

# Bagging-TPMiner: A classifier ensemble for masquerader detection based on typical objects

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**Abstract** This document includes a description of the extended WUIL repository and the accuracy results obtained in the paper entitled *Bagging-TPMiner: A classifier ensemble for masquerader detection based on typical objects* submitted to *Soft Computing* on May, 2016.

**Keywords** One-class classifier · Classifier ensemble · Masquerader detection

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**Table 1** Description of the extended WUIL repository.

| User | Role         | Ver.  | Genuine User |             | Masquerader 1  |             | Masquerader 2  |             | Masquerader 3  |             |
|------|--------------|-------|--------------|-------------|----------------|-------------|----------------|-------------|----------------|-------------|
|      |              |       | Time (days)  | Log windows | Time (min:sec) | Log windows | Time (min:sec) | Log windows | Time (min:sec) | Log windows |
| 1    | Manager      | XP    | 49           | 3269        | 04:54          | 8           | 04:53          | 8           | 04:56          | 10          |
| 2    | Manager      | XP    | 48           | 1559        | 04:50          | 10          | 04:37          | 9           | 04:50          | 4           |
| 3    | Systems Area | XP    | 35           | 606         | 04:29          | 8           | 04:35          | 9           | 03:14          | 4           |
| 4    | Accountant   | XP    | 29           | 1715        | 04:13          | 8           | 04:32          | 9           | 04:46          | 10          |
| 5    | Secretary    | XP    | 54           | 1734        | 04:50          | 10          | 04:39          | 10          | 04:47          | 10          |
| 6    | Secretary    | XP    | 57           | 4189        | 04:51          | 9           | 04:42          | 9           | 03:56          | 8           |
| 7    | Secretary    | XP    | 56           | 3309        | 04:51          | 10          | 04:53          | 9           | 04:50          | 10          |
| 8    | Secretary    | XP    | 31           | 1213        | 04:43          | 10          | 04:45          | 10          | 04:54          | 10          |
| 9    | Secretary    | XP    | 34           | 3086        | 04:54          | 10          | 04:43          | 10          | 04:50          | 10          |
| 11   | Secretary    | XP    | 13           | 6597        | 04:57          | 10          | 04:51          | 9           | 02:20          | 5           |
| 12   | Programmer   | 7     | 44           | 3288        | 04:58          | 9           | 04:41          | 8           | 04:57          | 9           |
| 14   | Sales        | 7     | 34           | 1011        | 04:58          | 10          | 04:54          | 9           | 04:59          | 10          |
| 15   | PhD Student  | Vista | 54           | 9413        | 04:58          | 9           | 04:59          | 10          | 04:53          | 10          |
| 16   | PhD Student  | 7     | 37           | 8382        | 04:59          | 10          | 04:57          | 8           | 04:58          | 10          |
| 17   | Student      | 7     | 35           | 4467        | 04:52          | 10          | 04:56          | 10          | 04:57          | 10          |
| 18   | Student      | 7     | 30           | 720         | 04:59          | 10          | 04:39          | 7           | 04:59          | 10          |
| 19   | Secretary    | Vista | 36           | 2708        | 04:42          | 8           | 03:37          | 7           | 03:59          | 3           |
| 20   | PhD Student  | XP    | 23           | 1057        | 04:56          | 10          | 04:54          | 10          | 04:53          | 10          |
| 21   | Student      | 8     | 56           | 4610        | 04:53          | 9           | 04:56          | 9           | 04:53          | 10          |
| 22   | Student      | 8.1   | 38           | 2684        | 04:41          | 7           | 04:19          | 8           | 04:29          | 9           |
| 24   | Student      | 7     | 43           | 2613        | 04:43          | 9           | 04:55          | 9           | 04:29          | 9           |
| 25   | Student      | 7     | 41           | 1018        | 04:56          | 10          | 04:49          | 10          | 04:49          | 10          |
| 26   | Student      | 7     | 56           | 9606        | 04:22          | 8           | 04:49          | 9           | 04:53          | 10          |
| 27   | Student      | 8     | 63           | 7880        | 04:54          | 8           | 04:38          | 9           | 02:55          | 6           |
| 28   | Student      | 7     | 60           | 5919        | 04:55          | 10          | 04:58          | 10          | 04:56          | 10          |
| 29   | Student      | 7     | 58           | 4266        | 03:37          | 7           | 03:23          | 7           | 04:30          | 10          |
| 30   | Student      | 7     | 37           | 6927        | 04:59          | 10          | 04:59          | 10          | 04:59          | 10          |
| 31   | Student      | 8     | 7            | 176         | 04:27          | 9           | 04:25          | 6           | 04:20          | 9           |
| 32   | Student      | 7     | 63           | 3226        | 04:44          | 8           | 04:44          | 7           | 04:48          | 10          |
| 33   | Student      | 7     | 50           | 1626        | 04:55          | 10          | 04:45          | 9           | 03:59          | 8           |
| 34   | Student      | 8     | 47           | 3766        | 04:31          | 9           | 04:33          | 9           | 04:52          | 10          |
