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A Hybrid Cryptosystem Using Elgamal Algorithm and Matrix Encryption

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ABSTRACT

The increasing use of electronic means in data communication from one point to another, coupled with the growth of networking comes with a corresponding increase in vulnerability of privacy. Modern cryptography entails the study of mathematical techniques of encryption and decryption to solve security problems in communication. This research work harnessed the advantage of speed of implementation in a secret cryptosystem and the component advantage that allows strangers to exchange messages in a public key cryptosystem, thereby forming a suitable hybrid cryptosystem which guarantees a secure communication between communicating parties. This is achieved by integrating the Elgamal public key algorithm and matrix encryption technique to achieve the hybrid cryptosystem. This hybrid cryptosystem combines advantages of 'speed of implementation' over typical public key cryptosystems, as well as the advantage of 'secure key distribution' over typical secret key encryption scheme. The hybrid cryptosystem provides an alternative to this limitation as it utilizes its matrix encryption component to step down to a secret key scheme after the first contact of intending users, thereby showing a superior advantage over typical implementation of the Elgamal and matrix encryption schemes as separate entities.

Keywords – Encryption; decryption; key, Network; bandwidth.

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1. INTRODUCTION

More than ever before, people are connected in one way or the other, such that even the entire world has become a single community. The increasing use of electronic means in data communication from one point to another, coupled with the growth of networking comes with a corresponding increase in vulnerability of privacy for the communicating persons [Goshwe, 2013]. A principal goal of cryptography is to allow two people to exchange confidential information, via a channel that is being monitored by an adversary [Adewumi and Garba, 2003]. A typical example of such insecure environments that may require the technique of cryptography to guarantee privacy is the well-known internet. Although the use of cryptographic systems (cryptosystems) in achieving communication security has been in existence, the two broad categories of cryptographic systems viz: secret key cryptography (SKC) and public key cryptography (PKC) have evolved along with their limitations in the implementation front, viz 'secure key distribution' and 'speed of implementation' respectively [Goldreich, 2004]. This paper presents a method which harnessed the advantage of speed of implementation in a secret cryptosystem and the component advantage that allows strangers to exchange messages in a public key cryptosystem, thereby forming a suitable hybrid cryptosystem which guarantees a secure communication between strangers and yet makes up for the respective limitations stated above



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2. METHODOLOGY

According to [Hoffstein*et al*, 2008], Cryptographic methods are aimed at applying an encryption scheme by a message sender to a *plaintext* to transform it into a *ciphertext* before sending, and the reverse process of applying a decryption scheme by the receiver to the *ciphertext* in order to recover the original *plaintext* as illustrated in the figure below:



Figure 1.Schematic illustration of a Cryptosystem showing Encryption and Decryption in an unsecure channel.

For the purpose of this paper, we considered the methods of matrix encryption from the family of secret key cryptosystems, the Elgamal algorithm from the family of public key cryptosystems to form a hybrid method that is made of the combination of Elgamal algorithm and matrix encryption [Yan, 2013]. Also, taking into cognizance, the fact that these three methods require that the message to be encrypted is converted into an integer before it is made suitable for the mathematical operations embedded in these algorithms, we hereby consider the first twenty six English alphabets, the number digits from zero through nine, and some characters which we deem as most frequently use (our arbitrary choice) to form a character to numeric value transformation figure as shown below:



Figure 2: Character to numeric-value transformation table.

2.1. The Elgamal Algorithm

According to (Yan, 2013), The Elgamal public key cryptosystem can be described as follows:

- 1. A prime q and a generator $g \in F_q$ is made public.
- 2. BOB chooses a private key at random $a \in \{1, 2, ..., q 1\}$

This a is the private decryption key. The public encryption key is $\{g, q, g^a \mod q\}$

3. Suppose now that ALICE wishes to send a message to BOB, he chooses a random number $b \in \{1, 2, ..., q - 1\}$ and sends to BOB the following pair of elements of F_q :

 g^b, Mg^{ab} where M is the message.

4. Since BOB knows the private decryption key a, he can recover M from this pair by computing g^{ab} (mod q) and divides this result into the second element. That is, $M \equiv M g^{ab} / (g^b)^a \pmod{q}$.

