Building Trust in Online Rating Systems through Signal Modeling

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Trust-based Reliable Rating Aggregation

Motivation
Introduction
System
Algorithms
(1) Detection
(2) Trust in raters
(3) Rating Aggregation
Simulation
Rating Challenge

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Online Feedback-based Rating Systems

Web Site	Category	Summary of reputation mechanism
eBay	Online auction house	Buyers and sellers rate one another following transactions
eLance	Professional Services marketplace	Contractors rate their satisfaction with subcontractors
Epinions	Online opinions forum	Users write reviews about products/services; other members rate the usefulness of reviews
Slashdot	Online Discussion board	Postings are prioritized or filtered according to the ratings they receive from readers
YouTube	Multimedia broadcasting	Viewers rate the video clips
Amazon	Online shopping site	Shoppers rate the products

- Users submit their opinions regarding to products, services, or other users;
- Submitted opinions are analyzed, aggregated and made publicly available.

An Important Problem: Unfair Ratings

- Unfair ratings -- a critical factor that undermine the reliability of online rating systems.

Individual unfair ratings

– an individual rater provides unfairly high or low ratings, resulting from raters' personality/habit, careless, or randomness in rating behavior.

Collaborative unfair ratings

– a group of raters providing unfairly high or low ratings to boost or downgrade the overall rating of an object.

Existing Solutions

- Existing solutions
  - Clustering techniques
  - Statistically analysis
  - Endorsement-based quality estimation
  - Entropy-based detection

All based on *Majority Rule*

A Challenging Problem: Unfair Ratings

- No sufficient number of ratings → Statistical methods, such as clustering, will not work.
- Rating values are highly discrete; → Detecting rating is low unless tolerate a high false alarm rate;
- With smart, collaborative unfair raters, majority rule may not hold → Most existing schemes lost their foundation.

Our Novel Idea

- Rating values → samples of a random process
- Fair ratings → noise
- Unfair ratings → signal

Basic Idea: Model the overall rating values using an autoregressive (AR) signal modeling technique, and exam the model errors. When the 'signal' is presented, the model error is low.

Our Contributions

- An **algorithm** that detects suspicious ratings in the scenarios where existing techniques do not work;
- A **system** that utilizes trust models for rating aggregation and improves system reliability.

Classification of Unfair Ratings

- *Individual unfair ratings*
  - an individual rater provides unfairly high or low ratings, resulting from raters' personality/habit, careless, or randomness in rating behavior.

- *Collaborative unfair ratings*
  - a group of raters providing unfairly high or low ratings to boost or downgrade the overall rating of an object.

  Strategy 1: large bias

  Strategy 2: moderate bias

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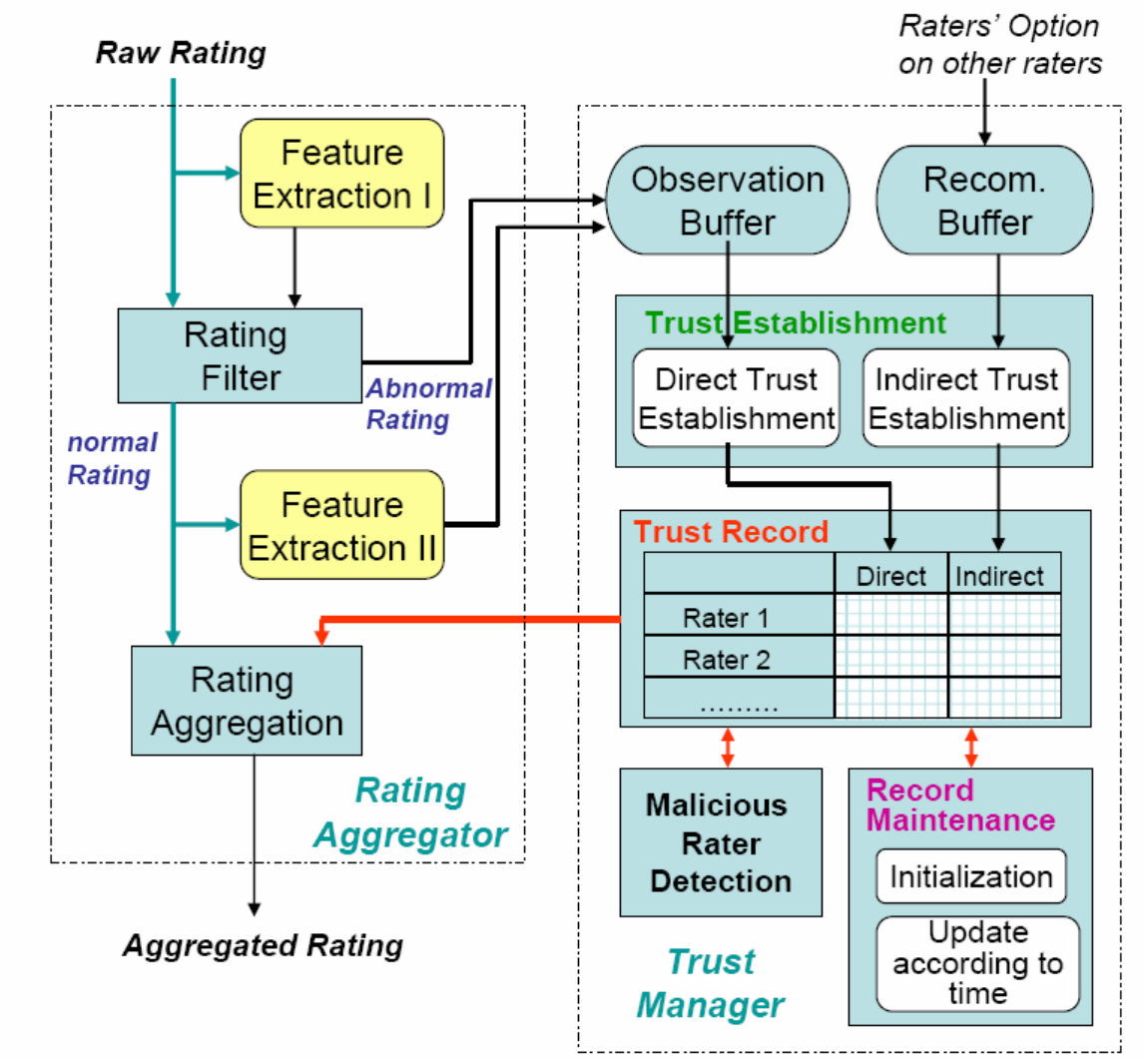
System



