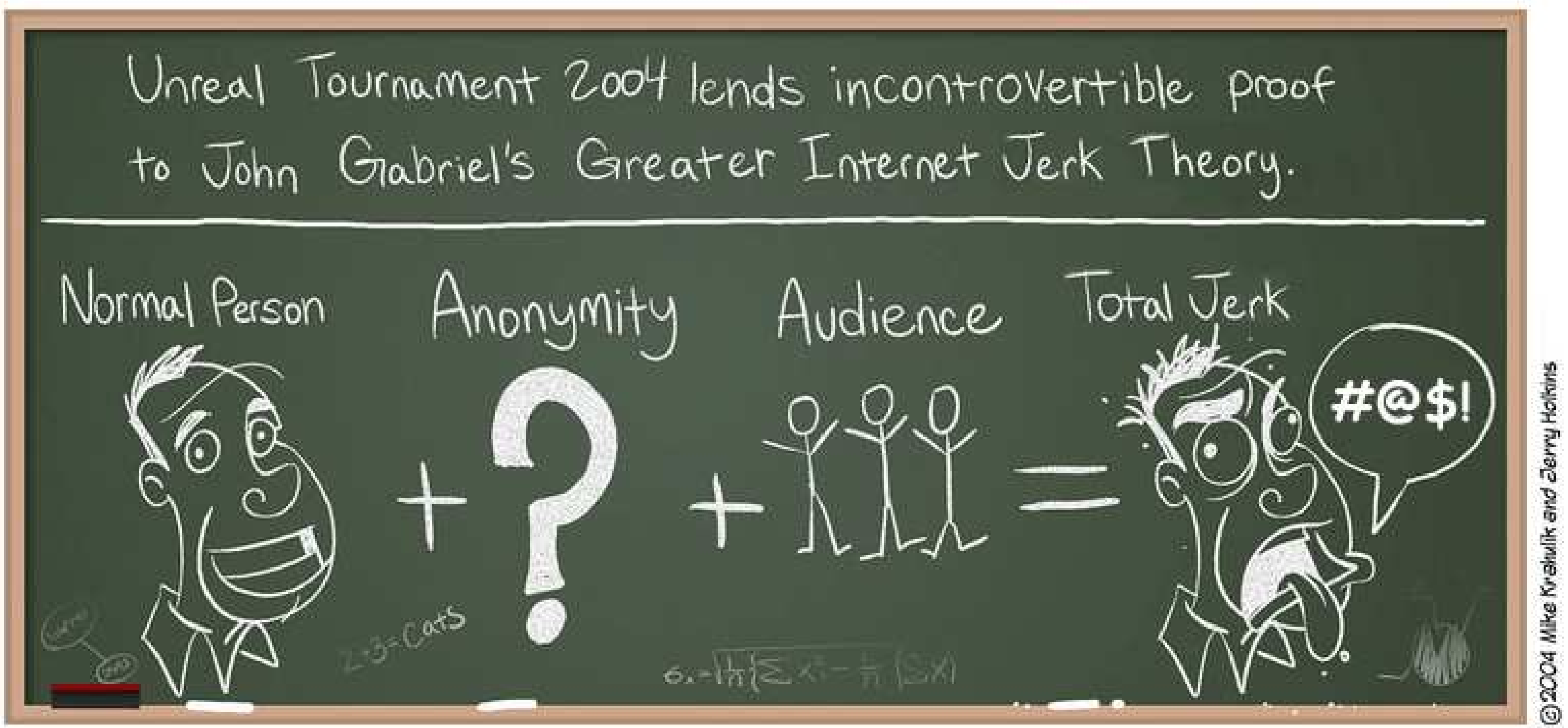
PlayerRating: A Reputation System for Multiplayer Online Games

Ed Kaiser

Wu-chang Feng

Portland State University

The Online Behavior Problem



Penny Arcade 03/19/2004

Motivation

- **Players misbehave**
  - premeditated (e.g., harassment, cheating, scamming, *griefing*)
  - unpremeditated (e.g., poor sportsmanship, *rage-quitting*)
- **Difficult to control antisocial behavior**
  - limited policing resources (i.e., manpower, storage)
  - hard to catch after the fact
- **Existing social tools fall short**
  - experiences are not shared (e.g., friend-list, ignore-list)
  - too discrete – only 3 options: like / dislike / unknown
  - impersonal (e.g., accumulated score systems)

