

# What's Hot and What's Not: Windowed Developer Topic Analysis

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Software Architecture Group

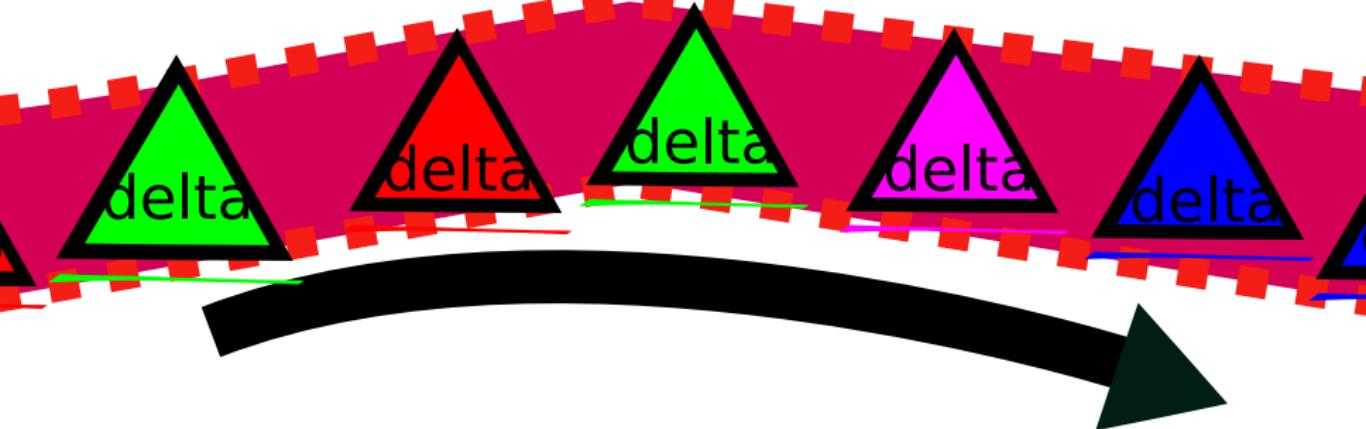
David R. Cheriton School of Computer Science

University of Waterloo

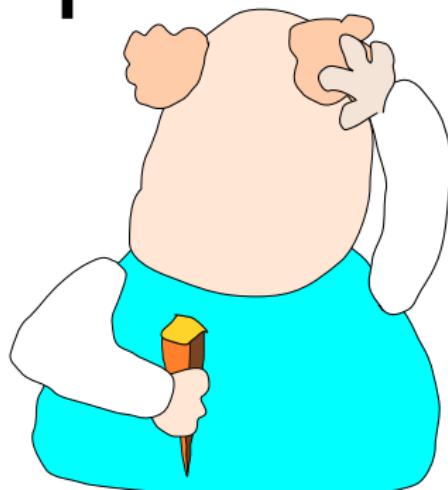
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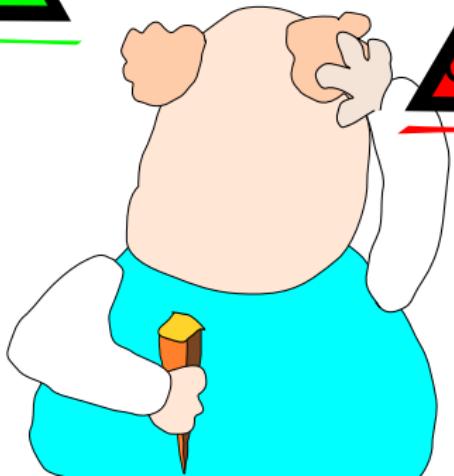
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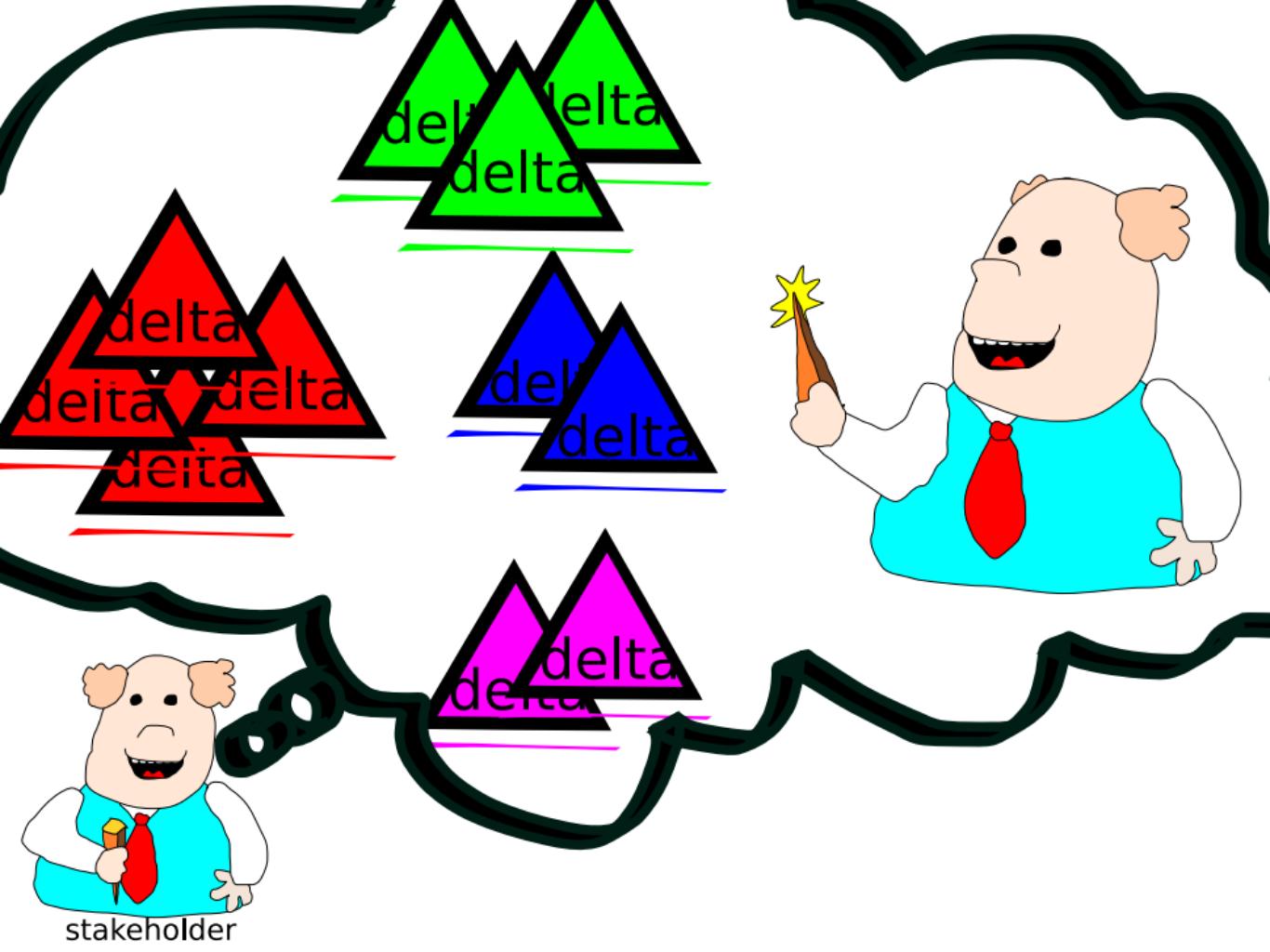
{ahindle,migod,holt}@cs.uwaterloo.ca



# Development History

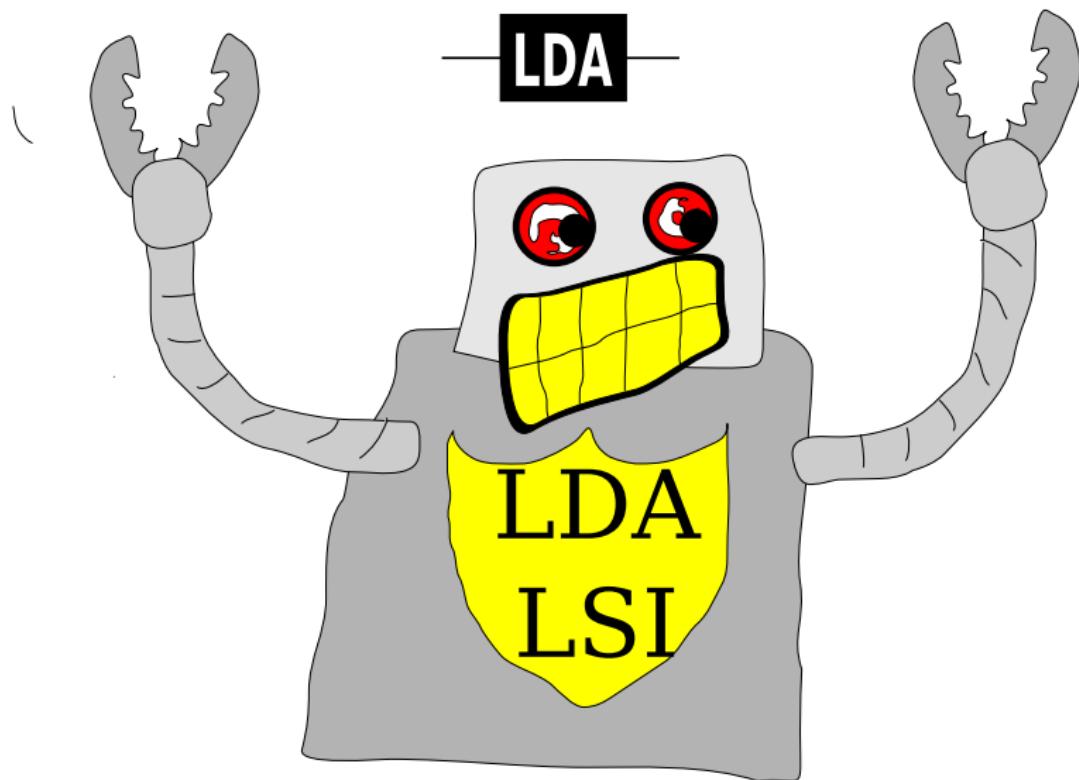




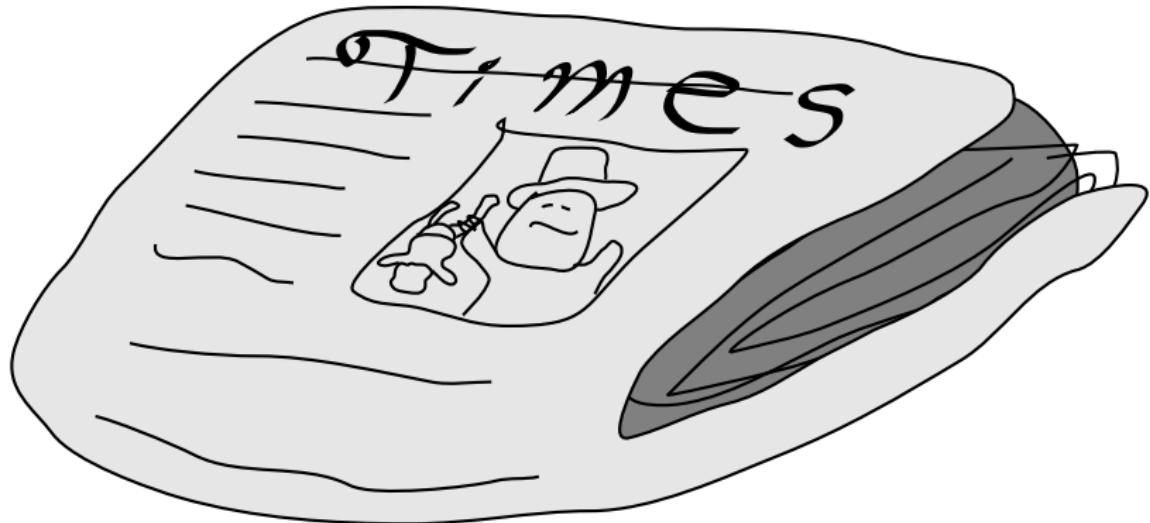




# Our blackbox

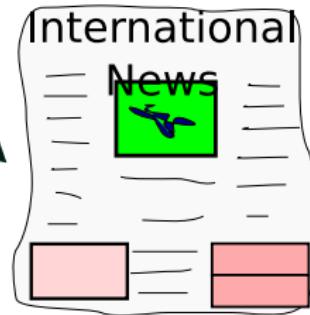
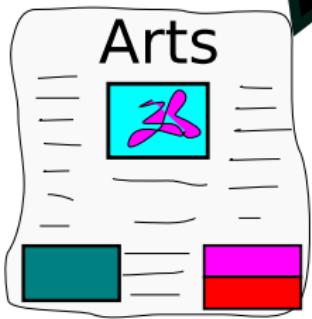
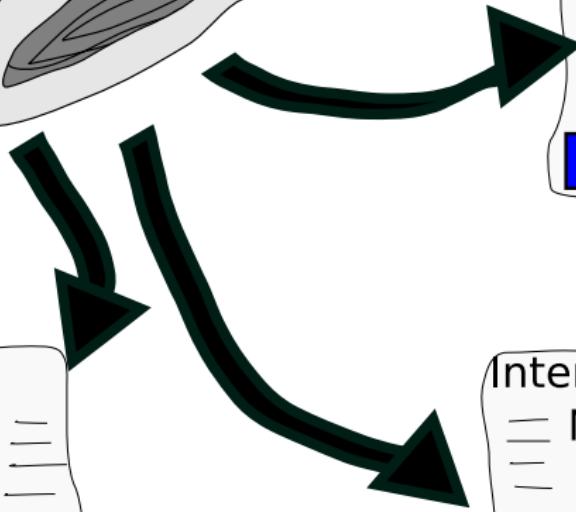
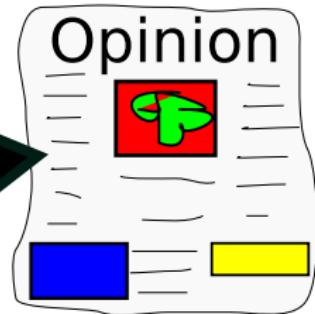
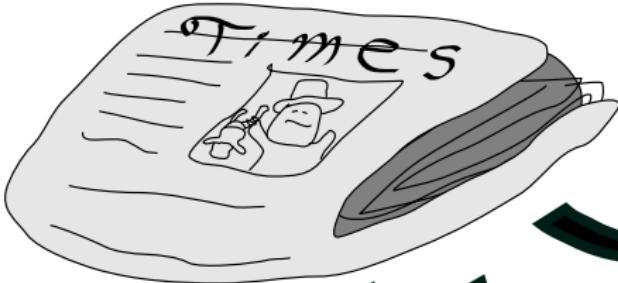


