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Knowledge Base for Intrusion Detection System

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1 Introduction

With security of communication on the Internet becoming an important issue, the need for an intrusion detection system becomes inherent. This need is heightened in the case of high assurance data being put on the communication channel. Presently secure communication uses cryptography to provide security and integrity of data, but in order to do so communicating parties have to follow security protocols to establish communication. In such an environment detecting intrusion without looking into the payload of the message is a novel idea, as many of the systems presently used in industry detect attacks by analyzing the payload of the message.

The idea of attack detection by using meta- information about the packets on the network was introduced in **[1]**. The author details three components of such a system: The Monitor, the Intrusion Detection Engine and the Knowledge Base. This project implements the knowledge base and designs the signature that can be used in an intrusion detection system operating in an environment that uses security protocols to establish the communication between the involved parties.

1.1 Security Protocols

Protocols are rules that govern interactions between communicating parties. Authentication, the act of determining the identity of a principal, is a basic necessity of any security system. Because of this, and because of its complexity and potential for error, authentication methods have been topic of intense research.

Research in authentication protocols is aimed at identifying potential threats to authentication and to devising interaction that cannot be broken, i.e., that the successful execution of the authentication protocol does indeed provide strong evidence as to the identity of the subject(s). "Cryptography is very useful for this purpose". There is no doubt that the introduction of keys into cryptographic systems was a revolutionary change that gave cryptographers a decided advantage over the intruders, at least for a while. It also introduced the problem of key distribution into cryptographic systems. Security protocols are aimed at solving the problem of key distribution.

Even security protocols that look relatively straightforward have subtle flaws, which a sophisticated intruder can exploit in order to defeat the protocol and compromise the security. This led to the idea of intrusion detection in secure environments, which is described next.

1.2 Overview of Detecting Intrusions in secure environment

A secure environment can be described as an enclave where trusted parties communicate with each other with the use of cryptography enabled by security protocols. The communication channel itself may not be secure and an intruder may be able to exploit the channel for malicious purposes. A model described in **[7]** shows the way to develop intrusion detection system for such an environment. "Secure Enclave Attack Detection System", described in next section uses the same model.

1.3 SEADS

"SEADS" is an acronym for "Secure Enclave Attack Detection System" SEADS has three major components to it viz: -

i) Monitor

ii) Detection Engine

iii) Knowledge Base

The roles played by these components in implementation of SEADS are described in the subsequent sections, with detailed explanation of their functionality. Knowledge Base is the focus of this project.

2 Intrusion Detection

Intrusion detection technology has been an area of intense research over past few years. Due to this research various methodologies have been suggested. Denning gives an outline for the model that can be used for intrusion detection in **[4]**. "Common Intrusion Detection Framework" (CIDF), which suggests the use of monitor, knowledge base and a detection engine described in **[7].** This model is used to develop the idea of SEADS. Based on the type of detection methodology used, the knowledge base can contain various types of information, which is described next. Generic detection techniques can be classified into either

- Behavior based detection.

Or

- Knowledge based detection.

2.1 Behavior Based Detection

The behavior based detection technique focuses on characteristics of normal network traffic and normal user behavior in the target environment. Historical data is tracked and modeled by statistical measures to establish profiles, which form a baseline against which to compare new activities. The system beacons when it finds abnormal activity on the network that is not listed in the profile.

2.1.1 Models used in behavior based detection

The following models are commonly employed for detection of attacks:

a) Statistical Modeling

b) Expert Systems

c) Neural Networks.

Statistical Modeling

This model is widely used for behavior based detection systems. The system gathers user activities over a period of time and stores them as the user profiles. The period is not fixed and can vary from just a few hours to months. The idea is to gather a comprehensive set of user activities, so that the user profile correctly represents "normal" user behavior. Some common parameters may include login frequency, commands being regularly issued by the user, resource consumption, etc. The system then monitors the activity of this user and beacons when it finds something that is not listed in the profile.

Expert Systems

Denning has described a prototype of such a system in **[4]**. This prototype monitors the target system by comparing the audit records generated by the target environment to its store of profiles. These profiles are always changing and reflect the user behavior closely. The profiles themselves are dynamic and the expert system adapts to these changes.

Neural Networks

Intelligent systems are the latest addition to the methodology of intrusion detection. These systems are still in the developmental stages and few instances are listed in the literature. The idea behind this concept is that the system can be trained to deduce the normal behavior of the user so it can easily identify if any malicious activities are taking place in the target environment. However, this technique is computationally intensive and is not widely used.

2.2 Knowledge based intrusion detection

In knowledge based approach, the intrusion detection system (IDS) accumulates bad actor signatures and monitors the target environment for the pre-defined malicious activities listed in the knowledge base, in the form of signatures. Knowledge-based systems beacon when they recognize activity that is in their knowledge base. It is also sometimes termed as misuse detection or detection by appearance, as the detection methodology is based on matching the events of the network with the events listed in the knowledge base.

2.2.1 Models used in knowledge based detection

2.2.1.1 Finite State Machines

The signature can be represented as a finite state machine. As a result, the detection engine can spawn a finite state machine every time a new user wants to communicate and keep track of all the events that take place between the user and other parties involved in the communication. As soon as any of the finite state machines that were spawned by the system reaches the final state the system can beacon an attack. This is the method adopted in this project.

2.2.1.2 Colored Petri Nets

Another way of representing signatures of attacks on encrypted traffic is by the use of Petri Nets. Petri Nets depict the signature in a graphical form, which makes representing complex signatures easy and lucid. Petri Nets offer the advantage when it comes to representing signatures in a generic manner.

3 Scope of Project

The intrusion detection system implemented uses knowledge-based detection methodology to detect attacks in a secure enclave. The following sections describe the role of knowledge base in SEADS, as well as the constraints and assumptions used to implement the knowledge base.

3.1 Role of Knowledge Base in SEADS

Secure Enclave Attack Detection system is based on the CIDF model **[7]**. It detects attacks in real time in the secure environment that uses security protocols to establish the keys between the communicating parties. SEADS uses meta-information of the packet on the network and dynamically analyzes the ongoing activity with the knowledge base to determine the nature of activity, legal or malicious. In order to do so, SEADS utilizes the signatures represented in the knowledge base, so the knowledge base a crucial component of the system. *Figure1* is a model of the SEADS. It reflects the interaction of knowledge base with other the components of SEADS.

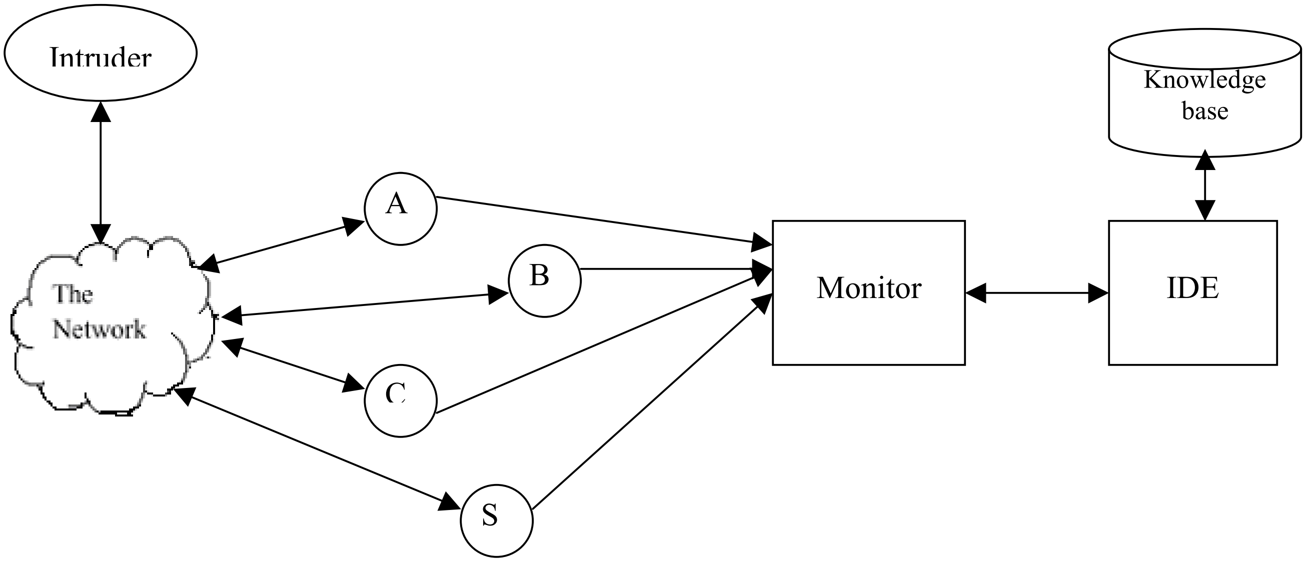


Figure 1: SEADS

Figure 1 shows the three components of SEADS, namely,

1. *Monitor:* - The principals of the enclave communicate with the monitor, informing it of all the messages exchanged between the parties involved. In a way monitor keeps track of the activities going on in the network. The monitor passes on this information to the detection engine.

