RANDOMNESS ANALYSIS REPORT

Object: regular games – low blind level set
from : *01/06/2009 00:00:02*
to : *31/12/2009 23:59:59*

Applicant: Everleaf Gaming Limited.
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Assignment Description: The randomness of the cards generated by the gaming platform of Everleaf Gaming Limited. must be analysed. The frequency and serial tests randomness tests, confirming that the random cards generator distributes numbers with sufficient non-predictability, fair distribution and lack of bias to particular outputs, are used. Specifically, the set of data is considered random if each card and each pair of cards is equally likely within statistical variations. Pearson's chi-square (χ^2) test is used to analyse statistical randomness.

1. Introduction

This document describes the technical aspects of the analysis performed on the set of regular poker games with a low blind level generated by Everleaf Gaming Limited. using the frequency and serial tests.

2. Set of data

The set of data consists of the 3'154'514 regular poker games with a low blind level generated between June 1st and December 31st 2009. The cards of the poker games are generated using a certified random numbers generator and their distribution is expected to be random.

Four kinds of games are proposed – 'Hold'em', 'Omaha', 'Omaha Hi/Lo' and '7Stud' – and three limits are possible – 'fix limit', 'no limit', 'pot limit'. The card hands of the different games and limit types have be all been put together into a single set of games. Each card is represented by a number between 0 and 51. All the games are composed of at least four cards. Only the first four cards of a game will be considered in the following tests because their

generation depends only on the random number generator, whereas the number and the distribution of the following cards also depend on the players' strategies.

A sample of the raw data file is shown below:

```
D8F9E0F6C8C4C8F42BE8F9FD47D861D4,HOLD,N,Low,33,39,4,1,9,40,47
05B8CE4C2A950702AA27FC25083A1424,HOLD,N,Low,27,21,14,45,29,17,34,25,31,2,49,18,1,13,35
8C2D39BCA7E261233745DE7814892EAF,HOLD,N,Low,39,34,21,28
14BA3C8DDD911183B1D8879B832519FA,HOLD,F,Low,18,46,14,11,35,23,13,24,15,6,36,38,37
A1C3E3ECABD6E3BF5ED7F7D24E313B40,HOLD,N,Low,27,29,46,47,22,23,15,18,30,39,48
BB7C8F93B2EAC6ADE3E86BD1E244CD16,HOLD,N,Low,45,25,11,39,29,47,13
979CADDAF0EEC2F76DBB32C1F934C704,HOLD,N,Low,18,38,17,21,2,23,46,24,20,33,41,39,45,48
7542DDBFB3774072776B870E198F6291,HOLD,N,Low,10,35,48,16
CD7A0300A3B0874A8205EE92F80881E4,HOLD,N,Low,48,40,27,36,31,2,37,38,4,30,5,44,17,22,39,12,14,7
CD5DD0A50BD5DC27E3B95F5776B154B5,HOLD,N,Low,49,8,38,29,10,39,47,24,33,50,40
9B4DE5E9727CFE079E9DA3B1BB9235FB,HOLD,N,Low,35,50,45,17,4,9,6,26,1
06F22C9EE7368FFC144036BC850F3310,HOLD,N,Low,13,27,3,41,32,51,48,14,19,42,8,6
D0B9D76F646FC1FDFD957BA64B18F213,HOLD,F,Low,29,23,37,9,38,6,35,45,11,14,8,33,39,49,48
```

The format used is describe below:

```
Pattern:
<ID>,<Game type>,<Limit type>,<Blind level>, card1, card2, … , cardN\endline
Where:
<Game type> = {"HOLD", "OMNM", "OMHL", "7CNM"}
"HOLD": Hold'em
"OMNM": Omaha
"OMHL": Omaha Hi/Lo
"7CNM": 7Stud
<Limit type> = {"F", "N", "P"}
"F": Fix limit
"N": No limit
"P": Pot limit
<Blind level> = {"Low", "Med", "High", "Tourn"}
"Low": small blind <= 0.1$
"Med": 0.1$ < small blind <= 0.5$
"High": small blind > 0.5$
"Tourn": Tournaments games
```

3. Data Reformating

The first step of the analysis is to select the data which will be tested, ie the first four cards of each game. A new data file is created by erasing the first four columns as well as all the columns after the 8th one.