# Example

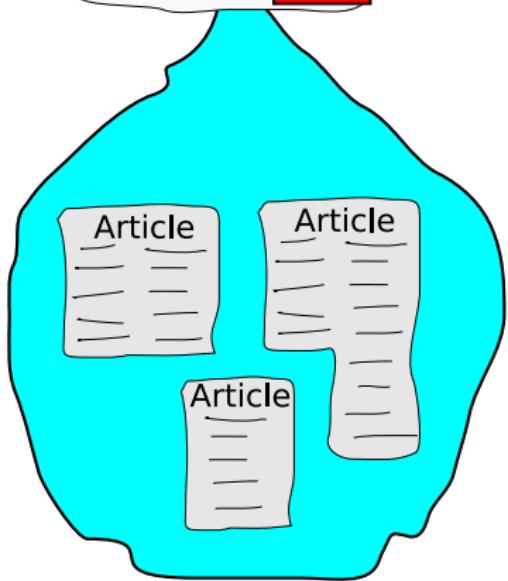
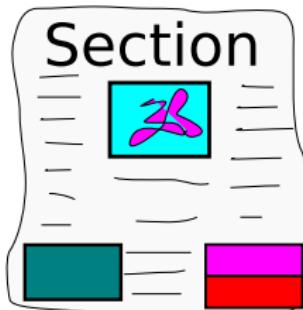


[Blei]

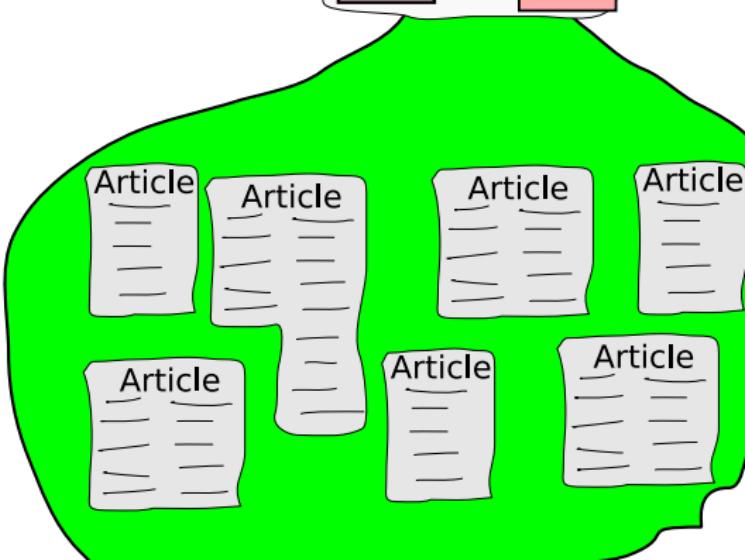
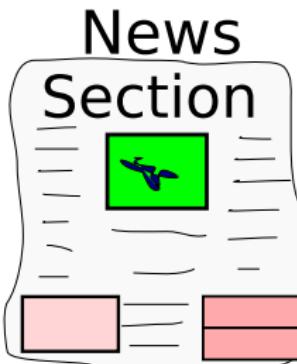
**apologies to those with  
prior LDA/LSI experience**