2. *Detection Engine:* - The detection engine checks the sequence of events it receives from the monitor with the sequence listed in the knowledge base. If a match is found, the detection engine raises an alert for an attack. So the detection engine has to interact with the monitor and the knowledge base.

3. *Knowledge Base:* - The knowledge base has record of all the protocol signatures being executed in the enclave. Based on these signatures, the detection engine analyzes the network activity to detect attacks on the protocols.

3.2 Functionality of Knowledge Base

The knowledge base is like a database of signatures, so it has to have functional capability of any other database. Among its tasks we must be able to:

a. Add signatures to the database.
b. Delete signatures from the database.
c. Modify the existing signatures from the database.
d. Read existing signatures.

Apart from this, it was found during the research that there has to be a provision for adding protocol ids, which is described in the later section and provision to regulate access to valid users only. Therefore, these capabilities are also added to the above set:

a. Add protocol id to the database.
b. Provide password protection.

c. Since the user must enter the signature manually, above functionality needs a neat user interface to manipulate the signatures. A Graphical User Interface (GUI) is provided to achieve this purpose.

d. The knowledge base has to interface with the IDE, so the database is represented as a “Flat File”. The use of flat file structure is done to provide a simple Application Program Interface (API) to the IDE.

4 Attack Detection Methodology

The intrusion detection system developed is knowledge based detection system; that is it looks up the sequence of malicious activities for the protocol being executed from the knowledge base and compares them with the sequence occurring in the monitored network. As described section 2.2.1 finite state machine analysis technique is used to detect attacks. The signatures are represented as finite state machines in this approach of attack detection.

4.1 Forming Signatures of Attack

Signatures of attack have to be derived from the protocol description. The IDS does not depend upon the payload information of the messages exchanged between principals during protocol sessions. It rather uses the meta-information of the packet to analyses the possibility of attack.

As an example, consider famous security protocol called *Needham and Schroeder Conventional Key Protocol (NSCKP)* described in **[5]**. This protocol has three principals: A, B and S, where S is a trusted third party server S. The protocol is used to establish a secret key Kab that is to be used by the principals A and B to encrypt their future exchanges.

The protocol in discussion is as follows:

1) A → S : A, B, Na
2) S → A : E(Kas: Na, B, Kab, E(Kbs : Kab, A))
3) A → B : E(Kbs : Kab, A)
4) B → A : E(Kab : Nb)
5) A → B : E(Kab : Nb-1)

The stepwise explanation of the above protocol is given below.

Step1: Principal A requests trusted server S for a key to be used for secure communication with principal B. The message that A sends to the server S is shown above after ":" includes the name of the sending and the receiving principal and a random number generated by A called nonce Na, used to know the freshness of message.

Step 2: This is most important step wherein server S on receiving the request generates the message to be sent to principal A which contains the requested key Kab (shared by A and B only). The message that S sends to A is encrypted by the key, which S shares with A, so that only A can decrypt the message. The message generated here contains the secret key that A and B would be using for exchanging messages among themselves.

Step 3: On receiving the message from S, A decrypts it with the key it shares with S and sends the part of the message encrypted with key Kab to B. This way B would also come to know the key it would be sharing for the communication with A.

At the end of protocol both the parties A and B are sure that they are communicating with the intended parties and not anyone else. The protocol achieves the purpose of authentication and integrity.

However the intrusion detection system does not use all the information the protocol provides about the encryption and hence in the representation of the protocol for the intrusion detection system, all that information can be stripped off. Thus the protocol can be represented by send and receive events is as shown below:

1) A → S

2) S ← A

3) S → A

4) A ← S

5) A → B

6) B ← A

7) B → A

8) B → A

9) A → B

10) B ← A

The above signature has ten steps instead of 5, which were in the original protocol, the reason being that each step in the original protocol has a send event only, the signature represented above has a receive event for every send event.

Steps 2, 4, 6, 8 and 10 represent the receive event which are not listed in the protocol but are taken to be implicit operations.

Each step of the protocol is called an event. There are two types of events, namely send and receive. Whenever a principal executes any of the two events it informs the monitor about the event. Thus the monitor knows exactly what each principal is doing at any given time. But the exchange of the messages between the principals take place on an insecure network channel so there is a possibility of lost messages, in which case the monitor will not know whether the send event was completed, so it becomes necessary to include a receive event.

The protocol just described is a normal or the legitimate run of the protocol. Although it looks straightforward, it nevertheless has subtle flaws that can be exploited by the intruder for malicious purposes. Illustration of one such attack is given in **[6]**.

Consider step 3 of the above protocol. Although B decrypts this message and assumes legitimately that is created by the server S, there is nothing in the message to indicate that the message was actually created by S as a part of current run of protocol. Suppose that the intruder Z was monitoring the network and has got hold of a previously distributed key K’ab, and is able to break it (say by cryptanalysis). Now Z can fool B into accepting the key as a legitimate key for the current run of protocol in following manner:

3) Z(A) → B : E(Kbs: K’ab, A)

4) B → Z(A) : E(K’ab: Nb)

5) Z(A) → B : E(K’ab: Nb –1)

Note: Z(A) means Z masquerading as A.

Now, at the end of the protocol B believes that A is the other party in session. Thus the protocol is attacked.

The signature that can detect the above attack is shown below.

1) B ← A
2) B → A
3) B ← A

The above signature comprises of only three events, two receives and a send event. Since the malicious intruder is not the part of secure enclave it cannot communicate with the monitor and so the monitor will not record any send events on the part of intruder, which is masquerading as A. Thus the above attack signature will consist only of events, reported by B, to the monitor.

4.2 Signature representation

The IDS implements the knowledge based detection technique. It uses finite state machine analysis to detect the attack on the security protocol. In this model the signature is represented as a finite state machine. Therefore, each time IDE receives an event corresponding to the first event of a new protocol, it looks up in the knowledge base and constructs a finite state machine corresponding to the signature of the protocol being executed. Each time IDE receives an event particular to a protocol, it changes the state of corresponding finite state machine.

4.2.1 Signature Format

The signature of a protocol is sequence of events occurring in the protocol. An event as represented in the knowledge base can either be a send or receive event. The general representation of event is as shown in figure 2.

Cur_State	Principal_1	send/receive	Principal_2	next_state	Message_#	Session_#

Figure 2: Event Representation.

All the attributes used in event representation are explained below.

- Cur_state: Indicates the current state of finite state machine. It also indicates the state the machine was before the event occurred. (ss: start state, s1: state1..Etc)
- Principal_1 / Principal_2: Indicates the principals involved in the communication. (A, B, C…S: Single letter identifier of principals)
- Send / receive: Indicates the kind of event. (send: "→", receive: "←")
- Next_state: Indicates the state of machine after the event takes place. (fs: final state, s1: state1…etc.)
- Message #: Indicates the sequence number of the message being exchanged.
- Session #: Indicates the session number of the protocol between the communicating parties. This field is unused as of now in this implementation and always set to 1. This field may be used in future as needed.

An example of event is shown below:

s3 A → B s4 1 1

Now that the structure of event is known, we can represent a signature in a generic manner as shown in figure 3.

```
begin Protocol_ID Signature_ID Type
Event # 1
Event #2
   :
   :
   :
Event # n
end
```

Figure 3: Signature Representation.

The first line of the signature gives information about the protocol for which the signature is written *(Protocol_id)*, the number of the signature *(signature_id)* [there can be more than one attack on a protocol] and the type of attack the signature represents *(Type).*

Finally let us consider an actual signature of attack on "Needham and Schroeder Conventional Key Protocol" (NSCKP) discussed in section 4.1.

begin NSCKP 0 S

ss B ← A s1 1 1

s1 B → A s2 2 1

s2 B ← A fs 3 1

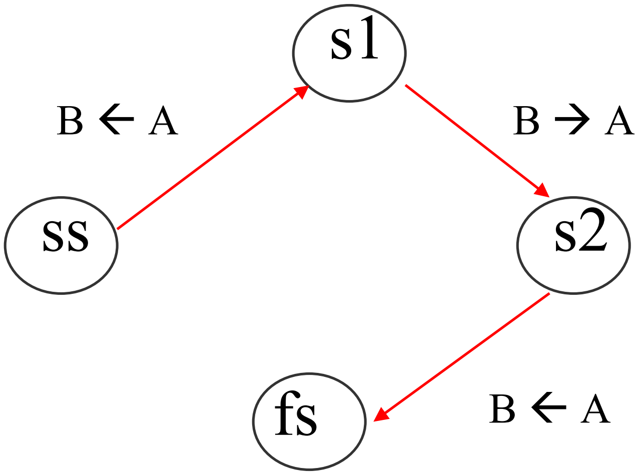
end

4.3 Finite State Machine Representation Of Signature

The above signature can be represented as a finite state machine in following way:

Current State	Event	Next State	Message Number
SS	B ← A	S1	1
S1	B → A	S2	2
S2	B ← A	FS	3

We can represent the finite state machine from the above table graphically as shown below:



The IDE spawns this machine when it gets the first event of the signature of the attack. Initially, the machine is in the start state “ss”. As the events come, the IDE compares them with the events in the signature of the attack and advances the machine state accordingly. When the machine reaches the final state “fs”, the IDE signals an attack on the protocol. This way all that the IDE has to do is to spawn the finite state machines corresponding to the signature and keep track of the state of the machine. If any of the machines corresponding to the protocol reach a final state, an attack can be signaled. Since there can be more than one attack on a protocol, the number of finite state machines for a protocol can vary from one to many. But as soon as any of them reach a final state, the IDE can signal an attack on that protocol. This is true for machines that represent the attack signatures only, as stated earlier, the knowledge base has the signature of normal run of protocol in it, so the IDE has to spawn finite state machine for it too. But if that machine reaches final state then it only means that a legitimate session has executed between the involved parties and the IDE does not signal an attack.

