A Novel Framework for Detection and Prevention of JavaScript-XSS Attacks in Android based Hybrid Applications

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The development and analysis of mobile applications have become an active research area. The concept of hybrid applications has emerged in the last three years where applications are developed in both native and web languages. The use of web languages raises certain security risks in hybrid mobile applications as it creates possible channels where malicious code can be injected inside the application. In hybrid mobile applications, WebView, an important component, implements the sandbox mechanism to protect the local resources of smartphone devices from un-authorized access of JavaScript. The WebView application program interfaces (API’s) has security issues as the attackers can attack the hybrid application via JavaScript code by bypassing the sandbox security by accessing the public methods of the applications. Cross-Site Scripting (XSS) is one of the most popular malicious code injection techniques for accessing the public methods of the application through JavaScript. This research study proposes the framework for detection and prevention of XSS attacks in hybrid applications using state of the art Machine Learning (ML) algorithms. The proposed framework detects the attacks using the registered Java object features. The dataset and the sample hybrid applications have been developed using the android studio. Then the widely used RapidMiner toolkit has been used for empirical analysis. The results reveal that ensemble based Random Forest algorithm outperforms other algorithms and achieves the accuracy and F-measures as high as of 99%. The proposed framework can be helpful to detect and prevent XSS based attacks on hybrid applications in the future.

Index Terms—Artificial Intelligence, sandbox, WebView component, hybrid mobile applications, XSS Attacks.

I. INTRODUCTION

In the past few years, the rate of using smart phones and mobile applications has increased tremendously. There are two main types of XSS attacks: Persistent XSS attack, Non-Persistent attack ¹. In persistent attack attacker store malicious script in server and when victim access that server then that malicious script start working in victim’s browser and in return important information send to the attacker. In non-persistent attack attacker sends malicious script in victim browser and when victim runs that script then in return web application open and from there attacker steal important information. According to the report of WhiteHatSecurit ², almost 432 million android smartphones have been sold in year 2017. This study also reports that almost 30% attacks are involved in web applications (Asynchronous JavaScript and Extensible Markup Language (AJAX) Intrusion ³, Phishing Attacks etc), 62% attacks are based on feature hacking to exploit vulnerabilities, 81% attacks are hacking related breaches that leveraged weak or stolen passwords and 32% attacks are exploited structured query language (SQL) Injection errors in dynamic web applications ⁴. Another report by Gartner indicate that more than 50% mobile applications are using hybrid technology ⁵. Hybrid applications are developed using both Java and Web languages such as Hypertext Markup Language (HTMIL), Cascading Style Sheets (CSS) and JavaScript ⁶. The structure of hybrid applications is similar to web applications, but in hybrid applications the main component is WebView ⁷. ⁸, which is a component provided by the browser engine named WebKit. WebView provides the basic browser functionality to load and display web pages within android applications without switching to the default browser. This WebView based facility decreases the time of loading of web pages. More importantly, android application can interact with JavaScript code embedded in web pages directly ⁹. WebView component is placed inside a native container. Therefore, it can easily access mobile hardware resources such as mobile libraries, messages, contacts with the help of API’s. Since, WebView uses different API’s to access resources and due to the potential loopholes in these API’s almost 90% hackers uses XSS attacks to hack different types of smart phone devices ², ¹⁰. In hybrid applications, the XSS attack mechanism is a little bit different from normal web attack but the main concept behind the attack is same. Most common attacks in hybrid applications are Invoking native Java from JavaScript (through WebView) and invoking JavaScript from native Java (through WebView) ⁹. In hybrid applications while invoking of Java from JavaScript attacker stores the malicious JavaScript code in webpage when that webpage open in the application then an object is registered in the WebView. First of all, attacker access that object through JavaScript and through that object attacker access the native method of that application from where an attacker can easily get different smartphone resources by triggering important built in functions inside the native method.

