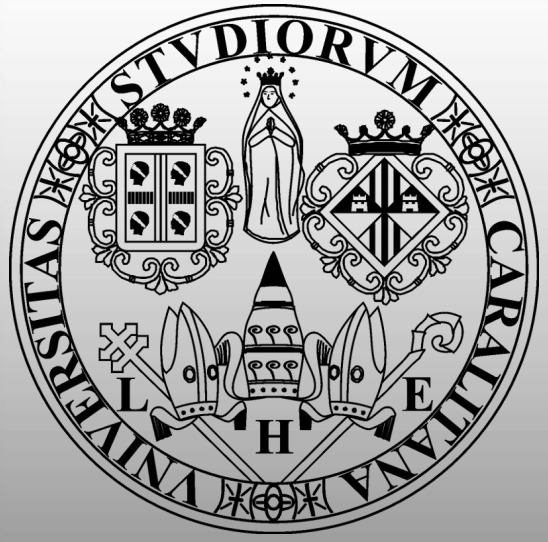

A Discretized Extended Feature Space (DEFS) Model to Improve the Anomaly Detection Performance in Network Intrusion Detection Systems

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Outline

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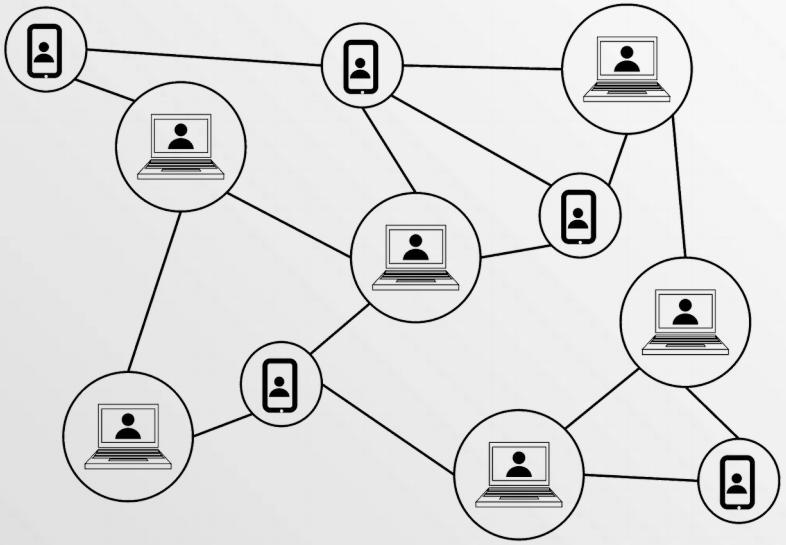
OVERVIEW

Introduction

Network security represents one of the most crucial aspects of today's society, in which an ever increasing number of services is performed through networks such as the Internet



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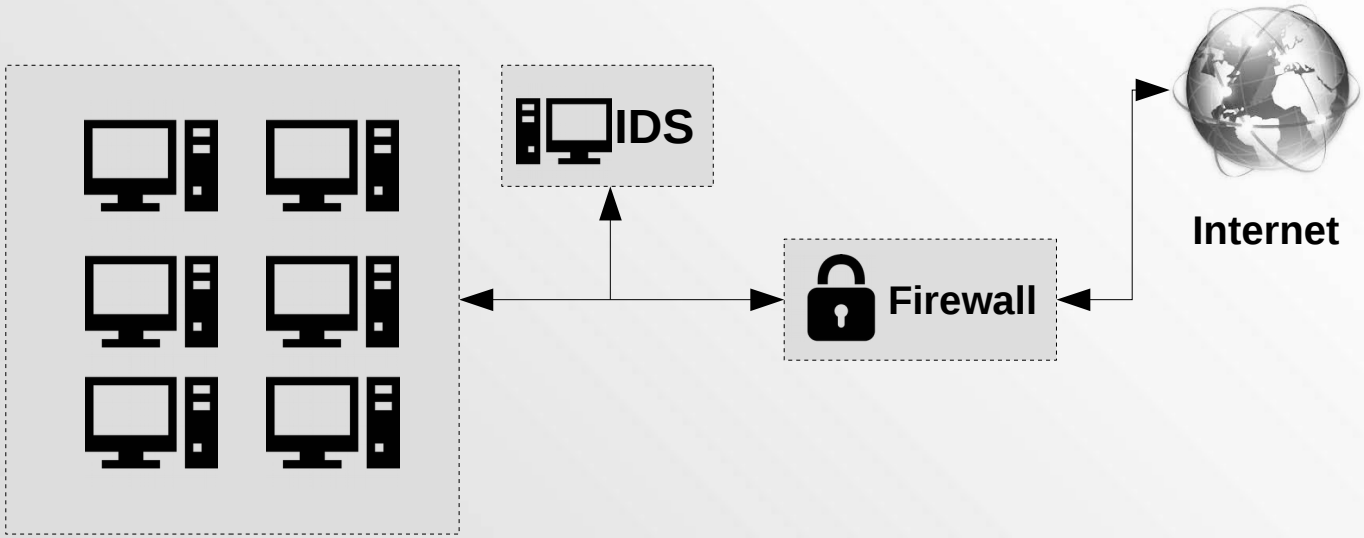
Introduction

The **Intrusion Detection Systems** (IDSs) are the main instruments to face such a problem, since they have been designed in order to classify the network events into two classes, **normal** or **intrusion**



State of the Art

- Many **approaches** have been used in order to detect anomalous network activities, for instance:
  - *Fuzzy Logic*
  - *Clustering Algorithms*
  - *Support Vector Machines*
  - *Genetic Algorithms*
  - *Hybrid Solutions*

