Detecting Wikipedia Vandalism via Spatio-Temporal Analysis of Revision Metadata

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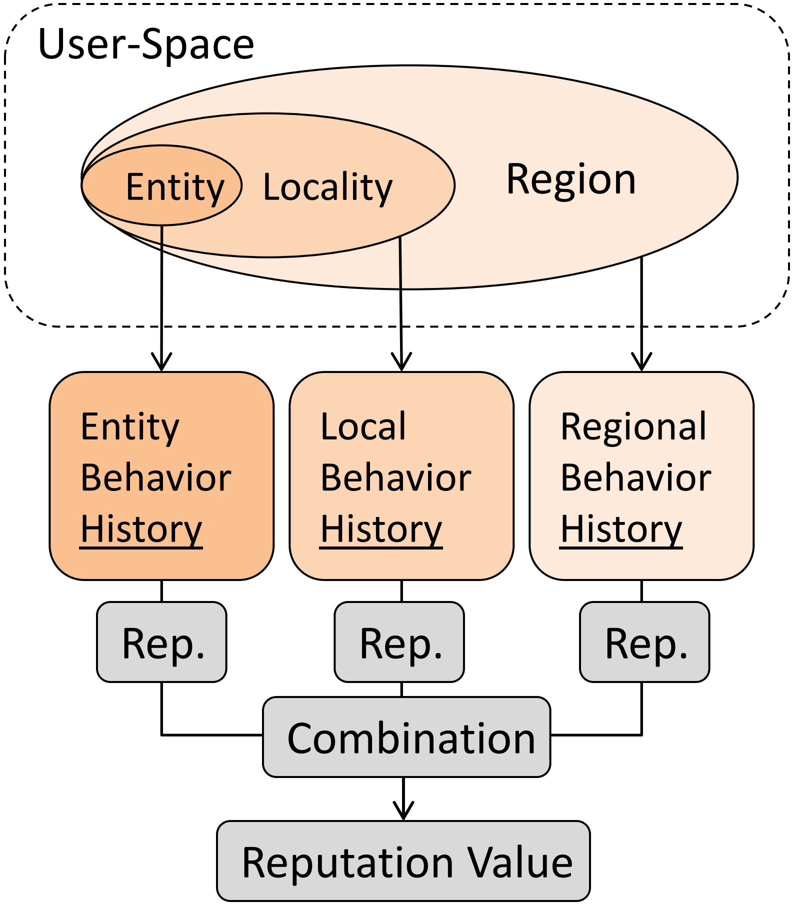
ONR-MURI Presentation

Where we left off….

FROM THE LAST MURI REVIEW

Spatio-Temporal Reputation

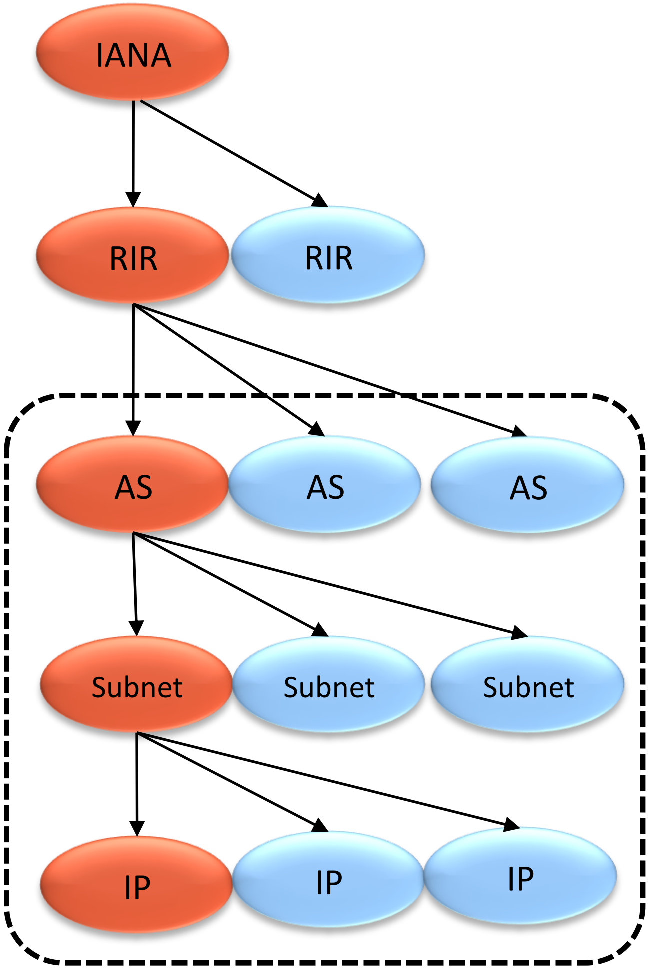


- Single-entity reputation values are the status quo
  - Issue: Sybil attacks (*e.g.*, spam botnets)
- Spatial reputation:
  - No entity-specific data? Use broader groupings
  - Exploit homophily
  - Clarity in borderline classification cases

