Topics in Privacy & Security

Trust-Enhanced Reputation Metrics

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Contents

i Description

In my implementation of the tool, a number of steps have been taken to help the tool scale. The tool utilises relational databases to quickly access product rating data. `CUSTOMERS` and `PRODUCTS` as mentioned in the pseudocode are tables in the database. This means that the tool does not need to store all data in memory which is usually the most limited resource.

As is visible from the pseudocode of the tool, I have also attempted to cut down on superfluous computation wherever possible.

```
1  MAX_RATE, ALPHA, FILE = take input from user
2  CUSTOMERS, PRODUCTS = initialise empty array: []
3
4  for each RATING of PRODUCT_J by CUSTOMER_I in FILE:
5      if RATING made by a new customer:
6          CUSTOMERS.append(New CUSTOMER_I with Default Trust Level of 0.5)
7
8      if RATING made of a new PRODUCT:
9          PRODUCTS.append(New PRODUCT_J with RATING)
10         continue to next RATING
11     else:
12         Update the Product Rating for PRODUCT_J
13
14     for each CUSTOMER of PRODUCT_J in CUSTOMERS:
15         Update the Trust Level of CUSTOMER
16
17     for each PRODUCT bought by CUSTOMERS of PRODUCT_J:
18         Update the Product Rating of PRODUCT
```

On Line 6 of the above pseudocode, Equation 3 (from the brief) always returns 0.5 when run with an empty set of products. There is no need to run this calculation equation each time, and not doing so will save us a small amount of compute time. On Line 10, in the case that this rating is for a new product, the algorithm skips the updating of related customers and products as this will have little effect. This is because, if a product only has one customer, its overall rating is the same as that customer's rating.

The loops to update customer trust levels and product ratings on Lines 14 and 17 respectively, are kept to a minimum by filtering down to only updating trust levels of customers that bought the newly rated product. For efficiency, the final implementation need to take care to ensure that each of customer and product is updated only once. If required, further steps to reduce runtime that have not been taken in my implementation, could include only updating Product Ratings (Line 18) if the customer trust levels have changed significantly and running trust level (Line 15) and product rating (Line 18) updates in different, parallel threads.

As systems scale, they are more likely to become the target of a form of cyber attack. Prepared statements have been used to sanitise inputs whenever input data from outside the program's control is entered into the database in order to protect against SQL injection attacks.

ii Analysis

1

iii Simulated Attacks

Self-promoting attacks of varying sizes have been simulated on product #4, this is shown by Fig. 2a. Slander attacks of varying sizes have been simulated on product #29, this is shown by Fig. 2b.

iv Results

The results show that the system is least susceptible to attack when an α value of 2 is used. Using values of alpha that ignore new reviews may prevent genuine customer reviewers' opinions from being heard.

v Appendix

v.1 run.php

```php
<?php
require_once("setup.php");
require_once("process.php");

while(!feof($myfile)){
    //FOR EACH RATING.. update the database:
    $data = explode(" ", fgets($myfile));
    if(count($data) != 3){break;}
    $customer_id = $data[0];
    $product_id = $data[1];
    $rating = $data[2];

    log_new_rating($db, $data[0], $data[1], $data[2]);
}
fclose($myfile);

if (basename(__FILE__) == basename($_SERVER["SCRIPT_FILENAME"])) {
    //Only run output if file was run DIRECTLY from console,
    //NOT included in another file: i.e. attack.php
    $base_output = "output/Alpha_" . strval(ALPHA) . "_";
    require_once("output.php");
}
```

v.2 attack.php

```php
<?php

//$attack_type = readline("Attack Type (slander/promote): ");
$attack_type = "slander";
require_once("run.php");

for($j = 0; $j < 5; $j++){
    for($i = 0; $i < 5; $i++){
        //Rating is 0 if slander, MAX_RATE if self-promoting
        $rating = MAX_RATE;
        $product_id = 4;
        if($attack_type == "slander"){
            //Lowest rating is 1 NOT 0
            $rating = 1;
            $product_id = 29;
        }

        //Null customer rating- creates new customer id
        //product id = 29, as stated in question
        log_new_rating($db, null, $product_id, $rating);
    }

    $base_output = "output/" . ucfirst($attack_type) . "_" .
        strval(5 * ($j + 1)) . "_Alpha_" . strval(ALPHA) . "_";
    require("output.php");
}
```