To address aforementioned research issues, we propose XSS detection and prevention framework. The steps of the proposed approach are as follows. First of all, when a Java object is registered in WebView then in our prevention system, Threat
WebView bypasses the sandbox mechanism, WebView component and describes how it works. We hooked the addJavascriptInterface API and detection framework, thus that every Java object that is intended to be registered into WebView can be inspected. Prevented threats by performing analysis by using analysis framework in which we classify our recorded inputs into two categories 1) No threats found 2) Threat found.

B. Organization

The paper organization is as follows: Section II is Related work, it reviews the existing studies. Section III analyzes the sandbox mechanism, WebView component and describes how WebView by passes the sandbox mechanism. Section IV and V will present our problem statement and propose framework which will be based on following parts detection of XSS and prevention of XSS. Tools which have been use and dataset which have been generate for evaluation will explain in section VI. The results of our analysis are presented in section VII. On the basis of these results we will decide which algorithm is better for our detection system. Section VIII concludes this paper.

II. RELATED WORK

The relevant literature presents a number of research studies to detect and prevent the security attacks on the hybrid applications. We have differentiate several examined approaches into three categories: a) Classification based techniques b) Simple techniques, and c) Soft computing based techniques.

A. Classification based techniques

There are a lot of mobile frameworks which are used in development. Mostly android hybrid applications developed with PhoneGap framework and through this framework attacker can easily bypass sandbox mechanism. That is why hybrid applications provide a way to bypass access control policies of WebView and webkit and run malicious code in users application. In PhoneGap plugins, malicious code can access and steal users private information and destroy users file system. In hybrid application JavaScript is also used in development. Therefore, attackers can launch their attack through encoded JavaScript in human-unreadable form on rendering webpages in users application. On classifying different types of applications result came up with 95.3% precision. That means most of the applications are suffering from this issue [4], [11]. As different type of websites render in WebView in hybrid applications. Attackers can also launch attack through malicious URLs. Then by applying improved semisupervised algorithm to construct URL multi-classification model. Hybrid applications can detect and blacklist URLs through efficient URL classification in [12]. Different websites render in WebView consist of HTML tags, script functions, hyperlinks and advanced features. However, these features increase the security risk. Features extracted by Angelo et al in [13] accuracy of automatic XSS classification is improved by 98.5%.

B. Simple techniques

WebView is an essential component in hybrid applications which provides different API’s through which application can interact with web pages. This interaction allows to access resources using Java Object. Access control on security-sensitive API’s at java object level uses static analysis to detect these sensitive API’s at runtime and notify user if finds any threat [7], [9]. Since, attacker can launch attack using different strategies, SQL injection is one of them. Inyong et al removes the value of an SQL query attribute of web pages when parameters are submitted and then compares it with a predetermined one. This method shows an effective results [17], [19]. Another emerged strategy is ADSandbox a system which detects malicious websites attacks through JavaScript by logging every critical action of website. Using these logs ADSandbox decides that website is malicious or not [14]. Android Application (AA) Sandbox is also an efficient strategy which performs both static and dynamic testing in android programs to automatically detect suspicious applications [15]. Different hybrid applications are developed in multiple languages with different semantics which may be vulnerable. HybriDroid, a static analysis framework which investigates semantics especially for the interoperation mechanism of Android Java and JavaScript. This framework analyzes inter-communication between Android Java and JavaScript. [8] Another framework Crowdroid which is embed in framework for collection of traces. It works on two types of datasets. 1) Artificial malware created for test purposes 2) real malware found in the wild. In [20], a simple technique have been proposed to detects the XSS attack in an efficient way. Another framework Cordenove combine HTML5, JavaScript (JS) and Native application code to develop hybrid application. However, combining languages increases security threat. Achim et al method constructs a uniform call graph for hybrid applications through which system can detect malicious calls [22], and there are a lot of hidden injection points in HTML5 based web applications through which attacker can attack and steal important information. Context-Sensitive sanitization based XSS framework can detect those injection points and sanitize them and remove XSS.
attacks \cite{30}. It's very important to analyze and detect malicious behavior in applications for analysts. Mobile Sandbox covers this whole perspective in two ways: 1) by combining static and dynamic analysis. 2) by using specific techniques to log calls to native API's. This system works on 36000 applications and results came up with just 24% applications use native calls \cite{16}. In hybrid applications Permissions are not enough to ensure the security of private information. SCANDAL, a sound and automatic static analyzer which detects privacy leaks in android applications and alerts the user if threat found. It analyzes real-time applications and detects privacy leaks in 11 applications and 8 known malicious applications \cite{21}. Malicious applications can be third party applications which can access and steal sensitive data. TaintDroid provides real-time analysis of third-party applications, 68 instances of potential misuse detected \cite{28}.