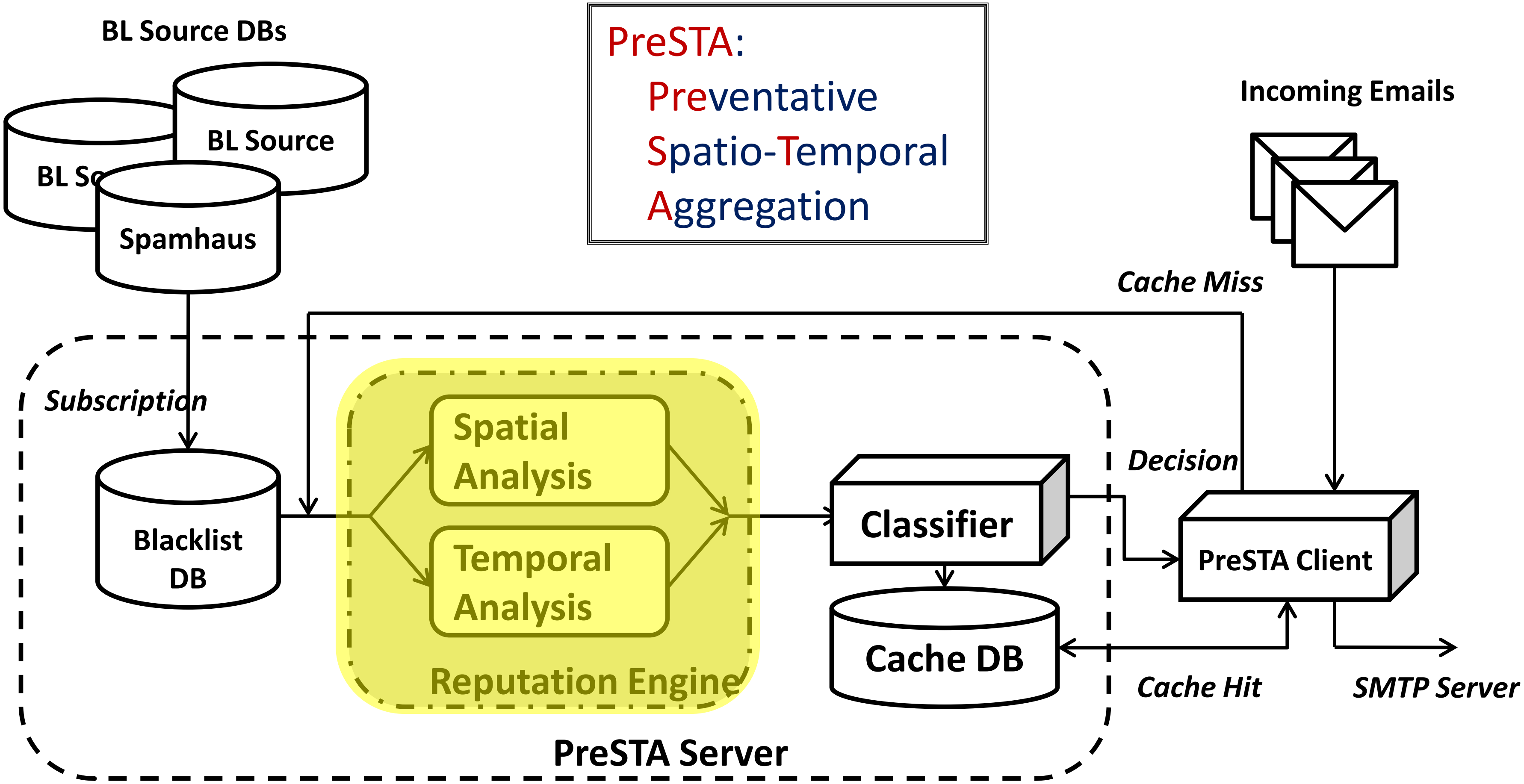
Hierarchical Groupings = TDG = QTM

- Spatial groupings for spam detection leverage the IP assignment hierarchy
  - Entities are IP addresses
  - {AS, Subnet, IP} groups used

- TDGs are hierarchies, thus spatio-(temporal) techniques may fulfill the reputation component of QTM/QuanTM



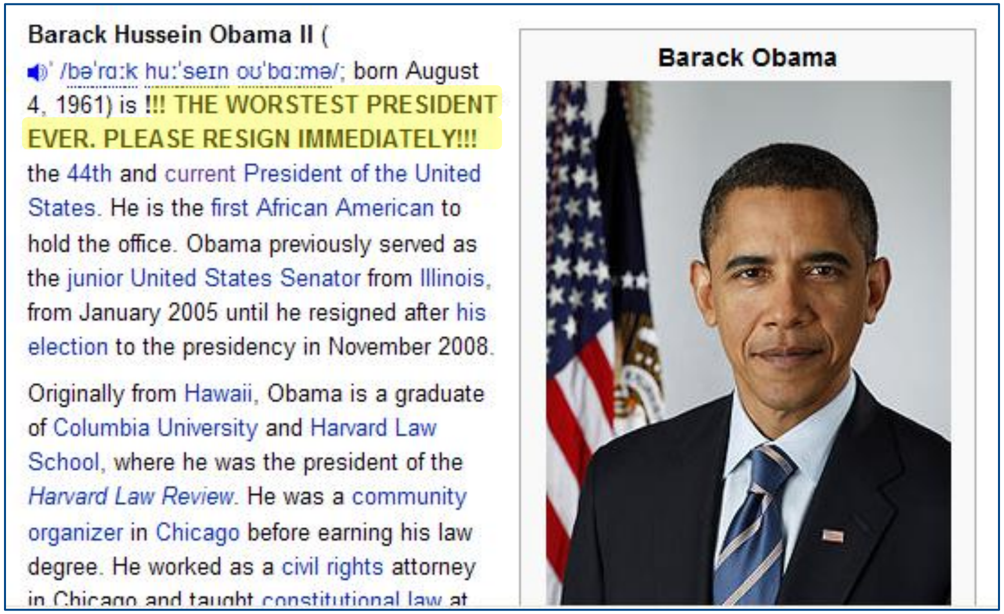
PreSTA for Spam Detection



New Contributions…

APPLYING SPATIO-TEMPORAL PROPERTIES TO WIKIPEDIA

Vandalism



Barack Hussein Obama II (🔊 /bəˈrɑːk huːˈseɪn oʊˈbɑːmə/; born August 4, 1961) is !!! THE WORSTEST PRESIDENT EVER. PLEASE RESIGN IMMEDIATELY!!! the 44th and current President of the United States. He is the first African American to hold the office. Obama previously served as the junior United States Senator from Illinois, from January 2005 until he resigned after his election to the presidency in November 2008.

Originally from Hawaii, Obama is a graduate of Columbia University and Harvard Law School, where he was the president of the *Harvard Law Review*. He was a community organizer in Chicago before earning his law degree. He worked as a civil rights attorney in Chicago and taught constitutional law at

Barack Obama

VANDALISM: Informally, an edit that is:

- Non-value adding
- Offensive
- Destructive in content removal

- Serious problem. One source [3] estimates hundreds of millions of `damaged page views’
- NLP effective for blatant instances. Subtle ones (*e.g.*, insertion of ‘not’, name replacement) – much harder to find
- Our method: Alternative means of detection, complementing NLP

Big Idea

- Wikipedia revision metadata (not the article or `diff` text) can be used to detect instances of vandalism
  - – As effective as language-processing [2] efforts
  - – Machine-learning over spatio-temporal props:
    - Simple features: Straightforward metadata analysis
    - Aggregate features: Reputation values for single entities (editors, articles) and spatial groupings thereof (geographical location, topical categories)

Outline

- Labeling revisions (*rollback*)
- Simple features
  - Motivation: SNARE [1] spam-blocking
  - Edit time-of-day, day-of-week, comment length…
- Aggregate features
  - Motivation: PreSTA [5] reputation algorithm
  - Article rep., editor rep., spatial reputations…
- Classifier performance
- STiki [4] (a real-time implementation)

Metadata

Wikipedia provides metadata via DB-dumps:

#	METADATA ITEM	NOTES
(1)	**Timestamp** of edit	In GMT locale
(2)	**Article** being edited	Able to deduce namespace from title
(3)	**Editor** making edit	May be user-name (if registered editor), or IP address* (if anonymous)
(4)	Revision **comment**	Text field where editor can summarize changes

Labeling Vandalism

"Reversion" (*i.e.*, undo)

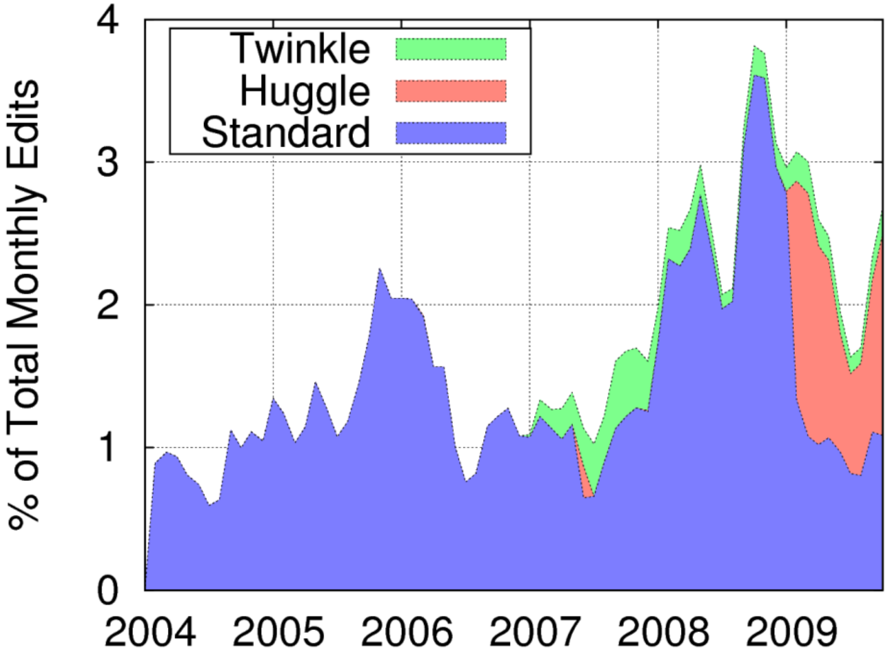
- Any user can execute:
- (1) Press button
- (2) Enter edit summary
- (3) Confirm reversion

