Henry Clausen, David Aspinall, Michael Gibson

Evading stepping-stone detection with enough chaff

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EPSRC
Pioneering research and skills

The Alan Turing Institute

BT

Contribution

Large public Stepping-stone dataset:

- 90,000 connection pairs
- Chaff/delay tactics
- realistic setup

Re-evaluation of eight SSD-methods

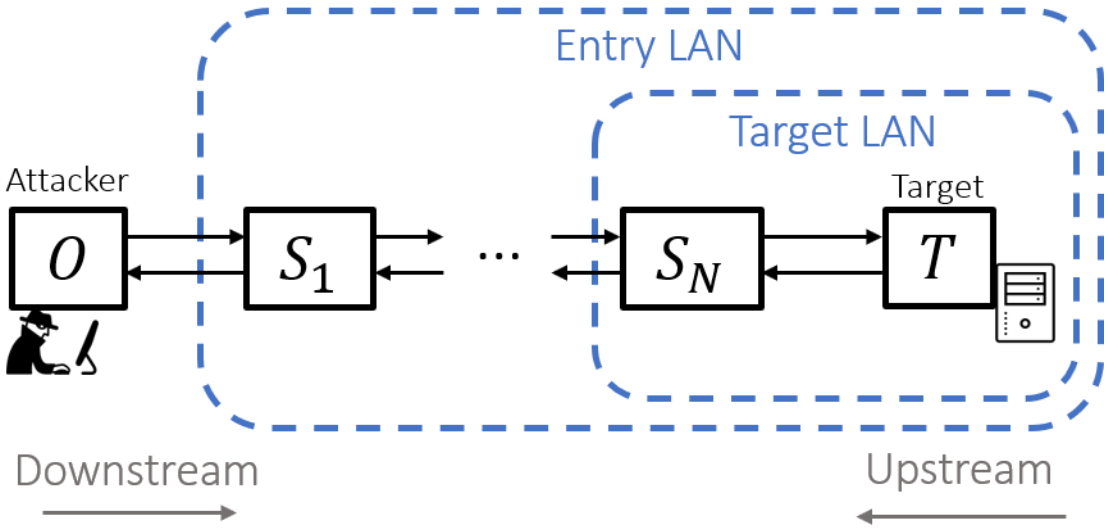
- Fair comparison of capabilities
- different settings
- Detection rates and

  AUC-scores

Stepping-stone

Relay of attack via “stepping-stone”

- Hide attack origin
- Access protected resources
- Interactive access



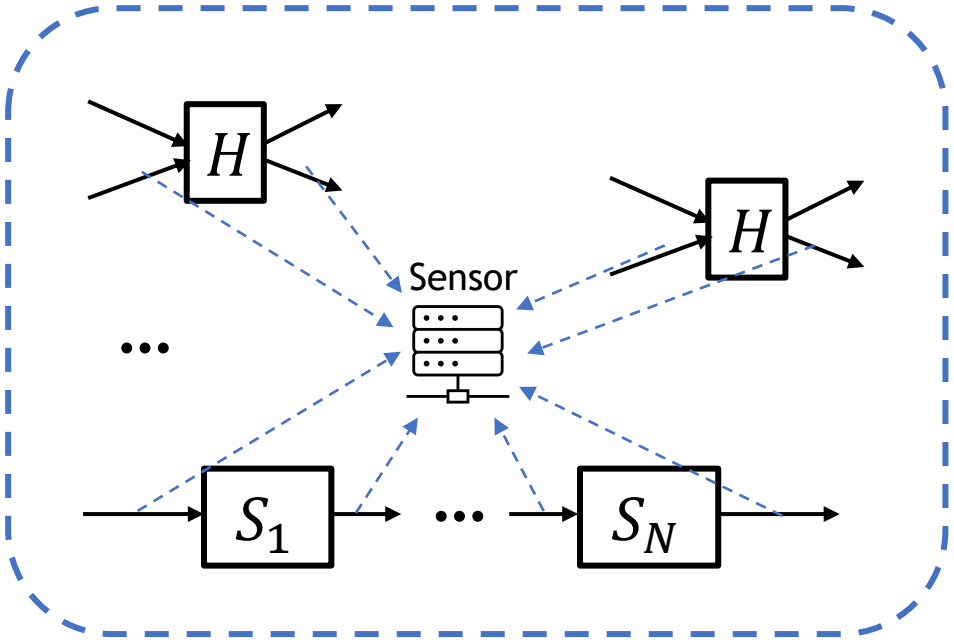
Tools

- SSH-tunnels
- Netcat backpipe
- SOCKS proxy
- …

Usually encrypted

Stepping-stone detection

- Sensor records incoming and outgoing connections
- Measure correlation between pairs



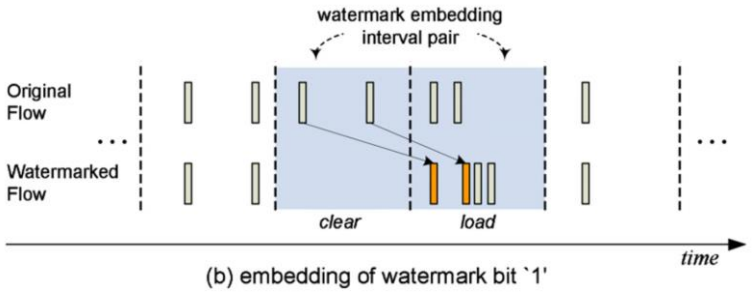
Goal

- Identify stepping-stones early before attacker
  - reaches target
  - exfiltrates data
- Trace attack back to origin