The mathematical basis for the security of the Elgamal public key cryptosystem is rooted in the discrete logarithm problem of finding the private key a, by solving the DLP:

$$a \equiv \log_{g} x \pmod{q-1},$$

such that
$$x \equiv g^{a} \pmod{q}.$$

Anyone who can solve the discrete logarithm problem $\inf_{\mathbf{q}} breaks$ the cryptosystem by finding the secret decryption key g^{a} [Yan, 2013]. In theory, there could be a way to use knowledge of g^{a} and g^{b} to find g^{ab} and hence break the cipher without solving the discrete logarithm problem, but there is no known way to go from g^{a} and g^{b} to g^{ab} without essentially solving the discrete logarithm problem and hence, the security basis of the Elgamal public-key cryptosystem.

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2.2. Matrix Encryption

According to [Yan, 2013], the matrix encryption method utilizes the block enciphering method to achieve the process of encryption. The block enciphering method suggests that the plaintext to be encrypted be broken into groups of letters, and performing the encryption and decryption on the blocks of letters, as compared to other monographic methods where the encryption is done on the single letters of the plaintext. This principle of splitting the plaintext into groups before performing encryption is called block ciphering [Stallings, 2005]. The matrix encryption is a process of performing an encryption on each of these blocks (groups of letters) using any arbitrarily chosen matrix.

We carry out this process using the procedure outlined below:

(i) Split the message M into blocks of n-letters, say M_1, M_2, \dots, M_j ; each block M_i , for $1 \le i \le j, i = 1, 2, \dots, j$ is a block consisting of n letters.

(ii) Translate the letters into their numerical equivalents and form the cipher-text:

 $C_i \equiv AM_i \pmod{N}, i = 1, 2, ..., j$ Where A is the key, and is an invertible $n \times n$ matrix with: gcd[det(A), N] = 1,

$$C_i = (C_1, C_2, ..., C_n)^T$$
 and $M_i = (M_1, M_2, ..., M_n)^T$

Using matrix encryption, we shall consider an arbitrary matrix A, and perform $C_i = AM_i \pmod{52}$ as the encryption algorithm. To decrypt the message, we use the decryption function: $M_i = A^{-1}C_i \pmod{N}$, where A^{-1} is the inverse of the arbitrarily chosen encryption matrix -A. We shall consider the decryption function: $M_i = A^{-1}C_i \pmod{52}$

2.3. The Hybrid Cryptosystem

In this section, we put up an encryption algorithm that combines the Elgamal public-key cryptosystem and the matrix encryption. This hybrid cryptosystem combines advantages of 'speed of implementation' over typical public key cryptosystems, as well as the advantage of 'secure key distribution' over typical secret key cryptosystems. The Algorithm is given below: Algorithm 1: Mathematical Description of the Hybrid Cryptosystem

- 1. An arbitrary prime p and a generator $g \in F_q$ are first published.
- 2. BOB chooses a private key at random: $a \in \{1, 2, ..., p-1\}$. This *a* is the private decryption key. The public encryption key is $\{g, p, g^a \mod p\}$
- 3. Suppose now that ALICE wishes to send a message to BOB, she chooses a random number $b \in \{1, 2, ..., p 1\}$ and sends to BOB the following pair of elements:

 g^{b}, Mg^{ab} where M is precisely the matrix encryption formular: E = AM, D = INV(A) C

4. Since BOB knows the private decryption key
$$a$$
, he can recover M from this pair by computing:
 $M \equiv Mg^{ab}/(g^b)^{a} (mod p)$

5. Having recovered M (E = AM, D = INV(A)C), ALICE and BOB can now proceed to exchange messages using the algorithm described in M as follows:

- 6. Split the message M into blocks of n-letters, say M_1, M_2, \dots, M_j ; each block M_i , for $1 \le i \le j, i = 1, 2, \dots, j$ is a block consisting of n letters.
- 7. Translate the letters into their numerical equivalents and perform the Encryption: $C_i \equiv AM_i \pmod{N} = 52$, i = 1, 2, ..., j where A is the key, and is an invertible $n \times n$ matrix.
- 8. Decrypt encrypted messages by performing the reverse operation:

 $M_{\rm f} = A^{-1}C_{\rm f}$ (mod N = 52), where A^{-1} is the inverse of the arbitrarily chosen encryption matrix -A.