"Rollback" (expedited revert)

- Privileged: ≈4,700 users
- (1) Press button. Done.
- Auto-summarization: "Reverted edits by *x* to last revision by *y*"

Test-set contains ≈50 million edits:

- (1) only NS0 edits (71% of all edits)
- (2) only edits within last year (2008/11+)



Prevalence/Source of Rollbacks

Rollback-based Labels

- Use rollback-based labeling:
  - (1) Find special comment format
  - (2) Verify permissions of editor
  - (3) Backtrack to find offending-edit (OE)
  - All edits not in set {OE} are {Unlabeled}
- Alternatives: Manual labeling, page-hashing
- Advantages of using rollback:
  - (1) Automated (just parsing)
  - (2) High-confidence (privileged users are *trusted*)
  - (3) Per-case (vandalism need not be defined)

Simple Features

SIMPLE FEATURES

* Discussion abbreviated to concentrate on aggregate ones

Spatio-Temporal Basics

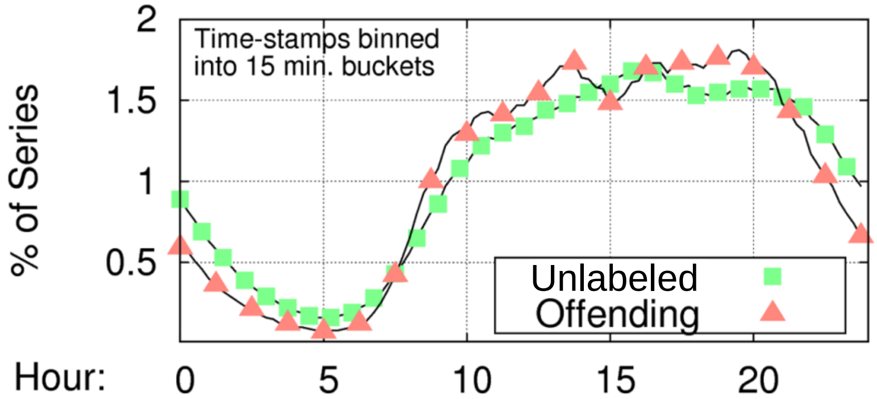
- Temporal props: A function of when events occur
- Spatial props: Appropriate wherever a size, distance, or membership function can be defined

Motivating work: SNARE [1]

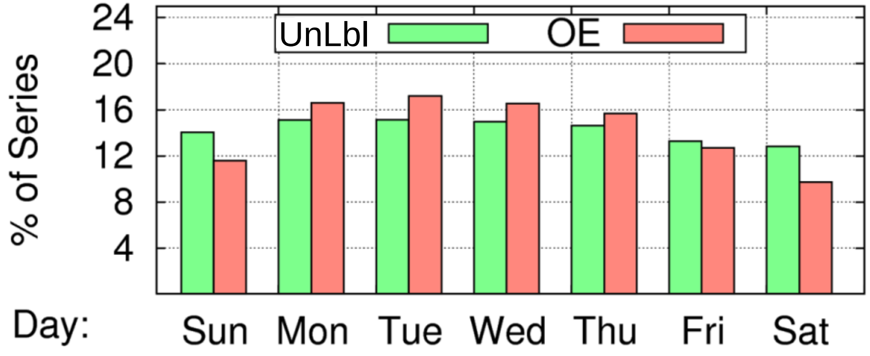
- Spatio-temporal props. effective in spam-mitigation
  - Physical distance mail traveled, time-of-day, mail sent, message size (in bytes), AS-membership of sender… (13 in total)
- Advantages of approach:
  - NLP-filters easy to evade… More difficult for spatio-temporal props.
  - Computationally simpler than NLP

Edit Time, Day-of-Week

- Use IP-geo-location data to determine origin time-zone, adjust UTC timestamp
- Vandalism most prevalent during working hours/week: Kids are in school(?)
- Fun fact: Vandalism almost twice as prevalent on a Tuesday versus a Sunday



Local time-of-day when edits made



Local day-of-week when edits made

Time-since (TS) …

TS Article Edited	OE	UnLbl
All edits (median, hrs.)	1.03	9.67
TS Editor Registration	**OE**	**UnLbl**
Regd., median (days)	0.07	765
Anon., median (days)	0.01	1.97

- Long-time participants vandalize very little
  - “Registration”: time-stamp of first edit made by user
  - Sybil-attack to abuse benefits?

- High-edit pages most often vandalized
  - ≈2% of pages have 5+ OEs, yet these pages have 52% of all edits
  - Other work [3] has shown these are also articles most visited

Misc. Simple Features

FEATURE	OE	UnLbl
Revision comment (average length in characters)	17.73	41.56
Anonymous editors (percentage)	85.38%	28.97%
Bot editors (percentage)	00.46%	09.15%
Privileged editors (percentage)	00.78%	23.92%

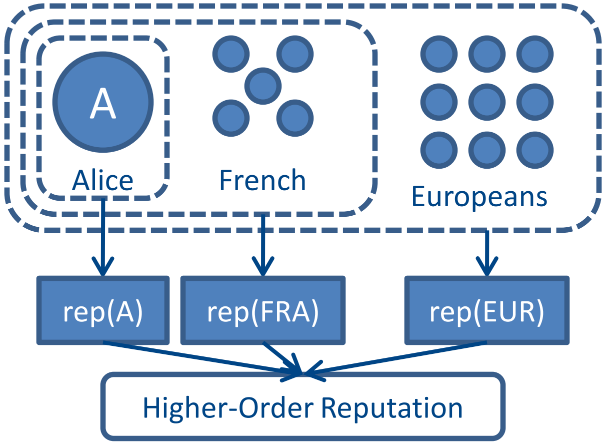
- Revision comment length
  - Vandals leave shorter comments (lazy-ness? or just minimizing bandwidth?)
- Privileged editors (and bots)
  - Huge contributors, but rarely vandalize

Aggregate Features

AGGREGATE FEATURES

PreSTA Algorithm

CORE IDEA: No entity specific data? Examine spatially-adjacent entities (homophily)



