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SURVEY: PERFORMANCE EVALUATION OF SELECTIVE ENCRYPTION ALGORITHM FOR MOBILE ADHOC NETWORK

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ABSTARCT:

Information Security has become an important issue in data communication. Encryption has come up as a solution, and plays an important role in information security system. This security mechanism uses some algorithms to jumble data into unreadable text which can be only being decoded or decrypted by party those possesses the associated key. In this article we present a survey of secure ad hoc routing protocols for wireless networks. These algorithms consume a significant amount of computing resources such as CPU time, memory and battery power and computation time. We briefly present the performance of different selective encryption algorithm; Full encryption algorithm, Toss-a-coin selective encryption algorithm and Probabilistic selective encryption algorithm. The comparison between the proposed solutions and parameters of ad hoc network shows the performance according to parameter used in simulation. our simulation indicates that the technique of selective algorithms can indeed improve the efficiency of message encryption.

Keywords *— WirelessSecurity; Data Confidentiality; Selective Cryptographic Algorithm; Symmetric Key Encryption; Wireless Ad hoc Networks.*

1. INTRODUCTION

Wireless networks [1] consist of a number of nodes which communicate with each other over a wireless channel which have various types of networks: sensor network, ad hoc mobile networks, cellular networks and satellite networks. Wireless sensor networks consist of small nodes with sensing, computation and wireless communications capabilities. Many routing protocols have been specifically designed for WSNs where energy awareness is the key issue. Routing protocols in WSNs [2] differ depending on the application and network architecture. Ad-hoc networks are a new paradigm of wireless communication for mobile hosts where node mobility causes frequent changes in topology. In recent years, the explosive growth of mobile computing devices, which mainly include laptops, personal digital assistants (PDAs) and handheld digital devices, has impelled a revolutionary change in the computing world: computing will not merely rely on the capability provided by the personal computers, and the concept of ubiquitous computing emerges and becomes one of the research hotspots in the computer science society [3]. In the ubiquitous computing environment, individual users utilize, at the same time, several electronic platforms through which they can access all the required information whenever and wherever they may be [4]. The nature of the ubiquitous computing has made it necessary to adopt wireless network as the interconnection method: it is not possible for the ubiquitous devices to get wired network link whenever and wherever they need to connect with other ubiquitous devices. A Mobile Ad hoc NETwork (MANET) is a system of wireless mobile nodes that dynamically self-organize in arbitrary and temporary network topologies In the mobile and ad hoc network, nodes can directly communicate with all the other nodes within their radio ranges; whereas nodes that not in the direct communication range use intermediate node(s) to communicate with each other. In these two situations, all the nodes that have participated in the communication automatically form a wireless network, therefore this kind of wireless network can be viewed as mobile ad hoc network. The ad hoc network has the following typical features [5]:

- Unreliability of wireless links between nodes. Because of the limited energy supply for the wireless nodes and the mobility of the nodes, the wireless links between mobile nodes in the ad hoc network are not consistent for the communication participants.

- Constantly changing topology. Due to the continuous motion of nodes, the topology of the mobile ad hoc network changes constantly: the nodes can continuously move into and out of the radio range of the other nodes in the ad hoc network, and the routing information will be changing all the time because of the movement of the nodes.
- Lack of incorporation of security features in statically configured wireless routing protocol not meant for ad hoc environments. Because the topology of the ad hoc networks is changing constantly, it is necessary for each pair of adjacent nodes to incorporate in the routing issue so as to prevent some kind of potential attacks that try to make use of vulnerabilities in the statically configured routing protocol.

Because of the features listed above, the mobile ad hoc networks are more prone to suffer from the malicious behaviors than the traditional wired networks. Therefore, we need to pay more attention to the security issues in the mobile ad hoc networks. For a wireless and mobile network, since wireless devices are usually equipped with batteries as their power supply, they have limited computational capability and the issue of energy saving is one of the most important concerns. As a result, an efficient selective encryption algorithm is a potential solution to save considerable power for wireless devices, and at the same time, to provide sufficient protection for data communication.

