



environments made MANETs vulnerable against many security threats. As a result, providing security requirements in MANETs is one of the most interesting challenges in such a network. Moreover, there are many security issues in mobile ad hoc networks [7]. It can be claimed that a subset of these issues are trying to prevent network nodes from external attacks by the use of some mechanisms such as authentication of existing network nodes [8-10] or through proposing secure routing protocols [11-14]. Although it seems that such preventing mechanisms are useful to securing MANETs, they are not perfect enough. More precisely, there must be other classes of security mechanisms to detect occurred attacks or resist against possible security problems. To reach this goal, on one hand a subset of researches has tried to propose a prevention mechanism by the use of Intrusion Detection Systems (IDS) [15-17]. On the other hand, the use of appropriate cryptographic schemes in MANETs attracted other researchers recently. It is necessary to note that the focus of this research is based on the second group. In this way, eliminating the need to Public Key Infrastructure (PKI) made the use of Identity Based cryptographic schemes one of the most popular cryptosystems in such networks. However, in an Identity-based cryptosystem each entity must collect its private key from PKG hence PKG can eavesdrop the messages or impersonate entities. This inherent problem in Identity-based cryptosystems called “key escrow”. This problem limits the use of Identity-based cryptosystems to closed organizations [18]. Early solutions focus on utilizing more key pairs, using threshold, and considering expiry date for the master key. However, they have some drawbacks that make them unsuitable for MANETs such as too much overhead to the network, more computation /communication for nodes which are resource constrained devices [19].

In 2003, the suggested public key cryptosystem by Al-Riyami and Paterson in [20] named “Certificateless public key” could overcome the problems of Traditional and Identity-Based cryptosystems. This new cryptosystem utilizes a trusted third party known as called Key Generator Center (KGC) who generates partial keys for the involving entities. Each entity can generate its own private key by the use of received partial value from KGC and a confidential value chosen by the entity therefore there is no key escrow problem [18]. In this paper, several Certificateless public key schemes have been investigated based on the same

notations and assumptions [21-24]. Moreover we made a comprehensive comparison over the computational cost of the considered schemes.

The rest of this paper is organized as followed. Next section consists of required notation and assumption for the rest of this paper. In the third section, several Certificateless Public Key cryptosystems have been investigated in detail. Section 4 is dedicated to the comparison of computational costs of considered schemes. Finally the last section draws the conclusion of this paper.

## II. METHODS AND MATERIAL

### Notation and Assumptions

The suggested notation and assumption for the rest of this paper are as followed.

- $G_1$ : an additive algebraic group
- $G_2$ : an additive algebraic group
- $G_T$ : a multiplicative algebraic group
- $q$ : the order of mentioned groups
- $P$ : an element of  $G_2$
- $\hat{e}$ : a bilinear pairing over mentioned algebraic groups  
 $\hat{e}: G_1 \times G_2 \rightarrow G_T$
- $n$ : a positive integer number that determines the number of bits of the two components of the RSA public key (e and N)
- $H_1$ : one-way collision-free hash functions  
 $H_1: \{0,1\}^* \rightarrow G^*$
- $H_2$ : one-way collision-free hash functions  $H_2: G \rightarrow \{0,1\}^n$
- $H_3$ : one-way collision-free hash functions  
 $H_3: \{0,1\}^* \rightarrow \{0,1\}^n$

### Certificateless Public Key Cryptosystems in MANETS

The purpose of this section is to probe into four existing Certificateless public key cryptosystem in MANETs from cryptographic functionality viewpoint named IDRSA,  $C_{less}$ RSA, EIDRSA, and CLPKKM [21-24].

#### A. A review of IDRSA scheme

The main objective of this subsection is to investigate the IDRSA protocol [21]. IDRSA tries to guarantee that the public keys are just accessible by the trusted entities to make the protocol protected against RSA cryptanalysis attacks. To reach this goal, it is assumed that any user is a member of a logical group of users named coalition. To obtain the public key of other side party, existing users must ask the required public key

from the coalition that the considered user is a member of. Based on these assumptions, the rest of this subsection investigates the phases of IDRSA and the correctness of this protocol logically.