4.4 Classification Of Attacks

In order to aid the successful detection of attacks on protocols, attacks are classified into categories, these categories are not necessarily the ones followed in literature. It was found out during research that the categorization followed in literature made it hard for SEADS to detect all possible attacks on the protocols. Each category has a distinct characteristic that can be used for detecting an attack. Broadly speaking, the attacks are classified into two categories:

1. Single session attacks
2. Multiple session attacks

4.4.1 Single Session Attacks

These types of attacks are carried out on current run of the protocol, i.e. they may or may not use information from the previous session of the protocol, like the secret keys or the encrypted message itself. The attack on Needham and Schroeder Conventional Key Protocol described earlier is a canonical example of Replay Attack as listed in the literature. The attack uses the information that was used in the previous run of the protocol, this run could have taken place few hours back or a even few years back and the detection engine would have to keep track of that information. This is not possible in SEADS, as the concept of infinite memory to store such data is not practical. Thus the information that is visible to SEADS, which may be couple of sessions old, can be used for detection purpose. Therefore we have categorized such attacks, which use information visible in a single session as “Single Session Attacks”. Hence the categorization of attack on Needham and Schroeder protocol as a Single Session attack. The detection of such attack is straight forward, in the sense, all that IDE has to do is to follow the finite state machine for the signature and when that reaches the final state, attack is detected. These types of attacks are generally carried out on protocols that do not employ timestamps in the messages to check for the freshness of the message. This is evident from the

Needham and Schroeder protocol described earlier. All that it uses to check the freshness of the message is the randomly generated nuances. This type of attack is listed as a Replay attack in the literature but according to our categorization, these attacks fall under single session attacks.

4.4.2 Multiple Session Attacks

These types of attacks are carried out using information from two or more runs of the same protocol. These attacks are further classified into two categories, based on the information they use to subvert the protocol.

1. Replay Attacks
2. Parallel Session Attacks

4.4.2.1 Replay Attacks

As the name suggest, these attacks are carried out by replaying information from the previous run of the same protocol. The information that is replayed has to be fresh, i.e. the information has to be replayed within a time limit or else it would become invalid. The time limit for such attacks is generally the longest network delay a packet can suffer when transmitted from the sender to receiver. This time limit is calculation is described in **[6]**. These attacks are carried out on protocols that use timestamps to check the freshness of the message.

To detect such attacks the IDE would not have to follow the finite state machine corresponding to the signature but it would also have to keep track of the timing characteristic of the message. That is the IDE will have to check whether the message delivered was within the stipulated time period that the protocol uses. If the message were delivered after the time limit, it would be considered as a suspicious activity. The IDE will then follow the finite state machine corresponding to the signature of the protocol and would detect an attack as soon as the machine reaches its final state.

4.4.2.2 Parallel Session Attacks

Parallel session attacks are carried out when two or more runs of the protocols are executed simultaneously and the information from one run is used in the other run to subvert the protocol. These attacks have the characteristic of the replay attack in them, i.e. the information being replayed has to be fresh in order to be valid.

Again the detection of such attacks involves monitoring of concurrent sessions of the same protocol as well as the timing characteristics of the transmitted message. These attacks are carried out by concurrently initiating a session using the same protocol, with same principals and then replaying the information from one session in another session.

5 Design Of Knowledge Base

This section gives complete and comprehensive design of knowledge base. It discusses the evolution of all the functionality there is to the knowledge base and the design decisions taken with the justification for them. It highlights the modules, their functionality and interconnection. The basic functionalities of the knowledge base will be a good starting point to design the modules.

5.1 Identifying The Operations

From the topmost level, the following operations are performed on the knowledge base:

- Adding signatures.
- Reading signatures.
- Modifying signatures.
- Deleting signatures.

Figure 4 shows these operations schematically.

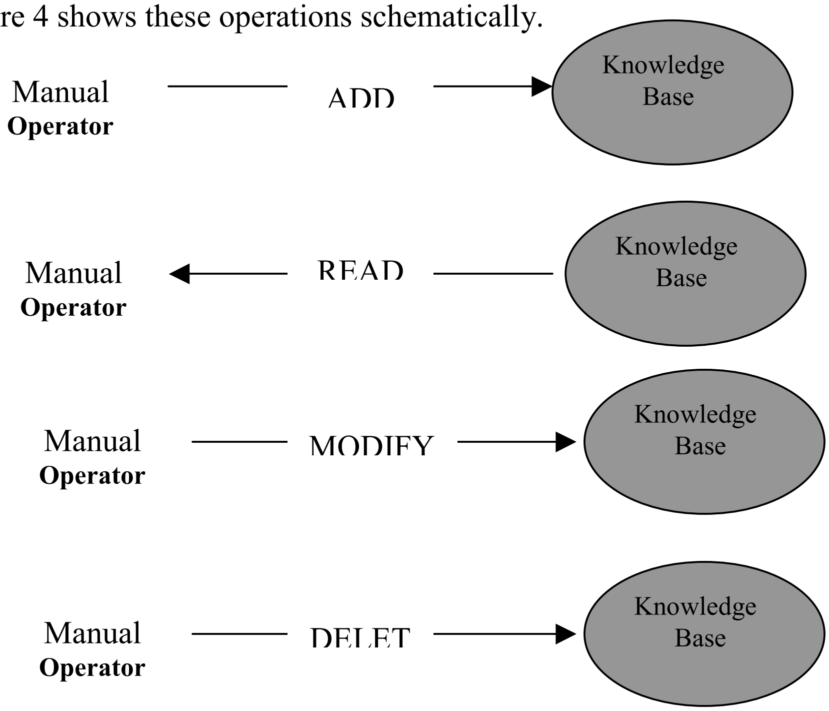


Figure 4: ADD, READ, UPDATE & DELETE are the basic operations that can be performed on the knowledge base.

From Figure 4, it can be gathered that the knowledge base is designed taking above operations that it has to support as a design criteria. Representing the above diagram as a structure chart condenses the entire picture.

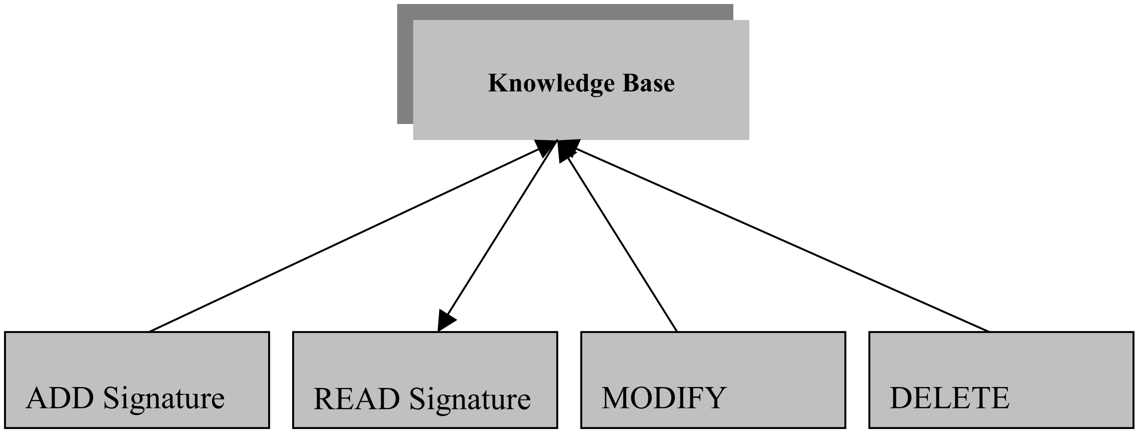


Figure 5: Structure Chart

From the above two diagrams it is quite clear that the knowledge base provides for signature taxonomy which facilitates the four basic operations imperative to its efficient functionality. This knowledge base pivots around the security protocols. The most prominent security protocols include Needham Schroeder Protocol, Denning Saco Protocol and Otway Rees Protocol. The knowledge base is designed to store signatures for such protocols.