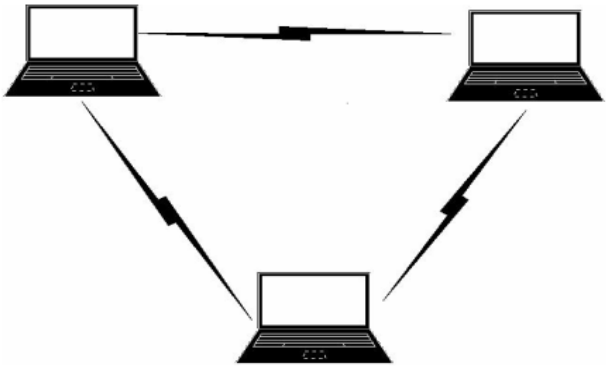

Figure1: Ad-hoc Network.

The rest of the paper is organized as follows. A general description of selective encryption algorithm that explain the architecture of SEA MANET is depicted in section 2. We explain the full selective encryption algorithm and Toss-a-coin selective encryption algorithm in section 3. The simulation environment is described in section 4. , we draw the conclusion for the paper and point out some potential works in the future.

2.RELATED WORK

To give more prospective about the performance of the compared algorithms, this section discusses the results obtained from other resources. *It was concluded in [8]* that AES is faster and more efficient than other encryption algorithms. When the transmission of data is considered there is insignicant difference in performance of different symmetric key schemes (most of the resources are consumed for data transmission rather than computation). *A study in [9]* is conducted for different popular secret key algorithms such as DES, 3DES, AES, and Blowsh. They were implemented, and their performance was compared by encrypting input less of varying contents and sizes. The results showed that Blowsh had a very good performance compared to other algorithms. Also it showed that AES had a better performance than 3DES and DES. It also shows that 3DES has almost 1/3 throughput of DES, or in other words it needs 3 times than DES to process the same amount of data. *A study in [7]* is conducted for different popular secret key algorithms such as RC4, AES, and XOR. They were implemented, and their performance was compared by encrypting for real time video streaming of varying contents. The results showed; encryption delay overhead using AES is less than the overhead using RC4 and XOR algorithm. Therefore, AES is a feasible solution to secure real time video transmissions. *It was shown in [6]* that energy consumption of different common symmetric key encryptions on hand-held devices. It is found that after only 600 encryptions of a 5 MB using Triple-DES the remaining battery power is 45% and subsequent encryptions are not possible as the battery dies rapidly. Using H.264 to compress and encrypt, videos can solve the speed and security problems in mobile application. Protecting the video information by encrypting selective data.[10] The FSET Encryption algorithm, is a direct mapping algorithm using matrix and arrays. Consequently, it is very fast and suitable for high speed encryption applications. The matrix based substitution resulting in poly alphabetic cipher text generation followed by multiple round arrays based transposing and XOR logic based translations give strength to this encryption algorithm.[11]. While several studies of selective encryption for video and image compression have been performed and documented [12, 13, 14], very few results on selective encryption of coded speech have been presented. Servetti and De Martin [15] investigated partial encryption of G.729 at 8 kbps with respect to what bits should be encrypted to provide security with respect to several factors, including intelligibility, gender identification, plain-text identification, and speech/non-speech discrimination. They demonstrate that partial encryption of about 45% of the bit stream provides protection equivalent to full encryption, and that encryption of as little as 30% of the bit stream precludes intelligibility. An important type of scalable speech coding, called SNR scalability, consists of a minimum rate bit stream that provides acceptable coded speech quality, along with one or more enhancement bit streams, which when combined with a lower rate coded bit stream, provide improved speech quality. SNR scalable speech coding addresses both the bandwidth efficiency and the resource conservation problems by allowing the nodes to prune the enhancement layers when wireless channels become congested, or in the case of MANETs, in order to conserve mobile node battery power, by avoiding excessive transmissions of enhancement layer bit streams [16].