v.3 setup.php

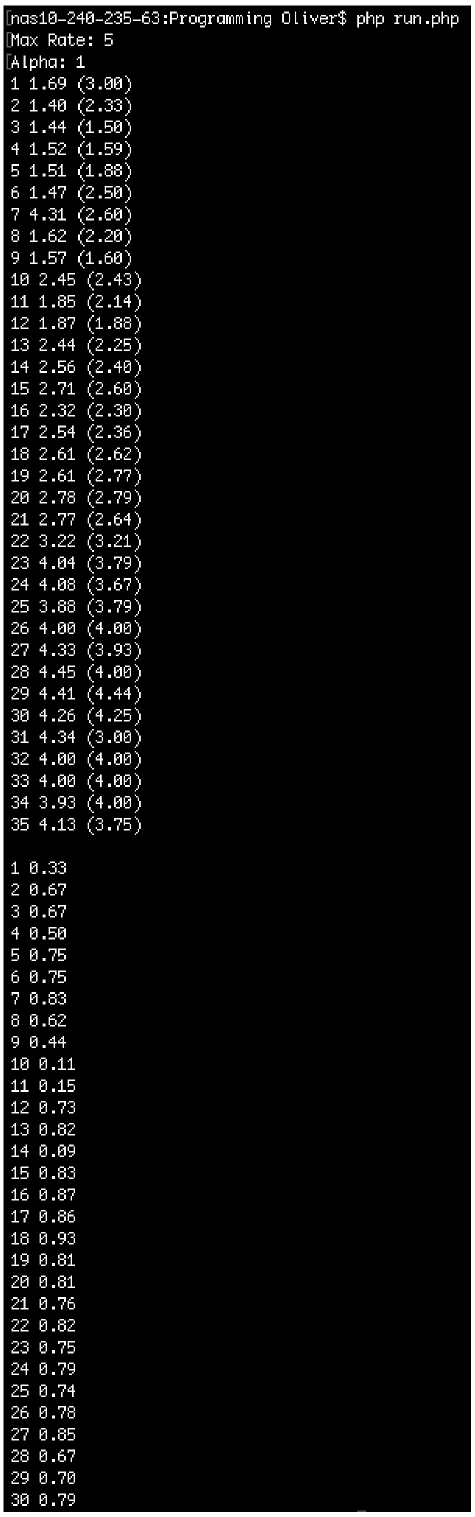
```
<?php
$filename = readline("Input File: ");
$myfile = fopen($filename, "r");

define("MAX_RATE", intval(readline("Max Rate: ")));
define("ALPHA", floatval(readline("Alpha: ")));


$db = new mysqli("localhost", "psec", "password");
$db->query("DROP DATABASE psec_assessment;");
$table_setup = "
   CREATE DATABASE psec_assessment;
   USE psec_assessment;
   CREATE TABLE ratings(
      id INT AUTO_INCREMENT PRIMARY KEY,
      customer_id INT,
      product_id INT,
      rating INT
   );
   CREATE TABLE customers(
      id INT AUTO_INCREMENT PRIMARY KEY,
      trust_level FLOAT
   );
   CREATE TABLE products(
      id INT AUTO_INCREMENT PRIMARY KEY,
      rating FLOAT
   );
";
$db->multi_query($table_setup);
while($db->more_results()){
    $res = $db->next_result();
}
```