Stepping-stone detection

Most common techniques:

- Watermarking
- Packet correlation

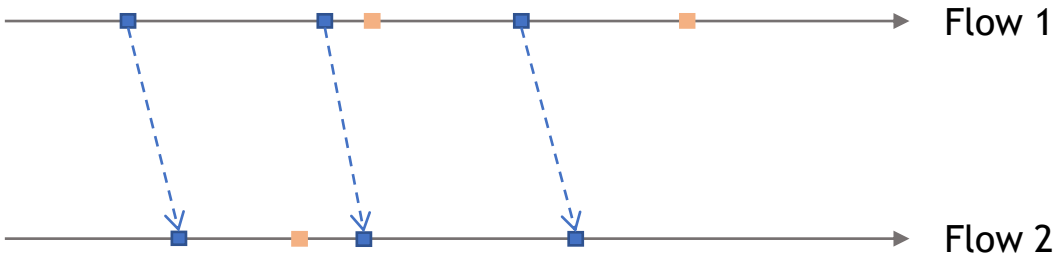


Evasive techniques

- Transfer delays
- Chaff packets

- Repacketisation
- Flow splitting

- RTT-based
- Anomaly-detection



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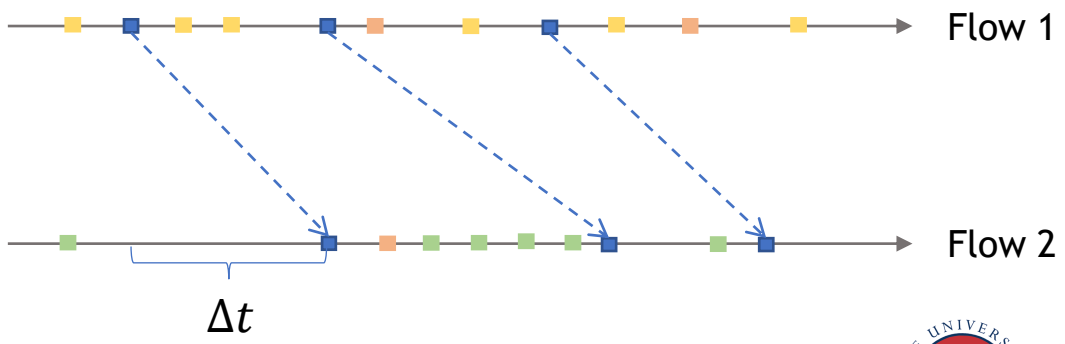


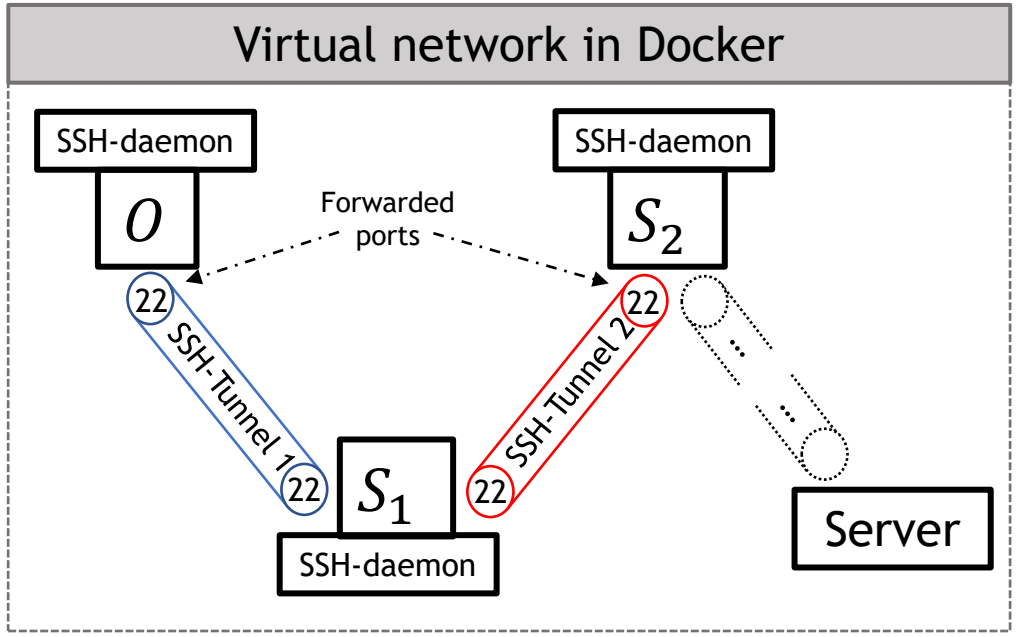
Evaluation problems

- No public data!
- Widespread use of self-generated data
  - Simplistic attack scenario
  - restrictive evasive tactics
  - Unrealistic background traffic
- No standard on number of packets
- Setup shielded from other influences

→ Impossible to compare detection rates

Data generation set-up

- Interactive SSH-session
  - relayed using SSH-tunnels
- SSH-script
  - commands drawn randomly
  - randomized inputs
  - sleep intervals to simulate reaction times
- Containers for reproducibility