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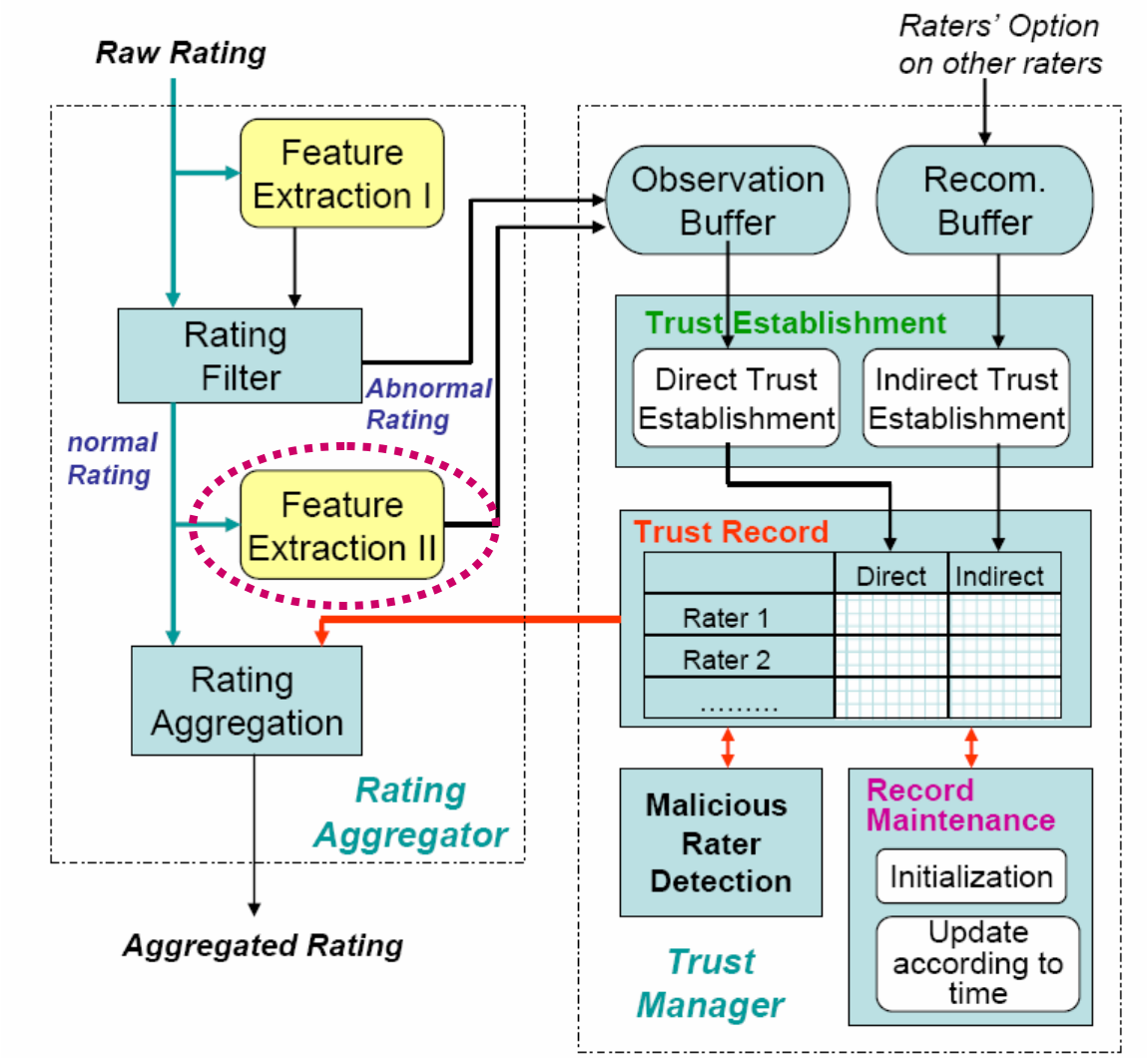
Algorithm 1: Detect Suspicious Interval



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Algorithm 1

Algorithm - 1

Procedure 1 Detecting suspicious interval and updating raters' suspicious values

1: For each rater i, initialize $L_i^{latest} = 0$
2: **for** $k = 1 : W$ **do**
3: let R denote the ratings for a certain object in the k^{th} window.
4: find the all-pole model of the signal R using the covariance method [7]. In particular, given the model order p, calculate the model coefficients $a = [1, a(1), ...a(p)]$ and normalized model error $e(k)$ $(0 < e(k) < 1)$.
5: **if** $e(k) < threshold$ **then**
6: The k^{th} window is marked as the suspicious
7: A suspicious level is calculated as $L(k) = scale(1 - e(k))/threshold$, where $scale$ is scaling factor between 0 and 1.
8: **for** each rating in the k^{th} window. **do**
9: assume this rating is from rater j
10: **if** $L_j^{latest} = 0$ **then**
11: $C_i = C_i + L(k)$; $L_j^{latest} = L(k)$;
12: **else**
13: **if** $L_j^{latest} > L(k)$ **then**
14: $C_i = C_i + L(k) - L_j^{latest}$, $L_j^{latest} = L(k)$;
15: **end if**
16: **end if**
17: **end for**
18: **end if**
19: **end for**

AR signal modeling

Examining model error

Suspicious level depends on the model error

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Evaluation of Algorithm 1

- Simulation Parameters

$simu\_time = 60$	simulation time is 60 days
$arrival\_rate = 3$	rating arrival is a Poisson process with arrival rate 3
$R\_level = 11$	ratings which have 11 levels can be 0, 0.1, 0.2, $\cdots$, or 1
$quality\_start = 0.7$ $quality\_end = 0.8$	The quality of the object is 0.7 at the beginning and linearly increases to 0.8 at the end of the experiment.
$goodVar = 0.2$	The ratings from honest raters follow a Gaussian distribution with mean being the quality of the object and variance being 0.2.

$A\_start = 30$ $A\_end = 44$	The unfair ratings arrive between day 30 and day 44
$biasshift_1 = 0.2$ $recruitpower_1 = 0.3$	during the attack interval, 30% raters increase their original ratings by 0.2
$biasshift_2 = 0.15$ $badVar = 0.02$ $recruitpower_2 = 1$	type 2 collaborative ratings, whose arrival rate is 3, follow a Gaussian distribution with variance 0.02, and mean = object quality + 0.15.