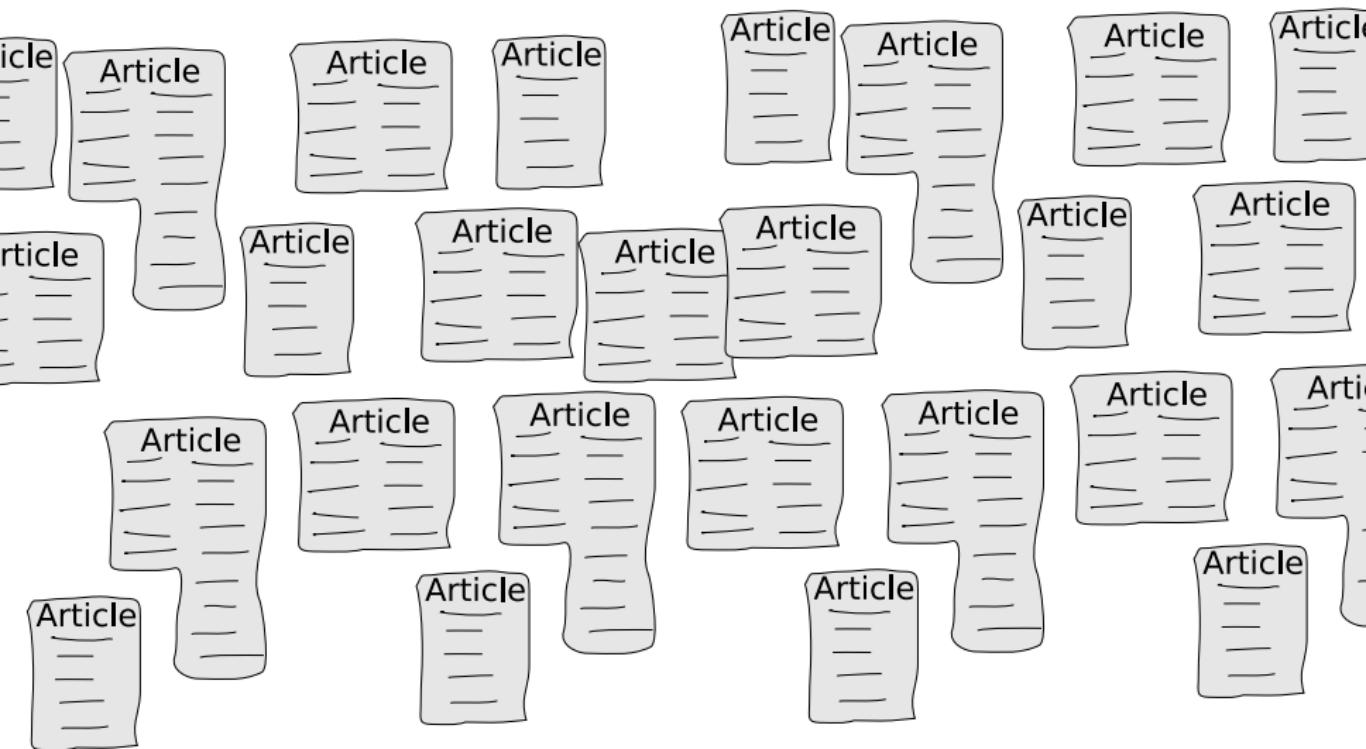
# Arts

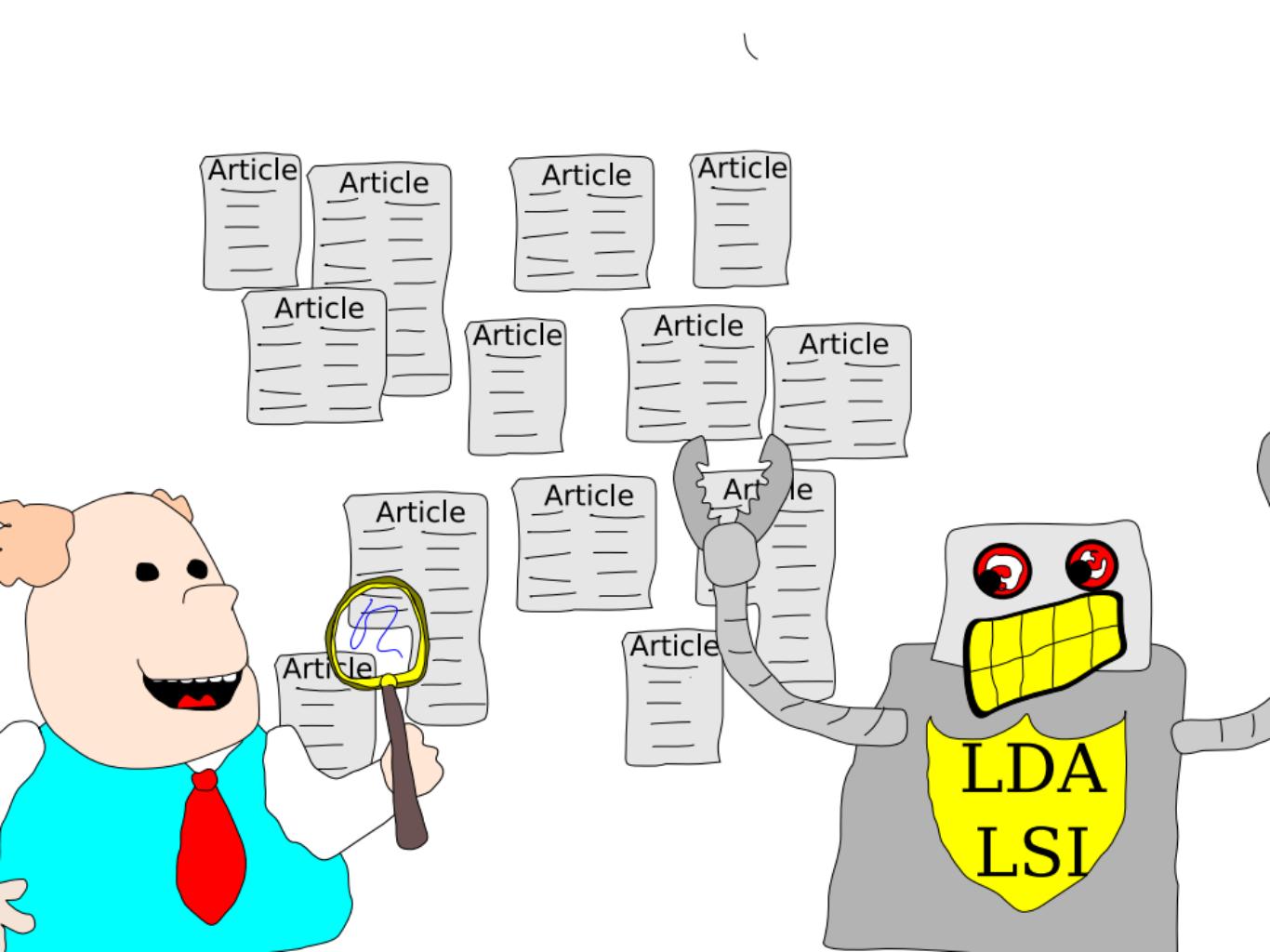


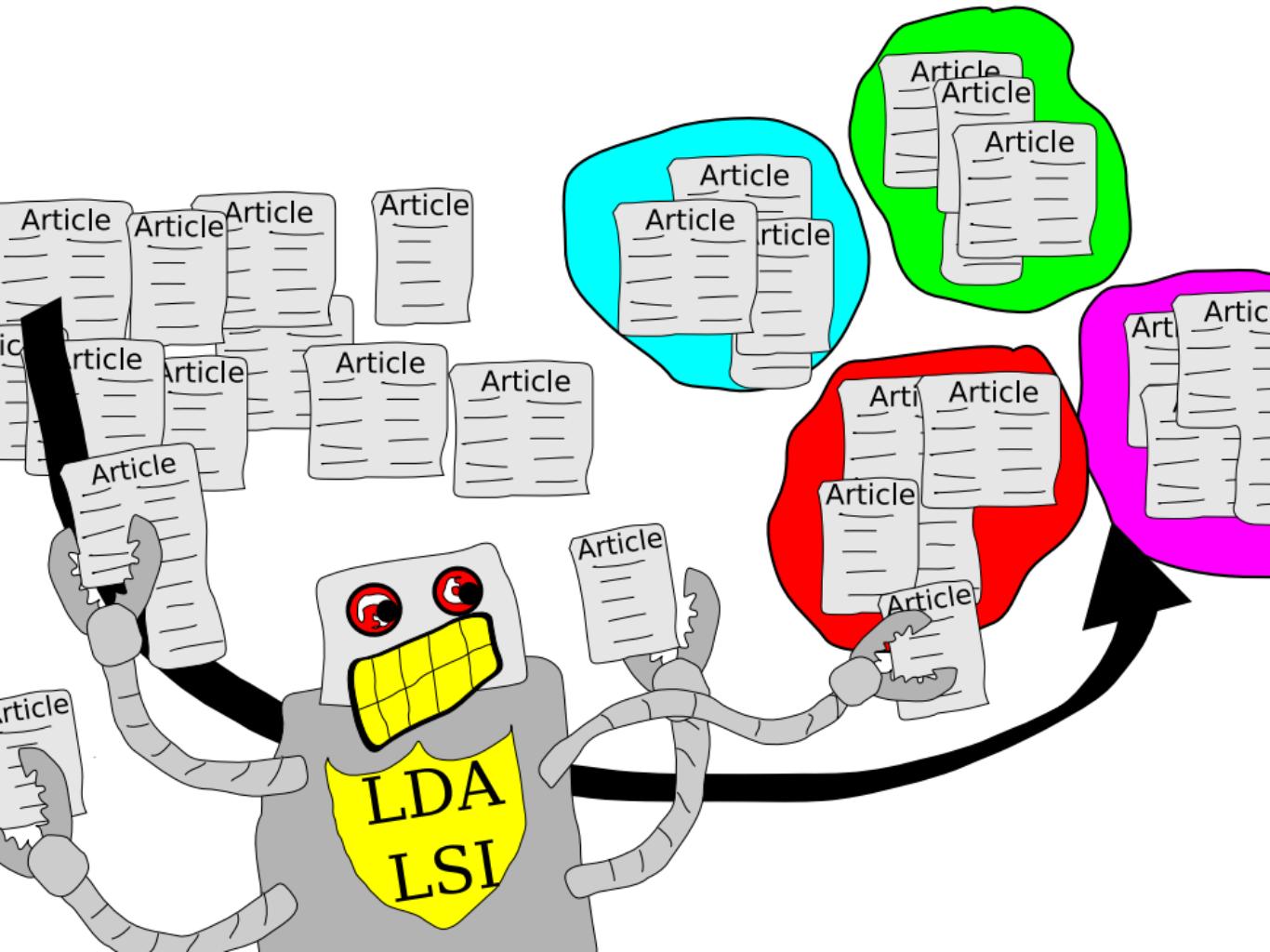
# International



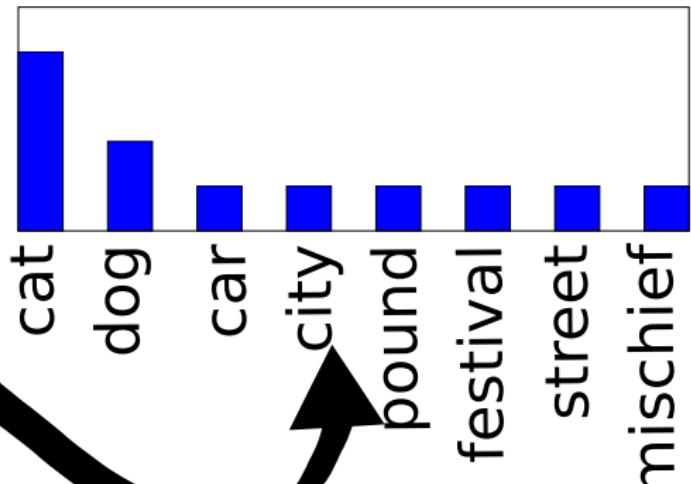
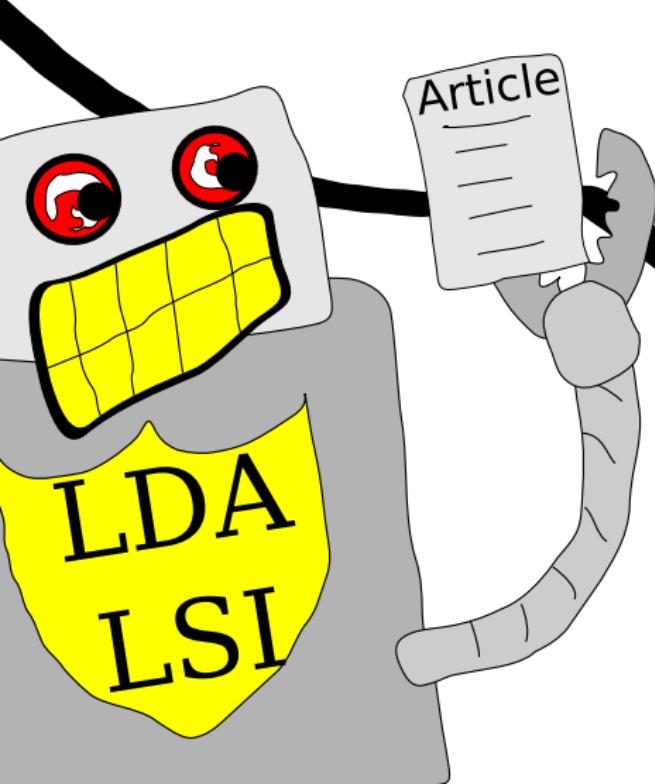
# What if we didn't know what section the articles were in?





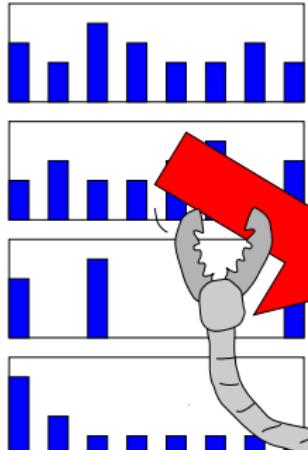


# Word Distribution

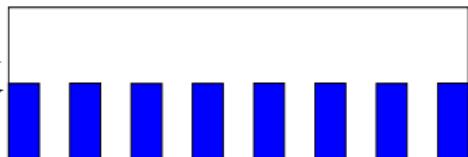


Documents are represented as word distributions (word counts)

## Word Distributions

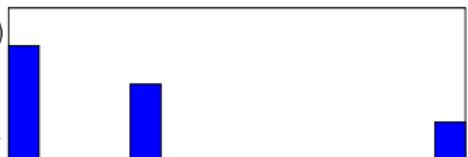


## Topics: Independent Word Distributions



LDA finds independent word distributions that the documents are related to.

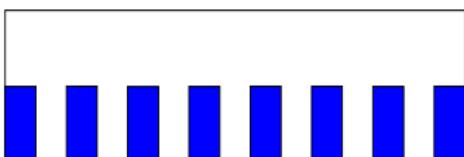
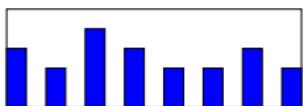
Documents can be associated with more than one topic.



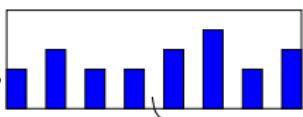
# Topics: Independent Word Distributions

Original Article      Word Distributions

Baseball  
Movie



Athlete  
and Actor

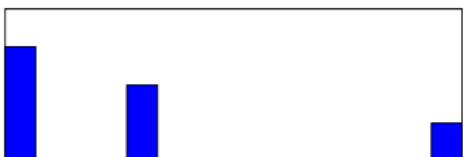
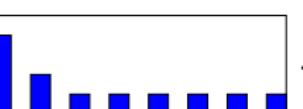


Sports

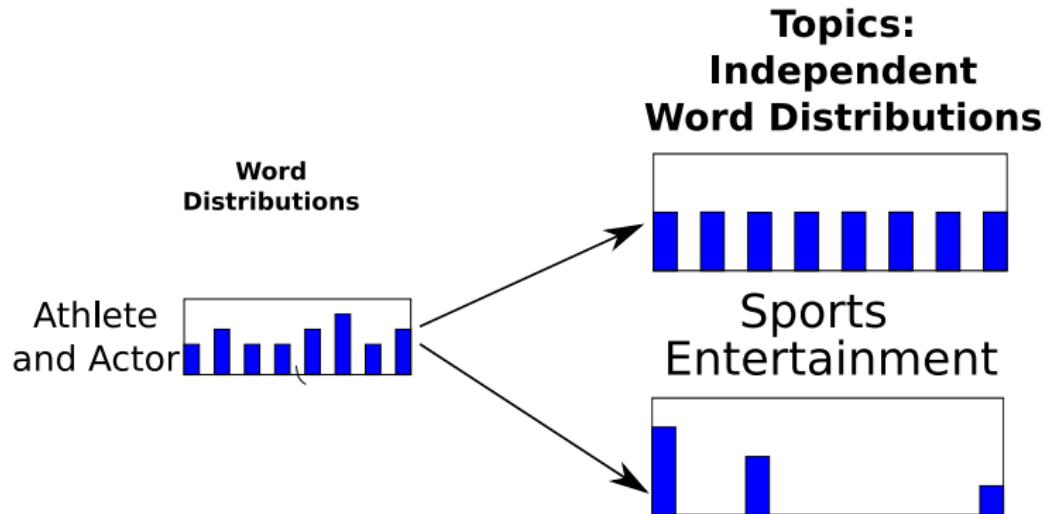
Award  
Nominees



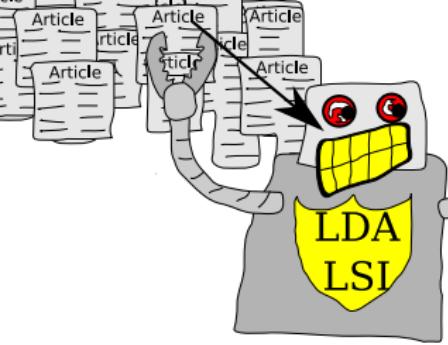
Theatre  
Review



Documents are represented as a linear combination of independent topics



$$C_0 \times \begin{array}{|c|c|c|c|c|c|c|} \hline & \text{Bar 1} & \text{Bar 2} & \text{Bar 3} & \text{Bar 4} & \text{Bar 5} & \text{Bar 6} \\ \hline \end{array} + C_1 \times \begin{array}{|c|c|c|c|c|c|} \hline & \text{Bar 1} & & \text{Bar 3} & & \text{Bar 5} & \\ \hline \end{array} \approx \begin{array}{|c|c|c|c|c|c|} \hline & \text{Bar 1} & \text{Bar 2} & \text{Bar 3} & \text{Bar 4} & \text{Bar 5} & \text{Bar 6} \\ \hline \end{array}$$



Here are two topics. I don't know what they are about!

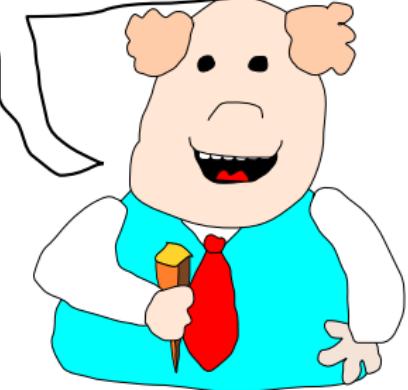
## Topic 1

- \* play
- \* game
- \* inning
- \* player
- \* quarter
- \* opponent
- \*
- ...

## Topic 2

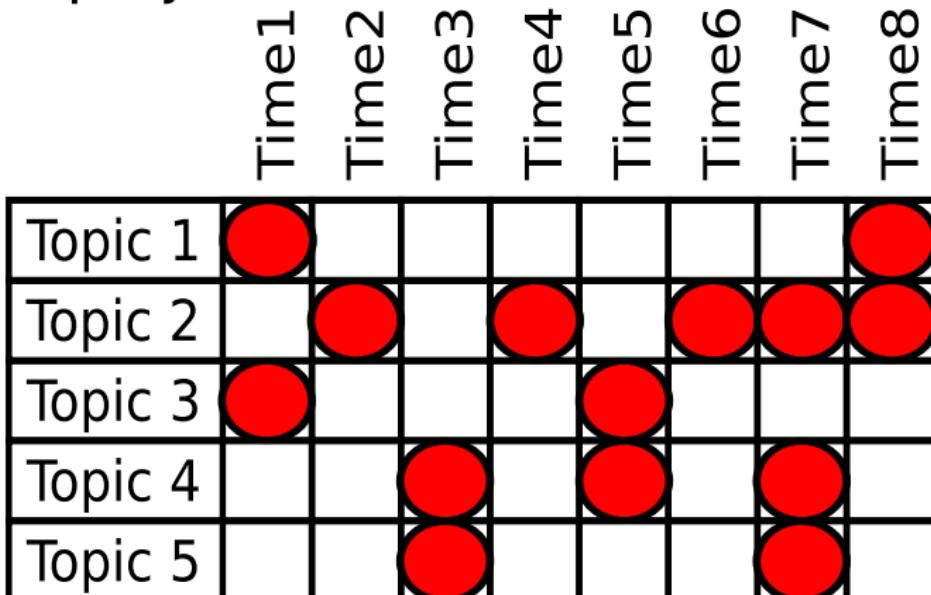
- \* gambling
- \* play
- \* night life
- \* comedy
- \* movie
- \* theatre
- \*
- ...

These word lists look like: **Sports** and **Entertainment** !

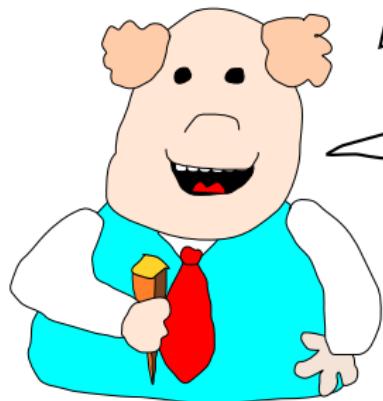


## Previous authors

- \* Linstead et al. & Lukins et al.
- \* analyzed the entire history
- \* extracted N topics across the entire project's life time.



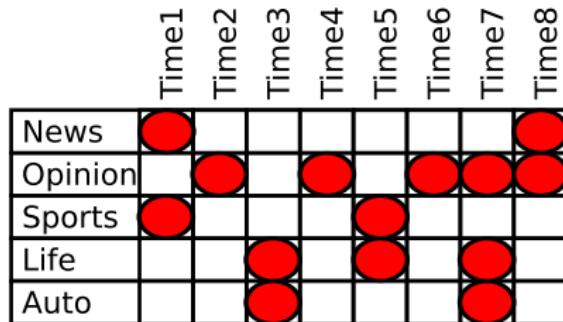
**Topic analysis (LDA) can group articles around topics.  
Can we apply this to software?**



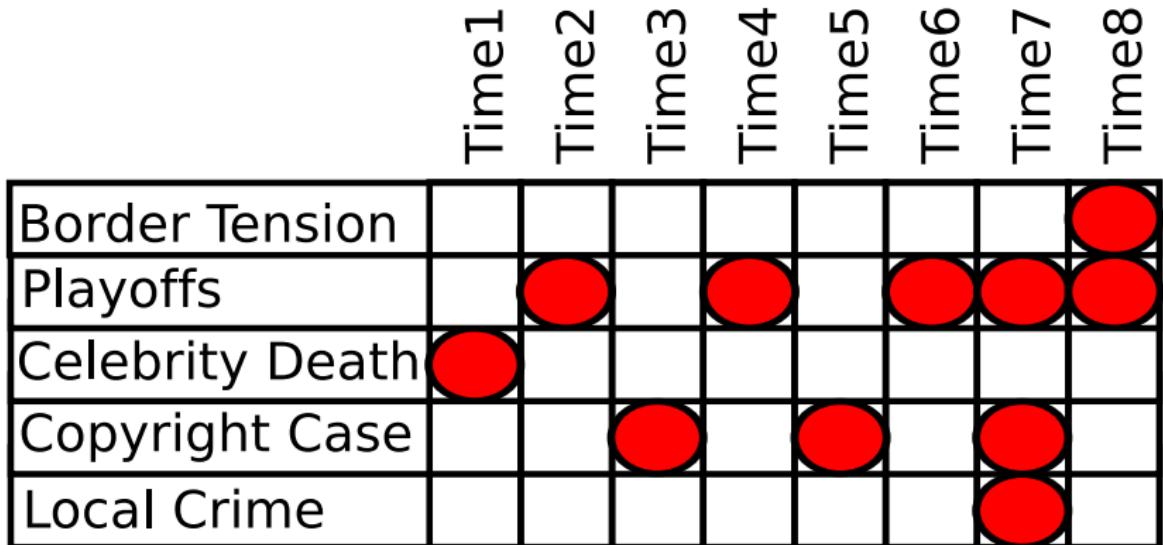
**Can we find topics,  
that developers  
were concerned  
with, from change-  
logs**

# Common topics dominate!

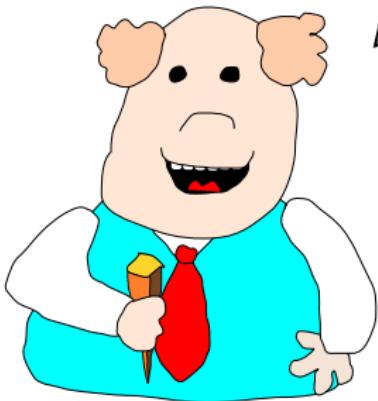
If we did this to newspapers we'd expect to extract the sections, not necessarily local news trends!



