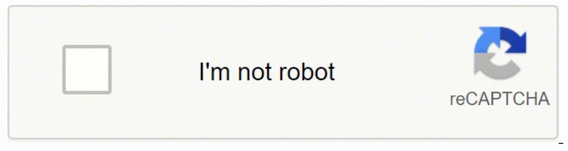

Continue

82101566.625 161022546056 32768528275 26920372.576923 8484370.5 108651354.66667 49762296275 29088852.384615 74252754.625 21548042.325301 32588744.258065 31067508297 316898816 80605236768 25293841692 33268975.754717 21735020547 322968.80263158 85073531140

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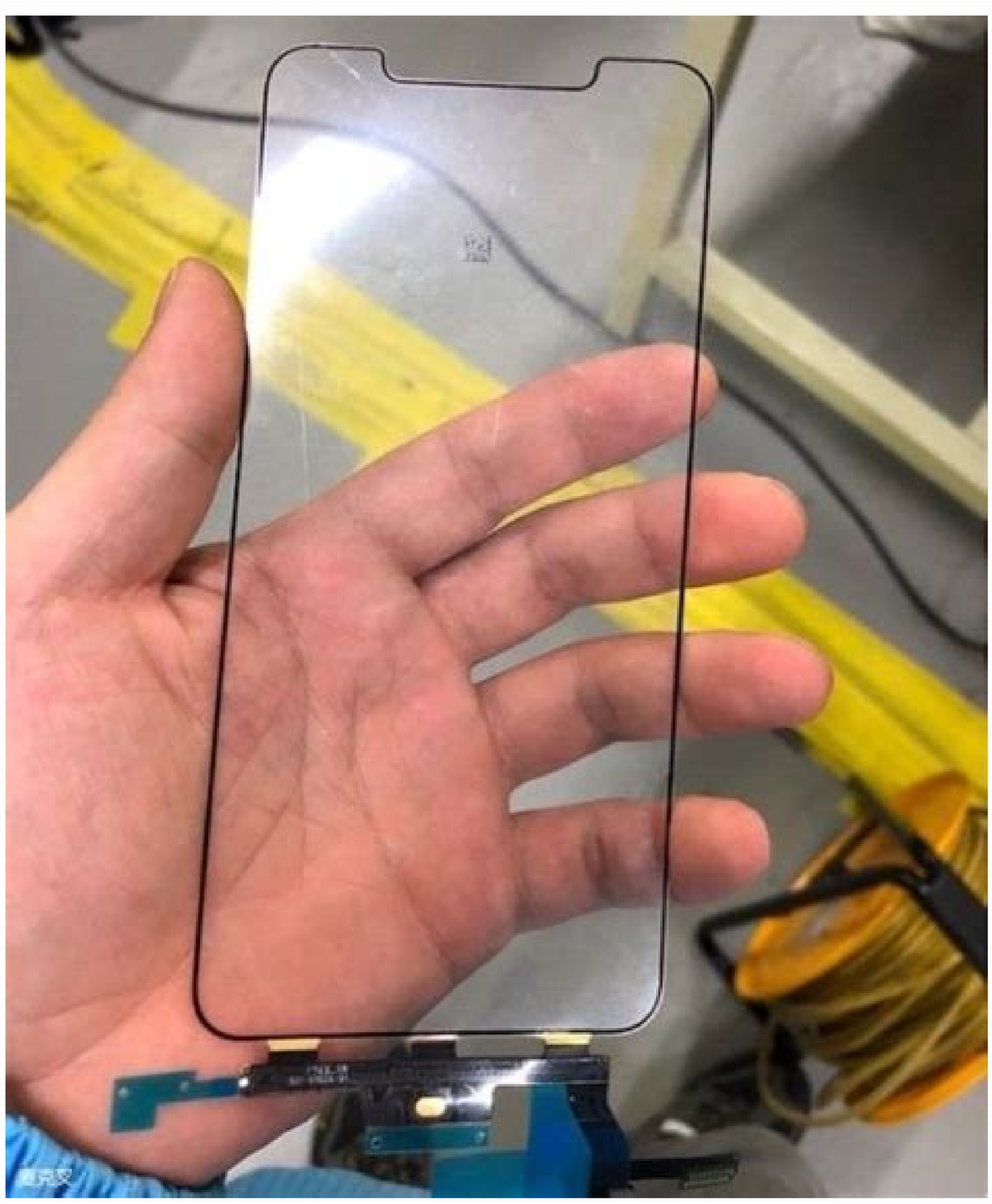

What is security network. What is networking and system security. What is the meaning of network security key.

The key must be less than or equal to the size of the message. The input to the hash function is of arbitrary length but output is always of fixed length. Decryption algorithm: The sequence of data processing steps that go into transforming cipher text back into plaintext. Thus, all traffic over all communications links is secured. Keccak offers many benefits, such as efficient performance and good resistance for attacks. − After the expansion permutation, DES does XOR operation on the expanded right section and the round key. Avalanche effect results in substantially different hash values for two messages that differ by even a single bit of data. On the other hand, in the more modern cryptographic algorithms, the encryption and decryption keys are not only different, but also one of them is placed in the public domain. It is used to generate the checksums on data files. A cryptographic system based on Feistel cipher structure uses the same algorithm for both encryption and decryption. At the lowest practical level, the encryption function could be performed at the network layer. This collision attack resulted in compromised MD5 and hence it is no longer recommended for use. 42 43. The following steps occur: 1. The DES function applies a 48-bit key to the rightmost 32 bits to produce a 32-bit output. The last block of bits needs to be padded up with redundant information so that the length of the final block equal to block size of the scheme. In future, when an attacker gets the ciphertext, he refers the dictionary to find the corresponding plaintext. The cipher text is ‘gnuneaoseenvltiltedasehetivc’. Using the newly minted session key for encryption, B sends a nonce, N2, to A. ComponentsofaCryptosystem The various components of a basic cryptosystem are as follows − Plaintext. For example, the range of salary can be guessed. 45 46. Using these rules, the result of the encryption of ‘hide money’ with the key of ‘tutorials’ would be − QC EF NU MF ZV Decrypting the Play fair cipher is as simple as doing the same process in reverse. It requires a secure key establishment mechanism in place. Each of the 25 alphabets must be unique and one letter of the alphabet (usually J) is omitted from the table as we need only 25 alphabets instead of 26. The packets do not need to be decrypted and then encrypted again at each hop, because the headers and trailers are not encrypted. As the packet traverses the network, each switch decrypts the packet, using a link encryption key to read the header, and then encrypts the entire packet again for sending it out on the next link. Vigenere cipher becomes a cryptosystem with perfect secrecy, which is called One-time pad. 28. In this mode, both the sender and receiver need to access to a reliable counter, which computes a new shared value each time a cipher text block is exchanged. This number which is between 0 and 25 becomes the key of encryption. o In other words, if a hash function h for an input x produces hash value h(x), then it should be difficult to find any other input value y such that h(y) = h(x). These feedback blocks provide string of bits to feed the encryption algorithm which act as the key-stream generator as in case of CFB mode. But the left half, L, goes through an operation that depends on R and the encryption key. The first eight sub-keys are extracted directly from the key, with K1 from the first round being the lower sixteen bits; further groups of eight keys are created by rotating the main key left 25 bits between each group of eight. Link versus End-to-End Encryption: The most powerful and most common approach to securing the points of vulnerability highlighted in the preceding section is encryption. This means that each round uses a different key, although all these sub keys are related to the original key. Prior to 1970, all cryptosystems employed symmetric key encryption. Steps in operation are − Load the initial counter value in the top register is the same for both the sender and the receiver. So he has the ciphertext-plaintext pair of his choice. For a connectionless protocol, a new session key is used for a certain fixed period only or for a certain number of transactions. Digital signature is a cryptographic value that is calculated from the data and a secret key known only by the signer. The process of encryption and decryption is depicted in the following illustration − The most important properties of public key encryption scheme are Different keys are used for encryption and decryption. 46 47. KEY DISTRIBUTION: For symmetric encryption to work, the two parties to an exchange must share the same key, and that key must be protected from access by others. It can be intercepted or compromised by anyone who has access to the communication channel. 6. o In order to maintain communication, the attacker re-encrypts the data after reading with his public key and sends to B. These keys are mathematically related − when one key is used for encryption, the other can decrypt the ciphertext back to the original plaintext. Password Storage Hash functions provide protection to password storage. Occasionally, the encryption key can be determined from this attack. It comprises of a series of linked operations, some of which involve replacing inputs by specific outputs (substitutions) and others involve shuffling bits around (permutations). Hence, he applies maximum effort towards finding out the secret key used in the cryptosystem. All of the substitution ciphers we have discussed earlier in this chapter are monoalphabetic; these ciphers are highly susceptible to cryptanalysis. The process of encrypt-then- sign is more reliable and widely adopted. Ciphertext. To encrypt the first plaintext P, which is a number modulo n. 31. 2. We will see two aspects of the RSA cryptosystem, firstly generation of key pair and secondly encryption-decryption algorithms. Input p = 7, q = 13, and e = 5 to the Extended Euclidean Algorithm. 8 Symmetric cryptosystems are a natural concept. It is the data to be protected during transmission. Instead, it is launched to exploit the weakness in physical implementation of the cryptosystem. The source host or terminal encrypts the data. If there is an odd number of letters, a Z is added to the last letter. Keys are recommended to be changed regularly to prevent any attack on the system. Variants of Vigenere Cipher: There are two special cases of Vigenere cipher The keyword length is same as plaintect message. Fourth row is shifted three positions to the left. DES is an implementation of a Feistel Cipher. Key distribution centre: The use of a key distribution center is based on the use of a hierarchy of keys. Operation The user takes the first block of plaintext and encrypts it with the key to produce the first block of cipher text. Length of Keys (number of bits) in this encryption is large and hence, the process of encryption- decryption is slower than symmetric key encryption. It had few weaknesses and did not become very popular. Similarly, if the hash function produces 64 bit hash values, the possible hash values are 1.8x1019 . 7. The message includes the identity of A and B and a unique identifier, N1, for this transaction, which we refer to as a nonce. For a given cryptosystem, a collection of all possible decryption keys is called a key space. Pre-decided IV is initially loaded at the start of decryption. As number of parties grow, some variant of 4 is only practical solution to the huge growth in number of keys potentially needed. An example of this attack is differential cryptanalysis applied against block ciphers as well as hash functions. Do not have very large block size − With very large block size, the cipher becomes inefficient to operate. The attacker knows the ciphertext and the algorithm, now he attempts all the 256 keys one by one for decryption. For example, actions such as intercepting and eavesdropping on the communication channel can be regarded as passive attack. The process is said to be almost similar and not exactly same. This is a strength of this scheme. 5. 12. Entity authentication is assurance that data has been received from a specific entity, say a particular website. Based on how these binary strings are processed, a symmetric encryption schemes can be classified in to BlockCiphers In this scheme, the plain binary text is processed in blocks (groups) of bits at a time; i.e. a block of plaintext bits is selected, a series of operations is performed on this block to generate a block of ciphertext bits. o In other words, if a hash function h produced a hash value z, then it should be a difficult process to find any input value x that hashes to z. The services are intended to counter security attacks and they make use of one or more security mechanisms to provide the service. Cryptosystems: A cryptosystem is an implementation of cryptographic techniques and their accompanying infrastructure to provide information security services. Therefore, the term that refers to the means of delivering a key to two parties who wish to exchange data, without allowing others to see the key. Hence, NIST called for new competitive hash function designs. Let us now see the possible goals intended to be fulfilled by cryptography. In addition to separating master keys from session keys, may wish to define different types of session keys on the basis of use. Most popular and prominent block ciphers are listed below. 35 master key is shared by the key distribution center and an end system or user and used to encrypt the session key. It is based on ‘substitution–permutation network’. HI → QC A L S B C D E F G H K M N P Q V W X Y Z If both letters are in the same row, take the letter to the right of each one (going back to the left if at the farthest right) T U O R I ‘D’ and ‘E’ are in same row, hence take letter to the right of them to replace. These two challenges are highly restraining for modern day communication. The keyword is used only once. Permutation logic is graphically depicted in the following illustration − The graphically depicted permutation logic is generally described as table in DES specification illustrated as shown − XOR (Whitener). When plaintext is available, it is encrypted and transmitted. The result is another new matrix consisting of 16 new bytes. 