It can be claimed that the core part of IDRSA scheme consists of three main phases that we named them Setup, Node Initialization, and Public-key Obtaining Process. In continue, these main phases are reviewed briefly.

**Setup:** In this phase, a trusted third party generates public parameters of the cryptosystem  $Params: \langle G_1, G_2, G_T, q, P, \hat{e}, n, H_1, H_2, H_3 \rangle$  after taking the required security parameters. The elements of Params have been explained in the second section.

**Node Initialization:** The basis of this phase is to generate a subset of public and private parameters for existing users and coalitions, beside of publishing a subset of public ones. The public parameters of mentioned entities are named Identity-key, General-key and public-key. Here, Identity-key of any user is computable by all other existing ones, while General-key and Public-key must be generated by the owner of them. To support freshness, Identity-key of the user or coalition "i" (which possess  $ID_i$ ) would be created as below:

$$Q_i = H_1(ID_i \parallel time)$$

Here, the entity who possess  $ID_i$  randomly chooses the prime number "e<sub>i</sub>" as a randomly chosen element of  $\mathbb{Z}_q^*$  or  $e_i \in_r \mathbb{Z}_q^*$ . Then, each node such as node "i" runs the RSA key generation algorithm to generate the parameter  $e_i, d_i, N_i$ . Such as traditional RSA scheme,  $d_i$  and  $\langle e_i, N_i \rangle$  are the private-key and public-key of mentioned entity, respectively. After that, mentioned user or coalition publishes the value  $P_i = (d_i \cdot P)$  as the General-key.

**Public key obtaining process:** In the last predicted phase of IDRSA, each user can refer to the considered coalition that the other party is a member of, to take the required Public-key securely. In the sake of simplicity, assume that node A needs the Public-key of node B, and sends the request to the desirable coalition named  $IDRSA_i$ . Then, the "Public key obtaining process" will be done by performing followed three steps:

$$\text{Step1: } A \rightarrow IDRSA_i: P_A, ID_B$$

In this step, the node A introduces himself by sending  $P_A$ , then requests to obtain the Public-key of the node B ( $e_B$  and  $N_B$ ) by sending  $ID_B$  to the  $IDRSA_i$  coalition.

$$\text{Step2: } IDRSA_i \rightarrow A: \langle U, C, W, Y \rangle$$

In this step, the coalition  $IDRSA_i$  first of all checks if the node B is in the list or not. Then it will send mentioned parameters to the node A. here, the mentioned four parameters are as below:

$$U = P_i, C = e_B \oplus H_2(g_i) \text{ that } g_i \text{ is equal to } \hat{e}(Q_A, P_A)^{d_i} \times \hat{e}(d_i Q_i, P_A), W = e_B \cdot P \text{ and } Y = N_B \oplus H_3(e_B).$$

$$\text{Step3: Public key extraction by A}$$

In this step, the node A tries to extract the requested Public-key of the node B ( $e_B$  and  $N_B$ ) and verify its authenticity by performing followed computations:

First of all, A computes  $g_A = \hat{e}(d_A Q_A, P_i) \times \hat{e}(Q_i, P_i)^{d_A}$ , then computes  $e_B = C \oplus H_2(g_A)$ . Obviously, the result of  $g_A$  must be equal to  $g_i$ . After that, the node A computes  $N_B = Y \oplus H_3(e_B)$ . Finally, to verify the authenticity of the Public-key of the node B ( $e_B$  and  $N_B$ ), the node A checks if  $(W = e_B \cdot P)$  to decide whether accept or reject the calculated Public-key pair of the node B.