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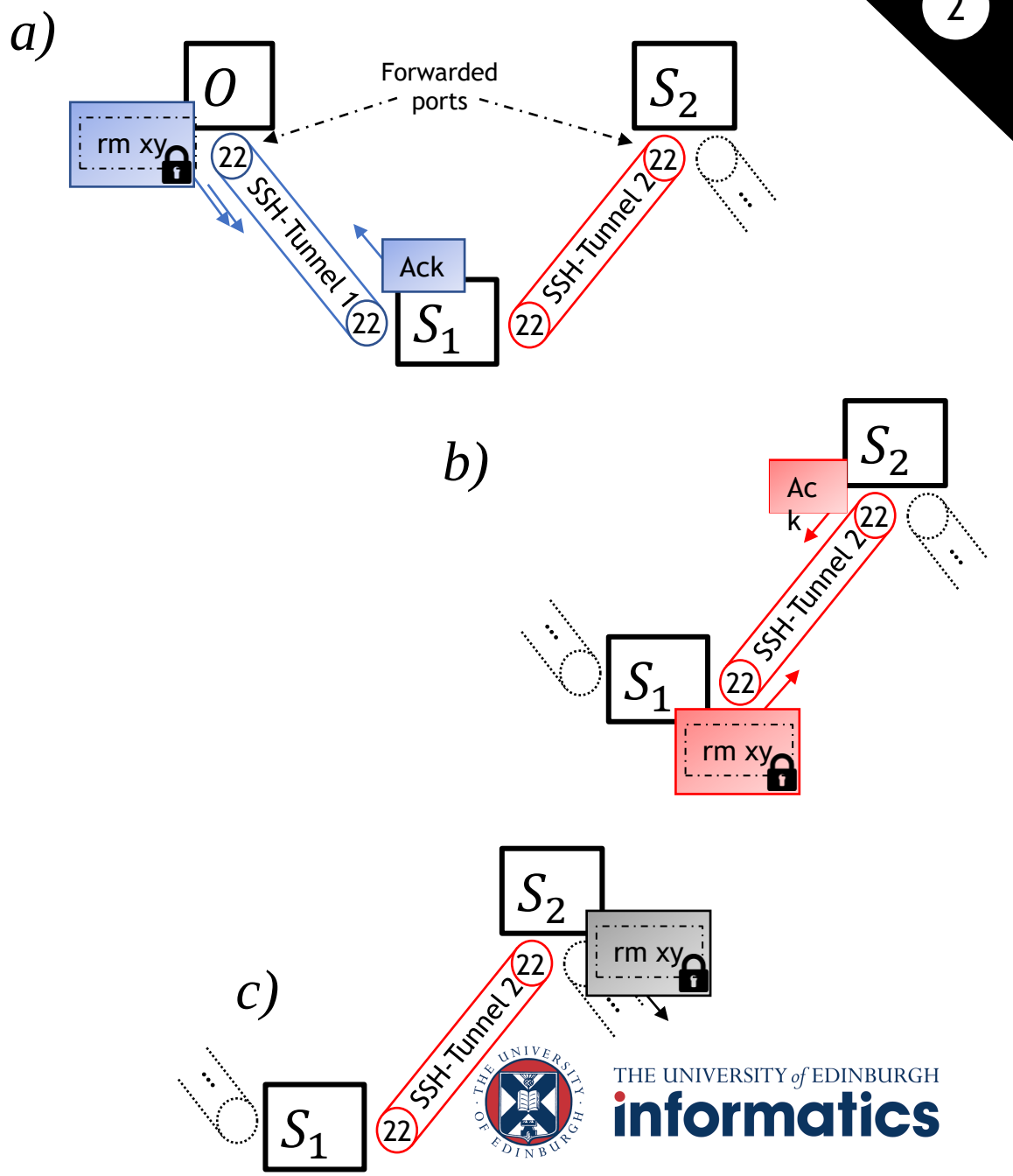


Data generation set-up

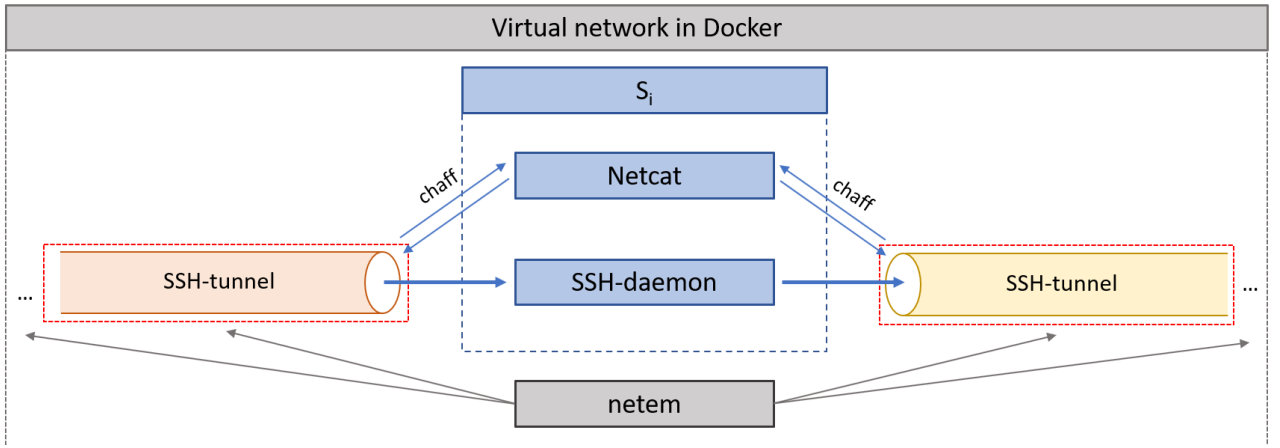
NetEm to emulate network settings

Chaff:

- Netcat
- mimics stream buffering[1]
  - Packet IAT in $[\frac{d_C}{2}, d_C]$

Jitter delays:

- NetEm
- mimics stream buffering[1]
- Δt in $[0, d_D]$
  - d_D up to 1500ms



[1] Padhye et al. (2010)