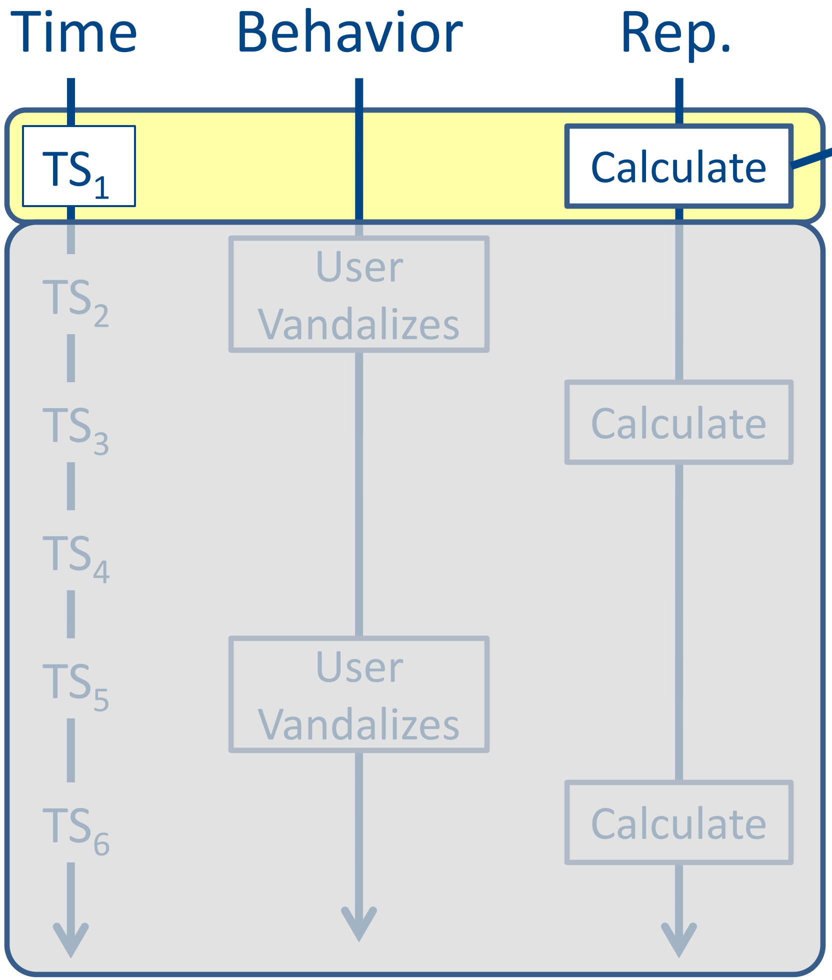
PreSTA [5]: Model for ST-rep:

$$\text{Rep}(\mathit{group}) = \sum \frac{\mathit{time\_decay}\,(\text{TS}_{\text{vandalism}})}{\mathit{size(group)}}$$

Timestamps (TS) of vandalism incidents by *group* members

- Grouping functions (spatial) define memberships
- Observations of misbehavior form feedback – and observations are decayed (temporal)

Example Reputation



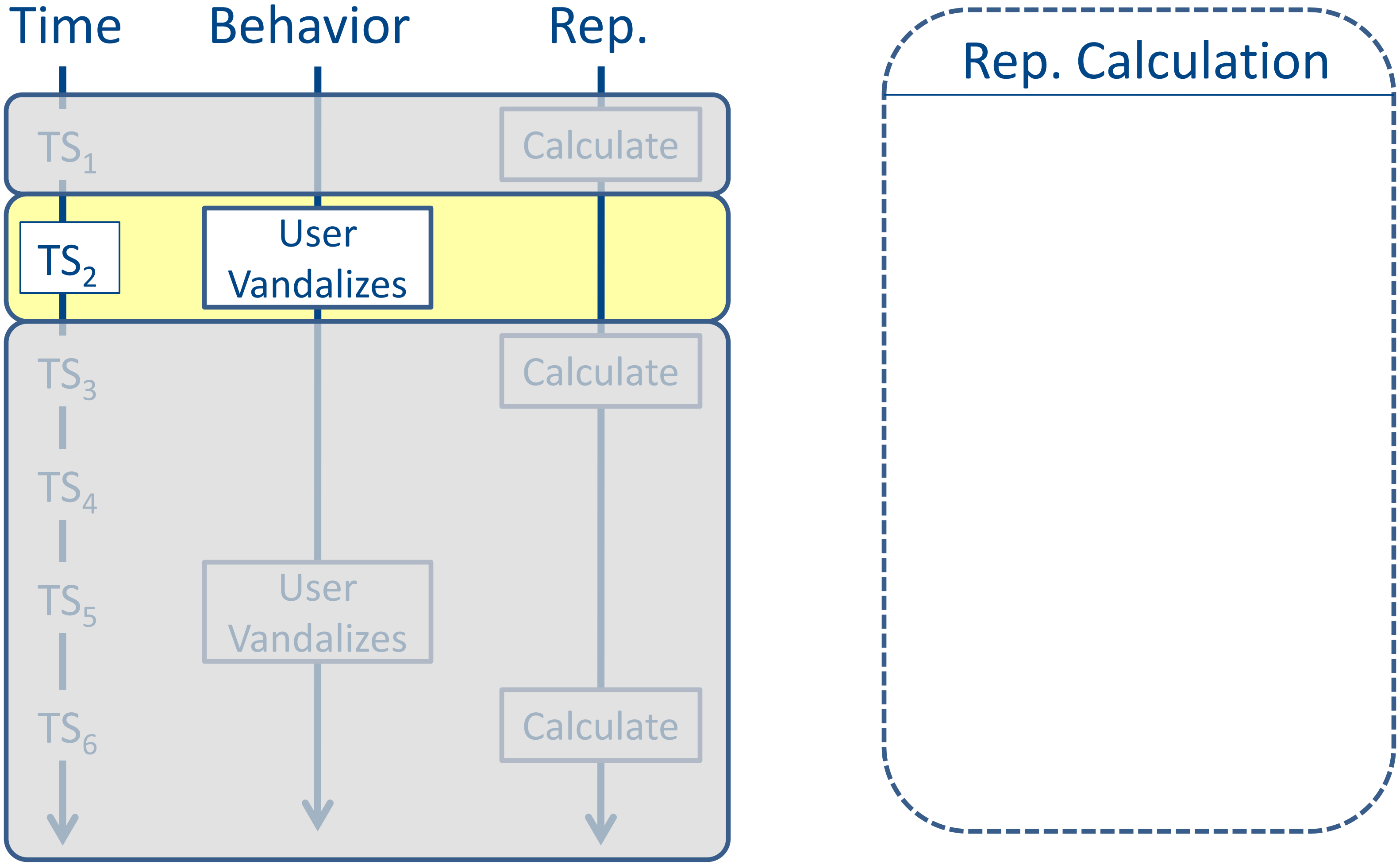
Rep. Calculation

No history?