Influenced →

Recruited →

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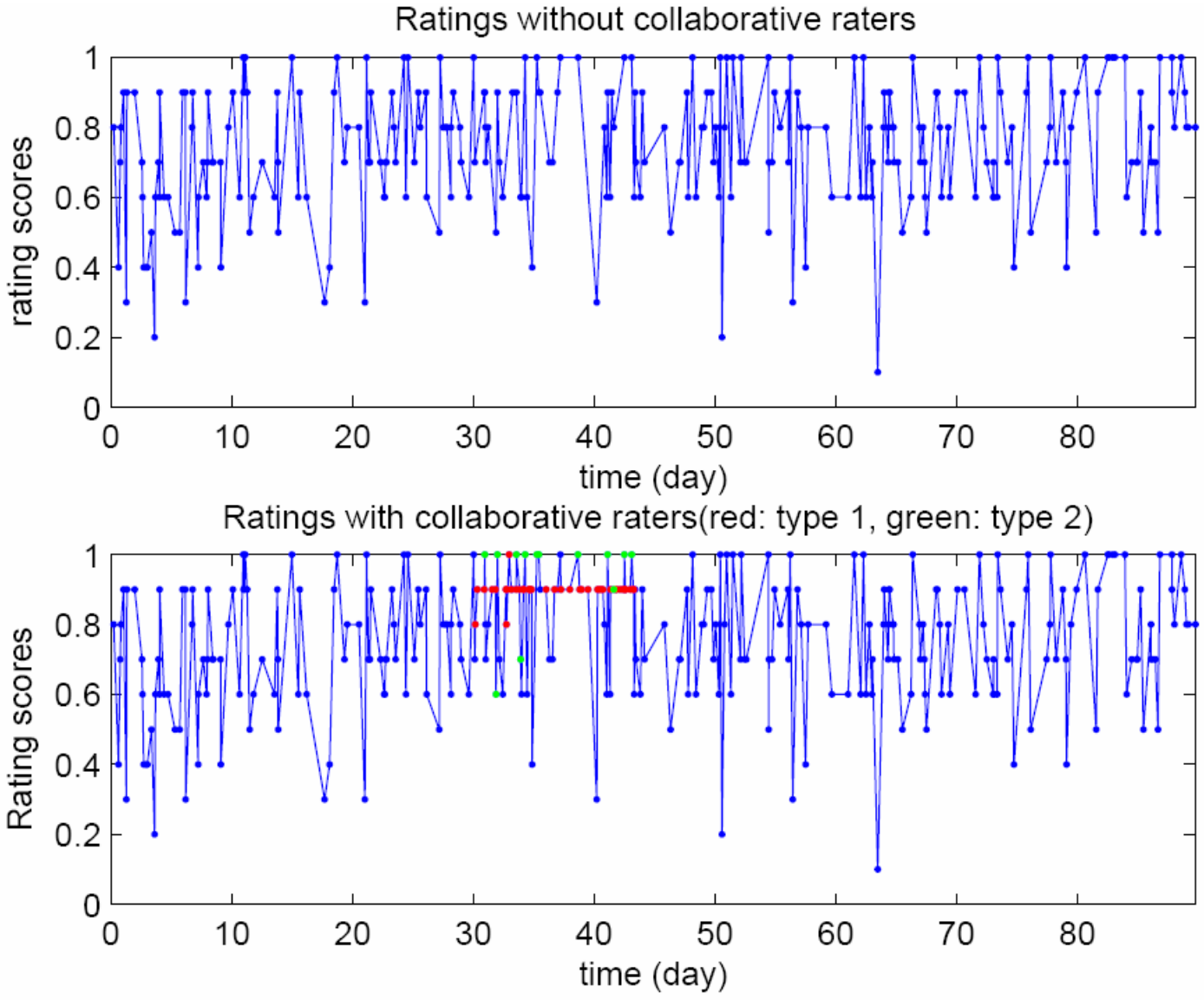
Raw Ratings



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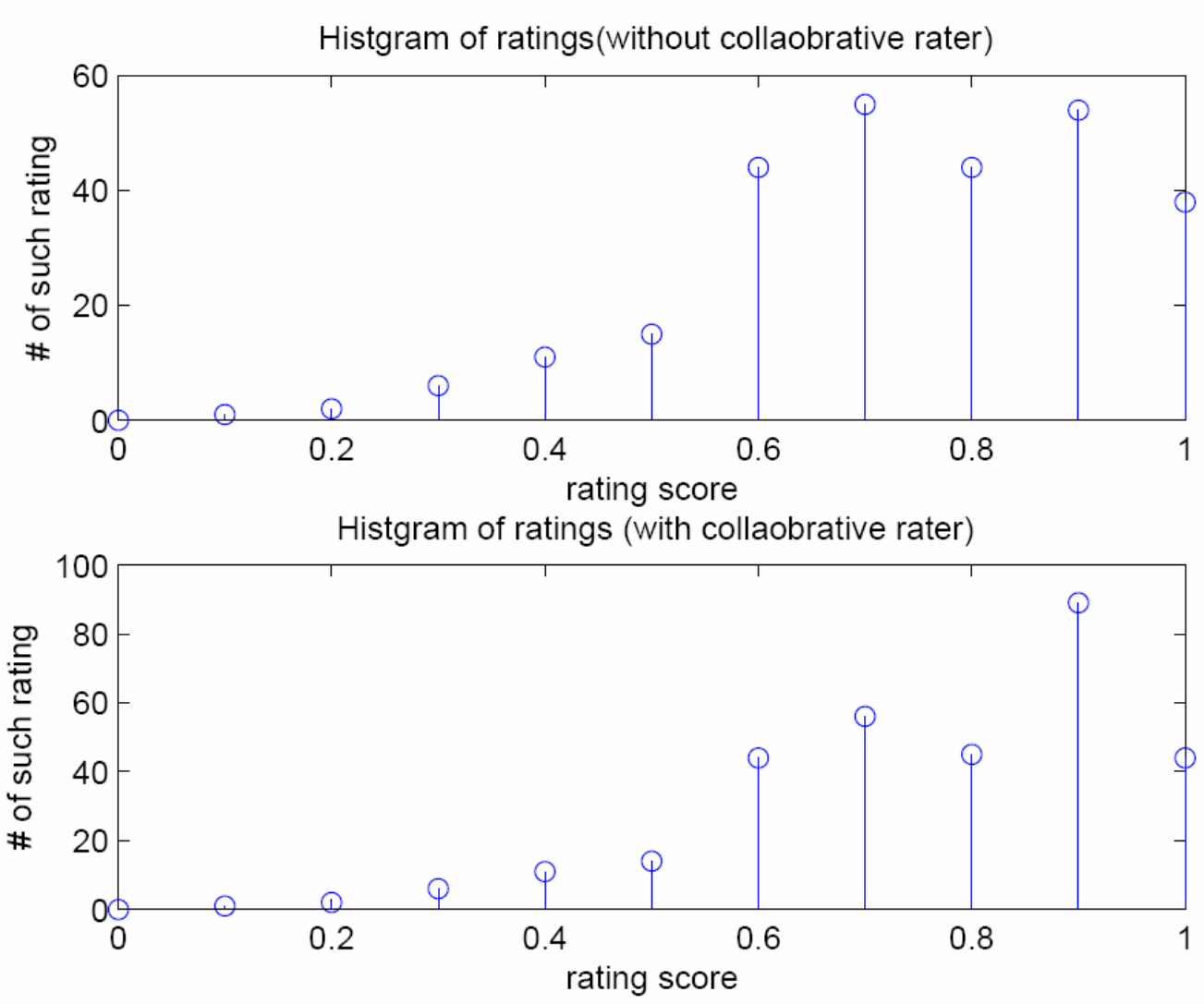
Majority Rule won't work



