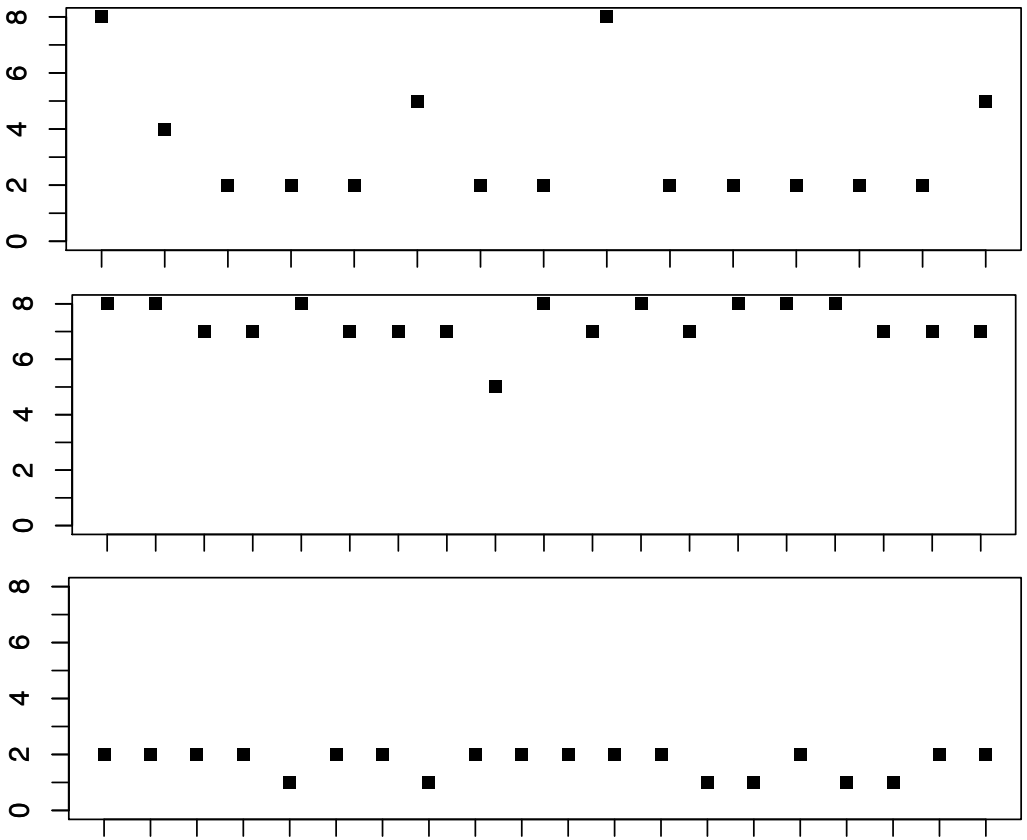
RQ1b: Author contributions

76% of authors submitted only one pipe
24% of authors submitted 53% of the pipes

Take Away: This end-user community has attrition and contribution patterns similar to other online communities

RQ3: Characteristics of most prolific authors

RQ3b: Author Skills



17.2% of prolific authors exhibit a variable skills pattern

55.6% of prolific authors exhibit a high skills pattern

27.2% of prolific authors exhibit a low skills pattern

Take Away: Authors utilize the repository in different ways

RQ3: Characteristics of most prolific authors

RQ3c: Author Awareness

Two types of awareness:

Local : awareness of author's previous contributions

Community : awareness of pipes in community

Local		Community	Awareness	Avg. % of Pipes
low	$=$	low	None	50.06%
*	$>$	*	Local	19.20%
high	$=$	high	Community	30.74%

Take Away: Authors have varying levels of community awareness