3.THE SELECTIVE ENCRYPTION ALGORITHM (SEA)

AES-Rijndael with 128/192/256 bit keys and 16 byte data treats data in 4 groups of 4 bytes, operating an entire block in every round. At that time, AES are considered not suitable for visual data such as digital image because of long computation process. Recent advances in hardware capability and improvement in software have led to achieve the optimal execution rate when we can find the size of input state by implementing our SEA algorithm system. The result shows that the size of input state among 20 × 20 to 30 × 30 can get the least execution time. In this paper, we proposed a novel encryption algorithm called SEA which is selective and improves the AES algorithm. The Architecture of SEA is shown in Figure 1. The Architecture allows one to perform core idea of our algorithm is a optional manner implemented by Selector component given in Figure 1. The digital visual data have some different types, like video, audio, Image, text file, and so on. As we known, many kinds of platforms from many kinds of devices are over the wire/wireless network. Protection against unwanted eavesdropping is essential for the viability of wireless multimedia services. Furthermore, in many wireless applications, network resources, such as bandwidth, and node resources, such as battery power, must be conserved. Since full encryption of transmitted data streams can place a heavy signal processing burden on originating and receiving nodes, one is led to consider the concept of partial encryption of the data streams.

In partial encryption only a percentage of the transmitted data stream is processed by an encryption algorithm, with the remainder of the data stream being sent in the clear. The questions to be addressed in partial encryption are:

(i) What data must be encrypted to provide the needed level of security? (ii) Can a cryptanalytic attack on the data sent in the clear be mounted that will allow important information about the transmitted data to be discerned by an eavesdropper?

(iii) What is the percentage of the data stream that must be protected? Clearly, the data chosen to be protected must be the “most important” bits in terms of reconstruction of the content from the overall data stream, and this idea has lead partial encryption to sometimes be denoted as selective encryption, which is the terminology that we adopt in this paper.

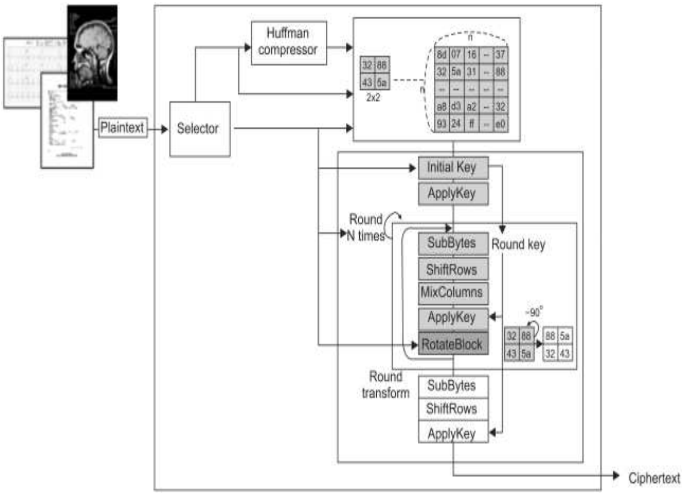

Figure2 **:** Architecture of SEA

4.THE ISSUES OF SELECTIVE ENCRYPTION AGLORITHMS

As we stated above, selective encryption are widely accepted in energy-aware contexts, due to the fact that they can reduce the overhead spent on data encryption/decryption, and improve the efficiency of the network. In this section, we present the principle of selective encryption and then study one of the most important methodologies.

Selective encryption can be measured in a number of different ways and optimized for a number of different objectives. Key factors and metrics in selective encryption include:

4.1 Security Criterion

selective encryption is proposed both in applications where it is sufficient to damage an attacker's "degraded" – and in applications where it is hoped that an attacker can gain no useful information at all about the content – a level we will call "secret." Obviously, it is not particularly damning to show that a system only intended to degrade content fails to make it secret. It is true, however, that "degraded" is vague as a metric as it will vary by particular attacker and be affected by the cost of the alternative purchase. A further complication is that in some applications the intention is to both degrade the content to make it desirable to purchase yet leave enough fidelity that the degraded content can serve as an advertisement for the purchased content.

4.2 Security Validation

In some cases researchers validate security (against their choice of criterion) by feeding a selectively encrypted stream to a standard decoder implementation and observing resulting reconstructions. In others, researchers use a cryptanalytic approach, playing the role of an active attacker able to work with a modified decoder and other available information to defeat the selective encryption.

4.3Complexity

One common goal of selective encryption is a reduction in the fraction of material that needs to be encrypted. This reduction needs to be measured and be offset against increases in complexity in, say, additional parsing operations necessary to implement selective encryption.