v.4 process.php

```
<?php
function log_new_rating($db, $customer_id, $product_id, $rating){
    $trust = 0.5; //Equation 3 returns 0.5 when given the EMPTY SET
    //Check if this is a new user:
    if($customer_id == null){
        //This is a simulated attack:
        //completely new customer ID must be created:
        $stmt = $db->prepare(
            "INSERT INTO customers (trust_level) VALUES(?);"
        );
        $stmt->bind_param("s", $trust);
        $stmt->execute();

        $customer_id = $db->insert_id;
    }else{
        $stmt = $db->prepare(
            "SELECT␣COUNT(*)␣FROM␣customers␣where␣id=?;"
        );
        $stmt->bind_param("s", $customer_id);
        $stmt->execute();
        if($stmt->get_result()->fetch_assoc()["COUNT(*)"] == 0){
            //initialise trust level if new customer: This is 0.5
            if($stmt =
                $db->prepare(
                    "INSERT␣INTO␣customers␣VALUES␣(?,␣?);"
                )){
                $stmt->bind_param("ss", $customer_id, $trust);
                $stmt->execute();
            }
        }
    }


    //LOG THE NEW RATING:
    $stmt = $db->prepare(
        "INSERT␣INTO␣ratings␣(customer_id,␣product_id,␣rating)
␣␣␣␣␣␣␣VALUES(?,␣?,␣?);"
    );
    $stmt->bind_param("sss", $customer_id, $product_id, $rating);
    $stmt->execute();

    //Calculate overall product rating
    $stmt = $db->prepare("SELECT␣COUNT(*)␣FROM␣products␣where␣id=?;");
    $stmt->bind_param("s", $product_id);
    $stmt->execute();
    //If NEW product
    if($stmt->get_result()->fetch_assoc()["COUNT(*)"] == 0){
        //initialise rating with the rating of the NEW customer:
        if($stmt = $db->prepare("INSERT␣INTO␣products␣VALUES␣(?,␣?);")){
            $stmt->bind_param("ss", $product_id, floatval($rating));
            $stmt->execute();
        }
        //NEW PRODUCT, nothing left to update?
        return;
    }//IF EXISTING product:

    //Update trust levels of all customers who bought this product
    $stmt = $db->prepare(
        "SELECT␣customer_id␣FROM␣ratings␣WHERE␣product_id=?;"
    );
    $stmt->bind_param("s", $product_id);
    $stmt->execute();
    $result = $stmt->get_result();
    while($row = $result->fetch_assoc()){
        update_trust($db, $row["customer_id"]);

    }

    //Recalculate all products other than project j
    //LIMIT THIS TO PRODUCTS THAT HAVE BEEN AFFECTED!:
    $stmt = $db->prepare(
        "SELECT DISTINCT product_id FROM ratings
      WHERE customer_id IN
      (SELECT customer_id FROM ratings WHERE product_id = ?)"
    );
    $stmt->bind_param("s", $product_id);
    $stmt->execute();
    $result = $stmt->get_result();
    while($row = $result->fetch_assoc()){
        update_rating($db, $row["product_id"]);
    }
}

function update_rating($db, $product_id){
    $stmt = $db->prepare(
        "SELECT rating, trust_level FROM ratings, customers
      WHERE customer_id = customers.id AND product_id = ?;"
    );
    $stmt->bind_param("s", $product_id);
    $stmt->execute();
    $result = $stmt->get_result();

    //Equation 2 (Brief.pdf):
    $numerator = 0;
    $denominator = 0;

    foreach($result as $rating){
        $numerator += $rating["rating"] * $rating["trust_level"];
        $denominator += $rating["trust_level"];
    }

    $stmt = $db->prepare("UPDATE products SET rating = ? WHERE id = ?;");
    $rating = $numerator / $denominator;
    $stmt->bind_param("ss", $rating, $product_id);
    $stmt->execute();
}


function update_trust($db, $customer_id){
    $fetch_products = "SELECT
      ratings.rating AS customer_rating,
      products.rating AS overall_rating
      FROM ratings, products
      WHERE product_id=products.id AND customer_id=?;";

    $stmt = $db->prepare($fetch_products);
    $stmt->bind_param("s", $customer_id);
    $stmt->execute();
    $result = $stmt->get_result();

    $stmt = $db->prepare(
        "UPDATE customers SET trust_level = ? WHERE id = ?;"
    );
    $tl = trust_index($result);
    $stmt->bind_param("ss", $tl, $customer_id);
    $stmt->execute();
}

//Equation 3 (Brief.pdf):
function trust_index($products){
    $numerator = 1;
    $denominator = 2;

    foreach($products as $product){
        $numerator += is_trusted(
            $product["overall_rating"],
            $product["customer_rating"]
        );

        $denominator++;
    }

    return $numerator / $denominator;
}

//Equation 4 (Brief.pdf):
function is_trusted($overall_rating, $customer_rating){
    if(abs($overall_rating - $customer_rating) <= ALPHA){
        return 1;
    }
    return 0;
}
```