Evaluation data

Connection pairs from S_N

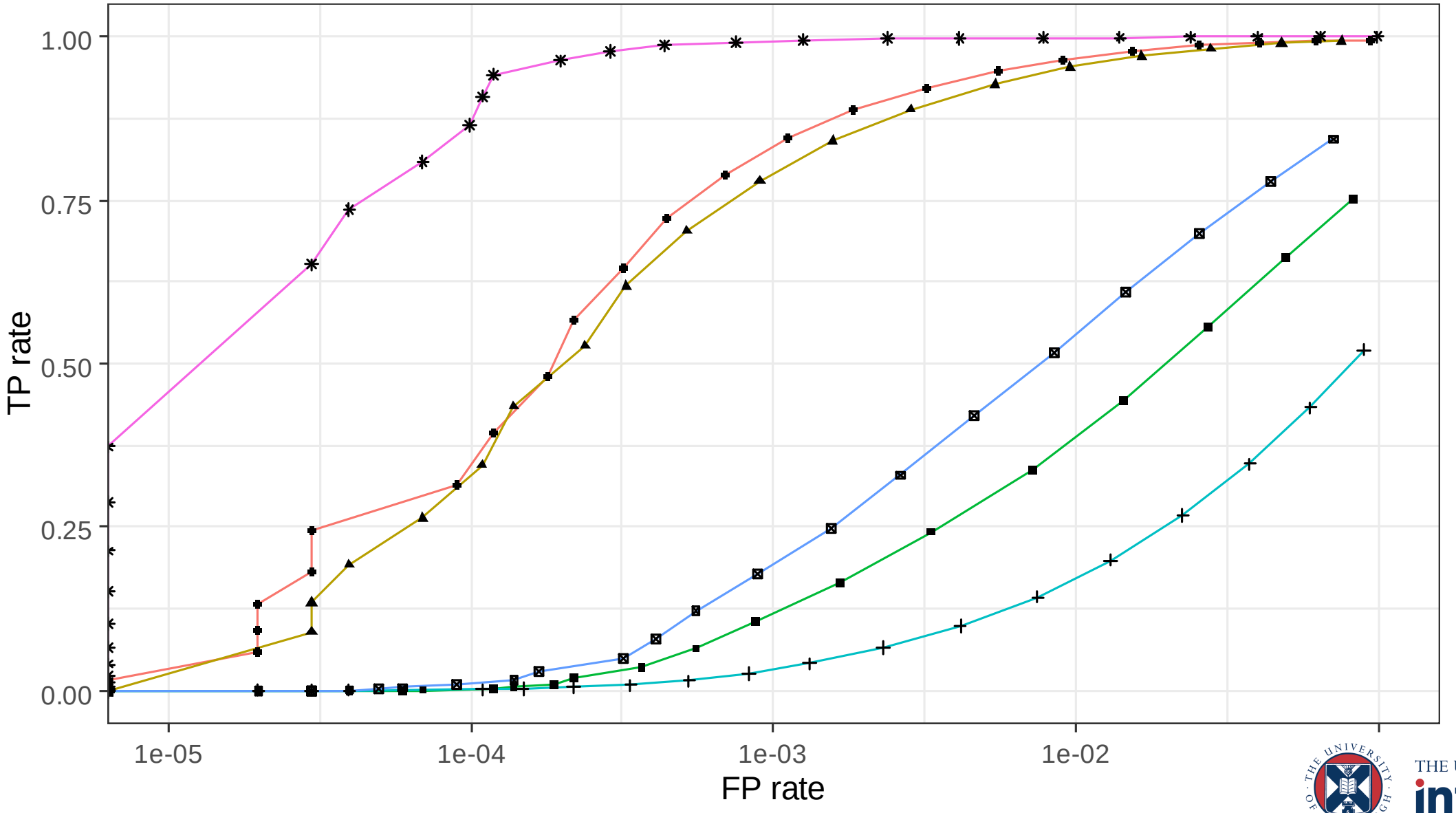
- 1,400 packets

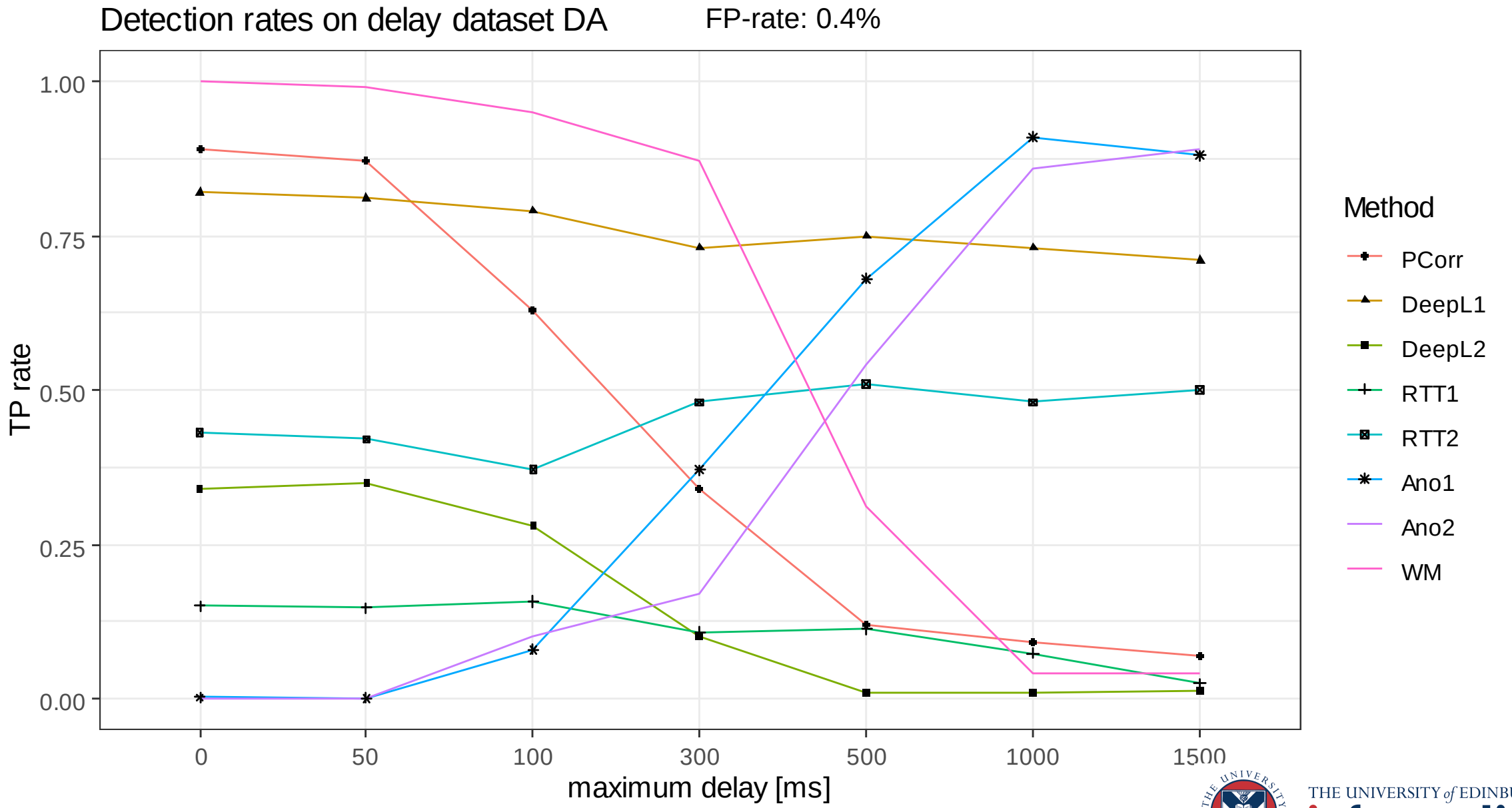
	Label	#conn	purpose
SS data	BA	30,000	Baseline attack
	DA	30,000	Delays with varying d_{D}
	CA	30,000	Chaff with varying d_{C}
Background data	CAIDA	60.000	General background
	SSH	20.000	Similar to attack commands
	Multim.	20.000	Similar to chaff pert.