Under each security protocol there may be more than one signature that represent malicious activity. The knowledge base serves as a repository for these signatures. This repository refers to a file, which contains all the signatures that are generated from the input information supplied by the manual operator.

5.2 Signature Formation In Knowledge Base

Figure 6 depicts the Data Flow Diagram for the Knowledge Base. The flow is mapped by the number increasing monotonically, which determines the flow of data and/or the execution of each function performed by the knowledge base. The legend explains the detailed process of signature formation in the knowledge base.

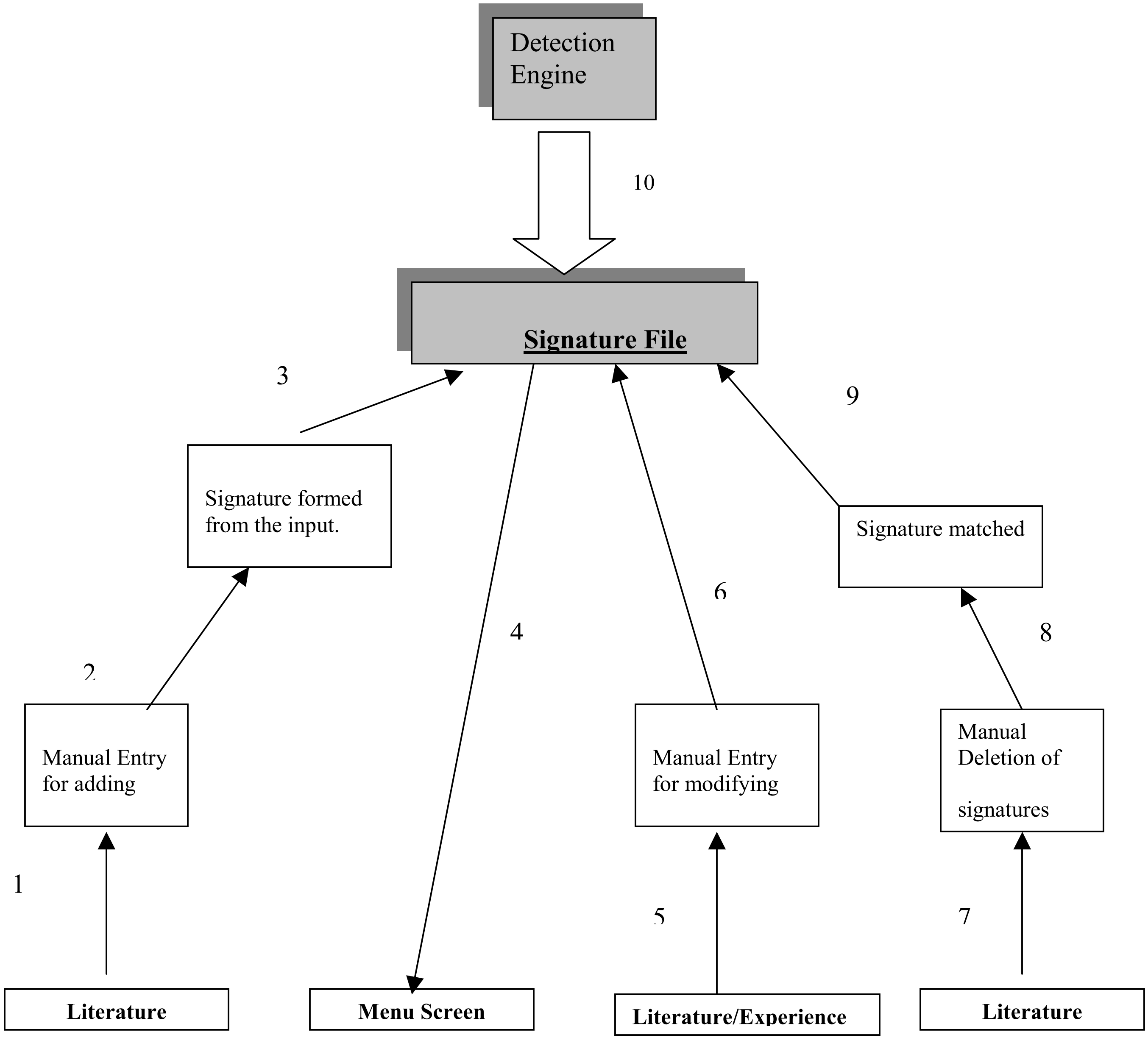


Figure 6: Data flow diagram.

Legend

Action Sequence	Related Action
1	Gathering information from literature.
2	Feeding the gathered information as a signature.
3	The signature file is opened only if there are no read operations on it
4	The signatures can be read from the signature file.
5	This option is used for modifying the existing signature.
6	Access the signature record from the knowledge base and then update it.
7	A signature is found to be invalid or obsolete.
8	Look for the signature record. If present then go to the next step. Else inform the manual operator.
9	Delete the signature from the file.
10	The detection engine shall access the signature file for Starting its recognizers.

This is how a signature evolves in the knowledge base (and finally, may even expire). But this is not a rigid scenario. For some signatures the highest evolvement may be just steps 1 – 4.

5.3 Module Explosion

For the basic operations

- ADD a new signature to the knowledge base
- READ signatures from the knowledge base
- UPDATE signatures that are present in the knowledge base
- DELETE signatures present in the knowledge base

Figure 7 shows the detailed module explosion.

MODULE EXPLOSION

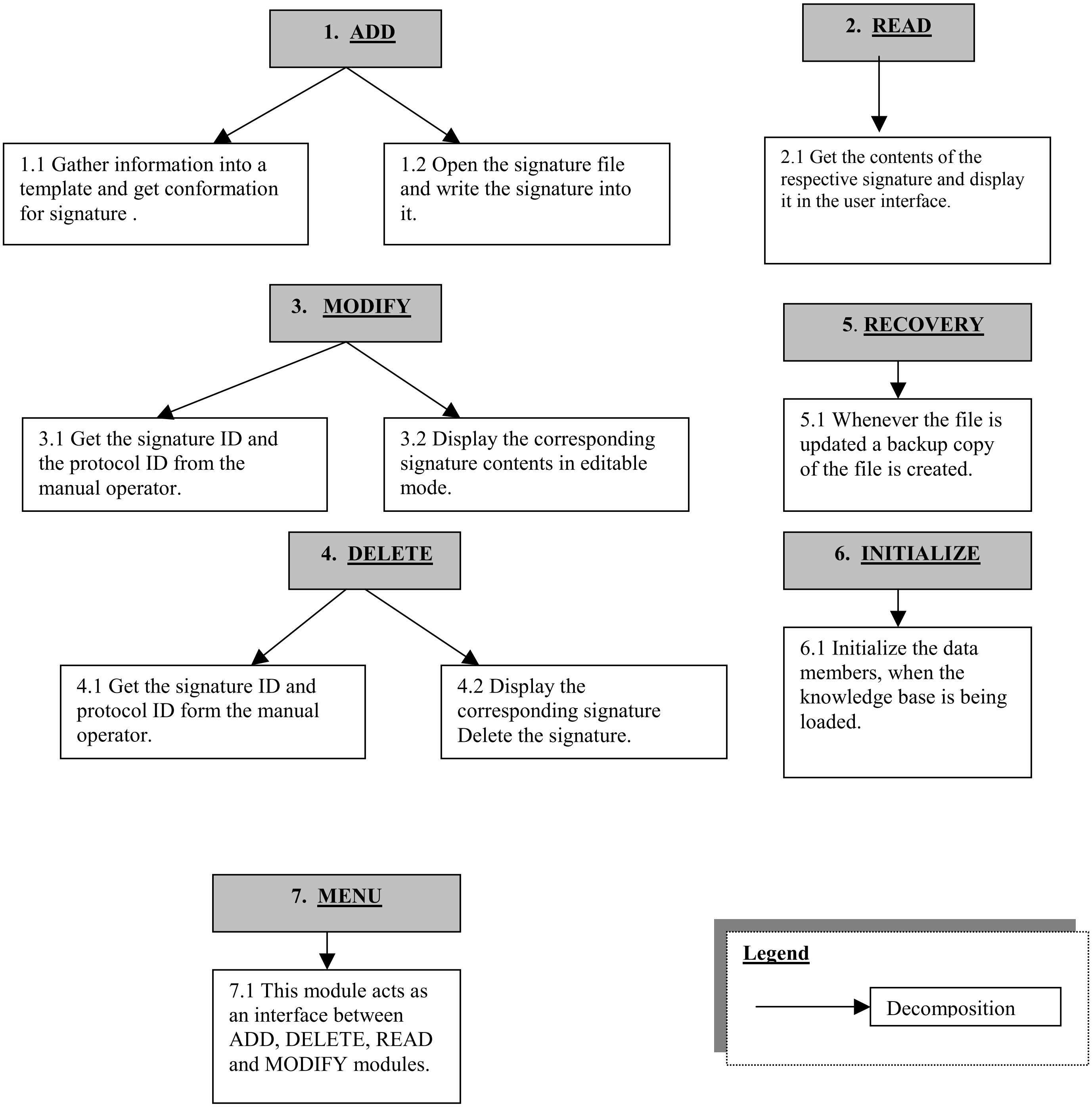

1. ADD
1.1 Gather information into a template and get conformation for signature .
1.2 Open the signature file and write the signature into it.
2. READ
2.1 Get the contents of the respective signature and display it in the user interface.
3. MODIFY
3.1 Get the signature ID and the protocol ID from the manual operator.
3.2 Display the corresponding signature contents in editable mode.
5. RECOVERY
5.1 Whenever the file is updated a backup copy of the file is created.
4. DELETE
4.1 Get the signature ID and protocol ID form the manual operator.
4.2 Display the corresponding signature Delete the signature.
6. INITIALIZE
6.1 Initialize the data members, when the knowledge base is being loaded.
7. MENU
7.1 This module acts as an interface between ADD, DELETE, READ and MODIFY modules.
Legend
Decomposition