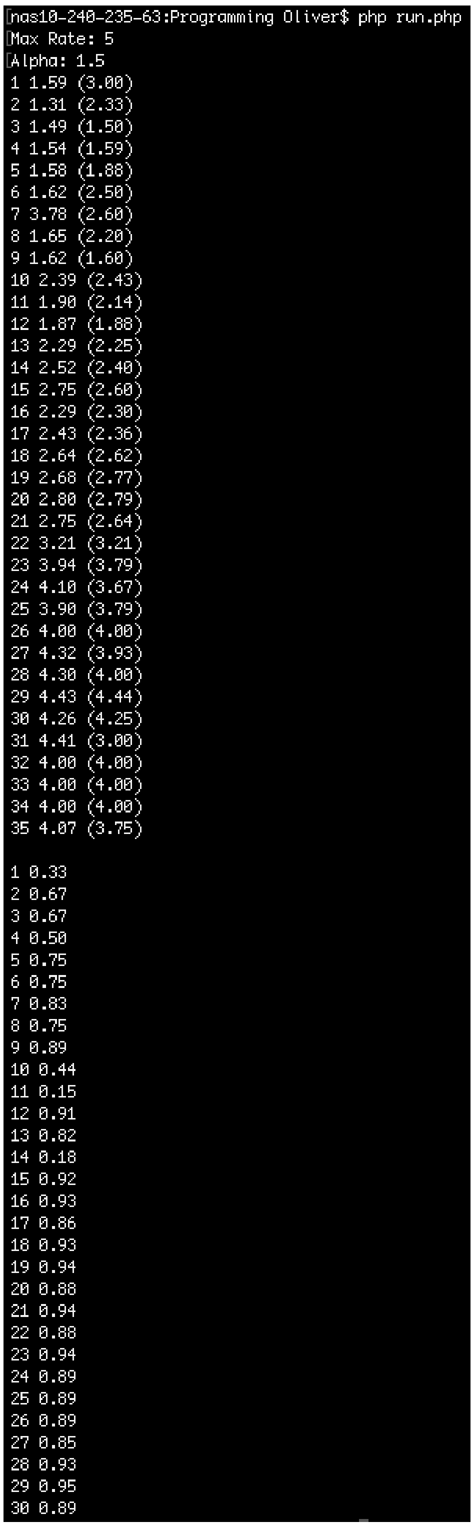
v.5 output.php

```
<?php
//Output to file or console:
$customers = fopen($base_output . "Customers.txt", "w");
$products = fopen($base_output . "Products.txt", "w");

$rep_based = $db->query("SELECT * FROM products;");
$average = $db->query(
    "SELECT AVG(rating) rating FROM ratings
    GROUP BY product_id ORDER BY product_id;"
);
foreach($rep_based as $product){
    $avg = $average->fetch_assoc();

    $out_str = sprintf("%u %0.2f (%0.2f)\n",
        $product["id"],
        $product["rating"],
        $avg["rating"]
    );

    echo $out_str;
    fwrite($products, $out_str);
}
echo "\n";
$result = $db->query("SELECT * FROM customers;");
foreach($result as $customer){
    $out_str = sprintf("%u %0.2f\n",
        $customer["id"],
        $customer["trust_level"]
    );

    echo $out_str;
    fwrite($customers, $out_str);
}
```