Reputation Systems

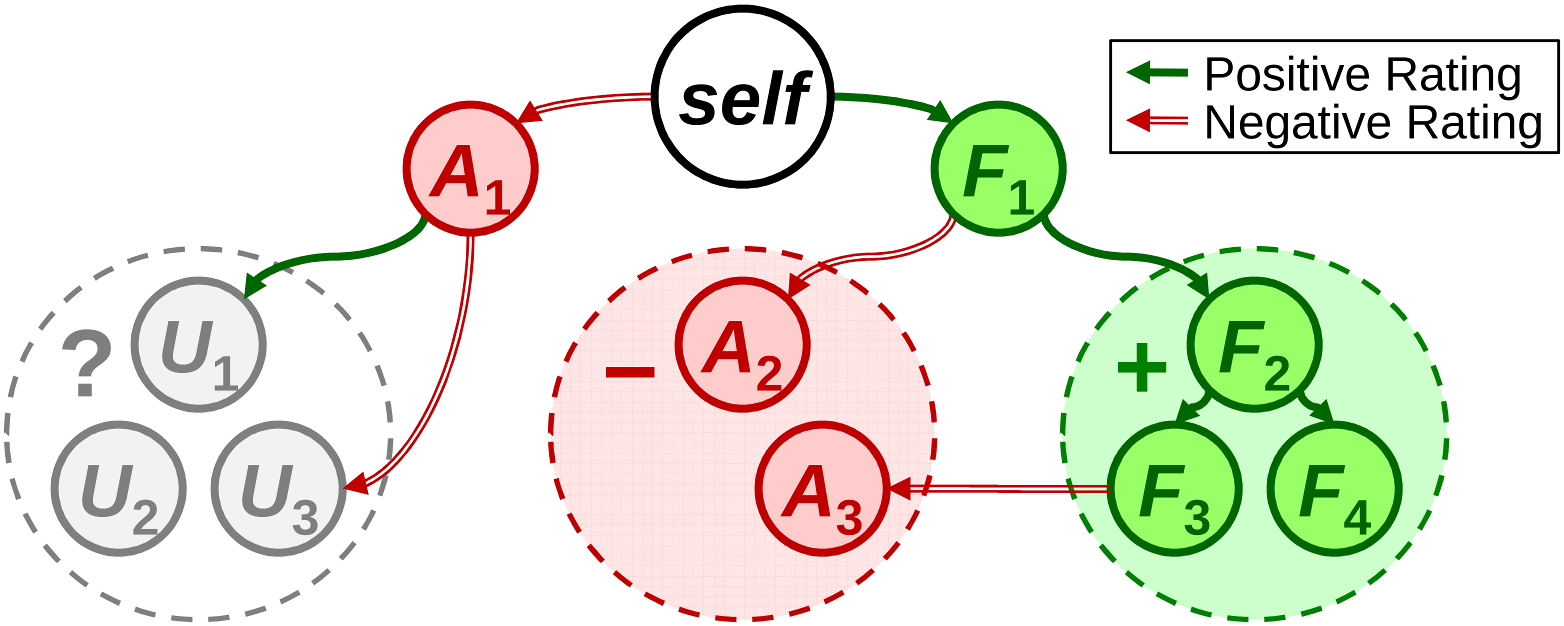
- **Share experiences**
  - avoid antisocial players encountered by peers
  - reward players for behaving well
- **Personalized view of the community**
  - based on peers whom the player likes / dislikes
- **Fine granularity**
  - affinity for peers can be sorted
    - players can be auto-grouped more accurately
    - developer can focus investigation on worst offenders

The PlayerRating Approach

- **Calculate reputation in distributed fashion**
  - minimizes server resources needed
  - yet can still be centralized
- **Incrementally deployable**
  - useful to adopters without majority adoption
  - *implemented as a World of Warcraft mod*
- **Encourages participation**
  - calculated reputations become more accurate as player creates additional accurate ratings
- **Resistant to abuse**
  - no collusion or Sybil attacks