C. Soft computing based techniques

Artificial Intelligence plays a vital role in detection and prevention of XSS attacks in hybrid applications: Static analysis detects different XSS vulnerabilities and then genetic algorithm searches input values and detect the threat by exposing vulnerabilities by using those inputs \cite{24}. Another approach to expose XSS attacks using genetic algorithm is by creating XSS attack patterns. By using test data if it uncovers any path then it records as malicious. So genetic algorithm-based test data generator uses a database of XSS attack patterns to generate possible attacks and assess whether the attack is successful or not \cite{25}. By applying Machine Learning techniques on static features extracted from Androids application files for the classification of the files. Features are extracted from Androids Java byte-code and other file types such as XML-files. Evaluation performed on 2850 applications and gain an accuracy level of 91.8% \cite{26}. One of the popular ML technique is data mining which can also detect XSS attacks. With the combination of data mining and taint analysis (detects candidate vulnerabilities) techniques to detect false positives generate 5% better results than PhpMinerII’s and 45% better results than Pixy’s \cite{27}. We can also improve our XSS detection results by combining genetic algorithm and static analysis. Pixy is used to detect vulnerabilities then using CFG infeasible paths are removed using test data to uncover XSS attack if exist. Then GA is applied to only those paths to detect XSS Attacks \cite{31}. Finally XSS attacks can also detect by combining model inference and evolutionary fuzzing. Inference model is used to obtain knowledge. Based on this knowledge genetic algorithm (GA) generate inputs with better fitness values \cite{32}.

III. BACKGROUND INFORMATION: ANALYSIS OF SANDBOX AND WEBVIEW

To understand that how XSS attacks are launched through WebView component? To answer this question first of all we have to understand following two main concepts: Sandbox mechanism (WebView Security) and WebView component (Working of WebView).

![Sandbox mechanism](image)

Fig. 1: Sandbox mechanism.

A. Sandbox:

WebView is a mini browser inside each hybrid application. All the browsers have an access control mechanism which is called Sandbox. It isolates the web pages which are running inside WebView component. Therefore, if there is malicious JavaScript is running inside WebView through web page, then Sandbox will isolate that JavaScript and block it, thus JS cannot access to the mobile local resources. There are two main objectives which are achieved by the sandbox:

- Isolate web pages from the system and isolate web pages of one origin from those of another.
- Enforce the Same-Origin-Policy (SOP).

The whole process of sandbox is presented in Figure 1 and it is clearly shown that sandbox is isolating JavaScript and blocking it from accessing to local resources of mobile. This JS is running inside the web pages and these web pages are executed inside the WebView component \cite{4, 7, 9, 14}.

B. WebView

WebView component is mainly powered by a browser engine which is named as WebKit. WebView provides basic browser functionality to load and display web pages within Android applications without switching to the default browser. In other words, we can say that WebView is a mini browser inside an application. More importantly, Android application can interact with JavaScript code embedded in web pages by using the WebView API’s. API’s are used in the interaction between the android application and web pages and those API’s are setJavaScriptEnabled API, addJavascriptInterface API, loadUrl (Uniform Resource Locator) API \cite{7}. SetJavaScriptEnabled API enables the JavaScript and addJavascriptInterface API registers the Java object and loadURL API loads the web page.