### 1) Investigating the correctness of IDRSA

To investigate IDRSA logically, it must be proved that the user A and the coalition  $IDRSA_i$  will achieve the same value by computing  $g_A$  and  $g_i$ , respectively. The calculations below, can show that the result of both computations is the same value

$$\begin{aligned} & \hat{e}(Q_A + Q_i, P)^{d_i d_A} \\ g_A &= \hat{e}(d_A Q_A, P_i) \times \hat{e}(Q_i, P_i)^{d_A} \\ &= \hat{e}(Q_A, P)^{d_i d_A} \times \hat{e}(Q_i, P)^{d_i d_A} \\ &= \hat{e}(Q_A + Q_i, P)^{d_i d_A} \end{aligned}$$

$$\begin{aligned} g_i &= \hat{e}(Q_A, P_A)^{d_i} \times \hat{e}(d_i Q_i, P_A) \\ &= \hat{e}(Q_A, P)^{d_i d_A} \times \hat{e}(Q_i, P)^{d_i d_A} \\ &= \hat{e}(Q_A + Q_i, P)^{d_i d_A} \end{aligned}$$

As a result, it can be concluded that IDRSA is logically a correct scheme.

### B. Review of C<sub>less</sub> RSA Scheme

The  $C_{less}RSA$  scheme is an improved version of IDRSA, from computational efficiency perspective. The outline of current subsection is to investigate this scheme in detail [22]. Since the Setup and Node Initialization phases of  $C_{less}RSA$  scheme is similar to IDRSA, only the Public-key Obtaining Process is described in this subsection. Note that in the  $C_{less}RSA$  scheme computational expenses are more lightweight than IDRSA. In more detail, the Public-key Obtaining Process is as followed:

**Public key obtaining process in  $C_{less}RSA$ :** Similar to IDRSA, in the last phase each user refers to the considered coalition and requests for the Public-key of the other side party. If roughly speaking, we assume that node A needs the public key of node B, and sends the request to the desirable coalition named  $C_{less}RSA_i$ . Then, the "Public key obtaining process" will be done by performing three steps below:

Step1;  $A \rightarrow C_{less}RSA_i: P_A, ID_B$

In this step, the public parameter  $P_A$  introduces the node A as the one who issued his request. Moreover, the public identity  $ID_B$  determines the other party who his public key ( $e_B$  and  $N_B$ ) is requested by A.

Step2;  $C_{less}RSA_i \rightarrow A: \langle U, C, W, Y \rangle$

In this step, the coalition  $C_{less}RSA_i$  will send back the tuple  $\langle U, C, W, Y \rangle$  to node A. here, the mentioned four parameters are as below:

$U = P_i$ ,  $C = e_B \oplus H_2(g_i)$  that  $g_i$  is equal to  $g_i = \hat{e}(d_i Q_A, P_A)$ ,  $W = e_B \cdot P$  and  $Y = N_B \oplus H_3(e_B)$ .

Step3; Public key extraction by A

In this step, the node A extracts the public key of the node B ( $e_B$  and  $N_B$ ) and verifies its authenticity by performing followed computations:

At first, A computes  $g_A = \hat{e}(d_A Q_A, P_i)$ , then computes  $e_B = C \oplus H_2(g_A)$ . Clearly, the result of  $g_A$  must be the same as  $g_i$ . In continue, node A computes  $N_B = Y \oplus H_3(e_B)$ . Finally, to verify the authenticity of the public key of the node B ( $e_B$  and  $N_B$ ), the node A checks if  $(W = e_B \cdot P)$  to decide whether accept or reject the calculated public key pair of the node B.

## 1) Investigating the correctness of $C_{less}RSA$

To investigate logical functionality of  $C_{less}RSA$ , we show that the user A and the coalition  $C_{less}RSA_i$  will achieve the same value by computing  $g_A$  and  $g_i$ , respectively. The two calculations below, prove that the result of both computations is the same value  $\hat{e}(Q_A, P)^{d_i d_A}$

$$g_A = \hat{e}(d_A Q_A, P_i) = \hat{e}(Q_A, P)^{d_i d_A}$$

$$g_i = \hat{e}(d_i Q_A, P_A) = \hat{e}(Q_A, P)^{d_i d_A}$$

As a result, the functionality of  $C_{less}RSA$  is logically correct.