32. In this example, an electronic mail gateway is used to interconnect an internetwork that uses a TCP/IP-based architecture. Here is the cipher text alphabet for a Shift of 3. In more detail, these operators, which all deal with 16-bit quantities, are: Bitwise eXclusive OR (denoted with a blue circled plus ⊕). XOR the n-bit plaintext block with data value in top register. Completeness − Each bit of ciphertext depends on many bits of plaintext. Length of Key (number of bits) in this encryption is smaller and hence, process of encryption- decryption is faster than asymmetric key encryption. He then replaces the cipher text letter by the plaintext letter on the sliding ruler underneath. By measuring such timings, it is be possible to know about a particular computation the processor is carrying out. Collision Resistance o This property means it should be hard to find two different inputs of any length that result in the same hash. 8. If the computed MAC does not match the MAC sent by the sender, the receiver cannot determine whether it is the message that has been altered or it is the origin that has been falsified. CHAP - Challenge-handshake authentication protocol: The authentication process in this protocol is always initialized by the server/host and can be performed anytime during the session, even repeatedly. The system was invented by three scholars Ron Rivest, Adi Shamir, and Len Adleman and hence, it is termed as RSA cryptosystem. The result is a new matrix consisting of the same 16 bytes but shifted with respect to each other. After the eight rounds comes a final “half round”, the output transformation illustrated below (the swap of the middle two values cancels out the swap at the end of the last round, so that there is no net swap): Structure: The overall structure of IDEA follows the Lai-Massey scheme. Security mechanism – A mechanism that is designed to detect, prevent or recover from a security attack. For communication among entities within the same local domain, the local KDC is responsible for key distribution. It operates on numbers modulo n. Secure Hash Function (SHA) Family of SHA comprise of four SHA algorithms; SHA-0, SHA-1, SHA-2, and SHA-3. 52 The receiver now checks equality of freshly computed MAC with the MAC received from the sender. Find Derived Number (e) o Number e must be greater than 1 and less than (p − 1)(q − 1). Therefore, 2TDES has a key length of 112 bits. These actions are passive in nature, as they neither affect information nor disrupt the communication channel. If the attacker discovers the plain text blocks corresponding to some 17. DE → EFA L S B C 13. 56. The process of using MAC for authentication is depicted in the following illustration – Let us now try to understand the entire process in detail − The sender uses some publicly known MAC algorithm, inputs the message and the secret key K and produces a MAC value. Some of the mechanisms are: A. He will arrange plaintext and numeric key as follows − 14. Initiating unintended or unauthorized transmission of information. 40 41. o In general, the hash is much smaller than the input data, hence hash functions are sometimes called compression functions. The use of IDEA scheme has a restricted adoption due to patent issues. Hence the cipher text ‘WXWRULDO’ is decrypted to ‘tutorial’. The transport and network connections from each end system terminate at the mail gateway, which sets up new transport and network connections to link to the other end system. Receiver has the same key and can create the same key table, and then decrypt any messages made using that key. The first round process is depicted below − 25. Thus, the operation is analogous to the assignment of code words in a codebook, and hence gets an official name − Electronic Codebook mode of operation (ECB). These limitations of symmetric key encryption gave rise to asymmetric key encryption schemes. This provides backwards compatibility with DES. The choice of block size does not directly affect to the strength of encryption scheme. Most of them are using a password as the cornerstone of the authentication. Thus, the message is vulnerable at each switch. The IV need not be secret. AESAnalysis In present day cryptography, AES is widely adopted and supported in both hardware and software. IDEA − It is a sufficiently strong block cipher with a block size of 64 and a key size of 128 bits. Both these limitations can be overcome by using the public key based digital signatures discussed in following section. Refer the following illustration − The S-box rule is illustrated below − 21. Logically, in any cryptosystem, both the keys are closely associated. TRAFFIC CONFIDENTIALITY: The following types of information that can be derived from a traffic analysis attack: Identities of partners How frequently the partners are communicating Message pattern, message length, or quantity of messages that suggest important information is being exchanged The events that correlate with special conversations between particular partners Another concern related to traffic is the use of traffic patterns to create a covert channel. It is significantly more secure than a regular Caesar Cipher. Differences between Link encryption & End to End Encryption: Link Encryption End-to-End Encryption Link encryption encrypts all the data along a specific communication path. Also using Ks, A responds with f(N2), where f is a function that performs some transformation on N2 (e.g., adding one). Similarly, a digital signature is a technique that binds a person/entity to the digital data. In a group of n people, to enable two-party communication between any two persons, the number of keys required for group is n × (n – 1)/2. The features of AES are as follows − Symmetric key symmetric block cipher 128-bit data, 128/192/256-bit keys Stronger and faster than Triple-DES 24. Therefore, it will not be able to route the packet. By repeatedly evaluating the function for different inputs, the same output is expected to be obtained after about 5.1x109 random inputs. Signing large data through modular exponentiation is computationally expensive and time consuming. Later in 1995, SHA-1 was designed to correct alleged weaknesses of SHA-0. Essentially, the previous cipher text block is encrypted with the key, and then the result is XORed to the current plaintext block. It is a simplest form of substitution cipher scheme. Plaintext = Cd mod n Returning again to our numerical example, the ciphertext C = 82 would get decrypted to number 10 using private key 29 − Plaintext = 8229 mod 91 = 10 RSA Analysis The security of RSA depends on the strengths of two separate functions. 14 He now shifts each plaintext alphabet by the number written below it to create ciphertext as shown below − Here, each plaintext character has been shifted by a different amount – and that amount is determined by the key. To begin, this section examines the potential locations of security attacks and then looks at the two major approaches to encryption placement: link and end to end. 58. We discuss them in following sections RSACryptosystem: This cryptosystem is one the initial system. For example, file servers often provide a pre-computed MD5 checksum for the files, so that a user can compare the checksum of the downloaded file to it. FeistelBlockCipher: Feistel Cipher is not a specific scheme of block cipher. A stores the session key for use in the upcoming session and forwards to B the information that originated at the KDC for B, namely, E(Kb, [Ks || IDA]). A issues a request to the KDC for a session key to protect a logical connection to B. In addition, null messages can be inserted randomly into the stream. More than 40 EAP-methods exist, the most common are: EAP-MD5 EAP-TLS EAP-TTLS EAP-FAST EAP-PEAP Authentication applications: KERBEROS: It is a computer network authentication protocol that works on the basis of tickets to allow nodes communicating over a non-secure network to prove their identity to one another in a secure manner. Birthday Attack − This attack is a variant of brute-force technique. Thus, many keys must be provided. Since digital signature is created by ‘private’ key of signer and no one else can have this key; the signer cannot repudiate signing the data in future. Understand the difference between hash function and algorithm correctly. 58 Authentication protocol: An authentication protocol is a type of computer communications protocol or cryptographic protocol specifically designed for transfer of authentication data between two entities. The sender and the receiver may choose any one of these possible permutation as a cipher text alphabet. Security Value: Let us compare Shift cipher with one-time pad. All the user processes and applications within each end system would employ the same encryption scheme with the same key to reach a particular target end system. Then the cipher text is read vertically as shown. If working with a public network, the user has no control over the security of the nodes. However, it is still possible in those circumstances for an attacker to assess the amount of traffic on a network and to observe the amount of traffic entering and leaving each end system. The plaintext letter is then encrypted to the cipher text letter on the sliding ruler underneath. Signature is appended to the data and then both are sent to the verifier. A can select a key and physically deliver it to B. 18. Otherwise, the resulting 128 bits are interpreted as 16 bytes and we begin another similar round. The number of columns is equal to key number. For instance, the values of subkeys K1 - K4 are replaced by the inverse of K49 - K52 for the respective group operation, K5 and K6 of each group should be replaced by K47 and K48 for decryption. PassiveAttacks: The main goal of a passive attack is to obtain unauthorized access to the information. The resulting text is shown below. The function produces the output f(R,K). With 26 letters in alphabet, the possible permutations are 26! (Factorial of 26) which is equal to 4x1026 . On receiving the cipher text, the receiver who also knows the secret shift, positions his sliding ruler underneath the cipher text alphabet and slides it to RIGHT by the agreed shift number, 3 in this case. Continue in this manner until the last plaintext block has been encrypted. 33. Encryption Key. For example, it may happen that the receiver has lost the key to an attacker and the sender is not informed. In this example, the chosen permutation is K, D, G, ..., O. First, we apply an encrypting function ‘f’ that takes two input − the key K and R. Number of rounds in the systems thus depend upon efficiency–security tradeoff. 