| 35   | Student      | 7     | 61           | 5349        | 04:43          | 9           | 04:51          | 10          | 04:00          | 9           |
| 36   | Student      | 8     | 62           | 2559        | 04:48          | 9           | 04:34          | 9           | 04:52          | 10          |
| 37   | Student      | 7     | 62           | 8122        | 04:33          | 8           | 04:43          | 8           | 04:58          | 10          |
| 39   | Student      | 8     | 53           | 4333        | 04:58          | 8           | 04:50          | 3           | 03:39          | 8           |
| 40   | Student      | 8.1   | 51           | 4713        | 04:41          | 8           | 04:54          | 7           | 01:55          | 4           |
| 41   | Student      | 7     | 29           | 195         | 04:57          | 9           | 04:41          | 8           | 04:00          | 8           |
| 42   | Student      | 7     | 54           | 2201        | 04:49          | 10          | 04:38          | 9           | 04:59          | 10          |
| 43   | Student      | 7     | 63           | 7541        | 04:54          | 10          | 04:41          | 9           | 04:54          | 9           |
| 44   | Student      | 7     | 50           | 2361        | 04:51          | 9           | 00:33          | 0           | 04:53          | 10          |
| 45   | Student      | 7     | 56           | 3328        | 04:54          | 9           | 04:50          | 9           | 04:55          | 10          |
| 46   | Student      | 8     | 3            | 1018        | 04:52          | 10          | 04:34          | 9           | 04:57          | 10          |
| 47   | Student      | 7     | 12           | 2964        | 04:10          | 9           | 04:53          | 10          | 04:45          | 8           |
| 48   | Student      | 8     | 62           | 5523        | 04:40          | 7           | 03:57          | 6           | 03:18          | 2           |
| 50   | Student      | XP    | 58           | 3078        | 04:55          | 9           | 04:45          | 9           | 04:56          | 10          |
| 51   | Student      | 7     | 56           | 6115        | 04:57          | 7           | 04:43          | 9           | 04:51          | 10          |
| 52   | Student      | 8     | 45           | 3602        | 04:57          | 9           | 04:53          | 9           | 01:07          | 2           |
| 53   | Student      | 8     | 18           | 2757        | 04:59          | 10          | 04:49          | 10          | 04:49          | 10          |
| 54   | Student      | 7     | 17           | 529         | 04:52          | 9           | 04:58          | 9           | 04:46          | 10          |
| 55   | Student      | 7     | 59           | 5034        | 04:54          | 9           | 04:58          | 9           | 04:56          | 10          |
| 56   | Student      | 7     | 58           | 2660        | 04:59          | 8           | 04:17          | 7           | 03:54          | 8           |
| 57   | Student      | 8     | 61           | 3376        | 04:52          | 10          | 04:56          | 10          | 04:58          | 9           |
| 58   | Student      | 7     | 59           | 3499        | 04:58          | 8           | 04:53          | 9           | 04:29          | 9           |
| 59   | Student      | 7     | 47           | 5365        | 04:59          | 10          | 04:19          | 9           | 04:58          | 10          |
| 60   | Student      | 7     | 9            | 847         | 04:00          | 8           | 04:52          | 10          | 04:58          | 10          |
| 61   | Student      | 8     | 44           | 3671        | 02:58          | 6           | 04:49          | 10          | 04:55          | 9           |
| 62   | Student      | 7     | 49           | 1781        | 04:52          | 10          | 04:58          | 9           | 04:57          | 10          |
| 63   | Student      | 7     | 48           | 3389        | 04:47          | 8           | 04:47          | 8           | 04:53          | 9           |
| 64   | Student      | 8     | 51           | 4223        | 04:52          | 9           | 04:42          | 7           | 04:45          | 10          |
| 65   | Student      | 7     | 49           | 2502        | 04:55          | 9           | 04:58          | 9           | 04:48          | 10          |
| 66   | Student      | 7     | 58           | 2880        | 04:48          | 8           | 04:56          | 9           | 04:50          | 10          |
| 67   | Student      | 8     | 61           | 1927        | 04:51          | 3           | 04:21          | 9           | 04:02          | 8           |
| 68   | Student      | 7     | 54           | 3225        | 04:54          | 10          | 04:42          | 10          | 04:42          | 10          |
| 69   | Student      | 7     | 64           | 6170        | 04:52          | 7           | 04:51          | 9           | 04:39          | 10          |
| 71   | Student      | 7     | 49           | 7316        | 04:56          | 9           | 04:59          | 9           | 04:50          | 10          |
| 72   | Student      | 8     | 47           | 3476        | 04:53          | 10          | 04:44          | 9           | 04:49          | 10          |
| 73   | Student      | 8     | 50           | 17863       | 04:53          | 9           | 04:43          | 5           | 01:02          | 3           |
| 74   | Student      | 7     | 47           | 5606        | 04:48          | 9           | 04:50          | 10          | 04:59          | 10          |
| 75   | Teacher      | 7     | 33           | 998         | 04:56          | 10          | 04:55          | 10          | 04:58          | 10          |

