Chinese Keyword Censorship of Instant Messaging Programs (and Work in Progress)

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Who Determines What's Censored in Chinese IM Programs?
IM Usage in China

- In 2010, 77.2% of Internet users in China used instant messaging
- 350 million users
- Growth rate of 30% from 2009
- Popular IM programs include Tencent QQ, Alitalk, TOM-Skype, Sina UC...

# Popular IM Programs in China

<table>
<thead>
<tr>
<th>Program</th>
<th>Millions of daily users September 2009*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tencent QQ/TM</td>
<td>139.85</td>
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<td>Baidu Hi</td>
<td>2.08</td>
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</table>

Questions

- Which IM programs perform keyword censorship? Surveillance?
- Is there a “master” keyword list?
- What keywords are censored by which programs?
- Do programs tend to censor the same keywords?
## Which Censor?

<table>
<thead>
<tr>
<th>Program</th>
<th>Millions of daily users Sept. 2009*</th>
<th>Censors keywords?</th>
<th>Example keyword</th>
<th>Client-side?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tencent QQ/TM</td>
<td>139.85</td>
<td>Yes</td>
<td>法轮 (falun)</td>
<td>No</td>
</tr>
<tr>
<td>Alitalk</td>
<td>22.87</td>
<td>Yes</td>
<td>吾尔开希 (Wu'er Kaixi)</td>
<td>No</td>
</tr>
<tr>
<td>MSN</td>
<td>20.11</td>
<td>No</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fetion</td>
<td>18.51</td>
<td>Yes</td>
<td>falundafa</td>
<td>No</td>
</tr>
<tr>
<td>Caihong</td>
<td>16.94</td>
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<td>No</td>
</tr>
<tr>
<td>(TOM-)Skype</td>
<td>2.67</td>
<td>Yes</td>
<td>fuck</td>
<td>Yes</td>
</tr>
<tr>
<td>Sina UC</td>
<td>2.53</td>
<td>Yes</td>
<td>六四 (six four)</td>
<td>Yes</td>
</tr>
<tr>
<td>Baidu Hi</td>
<td>2.08</td>
<td>Yes</td>
<td>六四 (six four)</td>
<td>No</td>
</tr>
</tbody>
</table>

Client-side Censorship?

- TOM-Skype and Sina UC do censorship “client-side”
- When the censorship happens inside of the program
  - Not by remote server
  - Not somewhere on the network
- Encrypted keyword lists are hidden in program and/or downloaded
TOM-Skype

- TOM-Skype
  - Modified version of Skype by TOM Group Limited, a China-based media company
  - Uses Skype's network
Empirical Analysis of TOM-Skype

- TOM-Skype uses “keyfiles”
  - List of encrypted keywords triggering censorship and surveillance of text chat
  - One built-in
  - At least one other downloaded
  - Lists vary by version of TOM-Skype
3.6-4.2 Keyfiles

- TOM-Skype 3.6-3.8 downloads from http://skypetools.tom.com/agent/newkeyfile/keyfile
- TOM-Skype 4.0-4.2 downloads from http://a[1-8].skype.tom.com/installer/agent/keyfile
- Encrypted with naïve xor algorithm...

procedure DECRIPT (C₀..n, P₁..n)

for i ← 1, n do
    \[ P_i = (C_i \oplus 0x68) - C_{i-1} \mod 0xff \]
end for

end procedure
3.6-4.2 Keyfiles

• To crack: point skypetools.tom.com DNS queries to our server
  1EB412B019
  77B543CE52 # fuck
• TOM-Skype downloads our keyfile
  98068426842599
• Binary search to find “fuck”
3.6-4.2 Keyfiles

- To crack: point skypetools.tom.com DNS queries to our server
- TOM-Skype downloads our keyfile
- Binary search to find “fuck”
- Perform chosen ciphertext attack
- See what gets censored

77B543CE52 # fuck
77B543CE53 # fucl
77B543CE54 # fucm

... 77B341CC50 # duck
...
3.6-4.2 Keyfiles

- To crack: point skypetools.tom.com DNS queries to our server
- TOM-Skype downloads our keyfile
- Binary search to find “fuck”
- Perform chosen ciphertext attack
- See what gets censored
- Pattern emerges

77B543CE52 # fuck
77B543CE53 # fucl
77B543CE54 # fucm
...
77B341CC50 # duck
...

procedure DECRYPT \((C_{0..n}, P_{1..n})\)

for \(i \leftarrow 1, n\) do

\[ P_i = (C_i \oplus 0x68) - C_{i-1} \pmod{0xff} \]

end for

end procedure
5.0-5.1 Keyfiles

- TOM-Skype 5.0-5.1 downloads keyfiles from http://skypetools.tom.com/agent/keyfile
- TOM-Skype 5.1 downloads *surveillance-only* keyfile from http://skypetools.tom.com/agent/keyfile_u
- Keywords AES encrypted in ECB mode
- Key reused from TOM-Skype 2.x
- When encoded in UTF16-LE, 32 bytes: 0sr(TM#RWFD,a43
- Half of bytes printable ASCII, other half null (weak)
TOM-Skype Surveillance