C. Bypassing sandbox mechanism

Whenever, user click on any type of link in the application, then that application close and open that link in mobile browser so this whole process take too much time. To remove this issue (time consuming) android companies create a built in component which is WebView. It is a custom and powerful browser inside the application. Applications with this browser whenever user click on any type of link, then that link opens in that WebView and does not jump to the mobile browser. As a result this component eliminates the jump from
application to mobile browser and increase the time efficiency. However, this WebView component opens a new Pandora box of security threat through this WebView attacker can easily access mobile resources by launching XSS attacks. We have to understand the weakness of the sandbox which is not detecting those attacks. As shown in Figure 2 in WebView there is a sandbox security mechanism which protects the local resources of mobile from JavaScript attacks, but WebView component bypasses the sandbox mechanism with the help of WebView API which are already explained in the previous section. And this creates a path through which JavaScript can easily communicate with native Java through this path attacker can trigger different class methods of Java and he can also access important functions of mobile. In this way, an attacker can easily access the local resources through native Java code. The attacker can easily launch his attack by running malicious website inside WebView with the help of malicious JavaScript attacker can access mobile resources by accessing native code through WebView by registering objects.

IV. PROBLEM ILLUSTRATION AND STATEMENT

The hybrid application concept comes in 2016. Hybrid applications are those applications which are developed by using both web language and mobile language (Native language). Whenever user click on any type of link in the application, then that application close and open that link in mobile browser so this whole process take too much time. To remove this issue android company creates a component which is WebView. It is custom powerful browser inside the application. Whenever user click on any type of link, then that link open in WebView without switching to the mobile browser. Thus, this WebView component eliminates switching of application. In WebView there is a sandbox security mechanism which protects the local resources of mobile from JavaScript. If we analyze WebView component, then this component bypasses the sandbox mechanism as explained in section 3.3 and creates a path through which an attacker can easily launch his attack using API’s by running malicious website inside WebView by accessing registered Java object using AddJavaScriptInterface API. Through this API attacker can access native JavaScript code. Therefore, our aim is to detect and prevent these XSS attacks in WebView.

V. THE PROPOSED FRAMEWORK

The proposed framework is organized as follows: 1) Steps through which we will detect attacks on sensitive API’s. Then those challenges which we face to perform following steps. 2) Detection framework which detects attacks on API’s. 3) Prevention framework which will prevent an attack.

A. Steps and Challenges

As discussed in the previous section that in WebView main threat is generated from the use of different types of WebView API’s. One of the most important and vulnerable API is addJavaScriptInterface() which registers the Java object. Thus, we need to take control of that Java object. Therefore, we performed the following steps:

1) We applied our proposed model on the Java object level.
2) We detected that if this object is accessing important API which can cause harm to the user information.

To perform the above two steps we need to address the following main challenges:

a) We need to understand that how WebView API’s can be executed by Java object.
b) What type of security-sensitive API’s can be triggered through Java object.
c) What to do if a threat is detected at Java object level.

Below is the description of how to address these challenges. To address the challenge (a), we need to understand three things Java object registration, JavaScript, enabling and loading of the website. In WebView API named as addJavascriptInterface() help the Java object to be registered in WebView. By default JavaScript is disabled in WebView to make JavaScript enable API setJavascriptEnabled() is set to true. Then API LoadURL() loads the website inside WebView container. As JavaScript object is registered with loaded URL and JavaScript is enabled so JavaScript inside website can easily access that registered object and by access that object JavaScript can access native methods from where JavaScript will trigger/execute WebView API’s [9].

To address the challenge (b), we have to identify all those API’s through which an attacker can steal any information. Therefore, most of sensitive API’s have been enlisted in Table I.
To address the challenge (c), we will apply the ML technique to detect these types of attacks. We will use the same concept of threat detection at runtime to detect weather threat exist in Java object or not as explained in [7]. Now, to prevent these types of attacks, we have to develop such type of system using ML technique which detects an attack and ask for the users permission. And for that, we will apply the ML algorithm using classification techniques which will detect the attack in detection unit and sends the result to prevention framework. Then prevention framework will ask the user to allow it or not. If user gives the permission then go on or block that attack. We will find out the answer of this challenge in section 5. In which we will explain our full framework in detail. From where the main concept of our proposed system will be clear out.