**Table 2** Area (in percentage) under the curve of TP versus FP. The best result by user appears in bold.

| User   | SVM          | Parzen       | <i>k</i> -means1 | <i>k</i> -means2 | Bagging-TPMiner |
|--------|--------------|--------------|------------------|------------------|-----------------|
| User1  | 93.67        | 92.73        | 93.73            | 92.77            | <b>96.23</b>    |
| User2  | 86.33        | 86.01        | 87.34            | 86.17            | <b>92.68</b>    |
| User3  | 92.94        | 90.41        | 90.32            | 90.06            | <b>98.03</b>    |
| User4  | 97.39        | 96.59        | 97.08            | 96.57            | <b>97.44</b>    |
| User5  | 81.78        | 81.68        | 85.59            | 81.88            | <b>89.52</b>    |
| User6  | 91.57        | 90.24        | 93.29            | 90.58            | <b>98.74</b>    |
| User7  | 96.94        | 97.96        | 98.26            | 97.92            | <b>99.38</b>    |
| User8  | 93.19        | 92.04        | 92.97            | 92.02            | <b>93.74</b>    |
| User9  | 94.01        | 92.44        | 94.59            | 92.62            | <b>96.06</b>    |
| User11 | 94.95        | 97.65        | 98.43            | 97.80            | <b>99.48</b>    |
| User12 | 79.83        | 87.93        | 91.32            | 88.11            | <b>95.98</b>    |
| User14 | 84.88        | 92.02        | 94.06            | 91.55            | <b>98.42</b>    |
| User15 | 83.56        | 87.64        | 90.13            | 87.92            | <b>91.29</b>    |
| User16 | 88.25        | 87.05        | 89.49            | 87.94            | <b>96.10</b>    |
| User17 | 76.62        | 80.38        | 81.21            | 80.31            | <b>90.91</b>    |
| User18 | 93.39        | 97.84        | <b>97.87</b>     | 97.73            | 95.55           |
| User19 | <b>98.46</b> | 92.13        | 92.92            | 92.51            | 94.73           |
| User20 | 92.91        | 96.07        | 96.83            | 96.17            | <b>98.88</b>    |
| User21 | 91.71        | 94.30        | 94.63            | 94.12            | <b>96.21</b>    |
| User22 | 85.64        | 88.75        | 92.17            | 88.68            | <b>93.87</b>    |
| User24 | 87.30        | 96.86        | 97.27            | 96.83            | <b>98.22</b>    |
| User25 | 91.21        | 93.31        | 94.25            | 93.28            | <b>96.86</b>    |
| User26 | 80.97        | 80.80        | 82.25            | 80.61            | <b>88.09</b>    |
| User27 | 85.92        | 91.91        | 94.38            | 92.30            | <b>97.14</b>    |
| User28 | 76.89        | 72.84        | 78.36            | 72.91            | <b>81.15</b>    |
| User29 | <b>94.00</b> | 87.86        | 90.20            | 87.96            | 91.87           |
| User30 | 84.55        | 91.40        | 92.44            | 91.52            | <b>96.62</b>    |
| User31 | <b>95.75</b> | 94.14        | 93.73            | 94.04            | 84.40           |
| User32 | 85.88        | 85.00        | 90.23            | 84.63            | <b>92.67</b>    |
| User33 | 92.19        | 88.53        | 90.93            | 88.58            | <b>94.89</b>    |
| User34 | 76.31        | 75.95        | 77.22            | 75.86            | <b>82.47</b>    |
| User35 | 85.84        | 84.17        | 87.80            | 84.48            | <b>96.52</b>    |
| User36 | 85.23        | 86.51        | 89.70            | 86.39            | <b>97.22</b>    |
| User37 | <b>77.92</b> | 69.16        | 73.30            | 68.39            | 72.95           |
| User39 | 76.09        | 80.91        | 82.78            | 81.61            | <b>91.43</b>    |
| User40 | 83.62        | 89.15        | 89.17            | 89.17            | <b>93.78</b>    |
| User41 | 77.90        | <b>90.49</b> | 90.12            | 90.38            | 87.33           |
| User42 | 96.52        | 98.20        | 98.46            | 98.18            | <b>99.74</b>    |
| User43 | 91.48        | 93.38        | 95.51            | 93.25            | <b>97.37</b>    |
| User44 | 85.24        | 80.79        | 80.09            | 80.74            | <b>90.57</b>    |
| User45 | 84.58        | 86.51        | 90.23            | 86.67            | <b>94.83</b>    |
| User46 | 76.76        | 87.69        | 88.81            | 87.43            | <b>90.20</b>    |
| User47 | 88.25        | 83.33        | 88.21            | 83.68            | <b>92.32</b>    |
| User48 | 79.84        | 80.13        | 78.14            | <b>80.36</b>     | 79.94           |

