An SVM-based Masquerade Detection Method with Online Update Using Co-occurrence Matrix

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Outline

- Background
- Conventional results
- Our proposal
- Experiments
- Conclusion

Background

- A computer can provide multiple services to multiple users
- Users can login to a computer through network

Security mng. costs increase

- Hard to protect computers from malicious access completely

Masquerade detection

Conventional results

Researchers	Approaches	False Positive Rate	Hit Rate
Schonlau et al.	Uniqueness	1.4%	39.4%
	Bayes one-step Markov	6.7%	69.3%
	Hybrid multistep Markov	3.2%	49.3%
	Compression	5.0%	34.2%.
	Sequence Matching	3.7%	36.8%
	IPAM	2.7%	41.1%
Maxion and Townsend	Naïve Bayes (updating)	1.3%	61.5%
	Naïve Bayes (no updating)	4.6%	66.2%
Kim and Cha	SVM-based approach with voting	9.7%	80.1%
Oka et al.	ECM	2.5%	72.3%

Problems

- Conventional researches have attempted to improve the accuracy rate
- Users' behaviors would change with time

↓

Need to adapt to changes

	ECM
False Positive	2.5%
Hit Rate	72.3%
ROC Score	0.918
Training cost	1046.37 min.
Detection cost	22.13 sec.
CPU	Xeon 3.2GHz
Memory Size	4GB

Our strategy

- To borrow the same data
  - To compare results with conventional work
- To borrow ECM
  - Low false positive rate
  - High hit rate
  - High ROC score
- To exploit SVM
  - Low training cost
  - Adapt to changes of users' behaviors

Correlation of commands

time →

User1 :	*cd ls less ls less cd ls cd cd ls*
User2 :	*emacs gcc gdb emacs ls gcc gdb ls ls emacs*
User3 :	*mkdir cp cd ls cp ls cp cp cp cp*

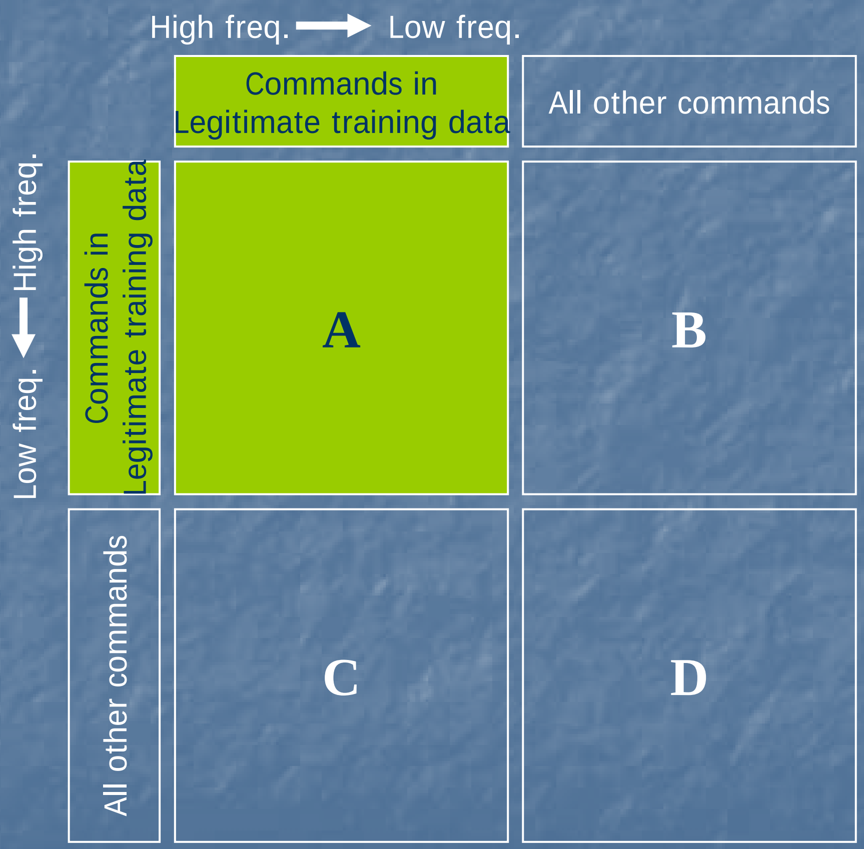
Strength of correlation of ls and *less* ： 2+1=3