4.4Algorithmic Constraints

Some selective encryption systems limit themselves to working with fixed compression algorithms (e.g., standard MPEG), while others allow some variation in the compression algorithm to enhance selective encryption.

5. FULL ENCRYPTION ALGORITHM

In order to protect the confidentiality of communicated messages, selective encryption algorithm takes advantage of major categories of cryptographic techniques, symmetric and asymmetric key algorithms, to guarantee the security of exchanged information. Nevertheless, due to the constrained computational power of wireless devices, it is not realistic to encrypt all information always using the public key algorithms (PKI). Hence, all official data communication between two nodes will be encrypted through symmetric key, and in the meantime, these symmetric keys will be distributed by public key encryption algorithm. In a network, when a node wants to communicate with another node, a secret key (symmetric key) will be generated for their communication [16]. Let us denote the initiating node as *S* and receiving node as *R*. If an initiating node *S* moves into the neighborhood of node *R*, it will inform the node *R* of its public key for the authentication between them. The receiving node *R* then assigns a secret key to the initiating node *S* for the purpose of encryption/decryption. In order to distribute the secret key securely, *R* will encrypt this secret key using the public key of node *S* before sending it. Furthermore, *R* generates different secret keys for different initiating nodes. Thus, each sender has a unique secret key for communicating with the receiver and all information is encrypted using the corresponding secret key.

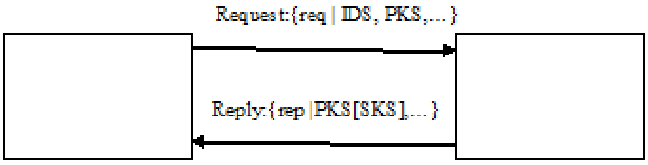
Request:{req | IDS , PKS ,... }
Reply:{ rep |PKS [SKS],... }

Figure 3:The schematic diagram of key distribution

The above figure illustrates the procedure of secret key distribution between a pair of nodes. The message's sender composes a communicating request message *req* which contains not only its identifier *IDS* , but also its public key *PKS* , for the purpose of their later mutual authentication. Once the receiver gets such a communication request, a secret key (symmetric key) *SKS* will be generated by the receiver and encrypted using the public key *PKS* of the requester, which is included in the communicating request message. Later, the receiver composes a communicating reply *rep* message and replies it to the communicating sender, in order to indicate that their communication has been successfully established. After the sender obtains the response from the receiver, it will use its corresponding private key *PRS* to decrypt the secret key *SKS* issued from the receiver.

6. A TOSS-A-COIN SELECTIVE ENCRYPTION ALGORITHM

First of all, in order to provide sufficient security to data encryption, in the first proposed approach, we choose a relatively high proportion as encryption ratio. Since the toss-a-coin algorithm is a basic approach, little uncertainty is involved. For all transmitted messages, we divide them to two groups: the odd number messages and the even number messages. For instance, messages *M1, M3, M5, … M*(*2n-1*) represent the odd number messages; messages; *M2, M4, M6, … M*(*2n*) represent the even number messages. When the sender needs to decide which group should be encrypted, it makes use of a toss-a-coin method to determine whether the even number messages or odd number messages are encrypted. As an example, we consider the following scenario, in which the even number messages are encrypted. After the method of toss-a-coin is applied, the sender makes the decision that only the even number messages *M2, M4, … M*(*2n*) are encrypted. Thus, half of the whole messages are chosen to be encrypted and this approach shows a basic selective encryption algorithm with a semi-determined encryption pattern. As we described before, the more data are encrypted, the more secure the communication is, but the more overhead is spent. Hence, the value of encryption ratio here is tentatively determined to be 0.5, which means that 50 percents of the communicated data will be encrypted.