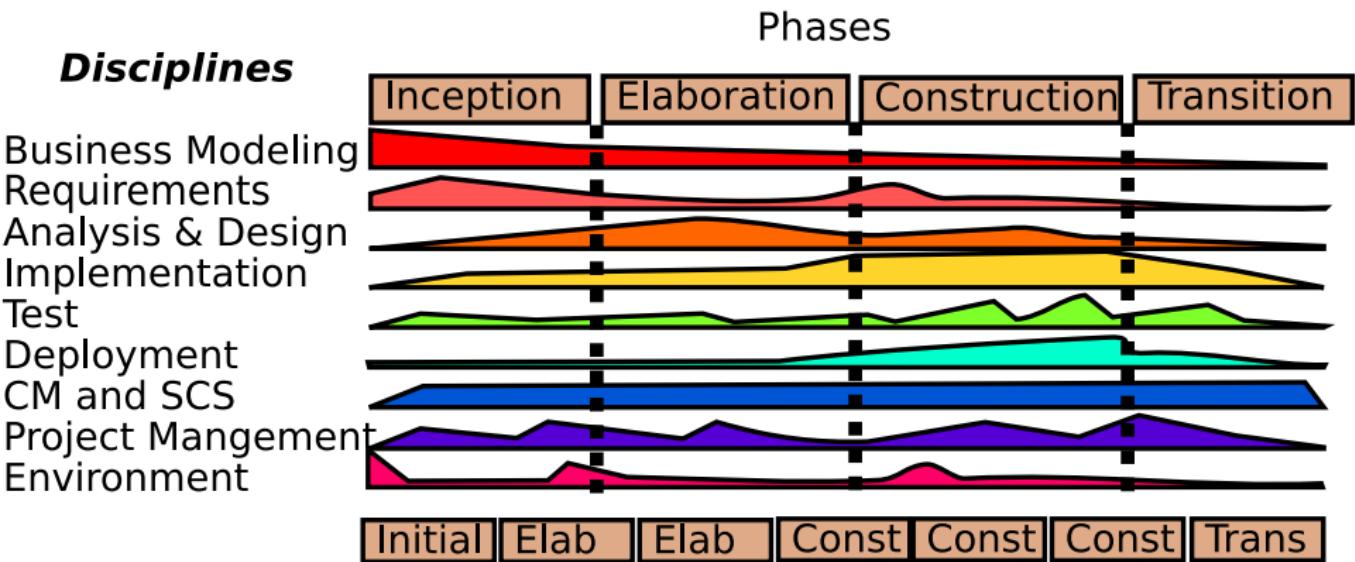
Perhaps more local topics are more interesting?



Local topic analysis is relevant to software because we care about what just occurred and often deal with iterations of development

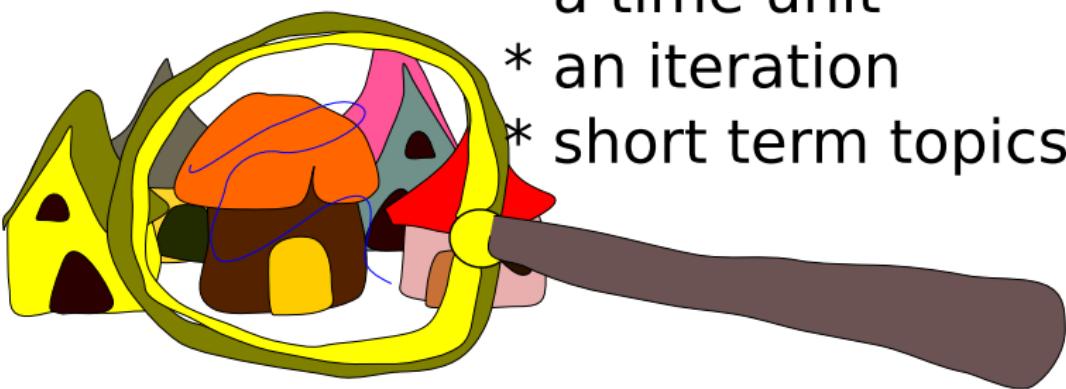


One iteration might have totally different development topics than another



**Iterations**

**This Rational Unified Process** diagram shows different disciplines are used at different times. This is an example of locality.



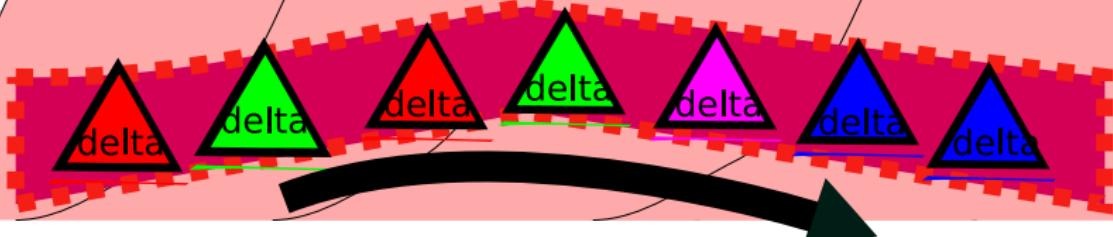
## Local analysis

- \* a time unit
- \* an iteration
- \* short term topics

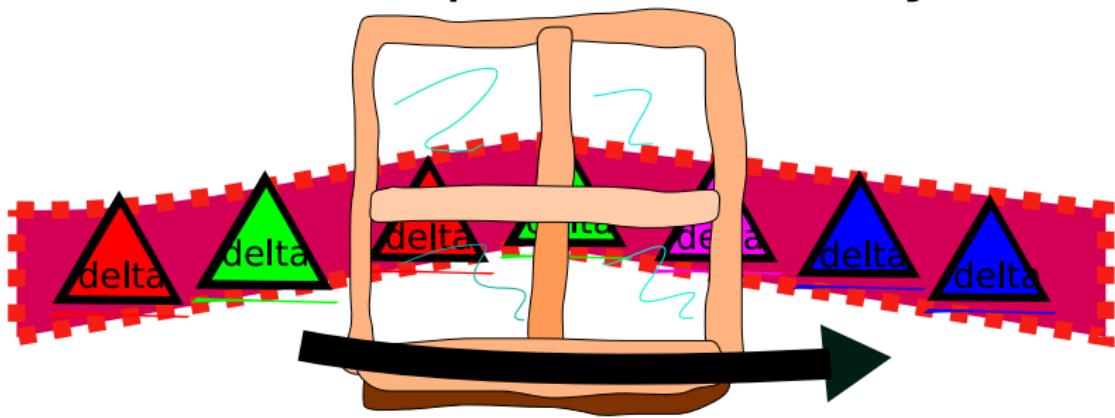


## Global Analysis

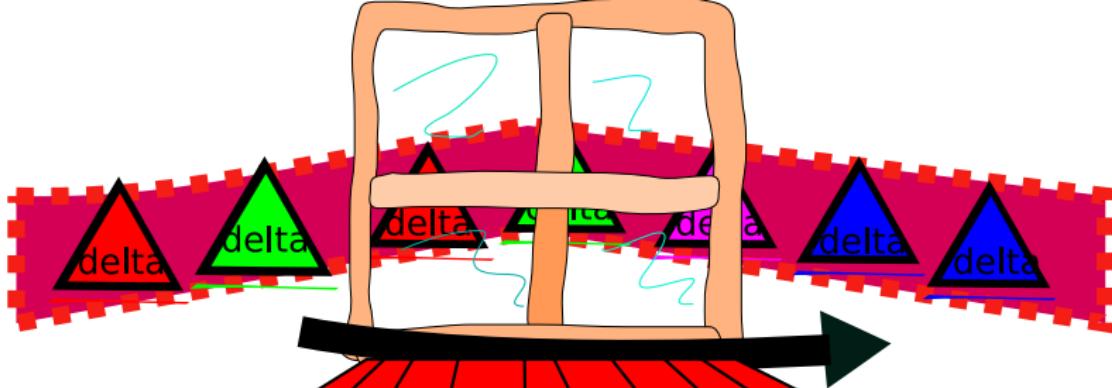
- \* relate local topics globally
- \* Recurring or dominant topics



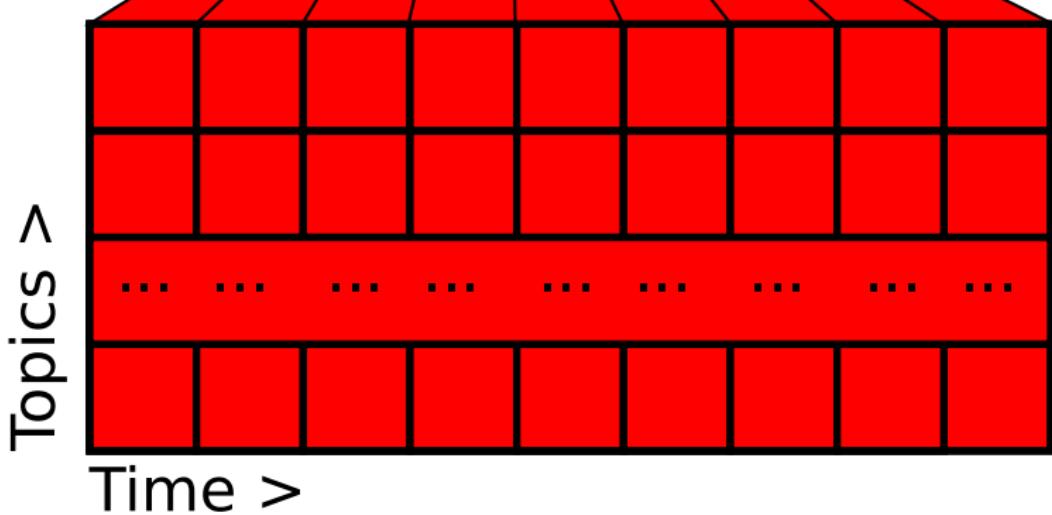
Development History



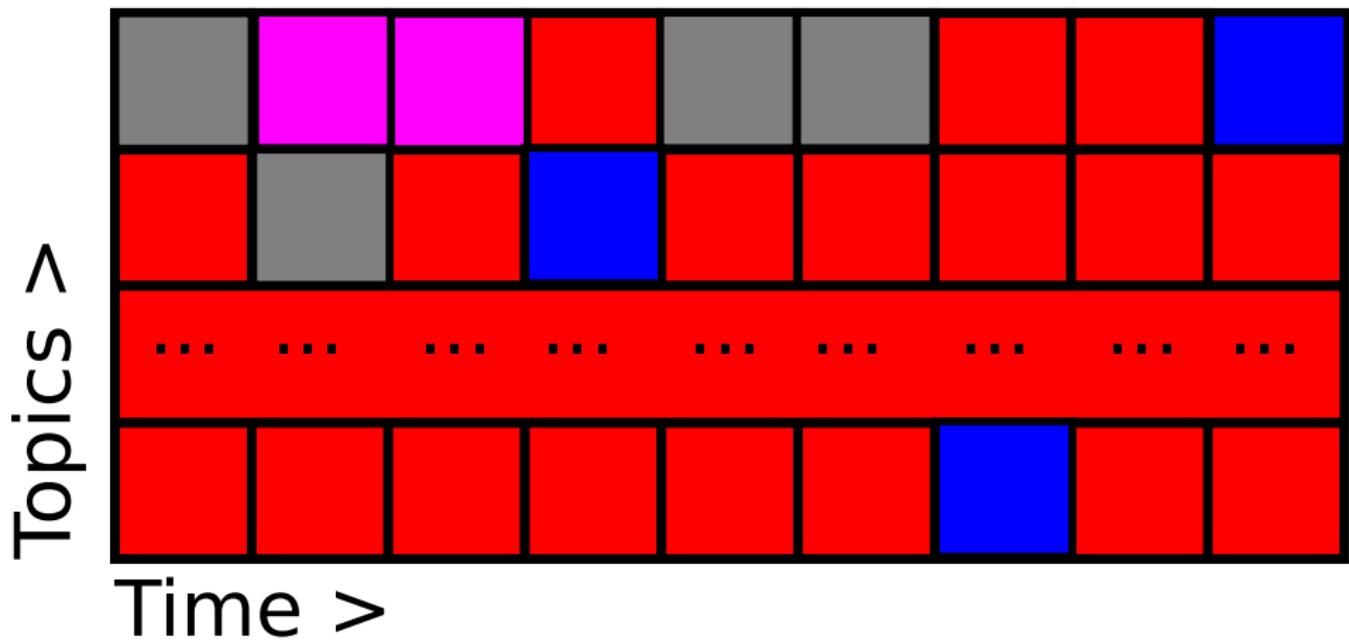
Apply a sliding window



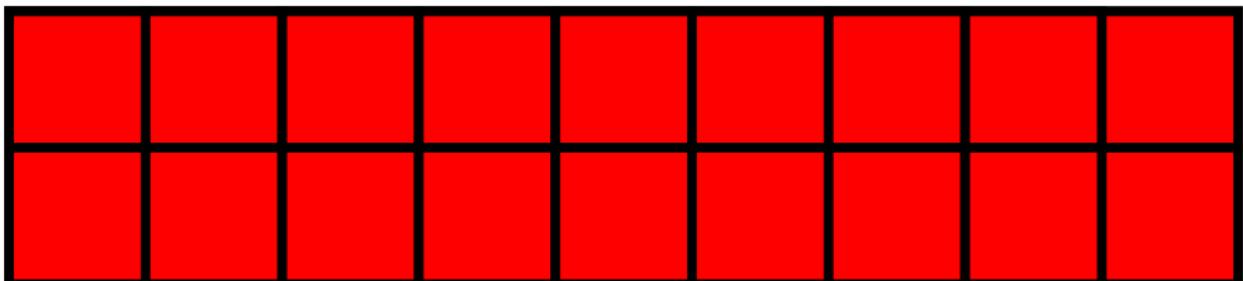
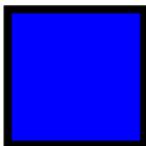
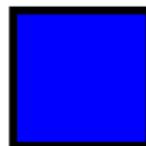
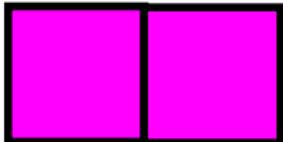
We extract N unique topics per window!