PlayerRating Intuition

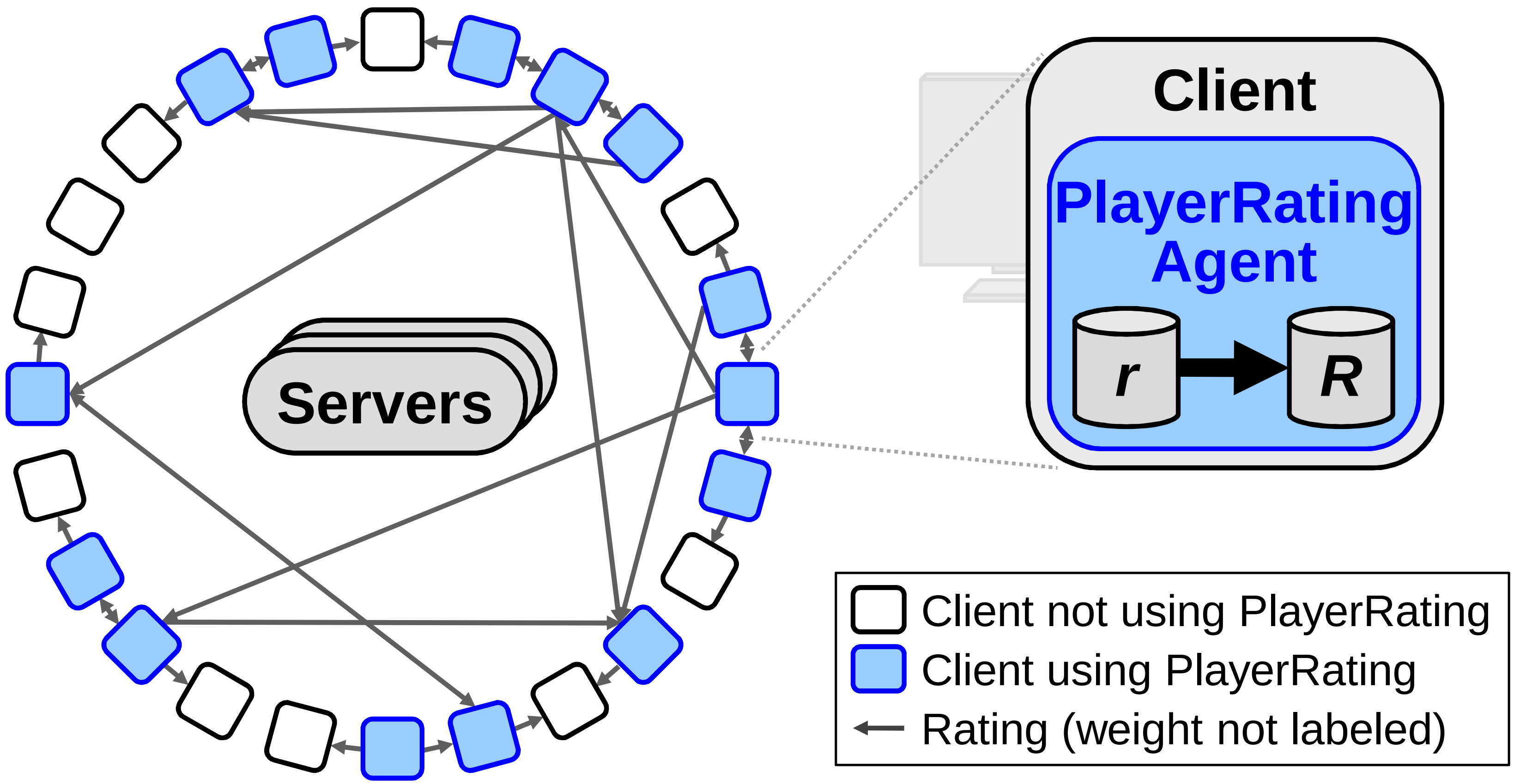
- Ratings $\boldsymbol{r_{i,j}}$ and reputations $\boldsymbol{R_j} \in [-1.0, 1.0]$
  - negative $\rightarrow$ dislike, zero $\rightarrow$ unknown, positive $\rightarrow$ like
  - positive ratings are transitive (friend-of-friend is friend)



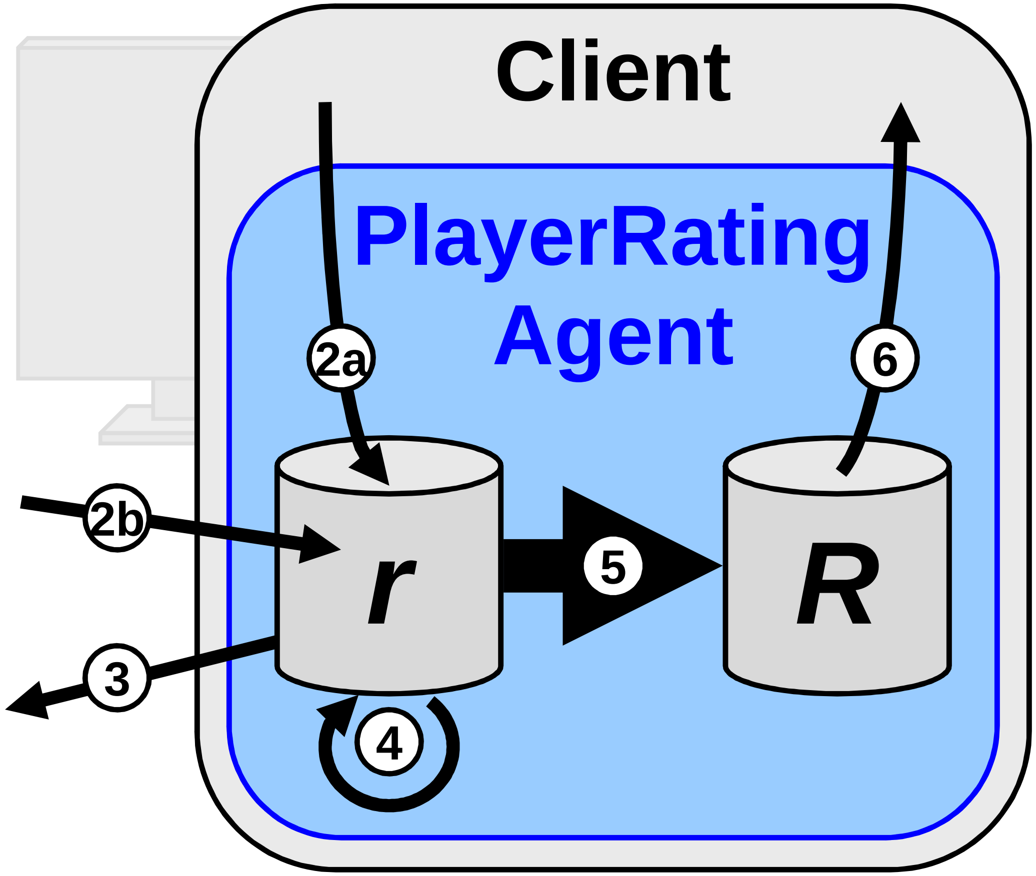
- Challenge is to reconcile conflicting ratings