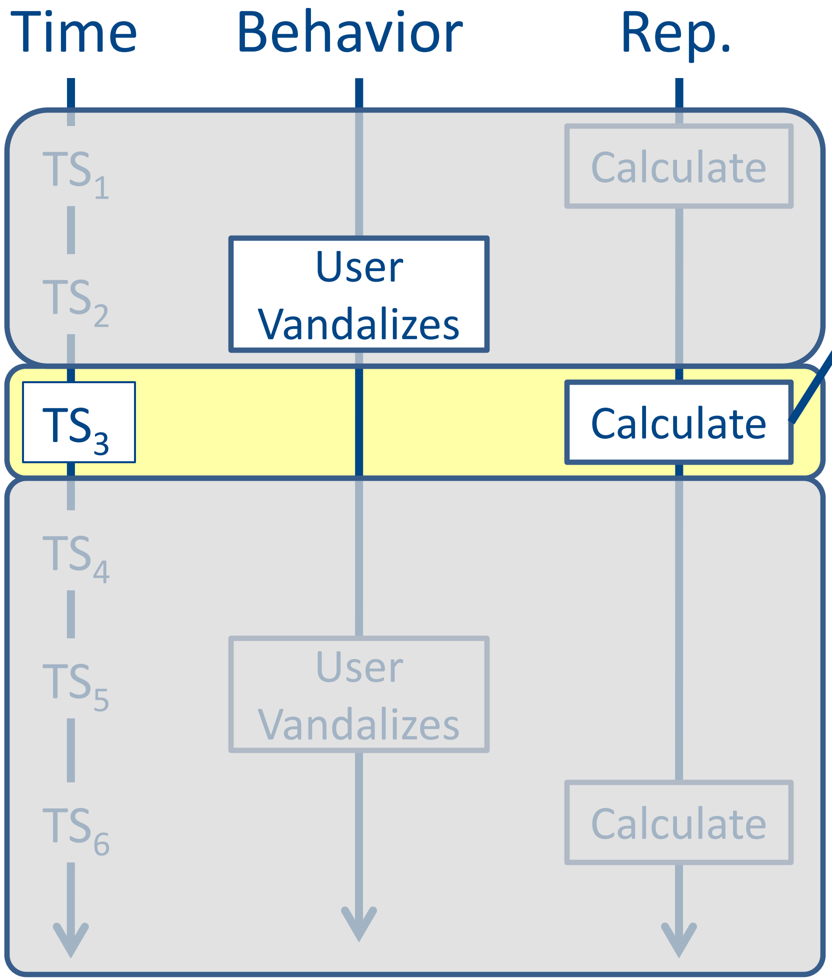
Reputation = 0.0

Completely Innocent!