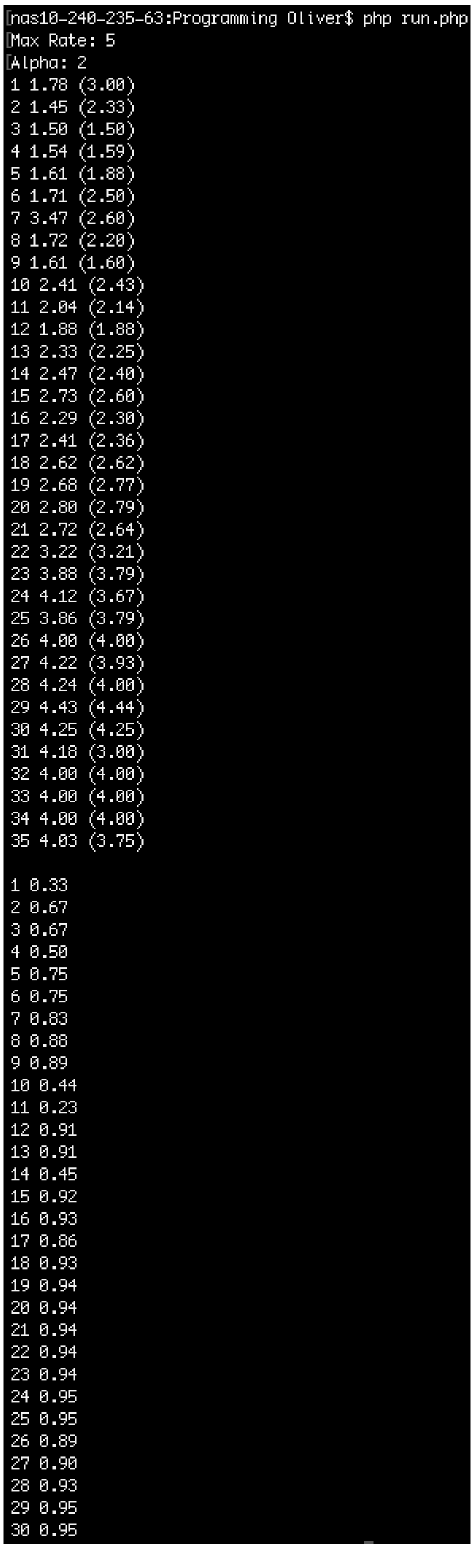
```
[nas10-240-235-63:Programming Oliver$ php run.php
[Max Rate: 5
[Alpha: 1
1 1.69 (3.00)
2 1.40 (2.33)
3 1.44 (1.50)
4 1.52 (1.59)
5 1.51 (1.88)
6 1.47 (2.50)
7 4.31 (2.60)
8 1.62 (2.20)
9 1.57 (1.60)
10 2.45 (2.43)
11 1.85 (2.14)
12 1.87 (1.88)
13 2.44 (2.25)
14 2.56 (2.40)
15 2.71 (2.60)
16 2.32 (2.30)
17 2.54 (2.36)
18 2.61 (2.62)
19 2.61 (2.77)
20 2.78 (2.79)
21 2.77 (2.64)
22 3.22 (3.21)
23 4.04 (3.79)
24 4.08 (3.67)
25 3.88 (3.79)
26 4.00 (4.00)
27 4.33 (3.93)
28 4.45 (4.00)
29 4.41 (4.44)
30 4.26 (4.25)
31 4.34 (3.00)
32 4.00 (4.00)
33 4.00 (4.00)
34 3.93 (4.00)
35 4.13 (3.75)

1 0.33
2 0.67
3 0.67
4 0.50
5 0.75
6 0.75
7 0.83
8 0.62
9 0.44
10 0.11
11 0.15
12 0.73
13 0.82
14 0.09
15 0.83
16 0.87
17 0.86
18 0.93
19 0.81
20 0.81
21 0.76
22 0.82
23 0.75
24 0.79
25 0.74
26 0.78
27 0.85
28 0.67
29 0.70
30 0.79
```

