Stop, Don’t Click Here Anymore

Boosting Website Fingerprinting By Considering Sets of Webpages

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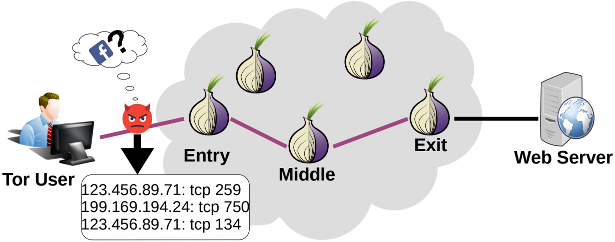
  - High efficiency in laboratory settings



```
123.456.89.71: tcp 259
199.169.194.24: tcp 750
123.456.89.71: tcp 134
```

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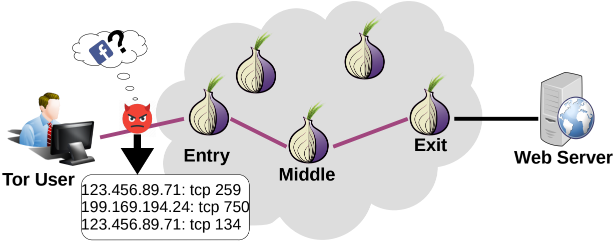

- **Limitations**
  - *Scalability* in real-world settings still *under research*
  - Typical scenario: detection of *isolated webpage loads*

However,

users visit multiple pages of a website sequentially, e.g., by following links!

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- **Limited protection provided by existing WFP defenses**
  - Up to five times less effective than expected or even completely useless

Our Novel Fingerprinting Techniques

- **Voting-based strategies**
  - Train state-of-the-art webpage classifier on multiple pages of websites
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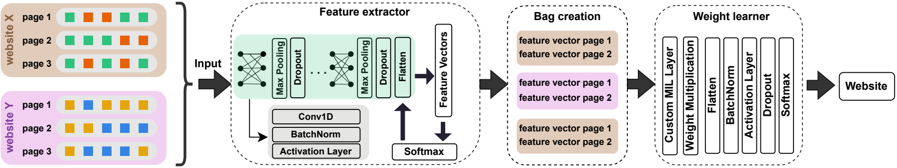
- **Set-aware MIL-based classifier**
  - A set of pages belonging to single website forms a *bag*
  - Learn a classification model to predict labels of bags
  - Adaptive learning of weights for single pages in a bag



Analysis of Our Fingerprinting Techniques (1/3)

- **Dataset and evaluation setup**
  - *100 monitored websites* from different categories, layout, and content
  - *90 different pages* per website
  - Four state-of-the-art webpage classifiers
  - 10-fold cross-validation for all experiments

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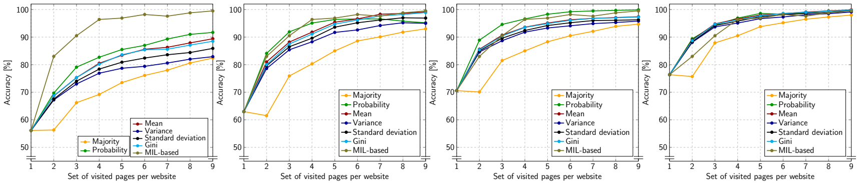
- **Evaluation in laboratory settings**
  - Users browse consecutively multiple pages of a single website
  - Increase of the detection rate *by almost 30% to 40%*



(a) CUMUL (b) k-FP (c) DF (d) Var-CNN

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- **Impact of different training tactics**
  - *Our voting-based strategies*
    - 70 training pages are enough to obtain high accuracy
  - *Our set-aware MIL-based classifier*
    - Use of two training bags
    - Over 90% accuracy when four pages are consecutively visited
  - We refer to our paper for the extensive analysis of our methods

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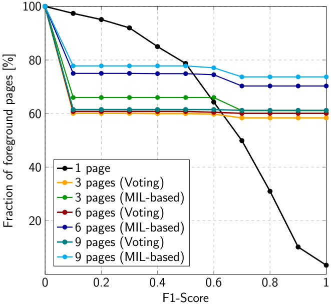
- **Real-world evaluation**
  - Use of 5000 unmonitored websites
  - Our methods achieve *F1-scores of 1.0* for *more than half* of the websites
  - When visiting *at least three consecutive pages* of a website



Analysis of Our Fingerprinting Techniques (3/3)

- **Increased robustness against existing WFP defenses**
  - Increase of the detection rate *up to 5 times*
  - No protection by defenses with low implementation costs

Defense	Classifier	Set of pages								
		1	2	3	4	5	6	7	8	9
Tamaraw	Voting	4.61	7.20	9.93	12.47	12.67	14.07	16.27	17.80	18.93
	MIL-based	–	5.37	7.25	8.81	10.79	12.19	13.77	14.73	16.36
CS-Buflo	Voting	**10.89**	18.13	23.33	33.27	37.40	43.93	46.93	52.47	**56.00**
	MIL-based	–	12.89	19.25	24.77	29.62	34.19	37.18	40.21	**43.17**
TrafficSliver-Net	Voting	19.92	29.93	34.48	38.73	40.45	42.79	43.80	44.85	46.55
	MIL-based	–	10.40	14.48	18.62	22.06	25.67	28.69	32.18	35.21
WTF-PAD	Voting	90.72	99.20	99.73	100.00	100.00	100.00	100.00	100.00	100.00
	MIL-based	–	98.28	99.61	99.89	99.99	99.99	99.99	100.00	100.00
RegulaTor	Voting	**17.17**	27.67	38.27	44.20	50.20	56.20	61.53	63.60	**64.87**
	MIL-based	–	16.11	22.83	27.77	31.89	36.19	40.29	43.44	46.48
FRONT	Voting	**67.00**	88.60	**96.87**	98.73	99.40	99.67	99.87	99.93	**100.00**
	MIL-based	–	86.41	**94.82**	97.70	98.85	99.38	99.55	99.77	**99.86**

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    - Significant improvement of the detection rate in real-world settings
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Stop, Don't Click Here Anymore: Boosting Website Fingerprinting By Considering Sets of Subpages

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