**Table 3** The value of TP (in percentage) when TP=TN. The best result by user appears in bold.

| User   | SVM          | Parzen       | <i>k</i> -means1 | <i>k</i> -means2 | Bagging-TPMiner |
|--------|--------------|--------------|------------------|------------------|-----------------|
| User1  | 86.67        | 84.52        | 86.02            | 84.98            | <b>88.22</b>    |
| User2  | 80.72        | 80.97        | 83.33            | 81.71            | <b>87.72</b>    |
| User3  | 88.76        | 87.71        | 87.54            | 87.55            | <b>93.68</b>    |
| User4  | 92.51        | 90.21        | <b>93.42</b>     | 90.53            | 93.19           |
| User5  | <b>81.64</b> | 73.35        | 76.98            | 74.19            | <b>81.64</b>    |
| User6  | 87.83        | 81.56        | 84.84            | 81.88            | <b>95.50</b>    |
| User7  | 91.62        | 94.06        | 94.54            | 94.28            | <b>97.59</b>    |
| User8  | 85.5         | 89.26        | 88.96            | 89.51            | <b>90.86</b>    |
| User9  | 88.45        | 85.7         | 89.15            | 86.27            | <b>92.96</b>    |
| User11 | 90.75        | 94.22        | 96.68            | 94.59            | <b>98.40</b>    |
| User12 | 74.9         | 79.35        | 84.44            | 79.06            | <b>94.90</b>    |
| User14 | 80.7         | 85.58        | 87.16            | 85.42            | <b>95.05</b>    |
| User15 | 80.63        | 82.19        | 85.44            | 82.93            | <b>88.99</b>    |
| User16 | 80.07        | 78.6         | 81.48            | 79.79            | <b>91.54</b>    |
| User17 | 75.46        | 75.04        | 76.78            | 74.83            | <b>85.94</b>    |
| User18 | 91.46        | <b>95.63</b> | 95.35            | 95.26            | 89.91           |
| User19 | <b>95.43</b> | 91.88        | 93.38            | 92.07            | 95.19           |
| User20 | 86.61        | 90.81        | 91.41            | 90.9             | <b>95.67</b>    |
| User21 | 85.55        | 87.03        | 88.73            | 87.21            | <b>92.12</b>    |
| User22 | 82.47        | 85.14        | 89.19            | 84.99            | <b>89.22</b>    |
| User24 | 82.51        | 92.72        | 92.94            | 92.82            | <b>94.22</b>    |
| User25 | 86.85        | 90.46        | 90.13            | 90.46            | <b>92.18</b>    |
| User26 | 78.59        | 74.94        | 74.24            | 76.08            | <b>80.42</b>    |
| User27 | 82.75        | 82.88        | 85.56            | 83.29            | <b>91.20</b>    |
| User28 | 71.34        | 68.77        | 73.35            | 69.16            | <b>74.15</b>    |
| User29 | <b>89.98</b> | 83.00        | 82.67            | 82.84            | 88.06           |
| User30 | 78.41        | 85.83        | 85.48            | 85.16            | <b>93.38</b>    |
| User31 | <b>92.88</b> | 90.69        | 90.80            | 90.69            | 81.39           |
| User32 | 80.68        | 80.96        | 83.83            | 81.25            | <b>88.78</b>    |
| User33 | 86.64        | 85.15        | 87.09            | 85.18            | <b>87.95</b>    |
| User34 | 70.99        | 69.87        | 71.80            | 69.32            | <b>76.21</b>    |
| User35 | 85.07        | 78.16        | 81.10            | 78.66            | <b>92.73</b>    |
| User36 | 80.71        | 83.97        | 82.52            | 84.07            | <b>93.75</b>    |
| User37 | <b>69.45</b> | 60.09        | 63.76            | 60.00            | 63.95           |
| User39 | 69.44        | 74.86        | 79.23            | 76.45            | <b>84.74</b>    |
| User40 | 78.53        | 82.65        | 84.49            | 82.55            | <b>87.89</b>    |
| User41 | 72.55        | <b>86.69</b> | 85.97            | 86.21            | 83.34           |
| User42 | 91.93        | 95.15        | 94.40            | 95.35            | <b>98.36</b>    |
| User43 | 84.42        | 82.98        | 88.65            | 82.89            | <b>93.50</b>    |
| User44 | 80.43        | 77.15        | 76.03            | 76.8             | <b>86.46</b>    |
| User45 | 77.21        | 78.8         | 81.64            | 79.11            | <b>88.42</b>    |
| User46 | 73.33        | 80.44        | <b>81.76</b>     | 80.69            | 80.05           |
| User47 | 79.09        | 77.03        | 79.8             | 77.33            | <b>85.27</b>    |
| User48 | <b>77.00</b> | 75.11        | 75.32            | 75.64            | 75.57           |

**Table 4** The best accuracy value, *i.e.* max(TP(in percentage)+TN(in percentage)). The best result by user appears in bold.