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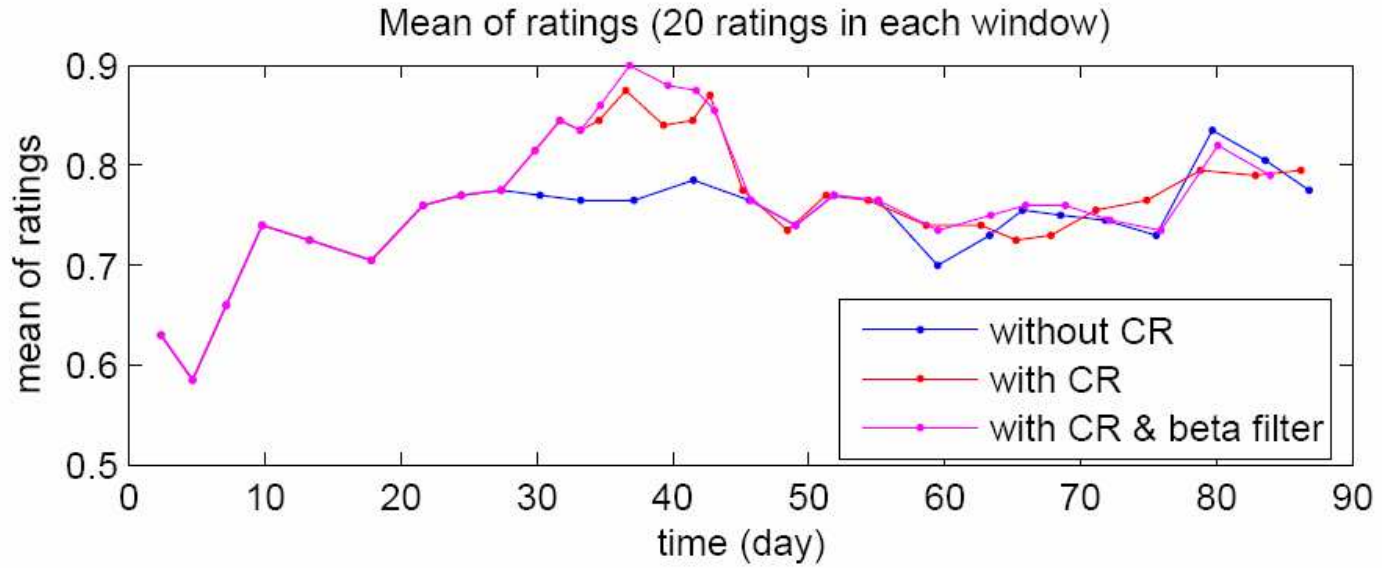
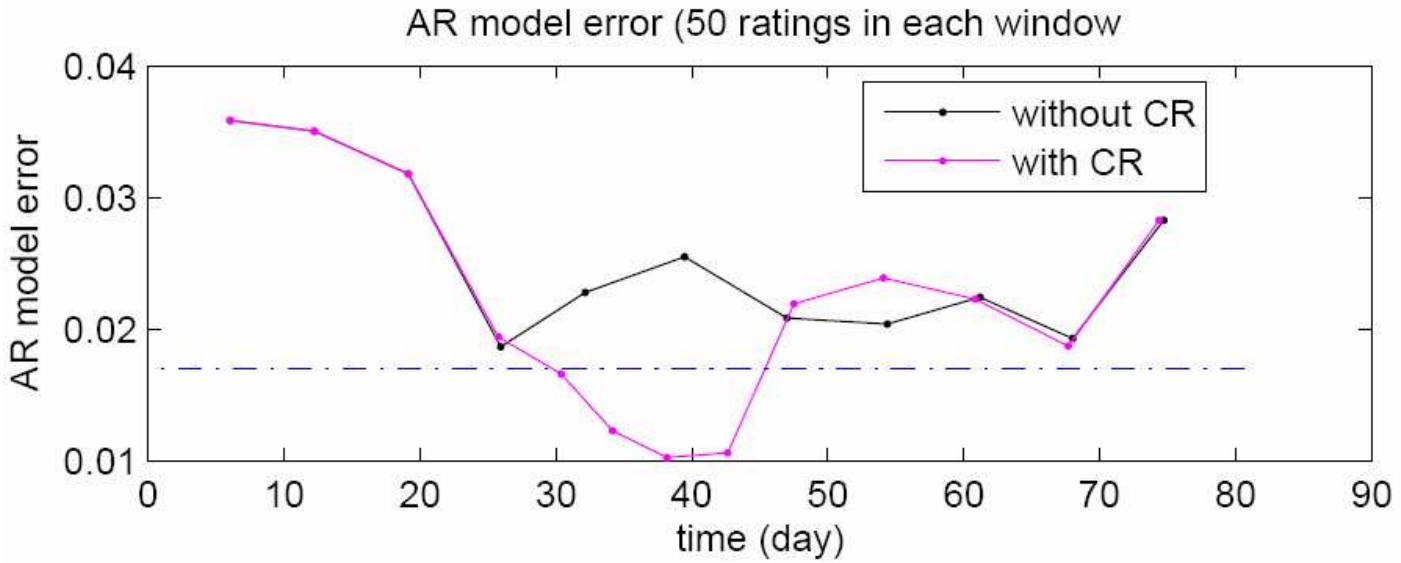
Our Algorithm Worked !