We noticed that some topics are quite similar, they might not appear just locally, they might reoccur globally!



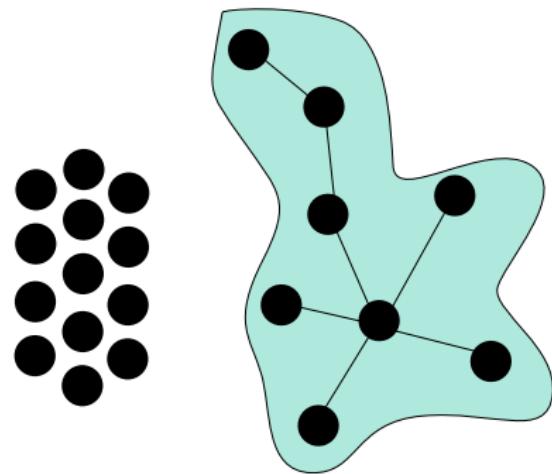
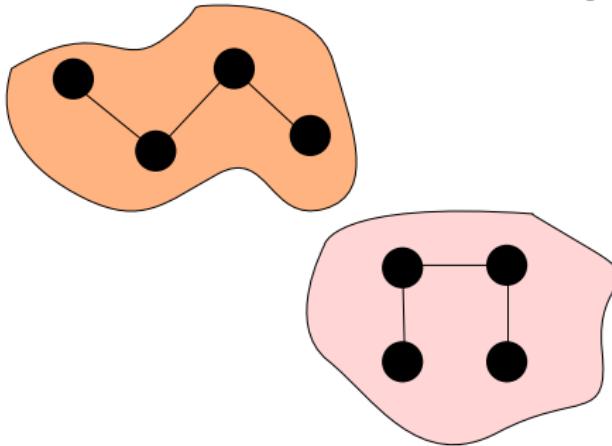
We could group the similar topics together

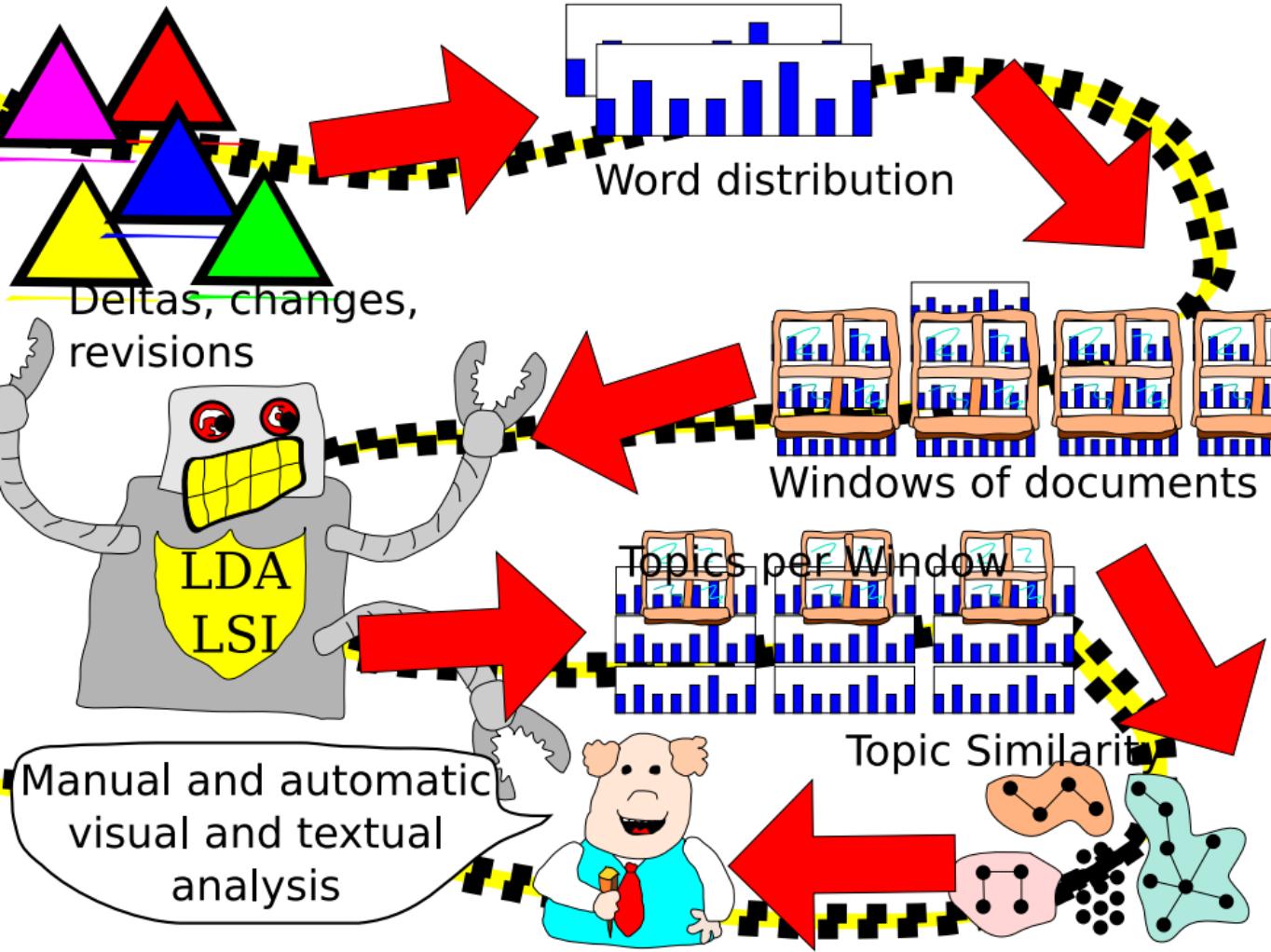


.... .... .... .... .... .... .... .... ....

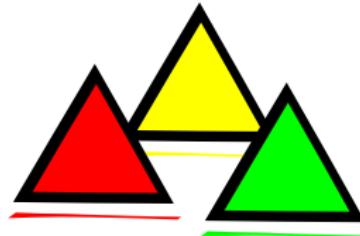
## Our method of similarity:

- \* Compare top 10 most frequent words per topic
- \* Those that match beyond a threshold are immediately similar
- \* Otherwise 2 topics are similar if they are transitively related

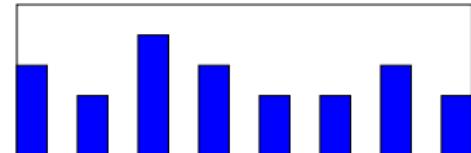




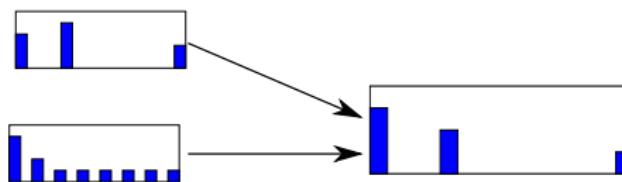
# Message



# Word Distribution



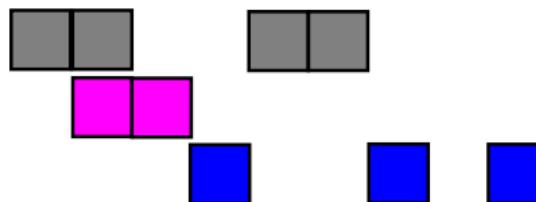
# Topic



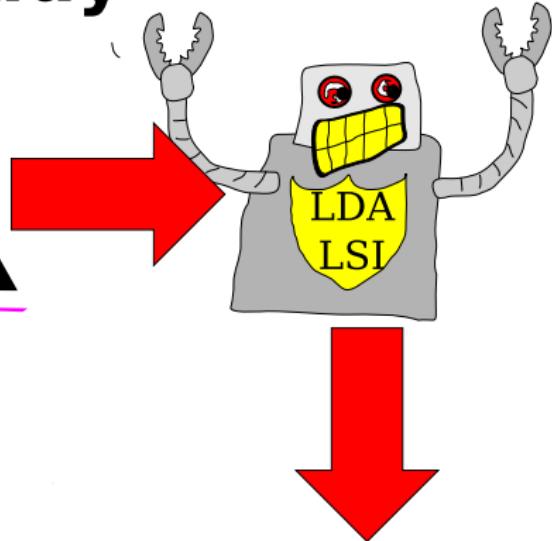
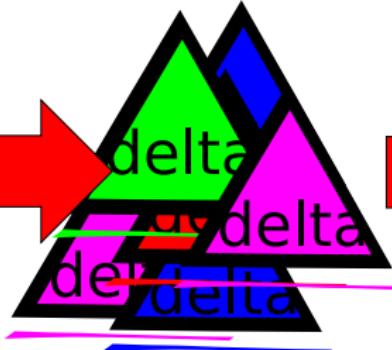
**Top 10 Words:**

- \* **perform**
- \* **bug #**
- \* **POSIX**
- \* **Opteron**
- \* ...

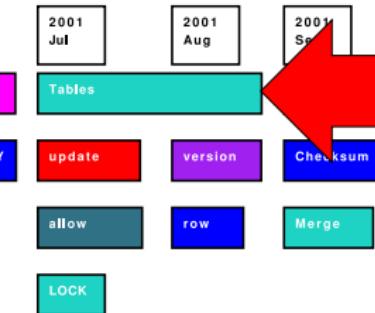
# Trend



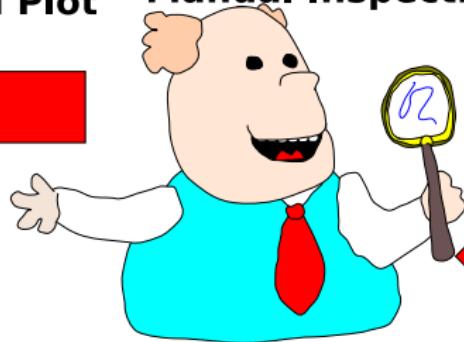
# Initial Case Study



## Manual Generated Plot

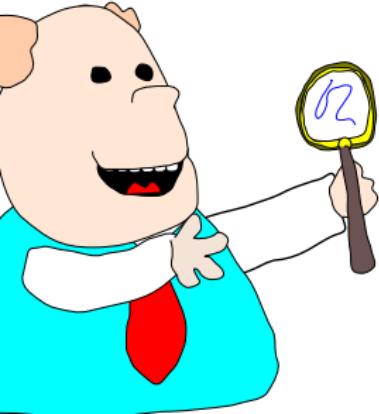
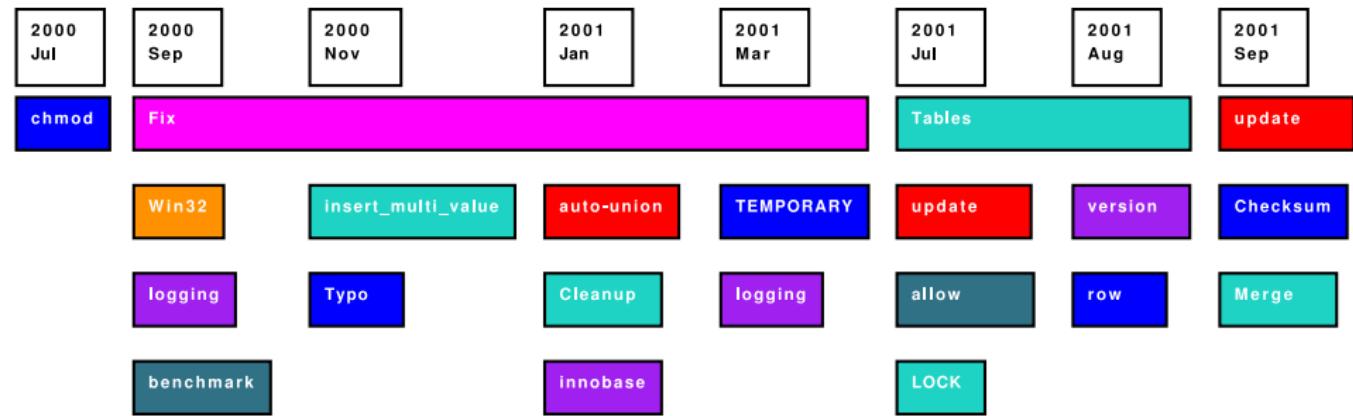