49 UNIT-6 PUBLIC KEY CRYPTOGRAPHY PublicKeyCryptography: Unlike symmetric key cryptography, we do not find historical use of public-key cryptography. Data Integrity − In case an attacker has access to the data and modifies it, the digital signature verification at receiver end fails. It however, does not provide any assurance about originality. The computational difficulty of algorithms, absence of secret key, etc., make it impossible for an attacker to obtain the original information even if he knows the algorithm used for coding. Process of Shift Cipher In order to encrypt a plaintext letter, the sender positions the sliding ruler underneath the first set of plaintext letters and slides it to LEFT by the number of positions of the secret shift. Similar steps are followed for decryption. Encryption algorithm is complex enough to prohibit attacker from deducing the plaintext from the ciphertext and the encryption (public) key. Hence, this scheme of encryption is also called Public Key Encryption. Even today, its relevance is very high and it is being used extensively in many cryptosystems. That’s for a message with 5 alphabets. Process of Vigenere Cipher: The sender and the receiver decide on a key. It is a design model from which many different block ciphers are derived. There are three types of Public Key Encryption schemes. The password has to be shared between the communicating entities in advance.[5] PAP 2-way handshake scheme PAP - Password Authentication Protocol: Password Authentication Protocol is one of the oldest authentication protocols. The destination shares a key with the source and so is able to decrypt the data. Communication between end systems is encrypted using a temporary key, often referred to as a session key. It plays the same role as the IV in CFB (and CBC) mode. 30 UNIT-4 CONFIDENTIALITY USING SYMMETRIC ENCRYPTION Placement of Encryption Function: If encryption is to be used to counter attacks on confidentiality, we need to decide what to encrypt and where the encryption function should be located. Dictionary Attack − This attack has many variants, all of which involve compiling a ‘dictionary’. TypesofCryptosystems Fundamentally, there are two types of cryptosystems based on the manner in which encryption-decryption is carried out in the system − Symmetric Key Encryption Asymmetric Key Encryption The main difference between these cryptosystems is the relationship between the encryption and the decryption key. Instead of starting with a block of plaintext, the ciphertext block is fed into the start of the Feistel structure and then the process thereafter is exactly the same as described in the given illustration. The sender inputs the encryption key into the encryption algorithm along with the plaintext in order to compute the ciphertext. The concept is to replace each alphabet by another alphabet which is ‘shifted’ by some fixed number between 0 and 25. It is mainly based on ‘security through obscurity’. BlockSize Though any size of block is acceptable, following aspects are borne in mind while selecting a size of a block. Let two primes be p = 7 and q = 13. It is illustrated as follows − Analysis of ECB Mode In reality, any application data usually have partial information which can be guessed. Encrypt the data value in top register with underlying block cipher with key K. Let us say we want to encrypt the message “hide money”. Finally, encrypt the output of step 2 using single DES with key K3. Known Plaintext Attack (KPA) − In this method, the attacker knows the plaintext for some parts of the ciphertext. The advantage of EAP is that it is only a general authentication framework for client-server authentication - the specific way of authentication is defined in its many versions called EAP-methods. There are two fundamental alternatives: link encryption and end-to-end encryption. If they match, then the receiver accepts the message and assures himself that the message has been sent by the intended sender. Popular hash functions generate values between 160 and 512 bits. Example An example of generating RSA Key pair is given below. The KDC responds with a message encrypted using Ka Thus, A is the only one who can successfully read the message, and A knows that it originated at the KDC. The salient features of cryptosystem based on symmetric key encryption are − Persons using symmetric key encryption must share a common key prior to exchange of information. The decryption is the reverse process. B now knows the session key (Ks), knows that the other party is A (from IDA), and knows that the information originated at the KDC (because it is encrypted using Kb). Let us assume RSA is used as the signing algorithm. 1 UNIT-1INTRODUCTION THE OSI SECURITY ARCHITECTURE: To assess effectively the security needs of an organization and to evaluate and choose various security products and policies, the manager responsible for security needs some systematic way of defining the requirements for security and characterizing the approaches to satisfying those requirements. o Thus, whatever host A sends to host B, the attacker is able to read. Several implications of link encryption should be noted. If only end-to-end encryption is employed, then the measures available to the defender are more limited. HASH FUNCTION: Hash functions are extremely useful and appear in almost all information security applications. However, just as for DES, the AES security is assured only if it is correctly implemented and good key management is employed. 36 3. Mix Columns: Each column of four bytes is now transformed using a special mathematical function. In order to be unbreakable scheme, this function needs to have several important properties that are beyond the scope of our discussion. If the sender and receiver get involved in a dispute over message origination, MACs cannot provide a proof that a message was indeed sent by the sender. Shift rows Each of the four rows of the matrix is shifted to the left. Not only is the user information encrypted, but the header,

trailers, addresses, and routing data that are part of the packets are also encrypted. It is still a respected block ciphers but inefficient compared to the new faster block ciphers available. A has a master key, Ka, known only to itself and the KDC; similarly, B shares the master key Kb with the KDC. The CFB mode requires an initialization vector (IV) as the initial random n-bit input block. o It can provide message authentication among pre-decided legitimate users who have shared key. o This property of hash function protects against an attacker who has an input value and its hash, and wants to substitute different value as legitimate value in place of original input value. Decryption Key. Authentication is initialized by client/user by sending packet with credentials (username and password) at the beginning of the connection.[6] It is highly insecure because the credentials are being transmitted over the network in plain ASCII text thus it is vulnerable even to the most simple attacks like Eavesdropping and man-in-the- middle based attacks. Each round comprise of four sub- processes. The private key used for signing is referred to as the signature key and the public key as the verification key. In addition, the message includes two items intended for B: The one-time session key, Ks to be used for the session The original identifier of A (e.g., its network address), IDA These last two items are encrypted with Kb (the master key that the KDC shares with B). Integrity service confirms that whether data is intact or not since it was last created, transmitted, or stored by an authorized user. During the last few years, cryptanalysis have found some weaknesses in DES when key selected are weak keys. The strength of RSA encryption drastically goes down against attacks if the number p and q are not large primes and/ or chosen public key e is a small number. ElectronicCodeBook(ECB)Mode This mode is a most straightforward way of processing a series of sequentially listed message blocks. The key table works out to be − Process of Play fair Cipher: First, a plaintext message is split into pairs of two letters (digraphs). On receiving the cipher text, the receiver, who also knows the randomly chosen permutation, replaces each cipher text letter on the bottom row with the corresponding plaintext letter in the top row. o Also, if a hash function is collision-resistant then it is second pre-image resistant. Encipherment The use of mathematical algorithms to transform data into a form that is not readily intelligible. Man in Middle Attack (MIM) − The targets of this attack are mostly public key cryptosystems where key exchange is involved before communication takes place. In play fair cipher, initially a key table is created. Suppose that the receiver of public- key pair (n, e) has received a ciphertext C. Then to find the text student whose birthdate is 3rd Aug, we need to enquire 25 students. PropertiesofHashFunctions: In order to be an effective cryptographic tool, the hash function is desired to possess following properties − Pre-Image Resistance o This property means that it should be computationally hard to reverse a hash function. For example, in the present system, a message block has a size 's' bits where $1 < s < n$. All AES uses 10 rounds for 128-bit keys, 12 rounds for 192-bit keys and 14 rounds for 256-bit keys. Encryption algorithm: The sequence of data processing steps that go into transforming plaintext into cipher text. DecryptionProcess: The process of decryption of an AES cipher text is similar to the encryption process in the reverse order. For two parties A and B, key distribution can be achieved in a number of ways, as follows: 1. Major Issues with KDC: For very large networks, a hierarchy of KDCs can be established. Based on the comparison result, verifier decides whether the digital signature is valid. 37 UNIT-5 38. Data Integrity Check Data integrity check is a most common application of the hash functions. Confidentiality: Confidentiality is the fundamental security service provided by cryptography. 