Figure 7: Module Explosion diagram

5.4 Functionality Of Modules

1. ***Add***: - This module allows the user to enter the protocol id and the signature into a temporary buffer. Once this information is entered it waits for the user to confirm the entry. The signature that is generated is then put in a specific format described in section 4.2.1.The signature file is checked for write permission and if it has the write permission it is written into the file.

2. ***Read***: - This module searches the signature based upon the protocol id and the signature id selected by the user. The matching signature is displayed in the user interface in non-editable mode.

3. ***Modify***: - This module searches the signature based upon the protocol id and the signature id selected by the user. The matching signature is displayed in the user interface in editable mode. The corresponding signature can be updated by accessing the individual components of the signature. Once the signature is updated, it is written back into the file.

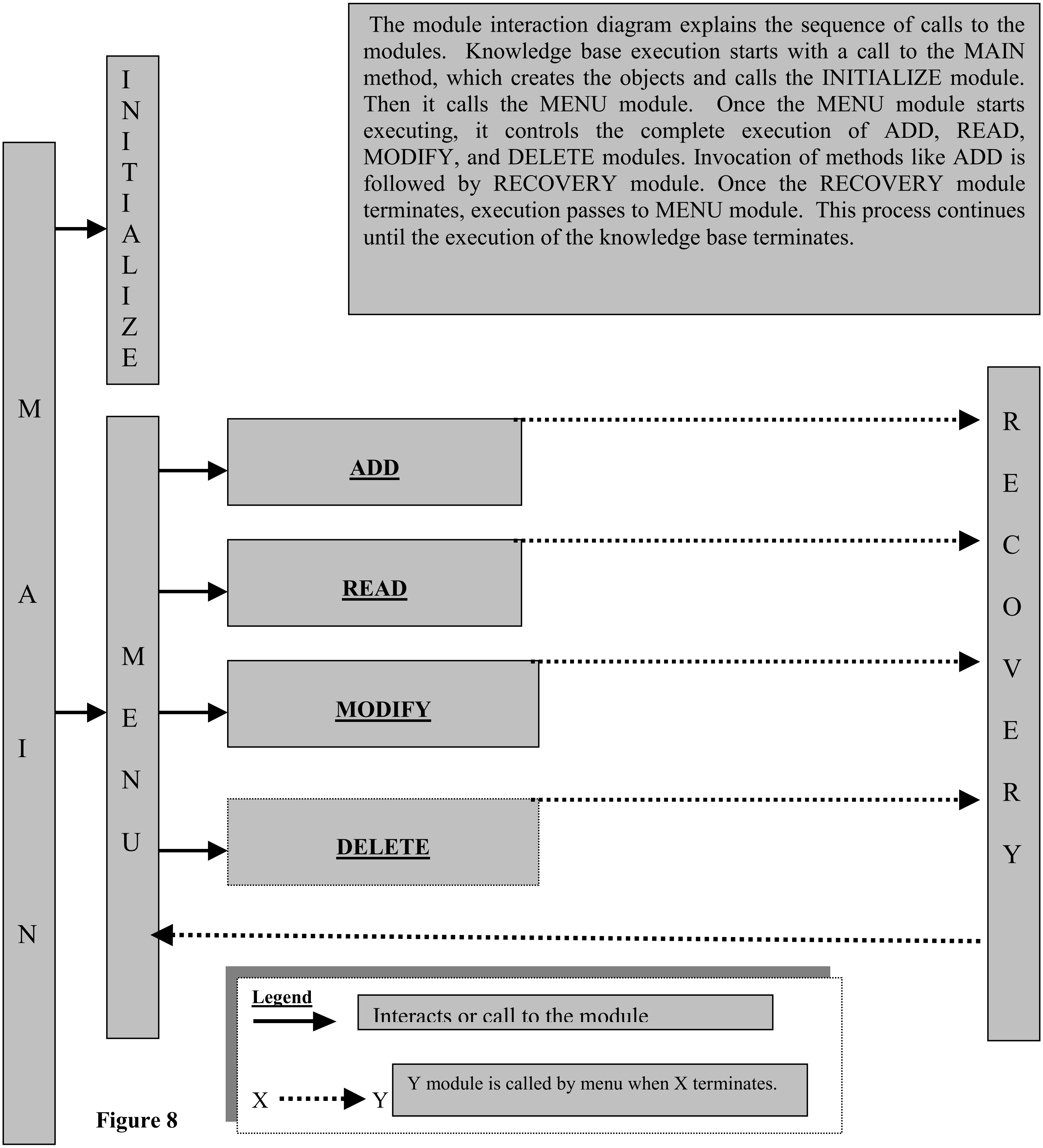
4. ***Delete***: - Based upon the signature's unique ID, the signature will be matched. If such a signature does not exist, then the manual operator will be informed about the absence of the record. When the signature is matched, the entire signature can be deleted.

5. ***Recovery***: - Each and every time an ADD, MODIFY or DELETE operation is done on the knowledge base, a backup file is updated.

6. ***Initialize***: - This module initializes all the needed variables. The control is then passed to the menu module.

7. ***Menu***: - This module acts as an interface for ADD, DELETE, MODIFY and READ modules.

Module Interaction Diagram



The module interaction diagram explains the sequence of calls to the modules. Knowledge base execution starts with a call to the MAIN method, which creates the objects and calls the INITIALIZE module. Then it calls the MENU module. Once the MENU module starts executing, it controls the complete execution of ADD, READ, MODIFY, and DELETE modules. Invocation of methods like ADD is followed by RECOVERY module. Once the RECOVERY module terminates, execution passes to MENU module. This process continues until the execution of the knowledge base terminates.

MAIN
INITIALIZE
MENU
ADD
READ
MODIFY
DELETE
RECOVERY
Legend
Interacts or call to the module
X
Y
Y module is called by menu when X terminates.

Figure 8

All the class diagrams for the classes used along with the method associated with them are given in the appendix section of this report. It gives detailed view of the classes used.

6 Testing

The most important part of testing was to check the correctness of the signatures of attack listed in the knowledge base. This part was accomplished by executing each types of signature on SEADS. SEADS was able to detect all types of attacks namely, Single Session, Replay and Parallel Session.

Testing of user interface

- Add module was tested to add the signature with wrong format. The interface does not write the signature in the file. It tells the user to change the format accordingly by popping a dialog box on the screen.

- Add protocol id module was tested to add protocol ids already present in the knowledge base. The module does not write the protocol id but tells the user that there is a protocol id with same id already present in the knowledge base.

- Read module was tested to read signatures which did not have entries in the knowledge base by giving false protocol ids. The user is informed that the signature is not present in the system.

- Delete modules was tested again to delete the signature not present in the knowledge base by giving false protocol id. The user is informed that the signature is not present in the knowledge base.

- Recovery Module was tested by recovering the signature.txt file continuously and then the file was checked to see if it was recovered by checking it in the windows explorer. The file was always recovered.

7 Conclusions

I have designed the signature format for the attacks on the security protocols and implemented the interface needed to manipulate the signatures in the knowledge base. The interface aids the user in entering the signatures in an efficient and error free way.

Extensive research on different attack types and their characteristics led to the development of the knowledge base and the signatures present in it. The characterization of attacks into different categories aided the detection of almost all the attacks listed in the literature.

Since the signatures have to be entered in a specific format, it would have been cumbersome and error-prone procedure for the user without the interface provided. The interface makes it easy for a layperson to enter, read and manipulate the signatures once provided with the format.

8 Appendix

A. Resources Used

The project was developed in the Windows network environment, using Microsoft Visual C++ 6.0. All code was written in C++. The Microsoft Foundation Classes were used to code the Graphical User Interface.