Detection Ratio = 0.782;

False Alarm Ratio = 0.06.





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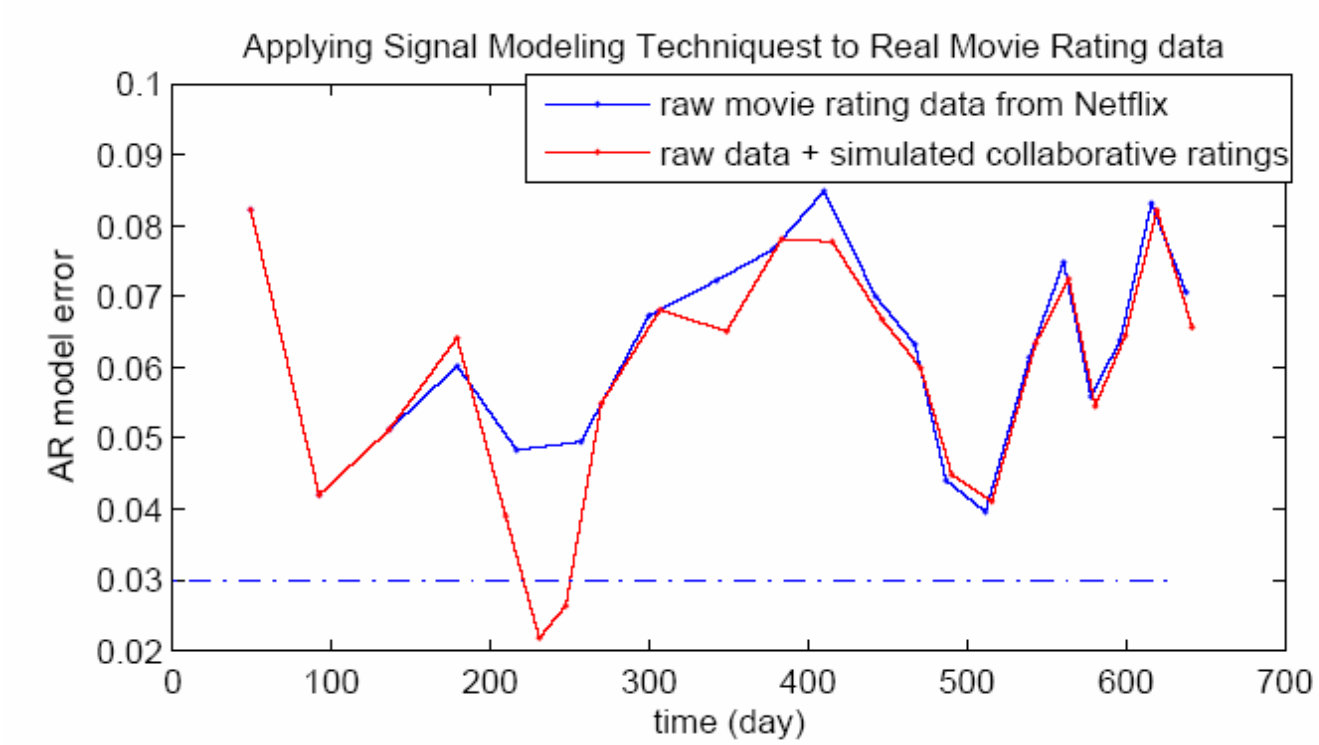
Our algorithm worked for real-world data



Model errors for original data and data with collaborative ratings. (Dinosaur Planet, 2003.)

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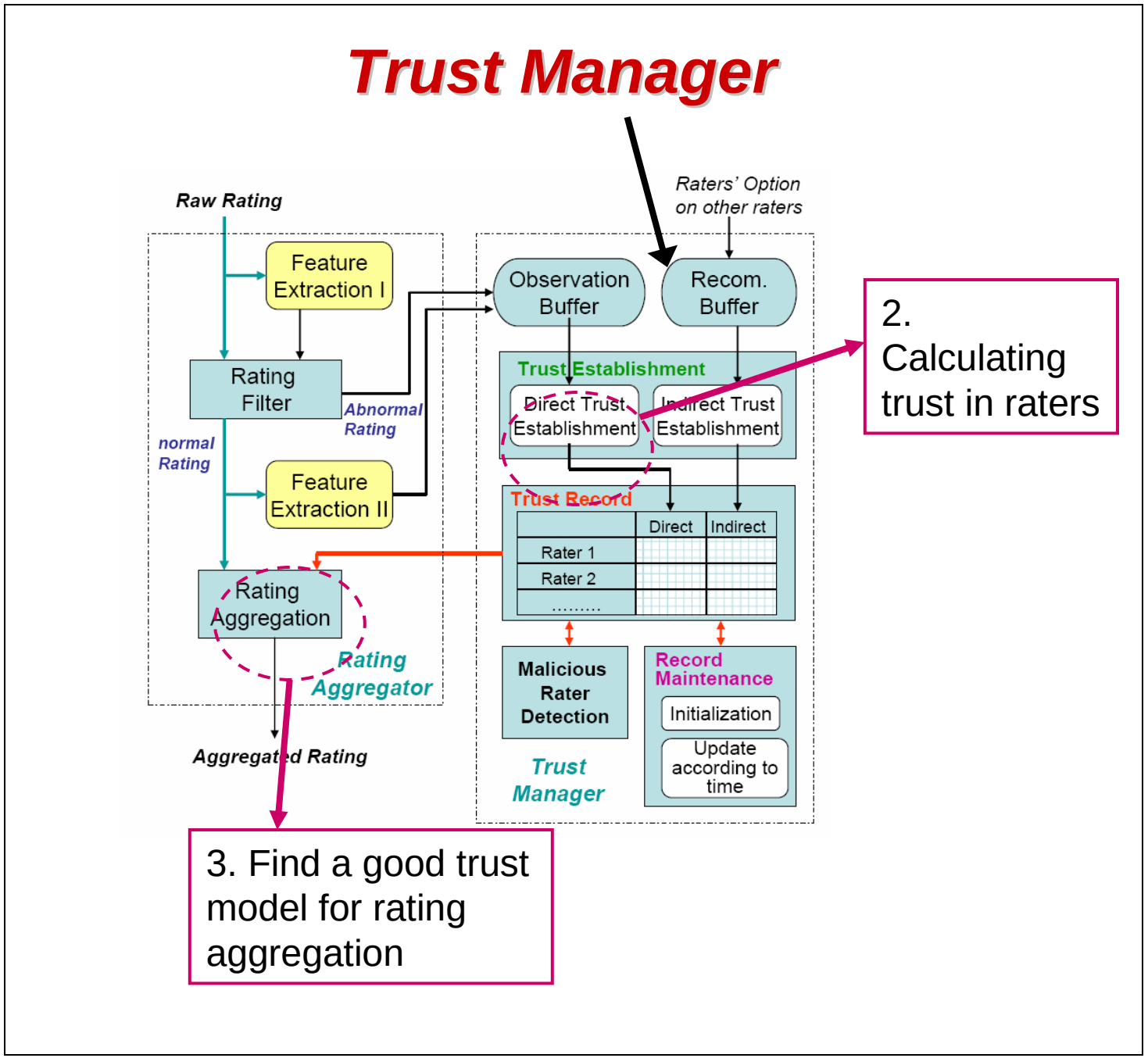