Example Reputation



Example Reputation



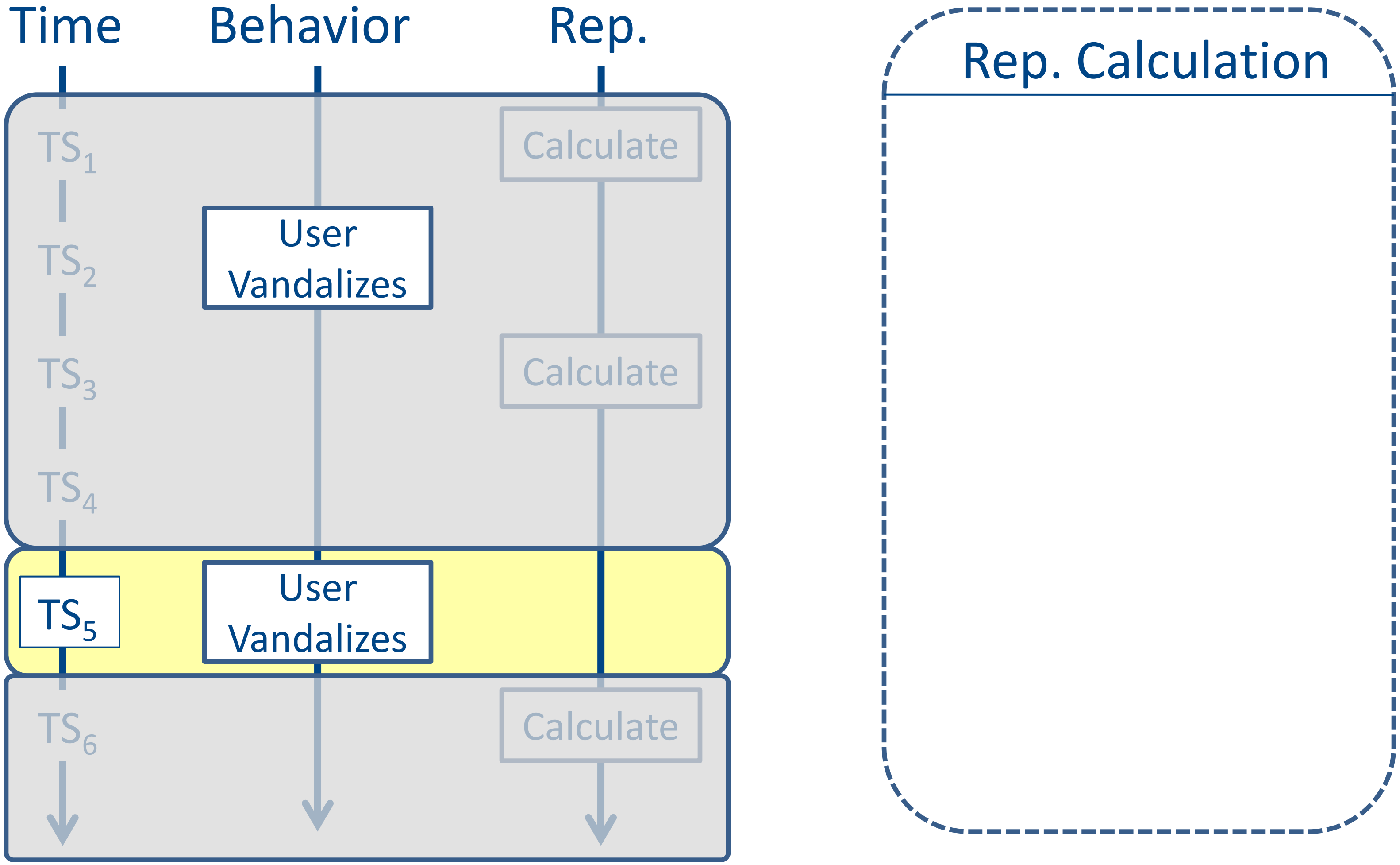
Rep. Calculation

One incident in history

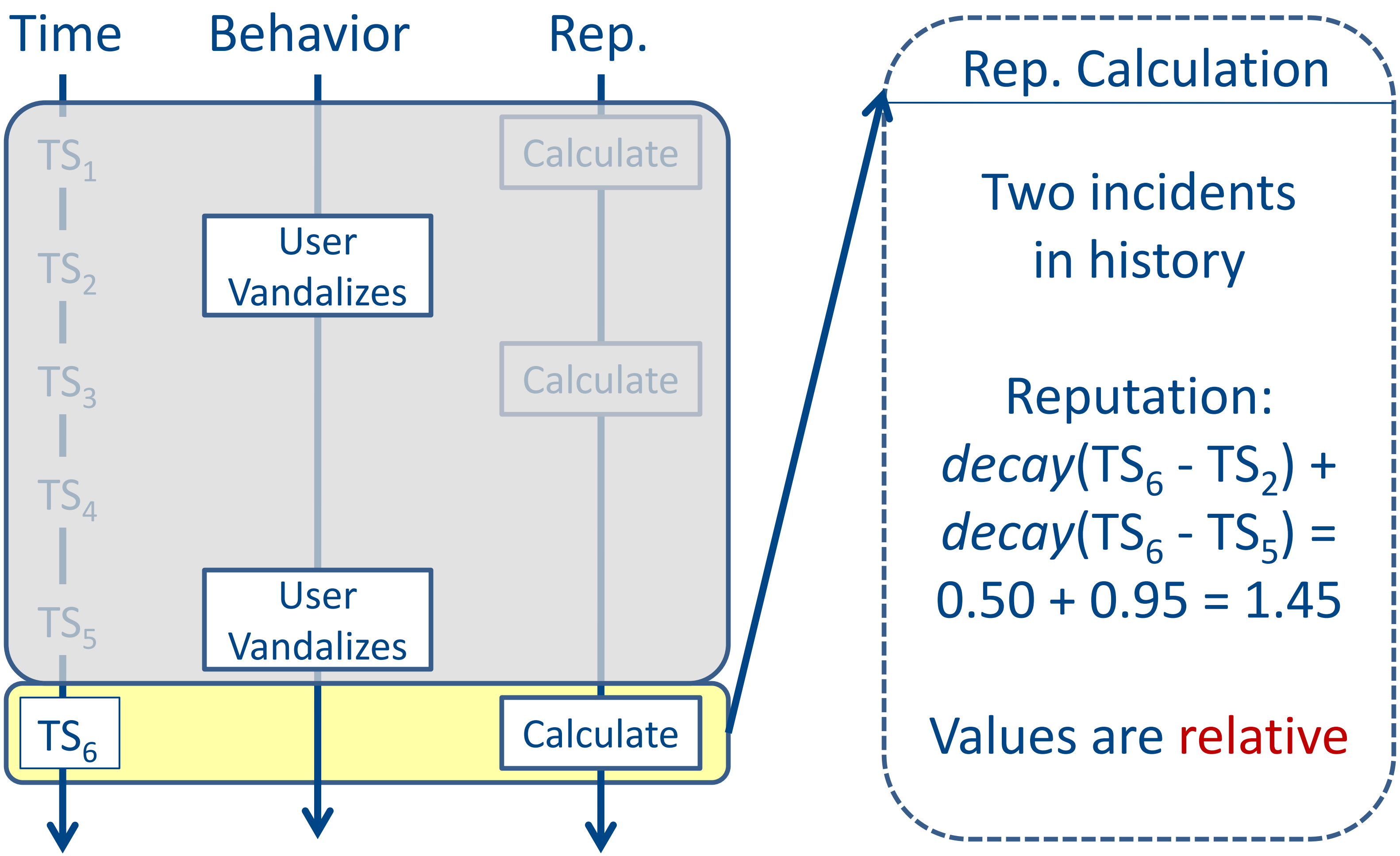
Reputation: *decay*(TS_3 - TS_2) = 0.95

decay() returns values on [0,1]

Example Reputation



Example Reputation



Rep. Calculation

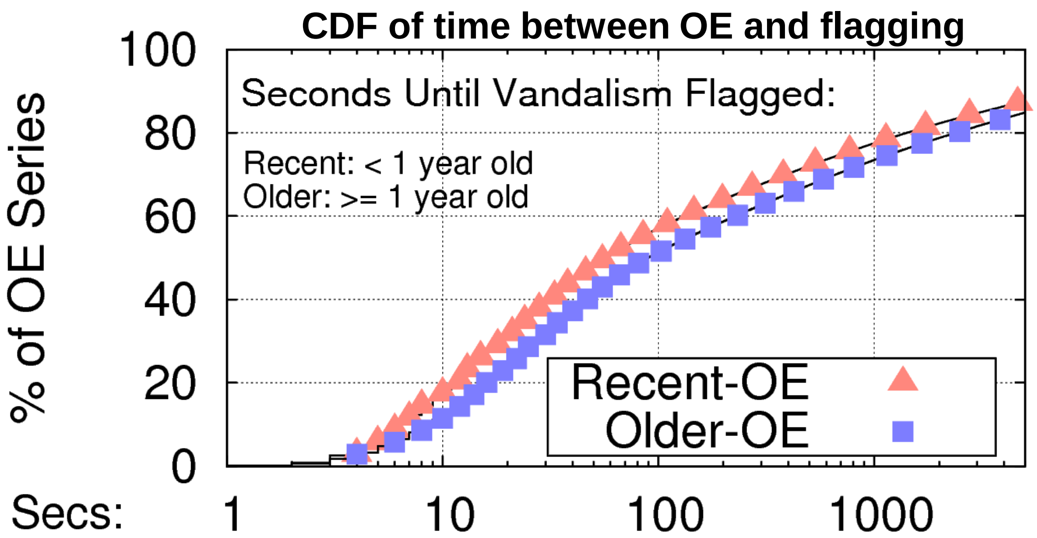
Two incidents in history

Reputation:
$$decay(TS_6 - TS_2) + decay(TS_6 - TS_5) = 0.50 + 0.95 = 1.45$$

Values are relative

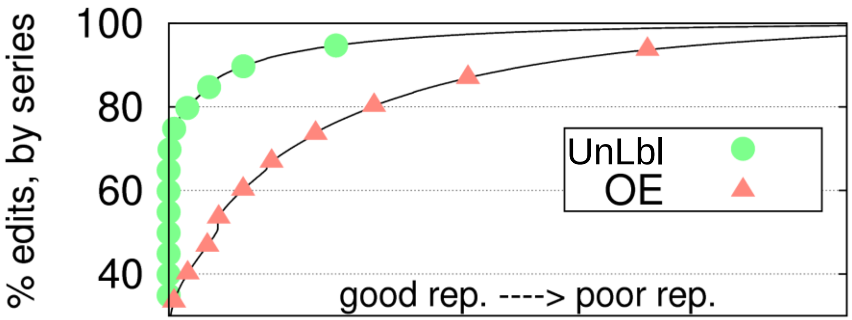
Rollback as Feedback

Use rollbacks (OEs) as neg. feedbacks for entities



- Key notion: A bad edit is not part of reputation until ($TS_{flag} > TS_{vandalism}$). Thus, vandalism must be flagged quickly so reputations are not latent.
  - Fortunately, median time-to-rollback: ≈80 seconds

Article Reputation



CDF of Article Reputation

ARTICLE	#OEs
George W. Bush	6546
Wikipedia	5589
Adolph Hitler	2612
United States	2161
World War II	1886

Articles w/most OEs

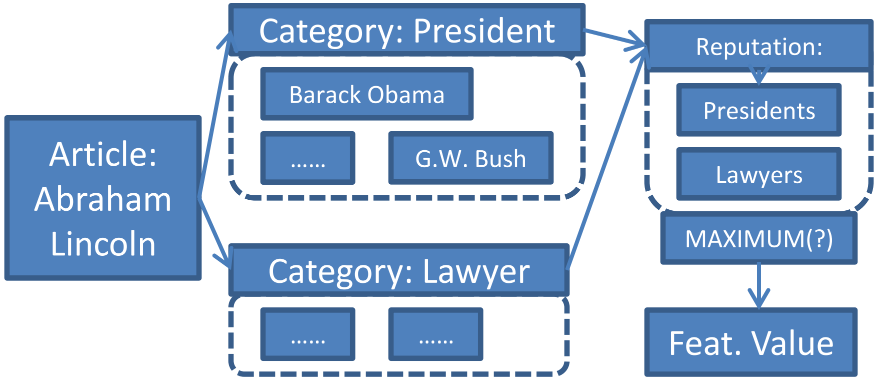
- Intuitively some topics are controversial and likely targets for vandalism (or temporally so).
- Trivial spatial grouping (size=1)
- 85% of OEs have non-zero rep (just 45% of random)

Category Reputation

- Category = spatial group over articles
- Wiki provides cats. /memberships – use only topical ones
- *size*() = Number of category members
- Overlapping grouping
- 97% of OEs have non-zero reputation (85% in article case)