56 DIGITAL SIGNATURES: Digital signatures are the public-key primitives of message authentication. However, two additional steps are desirable: 4. Practically, these values are very high). In this threat, the user is not sure about the originator of the message. This permutation is the secret key of the scheme. This process is often referred to as hashing the data. Various parameters used by an encryption algorithm are derived from the secret key. In the last chapter, we discussed the data integrity threats and the use of hashing technique to detect if any modification attacks have taken place on the data. For example, a 150-bit plaintext provides two blocks of 64 bits each with third block of balance 22 bits. Hence, AES treats the 128 bits of a plaintext block as 16 bytes. The cryptosystem was found to be non-practical due to challenges it faced for key management. If A and B each has an encrypted connection to a third party C, C can deliver a key on the encrypted links to A and B. Instead of storing password in clear, mostly all logon processes store the hash values of passwords in the file. 41 42. It is the scrambled version of the plaintext produced by the encryption algorithm using a specific the encryption key. LimitationsofMAC There are two major limitations of MAC, both due to its symmetric nature of operation − Establishment of Shared Secret. To obtain the text, he reads horizontally left to right and from top to bottom row. It is sometimes referred to as privacy or secrecy. Due to this design of Triple DES as an encrypt-decrypt-encrypt process, it is possible to use a 3TDES (hardware) implementation for single DES by setting K1, K2, and K3 to be the same value. C.Access Control A variety of mechanisms that enforce access rights to resources. To decrypt, the receiver prepares similar table. The result is in a matrix of four rows and four columns. MD5 digests have been widely used in the software world to provide assurance about integrity of transferred file. This makes it essential for users employing PKC for encryption to seek digital signatures along with encryption to be assured of message authentication and non-repudiation. A secret key is used to set some or all of the various parameters used by the encryption algorithm. The block size is 64-bit. Thus, many more secret keys need to be generated and distributed. Here is a jumbled Cipher text alphabet, where the order of the cipher text letters is a key. If these are not swapped then the resulting ciphertext could not be decrypted using the same algorithm. This integrity check application is useful only if the user is sure about the originality of file. The important thing to note is that, in classical cryptography, the same secret key is used for encryption and decryption. For decryption, IV data is XORed with first cipher text block decrypted. The steps are as follows − Load the n-bit Initialization Vector (IV) in the top register. As a bottom-line, a receiver safely assumes that the message is not the genuine. Though from same family, there are structurally different. These keys shall be avoided. Add roundkey: The 16 bytes of the matrix are now considered as 128 bits and are XORed to the 128 bits of the round key. In October 2012, the NIST chose the Keccak algorithm as the new SHA-3 standard. Security Value It is also a substitution cipher and is difficult to break compared to the simple substitution cipher. In this case, the plaintext 'tutorial' is encrypted to the ciphertext 'WXWRULDO'. To balance security & effort, a new session key should be used for each new connection-oriented session. One technique that might prove useful is to pad out data units to a uniform length at either the transport or application level. Encryption would then entail only looking up for required plaintext and select the corresponding cipher text. Second, the receiver of message needs assurance that the message belongs to the sender and he must not be able to repudiate the origination of that message. 16 UNIT-3 Modernencryptiontechniques: Digital data is represented in strings of binary digits (bits) unlike alphabets. The message includes two items intended for A: The one-time session key, Ks, to be used for the session The original request message, including the nonce, to enable A to match this response with the appropriate request Thus, A can verify that its original request was not altered before reception by the KDC and, because of the nonce, that this is not a replay of some previous request. o Since a hash is a smaller representation of a larger data, it is also referred to as a digest. Cryptography provides many tools and techniques for implementing cryptosystems capable of preventing most of the attacks described above. With network-layer encryption, Each end system can engage in an encrypted exchange with another end system if the two share a secret key. Thus, the key is: 16 15 9 14 20. He can see the ciphertext and may know the decryption algorithm. These two properties make cipher very strong. At this point, a session key has been securely delivered to A and B, and they may begin their protected exchange. Security Value Vigenere Cipher was designed by tweaking the standard Caesar cipher to reduce the effectiveness of cryptanalysis on the cipher text and make a cryptosystem more robust. In fact, if a technique for factoring efficiently is developed then RSA will no longer be safe. The attacker, instead of modifying the data, can change the entire file and compute all together new hash and send to the receiver. A popular public key cryptosystem, RSA is also vulnerable to chosen-plaintext attacks. Even if both end systems use TCP/IP or OSI, there are plenty of instances in actual configurations in which mail gateways sit between otherwise isolated internetworks. It is very unlikely that this encryption will fade away, as it has certain advantages over asymmetric key encryption. In real implementation of the Feistel Cipher, such as DES, instead of using the whole encryption key during each round, a round-dependent key (a sub key) is derived from the encryption key. The salient features of this encryption scheme are as follows − Every user in this system needs to have a pair of dissimilar keys, private key and public key. For example, a communication between online seller and customer. TranspositionCipher: It is another type of cipher where the order of the alphabets in the plaintext is rearranged to create the cipher text. To achieve greater security, both link and end-to-end encryption are needed, as is shown in Figure 7.2. When both forms of encryption are employed, the host encrypts the user data portion of a packet using an end-to-end encryption key. It allows to authenticate the connecting entity (e.g. Client connecting to a Server) as well as authenticate itself to the connecting entity (Server to a client) by declaring the type of information needed for authentication as well as syntax. 57 Verifier feeds the digital signature and the verification key into the verification algorithm. SHA-2 family has four further SHA variants, SHA-224, SHA-256, SHA-384, and SHA-512 depending on number of bits in their hash value. The process is depicted in the following illustration. AsymmetricKey Encryption was invented in the 20th century to come over the necessity of pre-shared secret key between communicating persons. 15 (26 x 26 x 26 x 26 x 26) = 26^5 = 11881376 times. NumberofRounds The number of rounds used in a Feistel Cipher depends on desired security from the system. The OFB mode requires an IV as the initial random n-bit input block. Triple DES systems are significantly more secure than single DES, but these are clearly a much slower process than encryption using single DES. The result of this is C1. In each round, the right half of the block, R, goes through unchanged. The hash of the data is a relatively small digest of the data, hence signing a hash is more efficient than signing the entire data. Hence, it is necessary to represent the plaintext as a series of numbers less than n. In fact, for a given key technically we can create a codebook of ciphertexts for all possible plaintext blocks. The verification algorithm gives some value as output. End-to-End Encryption Approach: Traffic padding is essentially a link encryption function. This means that C is also a number less than n. This simplifies his task of 3. end-to-end encryption, the headers, addresses, routing, and trailer information are not encrypted, enabling attackers to learn more about a captured packet and where it is headed. Processing power of computer system required to run symmetric algorithm is less. Efficiency of Operation o Generally for any hash function h with input x, computation of h(x) is a fast operation. The decryption key is related to the encryption key, but is not always identical to it. 11 example, A,B, ...,Y,Z and Z,Y,......B,A are two obvious permutation of all the letters in alphabet. It is a cryptographic algorithm that takes plaintext and an encryption key as input and produces a ciphertext. What part of each packet will the host encrypt? The number of rows is obtained by dividing number of total ciphertext alphabets by key value and rounding of the quotient to next integer value. An automated key distribution approach provides the flexibility and dynamic characteristics needed to allow a number of terminal users to access a number of hosts and for the hosts to exchange data with each other, provided they trust the system to act on their behalf. To ensure sufficient diffusion, two of the sub-blocks are swapped after each round. This gave rise to the public key cryptosystems. Link to Encryption: With link encryption, each vulnerable communications link is equipped on both ends with an encryption device. This process is shown in the following illustration. Traffic padding, illustrated in Figure 7.6. Traffic padding produces cipher text output continuously, even in the absence of plaintext. Then, we XOR the output of the mathematical function with L. It relies on publicly known mathematical algorithms for coding the information. E.Authentication Exchange A mechanism intended to ensure the identity of an entity by means of information exchange. Kerberos builds on symmetric key cryptography and requires a trusted third party, and optionally may use public-key cryptography during certain phases of authentication. CryptographyPrimitives: Cryptography primitives are nothing but the tools and techniques in Cryptography that can be selectively used to provide a set of desired security services − Encryption Hash functions Message Authentication codes (MAC) Digital Signatures The following table shows the primitives that can achieve a particular security service on their own. The keyword is a randomly generated string of alphabets. The OSI security architecture focuses on security attacks, mechanisms, and services. Inability to Provide Non-Repudiation o Non-repudiation is the assurance that a message originator cannot deny any previously sent messages and commitments or actions. This requirement can be avoided if key distribution is fully decentralized. Data are transmitted over such a network in the form of packets that consist of a header and some user data. o This requires establishment of shared secret prior to use of MAC. Client uses his password and the string received as parameters for MD5 hash function and then sends the result together with username in plain text. A robust mechanism needs to exist to exchange the key between the communicating parties. Non-repudiation − Since it is assumed that only the signer has the knowledge of the signature key, he can only create unique signature on a given data. SECURITY MECHANISM: A mechanism that is designed to detect, prevent or recover from a security attack. 