BRANDED WITH A SCARLET “C”: CHEATERS IN A GAMING SOCIAL NETWORK

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Video games are a huge industry

• Modern Warfare 2 released Nov. 2009
  • First 24 hours of release
    • 4.7 million units sold
    • $310 million in revenue
  • First 5 days of release
    • 8 million online players
• All these numbers eclipsed by MW3 in 2011!
Multiplayer gaming: growing eSports industry

Major League Gaming claims 225% growth from 2010 to 2011

Team Na’Vi won $1 million in the DOTA Intl. Tournament

“Flash” makes $250k a year playing StarCraft!

YOU FINISHED THE SINGLE PLAYER CAMPAIGN?

I FINISHED MULTIPLAYER.
But not all is well…

- Fame and fortune attracts deviant behavior
- Virtual goods worth $ attract criminal element
- Competitive gameplay attracts cheaters
  - Multiplayer games are a distributed system
  - Some computation left to gamers’ machines
  - Susceptible to attacks
- $100k a year to cheat creators for single game
Real world cheat: Wallhack

Players should not be visible (they are behind the wall).
What can we learn from a gaming community?

• Social systems have unethical actors
• Cheating in games is black and white
• Theories indicate unethical behavior has a social component

What are the network characteristics of unethical actors in a large scale online community?
Steam Community

- Large online social network for PC gamers
- Built on top of Steam digital delivery platform
- Purchased games permanently tied to account
- Steam account required to create Steam Community profile
  - Steam Community profile not required to play games
Steam Community Profile

- Unique SteamID
- Friends list
- User specified location
- Cheating flag (VAC ban)
- Nickname (mutable)
- Date of account creation
- Screenshots
- Videos
- Comments (“wall posts”)
- Profile information
- Game reviews
- Gameplay ownership/stats
- Virtual goods inventory
The cheating flag

- Cheating automatically detected via Valve Anti Cheat system
  - Method and timestamp not public
  - Delayed application
- Permanent
- Publicly viewable
  - Even private accounts
- Can’t play on VAC secured servers
  - Only applies to the game that was cheated in
- Most servers are VAC secured
  - 4,200 of 4,234 Team Fortress 2 servers
- Cheater not permanently removed from Steam Community
Steam Community data set

- Data collected March 16 – April 3, 2011
- Distributed BFS using Amazon EC2
- Cheaters make up 7% of profiles
- 7% of cheaters have private profiles
  - 3% of non-cheaters with private profiles
- Cheaters as likely to be friends-only as private
  - Non-cheaters about 3 times as likely to be friends-only as private

<table>
<thead>
<tr>
<th>Type</th>
<th>Nodes</th>
<th>Edges</th>
<th>Profiles</th>
<th>Public</th>
<th>Private</th>
<th>Friends-only</th>
<th>Location set</th>
</tr>
</thead>
<tbody>
<tr>
<td>All users</td>
<td>12,479,765</td>
<td>88,557,725</td>
<td>10,191,296</td>
<td>9,025,656</td>
<td>313,710</td>
<td>851,930</td>
<td>4,681,829</td>
</tr>
<tr>
<td>Cheaters</td>
<td>-</td>
<td>-</td>
<td>720,469</td>
<td>628,025</td>
<td>46,270</td>
<td>46,714</td>
<td>312,354</td>
</tr>
</tbody>
</table>

Cheaters more likely to be private than non-cheaters
Observing the gaming community

• How are cheaters positioned?
  • In the social community
  • Geographically

• What is the reaction to the cheating brand?
  • From cheaters themselves
  • In the social network
  • In game

• Does the social structure influence cheating?
Observing the gaming community

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Cheaters are well embedded…
...but are not central

<table>
<thead>
<tr>
<th>Top-N%</th>
<th>0.1</th>
<th>0.5</th>
<th>1.0</th>
<th>5.0</th>
<th>10.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree</td>
<td>3.25</td>
<td>4.46</td>
<td>5.11</td>
<td>7.06</td>
<td>8.20</td>
</tr>
<tr>
<td>Betweenness</td>
<td>5.16</td>
<td>5.95</td>
<td>6.35</td>
<td>7.86</td>
<td>8.58</td>
</tr>
</tbody>
</table>

- Cheaters under-represented among most central players
  - Cheaters make up 7% of player population, but far less than 7% of the top 0.1% central users
  - Not adequately represented until top 5% central users
Cheaters have more cheater friends

CDF: $P(\text{fraction} \leq x)$

- 70% of cheaters’ friends lists are at least 10% cheaters
- 15% of cheaters have mostly cheater friends

Fraction of cheaters in neighborhood
Non-uniform geo-political distribution

Ratio of cheaters to non-cheaters

Cheater : Non-cheater
Cheaters are geographically closer

<table>
<thead>
<tr>
<th>Network</th>
<th># of nodes</th>
<th># of edges</th>
<th>$\langle D_{uv} \rangle$ (km)</th>
<th>$\langle l_{uv} \rangle$ (km)</th>
<th>$\langle NL \rangle$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Community</td>
<td>4,342,670</td>
<td>26,475,896</td>
<td>5,896</td>
<td>1,853</td>
<td>0.79</td>
</tr>
<tr>
<td>Cheater-to-Cheater</td>
<td>190,041</td>
<td>353,331</td>
<td>4,607</td>
<td>1,761</td>
<td>0.79</td>
</tr>
<tr>
<td>BrightKite</td>
<td>54,190</td>
<td>213,668</td>
<td>5,683</td>
<td>2,041</td>
<td>0.82</td>
</tr>
<tr>
<td>FourSquare</td>
<td>58,424</td>
<td>351,216</td>
<td>4,312</td>
<td>1,296</td>
<td>0.85</td>
</tr>
</tbody>
</table>