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Open Problems

Regardless of the adopted technique, the definition of effective evaluation models represents a **hard challenge** for several factors, such as:

- High level of **heterogeneity** and **dynamism** is the involved data
- The **behavior** of an attack can be almost identical to that of a legitimate activity

INTUITION

Idea

- The idea behind the proposed approach relies into the observation that the main limitation of the state-of-the-art solutions is given by their inability to classify the new network events correctly
- In order to face this problem we introduce a new feature space where the event features have been transformed through a discretization and extension criterion

Formalization

- The discretization process is able to reduce the high number of event patterns by grouping the similar ones
- The extension process extends the number of event features by introducing a series of meta-information with the aim to obtain a better event characterization
- The extension process reduces the issues related to the loss of information caused by a canonical discretization process

IMPLEMENTATION

Implementation

Step 1 of 3 - Data Discretization

On the basis of a η value experimentally defined, we perform the **data discretization** process $\xrightarrow{\eta}$

$$\{f_1, f_2, \ldots, f_N\} \xrightarrow{\eta} \{d_1, d_2, \ldots, d_N\}, \ \forall \ e \in E$$

Where f_1, f_2, ..., f_N denotes the original feature values of an event **e**, and d_1, d_2, ..., d_N denotes these values after the discretization process

Implementation

Step 2 of 3 - Data Extension

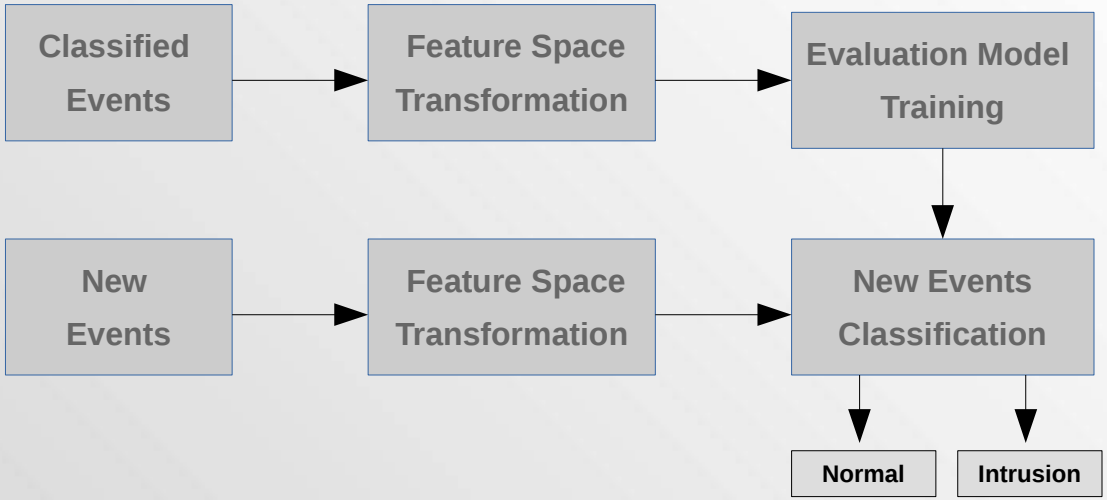
The discretized data are then extended by adding to them the **Minimum** (μ), **Maximum** (Λ), **Average** (α), and **Standard Deviation** (σ) meta-information

$$\Xi = \begin{cases} \mu = min(d_1, d_2, \ldots, d_N) \\ \Lambda = max(d_1, d_2, \ldots, d_N) \\ \alpha = \frac{1}{N} \sum_{n=1}^{N} (d_n) \\ \sigma = \sqrt{\frac{1}{N-1} \sum_{n=1}^{M} (d_n - \bar{d})^2} \end{cases}$$

Implementation

Step 3 of 3 – Event Classification

Our approach classifies the **new events** as ***normal*** or **intrusion** by using the new feature space



RESULTS

Experiments

- In addition to a canonical *k-fold cross validation* criterion, we **validated** our approach by dividing the dataset into two parts:
  - **In-sample part**, which has been used to select the internal algorithms parameters
  - **Out-of-sample part**, which has been used to evaluate the performance
- **NSL-KDD** is the real-world dataset used in order to evaluate the performance of the proposed approach
- Our competitor, experimentally selected on the basis of its performance, is **Random Forests**

Experiments

- We used the *80%* of each dataset (i.e., *PEA*, *DSA*, *RSA*, and *RAA* events) as **in-sample** data, using the remaining *20%* as **out-of-sample** data
- We evaluated our predictive model in terms of **Specificity** and **Matthews Correlation Coefficient**

Experiments

- The results show that our **DEFS** model **outperforms RF** in terms of capability to detect the intrusion in a context of datasets with a high level of unbalance, in almost all classes of events

		RF Default Model			RF DEFS Model		
Events	**DCI**	**Specificity**	**MCC**	**Average**	**Specificity**	**MCC**	**Average**
PEA	0.0015	0.5618	0.4077	0.4848	**0.7833**	**0.4835**	**0.6334**
DSA	0.6928	0.9957	0.9585	0.9771	0.9919	**0.9629**	**0.9774**
RSA	0.1826	0.9458	0.9102	0.9280	**0.9626**	**0.9175**	**0.9401**
RAA	0.0503	0.9704	0.7961	0.8833	**0.9714**	0.7891	0.8802

Conclusions

- We proposed a *Discretized Extended Feature Space* (**DEFS**) model to improve the anomaly detection performance in the IDS context
- The experimental results show its **effectiveness** in a real-world scenario
- A possible **future work** would be the experimentation of our model in the context of a classification approach based on several and different algorithms configured through an ensemble strategy

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THANK YOU FOR YOUR ATTENTION

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