## C. A review of EIDRSA Scheme

This section presents a brief review of Certificateless authenticating public key protocol named EIDRSA [23]. This scheme is designed on the basis of IDRSA scheme, however the EIDRSA uses Elliptic Curve based Algebraic Groups instead of multiplicative ones over Finite Fields as the output of Bilinear Pairings that leads to lower computational cost in Public-key Obtaining Process phase. EIDRSA scheme is constructed based on three phases named Setup, Node Initialization, and Public-key Obtaining Process as followed.

**Setup:** The public output of our scheme, Params, includes following items:

$$Params: \langle G, q, P, n, H_1, H_2, H_3 \rangle$$

Here,  $G$  is a cyclic Elliptic Curve group with order  $q$  and the generator  $P$ . The integer number  $n$  is the same as  $n$  in IDRSA protocol. In addition,  $H_1: \{0,1\}^* \rightarrow G^*$ ,  $H_2: G \rightarrow \{0,1\}^n$  and  $H_3: \{0,1\}^* \rightarrow \{0,1\}^n$  are three one-way collision-free hash functions.

**Node Initialization:** Similar to the ID-RSA scheme, the entities can be user or coalition logically. Here, the public and private parameters of mentioned entities are the same as what introduced in ID-RSA. In addition, each entity such as the entity who possesses  $ID_i$  generates the parameter  $E_i = e_i P_i$ .

**Public key obtaining process:** In this phase, the scenario is similar to what proposed in ID-RSA except

that the details of the steps. Here, these steps are as followed:

**Step1:**  $A \rightarrow Coalition_i: E_A, P_A, ID_B$

In this step, the second input introduces the node  $A$  as the entity who sent the request and the third one refers to the identity of the entity who his public key is requested.

**Step2:**  $Coalition_i \rightarrow A: \langle E_i, U, C, W, Y \rangle$

In this step, the inputs  $U, C, W$  and  $Y$  are as followed.

$U = P_i$ ,  $C = e_B \oplus H_2(g_i)$  that  $g_i$  is equal to  $g_i = d_i(E_A + e_i P_A)$   $W = e_B \cdot P$  and  $Y = N_B \oplus H_3(e_B)$ .

**Step3:** In this step, the node  $A$  must be able to extract the public key of  $B$  (which are  $e_B$  and  $N_B$ ) and verify its authenticity as followed:

First of all,  $A$  computes  $g_A = d_A(E_i + e_A P_i)$ , then computes  $e_B = C \oplus H_2(g_A)$ . Clearly, the result of  $g_A$  and  $g_i$  must be the same. In addition, the entity  $A$  computes  $N_B = Y \oplus H_3(e_B)$ . To verify authenticity of the obtained public key, the entity  $A$  investigates the equality of  $(W = e_B \cdot P)$  to decide whether accept or reject the obtained public key of  $B$ .

### 1) Investigating the correctness of EIDRSA

Beside of what mentioned above, it is necessary to prove that the computed values of  $g_A$  and  $g_i$  are the same. The two equalities below will lead to this result:

$$\begin{aligned} g_A &= d_A(E_i + e_A P_i) \\ &= d_A e_i P_i + d_A e_A P_i \\ &= (d_A e_i d_i)P + (d_A e_A d_i)P \end{aligned}$$

$$\begin{aligned} g_i &= d_i(E_A + e_i P_A) \\ &= d_i e_A P_A + d_i e_i P_A \\ &= (d_i e_A d_A)P + (d_i e_i d_A)P \end{aligned}$$

As a result, the functionality of our proposed protocol is logically correct.

### D. A review of CLPKKM scheme

This subsection reviews the *CLPKKM* protocol briefly [24]. Although *CLPKKM* is fundamentally in the category of public key cryptosystems, tries to guarantee the security of the scheme by the use of the idea of hybrid cryptosystems. In more detail, communicating parties try to share a secret whenever the system changes one of the broadcasted public parameters named Salt. To

reach this goal, it is assumed that each user possesses a changeable private key in any stage that the cryptosystem changes the Salt public parameter beside of the fixed public and private key pairs. It can be claimed that *CLPKKM* scheme includes three main phases that we named them Setup, Node Initialization, and Shared-Secret computation. In continue, these phases are introduced in more detail.