B. Lessons from this project

It was because of this project that my interest in network security grew, I was able to enhance my knowledge of security protocols and understand the subtleties involved in an attack on security protocols.

In implementing the knowledge base, I was able to learn a lot about the Visual C++ development environment and was able to appreciate the Foundation Classes provided by Microsoft for graphical user interface programming.

C. Class Diagram

SEADS_Signature Class		
String	Protocol_ID	// Stores protocol_ID for the given signature.
Integer	Signature_ID	//Identification of signatures for each protocol.
String	Signature_Buffer	//Stores entire signature before updating in file.
File	signature.txt	//File which consists of all signatures.
Vector[]	Num_of_Signatures	//Vector consisting of # of signatures.
Vector[]	Protocol_Name	//Vector consisting of all protocol names.
Void	ADD_Generate_Signature()	
Void	ADD_Write_Signature()	
Bool	READ_Find_Signature()	
Bool	MODIFY_Match_Signature ()	
Bool	MODIFY_Modify_Signature ()	
Bool	DELETE_Match_Signature()	
Bool	DELETE_delete_Signature()	
Void	RECOVERY_Copy_To_Backup_File()	
Void	INITIALIZE_Defaults()	
Void	MENU()	

D. Mapping protocols with protocols id

Sl. No	PROTOCOL NAME	PROTOCOL ID
1	Needham Schroeder Protocol with Conventional Keys Protocol	NSCKP
2	Denning Sacco Protocol	DSP
3	Otway-Rees Protocol	ORP
4	Amended Needham Schroeder Protocol	ANSP
5	Wide Mouthed Frog Protocol	WMFP
6	Yahalom Protocol	YP
7	Carlsen’s Secret Key Protocol	CSKP
8	ISO Four-Pass Authentication Protocol	IFOP
9	ISO Five-Pass Authentication Protocol	IFIPAP
10	Woo and Lam Authentication Protocol	WLAP
11	Woo and Lam Mutual Authentication Protocol	WLMAP
12	Needham Schroeder Signature Protocol	NSSP
13	Kerberos Version5 Protocol	KVP
14	Newman Stubblebine Protocol	NSP
15	Kehne Langendorfer Schoenwalder Protocol	KLSP
16	Tha Kao Chow Repeated Authentication Protocol	KCRAP
17	ISO Public Key One-Pass Unilateral Authentication Protocol	IPKOPUAP
18	ISO Public Key Two-Pass Unilateral Authentication Protocol	IPKTPUAP
19	SO Public Key Two-Pass Mutual Authentication Protocol	IPKTPMAP
20	ISO Three-Pass Mutual Authentication Protocol	ITPMAP
21	ISO Two-Pass Parallel Mutual Authentication Protocol	ITPPMAP
22	Bilateral Key Exchange with Public Key Protocol	BKEPKP
23	Diffie Hellman Exchange Protocol	DHEP
24	Needham-Schroeder Public Key Protocol	NSPKP
25	Hwang and Chen’s Modified SPLICE/AS Protocol	HCMSP

26	CCITT X.509 Protocol	CXP
27	Shamir Rivest Adelman Three Pass Protocol	SRATPP
28	Gong Mutual Authentication Protocol	GMAP
29	Encrypted Key Exchange –EKE Protocol	EKE
30	Davis Swick Private Key Certificates Protocol	DSPKCP
31	ISO Symmetric Key One-Pass Unilateral Authentication Protocol	ISKOPUAP
32	ISO Symmetric Key Two-Pass Unilateral Authentication Protocol	ISKTPUAP
33	ISO Symmetric Key Three-Pass Mutual Authentication Protocol	ISKTPMAP
34	Using Non-reversible Functions Protocol	UNRFP
35	Andrew Secure RPC Protocol	ASRPCP
36	ISO One-Pass Unilateral Authentication with CCFs Protocol	IOPUACP
37	ISO Two-Pass Unilateral Authentication with CCFs Protocol	ITPUACP
38	ISO Two-Pass Mutual Authentication with CCFs Protocol	ITWPMACP
39	ISO Three-Pass Mutual Authentication with CCFs Protocol	ITHPMACP

E User Manual and Installation Instructions

This manual is intended for those who are working in SEADS research group and want to populate the knowledge base with either signatures or protocol activities. The intended readers should have a little knowledge about the security protocols and their usage. This manual comes up with a detailed and graphical description of the knowledge base that makes it easy for the user to understand and use.

1) Installation Instructions

The knowledge base comes with an executable called:

- KB.exe

The folder first_try has the "KB.exe" stored in Debug folder. The file containing the signature is called "signature.txt", all the protocol ids are stored in a file called "protocol_id.txt", backup files for both the signature and the protocol ids are stored in the file "backup_signature.txt" and "backup_protocolid.txt" respectively. These files have to be in the folder where the KB.exe is placed. If these files are moved else where the application will not execute as it needs to read data from these files.

User can copy all the files from the first_try folder to any other folder and still execute the Knowledge Base.

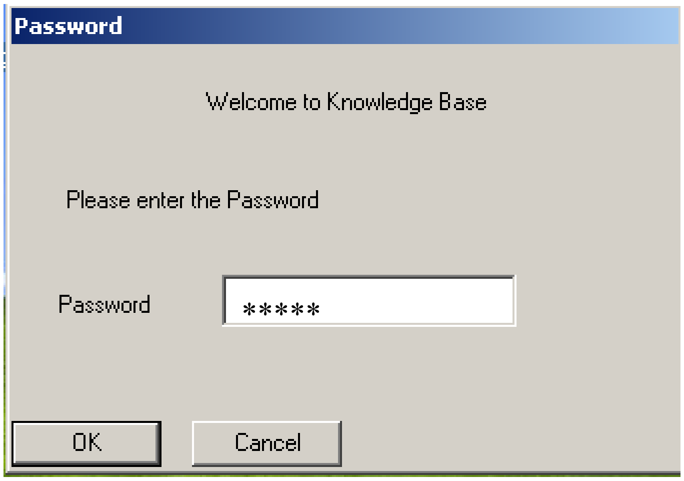
2) Explanation of Screens

There are in total 7 screens, this section provides explanation on their usage and relevancy. Seven screens are:

- Login Window (Password protected)
- Main Menu
- Add Signature
- Read Signature
- Delete Signature
- Modify Signature
- Add Protocol Id

Login Window

This is the entry point in the program and it regulates the access of knowledge base to privileged users only. The user has to enter the password inorder to get past this screen, if the password entered is incorrect the program exits. The password is case sensitive and is called "seads". The following screen shot shows the window.