(a) $\alpha = 1$



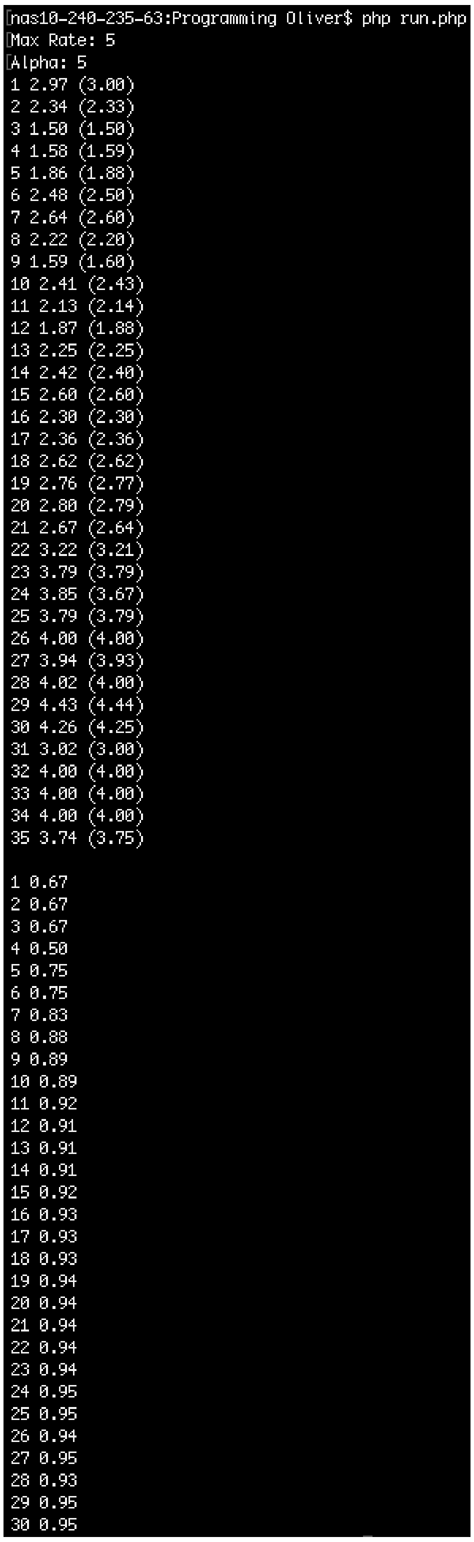
```
[nas10-240-235-63:Programming Oliver$ php run.php
[Max Rate: 5
[Alpha: 1.5
1 1.59 (3.00)
2 1.31 (2.33)
3 1.49 (1.50)
4 1.54 (1.59)
5 1.58 (1.88)
6 1.62 (2.50)
7 3.78 (2.60)
8 1.65 (2.20)
9 1.62 (1.60)
10 2.39 (2.43)
11 1.90 (2.14)
12 1.87 (1.88)
13 2.29 (2.25)
14 2.52 (2.40)
15 2.75 (2.60)
16 2.29 (2.30)
17 2.43 (2.36)
18 2.64 (2.62)
19 2.68 (2.77)
20 2.80 (2.79)
21 2.75 (2.64)
22 3.21 (3.21)
23 3.94 (3.79)
24 4.10 (3.67)
25 3.90 (3.79)
26 4.00 (4.00)
27 4.32 (3.93)
28 4.30 (4.00)
29 4.43 (4.44)
30 4.26 (4.25)
31 4.41 (3.00)
32 4.00 (4.00)
33 4.00 (4.00)
34 4.00 (4.00)
35 4.07 (3.75)

1 0.33
2 0.67
3 0.67
4 0.50
5 0.75
6 0.75
7 0.83
8 0.75
9 0.89
10 0.44
11 0.15
12 0.91
13 0.82
14 0.18
15 0.92
16 0.93
17 0.86
18 0.93
19 0.94
20 0.88
21 0.94
22 0.88
23 0.94
24 0.89
25 0.89
26 0.89
27 0.85
28 0.93
29 0.95
30 0.89
```