- TOM-Skype 3.6-3.8 encrypts surveillance traffic with DES key in ECB mode:
  
  32bnx231

- TOM-Skype 5.0: no surveillance

- TOM-Skype 4.0-4.2, 5.1 encrypts using different DES key:

  X7sRUjL\0

  0045BDBC FF FF FF FF 07 00 00 00
  0045BDC4 58 37 73 52 55 6A 4C 00
TOM-Skype Surveillance

• Example surveillance message:
  jdoe falungong 4/24/2011 2:25:53 AM 0

• Message author followed by triggering message followed by the date and time

• 0 or 1 indicates message is outgoing or incoming, respectively

• Sent in query string to
  a[1-8].skype.tom.com/installer/tomad/ContentFilterMsg.php
TOM-Skype 3.6-3.8 Surveillance

- Recall TOM-Skype 3.6-3.8 encrypts surveillance traffic with a different DES key.
- Reverse engineering it required circumventing Skype's built-in anti-debugging measures.
- Why not before? TOM-Skype 5.1 sends surveillance messages from an outside process called ContentFilter.exe.
- Our strategy: DLL injection, a way to execute our own code inside of TOM-Skype's process...
## TOM-Skype 3.6-3.8 Surveillance

- Hook our code into timer function called before encryption
- Our code sleeps for 20 seconds
- Attach with debugger
- Suspend all other threads
- Resume sleeping thread
- In switch statement, we observed the following DES key used: 32bnx231

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADD DH,AH</td>
<td>EAX, 33B200ED</td>
</tr>
<tr>
<td>CMP</td>
<td></td>
</tr>
<tr>
<td>JMP SHORT</td>
<td>Skype.00ED3DE8</td>
</tr>
<tr>
<td>MOV DL,32</td>
<td></td>
</tr>
<tr>
<td>JMP SHORT</td>
<td>Skype.00ED3DE8</td>
</tr>
<tr>
<td>MOV DL,62</td>
<td></td>
</tr>
<tr>
<td>JMP SHORT</td>
<td>Skype.00ED3DE8</td>
</tr>
<tr>
<td>MOV DL,6E</td>
<td></td>
</tr>
<tr>
<td>JMP SHORT</td>
<td>Skype.00ED3DE8</td>
</tr>
<tr>
<td>MOV DL,78</td>
<td></td>
</tr>
<tr>
<td>JMP SHORT</td>
<td>Skype.00ED3DE8</td>
</tr>
<tr>
<td>MOV DL,32</td>
<td></td>
</tr>
<tr>
<td>JMP SHORT</td>
<td>Skype.00ED3DE8</td>
</tr>
<tr>
<td>MOV DL,33</td>
<td></td>
</tr>
<tr>
<td>JMP SHORT</td>
<td>Skype.00ED3DE8</td>
</tr>
<tr>
<td>MOV DL,6C</td>
<td></td>
</tr>
<tr>
<td>JMP SHORT</td>
<td>Skype.00ED3DE8</td>
</tr>
<tr>
<td>MOV DL,24</td>
<td></td>
</tr>
<tr>
<td>JE SHORT</td>
<td>Skype.00ED3DF0</td>
</tr>
<tr>
<td>JNZ SHORT</td>
<td>Skype.00ED3DF0</td>
</tr>
</tbody>
</table>
5.0-5.1 Downloaded Keyfile

- Prurient interest: 15.2%
- Political: 35.2%
- Religious: 5.8%
- Location: 5.2%
- News/info source: 7%
- Political dissident: 10.1%
- Govt. official: 7%
- Info about spying: 7%
- Misc.: 12.8%
5.1 Surveillance-only Keyfile
Censored Keywords

- Keyfile contained political words (35.2%)
  - 六四 (“64,” in reference to the June 4th Incident)
  - 拿着麦克风表示自由 (Hold a microphone to indicate liberty)
- Prurient interests (15.2%)
  - 操烂 (Fuck rotten)
  - 两女一杯 (Two girls one cup)
Censored Keywords

• News/info sources (10.1%)
  • 中文维基百科 (Chinese language Wikipedia)
  • BBC 中文网 (BBC Chinese language)
• Political dissidents (7%)
  • 刘晓波 (Liu Xiaobo)
  • 江天勇 (Jiang Tianyong)
• Locations (7%)
  • 成都 春熙路麦当劳门前 (McDonald's in front of Chunxi Road in Chengdu)
Surveillance-only