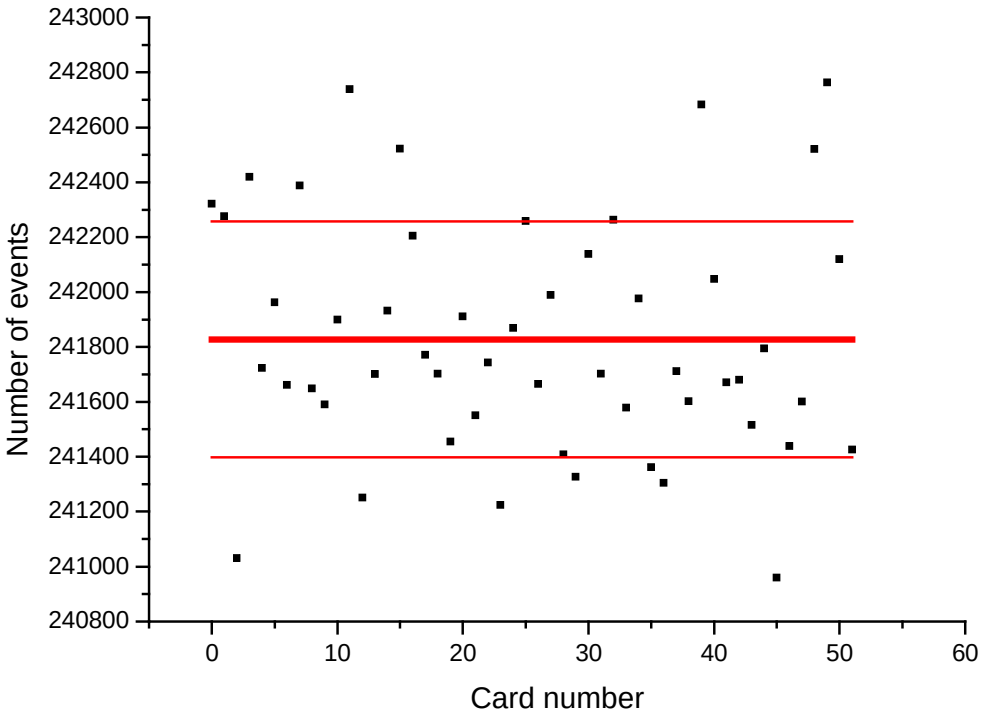
A sample of this new file is showed below:

```
33,39,4,1
27,21,14,45
39,34,21,28
18,46,14,11
27,29,46,47
45,25,11,39
18,38,17,21
10,35,48,16
48,40,27,36
49,8,38,29
35,50,45,17
13,27,3,41
29,23,37,9
```

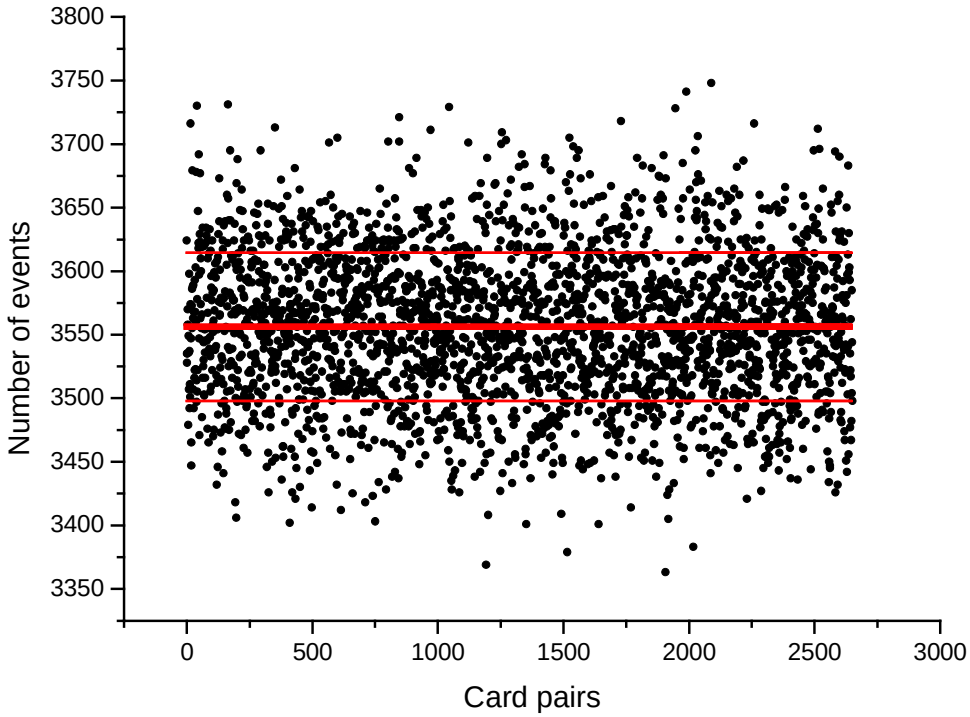
4. Frequency Randomness Test and Serial Randomness Test