'R' and 'L' are concatenated in this order to form the cipher text block. The size of block is fixed in the given scheme. An analytical attack was reported to be successful only in an hour by using computer cluster. This property is also referred to as collision free hash function. A hash function is a mathematical function that converts a numerical input value into another compressed numerical value. An attacker can carry out an exhaustive key search with available limited computing resources. Security service − A service that enhances the security of the data processing systems and the information transfers of an organization. There are a large number of locations at which an attack can occur. More number of rounds provide more secure system. Suppose that the host encrypts the entire packet, including the header. Instead of shifting the alphabets by some number, this scheme uses some permutation of the letters in alphabet. The cipher text is obtained by reading column vertically downward from first to last column. This hash function forms the part of the hashing algorithm. The schematic of AES structure is given in the following illustration − EncryptionProcess Here, we restrict to description of a typical round of AES encryption. He does not have access to corresponding plaintext. To obtain the plaintext, the attacker only needs to find out the secret decryption key, as the algorithm is already in public domain. The permutation step at the end of each round swaps the modified L and unmodified R. Shift is carried out as follows − First row is not shifted. For example, Modifying the information in an unauthorized manner. Typically the block sizes are from 128 bits to 512 bits. Its designers aimed it primarily at a client-server model and it provides mutual authentication— both the user and the server verify each other's identity. If the plaintext contains J, then it is replaced by I. There are two possibilities, sign-then-encrypt and encrypt-then-sign. A block cipher takes the data block of fixed size. The Play fair cipher was mainly used to protect important, yet non-critical secrets, as it is quick to use and requires no special equipment. CipherBlockChaining(CBC)Mode: CBC mode of operation provides message dependence for generating cipher text and makes the system non-deterministic. Second variant of Triple DES (2TDES) is identical to 3TDES except that K3is replaced by K1. Must trust intermediary not to abuse the knowledge of all session keys. This cryptosystem is generally referred to as the Shift Cipher. Too much padding makes the system inefficient. It is used against the cryptographic hash function. PaddinginBlockCipher Block ciphers process blocks of fixed sizes (say 64 bits). Alteration of authentication data such as originator name or timestamp associated with information Unauthorized deletion of data. MonoalphabeticandPolyalphabeticCipher: Mono alphabetic cipher is a substitution cipher in which for a given key, the cipher alphabet for each plain alphabet is fixed throughout the encryption process. 55. It requires the entire cryptosystem for communicating confidentially. This function takes as input the four bytes of one column and outputs four completely new bytes, which replace the original column. It is practically impossible to decrypt the ciphertext with the key that is unrelated to the encryption key. SHA-1 is the most widely used of the existing SHA hash functions. Consider the following situation. To break the ciphertext by brute force, you need to try all possibilities of keys and conduct computation for 15. Another type of threat that exist for data is the lack of message authentication. o Since, hash function is compressing function with fixed hash length, it is impossible for a hash function not to have collisions. o Interestingly, though n is part of the public key, difficulty in factorizing a large prime number ensures that attacker cannot find in finite time the two primes (p & q) used to obtain n. Essentially, a MAC is an encrypted checksum generated on the underlying message that is sent along with a message to ensure message authentication. 3 is most basic and 1 or 2 occurring first. It remains most employed cryptosystem even today. This case is called Vernam Cipher. Symmetric cryptography was well suited for organizations such as governments, military, and big financial corporations were involved in the classified communication. Interestingly, AES performs all its computations on bytes rather than bits. Polyalphabetic Cipher: is a substitution cipher in which the cipher alphabet for the plain alphabet may be different at different places during the encryption process. IDEA derives much of its security by interleaving operations from different groups — modular addition and multiplication, and bitwise eXclusive OR (XOR) – which are algebraically "incompatible" in some sense. Each alphabet of the key is converted to its respective numeric value: In this case, p → 16, o → 15, i → 9, n → 14, and t → 20. As in case of substitution cipher, cryptanalysis is possible on the Playfair cipher as well, however it would be against 625 possible pairs of letters (25x25 alphabets) instead of 26 different possible alphabets. 48 49. This is depicted in the following illustration − Verifier verifies the signature using sender's public key. Apart from ability to provide non-repudiation of message, the digital signature also provides message authentication and data integrity. A replacement for DES was needed as its key size was too small. The number of rounds are specified by the algorithm design. For example, if 'A' is encrypted as 'D', for any number of occurrence in that plaintext, 'A' will always get encrypted to 'D'. IDEA uses a key-dependent half-round function. Decryption Algorithm, It is a mathematical process, that produces a unique plaintext for any given ciphertext and decryption key. Classic Cryptography Modern Cryptography It manipulates traditional characters, i.e., letters and digits directly. The data may get modified by an unauthorized entity intentionally or accidently. In contrast, public-key cryptosystems are quite difficult to comprehend. o This relationship is written mathematically as follows − ed = 1 mod (p − 1)(q − 1) The Extended Euclidean Algorithm takes p, q, and e as input and gives d as output. For example, let's assume the key is 'point'. 32 Logical Placement of End-To-End Encryption Function: With link encryption, the encryption function is performed at a low level of the communications hierarchy i.e. physical or link layers. It works at a lower layer in the OSI model. This is a property which set this scheme different than symmetric encryption scheme. Second row is shifted one (byte) position to the left. The number of bits in a block is fixed. The operation is depicted in the following illustration − Counter(CTR)Mode: It can be considered as a counter-based version of CFB mode without the feedback. The Data Encryption Standard (DES) is a symmetric-key block cipher published by the National Institute of Standards and Technology (NIST). F.Traffic Padding The insertion of bits into gaps in a data stream to frustrate traffic analysis attempts. D.Data Integrity A variety of mechanisms used to assure the integrity of a data unit or stream of data units. This application provides assurance to the user about correctness of the data. Power Analysis Attacks − These attacks are similar to timing attacks except that the amount of power consumption is used to obtain information about the nature of the underlying computations. On the other hand, end-to-end encryption gives only the source and destination. The process of logon is depicted in the following illustration − An intruder can only see the hashes of passwords, even if he accessed the password. Now decrypt the output of step 1 using single DES with key K2. However, the crypto system based on sign-then-encrypt can be exploited by receiver to spoof identity of sender and sent that data to third party. The possible number of keys is large (26!) and even the modern computing systems are not yet powerful enough to comfortably launch a brute force attack to break the system. The OSI security architecture was developed in the context of the OSI protocol architecture, which is described in Appendix H. Hence, this method is not preferred. However, with each character now having its own individual shift between 1 and 26, the possible keys grow exponentially for the message. Decryption of a ciphertext is a reverse process. With increasing computing power, it was considered vulnerable against exhaustive key search attack. In classical cryptography, the various parameters used by a decryption algorithm are derived from the same secret key that was used in the encryption algorithm. Generally, the key pairs used for encryption/decryption and signing/verifying are different. 1.SECURITY ATTACKS: AttacksonCryptosystems: Attacks are typically categorized based on the action performed by the attacker. This means that it is rotated less than once per round, on average, for a total of six rotations. The following illustration demonstrates hash function − 54. DES has proved to be a very well designed block cipher. It is found at least six time faster than triple DES. In such a configuration, there is no end-to-end protocol below the application layer. Based on the methodology used, attacks on cryptosystems are categorized as follows − Ciphertext Only Attacks (COA) − In this method, the attacker has access to a set of ciphertext(s). The process is depicted in the following illustration – The integrity check helps the user to detect any changes made to original file. Feed cipher text block into top register and continue the operation till all plaintext blocks are processed. BlockCipherSchemes There is a vast number of block ciphers schemes that are in use. Security attack – Any action that compromises the security of information owned by an organization. No successful attacks have yet been reported on SHA-2 hash function. A continuous random data stream is generated. Furthermore, for wide area communications, many of these locations are not under the physical control of the end user. OutputFeedback(OFB)Mode It involves feeding the successive output blocks from the underlying block cipher back to it. 57. With the spread of more unsecure computer networks in last few decades, a genuine need was felt to use cryptography at larger scale. It works at Network layer. This effect, known as an avalanche effect of hashing. A number of applications use IDEA encryption, including early versions of Pretty Good Privacy (PGP) protocol. A cryptosystem is also referred to as a cipher system. The decryption algorithm essentially reverses the encryption algorithm and is thus closely related to it. Then the possible plaintext bits combinations are then 2m . Hash value and signature key are then fed to the signature algorithm which produces the digital signature on given hash. It is employed in several widely used applications and protocols including Secure Socket Layer (SSL) security. Encryption and Decryption Once the key pair has been generated, the process of encryption and decryption are relatively straightforward and computationally easy. Authentication: Authentication provides the identification of the originator. Timing Attacks − They exploit the fact that different computations take different times to compute on processor. In the case of decryption, the only difference is that the subkeys used in encryption are used in the reverse order. Multiplication modulo 216 +1, where the all-zero word (0x0000) in inputs is interpreted as 216 and 216 in output is interpreted as the all-zero word (0x0000) (denoted by a red circled dot ⊙). 