| User   | SVM           | Parzen        | <i>k</i> -means1 | <i>k</i> -means2 | Bagging-TPMiner |
|--------|---------------|---------------|------------------|------------------|-----------------|
| User1  | 179.30        | 172.52        | 175.49           | 173.22           | <b>183.16</b>   |
| User2  | 169.09        | 167.98        | 170.68           | 168.04           | <b>181.19</b>   |
| User3  | 181.55        | 175.42        | 175.90           | 175.10           | <b>188.94</b>   |
| User4  | 188.90        | 187.28        | 190.01           | 187.40           | <b>190.02</b>   |
| User5  | <b>167.36</b> | 150.29        | 156.18           | 151.12           | 166.72          |
| User6  | 180.88        | 166.13        | 176.31           | 167.50           | <b>192.63</b>   |
| User7  | 186.75        | 188.47        | 189.37           | 188.56           | <b>195.39</b>   |
| User8  | 176.63        | 180.08        | 180.76           | 180.21           | <b>184.47</b>   |
| User9  | 181.38        | 173.20        | 178.68           | 173.26           | <b>187.01</b>   |
| User11 | 187.24        | 192.54        | 195.33           | 193.10           | <b>197.34</b>   |
| User12 | 165.56        | 163.06        | 169.17           | 163.14           | <b>190.42</b>   |
| User14 | 167.56        | 172.04        | 175.01           | 171.17           | <b>191.81</b>   |
| User15 | 170.22        | 172.28        | 177.13           | 171.60           | <b>178.77</b>   |
| User16 | 169.80        | 164.31        | 167.01           | 164.79           | <b>183.41</b>   |
| User17 | 156.86        | 153.00        | 155.97           | 151.72           | <b>173.05</b>   |
| User18 | 186.06        | <b>191.30</b> | 191.16           | 191.16           | 180.83          |
| User19 | <b>194.91</b> | 184.66        | 187.19           | 185.00           | 190.38          |
| User20 | 181.51        | 185.24        | 185.46           | 185.14           | <b>192.21</b>   |
| User21 | 176.03        | 176.57        | 178.19           | 176.59           | <b>184.86</b>   |
| User22 | 170.45        | 173.14        | 178.91           | 172.68           | <b>178.95</b>   |
| User24 | 175.50        | 186.17        | 186.73           | 186.23           | <b>189.93</b>   |
| User25 | 180.86        | 180.92        | 180.46           | 180.92           | <b>185.56</b>   |
| User26 | 162.39        | 152.98        | 155.06           | 153.95           | <b>165.72</b>   |
| User27 | 170.75        | 169.67        | 176.44           | 170.38           | <b>183.20</b>   |
| User28 | <b>155.86</b> | 142.73        | 150.99           | 142.87           | 151.22          |
| User29 | <b>182.88</b> | 166.69        | 169.52           | 166.62           | 177.70          |
| User30 | 164.28        | 172.33        | 175.73           | 173.07           | <b>187.03</b>   |
| User31 | <b>188.26</b> | 186.39        | 185.49           | 185.83           | 168.19          |
| User32 | 170.50        | 162.85        | 170.15           | 163.13           | <b>179.82</b>   |
| User33 | 177.20        | 171.71        | 176.44           | 171.78           | <b>178.33</b>   |
| User34 | 149.28        | 144.30        | 146.89           | 143.53           | <b>154.57</b>   |
| User35 | 173.83        | 157.96        | 165.39           | 158.62           | <b>188.42</b>   |
| User36 | 172.24        | 168.25        | 168.10           | 168.85           | <b>188.17</b>   |
| User37 | <b>152.18</b> | 136.08        | 138.17           | 136.65           | 137.22          |
| User39 | 157.74        | 158.68        | 161.88           | 159.65           | <b>172.38</b>   |
| User40 | 161.66        | 166.99        | 170.70           | 167.18           | <b>178.70</b>   |
| User41 | 158.40        | 174.06        | 173.41           | <b>174.21</b>    | 170.86          |
| User42 | 187.05        | 190.29        | 189.05           | 190.70           | <b>197.73</b>   |
| User43 | 175.14        | 175.06        | 181.94           | 174.65           | <b>188.84</b>   |
| User44 | 165.66        | 157.37        | 157.38           | 157.08           | <b>177.08</b>   |
| User45 | 164.61        | 162.80        | 167.26           | 162.92           | <b>178.93</b>   |
| User46 | <b>165.54</b> | 163.90        | 165.16           | 164.29           | 164.92          |
| User47 | 164.98        | 156.26        | 163.87           | 156.96           | <b>171.87</b>   |
| User48 | <b>157.01</b> | 153.24        | 153.10           | 153.66           | 154.02          |