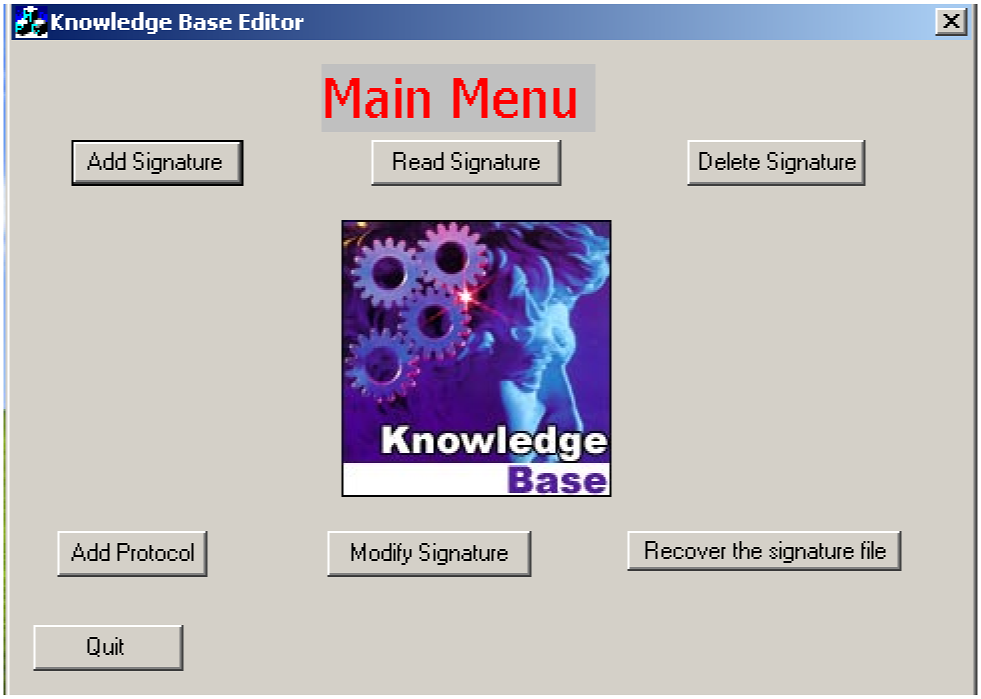

Password

Welcome to Knowledge Base

Please enter the Password

Password *****

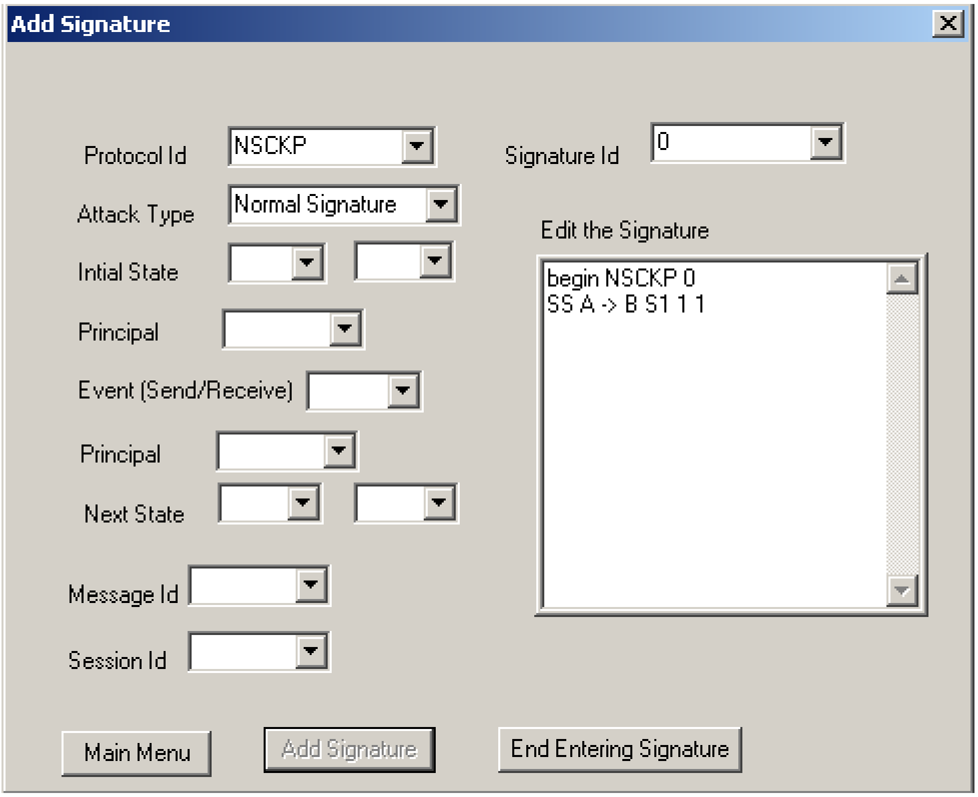
Main Menu



Once past the login window, the Main Menu is displayed, this is where all the functionality of the knowledge base is displayed. The buttons show the operations that can be performed on the knowledge base by the user. The "Quit" button quits the application.

"Add Signature" pops the screens where the user can enter a new signature. To add a new protocol id, the "Add Protocol" button is used, which brings up the screen to add a new protocol. "Recover the signature file" button is used for recovery of the signature file, this option is used whenever the file "signature.txt" is corrupted.

AddSignature



Protocol Id: NSCKP

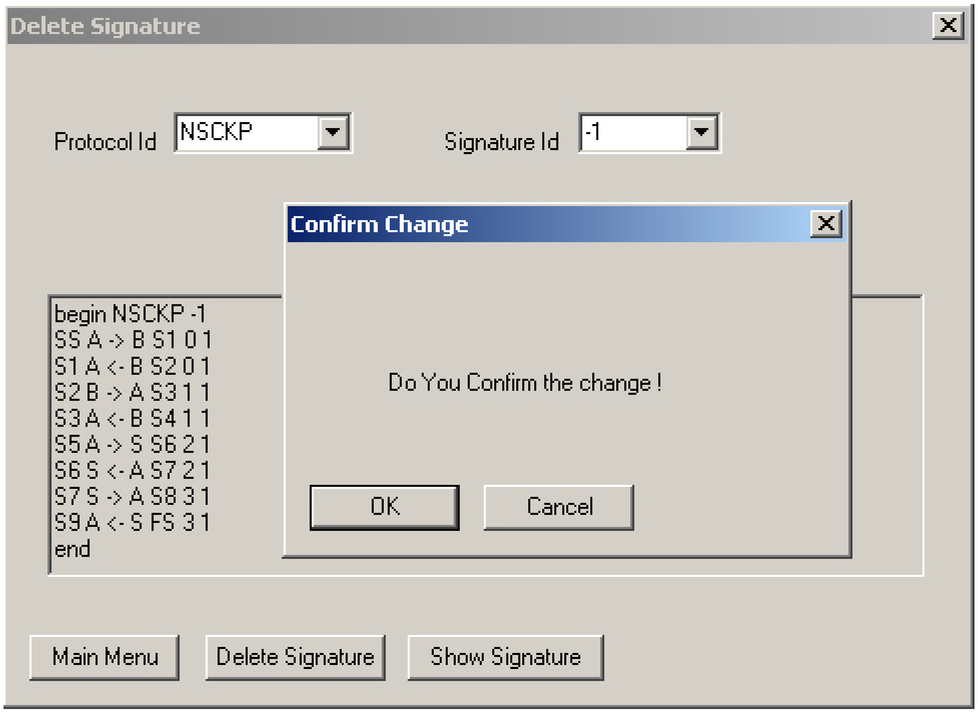
Signature Id: 0

Attack Type: Normal Signature

```
begin NSCKP 0
SS A -> B S1 1 1
```

This screen comes up when Add Protocol button is clicked by the user, the screen asks the user to enter the protocol id, signature id and all the relevant parts that make up the signature. The screen makes use of drop down boxes, which are automatically filled by the application, so all that the user has to do is to select the necessary filed values and the signature can be created as desired. If for some reason the signature has errors in it, which the user wants to correct, the editable display on the side can be used to make changes to the signature.

Delete Signature



Protocol Id: NSCKP

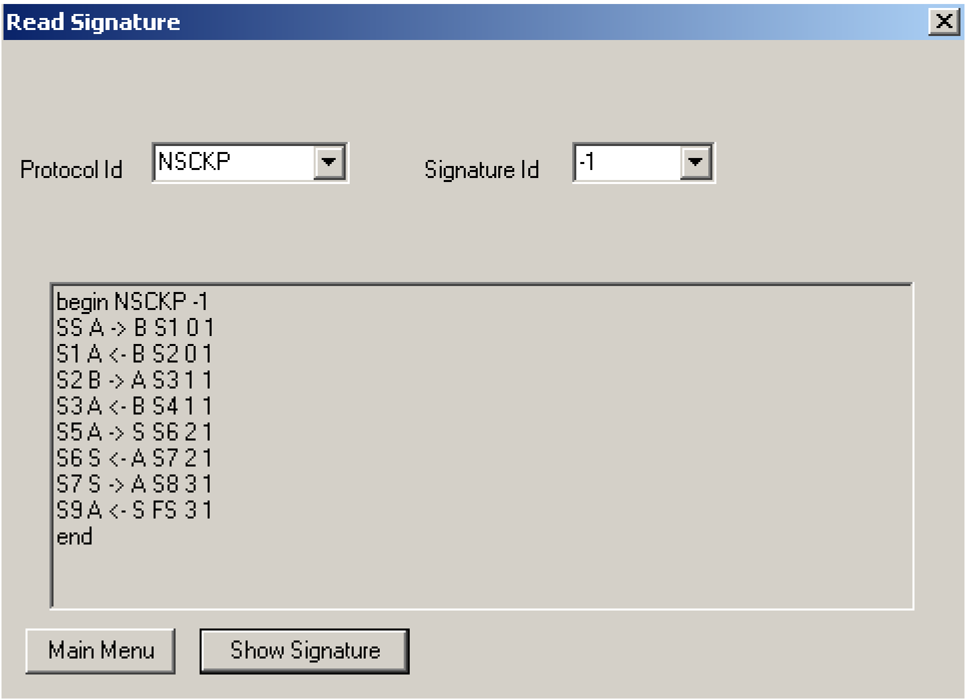
Signature Id: -1

```
begin NSCKP -1
SS A -> B S1 0 1
S1 A <- B S2 0 1
S2 B -> A S3 1 1
S3 A <- B S4 1 1
S5 A -> S S6 2 1
S6 S <- A S7 2 1
S7 S -> A S8 3 1
S9 A <- S FS 3 1
end
```

Do You Confirm the change !

To delete a signature the user has to choose the protocol id and the signature id of the signature. There are dropdown boxes to choose these fields. The boxes are filled up automatically when the screen is displayed to the user. Once the fields are chosen the signature is displayed in the window, clicking the Delete Signature button pops a confirm changes box, which asks user whether the signature should really be deleted, if the user decided against it cancel is clicked the control goes back to the Delete Signature screen.