### B. Detection Framework

In this section, we will explain our detection framework. In this part of the system we will explain the whole detection unit Part in which we will see that how we apply classification technique using machine learning algorithms and will also see that how this part of the system is playing an important role in the detection of XSS attacks. On what response of this framework, prevention framework takes a decision. Shown in Figure 3 this part of the system is divided into 4 levels. In level 1 collection of Dataset is performed and then pre-processing is performed and saved in the database. Then at level 2 we apply 10-fold cross validation using machine learning algorithms. We apply different Machine Learning algorithms which are evolutionary Support Vector Machine (SVM), Evolutionary-Support Vector Machine (E-SVM) which is a genetic engineering base algorithm, Random Forest, which is an ensemble based algorithm, Nave Bayes a classical probabilistic based algorithm, J48 which is decision tree based C4.5 algorithm and Artificial Neural Network (ANN) algorithm. The reason we apply different algorithm is to identify the best performance algorithm in this situation. We identify the performance of algorithms on the basis of performance measures which are Accuracy, Precision, Recall, F-Measures. At level 3 On the basis of classification results we identify the performance of algorithms using F-Measures and return decision to prevention framework. At level 4 we apply selection algorithms which are Information Gain (IG), Gain Ratio (GR) and Relief-F (RF) to identify the importance of features. Through this way we can identify that which feature is playing an important role in identifying of XSS attacks.

### C. Prevention Framework

In this section we will explain our prevention framework, which prevent an attack on the Java object level.

This framework defines the steps of prevention of XSS attacks in android system as shown in Figure 4. This part of the system is divided into three main parts which are applications layer, framework and libraries. The following process describes the flow in the proposed 1st part of the framework.

1. After opening of malicious website inside WebView the android application calls the addJavaScriptInterface() API.
2. The proposed method intercepts the call to the addJavaScriptInterface() API and pass all information about the object to Threat Prevention Unit.
3. Then features extractor, extracts the features of object from threat prevention unit. This feature extraction is performed by using the feature extraction algorithm.
4. Detection unit (which we will explain in 5.2 section) get all of the features and apply classification on that features using Machine Learning algorithm. After that it send final result (attack or not [Yes / No]) to threat prevention unit.
5. If threat prevention unit receives result Yes from detection unit, the proposed method calls the alert application: otherwise it proceed to step (9) where it takes the decision No automatically and then proceed to step (10)
6) The proposed method warns the user about the threat. Where it shows the information about attacking Webpage Name, Object Name, Security Sensitive API calls by the object.

7) The user reply to the Alert Application to decide, whether to disable the Java Object or not.

8) The alert application forwards the user’s decision to the threat prevention unit.

9) The threat prevention unit decides to disable the object or not on the basis of users’ decision.

10) If threat prevention unit decision is No then it allow object to register.

11) Then that object can access methods of Java class from where it can access different mobile libraries.

12) If threat prevention unit takes decision Yes then it disable Java object and block that website.

![Fig. 4: An architecture of the prevention framework for attack prevention.]

VI. EXPERIMENTAL SETUP

In this section we will discuss the tools which we used and dataset which generated for evaluation. And on that dataset, applied ML algorithms and with the help of performance evaluation measures we find the accuracy of every algorithm. On the basis of that accuracy, we selected the best ML algorithm for our experiment setup.

A. Tool

If we talk about the tool we use is rapidminer [33]. RapidMiner is a software platform for data science teams that unites data prep, machine learning, and predictive model deployment. Organizations can build machine learning models and put them into production faster than ever, using Rapid Miners lightning fast visual work-flow designer and automated modeling capabilities.

B. Algorithms

To check how accurate classifiers classified the XSS training set classification accuracy, precision, recall, are taken as the measure. We define accuracy, recall and precision respectively.

1) **Accuracy**: Accuracy is used as a performance measure in the domains of information retrieval and data mining. It depicts the fraction of the results that have been successfully retrieved.

\[
\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}
\]  

Here FP, FN, TN, and TP, stand for False Positive, False Negative, True Negative, and True Positive respectively.