## Manual Inspection



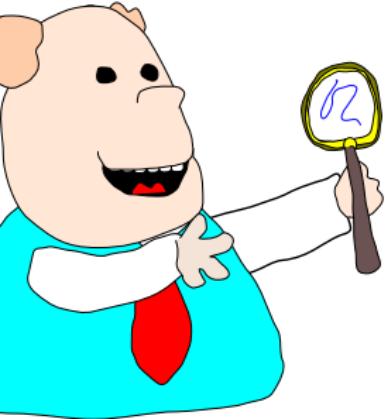
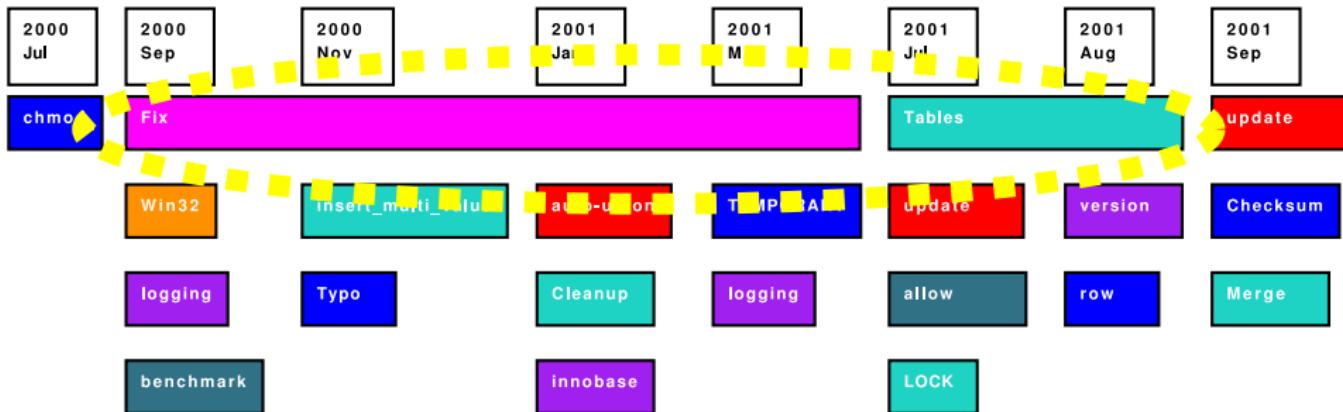
## Extracted Topics

# MySQL 3.23 Case Study



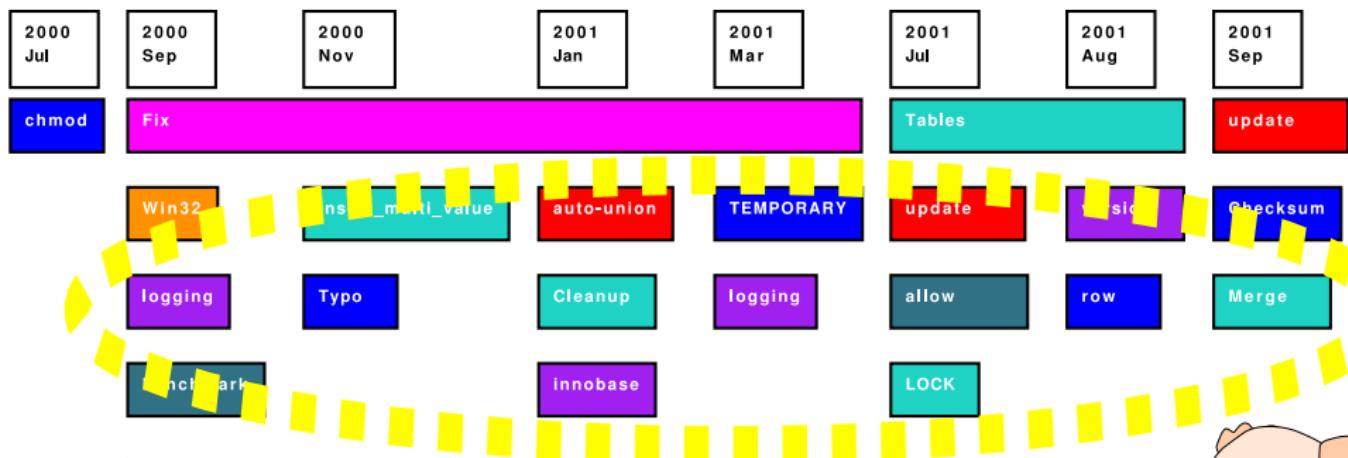
This plot was created  
from MySQL changelog  
topics that could be  
easily named

# MySQL 3.23 Case Study

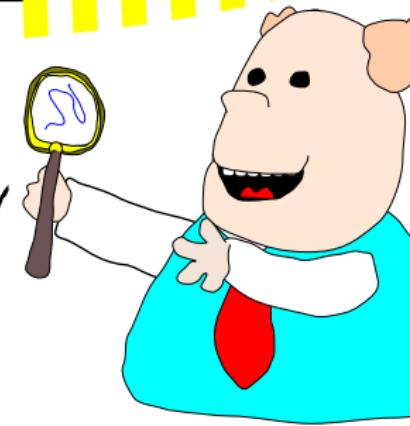


**Some named topics  
repeat across  
multiple periods**

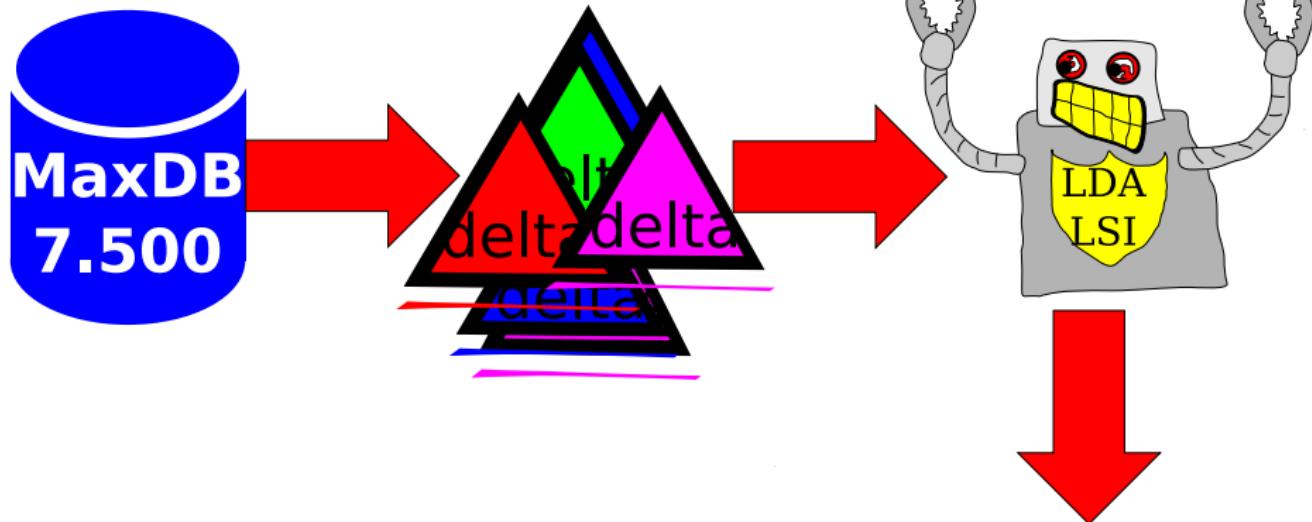
# MySQL 3.23 Case Study



**But many topics are local only to their particular time window!**



# MaxDB 7.500 Case Study



Auto-Generated Plot

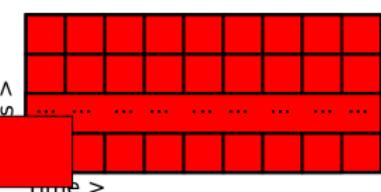
20 Aug 2005 Sep 2005 Oct 2005 Nov 2005 Dec 2005 Jan 2006 Feb 2006 Mar 2006 Apr 2006 May 2006



Automated Analysis



Extracted Topics



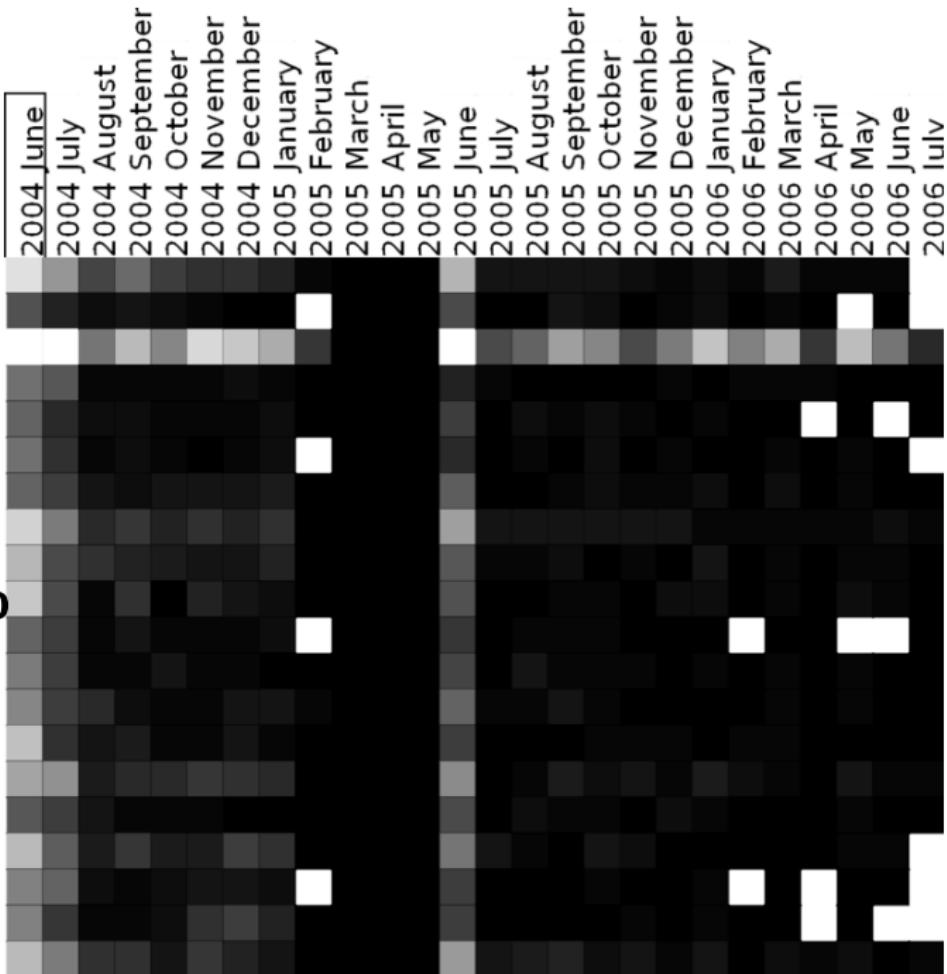
## Many Documents



## **Topic 1**

## Topic 10

## Topic 20



2004 Jun 2004 Jul 2004 Aug 2004 Sep 2004 Oct 2004 Nov 2004 Dec 2005 Jan 2005 Feb 2005 Mar 2005 Apr 2005 May 2005 Jun 2005 Jul 2005 Aug 2005 Sep 2005 Oct 2005 Nov 2005 Dec 2006 Jan 2006 Feb 2006 Mar 2006 Apr 2006 May 2006 Jun

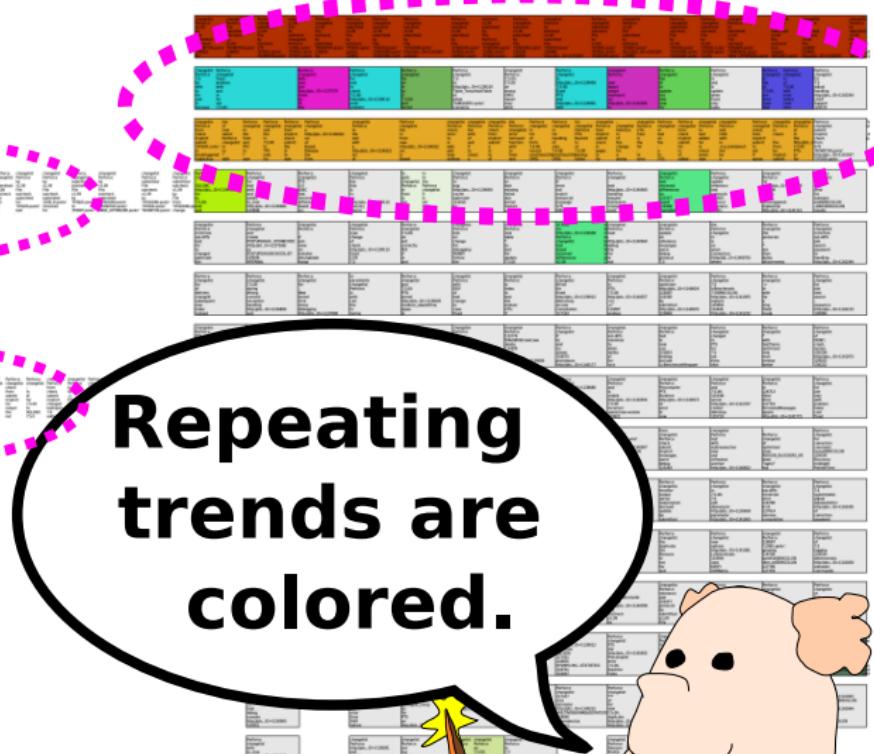
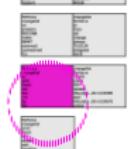


2004 Jun 2004 Jul 2004 Aug 2004 Sep 2004 Oct 2004 Nov 2004 Dec 2005 Jan 2005 Feb 2005 Mar 2005 Apr 2005 May 2005 Jun 2005 Jul 2005 Aug 2005 Sep 2005 Oct 2005 Nov 2005 Dec 2006 Jan 2006 Feb 2006 Mar 2006 Apr 2006 May 2006 Jun

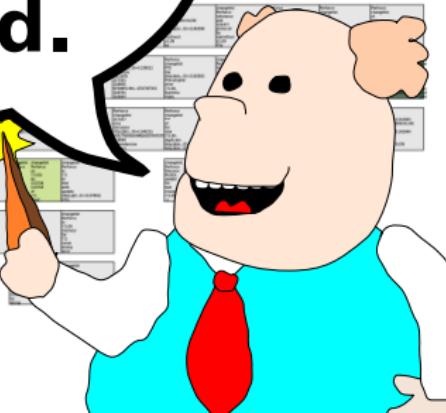
...and the other side of the world.