Read Signature



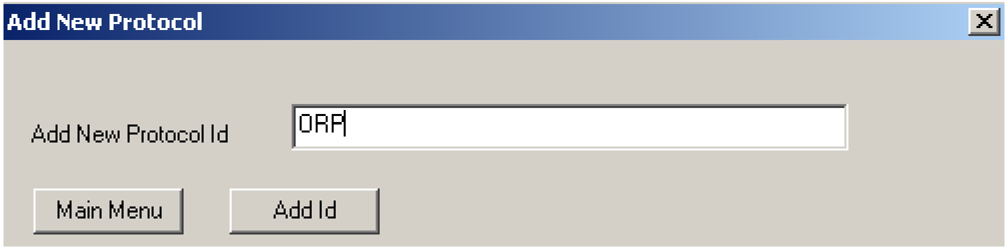
Protocol Id NSCKP

Signature Id -1

```
begin NSCKP -1
SS A -> B S1 0 1
S1 A <- B S2 0 1
S2 B -> A S3 1 1
S3 A <- B S4 1 1
S5 A -> S S6 2 1
S6 S <- A S7 2 1
S7 S -> A S8 3 1
S9 A <- S FS 3 1
end
```

To read signature from the knowledge base, Read Signature screen is called. User has to enter the Protocol Id and the Signature Id, which can be chosen from the dropdown box. Once the fields are selected clicking the Show Signature button displays the signature on the window.

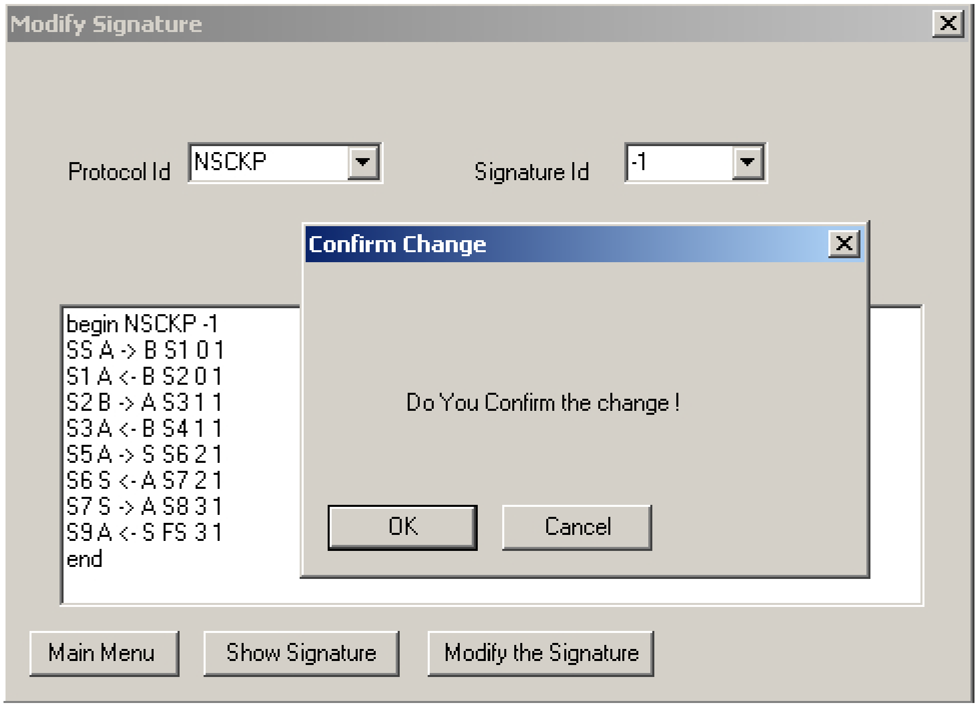
Add Protocol Id



Add New Protocol Id ORP

To add new protocol id in the knowledge bas, Add Protocol Id screen is used. The user simply has to enter the protocol id in the box, the id is converted to all capital letters and checked for duplication in the protocol id file. If there is already protocol id present then the user is informed about the duplicates and asked to enter another id.

Modify Signature



Protocol Id NSCKP

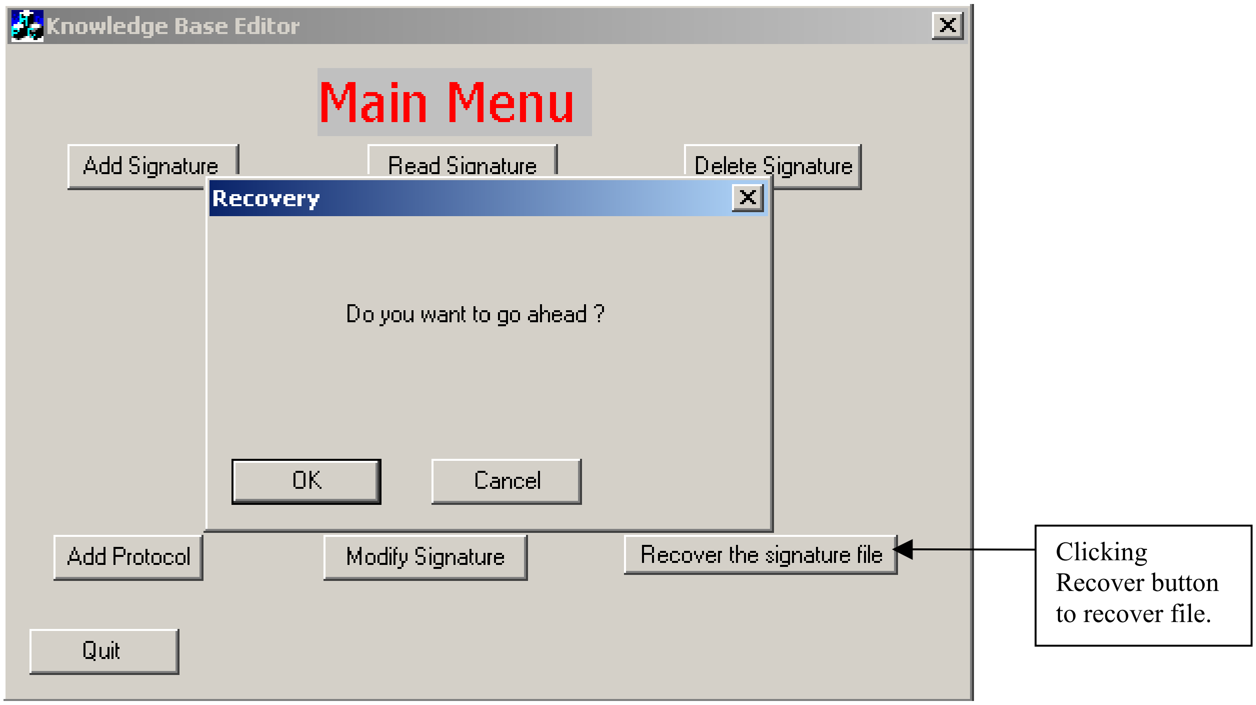
Signature Id -1

```
begin NSCKP -1
SS A -> B S1 0 1
S1 A <- B S2 0 1
S2 B -> A S3 1 1
S3 A <- B S4 1 1
S5 A -> S S6 2 1
S6 S <- A S7 2 1
S7 S -> A S8 3 1
S9 A <- S FS 3 1
end
```

Do You Confirm the change !

To modify an existing signature the Modify Signature screen is used, the user has to choose the protocol id and the signature id of the signature to be modified from the dropdown boxes. The corresponding signature is displayed in the editable window. A signature can then be modified and saved. Once there is any modification done on the signature the user is asked to confirm the change before the signature is saved. To cancel the change cancel button can be clicked when the application asks to save changes in the signature file.

Recovery of signatures



Do you want to go ahead ?

Clicking Recover button to recover file.

This feature is implemented for robustness of the application and to keep SEADS going on in the event of a loss of the signature file. By clicking the “Recover the signature file” button, the backup signature file is copied to the original file. The backup file has the latest changes done to the original signature file.

8. References

[1] Alec Yasinsac, “Detecting Intrusions in Security Protocols”, Proceedings of first workshop on Intrusion Detection Systems, in the 7th ACM Conference on Computer and Communications Security, June 2000, pp.5-8.

[2] John Clark and Jeremy Jacob, “Attacking Authentication Protocols”, High Integrity Systems, August 1996, pp.465-474.

[3] Dorothy Denning and G.Sacco, “Timestamp in Key Distribution Protocols”, Communications of ACM, 24(8), August 1981, pp. 533-534.

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[5] Roger Needham and Michael Schroeder, “ Using Encryption for Authentication in Larger Networks of Computers”, Communications of ACM, 21(12), December 1978, pp. 994-995.

[6] Paul Syverson, “A Taxonomy of Replay Attacks,” Proceedings of the Computer Security Foundations Workshop VII, Franconia NH, 1994 IEEE CS Press (Los Alamitos, 1994)

[7] CIDF, Common intrusion detection framework. http://gost.isi.edu/cidf.