(b) $\alpha = 1.5$



```
nas10-240-235-63:Programming Oliver$ php run.php
Max Rate: 5
Alpha: 2
1 1.78 (3.00)
2 1.45 (2.33)
3 1.50 (1.50)
4 1.54 (1.59)
5 1.61 (1.88)
6 1.71 (2.50)
7 3.47 (2.60)
8 1.72 (2.20)
9 1.61 (1.60)
10 2.41 (2.43)
11 2.04 (2.14)
12 1.88 (1.88)
13 2.33 (2.25)
14 2.47 (2.40)
15 2.73 (2.60)
16 2.29 (2.30)
17 2.41 (2.36)
18 2.62 (2.62)
19 2.68 (2.77)
20 2.80 (2.79)
21 2.72 (2.64)
22 3.22 (3.21)
23 3.88 (3.79)
24 4.12 (3.67)
25 3.86 (3.79)
26 4.00 (4.00)
27 4.22 (3.93)
28 4.24 (4.00)
29 4.43 (4.44)
30 4.25 (4.25)
31 4.18 (3.00)
32 4.00 (4.00)
33 4.00 (4.00)
34 4.00 (4.00)
35 4.03 (3.75)

1 0.33
2 0.67
3 0.67
4 0.50
5 0.75
6 0.75
7 0.83
8 0.88
9 0.89
10 0.44
11 0.23
12 0.91
13 0.91
14 0.45
15 0.92
16 0.93
17 0.86
18 0.93
19 0.94
20 0.94
21 0.94
22 0.94
23 0.94
24 0.95
25 0.95
26 0.89
27 0.90
28 0.93
29 0.95
30 0.95
```