**Setup:** In this phase, a trusted third party named KGC<sup>1</sup> takes the security parameters to generate followed confidential Master-key and publicly known parameters named Params.

Master – key:  $s \in_r Z_q^*$

Params:  $\langle G_1, G_2, G_T, q, P, P_{pub}, \hat{e}, H, Salt_1 \rangle$

In the mentioned parameters above,  $\langle G_1, + \rangle$ ,  $\langle G_2, + \rangle$  and  $\langle G_T, \times \rangle$  are three groups and  $q$  is the order of them. Moreover,  $P \in G_2$  and  $P_{pub} = sP$ . In addition,  $\hat{e}: G_1 \times G_2 \rightarrow G_T$  is a bilinear pairing over mentioned algebraic groups and  $Salt_1$  is an integer pre-deployed public value that will be changed in any stage based on a simple formula that we will see later. Beside of these,  $H: \{0,1\}^* \rightarrow G_1^*$  is a random one-way collision-free hash function.

**Node Initialization:** The basis of Node Initialization phase is to generate public and private keys for existing users. Before introducing the details and structures of these keys, it is necessary to mention the assumptions of this phase. As it is noted before, each user possesses a changeable private key in any stage that the cryptosystem changes the Salt public parameter beside of the fixed one. In the rest of this research, it is assumed that the name of the fixed public key and private key of the user who possesses the identity  $ID_i$  is named  $PK_i$  and  $SK_i$ , respectively. Moreover, in the stage "j" the changeable private key of the user who possesses the identity  $ID_i$  is named  $SK_{i,j}$ . The value of this changeable private key is related to the value of the *Salt* value on that stage. As it is explained before, the first value of *Salt*,  $Salt_1$ , is predetermined as one of the parameters of Params. After that, in the other stages such as stage  $j$ , this value is publicly computable as followed:

$$Salt_j = \begin{cases} Salt_1 & j = 1 \\ Salt_{j-1} + 1 & j > 1 \end{cases}$$

<sup>1</sup> Key Generator Center

It is necessary to point out that in the stage  $j$ , the  $KGC$  publicly publishes the value  $H_j = sH(Salt_j)$  to all existing users.

In continue to the assumptions above, the rest of this subsection introduces the mentioned public and private keys of an assumptive user such as the user who possesses the identity  $ID_i$ . First of all, this user refers to the  $KGC$  to take his partial private key,  $d_i$ . This partial private key is computable by  $KGC$  as below:

$$d_i = sQ_i$$

Here,  $Q_i = H(ID_i)$  Then, mentioned user randomly chooses the value  $x_i \in_r Z_q^*$ . After that he can compute the values  $SK_i$ ,  $PK_i$  and  $SK_{i,j}$  as follow:

$$\begin{aligned} SK_i &= x_i s Q_i \\ PK_i &= \langle u_i, v_i \rangle = \langle x_i P_{pub}, x_i P \rangle \\ SK_{i,j} &= x_i H_j \end{aligned}$$

In continue, the last phase of  $CLPKKM$  is investigated.

**Shared-Secret computation:** Since,  $CLPKKM$  tries to rely on hybrid cryptosystems to provide required security services, communicating entities can share a secret based on the number of stage that they are involving with. Assume that two users  $A$  and  $B$  who possess the identities  $ID_A$  and  $ID_B$ , respectively want to share a secret in the  $j$  stage. In this case,  $A$  and  $B$  must compute the same values  $K_{AB,j}$  and  $K_{BA,j}$ , respectively. These values are computable as following equations:

$$\begin{aligned} K_{AB,j} &= \\ \hat{e}(Q_B, u_B) \times \hat{e}(SK_A, P) \times \hat{e}(SK_{A,j}, v_B) K_{BA,j} &= \\ \hat{e}(Q_A, u_A) \times \hat{e}(SK_B, P) \times \hat{e}(SK_{B,j}, v_A) & \end{aligned}$$

Next section, logically investigates the correctness of the  $CLPKKM$  scheme.