PlayerRating Overview

- Community is a sparse directed graph
  - players are nodes, ratings are weighted edges



PlayerRating Design



1) Initialization
2) Set rating
   a) locally
   b) from peers
3) Distribute ratings
4) Expire ratings
5) **Calculate reputations**
6) Get reputation

`Initialization()`

- Start everything as unknown (i.e., zero)
  - ratings $\boldsymbol{r_{i,j}}$
  - corresponding time-to-live $\boldsymbol{TTL_{i,j}}$ values
  - reputations $\boldsymbol{R_j}$
- Set own reputation ($\boldsymbol{R_{self}}$) to maximum

SetRating()

- Player creates/changes ratings at any time
  - asynchronous to other system algorithms
  - unobtrusive addition to user interface

- One algorithm for inserting ratings
  - sourced locally
  - shared by one's peers
    - disallow peers from rating themselves
- Set $\boldsymbol{TTL_{i,j}}$ to **`TTL_MAX`**
  - indicates rating is fresh

`DistributeRatings()`

- Share ratings with peers
  - via in-game communication channels
    - source is authenticated by server (i.e., no spoofing)
    - prevents Sybil attacks
- According to game-specific policy
  - which may distribute ratings
    - by <u>channel broadcast</u> or directed
    - when rating is <u>created/changed</u>
    - when player <u>finishes interacting with ratee</u>
    - all at once
    - periodically (<u>sequentially</u> or randomly selected)
  - redundancy is necessary
    - peers may not be online to receive first broadcast

`ExpireRatings()`

- Peers' ratings should be aged and expired
  - new ratings are more relevant
  - old ratings may no longer be necessary
    - rating may have been revoked
    - rater or ratee may have quit playing
    - reduces overall state
- With period T_{expire}, decrement every TTL
  - if $TTL_{i,j}$ reaches 0, remove rating $r_{i,j}$
  - ratings will last for $T_{expire} \times$ **`TTL_MAX`**
    - T_{expire} = 1 *pHour*
    - **`TTL_MAX`** = $24 \times 30 \rightarrow$ 1 *pMonth*