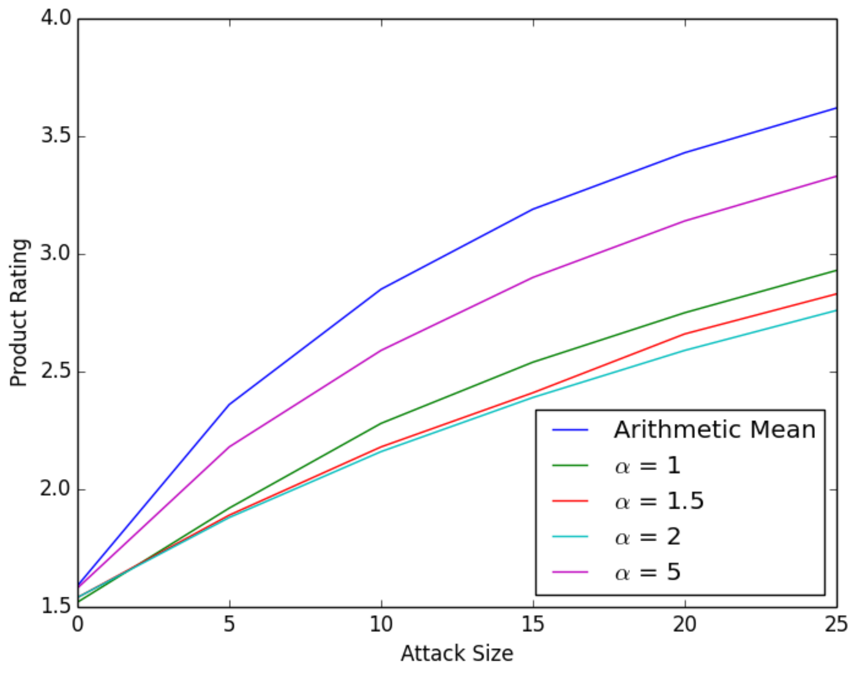
(c) $\alpha = 2$



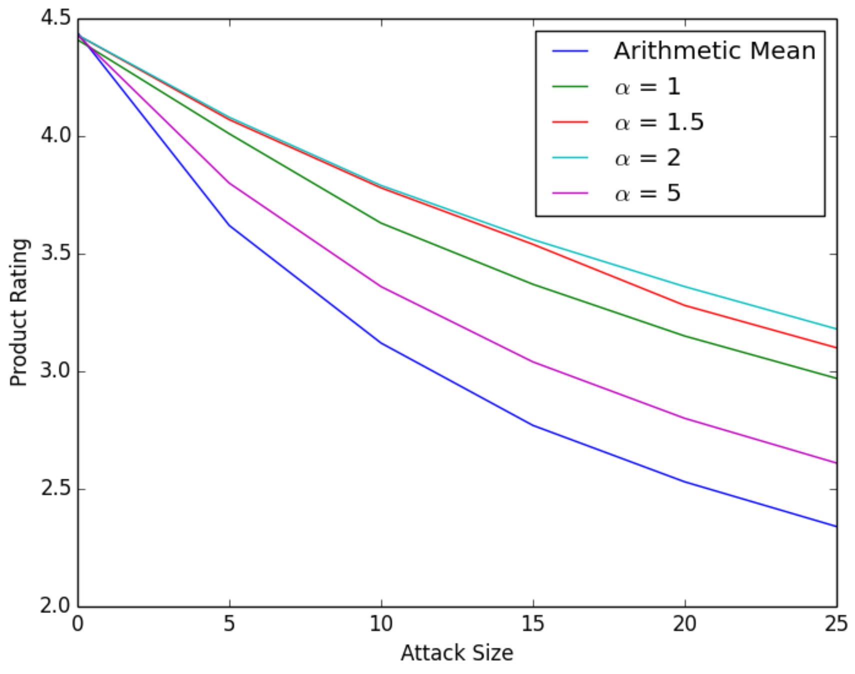
```
nas10-240-235-63:Programming Oliver$ php run.php
Max Rate: 5
Alpha: 5
1 2.97 (3.00)
2 2.34 (2.33)
3 1.50 (1.50)
4 1.58 (1.59)
5 1.86 (1.88)
6 2.48 (2.50)
7 2.64 (2.60)
8 2.22 (2.20)
9 1.59 (1.60)
10 2.41 (2.43)
11 2.13 (2.14)
12 1.87 (1.88)
13 2.25 (2.25)
14 2.42 (2.40)
15 2.60 (2.60)
16 2.30 (2.30)
17 2.36 (2.36)
18 2.62 (2.62)
19 2.76 (2.77)
20 2.80 (2.79)
21 2.67 (2.64)
22 3.22 (3.21)
23 3.79 (3.79)
24 3.85 (3.67)
25 3.79 (3.79)
26 4.00 (4.00)
27 3.94 (3.93)
28 4.02 (4.00)
29 4.43 (4.44)
30 4.26 (4.25)
31 3.02 (3.00)
32 4.00 (4.00)
33 4.00 (4.00)
34 4.00 (4.00)
35 3.74 (3.75)

1 0.67
2 0.67
3 0.67
4 0.50
5 0.75
6 0.75
7 0.83
8 0.88
9 0.89
10 0.89
11 0.92
12 0.91
13 0.91
14 0.91
15 0.92
16 0.93
17 0.93
18 0.93
19 0.94
20 0.94
21 0.94
22 0.94
23 0.94
24 0.95
25 0.95
26 0.94
27 0.95
28 0.93
29 0.95
30 0.95
```

(d) $\alpha = 5$

Figure 1: Tool Output for Varying Alpha



(a) Effect of Self-Promotion Attacks of Varying Sizes on Product 4



(b) Effect of Slander Attacks of Varying Sizes on Product 29

Figure 2: Attacks on the Online Store Rating System