### 1) Investigating the correctness of CLPKKM

To prove the correctness of  $CLPKKM$  scheme logically, the values  $K_{AB,j}$  and  $K_{BA,j}$  must be the same. Followed calculations can reach to this result:

$$\begin{aligned} K_{AB,j} &= \hat{e}(Q_B, u_B) \times \hat{e}(SK_A, P) \times \hat{e}(SK_{A,j}, v_B) \\ &= \hat{e}(Q_B, x_B P_{pub}) \times \hat{e}(x_A s Q_A, P) \times \hat{e}(x_A H_j, x_B P) \\ &= \hat{e}(Q_B, P)^{s x_B} \times \hat{e}(Q_A, P)^{s x_A} \times \hat{e}(H_j, P)^{x_A x_B} \end{aligned}$$

$$\begin{aligned} K_{BA,j} &= \hat{e}(Q_A, u_A) \times \hat{e}(SK_B, P) \times \hat{e}(SK_{B,j}, v_A) \\ &= \hat{e}(Q_A, x_A P_{pub}) \times \hat{e}(x_B s Q_B, P) \times \hat{e}(x_B H_j, x_A P) \\ &= \hat{e}(Q_A, P)^{s x_A} \times \hat{e}(Q_B, P)^{s x_B} \times \hat{e}(H_j, P)^{x_A x_B} \end{aligned}$$

As a result, it is proved that  $CLPKKM$  is logically a correct scheme.

## III. RESULTS AND DISCUSSION

### Efficiency Comparison

This section emphasizes on comparing the computational expense of the reviewed schemes in the previous section. We focused on the computational expense of  $g_A$  and  $g_i$  parts of "Public key obtaining process," in  $IDRSA$ ,  $C_{less}RSA$ , and  $EIDRSA$  schemes and  $K_{AB,j}$  and  $K_{BA,j}$  parts of  $CLPKKM$  scheme which is the core of the difference between mentioned schemes. Then, computational expense of these parts are calculated and compared together. Moreover, the rate of growth of computational expense for mentioned parts are depicted in two separate diagrams. This comparison is based on assuming that  $g_A$  and  $g_i$  parts of  $C_{less}RSA$  and  $IDRSA$  schemes and  $K_{AB,j}$  and  $K_{BA,j}$  parts of  $CLPKKM$  scheme are constructed by Type2 or Type3 Bilinear Pairings. It is worth to remind that  $EIDRSA$  do not require any pairing operation. The main reason is that the pairing operations are more expensive than modular exponentiation and scalar multiplication operations [18]. The TABLE I illustrates the expenses of operations (pairings, modular exponentiation and scalar multiplication) in Type2 and Type3 Bilinear Pairings based on the assumptions of the [18]. The reason that we just emphasized on Type2 and Type3 Bilinear Pairings is that Type1 Bilinear Pairing is limited to obtain less than 80 bits security level, while the use of Type2 and Type3 Bilinear Pairings can lead to obtaining 128 bits or 256 bits security level [18].

TABLE I. Computational expense of group operations in Type2 and Type3 Bilinear Pairings [18]

Group operation	Computational expense	
	Type2	Type3
Multiplication in $G_1$ ( $M_1$ )	1	1
Multiplication in $G_2$ ( $M_2$ )	45	3
Exponent in $G_T$ ( $E_T$ )	3	3
Pairing (P)	21	20

Based on the Table 1, computational expense of  $g_A$  or  $g_i$  part in  $IDRSA$  is equal to " $E_T + M_1 + 2P$ ". Hence, the total computational cost for the considered parts in

this scheme is equal to 46 and 44 for Type2 and Type3 of Bilinear Pairings, respectively.

Followed by what mentioned in Table 1, computational expense of considered parts of "Public key obtaining process" in  $C_{less}RSA$  is equal to " $M_1+P$ " which means the expense of these parts in  $C_{less}RSA$  scheme are 22 and 21 for Type2 and Type3 of Bilinear Pairings, respectively.