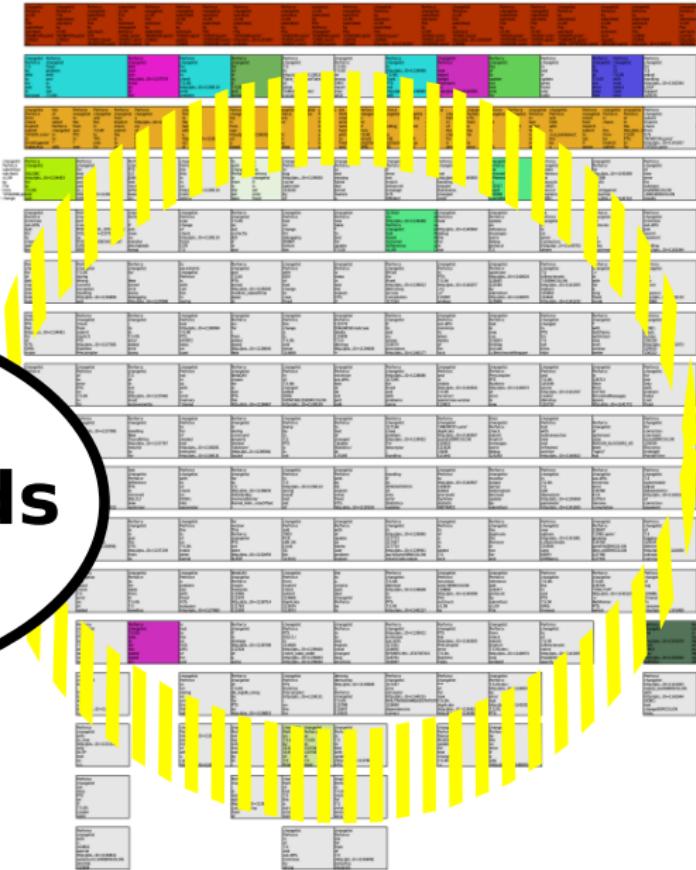
| Category | Sub-Category | Parameter        | Value   | Unit | Description                |
|----------|--------------|------------------|---------|------|----------------------------|
| System A | Processor    | Clock Speed      | 3.2 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 55°C    | °C   | Processor core temperature |
| System B | Processor    | Clock Speed      | 3.5 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 60°C    | °C   | Processor core temperature |
| System C | Processor    | Clock Speed      | 3.8 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 65°C    | °C   | Processor core temperature |
| System D | Processor    | Clock Speed      | 4.0 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 70°C    | °C   | Processor core temperature |
| System E | Processor    | Clock Speed      | 4.2 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 75°C    | °C   | Processor core temperature |
| System F | Processor    | Clock Speed      | 4.5 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 80°C    | °C   | Processor core temperature |
| System G | Processor    | Clock Speed      | 4.8 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 85°C    | °C   | Processor core temperature |
| System H | Processor    | Clock Speed      | 5.0 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 90°C    | °C   | Processor core temperature |
| System I | Processor    | Clock Speed      | 5.2 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 95°C    | °C   | Processor core temperature |
| System J | Processor    | Clock Speed      | 5.5 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 100°C   | °C   | Processor core temperature |
| System K | Processor    | Clock Speed      | 5.8 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 105°C   | °C   | Processor core temperature |
| System L | Processor    | Clock Speed      | 6.0 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 110°C   | °C   | Processor core temperature |
| System M | Processor    | Clock Speed      | 6.2 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 115°C   | °C   | Processor core temperature |
| System N | Processor    | Clock Speed      | 6.5 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 120°C   | °C   | Processor core temperature |
| System O | Processor    | Clock Speed      | 6.8 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 125°C   | °C   | Processor core temperature |
| System P | Processor    | Clock Speed      | 7.0 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 130°C   | °C   | Processor core temperature |
| System Q | Processor    | Clock Speed      | 7.2 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 135°C   | °C   | Processor core temperature |
| System R | Processor    | Clock Speed      | 7.5 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 140°C   | °C   | Processor core temperature |
| System S | Processor    | Clock Speed      | 7.8 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 145°C   | °C   | Processor core temperature |
| System T | Processor    | Clock Speed      | 8.0 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 150°C   | °C   | Processor core temperature |
| System U | Processor    | Clock Speed      | 8.2 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 155°C   | °C   | Processor core temperature |
| System V | Processor    | Clock Speed      | 8.5 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 160°C   | °C   | Processor core temperature |
| System W | Processor    | Clock Speed      | 8.8 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 165°C   | °C   | Processor core temperature |
| System X | Processor    | Clock Speed      | 9.0 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 170°C   | °C   | Processor core temperature |
| System Y | Processor    | Clock Speed      | 9.2 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 175°C   | °C   | Processor core temperature |
| System Z | Processor    | Clock Speed      | 9.5 GHz | GHz  | Processor clock speed      |
|          |              | Core Temperature | 180°C   | °C   | Processor core temperature |

| Section   | Topic   | Page   | Date       | Notes         |
|-----------|---------|--------|------------|---------------|
| Section 1 | Topic A | Page 1 | 01-01-2024 | Initial notes |
| Section 2 | Topic B | Page 2 | 01-01-2024 | Initial notes |
| Section 3 | Topic C | Page 3 | 01-01-2024 | Initial notes |
| Section 4 | Topic D | Page 4 | 01-01-2024 | Initial notes |



**Repeating  
trends are  
colored.**

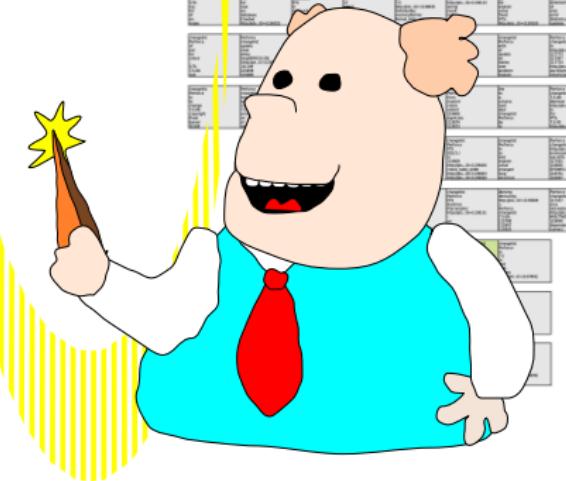




Local  
unique trends  
are grey



2004 Jun 2004 Jul 2004 Aug 2004 Sep 2004 Oct 2004 Nov 2004 Dec 2005 Jan 2005 Feb 2005 Mar 2005 Apr 2005 May 2005 Jun 2005 Jul 2005 Aug 2005 Sep 2005 Oct 2005 Nov 2005 Dec 2006 Jan 2006 Feb 2006 Mar 2006 Apr 2006 May 2006 Jun



**This gap indicates no development occurred**

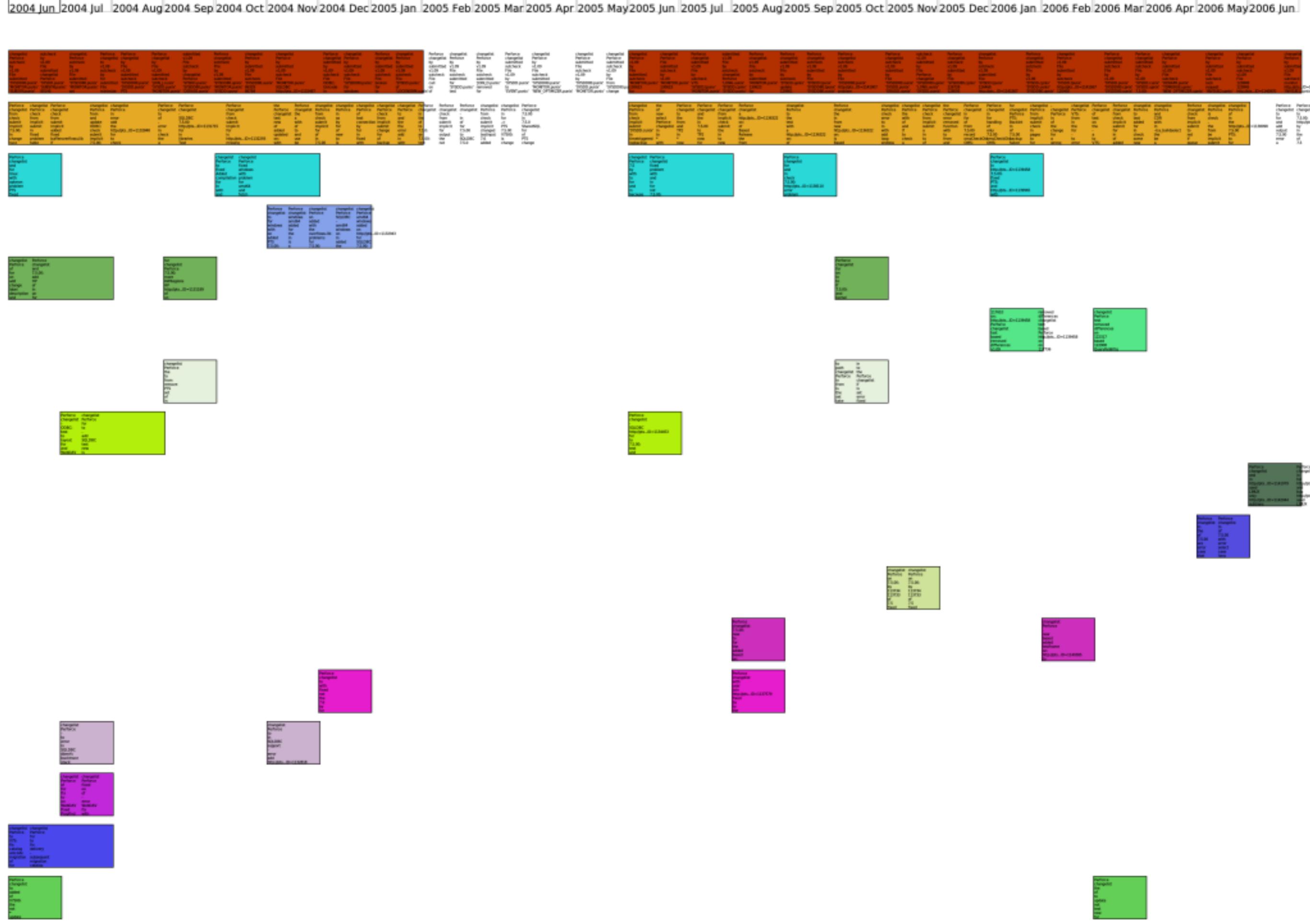
|  |   |  |   |   |   |   |  |   |   |
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| changelist<br>Perforce<br>sutcheck<br>by<br>v1.09<br>File<br>submitted<br>'SYSDD80.punix'<br>'MONITOR.punix'<br>'SUBSYN.punix' | sutcheck<br>by<br>v1.09<br>File<br>submitted<br>changelist<br>File<br>submitted<br>'SYSDD.punix'<br>'MONITOR.punix'<br>'SUBSYN.punix' | changelist<br>Perforce<br>sutcheck<br>to<br>v1.09<br>File<br>submitted<br>changelist<br>File<br>submitted<br>'SYSDD80.punix'<br>'JOIN J.cunix'<br>'SYSDD.punix'<br>'MONITOR.punix' | Perforce<br>changelist<br>to<br>v1.09<br>File<br>submitted<br>changelist<br>File<br>submitted<br>'SYSDD80.punix'<br>'SYSDD80.upunix'<br>'SYSDD80.punix'<br>'DERASE.punix' | submitted<br>v1.09<br>File<br>sutcheck<br>by<br>v1.09<br>File<br>submitted<br>changelist<br>File<br>submitted<br>'SYSDD80.upunix'<br>'SYSDD80.punix'<br>'MONITOR.punix'<br>'SYSDD80.tpunix' | Perforce<br>changelist<br>sutcheck<br>by<br>v1.09<br>File<br>submitted<br>changelist<br>File<br>submitted<br>'SYSDD80.upunix'<br>'SYSDD80.punix'<br>'MONITOR.punix'<br>'SYSDD80.tpunix' | changelist<br>Perforce<br>by<br>submitted<br>v1.09<br>sutcheck<br>File<br>submitted<br>changelist<br>File<br>submitted<br>'SYSDD80.punix'<br>86329<br>'MONITOR.punix' | changelist<br>Perforce<br>by<br>submitted<br>v1.09<br>sutcheck<br>File<br>submitted<br>changelist<br>File<br>submitted<br>'MONITOR.punix'<br>86784<br>'SQLDBC<br><a href="http://pts...ID=1132487">http://pts...ID=1132487</a> | Perforce<br>changelist<br>submitted<br>by<br>v1.09<br>sutcheck<br>File<br>ODBC:<br>Unicode<br><a href="http://pts...ID=1132487">http://pts...ID=1132487</a> | changelist<br>Perforce<br>submitted<br>by<br>v1.09<br>sutcheck<br>File<br>File<br>'SYSDD80.punix' |
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| Perforce<br>changelist<br>error<br>remove<br>fixed<br>problem<br>on<br>check<br>compile<br>errors | changelist<br>Perforce<br>of<br>for<br>fix<br>to<br>on<br>on<br>WebDAV<br>fixed<br>Propfind | changelist<br>Perforce<br>fixed<br>on<br>of<br>-<br>error<br>WebDAV<br>fix<br>with | Perforce<br>changelist<br>for<br>from<br>PTS<br>bug<br>show<br>more<br>console<br>dbmgui | changelist<br>Perforce<br>error<br>updated<br>testframe<br>catch<br>to<br>for<br>check<br>- | Perforce<br>changelist<br>In<br>PTS<br>as<br>3.0<br>fallback<br><a href="http://pts...ID=1132391">http://pts...ID=1132391</a><br>JDBC<br>windows | Perforce<br>changelist<br>added<br>fixed<br>linux<br>fake<br>bufferoverflowlib<br>opteron<br>PCR<br>to | changelist<br>Perforce<br>added<br>fixed<br>linux<br>fake<br>bufferoverflowlib<br>opteron<br>PCR<br>to | changelist<br>Perforce<br>http://pts...ID=1133372<br>change#<br>for<br>fixed<br>join<br>subsequent<br>88282<br>delivery |
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| Perforce<br>changelist<br>and<br>for<br>linux<br>with<br>opteron<br>problem<br>PTS<br>fixed | Perforce<br>changelist<br>-<br>ODBC:<br>test<br>to<br>-<br>add<br>layout<br>SQLDBC<br>for<br>and<br>new<br>WebDAV<br>Is | changelist<br>Perforce<br>for<br>to<br>pythondef<br>in<br>python-py15<br>to<br>from<br>change<br>problem<br>be | Perforce<br>changelist<br>pythondef<br>in<br>python-py15<br>to<br>from<br>change<br>problem<br>be | Perforce<br>changelist<br>7.5.00<br>OMS<br>with<br>when<br><a href="http://pts...ID=1126813">http://pts...ID=1126813</a><br>0<br>e_key_still_visible<br>casting | Perforce<br>changelist<br>to<br>windows<br>for<br>windows<br>with<br>when<br>on<br>added<br>PTS<br>is | Perforce<br>changelist<br>windows<br>amd64<br>added<br>for<br>the<br>in<br>a | changelist<br>Perforce<br>on<br>added<br>with<br>the<br>overflowu.lib<br>problems<br>for<br>added<br>the | changelist<br>Perforce<br>SQLDBC<br>-<br>amd64<br>windows<br>on<br>ht<br>for<br>SQL<br>7 |
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| Perforce<br>changelist<br>tests<br>WebDAV<br>for<br>the<br>Updated<br>to<br>and<br>added | changelist<br>Perforce<br>if<br>a<br>show<br>is<br>an<br>exception<br>78377<br>outside | changelist<br>Perforce<br>error<br>-<br>ODBC:<br>to<br>fix<br>is<br>+<br>for | changelist<br>Perforce<br>the<br>to<br>from<br>remove<br>PTS<br>set<br>of<br>in | changelist<br>Perforce<br>fixed<br>windows<br>compilation<br>on<br>bit<br>make<br>32<br>for | changelist<br>Perforce<br>to<br>'SYSDD.upunix'<br>in<br>Fixed<br>'LONG.cpnix'<br>'EVENT.punix'<br>user<br>for | Perforce<br>changelist<br>to<br>'SYSDD.upunix'<br>in<br>Fixed<br>'LONG.cpnix'<br>'EVENT.punix'<br>user<br>for | changelist<br>Perforce<br>on<br>'ALTERTAB.punix'<br>for<br>to<br>in<br>PTS<br>correct<br>V75: |
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| Perforce<br>changelist<br>from<br>check<br>submit<br>implicit<br>7.5.00:<br>In<br>change<br>race | changelist<br>Perforce<br>check<br>from<br>implicit<br>submit<br>Implicit<br>added<br>fixed<br>problem<br>table | changelist<br>Perforce<br>check<br>from<br>implicit<br>submit<br>Implicit<br>added<br>fixed<br>bufferoverflowu.lib | changelist<br>Perforce<br>from<br>and<br>update<br>ODBC:<br>the<br>check<br>submit<br>for<br>to<br>Implicit<br>7.5.00: | changelist<br>Perforce<br>to<br>of<br>-<br>error<br>add<br>the<br>submit<br>for<br>check<br>the<br>a | Perforce<br>changelist<br>-<br>SQLDBC<br>7.5.00<br><a href="http://pts...ID=1131715">http://pts...ID=1131715</a> | Perforce<br>changelist<br>from<br>check<br>submit<br>implicit<br>for<br>in<br>libraries<br>Test | the<br>Perforce<br>changelist<br>test<br>a<br>with<br>of<br>added<br>updated<br>on:<br>missing | Perforce<br>changelist<br>from<br>check<br>submit<br>implicit<br>for<br>of<br>new<br>in<br>to<br>is |
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|             |             |             |             |             |             |
|-------------|-------------|-------------|-------------|-------------|-------------|
| Performance | Performance | Performance | Performance | Performance | Performance |
| Test        | Test        | Test        | Test        | Test        | Test        |
| Test        | Test        | Test        | Test        | Test        | Test        |
| Test        | Test        | Test        | Test        | Test        | Test        |
| Test        | Test        | Test        | Test        | Test        | Test        |