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Example

Given that p = 14197 and g = 137. The following operation is an example of the communication between ALICE and BOB using the mathematical algorithm of the hybrid cryptosystem:

Suppose BOB chooses a ∈ {1,2,..., p − 1}. This a is the private decryption key. The public encryption key is {g, p, g^amod p}

> Take a = 5, the Bob's message to Alice is : {137,14197,2550} where 2550 = 137^{5} mod 14197 = 48261724457 mod 14197

Cryptanalysis on 2550 without the knowledge of $\alpha = 5$ is as follows:

$$2550 = g^{x}$$

$$a \equiv \log_{137} x \pmod{q-1}$$
, Such that

 $x \equiv g^{a} \pmod{q}$.

Suppose ALICE chooses $b = 3 \in \{1, 2, ..., p - 1\}$. And sends Upon receiving Alice's message, BOB recovers M by computing

$$M \equiv M g^{av}/(g^v)^a (mod p) \Rightarrow \frac{1636584543143246323011}{1696^5 mod 14197} = 537113404379142213 = M = [E = AM. D = INVAC]$$

With M being successfully exchanged, Alice and BOB can exchange encrypted messages using the knowledge of M, which is now the secret key component of the hybrid cryptosystem.

3. RESULTS AND DISCUSSION

We used the C# programming language to code the hybrid cryptosystem and we tested it on a campus area network (CAM) of the University of Agriculture Makurdi which follows a hierarchical design topology and runs on a network bandwidth of 45mbps (megabits per seconds) uplink and downlink as at the time this test was conducted.

 $\{g^b, Mg^{ab} = 1696, 1636584543143246323011\}$ where Public Key Exchange and Network Bandwidth Analysis 1636584543143246323011 = 2550³ mod 14197 * (M = A Emergane, Df ±he Network Bandwidth Analysis = 3047 * 537113404379142213 (M = A Emergane, Df ±he Network Bandwidth Analysis) where the public key exchange procedure of the hybrid cryptosystem.

Interfaces	ſ	In In	iterface List										F
Wireless	- 1	Inter			Dending								
Bridge		inten	Ethemet EoIP Tunnel IP	Tunnel VLAN VRRP	Bonding								
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Mech			Name 🛆	Туре	L2 MTU	Tx	Rx	Tx Pac	Rx Pac	Tx Drops	Rx Drops	Tx Errors	Rx I
Moarr		R	ether10_failover to RB1200	Ethemet	1598	16.6 Mbps	1633.9 k	1 643	1 350	0	0	0	
IP		R	ether11_server_farm	Ethernet	1600	3.6 kbps	1584 bps	3	3	0	0	0	
IPv6	N	R	ether12_fibre Vlan	Ethemet	1600	12.9 Mbps	715.3 kbps	1 200	969	0	0	0	
	-	R	vlan100_Juniper	VLAN	1596	364 bps	364 bps	1	1	0	0	0	
MPLS		R	vlan101_Animal Science	VLAN	1596	4.4 Mbps	153.8 kbps	390	259	0	0	0	
VPLS		R	vlan102_Engr	VLAN	1596	3.2 Mbps	145.2 kbps	297	216	0	0	0	
Destina	N	X	vlan103_Agric_CEC	VLAN	1596	0 bps	0 bps	0	0	0	0	0	
Routing	1	X	vlan104_Physical_Planni	VLAN	1596	0 bps	570 bps	0	1	0	0	0	
System	\land	X	vlan105_Library	VLAN	1596	0 bps	1473 bps	0	3	0	0	0	
0		X	♦ vlan106_Admin Bursary	VLAN	1596	0 bps	1933 bps	0	4	0	0	0	
Queues		X	♦ vlan107_FST	VLAN	1596	0 bps	650 bps	0	1	0	0	0	
Files		X	♦ vlan 108_Forestry	VLAN	1596	0 bps	0 bps	0	0	0	0	0	
Log		R	vlan109_blockB	VLAN	1596	908.8 kbps	44.9 kbps	94	70	0	0	0	
LUG		X	♦ vlan110_Step B	VLAN	1596	0 bps	0 bps	0	0	0	0	0	
Radius		R	vlan111_Sports	VLAN	1596	0 bps	0 bps	0	0	0	0	0	
Toole	N	R	vlan112_Agronomy	VLAN	1596	0 bps	0 bps	0	0	0	0	0	
10015	-	R	vlan115_HOD_EEE	VLAN	1596	111.7 kbps	11.6 kbps	13	21	0	0	0	
New Terminal		R	vlan116_Guidiance_Cou	VLAN	1596	0 bps	0 bps	0	0	0	0	0	
MetaBOUTER		R	vlan203_block A	VLAN	1596	805.1 kbps	67.0 kbps	87	98	0	0	0	
		R	≪ivlan206	VLAN	1596	0 bps	0 bps	0	0	0	0	0	
Make Supout.ri		R	♦vlan207_PG	VLAN	1596	2.7 Mbps	121.6 kbps	255	250	0	0	0	
Manual		R	vlan208_bursary_wifi	VLAN	1596	647.4 kbps	22.6 kbps	61	38	0	0	0	
		R	vlan209_bursary	VLAN	1596	0 bps	0 bps	0	0	0	0	0	
Exit		R	vlan210_PG_Sch_ICT	VLAN	1596	0 bps	0 bps	0	0	0	0	0	
		R	vlan213_blockA_wifi_2	VLAN	1596	0 bps	776 bps	0	2	0	0	0	
		R	vlan217_Engineering Cafe	VLAN	1596	0 bps	0 bps	0	0	0	0	0	
			ether13_Radius server	Ethemet	1600	0 bps	0 bps	0	0	0	0	0	_
		R	*ether1_Skannet	Ethemet	1598	2.4 Mbps	32.4 Mbps	2 478	3 107	0	0	0	
		X	<pre>*** ether2_Ngren_failover</pre>	Ethernet	1598	0 bps	0 bps	0	0	0	0	0	
		R	<pre>**ether3_VCs_Lodge</pre>	Ethemet	1598	0 bps	25.7 kbps	0	10	0	0	0	
		R	♦ ether4 Clinic AP	Ethemet	1598	1590.4 k	44.5 kbps	136	84	0	0	0	