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Trust in Raters

n : total number of ratings provided by this rater

n_f : the number of ratings that are filtered out

n_s : the number of ratings that are in suspicious interval

C_i : the suspicious level, $i = 1,2,....,n_s$

b : scaling factor between 0 and 1

$$F = n_f + b\sum_{i=1}^{n_s} C_i$$

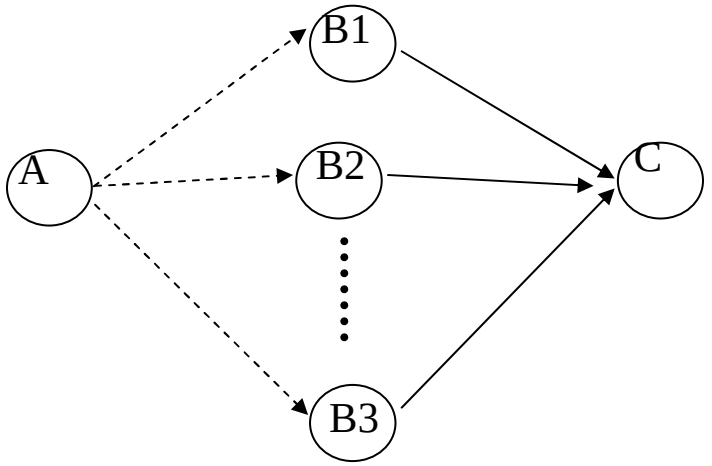
$$S = n - n_f - n_s$$

$$TrustValue = (S+1)/(S+F+2)$$

Rating Aggregation

Trust Relationship {A: B, task}

- {rater: product, have a certain quality} – Rating Value
- {system: rater, provide fair ratings} – Trust in Raters
- {system: product, having a certain quality} – aggregated ratings.



A Good Trust Model

- We have compared four popular trust models.
  - Simple averaging
  - Beta function based aggregation, without trust.
  - **Modified weighted average**

$$R_{ag} = \frac{1}{\sum_{i:i \in R} max(T_i - 0.5, 0)} \sum_{i:i \in R} max(T_i - 0.5, 0) \cdot r_i$$