Co-occurrence matrix

User1 :	*cd*	*ls*	*less*	*ls*	*less*	*cd*	*ls*	*cd*	*cd*	*ls*
User2 :	*emacs*	*gcc*	*gdb*	*emacs*	*ls*	*gcc*	*gdb*	*ls*	*ls*	*emacs*
User3 :	*mkdir*	*cp*	*cd*	*ls*	*cp*	*ls*	*cp*	*cp*	*cp*	*cp*

	cd	*ls*	*less*	*emacs*	*gcc*	*gdb*	*mkdir*	*cp*
cd	0	0	0	0	0	0	0	0
ls	0	3	0	3	1	1	0	0
less	0	0	0	0	0	0	0	0
emacs	0	4	0	1	3	3	0	0
gcc	0	4	0	2	1	3	0	0
gdb	0	5	0	2	1	1	0	0
mkdir	0	0	0	0	0	0	0	0
cp	0	0	0	0	0	0	0	0

Our co-occurrence matrix

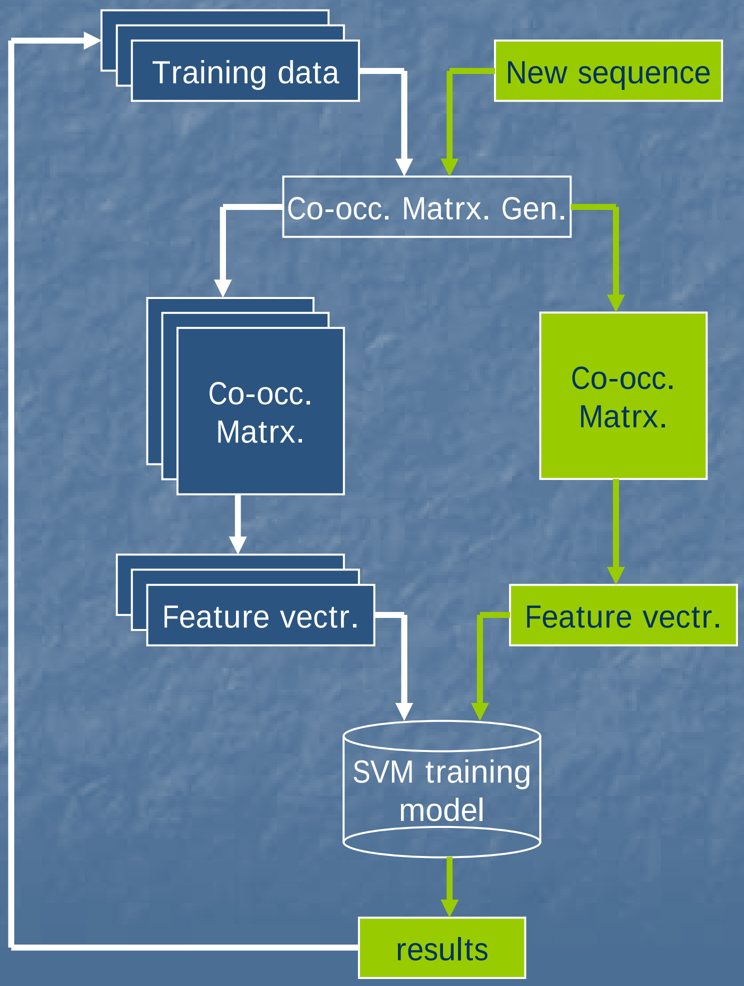


	cd	ls	less	emacs	gcc	gdb	mkdir	cp
cd	0	0	0	0	0	0	0	0
ls	0	3	0	3	1	1	0	0
less	0	0	0	0	0	0	0	0
emacs	0	4	0	1	3	3	0	0
gcc	0	4	0	2	1	3	0	0
gdb	0	5	0	2	1	1	0	0
mkdir	0	0	0	0	0	0	0	0
cp	0	0	0	0	0	0	0	0

	emacs	ls	gcc	gdb	cd	less	mkdir	cp
emacs	2	4	3	3	0	0	0	0
ls	3	3	1	1	0	0	0	0
gcc	2	4	1	3	0	0	0	0
gdb	2	5	1	1	0	0	0	0
cd	0	0	0	0	0	0	0	0
less	0	0	0	0	0	0	0	0
mkdir	0	0	0	0	0	0	0	0
cp	0	0	0	0	0	0	0	0

System overview

- Co-occ. Matrx. generation
- SVM feature vectr. generation
- SVM processing
- Results
- Refinement



Comparison with ECM

	ECM	Our method (based on 2-class SVM)
False Positive	2.5%	3.0%
Hit Rate	72.3%	72.74%
ROC Score	0.918	0.926
CPU	Xeon 3.2GHz	Pentium III 1.4GHz
Memory Size	4GB	512MB
Training cost	1046.37 min.	117.33 sec.
Detection cost	22.13 sec.	0.04 sec.