Figure 3: Capture of the bandwidth manager before commencement of public key exchange.



Alice makes a choice of a private decryption key which is kept secret, and computes and sends her first message to Bob, Using the knowledge of the known published prime number for the public key procedure:

Alice Choice of secret key and ge	enerated message
ALICE's Choice of Secret Key	/
Choice of Secret Key:	5
	Compute and Send to Bob
Generated Mess	sage:

Figure 4: Capture of Alice's choice of a secret decryption key and the first computed message to Bob.

In a similar fashion, Bob makes a choice of a private decryption key which is kept secret, and computes and replies Alice's message, using the knowledge of the known published prime number for the public key procedure.

•-	Bob's Choice of Secret and Messa	age 📃 💷 💻 💴						
[-Bob's Choice of Secret Key							
	Choice of Secret Key:	3						
	Bob's Message	E=AM,D=INVAC						
		Compute and Send Message to Alice						
	Generated Messga	96						

Figure 5: Capture of Bob's choice of a secret key together with the message reply to Alice.



Upon receiving Bob's reply, Alice clicks the 'decrypt Bob's reply' to get the mesasge which is the key to be used for the secret Key cryptosystem, -a component of the hybrid cryptosystem that utilizes matrix encryption for message encryption and decryption.

Alice Choice of secret key and g	enerated message
ALICE's Choice of Secret Key	y
Choice of Secret Key:	5
	Compute and Send to Bob
Generated Mes	sage: 2550
Bob's Message to Alice	
Bob's Reply to Alice:	1696, 1.63658472596325E+21
	Decrypt Bob's Reply
Decrypted Message:	E=AM,D=INVAC
	Continue to SKC

Figure 7: Capture of Alice's decryption of Bob's Public key message.