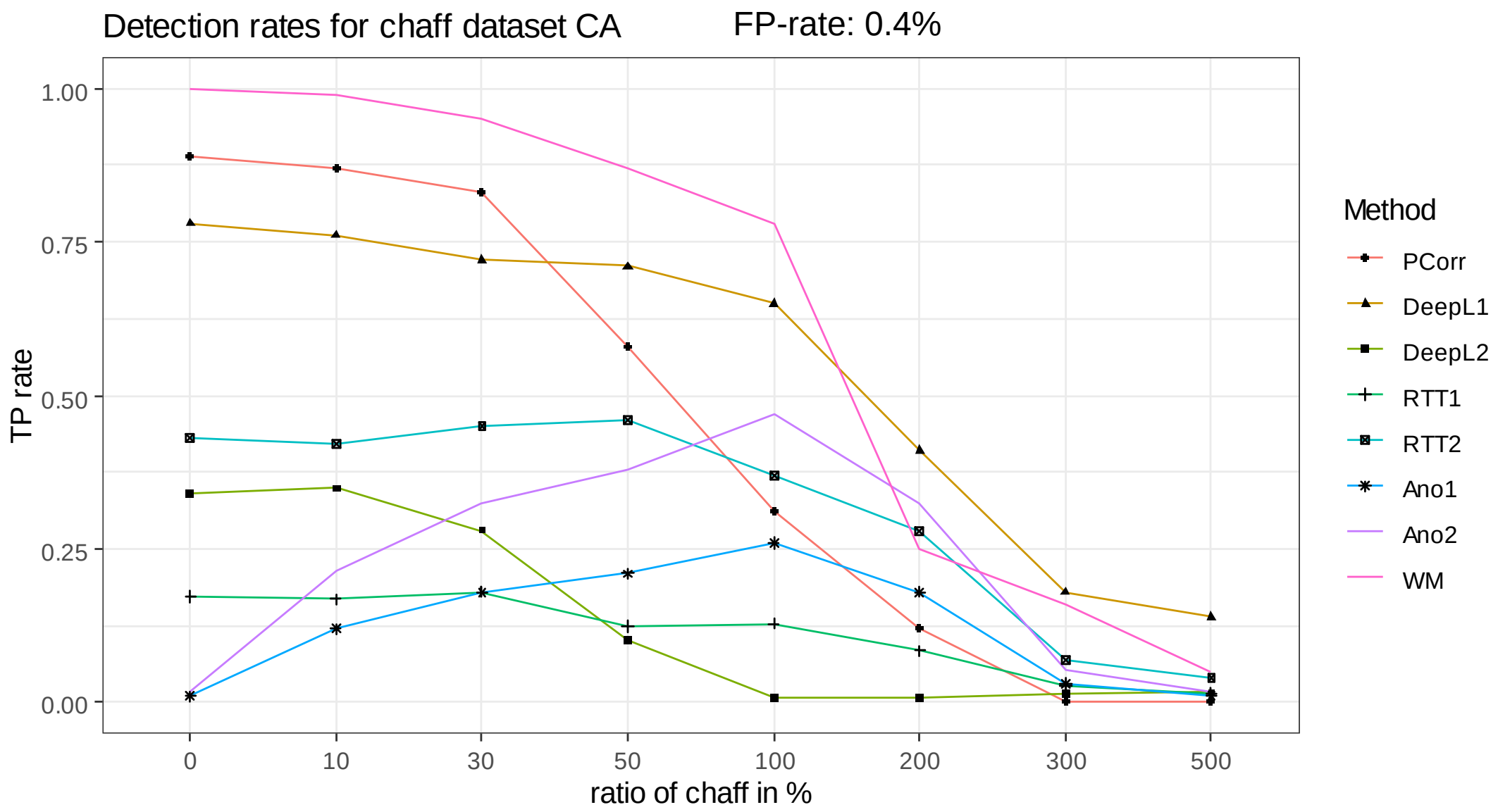
Selected methods

Label	TP	FP	Robustness	Category
PContext (2011)	100%	0%	jitter/chaff	Packet correlation
DeepCorr (2018)	90%	0.0002%	small jitter	Neural networks
WuNeur (2010)	100%	0%	-	
Rwalk (2015)	-	-	chaff	RTT-based
Crossover (2016)	85%	5%	-	
Ano1 (2011)	99%	1%	jitter/chaff	Anomaly-based
Ano2 (2011)	95%	0%	jitter/chaff	
WM (2011)	100%	0.5%	jitter	Watermarking