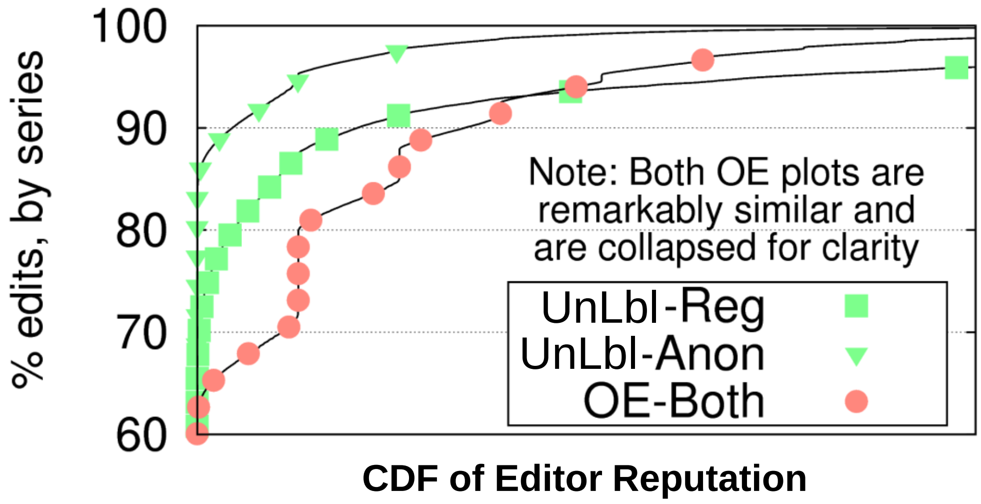
CATEGORY (with 100+ members)	PGs	OEs/PG
World Music Award Winners	125	162.27
Characters of Les Miserables	135	146.88
Former British Colonies	145	141.51

Categories with most OEs



Example of Category Rep. Calculation

Editor Reputation



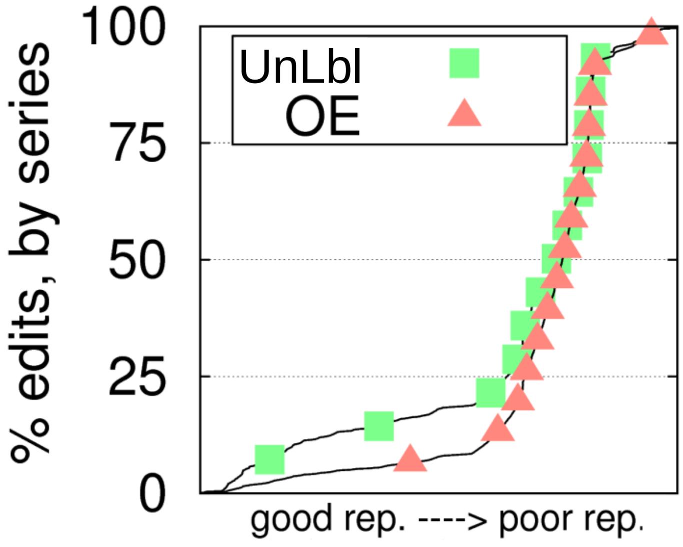
CDF of Editor Reputation

- Straightforward use of the *rep()* function, one-editor groups

- Problem: Dedicated editors accumulate OEs, look as bad as attackers (normalize? No)
- Mediocre performance. Meaningful correlation with other features, however.

Country Reputation

- Country = spatial grouping over editors
- Geo-location data maps IP → country
- Straightforward: IP resides in one country



CDF of Country Reputation

RANK	COUNTRY	%-OEs
1	Italy	2.85%
2	France	3.46%
3	Germany	3.46%
…	…	…
12	Canada	11.35%
13	United States	11.63%
14	Australia	12.08%

OE-rate (normalized) for countries with 100k+ edits

Classification and Performance

CLASSIFICATION & PERFORMANCE

ML Training

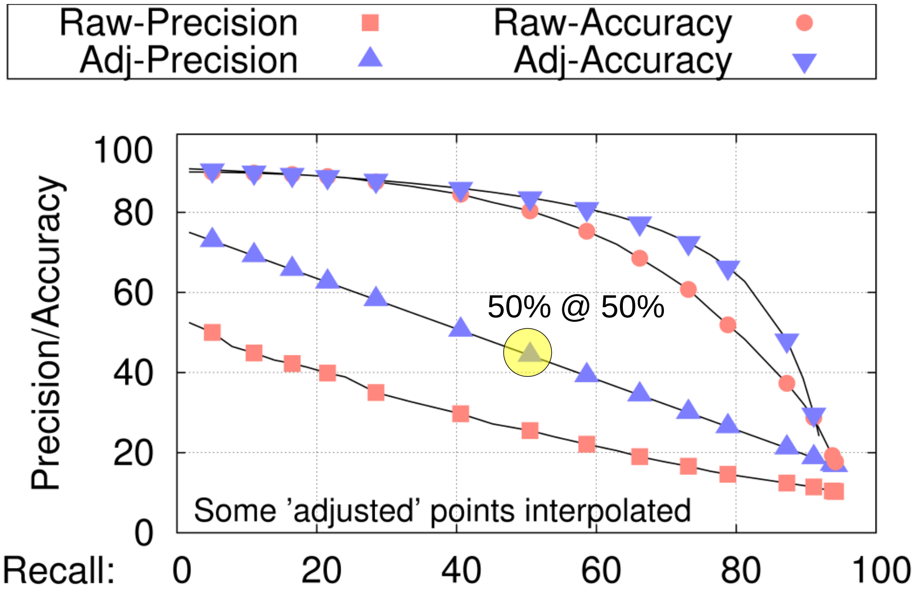
- Calc. features for all edits. Normalize onto [0,1]; polarity
- SVM: Support Vector Machine
- ISSUE: {Unlabeled} set is just that. Very low cost penalties so no over-compensation.
- Train over prior subset to classify now (100+ edits/sec).

#	FEATURE
1	Edit time-of-day
2	Edit day-of-week
3	Time-since page edited
4	Time-since user reg.
5	Time-since last user OE
6	Rev. comment length
7	Article reputation
8	Category reputation
9	Editor reputation
10	Country reputation

Review of features used (only IP-editors)

Performance

- ISSUE: Edits classified as OE but in {UnLbl} may not be FPs:
  - Manual inspection
  - Raw vs. adjusted
  - Corpus produced*
- Similar performance to NLP-efforts [2]
- Use as an *intelligent routing (IR)* tool
- Shown steady-state



50% @ 50%

Some ’adjusted’ points interpolated

Precision-recall trade-off

Recall: % OEs classified as such

Precision: % of edits classified OE that are actually vandalism

* http://www.cis.upenn.edu/~westand

Conclusions

- Showed spatio-temporal properties can locate Wikipedia-vandalism comparably to NLP
  - – Complementary; still some advantages:
    - Content/language independent
    - Harder to evade (analysis needed)
    - Faster (100+ edits/sec vs. 5 edits/sec)
- Spatio-temporal reputation as a general-purpose technique for content-based access control?
  - – Email spam: SNARE [1] and PreSTA [5]
  - – This work shows it also works for Wikipedia

References

[1] S. Hao, N.A. Syed, N. Feamster, A.G. Gray, and S. Krasser. **Detecting spammers with SNARE: Spatiotemporal network-level automated reputation engine**. In *18th USENIX Security Symposium*, 2009

[2] M. Potthast, B. Stein, and R. Gerling. **Automatic vandalism detection in Wikipedia**. In *Advances in Information Retrieval*, pp. 663-668, 2008.

[3] R. Priedhorsky, J. Chen, S.K. Lam, K. Achier, L. Terveen, and J. Riedl. **Creating, destroying, and restoring value in Wikipedia**. In *GROUP '07: The 2007 ACM Conference on Supporting Group Work*, pp. 259-268, 2007.