- Mostly political and locations
  - Almost all related to demolitions of homes in Beijing for future construction
  - A few related to illegal churches
  - A couple company names
Latest Updates

- TOM-Skype 5.5, 5.8 released
- DES key for keyfiles: \x7a\xdd\xe7\xdc\x23\x25\x53\x75
- All but one keyword is now surveillance-only
- 薄熙来 (Bo Xilai)
- 周永康兵变和警变 (Zhou Yongkang, mutiny and police change)
- 3月17日重庆人民大礼堂 (Chongqing People's Auditorium March 17)
Sina UC

- By SINA Corporation
  - China-based company
  - Owns weibo.com, popular Chinese microblogging site
- Uses Jabber protocol
Empirical Analysis of Sina UC

- Has five lists
- One set of five built-in
- Another set of five downloaded from http://im.sina.com.cn/fetch_keyword.php?ver=...
- All five lists JSON-encoded
- Then Blowfish encrypted in ECB mode with the following 16-byte ASCII-encoded key:
  H177UC09VI67KASI
List #4

- Used to censor text chat
- Large number of neologisms for the June 4th incident:
  - 五月三十五 (May 35th), 四月六十五号 (April 65th), 三月九十六号 (March 96th)
  - 六一过后三天 (three days after June 1st), 儿童节过后三天 (three days after Children's day)
  - 64, VIIIV, 8|9|6|4, six.4
  - 6.2+2
  - 八的二次方 (8^2), 2 的 6 次方 (2^6)
List #4

• Even Russian:
  • Четыре (four)
  • Шесть (six)
  • Девять (nine)
  • Восемь (eight)
  • Восемь-Девять-Шесть-Четыре (eight-nine-six-four)

• And French:
  • six-quatre (six-four)
List #2

- Used to censor usernames (username replaced with id#)
- Found prurient words like 妓子 (whore), 妓 (prostitute)
- Political: 法輪 (falun), falun, six four
- Phishing:
  - webmaster, root, admin, hostmaster, sysadmin, sinaUC, 新浪 (Sina), 系统通知 (system notice)
Other Lists

- List #1 is a shorter list used to censor both text chat and usernames
- List #3 contains a lot of domains; has unknown purpose
- List #5 contains prurient and political keywords; has unknown purpose (later removed)
Comparative Analysis

- TOM-Skype and Sina UC have lists for different purposes
- For each, let's union their sets of keywords
- TOM-Skype has 515 unique keywords
- Sina UC has 997 unique keywords
- Overall, 1446 keywords are seen in only TOM-Skype xor Sina UC
- Only 33 are common to both
- Conjecture: any “master” list must be short
Conjectures

1. Effectiveness Conjecture: *Censorship is effective, despite attempts to evade it.*

- Inspired by phrases in keyfiles taken from documents that did not get as widely distributed as the authors had probably intended.
Conjectures

2. Spread Skew Conjecture: Censored memes spread differently than uncensored memes.

- Inspired by Google trends data for “two girls one cup” in English (left) vs. Chinese (right)
Conjectures

3. Secrecy Conjecture: *Keyword based censorship is more effective when the censored keywords are unknown and online activity is, or is believed to be, under constant surveillance.*

- Inspired by clients' efforts to keep list of censored words and surveillance traffic secret
4. Peer-to-peer vs. Client-server Conjecture: The types of keywords censored in peer-to-peer communications are fundamentally different than the types of keywords censored in client-server communications.

• Inspired by the high number of proper nouns in keyfiles compared to other lists (such as for GET request filtering)
Conjectures

5. Neologism Conjecture: Neologisms are an effective technique in evading keyword based censorship, but censors frequently learn of their existence.

• Example: 六四 (64), 陆肆 (sixty four), but also “32 + 32” or “8 squared”
Keyword Censorship

• When programs censor client-side, we can find exact keyword lists

• Why do TOM-Skype, Sina UC censor client-side?
  • Skype network P2P, encrypted, not owned by China
  • Sina UC uses Jabber protocol; maybe a “stock” server solution?
  • “Distributed” censorship

• Censorship in other IM programs?

For keyword lists, machine and human translations, and source code, see

• http://cs.unm.edu/~jeffk/tom-skype/
• http://cs.unm.edu/~jeffk/sinauc/
Software Updates

An update to Adobe® Flash® Player is available.
This update includes:
- Improved video performance for smooth, high-quality playback
- Automatic Flash Player background updates
- Improved performance and compatibility
- Security enhancements described in this Security Bulletin

See details...

Updating takes under a minute on broadband - no restart is required.

Install this update?

You can change your update settings in the Local Settings Manager.