51 C = 105 mod 91 RSA Decryption The decryption process for RSA is also very straightforward. The result of this process is depicted in the following illustration for an agreed shift of three positions. The receiver then writes the received cipher text vertically down and from left to right column. Processing power of computer system required to run asymmetric algorithm is higher. 3 determining the encryption key. This means that the actual 3TDES key has length 3×56 = 168 bits. The result modulo n will be the plaintext P. The data in encrypted form are then transmitted unaltered across the network to the destination terminal or host. 17 previously sent ciphertext blocks, then the attacker can launch a type of 'dictionary attack' by building up a dictionary of plaintext/ciphertext pairs sent using that encryption key. Headers, addresses, and routing information are not encrypted, and therefore not protected. An interceptor (an attacker) is an unauthorized entity who attempts to determine the plaintext. The most important reason of using hash instead of data directly for signing is efficiency of the scheme. For example, once an order is placed electronically, a purchaser cannot deny the purchase order, if non-repudiation service was enabled in this transaction. It is also a one way function, going from p & q values to modulus n is easy but reverse is not possible. Triple DES was designed to overcome this drawback but it was found slow. A third party, whom all parties trust, can be used as a trusted intermediary to mediate the establishment of secure communications between them (4). Non-repudiation is a property that is most desirable in situations where there are chances of a dispute over the exchange of data. Server uses the username to apply the same function and compares the calculated and received hash. Steps of operation are − Load the IV in the top register. Though the keys are different, they are mathematically related and hence, retrieving the plaintext by decrypting ciphertext is feasible. 4 B. One of its disadvantages is that the message must be decrypted each time it enters a switch because the switch must read the address (logical connection number) in the packet header in order to route the frame. G.Routing Control Enables selection of particular physically secure routes for certain data and allows routing changes, especially when abreach of security is suspected. For this strategy to be effective, all the potential links in a path from source to destination must use link encryption. Thus, end-to-end encryption relieves the end user of concerns about the degree of security of networks and links that support the communication. 16. o Hash function with n bit output is referred to as an n-bit hash function. However, the traffic pattern is not, because packet headers are transmitted in the clear. Though, key length is 64-bit, DES has an effective key length of 56 bits, since 8 of the 64 bits of the key are not used by the encryption algorithm (function as check bits only). StreamCiphers In this scheme, the plaintext is processed one bit at a time i.e. one bit of plaintext is taken, and a series of operations is performed on it to generate one bit of ciphertext. It is a value that is known to the receiver. Server sends a random string (usually 128B long). Each pair of nodes that share a link should share a unique key, with a different key used on each link. Any entries that 'fall off' are re-inserted on the right side of row. 4. Authentication protocols developed for PPP Point-to-Point Protocol: Protocols are used mainly by Point-to-Point Protocol (PPP) servers to validate the identity of remote clients before granting them access to server data. Returning to our Key Generation example with plaintext P = 10, we get ciphertext C − 51. Hashing algorithm is a process for using the hash function, specifying how the message will be broken up and how the results from previous message blocks are chained together. They have no cryptography significance in DES. It is more secure than typical Vigenere cipher. Encrypt the contents of the counter with the key and place the result in the bottom register. Send C1 to the receiver and update the counter. Let us assume the first student's birthdate is 3rd Aug. Key Generation − The difficulty of determining a private key from an RSA public key is equivalent to factoring the modulus n. Check that the d calculated is correct by computing − de = 29 × 5 = 145 = 1 mod 72 Hence, public key is (91, 5) and private keys is (91, 29). 22 The logic for Parity drop, shifting, and Compression P-box is given in the DES description. The task is to decrypt the rest of the ciphertext using this information. It follows that the host may encrypt only the user data portion of the packet and must leave the header in the clear. All of the information is encrypted, and the packets must be decrypted at each hop so the router, or other intermediate device, knows where to send the packet next. He, however, must never know the decryption key. 1. Key schedule: Each round uses six 16-bit sub-keys, while the half-round uses four, a total of 52 for 8.5 rounds. It confirms to the receiver that the data received has been sent only by an identified and verified sender. Generation of RSA Key Pair Each person or a party who desires to participate in communication using encryption needs to generate a pair of keys, namely public key and private key. User first decrypt using K3, then encrypt with K2, and finally decrypt with K1. For our purposes, the OSI security architecture provides a useful, if abstract, overview of many of the concepts.. 34 Link Encryption Approach: With the use of link encryption, network-layer headers (e.g., frame or cell header) are encrypted, reducing the opportunity for traffic analysis. Thus, for applications like electronic mail that have a store-and-forward capability, the only place to achieve end- to-end encryption is at the application layer. Furthermore, frequent key changes are usually desirable to limit the amount of data compromised if an attacker learns the key. COA is said to be successful when the corresponding plaintext can be determined from a given set of ciphertext. To decrypt a message encoded with a Shift of 3, generate the plaintext alphabet using a shift of '-3' as shown below. The process followed in the generation of keys is described below − Generate the RSA modulus (n) 50. Underneath the natural order alphabets, write out the chosen permutation of the letters of the alphabet. Deciphering or Decryption: Recovering plaintext from cipher text. o This property makes it very difficult for an attacker to find two input values with the same hash. Many of them are publically known. The processes for encryption and decryption are similar. Hence, the long message is divided into a series of sequential message blocks, and the cipher operates on these blocks one at a time. Therefore, the L for the next round would be R of the current round. The ciphertext is not guarded. But at the same time, more rounds mean the inefficient slow encryption and decryption processes. An authentication is successful or unsuccessful. 9. In 2004, collisions were found in MD5. PlayfairCipher: In this scheme, pairs of letters are encrypted, instead of single letters as in the case of simple substitution cipher. Such plaintexts will need to be padded before being encrypted. BlockCipher The basic scheme of a block cipher is depicted as follows − A block cipher takes a block of plaintext bits and generates a block of cipher text bits, generally of same size. When students in a class are asked about their birthdays, the answer is one of the possible 365 dates. o Host A wants to communicate to host B, hence requests public key of B. For verification, this hash value and output of verification algorithm are compared. If either of these two functions are proved non one-way, then RSA will be broken. Security Value: Simple Substitution Cipher is a considerable improvement over the Caesar Cipher. 18 Above substitution and permutation steps form a 'round'. And R for the next round be the output L of the current round. The final swapping of 'L' and 'R' in last step of the Feistel Cipher is essential. Shift Cipher − Easy to Break In case of Shift cipher, the entire message could have had a shift between 1 and 25. Unlike modern systems which are digital and treat data as binary numbers, the earlier systems worked on alphabets as basic element. For example, if encryption is implemented at the application layer, then an opponent can determine which transport entities are engaged in dialogue. A larger block size makes attack harder as the dictionary needs to be larger. Third row is shifted two positions to the left. It is for this reason that classical cryptography is also referred to as symmetric key cryptography. Generally, this type of cryptosystem involves trusted third party which certifies that a particular public key belongs to a specific person or entity only. The cipher text 'MJBXZ' is decrypted to 'point'. The actual plaintext alphabets are not replaced. 