2) **Precision**: Precision is the performance evaluation measure that may be known as the ratio of retrieved documents that are related to the search

\[
\text{Precision} = \frac{TP}{TP + FP}
\]

3) **F-Measure**: The f-measure takes precision and accuracy. It may be considered as the weighted average of both values

\[
F = \frac{2 \times \text{precision} \times \text{Recall}}{\text{precision} + \text{Recall}}
\]

4) **Recall**: The recall is also known as the sensitivity is the ratio of related instances that have been retrieved over the total amount of retrieved instances.

\[
\text{Recall} = \frac{TP}{TP + FN}
\]

C. Dataset

We created our own dataset named as APK_XSS_ATTACK (where APK is Android Package Kit). To collect benchmark data, we created a demo victim application through that application, we launch a live attack, and then we record those live attacks at run time. We take 17 live attacks entries and then on the basis of that pattern which we record for XSS attacks, we generate 444 raw XSS attacks to meet standard dataset requirements. In this dataset the attack ratio is 50%. We have gathered 461 APKs samples.

| Feature Name | Description |
|--------------|-------------|
| App Names    | Name of victim applications |
| Permissions  | Include all webview permotes |
| APIName      | Name of all sensitive API |
| WebsiteName  | Name of malicious webpage |
| IP           | IP of website |
| Location     | Country Location of website. (From which country attack is launched) |
| Label        | Class of attack (Yes / No) |

We extract 6 main features which are described in Table II. One of the most important feature is API Name. In this feature we record the names of that sensitive API which gives access to sensitive information.
### RESULTS

In this research, 6 features are extracted from each XSS attack in the dataset. Three dimension reduction techniques are applied to the features of the dataset. These techniques are famous for feature selection: Information Gain (IG), Gain Ratio (GR), and Relief-F. Those 6 features are shown in Table III. We rank those features on the basis of feature selection algorithms. Through this, we identified that which feature is playing an important role in the detection of XSS attacks. We need this information to improve our accuracy.

### Table III: Characteristics of attacks.

| Categories | Total |
|------------|-------|
| Total XSS Attacks | 461 |
| XSS Attacks | 230 |
| Non XSS Attacks | 230 |

If we talk about the characteristics of the dataset shown in Table III, We record total 461 attacks. From these, we record total 230 XSS attacks (accessing sensitive API’s) and 230 are those entries which are not XSS attack (not accessing sensitive API’s).

#### D. Dataset Conversion:

As we know that a Machine Learning algorithm does not apply on nominal dataset. Thereby, we have to convert data to numerical form to apply ML algorithm. For that, we perform a conversion using component (Nominal to Numerical) in rapidminer. In this component, unique integers option is selected by this algorithm, the values of nominal attributes can be seen as equally ranked, therefore the nominal attribute simply be turned into a real valued attribute, the old values result in equidistant real values.

### VII. RESULTS

Through graphical representation of results shown in Table V, it is clear that which algorithm is giving better performance. On the basis of that performance, then best algorithm have been selected. As through these generated graphs, the whole picture of algorithm selection is clear now. Both of these parameters Accuracy and F-measure is calculated in %. Random Forest outperforms all other algorithms, apparent from Accuracy and F-Measure results shown in Figure 5 (Graphs are generated on the basis of Table V). Although other classifiers E-SVM, Naive Bayes and Neural Network also showed good results in the classification process. However, Random Forest is the most suitable classifier evident from accuracy and f-measure results. Thus, this proves that if we implement random forest, then it detect XSS attacks much better as compared to other algorithms in detection framework as discussed in Section V-B.