ROC-curves on dataset BA




Detection rates on delay dataset DA
FP-rate: 0.4%
TP rate
1.00
0.75
0.50
0.25
0.00
0
50
100
300
500
1000
1500
maximum delay [ms]
Method
PCorr
DeepL1
DeepL2
RTT1
RTT2
Ano1
Ano2
WM



Disproves chaff robustness claims by PCorr, RTT1, and both anomaly methods!

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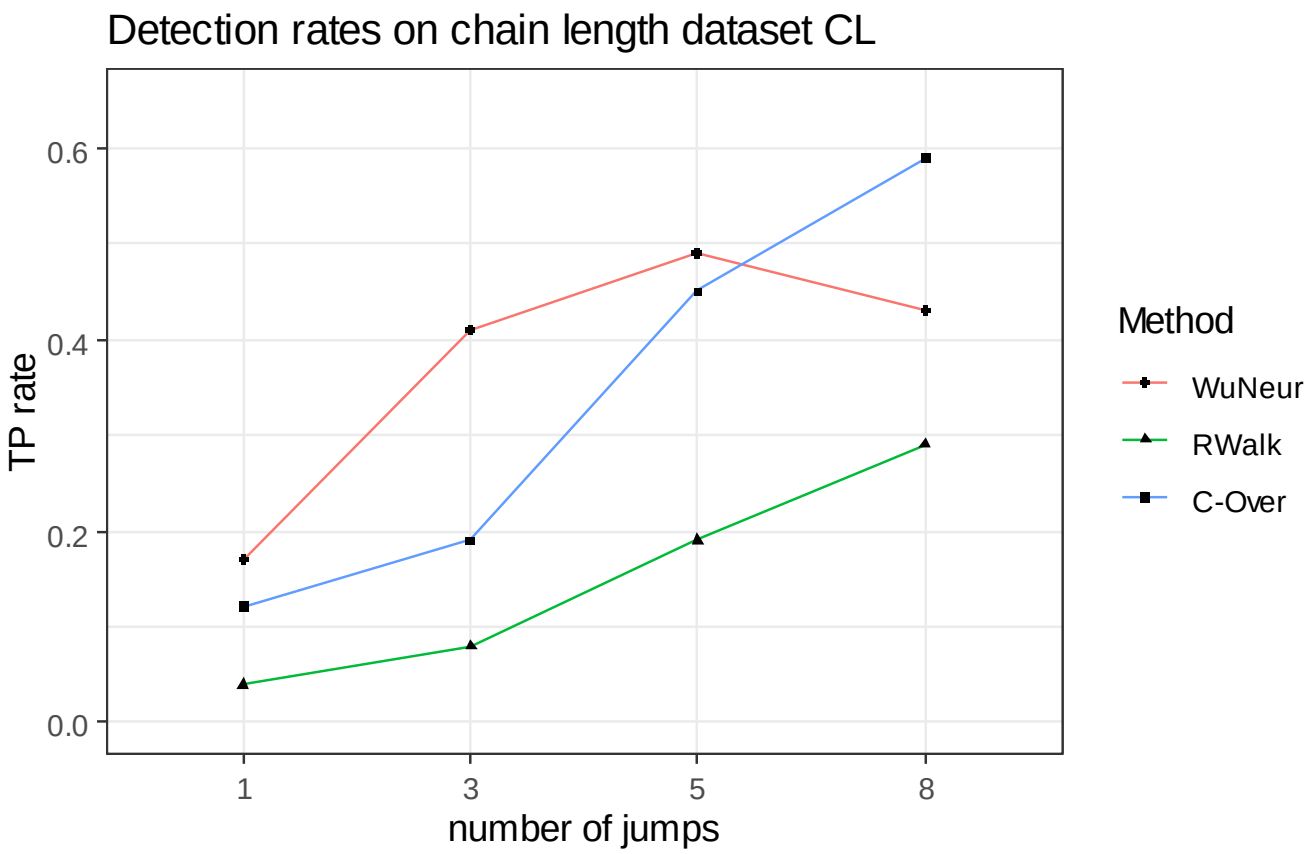
Limitations

