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(fraction ≤ 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

Ratio

USA, Brazil, Russia, Germany, France, UK, Poland, Canada, Australia, Sweden, Denmark, Norway
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>

![CDF: P(node locality ≤ x)](chart.png)
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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

<table>
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<tr>
<th>Change in Degree</th>
<th>Cheaters</th>
<th>Non-cheaters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net loss</td>
<td>44%</td>
<td>25%</td>
</tr>
<tr>
<td>Net gain</td>
<td>13%</td>
<td>36%</td>
</tr>
<tr>
<td>No change</td>
<td>43%</td>
<td>39%</td>
</tr>
</tbody>
</table>

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”

CCDF: $P(\text{interaction partners} \geq x)$
Number of distinct interaction “foes”
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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”

![Graph showing historical ban dates]

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: $P(\text{frac cheater friends} \leq x)$

Interval starting 2009-12-30

Interval starting 2010-06-29

Interval starting 2010-12-26

Interval starting 2011-06-25

Number of cheater friends

Number of cheater friends

Number of cheater friends

Number of cheater friends

Fraction of cheater friends

Fraction of cheater friends

Fraction of cheater friends

Fraction of cheater friends

Cheaters

Non-cheaters

Cheaters

Non-cheaters

Cheaters

Non-cheaters

Cheaters

Non-cheaters
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