27 CipherFeedback(CFB)Mode: In this mode, each cipher text block gets 'fed back' into the encryption process in order to encrypt the next plaintext block. Key establishment − Before any communication, both the sender and the receiver need to agree on a secret symmetric key. A network that supports hundreds of hosts may support thousands of users and processes. It uses 16 round Feistel structure. It was referred to as the unbreakable cipher due to the difficulty it posed to the cryptanalysis. The model of digital signature scheme is depicted in the following illustration − The following points explain the entire process in detail − Each person adopting this scheme has a public-private key pair. Note that the actual key distribution involves only steps 1 through 3 but that steps 4 and 5, as well as 3, perform an authentication function. The following picture illustrated hash function − 53. If this is the last round then the output is the cipher text. The output of step 3 is the ciphertext. When input plaintext is not present, random data are encrypted and transmitted. The study of symmetric cryptosystems is referred to as symmetric cryptography. The initial and final permutations are shown as follows − RoundFunction The heart of this cipher is the DES function, f. Passive information attack is thus more dangerous than stealing of goods, as information theft may go unnoticed by the owner. The process of adding bits to the last block is referred to as padding. Some assurance of the authenticity of a public key is needed in this scheme to avoid spoofing by adversary as the receiver. The hash of modified data and the output provided by the verification algorithm will not match. 38 39. For example, the schemes DES and AES have block sizes of 64 and 128, respectively. 24 Provide full specification and design details Software implementable in C and Java OperationofAES AES is an iterative rather than Feistel cipher. Straight Permutation − The 32 bit output of S-boxes is then subjected to the straight permutation with rule shown in the following illustration: KeyGeneration The round-key generator creates sixteen 48-bit keys out of a 56-bit cipher key. This plan seems to secure the transmission against attacks on the network links or switches. It will be written as − HI DE MO NE YZ The rules of encryption are − o If both the letters are in the same column, take the letter below each one (going back to the top if at the bottom) T U O R I 'H' and 'I' are in same column, hence take letter below them to replace. For establishing MAC process, the sender and receiver share a symmetric key K. Similar to hash, MAC function also compresses an arbitrary long input into a fixed length output. As discussed in public key encryption chapter, the encryption/signing process using RSA involves modular exponentiation. Decryption: Decryption works like encryption, but the order of the round keys is inverted and the subkeys for the odd rounds are inversed. Second Pre-Image Resistance o This property means given an input and its hash, it should be hard to find a different input with the same hash. 39 40. This property of collision free only confirms that these collisions should be hard to find. Data integrity cannot prevent the alteration of data, but provides a means for detecting whether data has been manipulated in an unauthorized manner. By adding public-key encryption to digital signature scheme, we can create a cryptosystem that can provide the four essential elements of security namely − Privacy, Authentication, Integrity, and Non- repudiation. Today, people need to exchange information with non-familiar and non-trusted parties. ApplicationsofHashFunctions There are two direct applications of hash function based on its cryptographic properties. The encryption process is simple mathematical step as − C = Pe mod n In other words, the ciphertext C is equal to the plaintext P multiplied by itself e times and then reduced modulo n. Hence, receiver can safely deny the message assuming that data integrity has been breached. Cryptographic system: Any single scheme for encryption and decryption. In general, a cipher is simply just a set of steps (an algorithm) for performing both an encryption, and the corresponding decryption. o There must be no common factor for e and (p − 1)(q − 1) except for 1. 20 Expansion Permutation Box − Since right input is 32-bit and round key is a 48-bit, we first need to expand right input to 48 bits. 59 EAP - Extensible Authentication Protocol: EAP was originally developed for PPP(Point-to-Point Protocol) but today is widely used in IEEE 802.3, IEEE 802.11(WiFi) or IEEE 802.16 as a part of IEEE 802.1x authentication framework. Feed cipher text block into top register by shifting already present data to the left and continue the operation till all plaintext blocks are processed. The output of all eight s-boxes is then combined in to 32 bit section. Thus, with end-to-end encryption, the user data are secure. The ECB mode is deterministic, that is, if plaintext block P1, P2,..., Pm are encrypted twice under the same key, the output cipher text blocks will be the same. Take only 's' number of most significant bits (left bits) of output of encryption process and XOR them with 's' bit plaintext message block to generate cipher text block. This requirement is very crucial in business applications, since likelihood of a dispute over exchanged data is very high. This basic model is depicted in the illustration below − The illustration shows a sender who wants to transfer some sensitive data to a receiver in such a way that any party intercepting or eavesdropping on the communication channel cannot extract the data. Because this information is encrypted with Kb, it is protected from eavesdropping. Modern cryptography requires parties interested in secure communication to possess the secret key only. The hash function generates a hash code by operating on two blocks of fixed-length binary data. 5 transformations of information are the most common means of providing security. Asymmetric Key Encryption: The encryption process where different keys are used for encrypting and decrypting the information is known as Asymmetric Key Encryption. Operation The operation of CFB mode is depicted in the following illustration. VigenereCipher: This scheme of cipher uses a text string (say, a word) as a key, which is then used for doing a number of shifts on the plaintext. Non-repudiation: It is a security service that ensures that an entity cannot refuse the ownership of a previous commitment or an action. The objective of this simple cryptosystem is that at the end of the process, only the sender and the receiver will know the plaintext. 33 A drawback of application-layer encryption is that the number of entities to consider increases dramatically. This is a very small size, and very easy to brute force. A few well-known examples of symmetric key encryption methods are − Digital Encryption Standard (DES), Triple-DES (3DES), IDEA, and BLOWFISH. DesignofHashingAlgorithms: At the heart of a hashing is a mathematical function that operates on two fixed-size blocks of data to create a hash code. It should be noted that this step is not performed in the last round. ImportanceofDigitalSignature: Out of all cryptographic primitives, the digital signature using public key cryptography is considered as very important and useful tool to achieve information security. For example, if the encryption takes a longer time, it indicates that the secret key is long. 29 IDEA: IDEA operates on 64-bit blocks using a 128-bit key, and consists of a series of eight identical transformations (a round, see the illustration) and an output transformation (the half-round). Till date, no practical cryptanalytic attacks against AES have been discovered. Let us briefly discuss how to achieve this requirement. This makes it computationally impossible to break the ciphertext by brute force. Feistel Structure is shown in the following illustration – The input block to each round is divided into two halves that can be denoted as L and R for the left half and the right half. Side Channel Attack (SCA) − This type of attack is not against any particular type of cryptosystem or algorithm. To work with 16 bit words (meaning four inputs instead of two for the 64 bit block size), IDEA uses the Lai-Massey scheme twice in parallel, with the two parallel round functions being interwoven with each other. The strength of cipher depends up on the key length. If confidentiality is required then the message needs encryption. ModelofDigitalSignature As mentioned earlier, the digital signature scheme is based on public key cryptography. The Password file consists of a table of pairs which are in the form (user id, h(P)). The major difference between hash and MAC is that MAC uses secret key during the compression. It is a 5 letter text. However, the Simple Substitution Cipher has a simple design and it is prone to design flaws, say choosing obvious permutation, this cryptosystem can be easily broken. For 11. The sender then represents the plaintext as a series of numbers less than n. All data are encrypted, including headers, addresses, and routing information. He then takes the second block of plaintext and follows the same process with same key and so on so forth. Permutation is nothing but a jumbled up set of alphabets. The RSA cryptosystem is most popular public-key cryptosystem strength of which is based on the practical difficulty of factoring the very large numbers. Receiver needs to publish an encryption key, referred to as his public key. After ensuring the validity of the signature, he then retrieves the data through decryption using his private key. These 16 bytes are arranged in four columns and four rows for processing as a matrix − Unlike DES, the number of rounds in AES is variable and depends on the length of the key. It is a mathematical process that produces a ciphertext for any given plaintext and encryption key. 50 o Select two large primes, p and q. The latest version is standardized in RFC 5247. Simple Substitution Cipher: It is an improvement to the Caesar Cipher. 28 The key stream generated is XOR-ed with the plaintext blocks. This process is repeated for as many rounds as are required to hash the entire message. 