![Node Locality CDF](image)
Observing the gaming community

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• What is the reaction to the cheating brand?
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  • In the social network
  • In game

• Does the social structure influence cheating?
Cheaters try to hide when caught…

- Recrawl in October, 2011
- 43,465 non-cheaters now flagged as cheaters
- 13% had privacy setting change
  - Compared to a bit more than 3% of non-cheaters
- 10% from public to more restrictive setting
  - Compared to less than 3% of non-cheaters
and for good reason: the community disapproves

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<tr>
<th>Change in Degree</th>
<th>Cheaters</th>
<th>Non-cheaters</th>
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<tr>
<td>Net loss</td>
<td>44%</td>
<td>25%</td>
</tr>
<tr>
<td>Net gain</td>
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<td>36%</td>
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<tr>
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<td>43%</td>
<td>39%</td>
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Cheaters tend to lose friends while non-cheaters tend to gain friends
Gameplay logs

• Team-based, objective oriented
  • Two teams, nine classes
  • “Friend” interactions
  • “Foe” interactions

• Popular TF2 server
  • VAC secured
  • Community owned
  • April 1 - June 8, 2011

• Interaction network
  • 10,354 players
  • 93 cheaters
  • 486,808 edges
Cheaters not mistreated in games

CCDF: \( P(\text{interaction partners} \geq x) \)

Number of distinct interaction “friends”

Number of distinct interaction “foes”
Observing the gaming community

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Does cheating spread over social links?

- Label nodes with the date of their VAC ban
- 180-day snapshots of the cheater status of nodes over time
  - For each snapshot, only those players whose ban date is from a previous snapshot are treated as cheaters

Do the neighborhoods for newly-marked cheaters differ from those of non-cheaters?
Historical ban dates

• 3rd party web site, vacbanned.com, provides historical data on when a VAC ban was first observed
  • Dates must be treated as banned “on or before”

P(ban observed before date)

Attempt made to populate database by vacbanned.com administrators in May, 2011
Evolution of cheaters’ social structure

CCDF: $P(\text{num cheater friends} \geq x)$

CDF: $P(\text{frac cheater friends} \leq x)$
Social ties as predictor of cheating

- Increasing probability of a player becoming a cheater as the number of cheaters in his social neighborhood increases*
- Decision tree classifier had ROCA of 0.61 based on number of cheater friends

(*plot not in paper)
Summary of results

- Homophily between cheaters
  - Even though cooperation not necessary
- Cheaters’ distribution not uniform
  - In social network
  - Geo-politically
- Cheaters face social penalty
  - But not in game
- Cheating behavior spreads via social links
  - Number of cheater friends predictor of future cheating
Impact

• Large scale study of unethical actors in online community
  • Correlation of unethical behavior and network structure
  • Useful for building models of unethical behavior

• Cheating is a *social problem*
  • Community serves out social punishment
  • Suggests exploring other social solutions for deviant behavior

• Scale of cheating of particular concern for gamified systems
  • Our study exposes a likely *lower bound* on cheating behavior
  • Social predictors can narrow focus to at-risk cheaters
Ranked locations of cheaters
(red = more)
BACKUP SLIDES
Social Network Data Collection

- Distributed BFS
- 6,445 random seeds
- Up to 6 `m1.medium’ instances
- Coordinated with Amazon SQS queue
- Two crawls
  - March 16th – April 3rd, 2011
  - October 18th – October 29th, 2011
Interaction vs. declared relationships

- More interaction partners (even on a single server) than declared Steam friends
- **Steam Community friendships have meaning in-game**
  - Declared friends likely to have more interactions with each other than non-friends
The community is disapproving

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Cheaters tend to lose friends while non-cheaters tend to gain them.

Cheaters lost 2x the number of friends that they gained.

CDF: \( P(\text{change in degree} \leq x) \)
Do cheaters form strong relationships?

- Overlap between two neighborhoods is an indicator of social strength
- **Cheaters form stronger relationships with each other than with non-cheaters**
  - Overlap of cheater-cheater and non-cheater-non-cheater neighborhoods greater than overlap of mixed neighborhoods
Distribution of cheater friends

- Cheaters likely to have more cheater friends when compared to non-cheaters
Privacy settings and inferred degree

- Position in network inferable from your public friends
Real world cheat: Wallhack

Player partially obscured, hiding behind cover
Cheating behavior outside of gaming

- Academics
  - Plagiarism
  - Cheating on exams
- Personal relationships
  - Cheating on your spouse
- Real-world crime
  - Confidence scams
- Minor law breaking
  - Speeding
- Real-world sports
  - Steroids
  - “Diving” in soccer
- Cyber crime
  - Spam
  - Malware distribution
- Business
  - Accounting fraud
  - Corporate espionage