The frequency and serial tests are commonly used to test the statistical randomness of a numeric sequence. The frequency test is used to make sure that there are roughly the same number of 0s, 1s, 2s, 3s, etc. The serial test does the same thing but for sequences of two digits at a time (00, 01, 02, etc.), comparing their observed frequencies with their hypothetical predictions were they are equally distributed. The criterion of being equally distributed is checked using Pearson's chi-square (χ^2) test with a statistical significance of 5%. This Pearson's chi-square test verifies if the frequency distribution of a sample of events is consistent with a given theoretical distribution.

The set of data has been analyzed with a GNU Octave (version 3.2.0) program running on a 32 bits Core2 Duo E8400 (3GHz) PC with Windows 7. This program rewrites the data file - as described above – and counts the occurrence of the different cards and pairs of cards. In the analysis, we have taken care of the order of the cards pairs (e.g., a pair (4♠,Q♦) is different from (Q♦, 4♠)).
The graphs obtained after the analysis are shown below. The data points are represented by the black dots. The thicker red line shows the mean value of the number of events. The two thinner red lines correspond to the mean value of the number of events plus or minus the expected standard deviation.



Graph of the occurrence of the different cards



Graph the occurrence of the pairs of cards

In order to test if the event of getting one card is equally likely for each card and the event of getting one pair of cards is equally likely for each pair, Pearson's chi-square (χ^2) test has been used with a statistical significance of 5% ($\chi^2_{1\text{-}5\%}[\upsilon]$). The number of samples, the computed χ^2 and the 5%-threshold of Pearson's test are listed in the following table.

	Number of samples (υ)	χ^2	$\chi^2_{1\text{-}5\%}[\upsilon]$).
Frequency test	52	39.0	68.7
Serial test	2652	2551	2773

One sees that in both cases, the χ^2 is smaller than the 5%-threshold. Consequently, one can conclude that:

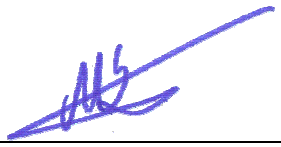
- the hypothesis the event 'getting a card' is uniformly distributed over all the possible cards is correct with a 95% probability
- the hypothesis that the event 'getting a pair of card' is uniformly distributed over all the possible pairs of cards is correct with a probability of 95%.

5. Results and Conclusions

The frequency and serial tests have been performed on the regular games with a low level blind set dealt in the gaming platform of Everleaf Gaming Limited. between June 1st and December 31st 2009. The hypothesis that the frequency distribution of a sample of events is consistent with a given theoretical distribution has been tested with Pearson's chi-square (χ^2) test and a statistical significance of 5%.

The set of data fulfils the criteria required by the frequency and serial tests. This shows that the probability of getting a card is equal to 1.9% (1/52) for each card and the probability of getting an ordered pair of cards is equal to 0.038% (1/2652).

This analysis has been performed in March 2010 in Geneva, Switzerland.



Dr. Matthieu Legré
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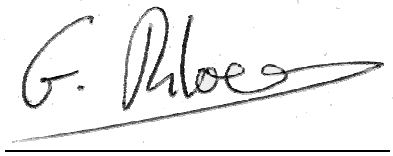

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