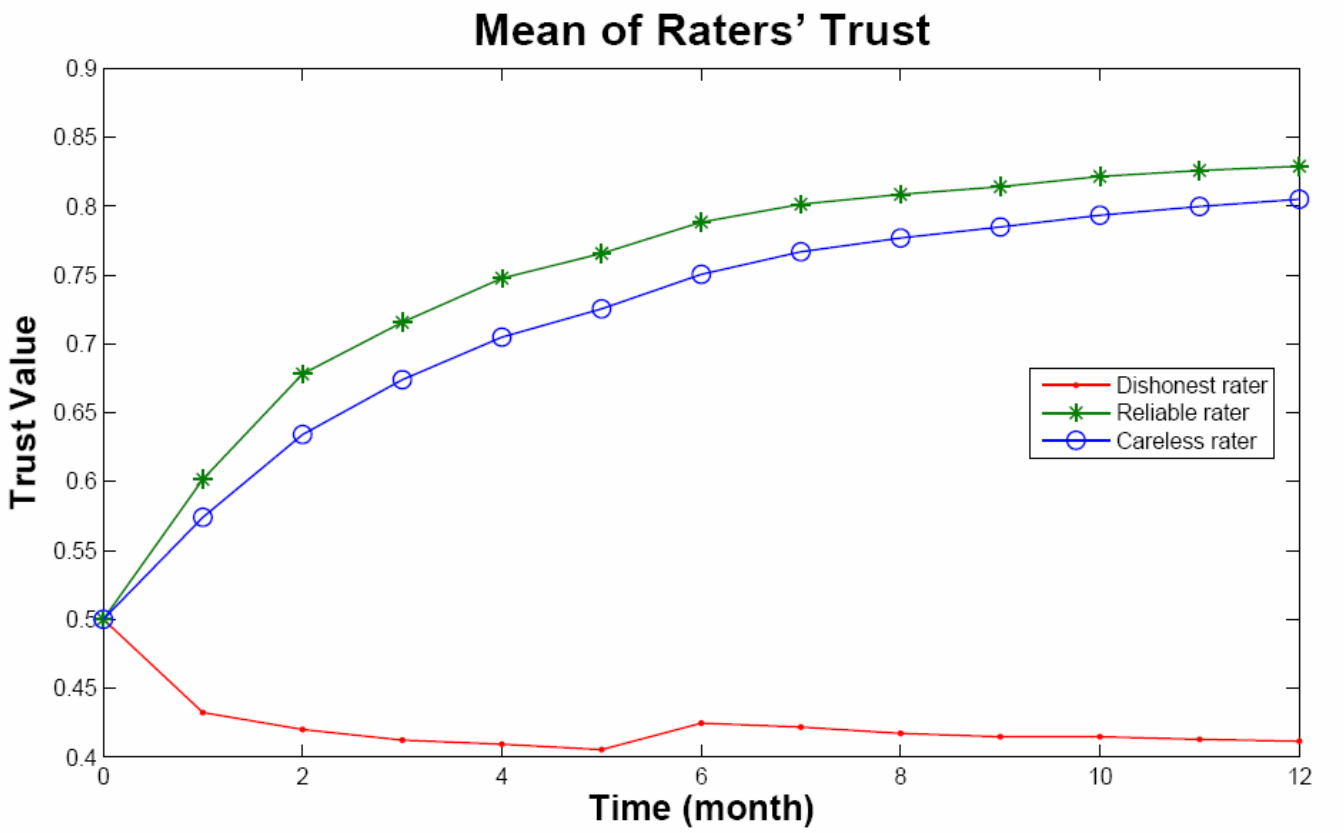
  - Beta-function based trust model

System Performance Setup

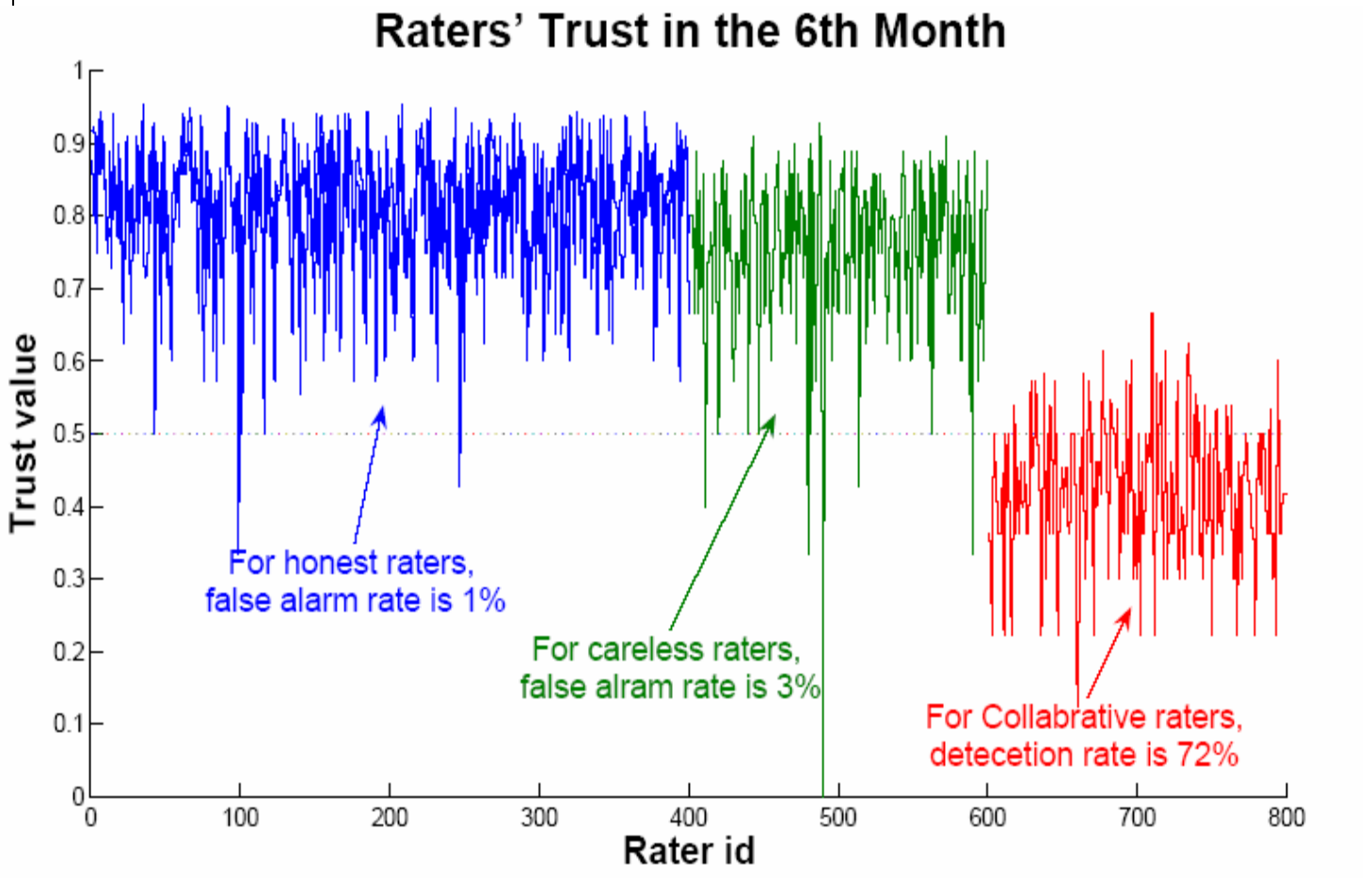
- The rating scores have 10 levels
- 400 are reliable raters, 200 are careless raters and 200 are potential collaborative unfair raters. (*good_var* = 0.2; *careless_var* = 0.3)
- collaborative rater
  - If recruited: *with a higher probability to rate*;
  - If not recruited: behave as a reliable rater, but with lower probability to rate.
- Rating 60 products during 360 days. In each month (30 days), the owner of 1 product recruit collaborative raters, who rate in 10 days.
- The quality of the products is assumed to be uniformly distributed between 0.4 and 0.6.