### Table IV: Feature ranking by IG, GR and Relief-F.

| Features | Information Gain | Gain Ratio | Relief-F |
|----------|------------------|------------|----------|
| API Name | 0.860            | 0.861      | API Name 2.875 |
| Permissions | 0.021       | 0.108     | Permissions 0.116 |
| Location | 0.006            | 0.018     | Location 0.018 |
| App Names | 0.005          | 0.108    | IP 0.007 |
| Website Name | 0.005     | 0.108    | Website Name 0.007 |
| IP | 0.005            | 0.097    | App Names 0.006 |

The API Name is ranked at 1st by IG, GR and Relief-F. Ranking of this feature clearly shows the importance of this feature. Permissions feature is ranked at 2nd by IG, 3rd by GR and 2nd by Relief-F. Location feature is ranked at 3rd by IG, 6th by GR and 3rd by Relief-F. App Names feature is ranked at 4th by IG, 2nd by GR and 6th by Relief-F. Website Name is ranked at 5th by IG, 4th by GR and 5th by Relief-F. IP feature is ranked at 6th by IG, 5th by GR and 4th by Relief-F.

#### A. Results of classifiers using Cross-Validation

On ranked attributes of dataset mentioned in Table III, machine learning classifiers are applied using cross-validation settings. E-SVM (Evolutionary Support Vector Machine), SVM (Support Vector Machine), NB (Naive Bayes), RF (Random Forest), Bagging and NN (Neural Network) apply to the selected feature set. 10-fold cross-validation is used to train the test data set. The accuracy and f-measure parameters are used to evaluate the performance of these algorithms. Now let's analyze the results of different classifiers.

### Table V: Performance of ML algorithms.

| Algorithm | Accuracy (%) | F-Measure (%) |
|-----------|--------------|---------------|
| E-SVM     | 99.13        | 99.11         |
| SVM       | 96.30        | 96.43         |
| Naive Bayes | 97.10      | 98.94         |
| Random Forest | 99.57    | 99.57         |
| Bagging   | 93.48        | 93.92         |
| Neural Network | 97.17    | 97.29         |
| J48       | 98.70        | 98.70         |

Fig. 5: Accuracy and F-Measure analysis of ML algorithms.
If we talk about the RF (Random Forest) algorithm then the execution time of this algorithm is best as compared to other algorithms which is 1s and accuracy of this algorithm is also better. Therefore, this proves that Random Forest is best suitable algorithm in every condition to detect XSS attacks. As a result, performance of Random Forest best as compared to all other algorithms.

C. ROC based Comparison

ROC curve, which shows the classification ability of classifier is shown in Figure [7]. In this research study the ability of classifiers is predicted by a threshold value in ROC curve graphs. ROC is measured by the TP rate and FP rate.

If we see more deeply the performance of classifiers then from this graph shown in Figure [7] it is clearly shown that the performance of NB and RF is much better as compared to other classifiers. And, if we compare these NB and RF with each other, then the accuracy of RF is 99.57% and accuracy of NB is 99.10%. It makes clear that in term of simple performance these two classifiers are better, but in term of accuracy and performance then RF is far better than NB. Therefore, for our system RF is the best classifiers to catch XSS attacks.

VIII. Conclusion

In this research paper, we proposed a detection and prevention framework for XSS attacks in hybrid applications. In hybrid applications attacker launch his attack on mobile resources through WebView and bypass the sandbox mechanism using WebView API’s. To prevent these types of attacks we propose our own detection system on Java object level, which have two main parts 1st is detection and 2nd is prevention through classification. To the best of our knowledge, there is no proposed system which is detecting XSS attacks using AI. Our approach is based on AI algorithm. Our research study shows that our proposed approach to detect and prevent XSS attacks much efficiently as compared to previous proposed systems, such as, [7]. We took different top ML classification algorithms, such as, Evolutionary SVM (E-SVM), Simple SVM (SVM), Nave Bayes (NB), Random Forest (RF), Neural Net (NN), Bagging. To assess the classification capability of these different classifiers, we extract new features and create our own dataset which is named as APK_XSS_ATTACKS in which we record 461 attacks. Cross-validation settings are applied to divide the data into test and training set. 10-fold settings are used. The classifier performance is assessed by the performance evaluation measures. On the bases of these performance evaluation measures Random Forest (RF) out performed all classifiers in term of accuracy and F-measure.
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