7. PROBABILISTIC SELECTIVE ENCRYPTION ALGORITHM

In this section, we will present the design of a probabilistic selective encryption algorithm step by step, which not only reflects the idea of probabilistic encryption, but also uses both of symmetric key and asymmetric key. Specifically, our algorithm aims to involve sufficient uncertainty into the encryption process, while providing satisfactory security protection to communicating nodes. In the ad hoc network we discuss, the links between wireless nodes are always bidirectional and every wireless node has enough computational power to finish these operations. Here, we propose a probabilistically selective encryption algorithm, which uses the advantages of the probabilistic methodology, aiming to obtain sufficient uncertainty. During the process of sending messages, the sender will randomly generate a value to indicate the encryption percentage, which represents how many messages will be encrypted among the transmitted messages. Then, the sender uses a probabilistic function to choose the already deterministic amount of messages to encrypt them. We can see that more uncertainty is included to the probabilistic encryption algorithm, in comparison to the toss-a-coin approach, since the encryption ratio is randomly decided and the encryption pattern is not pre-determined. Moreover, this proposed selective algorithm is comprised of the following three phases:

1) The sender of communicating parties *S* will first apply a random generator *RNG* to randomly obtain an encryption ratio *er*, which determines the percentages of encrypted messages among all messages. Here, in order to ensure that enough data are able to be encrypted so as to provide sufficient security protection, the generated encryption ratio should be higher than a pre-determined value of security requirement *SR* (*SR* means that data communication is secure if there are *SR* or more percents of messages are encrypted).

$$S \xrightarrow{RNG} er \;|\{er >= SR\} \qquad (1)$$

2) Then the sender *S* will employ a probabilistic function *PF* to generate an encryption probability *pi* to determine if one message *Mi* will be encrypted or not.

$$S \xrightarrow{PF(mi)} Pi \qquad (2)$$

3) Eventually, the sender selects the messages to encrypt based on the above pre-determined encryption ratio *er*. For example, once *S* finds out that the encryption probability *pi* is less than or equal to the encryption ratio *er*, it will encrypt the message *Mi* using its secret key *SK*; otherwise, this message will not be encrypted accordingly

$$\begin{cases} S \longrightarrow SK[Mi] \qquad Pi<=er \\ \qquad\qquad\qquad\qquad\qquad\qquad (3) \\ S \longrightarrow Mi \qquad\quad\; Pi<=er \end{cases}$$

Thus, the probabilistic selective encryption algorithm integrates both the probabilistic method and stochastic strategy, in order to increase the uncertainty in the process of message selection. As we discussed in the theory of selective encryption, the more uncertain the encryption algorithm is, the secure data communication is, based on the assumption that sufficient data is encrypted to provide reliable security.

Performance analysis of the selective encryption scheme is divided into four parts, described as follows:

- ***Encryption Time Percentage:*** The percentages of the total time spent on encryption and decryption of selected messages to the total time encrypted all messages.
- **Encryption Time:** The overall time is spent on message encryption and decryption.
- ***Overall Time:*** The overall time is spent on the encryption for all message and communication.
- ***Encryption Proportion:*** The ratio of encrypted messages to the messages that are not encrypted.

8. SIMULATION RESULTS

The first approach will encrypt all messages without any selective encryption, and the second approach is the toss-a-coin approach. For the purpose of simplification, we use "full" to represent the first approach, "toss-a-coin" to represent the second approach. First of all, we compare the performance and efficiency of these approaches. Figures 8 illustrate the comparison of encryption percentages and time based on two approaches. We can learn that toss-a-coin have an obvious lower encryption time percentage than full encryption, which is caused due to the fact that selective encryption takes effect and the overhead is greatly saved. In Figure 6, the time spent on encryption/decryption is compared to show that full encryption takes a longer time than toss-a-coin. This means that data transmission can be speeded up by virtue of toss-a-coin. Hence, selective encryption is more efficient than full encryption and it is able to better utilize the computational resource of a wireless device.

In Figure 6, the comparison focuses on their efficiency and the factor of saving time is taken into account. Toss-a-coin has a higher saving time when compared to full encryption, indicating that it is more efficient and spends less time on encryption/decryption. Therefore, through the comparison of their efficiency, we learn that the selective encryption does help reducing the encryption overhead and improving the efficiency of encryption.