System Performance Evaluation

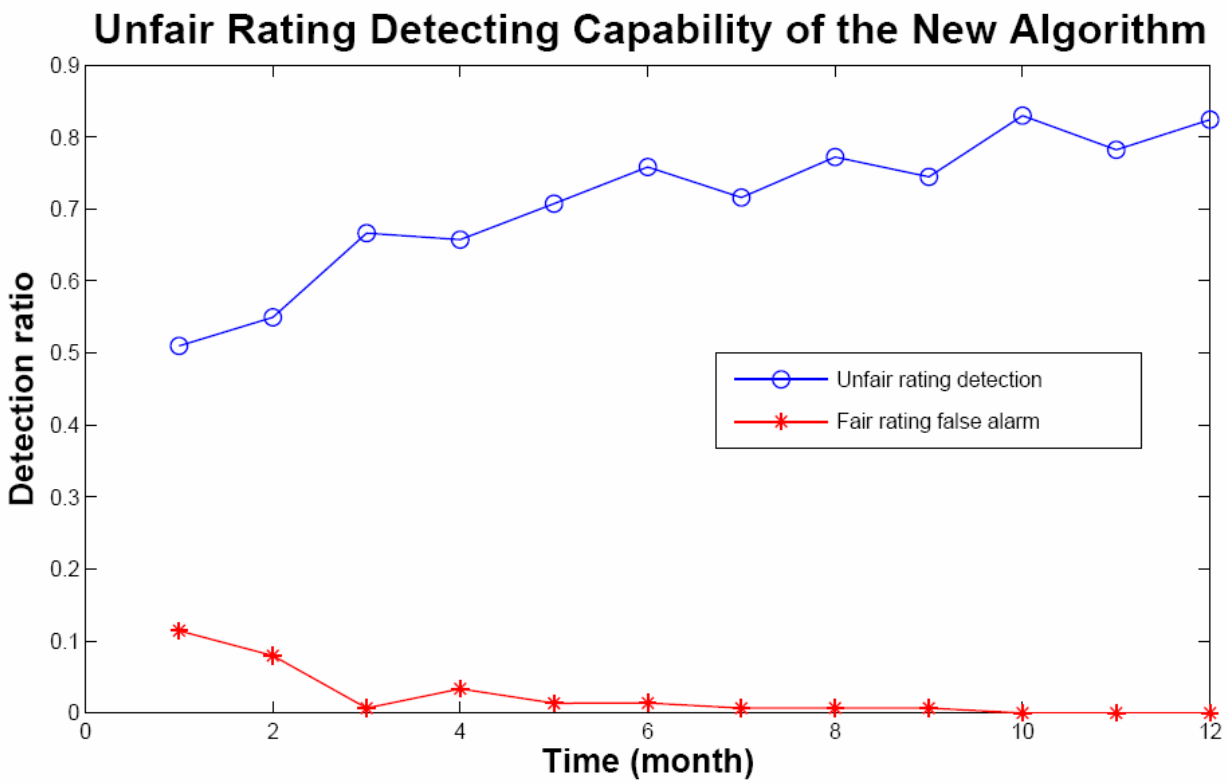
- Mean of Rater's Trust



- Trust Values

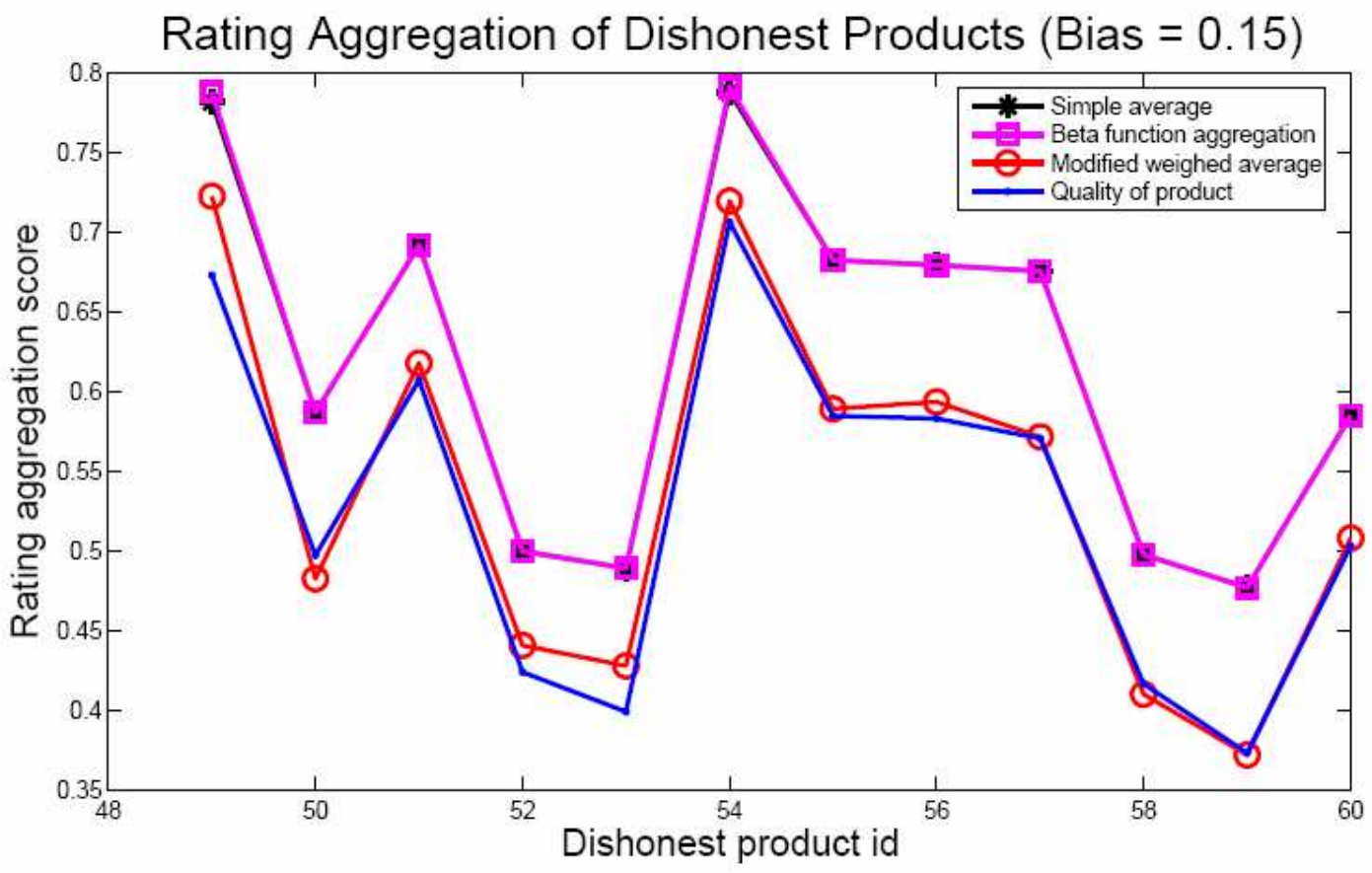


- Unfair rating detection ratio



No existing schemes are able to detect collaborative unfair raters that does not introduce a large bias and overpower honest raters in certain time intervals

- Aggregated Rating



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Rating Challenge

- Real online rating data for 9 flat panel TVs.
- Participants control 50 biased raters.
- The participants' goal is to boost the ratings of two products and reduce the ratings of another two products.
- The successfulness of the participants' attack is determined by the overall manipulation power.
- The participants that can generate the largest MP value win the competition.

www.etanlab.com/rating