- No behavioural/graph-based models
- No flow-splitting
- No store-forward-stepping stones
- Data might need updates for future methods

Conclusion

- Large public dataset
  - Realistic interactions
  - Evasive tactics
  - github.com/detlearsom/detgen/stepping-stone-data
- Evaluation of current state-of-the-art
  - Lower overall detection rates
  - Lack of robustness against chaff
  - Watermarking and deep-learning performs best

Additional results



WAN-influence

	Value	Deviation from average				
		Deep Corr	WuNeur	RWalk	COver	WM
RTT	5ms	-0.2%	+41.3%	-42.3%	-36%	+0.03%
	70ms	-5.6%	-5.8%	+35.1%	+51%	-2.2%
Packet loss	0%	+1.2%	+1.3%	+2.1%	+4.3%	+0.02%
	7%	-9.1%	-1.1%	-3.1%	-7.3%	-9.7%

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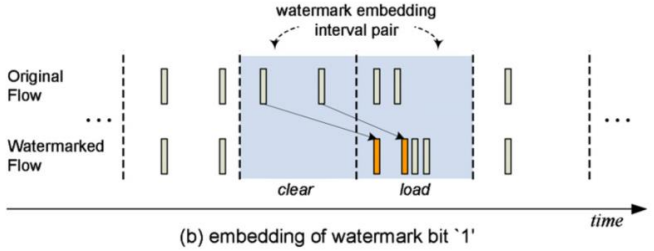
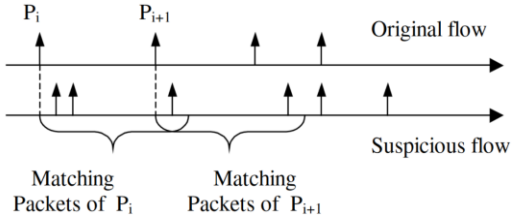
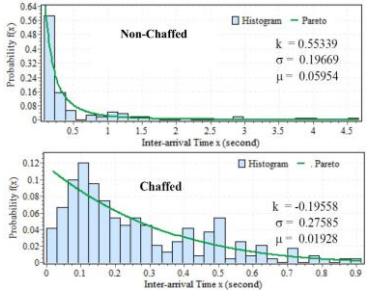
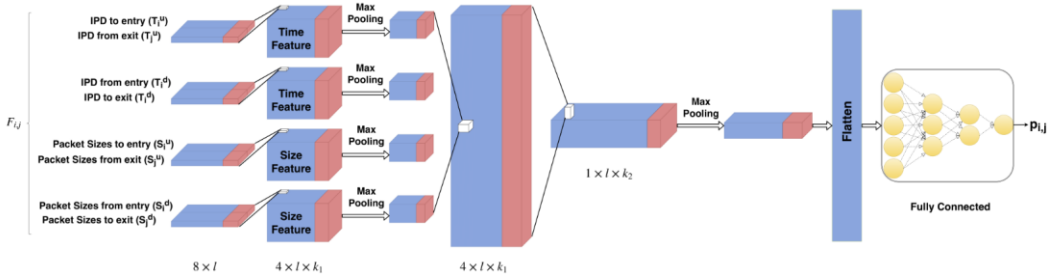
Models

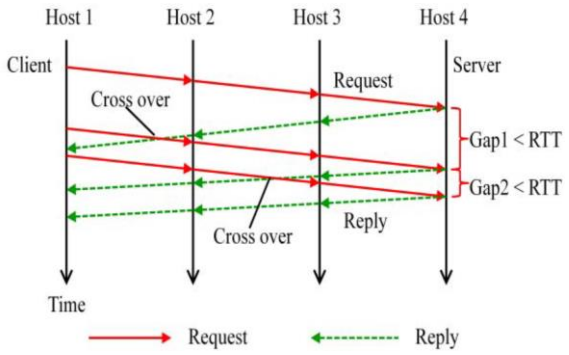


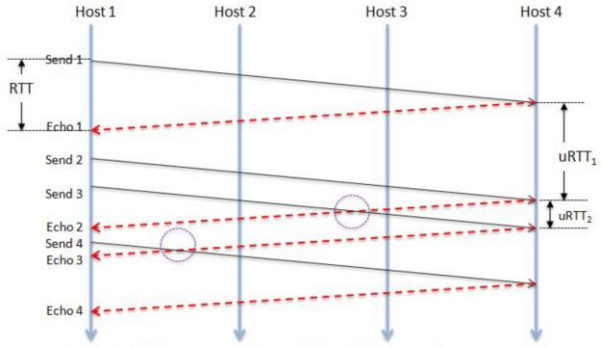


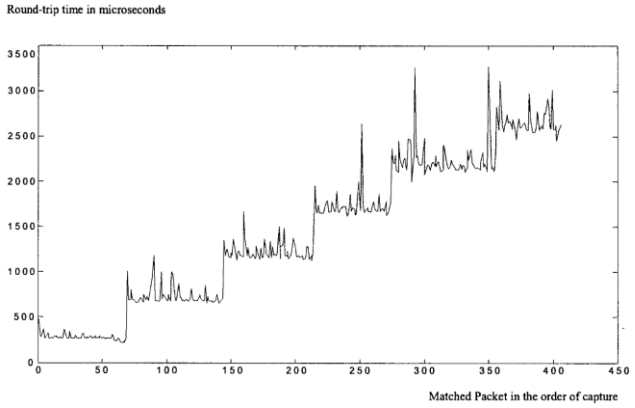




DeepCorr 2018, Nasr et al.