**Table 5** The value of TP (in percentage) when FP=0%. The best result by user appears in bold.

| User   | SVM          | Parzen       | <i>k</i> -means1 | <i>k</i> -means2 | Bagging-TPMiner |
|--------|--------------|--------------|------------------|------------------|-----------------|
| User1  | 0.00         | 15.39        | 21.54            | 17.69            | <b>43.85</b>    |
| User2  | 3.48         | 3.48         | 0.00             | 3.48             | <b>8.70</b>     |
| User3  | 46.67        | 32.38        | 37.14            | 32.38            | <b>57.14</b>    |
| User4  | 44.44        | 41.48        | 42.22            | 41.48            | <b>51.85</b>    |
| User5  | 2.00         | 9.33         | 9.33             | 8.00             | <b>26.00</b>    |
| User6  | 0.00         | 10.77        | 8.46             | 10.00            | <b>30.00</b>    |
| User7  | 9.66         | 20.00        | 20.00            | 20.00            | <b>35.86</b>    |
| User8  | 42.00        | 30.67        | 36.67            | 33.33            | <b>52.00</b>    |
| User9  | 12.67        | 8.67         | 14.67            | 9.33             | <b>34.00</b>    |
| User11 | 9.17         | 13.33        | 12.50            | 10.00            | <b>37.50</b>    |
| User12 | 13.85        | 25.39        | 26.92            | 23.85            | <b>34.62</b>    |
| User14 | 33.10        | 24.14        | 24.14            | 23.45            | <b>44.83</b>    |
| User15 | 12.41        | 11.03        | 22.76            | 11.03            | <b>30.35</b>    |
| User16 | 21.43        | 1.43         | 4.29             | 1.43             | <b>35.71</b>    |
| User17 | 0.00         | 5.33         | 1.33             | 5.33             | <b>10.00</b>    |
| User18 | 39.26        | 46.67        | 42.96            | 46.67            | <b>65.19</b>    |
| User19 | 6.67         | 2.11         | 4.21             | 2.11             | <b>37.90</b>    |
| User20 | 48.00        | 34.67        | 38.00            | 34.67            | <b>63.33</b>    |
| User21 | 22.86        | 22.86        | 23.57            | 20.71            | <b>36.43</b>    |
| User22 | 10.83        | 3.33         | 4.17             | 3.33             | <b>27.50</b>    |
| User24 | 40.74        | 54.82        | 54.07            | 54.82            | <b>56.30</b>    |
| User25 | 28.00        | 28.67        | 28.67            | 28.67            | <b>54.00</b>    |
| User26 | 6.67         | 5.93         | 4.44             | 4.44             | <b>9.63</b>     |
| User27 | 6.09         | 24.35        | 22.61            | 23.48            | <b>35.65</b>    |
| User28 | <b>0.67</b>  | 0.00         | 0.00             | 0.00             | 0.00            |
| User29 | <b>35.83</b> | 29.17        | 31.67            | 26.67            | 35.00           |
| User30 | 22.00        | 14.00        | 14.00            | 14.00            | <b>33.33</b>    |
| User31 | <b>79.17</b> | 72.50        | 70.83            | 71.67            | 25.83           |
| User32 | 24.80        | 27.20        | 23.20            | 24.00            | <b>33.60</b>    |
| User33 | 30.37        | 24.44        | 27.41            | 25.93            | <b>42.96</b>    |
| User34 | 8.57         | 0.00         | 6.43             | 0.00             | <b>16.43</b>    |
| User35 | 0.00         | 0.00         | 0.00             | 0.00             | <b>17.14</b>    |
| User36 | 7.14         | 2.86         | 4.29             | 2.86             | <b>45.00</b>    |
| User37 | 0.00         | 7.69         | 8.46             | 9.23             | <b>28.46</b>    |
| User39 | 16.84        | 11.58        | 8.42             | 11.58            | <b>24.21</b>    |
| User40 | 26.32        | <b>30.53</b> | <b>30.53</b>     | <b>30.53</b>     | 27.37           |
| User41 | 12.00        | <b>44.80</b> | 43.20            | <b>44.80</b>     | 19.20           |
| User42 | 55.17        | 48.28        | 46.90            | 47.59            | <b>76.55</b>    |
| User43 | 18.57        | 19.29        | 20.00            | 20.00            | <b>25.00</b>    |
| User44 | 7.37         | 17.14        | 16.43            | 15.71            | <b>24.29</b>    |
| User45 | 13.57        | 27.14        | 27.86            | 27.14            | <b>38.57</b>    |
| User46 | <b>50.34</b> | 37.24        | 37.24            | 37.24            | 45.52           |
| User47 | 28.15        | 19.26        | 23.70            | 22.22            | <b>44.44</b>    |
| User48 | 0.00         | <b>5.33</b>  | <b>5.33</b>      | <b>5.33</b>      | 0.00            |

**Table 6** The accuracy of Bagging-TPMiner when classifying persistent attacks. In bold appears the best result by user compared to the performance reported in Tables 2 to 5.