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Almost the same

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With lower power machine

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Smaller

Comparison with ECM

	ECM	Our method
False P		
Hit R		
ROC S		
CP		Hz
Memory Size	4GB	512MB
Training cost	1046.37 min.	117.33 sec.
Detection cost	22.13 sec.	0.04 sec.

With lower power machine

Training cost:535times smaller
Detection cost:553times smaller
Achieved almost the same good charac.

Online update

- **To run the system a.s.a.p. even if we don't have enough amount of data for training**
- **To adapt changes of users' behaviors**

•Our proposal is with low comput. cost
•Online update of training model
•By modifying application of the data

2-class and 1-class based methods

- 2-class vs. 1-class
  - Data: 2-class > 1-class
  - Cost: 2-class > 1-class
  - Accuracy: 2-class > 1-class
- We look them concretely by experiments

Update Under 2-class SVM

# trained commands	20 blks. (10000)	30 blks. (15000)	40 blks. (20000)	50 blks. (25000)
False Positive	8%	6%	5%	3%
Hit Rate	68%	69%	68%	72.74%
ROC Score	0.89	0.90	0.91	0.93
Update costs	43.86 s	59.53 s	89.65 s	107.30 s
SVM training costs	3.36 s	7.04 s	6.90 s	10.03 s
Detection cost	0.04 s			

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improved

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Detection cost	0.04 s			

improved

improved

improved

Update Under 1-class SVM

# trained commands	20 blks. (2000)	30 blks. (3000)	40 blks. (4000)	50 blks. (5000)
False Positive	12%	8%	7%	6%
Hit Rate	68%	64%	61%	62.77%
ROC Score	0.85	0.86	0.87	0.88
Update costs	0.88 s	1.53 s	1.79 s	2.15 s
SVM training costs	0.17 s	0.18 s	0.22 s	0.27 s
Detection cost	0.04 s			

Update Under 1-class SVM

# trained commands	20 blks. (2000)	30 blks. (3000)	40 blks. (4000)	50 blks. (5000)
False Positive	12%	8%	7%	6%
Hit Rate	68%	64%	61%	62.77%
ROC Score	0.85	0.86	0.87	0.88
Update costs	0.88 s	1.53 s	1.79 s	2.15 s
SVM training costs	0.17 s	0.18 s	0.22 s	0.27 s
Detection cost	0.04 s			

improved

Update Under 1-class SVM

# trained commands	20 blks. (2000)	30 blks. (3000)	40 blks. (4000)	50 blks. (5000)
False Positive	12%	8%	7%	6%
Hit Rate	68%	64%	61%	62.77%
ROC Score	0.85	0.86	0.87	0.88
Update costs	0.88 s	1.53 s	1.79 s	2.15 s
SVM **training costs**	0.17 s	0.18 s	0.22 s	0.27 s
Detection cost	0.04 s			

improved

improved

Results: 2-class vs. 1-class

2-class

# trained commands	20 blks. (10000)	30 blks. (15000)	40 blks. (20000)	50 blks. (25000)
False Positive	8%	6%	5%	3%
Hit Rate	68%	69%	68%	72.74%
ROC Score	0.89	0.90	0.91	0.93
Update costs	43.86 s	59.53 s	89.65 s	107.30 s
SVM training costs	3.36 s	7.04 s	6.90 s	10.03 s
Detection cost	0.04 s			

1-class

# trained commands	20 blks. (2000)	30 blks. (3000)	40 blks. (4000)	50 blks. (5000)
False Positive	12%	8%	7%	6%
Hit Rate	68%	64%	61%	62.77 %
ROC Score	0.85	0.86	0.87	0.88
Update costs	0.88 s	1.53 s	1.79 s	2.15 s
SVM training costs	0.17 s	0.18 s	0.22 s	0.27 s
Detection cost	0.04 s			

Conclusion

- Results
  - Extension of ECM with low computing costs
  - Availability with online update
- Future work
  - To do more experiments with other data
  - To improve accuracy by integrating several methods
  - To test and extend our proposal to other applications like databases (SQL injections)

Thank you