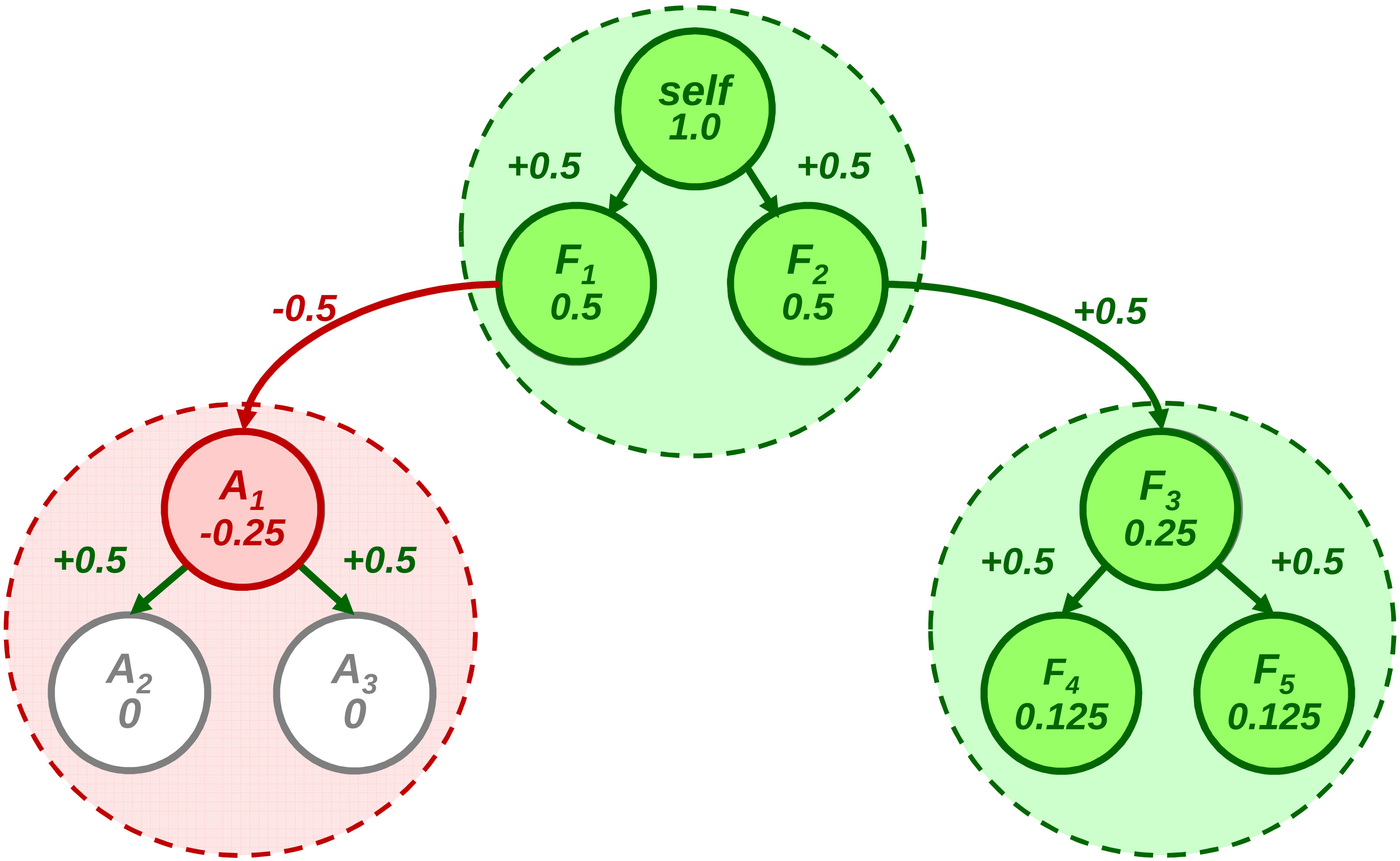
`CalculateReputations()`

- Reputations are the average of ratings
  - rating $r_{i,j}$ is modified by
    - rater's reputation (i.e., $\times$ R_i)
      - semantically: i trusts j relative to their self
      - prevents positive feedback loops
    - rating age (i.e., $\times$ **`Decay`**($TTL_{i,j}$))
      - ensures newer ratings are more relevant
      - function must be non-negative and non-decreasing
  - <u>weighted</u> by each rater's influence
    - determined by **`Influence(`**R_i**`)`**

$$\begin{cases} R_i & R_i > 0 \\ 0 & \text{otherwise} \end{cases}$$

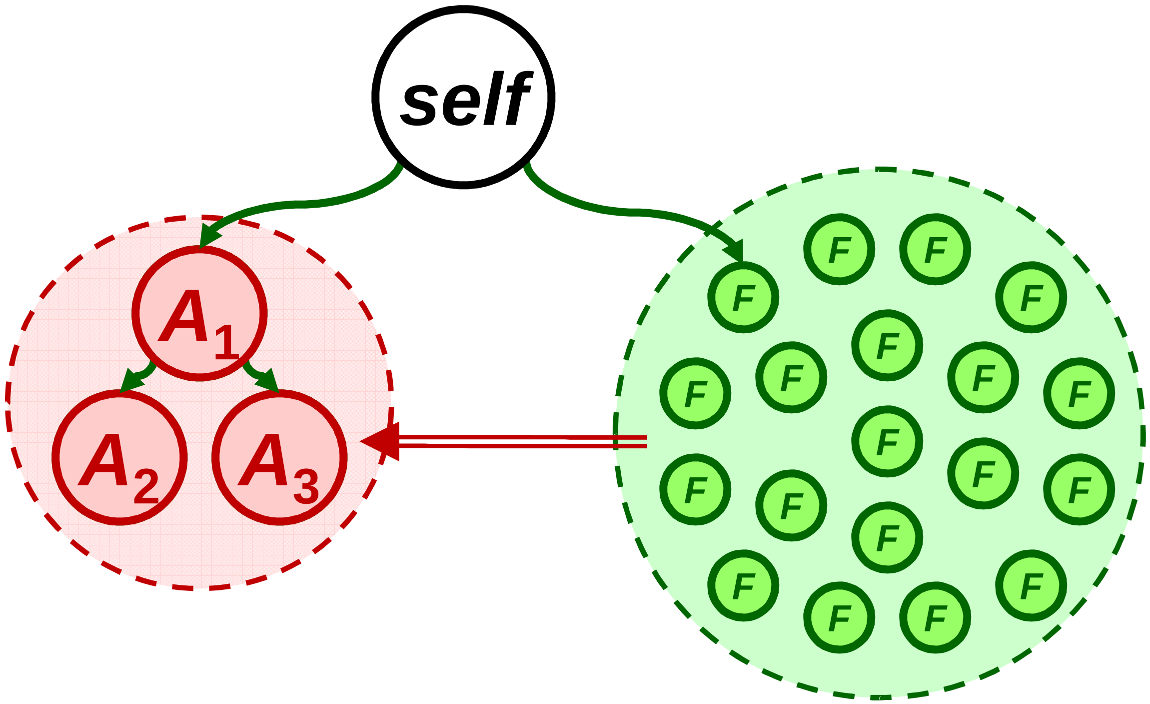
      - function must be non-negative and non-decreasing
    - must have positive influence to count
- Iterated periodically with period $T_{calculate}$
  - account for new, changed, or expired ratings