| User   | AUC          | TP=TN        | max(TP+TN)    | TP when FP=0% |
|--------|--------------|--------------|---------------|---------------|
| User1  | <b>96.61</b> | <b>89.79</b> | <b>183.16</b> | <b>47.69</b>  |
| User2  | <b>93.19</b> | <b>89.31</b> | <b>183.23</b> | <b>11.30</b>  |
| User3  | <b>98.78</b> | <b>94.97</b> | <b>190.72</b> | <b>78.10</b>  |
| User4  | <b>97.84</b> | <b>93.66</b> | <b>190.90</b> | <b>59.26</b>  |
| User5  | <b>90.19</b> | <b>82.93</b> | <b>168.18</b> | <b>26.00</b>  |
| User6  | 98.47        | <b>95.95</b> | 191.93        | <b>40.00</b>  |
| User7  | <b>99.57</b> | <b>98.07</b> | <b>196.66</b> | <b>42.76</b>  |
| User8  | <b>94.72</b> | <b>93.04</b> | <b>189.79</b> | <b>60.67</b>  |
| User9  | <b>97.05</b> | <b>94.14</b> | <b>190.79</b> | <b>36.67</b>  |
| User11 | <b>99.70</b> | <b>98.81</b> | <b>197.62</b> | <b>50.83</b>  |
| User12 | 95.52        | 94.61        | 189.88        | <b>41.54</b>  |
| User14 | <b>98.57</b> | <b>95.17</b> | 191.26        | <b>49.66</b>  |
| User15 | <b>93.05</b> | <b>91.38</b> | <b>183.20</b> | <b>33.79</b>  |
| User16 | <b>97.03</b> | <b>92.86</b> | 187.27        | <b>44.29</b>  |
| User17 | <b>91.29</b> | <b>86.10</b> | <b>174.13</b> | <b>12.00</b>  |
| User18 | 97.76        | 93.68        | 188.66        | <b>79.26</b>  |
| User19 | <b>98.97</b> | <b>97.09</b> | <b>195.76</b> | <b>47.37</b>  |
| User20 | <b>99.12</b> | 96.63        | <b>193.73</b> | <b>74.67</b>  |
| User21 | <b>96.34</b> | <b>92.16</b> | <b>184.92</b> | <b>42.14</b>  |
| User22 | <b>95.23</b> | <b>91.46</b> | <b>184.79</b> | <b>31.67</b>  |
| User24 | <b>98.78</b> | <b>95.89</b> | <b>192.61</b> | <b>68.15</b>  |
| User25 | <b>97.33</b> | <b>92.93</b> | <b>186.72</b> | <b>62.00</b>  |
| User26 | <b>89.37</b> | <b>80.80</b> | <b>167.52</b> | <b>9.63</b>   |
| User27 | <b>97.54</b> | <b>91.68</b> | <b>185.09</b> | <b>42.61</b>  |
| User28 | <b>82.13</b> | <b>74.42</b> | 154.88        | 0.00          |
| User29 | 92.07        | 89.68        | 179.73        | <b>41.67</b>  |
| User30 | <b>98.93</b> | <b>95.71</b> | <b>192.65</b> | <b>36.00</b>  |
| User31 | 95.37        | <b>95.69</b> | <b>191.39</b> | 56.67         |
| User32 | <b>95.61</b> | <b>93.92</b> | <b>187.91</b> | <b>35.20</b>  |
| User33 | <b>95.07</b> | 87.79        | <b>179.53</b> | <b>51.11</b>  |
| User34 | 82.29        | 75.47        | 153.80        | <b>19.29</b>  |
| User35 | <b>96.67</b> | 92.60        | <b>189.46</b> | <b>17.86</b>  |
| User36 | <b>97.49</b> | <b>94.06</b> | <b>188.41</b> | <b>52.14</b>  |
| User37 | 72.81        | 64.20        | 135.24        | <b>30.77</b>  |
| User39 | <b>94.89</b> | <b>89.55</b> | <b>184.61</b> | <b>25.26</b>  |
| User40 | <b>93.82</b> | 87.19        | 177.11        | <b>40.00</b>  |
| User41 | 90.12        | <b>88.36</b> | <b>181.23</b> | <b>55.20</b>  |
| User42 | <b>99.86</b> | <b>98.91</b> | <b>198.46</b> | <b>88.28</b>  |
| User43 | <b>97.80</b> | <b>93.72</b> | <b>191.46</b> | <b>28.57</b>  |
| User44 | <b>90.71</b> | <b>87.94</b> | <b>177.38</b> | <b>27.14</b>  |
| User45 | <b>95.38</b> | <b>89.39</b> | <b>179.47</b> | <b>42.14</b>  |
| User46 | 90.18        | 80.22        | 165.43        | 46.21         |
| User47 | <b>92.38</b> | 84.88        | <b>173.69</b> | <b>46.67</b>  |
| User48 | <b>80.94</b> | 73.66        | 153.07        | 2.67          |

**Table 7** The accuracy of our Bagging-TPMiner updating its knowledge. In bold appears the best result by user compared to the performance reported in Tables 2 to 5.