2010-2011  
Yearly Income Statement

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| Parameter | Current   | Changed | Current   | Changed | Current   | Changed |
|-----------|-----------|---------|-----------|---------|-----------|---------|
| host      | 127.0.0.1 |         | 127.0.0.1 |         | 127.0.0.1 |         |
| port      | 12345     |         | 12345     |         | 12345     |         |
| add       |           |         |           |         |           |         |
| del       |           |         |           |         |           |         |
| change    |           |         |           |         |           |         |
| list      |           |         |           |         |           |         |
| in        |           |         |           |         |           |         |
| option    |           |         |           |         |           |         |
| out       |           |         |           |         |           |         |
| url       |           |         |           |         |           |         |
| version   |           |         |           |         |           |         |

Page 1 of 1

卷之三

| Path      | Refuse | Accept |
|-----------|--------|--------|
| path      | to     |        |
| dangerous | to     |        |
| refuse    | to     |        |
| in        | to     |        |
| negotiate | to     |        |
| at        | to     |        |
| the       | to     |        |
| end       | to     |        |

| Performance | Change point | Performance | Change point |
|-------------|--------------|-------------|--------------|
| Domestic    | Refined      | Domestic    | Refined      |

www.ijerph.org | ISSN: 1660-4601 | DOI: 10.3390/ijerph17103333

pathway: Biotransq  
organisms: Biotransq  
enzymes: Biotransq  
substrates: Biotransq

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2015-2016  
2016-2017  
2017-2018  
2018-2019  
2019-2020  
2020-2021  
2021-2022  
2022-2023  
2023-2024

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19 19

[View Details](#)

**Champeón  
Mundial**

PSU-001-D-113374

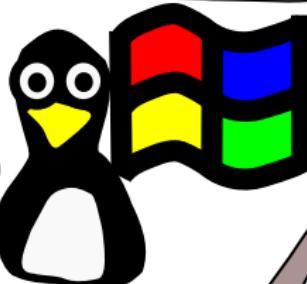
|                     |                     |
|---------------------|---------------------|
| <b>Unsupervised</b> | <b>unsupervised</b> |
| <b>Supervised</b>   | <b>supervised</b>   |
| <b>or</b>           | <b>task</b>         |

Project: [Project](#)

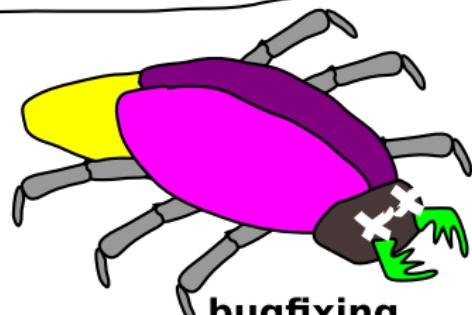
| Parameter | Parameter |
|-----------|-----------|
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| 100       | 100       |
| 1000      | 1000      |

| Portion  | Portion  | Portion  |
|----------|----------|----------|
| original | original | original |

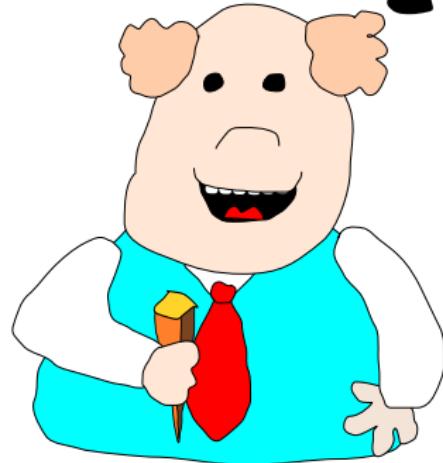
We can name topics based on certain kinds of words



portability



bugfixing



maintenance

'ilities

# Observations

- \* **some important local topics were not found with global topic analysis**



vs

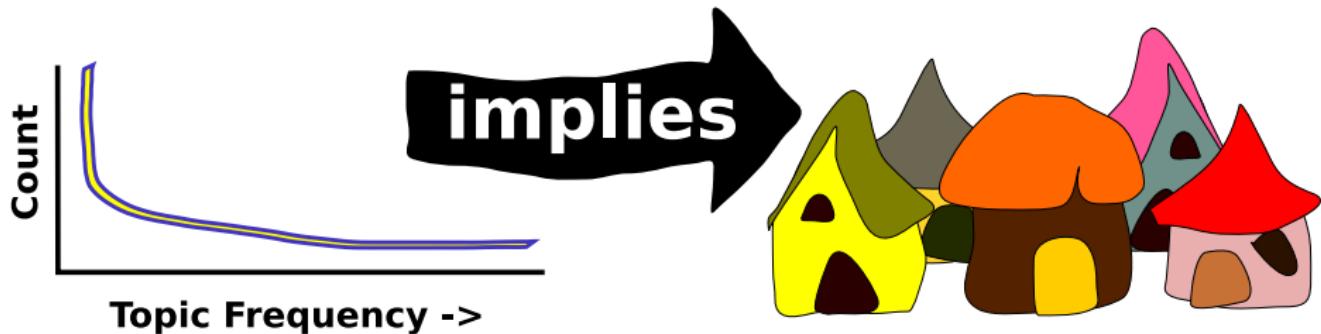


## Observations:



**Topic Frequency ->**  
**Only ~10% of topics reoccur!**

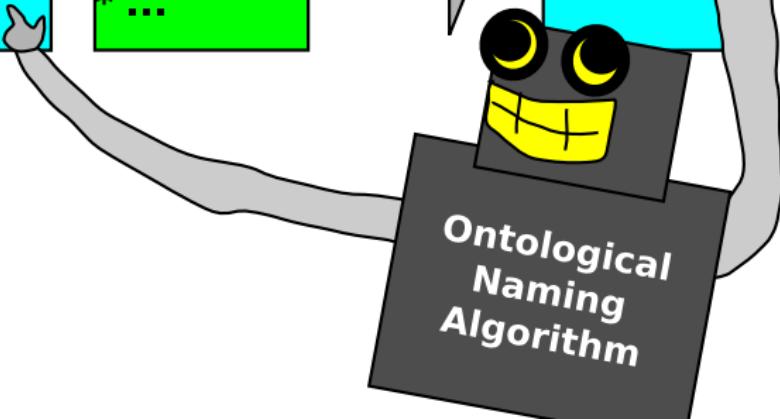
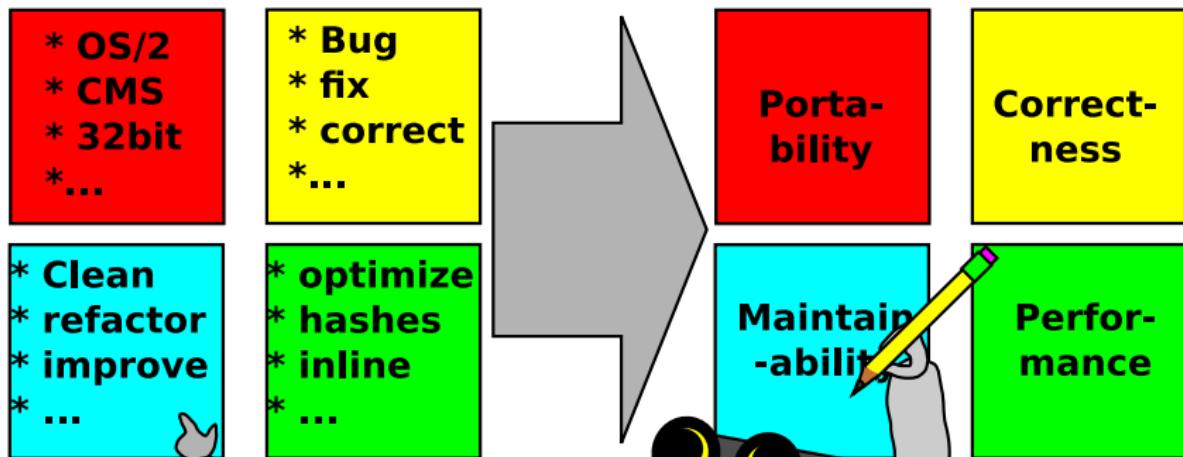
# Observations:



*with some*

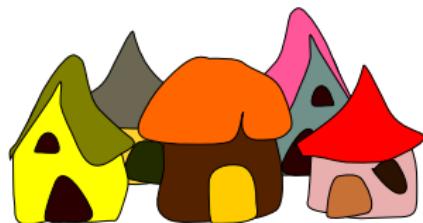
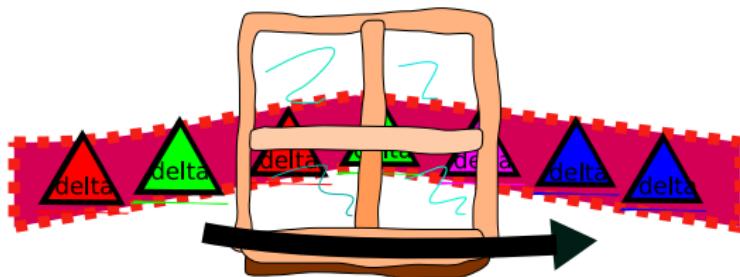


# Future Work



[Ernst et al.]

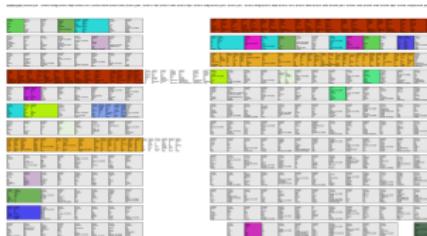
# Conclusions



**vs**



2004 June  
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2004 August  
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2005 April  
2005 May  
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2006 July



**vs**