Numerical Example



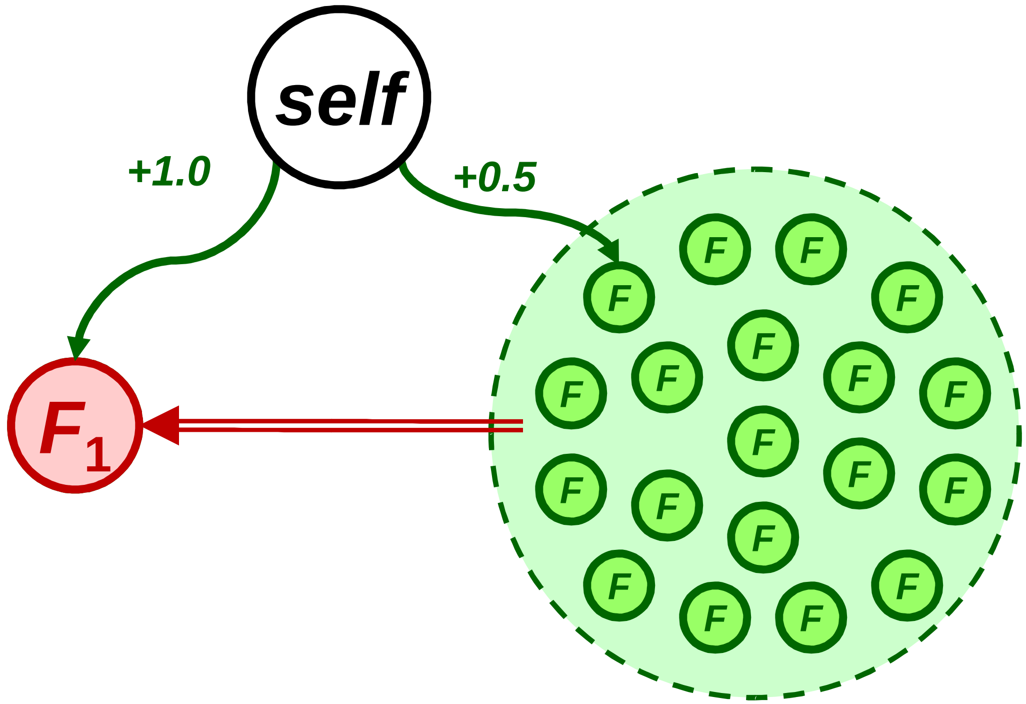
Corner Cases

- Dedicated adversaries to acquiring positive reputation and sharing it with malicious



Corner Cases cont'd

- Peers drastically overturning own ratings
  - consider it an intervention



GetReputation()

- Simply return $\boldsymbol{R_j}$ and $\boldsymbol{r_{i,j}}$
  - very efficient
  - could easily add confidence/variation
- Various ways to convey the information
  - in mouse-over tooltip

  - in player communication

  - in group invites

Evaluation

- Implemented in optimized C++
- Emulated player population
  - using subset of the Slashdot Zoo