| User   | AUC          | TP=TN        | max(TP+TN)    | TP when FP=0% |
|--------|--------------|--------------|---------------|---------------|
| User1  | <b>97.45</b> | <b>92.54</b> | <b>189.01</b> | <b>50.77</b>  |
| User2  | <b>96.82</b> | <b>92.06</b> | <b>187.26</b> | <b>15.65</b>  |
| User3  | <b>98.15</b> | 93.13        | 188.61        | <b>62.86</b>  |
| User4  | <b>98.08</b> | <b>93.68</b> | 189.62        | <b>56.30</b>  |
| User5  | <b>92.49</b> | <b>83.97</b> | <b>171.85</b> | <b>33.33</b>  |
| User6  | <b>99.12</b> | <b>97.11</b> | <b>194.81</b> | <b>32.31</b>  |
| User7  | 99.33        | 97.26        | 195.01        | <b>37.24</b>  |
| User8  | <b>97.07</b> | <b>93.46</b> | <b>188.29</b> | <b>57.33</b>  |
| User9  | <b>96.96</b> | <b>93.77</b> | <b>188.24</b> | <b>38.00</b>  |
| User11 | <b>99.73</b> | <b>99.19</b> | <b>198.38</b> | <b>45.83</b>  |
| User12 | <b>98.49</b> | <b>96.86</b> | <b>193.88</b> | <b>43.08</b>  |
| User14 | <b>98.56</b> | <b>95.05</b> | 191.76        | 43.45         |
| User15 | <b>97.10</b> | <b>92.16</b> | <b>185.99</b> | <b>42.07</b>  |
| User16 | <b>97.59</b> | <b>92.41</b> | <b>186.07</b> | 35.00         |
| User17 | <b>93.52</b> | <b>87.73</b> | <b>178.55</b> | 8.00          |
| User18 | 96.30        | 90.90        | <b>183.29</b> | <b>68.15</b>  |
| User19 | 96.40        | <b>95.48</b> | 190.96        | <b>43.16</b>  |
| User20 | <b>99.20</b> | <b>96.23</b> | <b>193.81</b> | 62.00         |
| User21 | <b>97.71</b> | <b>94.18</b> | <b>188.88</b> | <b>43.57</b>  |
| User22 | <b>96.25</b> | <b>90.69</b> | <b>182.29</b> | <b>27.50</b>  |
| User24 | <b>99.17</b> | <b>96.26</b> | <b>192.79</b> | <b>66.67</b>  |
| User25 | <b>97.63</b> | <b>92.61</b> | <b>186.29</b> | <b>58.67</b>  |
| User26 | <b>93.07</b> | <b>87.84</b> | <b>175.82</b> | <b>17.78</b>  |
| User27 | <b>97.60</b> | <b>91.57</b> | <b>183.86</b> | <b>39.13</b>  |
| User28 | <b>87.69</b> | <b>81.17</b> | <b>165.05</b> | 0.00          |
| User29 | <b>94.72</b> | 89.58        | 180.40        | <b>40.00</b>  |
| User30 | <b>97.84</b> | <b>93.59</b> | <b>187.43</b> | <b>38.67</b>  |
| User31 | 83.21        | 84.24        | 168.75        | <b>42.50</b>  |
| User32 | <b>94.84</b> | <b>91.10</b> | <b>182.20</b> | <b>34.40</b>  |
| User33 | <b>97.17</b> | <b>91.43</b> | <b>183.44</b> | 45.93         |
| User34 | <b>87.94</b> | <b>81.95</b> | <b>164.61</b> | <b>17.86</b>  |
| User35 | <b>97.41</b> | <b>94.76</b> | <b>192.74</b> | 16.43         |
| User36 | <b>98.54</b> | <b>95.27</b> | 193.05        | <b>50.71</b>  |
| User37 | <b>88.19</b> | <b>80.57</b> | <b>166.89</b> | <b>28.46</b>  |
| User39 | <b>94.14</b> | 83.92        | <b>177.11</b> | <b>25.26</b>  |
| User40 | <b>96.68</b> | <b>88.37</b> | <b>185.78</b> | <b>32.63</b>  |
| User41 | <b>90.53</b> | 84.46        | 174.80        | <b>44.00</b>  |
| User42 | <b>99.86</b> | <b>99.28</b> | <b>198.55</b> | <b>83.45</b>  |
| User43 | <b>97.92</b> | <b>94.40</b> | <b>189.47</b> | <b>27.86</b>  |
| User44 | <b>93.25</b> | <b>88.00</b> | <b>178.64</b> | <b>27.14</b>  |
| User45 | <b>96.35</b> | <b>90.68</b> | <b>183.95</b> | <b>38.57</b>  |
| User46 | <b>92.84</b> | <b>83.88</b> | <b>173.72</b> | 40.00         |
| User47 | <b>95.19</b> | <b>86.57</b> | <b>177.57</b> | <b>44.44</b>  |
| User48 | <b>84.05</b> | <b>80.06</b> | <b>160.37</b> | 0.00          |