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C*										Hid	e Passwo	nds
Interfaces		Interface List										
Wireless												
Bridge	Int	errace Ethernet EoIP Tunnel IP	YTUNNEI VLAN VE	RRP Bonding								
Dago	1 +	·• * * - 7									E	nd
PPP		Name	Time	12 MTH	Tv	Dv	Ty Pao	Py Pao	Ty Dropp	Pr Dmon	Ty Emore	Dy I
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IP D		Abother11 conver form	Ethemat	1600	507 bps	507 boo	1 4/4	1 203	0	0		1
	B	strether 12 fibre Man	Ethemet	1600	10.1 Mbps	650.8 kbps	991	809	0	0	C C	
IPv6 P	B	wylan 100 Juniper	VIAN	1596	0 bps	0 bps	0	000	0	0	(
MPLS	B	Van 101 Animal Science	VLAN	1596	4.8 Mbps	210 6 kbps	449	322	Ő	0	()
VPLC	R	Vlan102 Engr	VLAN	1596	2.8 Mbps	141.8 kbps	287	246	0	0	(j
VELS	X	Van 103 Agric CEC	VLAN	1596	0 bps	1719 bps	0	1	0	0	()
Routing 1	X	vlan104_Physical_Planni	VLAN	1596	0 bps	396 bps	0	1	0	0	()
System	X	vlan 105_Library	VLAN	1596	0 bps	1022 bps	0	1	0	0	()
-	X	♦ vlan 106_Admin Bursary	VLAN	1596	0 bps	4.0 kbps	0	7	0	0	(
Queues	X	vlan107_FST	VLAN	1596	0 bps	3.3 kbps	0	5	0	0	()
Files	X	vlan 108_Forestry	VLAN	1596	0 bps	0 bps	0	0	0	0	(1
1	R	vlan109_blockB	VLAN	1596	554.9 kbps	33.2 kbps	50	48	0	0	(1
Log	X	♦ vlan110_Step B	VLAN	1596	0 bps	0 bps	0	0	0	0	(1
Radius	R	vlan111_Sports	VLAN	1596	0 bps	0 bps	0	0	0	0	()
Tools	R	vlan112_Agronomy	VLAN	1596	0 bps	0 bps	0	0	0	0	()
	R	vlan115_HOD_EEE	VLAN	1596	172.4 kbps	22.9 kbps	24	17	0	0	(
New Terminal	R	vlan116_Guidiance_Cou	VLAN	1596	0 bps	0 bps	0	0	0	0	(1
MetaROUTER	K	Wan2U3_block A	VLAN	1596	553.1 kbps	/6.4 kbps	80	81	0	0		
	K	Vian206	VLAN	1596	0 bps	0 bps	0	0	0	0		
make Supout.nf	L R	db. l. 200 hours of	VLAN	1596	130.2 kbps	12.0 kbps	16	25	0	0		
Manual	K	www.anzuo_bursary_wfi	VLAN	1596	741.1 kbps	16.8 Kbps	68	38	0	0		1
Evit		Avian205_Dursary	VLAN	1596	Obps	0 bps	0	0	0	0		1
		Abylan213 block 4 wifi 2	VLAN	1596	204.4 kbps	79kbps	17	15	0	0		
		winz 13_blockA_win_z	VLAN	1596	204.4 KDps	0 bps	0	15	0	0		
		strether13 Badius server	Ethemet	1600	0 bps	0 bps	Ő	ő	0	ő		i i
	B	<pre>sether1_Skannet</pre>	Ethemet	1598	1958 1 k	26.3 Mbps	2 148	2 632	0	0	(8
	X	steether2 Noren failover	Ethemet	1598	0 bps	0 bps	0	0	0	0	(
	R	ether3 VCs Lodge	Ethemet	1598	0 bos	0 bps	Ő	Ő	Ő	0	()
	R	ether4 Clinic AP	Ethemet	1598	525.7 kbps	22.1 kbps	46	38	0	0	i)

Figure 8: Capture of the bandwidth manager at the completion of public key message exchange.

The table below shows a measure of the change in network speed before the commencement of the public key exchange procedure and after the completion of the key exchange procedure. We notice a speed drop of about 6mbps. This is exposes the practical implementation challenge with typical public key schemes.

Table 1: Table Showing the Change in Network Link Speed during Public Key Exchange.

Link speed before commencement of Public key message exchange.	Link speed after completion of Public key message exchange	Change in the link Speed
32.4mbps	26.3mbps	6.1mbps

Source – [Field Survey]

Secret Key cryptosystem established after a successful exchange of the secret key using the public key procedure. Subsequent exchanges of messages using the cryptosystem now uses this established secret key system, which depends on very little or no bandwidth resources as compared to typical public key schemes.

🔛 Secret Key Crypto System	
- Encryption and Decryption	n Test
Message	
	Encrypt Message
Encrypted Message	
	Decrypt Message
Decrypted Message	

Figure 9: Capture of the established Secret-key Cryptosystem after a successful key exchange message.



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Messages are either typed or copied and pasted into the message field of the established secret key system and clicking the 'encrypt' button executes the secret key component of the hybrid cryptosystem.

Secret Key C	Crypto System				×
- Encryption a	ind Decryption	Test			
Message	This is a hyb key algorithn	rid cryptosystem using a combination and matrix encryption and it actual	on of Elgan ly works!	nal pul	olic
		[Encrypt	lessa	ge
Encrypted	Message				
			Decrypt	Aessa	ge
Decrypted	i Message				

Figure 10. Capture of the secret key cryptosystem with a sample plaintext for encryption.