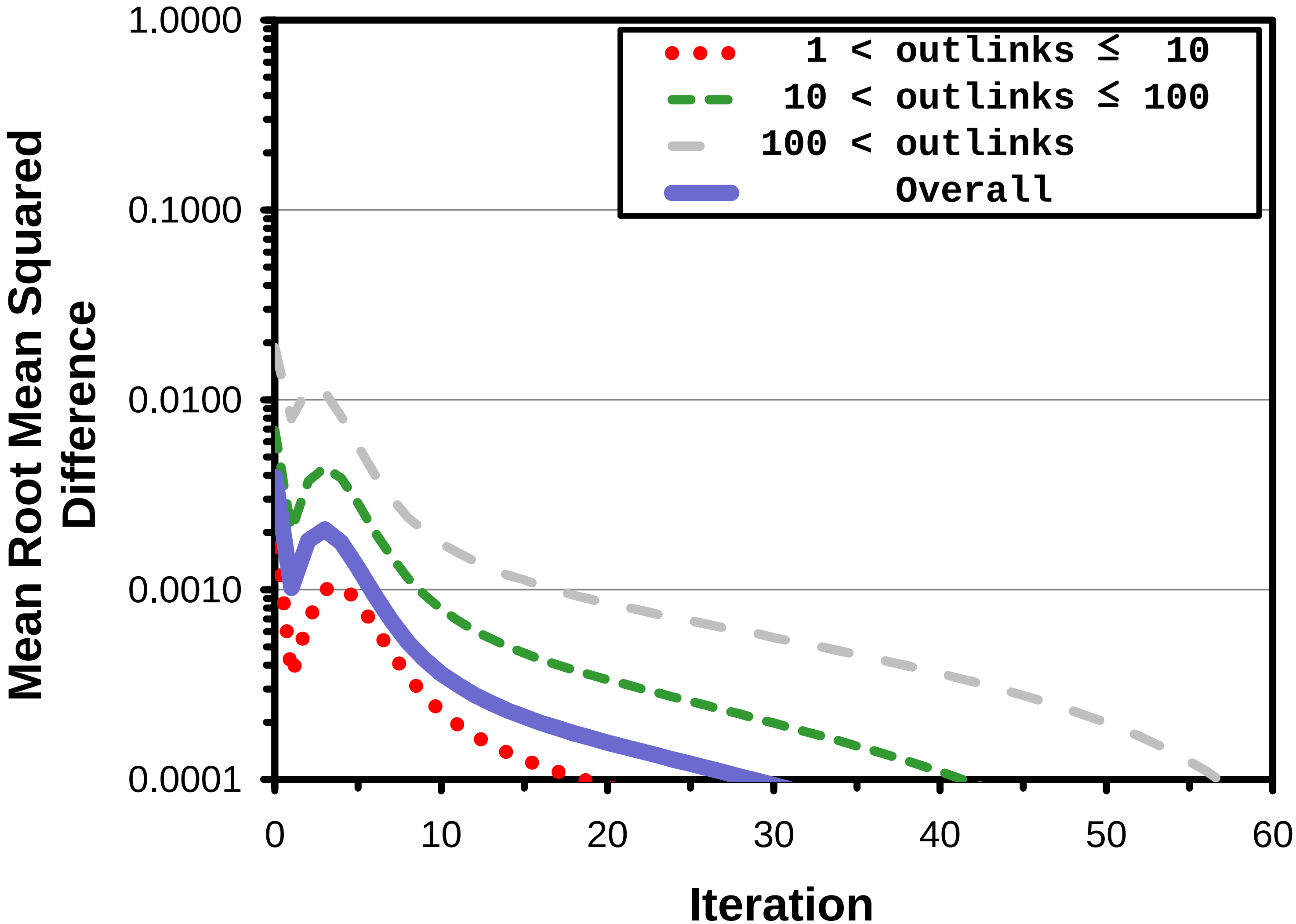
Characteristic	Value
Ratees	**30,000**
Raters	**3,919**
1 ≤ ratings < 10	2,402
10 ≤ ratings < 100	1,230
100 ≤ ratings	287
Total Ratings	**101,842**
positive	76,101
negative	25,741
Mean Ratings	**3.4**
positive	2.5
negative	0.9
Sparseness	**0.000113**

Reputation Convergence

- Measure the change in reputations between **`CalculateReputations()`** iterations
  - Root Mean Squared Difference (RMSD)
  - Calculate the average RMSD across all peers with at least one rating

$$RMSD = \sqrt{\frac{\sum_{i \in Players} \left(R_i' - R_i\right)^2}{\left|Players\right|}}$$