Launch Local Settings Manager

REMIND ME LATER  INSTALL
Software Updates

- Can we trust software updates on untrusted networks?
- Iran forged SSL certificates for update servers
  - Source: https://blog.torproject.org/blog/diginotar-damage-disclosure
- Software updates can make us vulnerable
  - Contrary to conventional wisdom
Sun Java

Java Update - Update Available

Java Update Available

Java 7 Update 04 is ready to install. Click the Install button to update Java now. If you wish to update Java later, click the Later button.

More information...
Sun Java

• We look at Java 6, but Java 7 is analogous
• Automatic updater periodically queries
  javadl-esd.sun.com/update/1.6.0/map-m-1.6.0.xml
• Maps older versions of Java to another URL, e.g.,
  javadl-esd.sun.com/update/1.6.0/au-descriptor-1.6.0_31-b79.xml
Sun Java

- XML file contains
  - Textual description
  - URL for installer
  - Command line arguments
  - SHA1 hash of installer
Sun Java

- Installer is downloaded and verified
  - Against XML-provided hash
  - To have “Sun Microsystems, Inc.” digital signature
  - To have a PE version number at least as high as the Java version presently installed
Sun Java

- We want an executable that
  - Has same SHA1 hash as in XML
    - We can provide a different hash
  - Has a “Sun Microsystems, Inc.” digital signature
  - Has a PE version number at least as high as the Java version presently installed
  - Can still somehow run arbitrary code
Sun Java

- javaws.exe
  - Comes with Java
  - Used to launch “Web start” applications
- Arguments:
  - -Xnosplash
  - -J-Djava.security.policy=http://url/to/grantall.jp
  - http://url/to/hello.jnlp
  - -open
- Java 6 Update 31, 7 Update 3 now use HTTPS
Impulse SafeConnect

- Network access control software
- Required to use UNM lobowifi network
- Silently updates itself
- Connects to hard-coded 198.31.193.211 via HTTP (only accessible on campus)
- XML communication encrypted via Blowfish key:
  \x4f\xbd\x06\x00\x00\xc\xa\x9c\x18\x03\xfc\x91\x3f
Impulse SafeConnect

- Server responds with URL's and MD5 hashes for updated files
- The files are verified to have “Impulse Point LLC” digital signature
- Blowfish encryption is symmetric
  - We can send client arbitrary XML
Impulse SafeConnect

- SafeConnect checks for digital signature
- “Upgrade” to an older client that is signed but performs no check
- “Upgrade” older client to arbitrary code
- Fixed by 5059.242 by using HTTPS
- Must be on campus to receive fix
Other Programs

- Virtualbox
  - Downloads update information via HTTP
  - Download links open in browser
Other Programs

- Adobe Flash
  - Downloads update information via HTTP
  - Verifies digital signature of installer
  - *Downloaded installer* verifies that a newer version of Flash is not installed

- Google Chrome
  - Downloads signed update information via HTTP
  - Downloads installer via HTTP
  - Verifies installer's hash
Possible Solutions

- People really have difficulty doing updates
- Find and fix all vulnerable software?
- OS-provided service?
- Walled gardens?
Mitigating Censorship

- How can we mitigate censorship?
- Tor
  - Overlay network over Internet
  - No theoretical guarantees
- Problem: Networks with theoretical guarantees are too inefficient
- Goal: Provable guarantees and efficiency
Self-Healing Network

• “Fool me once, shame on you. Fool me $\omega((\log^* n)^2)$ times, shame on me.”
Self-Healing Network

- $O(\log n)$-length quorum path of $O(\log n)$-sized quorums
- Allow $t < \frac{1}{4} - \varepsilon$ nodes to be byzantine
Operations

- **SEND-LEADER:**
  - Send through quorums' elected leaders
  - $O(\log n)$ messages

- **CHECK:**
  - $O(\log n(\log^*n)^2)$ messages
  - Perform with 1 in $(\log^*n)^2$ probability
  - Constant probability of detecting corruption

- **UPDATE:**
  - Only called to update network
  - Very expensive!
Properties

- Expected latency is $O(\log n)$
- Expected number of messages is $O(\log n)$, in an amortized sense
- Total number of times that a message can be corrupted is $O(t(\log^* n)^2)$ in expectation
Empirical Results

Network of size 14,116, first 100,000 queries

# of Messages per Query

Butterfly
Loglog

# of Bad Nodes

0 500 1000 1500 2000 2500 3000 3500 4000

7e+08
6e+08
5e+08
4e+08
3e+08
2e+08
1e+08
0
Empirical Results

Network of size 14,116, 0.125 fraction bad

# of Messages Per Query

# of Queries

Butterfly
Loglog

1.2e+09
1e+09
8e+08
6e+08
4e+08
2e+08
0

20000
265000
510000
755000
1e+06

2e+08

Conclusion

- Censorship detection and evasion are two sides of the same coin
- To protect free and open communication on the Internet, we need to
  - Understand how censorship is implemented
  - Continue to work on strategies to evade it
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