Secret Key C	Crypto System								
-Encryption and Decryption Test									
Message This is a hybrid cryptosystem using a conbination of Elgamal public key algorithm and matrix encryption and it actually works!									
		Encrypt Message							
Encrypted Message		""-N-FR%ZLX%UYG(TT5Y0+9)QV-J+RX +3%_&NELW4P?18CF?UFHC1? I/,IXCDD6I'Q5G57C_L- OH/GO-A@DQ2J724_X&S9F"5Y0CF?OT3+64PL'6BQ							
		Decrypt Message							
Decrypted	i Message								
-									

Figure 11: Capture of the secret key cryptosystem with a sample plaintext and the corresponding encrypted ciphertext.

Clicking the 'decrypt' button upon receiving and encrypted message recover's the original message (plaintext):

Secret Key C	rypto System			×
- Encryption a	nd Decryptio	n Test		
Message	This is a hyb key algorithr	orid cryptosystem using a conbination of Elgamal m and matrix encryption and it actually works!	public	1
		Encrypt Me	ssage	
Encrypted	Message	""-N-FR%ZLX%UYG(TT5Y0+9)QV-J+RX +3%_&NELW4P718CF?UFHC1? I/IXCDD6I'Q5G57C_L- OH/GO=A@DQ2J724_X&S9F"5Y0CF?OT3+64F	PL'6BQ	
		Decrypt Me	essage	
Decrypted	l Message	THIS IS A HYBRID CRYPTOSYSTEM USING A CONBINATION OF ELGAMAL PUBLIC KEY ALGORITHM AND MATRIX ENCRYPTION AND ACTUALLY WORKS!) IT	

Figure 12.Capture of the secret key cryptosystem showing the decrypted message from the ciphertext.

Cryptanalysis of the hybrid cryptosystem first poses the challenge of solving the discrete logarithm problem during the public key exchange procedure:

$$a \equiv \log_g x \pmod{q-1},$$

such that

$$x \equiv g^a (mod \ q),$$

followed by computing:

$$M_i = A^{-1}C_i \pmod{N} = 52$$
),

where A^{-1} is the inverse of the arbitrarily chosen encryption matrix -A.



Figure 13: .Capture of the encrypted message that EVE gets from eavesdropping on the communication line.

3.2 Analysis of Implementation Speed for the Hybrid Cryptosystem

We begin this analysis with Reference to Table 1 (Showing the change in network link speed during public key exchange). It is note-worthy that because the public-key process of this hybrid cryptosystem depends largely on network factors (such as bandwidth and throughput) other than just the computing power of the local host, we observed the link speed before the commencement of the exchange of key, as well as the link speed at the completion of the exchange of keys.

This is critical because the Elgamal public key component of the hybrid cryptosystem which guarantees a secure contact between intended users who may not have met before requires a network resource to ride on. Consequently, a fast and reliable network link only translates to speed and guarantee respectively, of a successful completion of the key exchange process, and hence, the relative speed of the hybrid cryptosystem. Figure 3 (Capture of the bandwidth manager before commencement of public key exchange) shows this link speed on ether1_skanet to be 32.4mbps (megabits per second).

Figure 8 (Capture of the bandwidth manager at the completion of public key message exchange) shows the link speed on the same ether1 skanet to be 26.3mbps (megabits per second). Column three of Table 1 shows the change in the link speed to be 6.1mbps (megabits per seconds). Like many other typical implementations of public key cryptosystems, the Elgamal algorithm known to have the challenge of slow implementation. However, the stepping down to matrix encryption (by design) of this hybrid cryptosystem limits the challenge to only the first contact of communicating parties, after which subsequent encryptions and decryptions of messages are handled by the matrix encryption component of the hybrid cryptosystem shown in Figure 9 (Capture of the established Secret-key Cryptosystem after a successful key exchange message) and hence, showing the unifying advantage of the hybrid cryptosystem.

4. CONCLUSION

In this paper, a hybrid cryptosystem was presented. It was successfully implemented and tested on a campus area network, with which message encryption and decryption can be achieved. An attacker who intercepts a message for malicious reasons is faced with the challenge of solving a discrete logarithm problem together with accompanying function to find meaning to the message. This cryptosystem which combines the advantages of 'secure key distribution' and 'speed of implementation', guarantees secure exchange of messages (like emails, and text messages) in insecure network environments like the internet or intranets which has become a part of our daily routine, and therefore provides a viable option to maintaining communication privacy even in insecure communication environments.

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