Furthermore, based on the Table 1, computational expense of  $g_A$  or  $g_i$  part in EIDRSA is equal to " $2M_1$ " with one point addition. Since the computational cost of point addition is negligible, the total computational cost for this scheme is equal to 2 which is quite efficient in compare with all mentioned works.

Beside of the mentioned computations above, based on the Table 1, computational expense of  $K_{AB,j}$  or  $K_{BA,j}$  parts of  $CLPKKM$  scheme is equal to " $3P$ " which means the expense of these parts in this scheme are 63 and 60 for Type2 and Type3 of Bilinear Pairings, respectively.

In order to have better understanding about the overall computational cost of the considered schemes in Type2 and Type3 of Bilinear Pairings, Figure 1 and Figure 2 depict the growth rate of computational expense for  $g_A$  or  $g_i$  parts of "Public key obtaining process" of the schemes IDRSA,  $C_{less}RSA$ , EIDRSA and the growth rate of computational expense for  $K_{AB,j}$  or  $K_{BA,j}$  parts of  $CLPKKM$  scheme as a function of the number of requests.

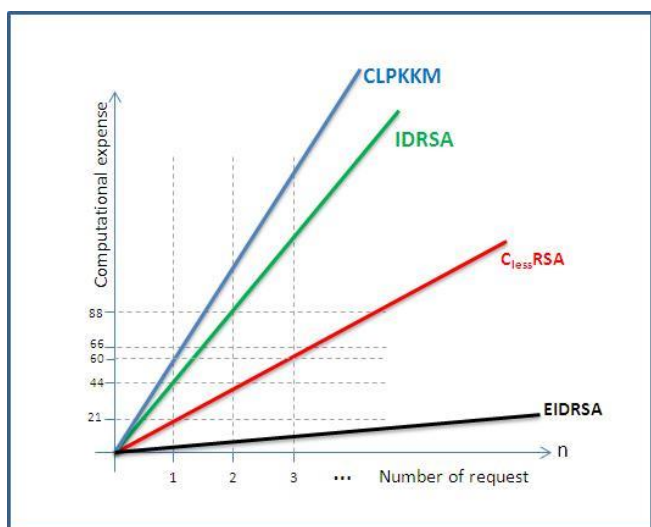


Fig.1 Growth rate of computational cost based on Type2 pairings

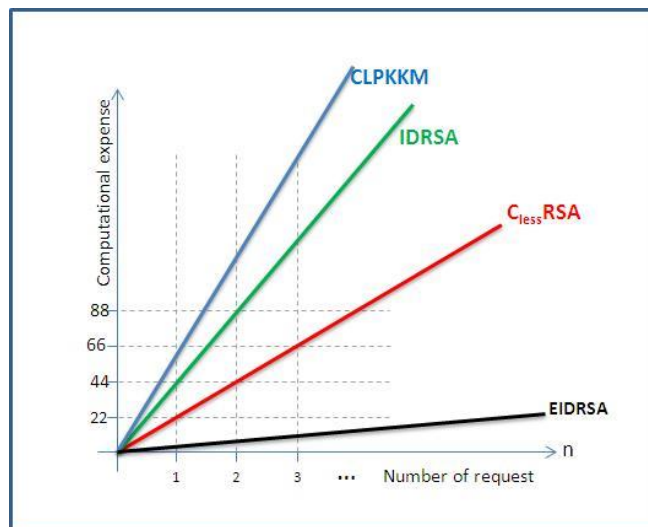


Fig.2 Growth rate of computational cost based on Type3 pairings

In the Figure 1 it is assumed that the utilized Bilinear Pairings in  $CLPKKM, IDRSA$  and  $C_{less}RSA$  schemes are Type2, whereas in Figure 2 utilized Bilinear Pairings are Type3.

#### IV. CONCLUSION

In this paper, several certificateless public key cryptosystems for Mobile ad Hoc Networks have been reviewed. The functionality of each scheme is introduced in detail. Finally, a separate section compared the computational expense of the considered schemes. The result of this paper indicates that due to the elimination of Bilinear Pairing operation EIDRSA scheme is more efficient than the other ones from both computational expense and the rate of growth of computational expense viewpoints.

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