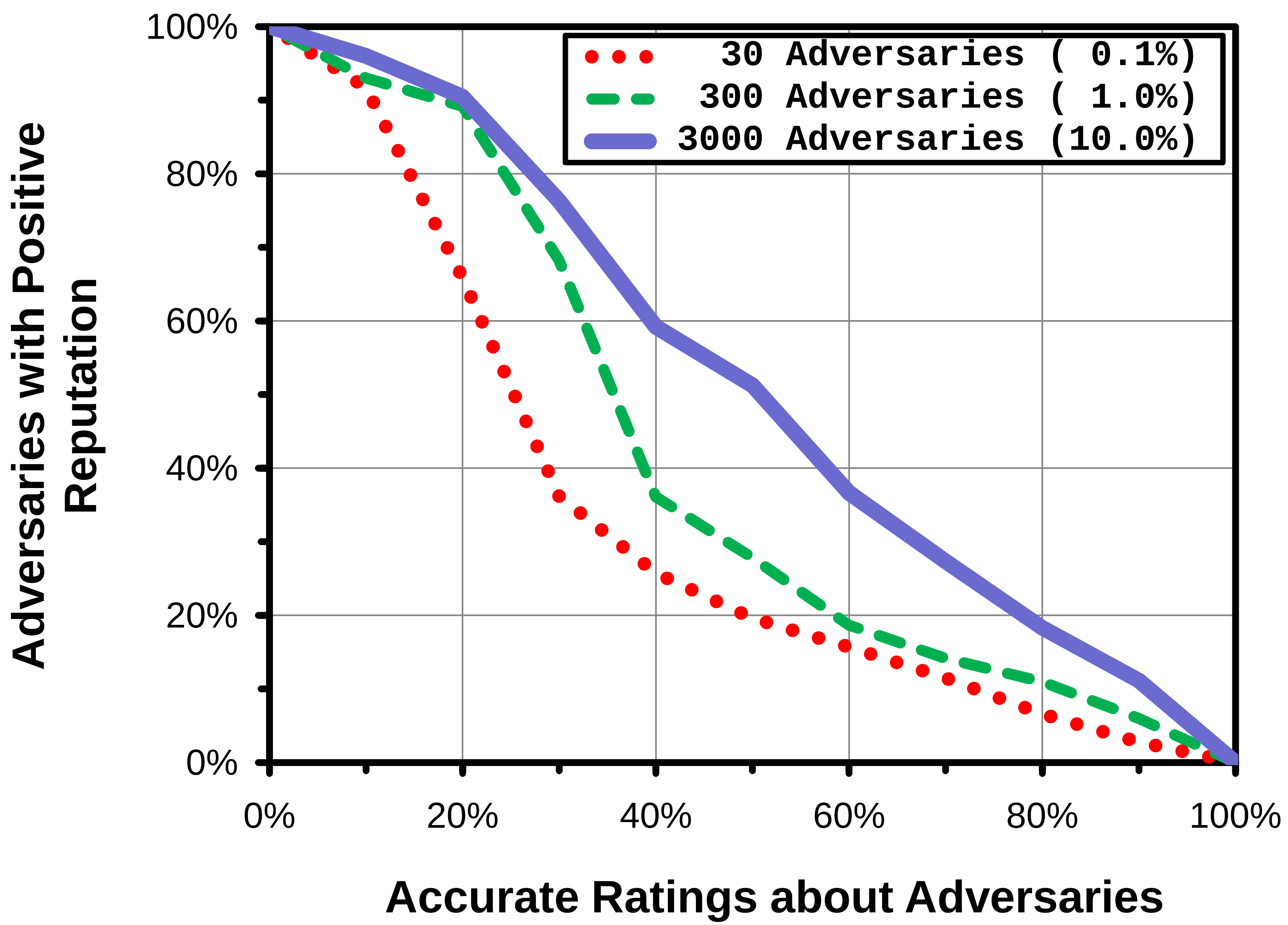
Reputation Convergence cont'd



Collusion Resistance

- Assume original graph is legitimate
- Add adversary population
  - fixed percent of original (**0.1%, 1.0%, 10.0%**)
  - fully connected with positive links
- Initially adversaries behave nicely to earn positive ratings from original peers
- Slowly start abusing trust (**negating positive ratings**)
- Calculate mean percentage of adversaries with positive reputation (**as viewed by original peers**)

Collusion Resistance cont'd



Observations

- Reputations converge relatively quickly
  - within tens of iterations
  - despite sudden ratings change
  - resistant to oscillation
- Resistant to collusion attacks
  - adversary discovery quickly corrects reputation
  - could hasten correction by weighting negative ratings heavier

Applications

- Better match-making functions
  - account for the possibility that certain players may or may not enjoy playing together
- Implement a recommender system on top
  - for systems that offer multiple game titles
  - "*people you enjoyed playing game X with also play game Y*"

Limitations

- Server doesn't observe this data yet
- Requires unique player identity
  - can be changed (**but only to another unique identity**)
- Player behavior may change suddenly
  - sell accounts with good reputation
    - raters will have to adjust their own ratings
- Single metric doesn't distinguish rating on component factors **(e.g., game skill, personality, etc.)**
  - scaled PlayerRating linearly in storage, computation, and communication

Conclusions

- Players misbehave
  - whether premeditated or not
  - hard for game developers to adequately police
- **PlayerRating** is specifically designed to allow good players to congregate
  - facilitates incremental deployment
  - encourages accurate participation
  - resists abuse
  - imposes minimal overhead

Thanks

Extra Slides

CalculateReputations()

$\mathbf{R'}, \mathbf{w} \leftarrow \emptyset$

for all $\mathbf{i} \in \mathit{Players}$ do

  $\mathbf{w}_\Delta \leftarrow \texttt{Influence}(\mathbf{R}_i)$

  if $\mathbf{w}_\Delta \leq 0$ then skip $\mathbf{i}$

  for all $r_{i,j} \neq 0.0$ and $j \neq \mathit{self}$ do

    $\mathbf{R'}_\Delta \leftarrow (r_{i,j} \times \mathbf{R}_i \times \texttt{Decay}(TTL_{i,j})) - \mathbf{R'}_j$

    $\mathbf{w}_j \leftarrow \mathbf{w}_j + \mathbf{w}_\Delta$

    $\mathbf{R'}_j \leftarrow \mathbf{R'}_j + (\mathbf{R'}_\Delta \times \mathbf{w}_\Delta / \mathbf{w}_j)$ **weighted average calculation**

  end for

end for

$\mathbf{R} \leftarrow \mathbf{R'}$ **only blocking action**