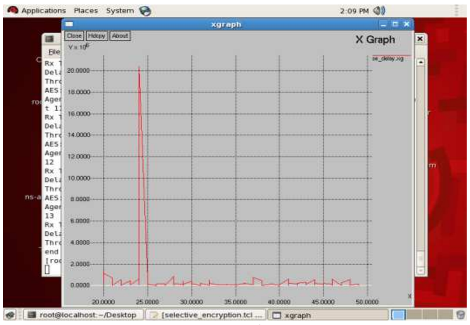

Figure4:Time required for Full encryption

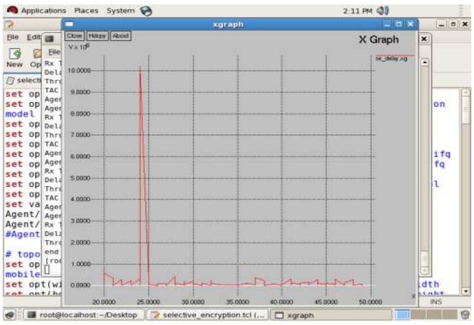

Figure5:Time required for toss-a-coin

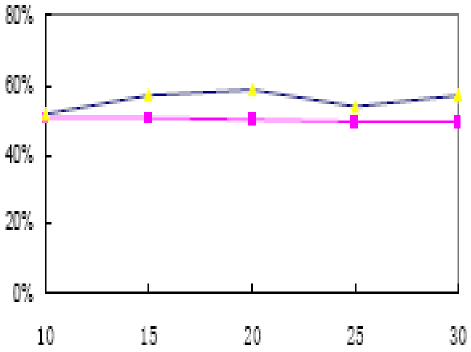

Figure6: Saving Time vs. Network Size

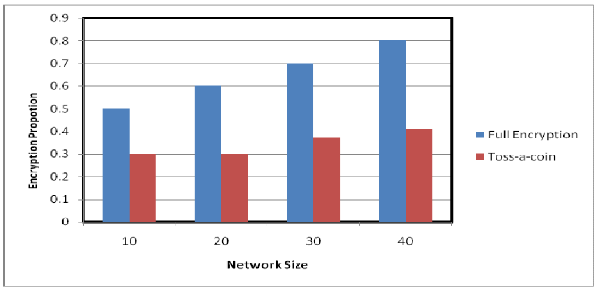

Figure7: Encryption Proportion vs. Network Size

9. CONCLUSION AND FUTURE WORKS

Theoretical analysis shows that the probabilistic selective encryption algorithm is one of the most promising solutions to reduce the cost of data protection in wireless and mobile networks. The probabilistic techniques the security for data communications between the messages' sender and receiver. The factor of encryption probability involves the uncertainty to data encryption. The first approach will encrypt all messages without any selective encryption, and the second approach is the toss-a-coin approach. For the purpose of simplification, we use "full" to represent the first approach, "toss-a-coin" to represent the second approach, and "probabilistic" to represent probabilistic approach. First of all, we compare the performance and efficiency of these approaches. The comparison of encryption percentages and time based on three approaches. We can learn that both toss-a-coin and probabilistic have an obvious lower encryption time percentage than full encryption, which is caused due to the fact that selective encryption takes effect and the overhead is greatly saved. The time spent on encryption/decryption is compared to show that full encryption takes a longer time than toss-a-coin and probabilistic encryption. This means that data transmission can be speeded up by virtue of toss-a-coin and probabilistic encryption. Hence, selective encryption is more efficient than full encryption and it is able to better utilize the computational resource of a wireless device. We compare the overhead spent on toss-a-coin and probabilistic encryption respectively, based on their encryption efficiency and effects. The probabilistic encryption has a little lower encryption proportion than toss-a-coin encryption but it is more flexible than toss-a-coin encryption. Because probabilistic encryption does not fix the encryption probability, the encryption proportion fluctuates in a relatively larger range. Thus, probabilistic encryption owns more uncertainty than toss-a-coin encryption, which matches with our expectation. Our comparison focuses on their efficiency and the factor of saving time is taken into account. Probabilistic encryption has a higher saving time when compared to toss-a-coin encryption, indicating that it is more efficient and spends less time on encryption/decryption. Therefore, through the comparison of their efficiency, we learn that the selective encryption does help reducing the encryption overhead and improving the efficiency of encryption.

Although an important and rich variety of selective encryption algorithms have been proposed in the literature, we believe that many research areas remain open in this field.

(i) Our future work, we will study the distribution of different packets sizes.

(ii) The algorithm should handle various kinds of data like images, videos, PDF etc we believe it will be fruitful to extend this type of analysis to other algorithms in the hope of motivating widespread application of selective encryption.

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