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Agenda

(1) ML and network data

(2) Problems in current datasets

(3) Containerization

(4) Traffic generation suite

(5) **Example use-case**

(6) Limitation & conclusion

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(1) Stepping-stones and detection

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Limitations

Not replicated well:

- Network-wide distribution
- long-term temporal structures

Data volume huge

- preprocessing required

Manual implementation

Conclusion

- Our traffic generation suite fuels ML through:
  - High degree of traffic variability
  - Ground truth labels through activity isolation
  - Scalability
  - Modularity
- github.com/detlearsom/detgen/
- Future work:
  - capture of syslogs
  - streamlined data coalescence

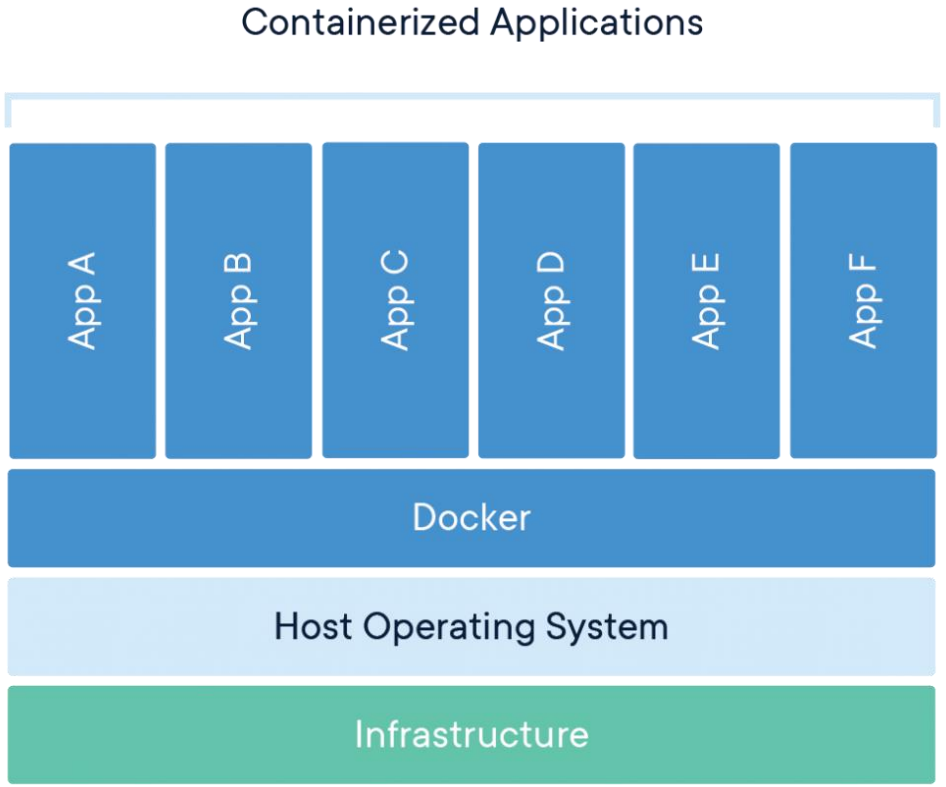
Containerization

Programs/process as standalone virtualised standard units

Advantages:

- lightweight
- runs uniformly
- safe through isolation

Containers can be arranged in virtual networks



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- ML-based flow correlation
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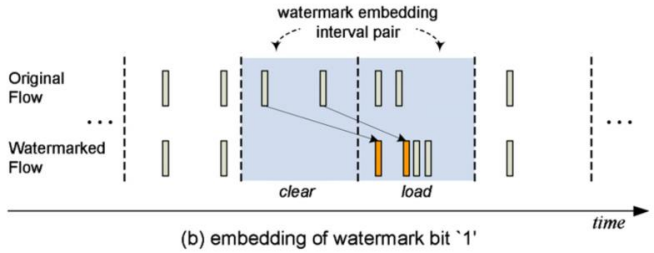

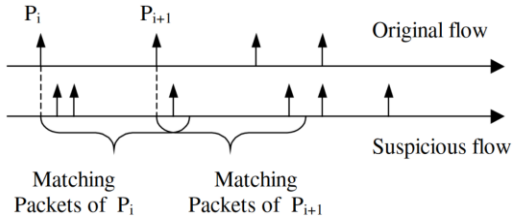

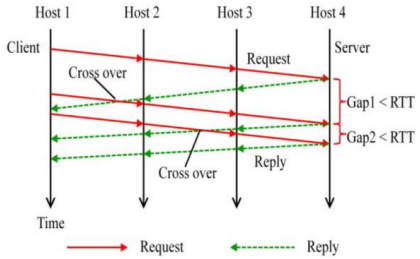

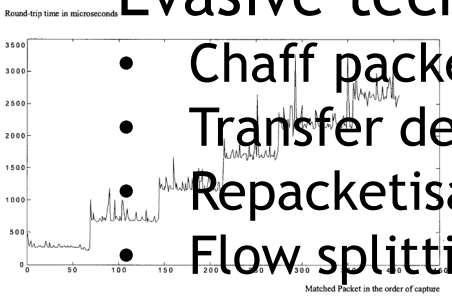

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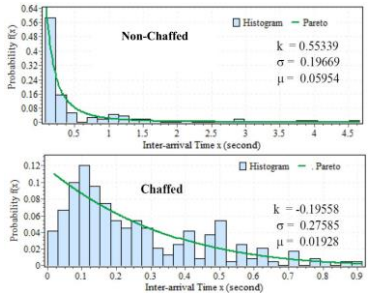

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