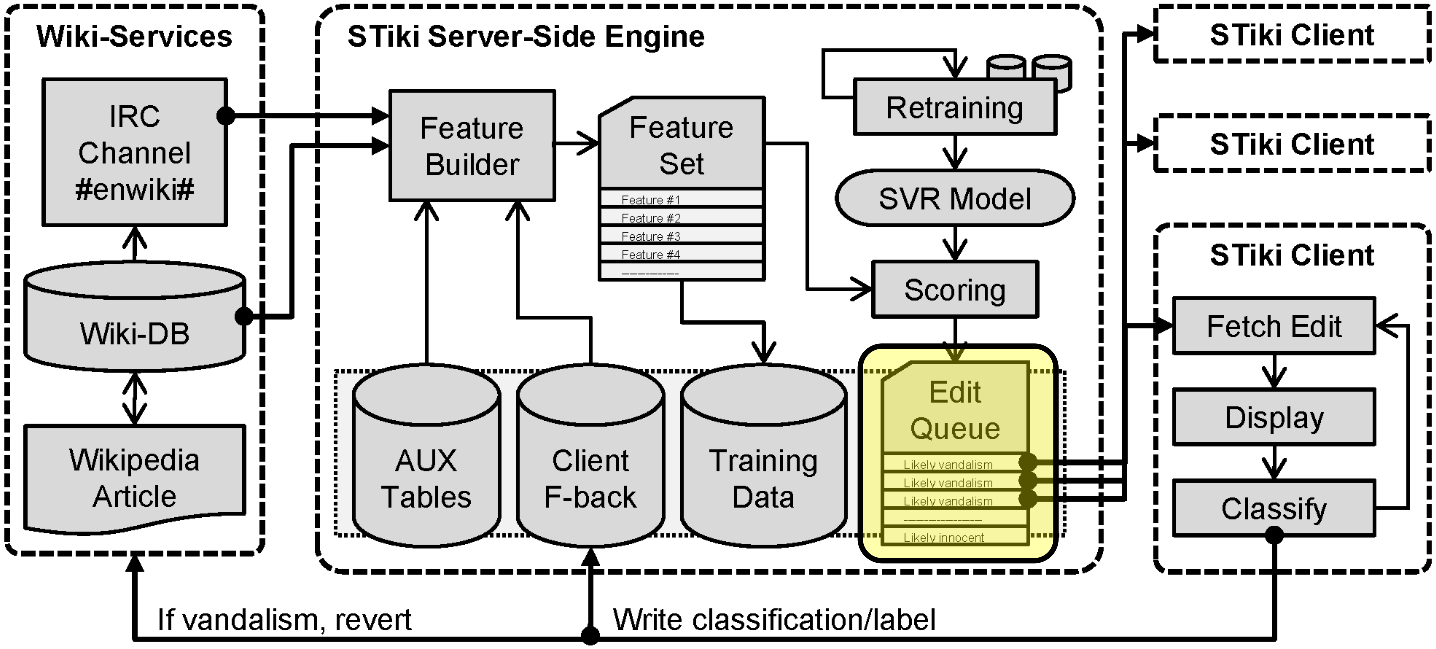
[4] A.G. West. **STiki: A vandalism detection tool for Wikipedia**. http://en.wikipedia.org/wiki/Wikipedia:STiki. *Software*, 2010.

[5] A.G. West, A.J. Aviv, J. Chang, and I. Lee. **Mitigating spam using spatio-temporal reputation**. *Technical report MS-CIS-10-04, University of Pennsylvania*, February 2010.

STiki

STiki [4]: A real-time, on-Wikipedia implementation of the technique

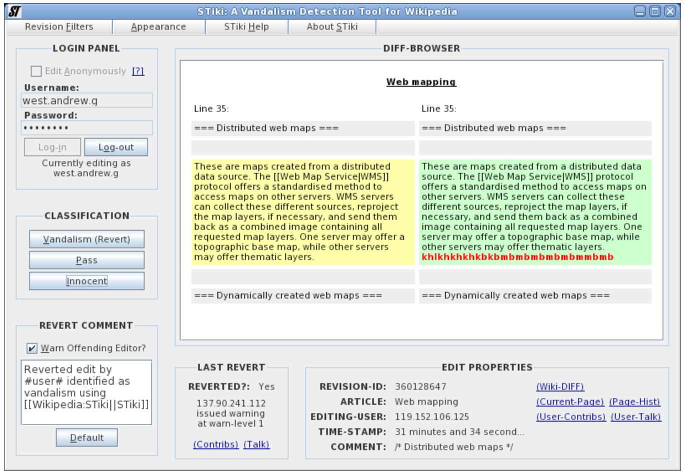
STiki Architecture



EDIT QUEUE: Connection between server and client side

- Populated: Priority insertion based on *vandalism score*
- Popped: GUI client shows likely vandalism first
- De-queued: Edit removed if another made to same page

Client Demonstration



□ Edit Anonymously [?]

Username: west.andrew.g

Password: ••••••••

Currently editing as west.andrew.g

☑ Warn Offending Editor?

Reverted edit by #user# identified as vandalism using [[Wikipedia:STiki||STiki]]

Web mapping

Line 35:	Line 35:
=== Distributed web maps ===	=== Distributed web maps ===
These are maps created from a distributed data source. The [[Web Map Service|WMS]] protocol offers a standardised method to access maps on other servers. WMS servers can collect these different sources, reproject the map layers, if necessary, and send them back as a combined image containing all requested map layers. One server may offer a topographic base map, while other servers may offer thematic layers.	These are maps created from a distributed data source. The [[Web Map Service|WMS]] protocol offers a standardised method to access maps on other servers. WMS servers can collect these different sources, reproject the map layers, if necessary, and send them back as a combined image containing all requested map layers. One server may offer a topographic base map, while other servers may offer thematic layers. **khlkhkhkhkbkbmbmbmbmbmbmmbmb**
=== Dynamically created web maps ===	=== Dynamically created web maps ===

REVERTED?: Yes

137.90.241.112 issued warning at warn-level 1

REVISION-ID: 360128647

ARTICLE: Web mapping

EDITING-USER: 119.152.106.125

TIME-STAMP: 31 minutes and 34 second...

COMMENT: /* Distributed web maps */

STiki

Client

Demo

STiki Performance

- Competition inhibits maximal performance
  - Metric: Hit-rate (% of edits displayed that are vandalism)
  - Offline analysis shows it could be 50%+
  - Competing (often autonomous) tools make it ≈10%
- STiki successes and use-cases
  - Has reverted over 3500+ instances of vandalism
  - May be more appropriate in less patrolled installations
    - Any of Wikipedia's foreign language editions
    - Corporate Wiki's and other small installations
  - Embedded vandalism: That escaping initial detection. Median age of STiki revert is 4.25 hours, 200× conventional

Alternative Code Uses

- All code is available [4] and open source (Java)
- Backend (server-side) re-use
  - Large portion of MediaWiki API implemented (bots)
  - Trivial to add new features (including NLP ones)
- Frontend (client-side) re-use
  - Useful whenever edits require human inspection
- Data re-use
  - Corpus building; crowd-sourcing
  - Incorporate vandalism score into more robust tools

Future Direction: Wiki-Spam

- Many people “see” vandalism and do nothing:
  - Becomes “embedded” for days/weeks accumulating views
  - Traffic spikes: During American Idol finale, the “Crystal Bowersox” article was vandalized for just 28 seconds, but 12,000+ viewed the page during this duration.
  - Shows evade-ability, apathy, or both
- What if vandalism was spam?
  - If immature vandalism can get this many views, what about the less detectable and incentivized spam?
  - Could it be more profitable than email spam?
  - What evasion strategies would work best?