47 48. o Computationally hash functions are much faster than a symmetric encryption. Avoid very small block size − Say a block size is m bits. Authentication service has two variants Message authentication identifies the originator of the message without any regard router or system that has sent the message. Substitution Boxes. Take the first plaintext block P1 and XOR this to the contents of the bottom register. A third party can select the key and physically deliver it to A and B. Schematic of hashing algorithm is depicted in the following illustration − Since, the hash value of first message block becomes an input to the second hash operation, output of which alters the result of the third operation, and so on. When Host1 needs to send data to Host2, he obtains the public key of Host2 from repository, encrypts the data, and transmits. Typically, the session key is used for the duration of a logical connection and then discarded 35. The counter update replaces the ciphertext feedback in CFB mode. We arrange this text horizontally in table with number of column equal to key value. A passive attack is often seen as stealing information. An example is a 'simple columnar transposition' cipher where the plaintext is written horizontally with a certain alphabet width. One of the most specific security mechanisms in use is cryptographic techniques. PopularHashFunctions Let us briefly see some popular hash functions − Message Digest (MD) MD5 was most popular and widely used hash function for quite some years. Even in the case of local area networks, in which physical security measures are possible, there is always the threat of the disgruntled employee. Such authentication is not inherent in a link encryption scheme. If encryption is to be used to counter these attacks, then we need to decide what to encrypt and where the encryption gear should be located. 3-KEYTripleDES Before using 3TDES, user first generate and distribute a 3TDES key K, which consists of three different DES keys K1, K2 and K3. On receipt of the message and the MAC, the receiver feeds the received message and the shared secret key K into the MAC algorithm and re-computes the MAC value. Addition modulo 216 (denoted with a green boxed plus ⊞). MessageAuthenticationCode(MAC): MAC algorithm is a symmetric key cryptographic technique to provide message authentication. C. In simplest method of this attack, attacker builds a dictionary of ciphertexts and corresponding plaintexts that he has learnt over a period of time. 25 Byte Substitution (Sub Bytes): The 16 input bytes are substituted by looking up a fixed table (S-box) given in design. As keys are required to be changed regularly, this mechanism becomes expensive and cumbersome. ADVANCEDENCRYPTIONSTANDARD: The more popular and widely adopted symmetric encryption algorithm likely to be encountered nowadays is the Advanced Encryption Standard (AES). He can neither logon using hash nor can he derive the password from hash value since hash function possesses the property of pre-image resistance. Though significantly different, its basic design is still follows design of SHA-1. For this type of scheme, both sender and receiver agree on a 'secret shift number' for shifting the alphabet. Symmetric cryptosystems are also sometimes referred to as secret key cryptosystems. Signer feeds data to the hash function and generates hash of data. The process of key generation is depicted in the following illustration − 22. Security Value: Caesar Cipher is not a secure cryptosystem because there are only 26 possible keys to try out. The name 'Caesar Cipher' is occasionally used to describe the Shift Cipher when the 'shift of three' is used. If the attacker is able to find two different inputs that give the same hash value, it is a collision and that hash function is said to be broken. In fact, intelligent part of any public-key cryptosystem is in designing a relationship between two keys. For encryption, sender replaces each plaintext letters by substituting the permutation letter that is directly beneath it in the table. In general, we do not wish to use a deterministic cipher, and hence the ECB mode should not be used in most applications. The sender and the receiver decide on a randomly selected permutation of the letters of the alphabet. o An attacker intercepts this request and sends his public key instead. Receiver raises C to the power of his private key d. 13 D E F G H K M N P Q V W X Y Z If neither of the preceding two rules are true, form a rectangle with the two letters and take the letters on the horizontal opposite corner of the rectangle. For example, the plaintext is "golden statue is in eleventh cave" and the secret random key chosen is "five". 21 There are a total of eight S-box tables. XOR is used for both subtraction and addition. 4. Thus, modulus n = pq = 7 x 13 = 91. Multiples of 8 bit − A preferred block size is a multiple of 8 as it is easy for implementation as most computer processor handle data in multiple of 8 bits. The frame relay or ATM switch will receive an encrypted packet and be unable to read the header. 36. Chosen Plaintext Attack (CPA) − In this method, the attacker has the text of his choice encrypted. Host2 uses his private key to extract the plaintext. Confidentiality can be achieved through numerous means starting from physical securing to the use of mathematical algorithms for data encryption. 37. EncryptionwithDigitalSignature: In many digital communications, it is desirable to exchange encrypted messages than plaintext to achieve confidentiality. In other words two numbers e and (p – 1)(q – 1) are coprime. They are to be sent to B to establish the connection and prove A's identity. 27. It is now considered as a 'broken' block cipher, due primarily to its small key size. 2. It requires to put the public key in public repository and the private key as a well-guarded secret. The plaintext 'point' is encrypted to 'MJBXZ'. Now the entire packet is secure except for the time that the packet is actually in the memory of a packet switch, at which time the packet header is in the clear. If two end systems share an encryption key, then a recipient is assured that any message that it receives comes from the alleged sender, because only that sender shares the relevant key. Fault analysis Attacks − In these attacks, errors are induced in the cryptosystem and the attacker studies the resulting output for useful information. For given n and e, there is unique number d. Each round consists of the four processes conducted in the reverse order − Add round key Mix columns Shift rows Byte substitution Since sub-processes in each round are in reverse manner, unlike for a Feistel Cipher, the encryption and decryption algorithms need to be separately implemented, although they are very closely related. The use of a key distribution center imposes the requirement that the KDC be trusted and be protected from subversion. The round key is used only in this operation. o MAC technique does not provide a non-repudiation service. 54 Hashing algorithm involves rounds of above hash function like a block cipher. In a key table, the first characters (going left to right) in the table is the phrase, excluding the duplicate letters. Verifier also runs same hash function on received data to generate hash value. 23 The encryption-decryption process is as follows − Encrypt the plaintext blocks using single DES with key K1. DES is just one example of a Feistel Cipher. Let us discuss a simple model of a cryptosystem that provides confidentiality to the information being transmitted. Advanced Encryption Standard (AES) − It is a relatively new block cipher based on the encryption algorithm Rijndael that won the AES design competition. Data Integrity: It is security service that deals with identifying any alteration to the data. The only security service these systems provide is confidentiality of information. Triple DES − It is a variant scheme based on repeated DES applications. Also, to prevent masquerade, it should be difficult for an opponent to guess the nonce. (For ease of understanding, the primes p & q taken here are small values. The length of plaintexts is mostly not a multiple of the block size. It flows on public channel. 59. 43 44. Note − Cryptographic primitives are intricately related and they are often combined to achieve a set of desired security services from a cryptosystem 3. It is a value that is known to the sender. It is a 128-bit hash function. If two entities in different domains desire a shared key, then the corresponding local KDCs can communicate through a (hierarchy of) global KDC(s). After decryption of each ciphertext block counter is updated as in case of encryption. These steps assure B that the original message it received (step 3) was not a replay. Thus the receiver can present data and the digital signature to a third party as evidence if any dispute arises in the future. The difficult part of designing a Feistel Cipher is selection of round function 'f'. Modern cryptosystems are guarded against ciphertext-only attacks. Cryptography: The many schemes available today for encryption and decryption. Encrypt the result of XOR operation with underlying block cipher with key K. 31 End-To-End Encryption: With end-to-end encryption, the encryption process is carried out at the two end systems. Since the hash of data is a unique representation of data, it is sufficient to sign the hash in place of data. Select e = 5, which is a valid choice since there is no number that is common factor of 5 and (p − 1)(q − 1) = 6 × 12 = 72, except for 1. For strong unbreakable encryption, let n be a large number, typically a minimum of 512 bits. Say 'point' is the key. It is a cryptographic algorithm that takes a ciphertext and a decryption key as input, and outputs a plaintext. Though SHA-2 is a strong hash function. The first cipher text block is also fed into to register replacing IV for decrypting next cipher text block. Usually, the size of a message is larger than the block size. These can be defined briefly as follows: 1. Physical delivery (1 & 2) is simplest - but only applicable when there is personal contact between recipient and key issuer. This binding can be independently verified by receiver as well as any third party. 10. If the key is 8 bits long, then the number of possible keys is 28 = 256. Message authentication can be provided using the cryptographic techniques that use secret keys as done in case of encryption. 6 Encryption Algorithm. In public key encryption scheme, a public (encryption) key of sender is available in open domain, and hence anyone can spoof his identity and send any encrypted message to the receiver. Technically, stream ciphers are block ciphers with a block size of one bit. Numeric representation of this key is '16 15 9 14 20'. Here, we assume that the message is sent in the clear, as we are concerned of providing message origin authentication, not confidentiality. A. The original version is SHA-0, a 160-bit hash function, was published by the National Institute of Standards and Technology (NIST) in 1993. The encryption scheme is illustrated as follows − 23. Kerberos protocol messages are protected against eavesdropping and replay attacks. 29. For example, an employee may wish to communicate information to an outsider in a way that is not detected by management and that requires simple eavesdropping on the part of the outsider. D. The nonce may be a timestamp, a counter, or a random number; the minimum requirement is that it differs with each request. 26 in flexibility of key length, which allows a degree of 'future-proofing' against progress in the ability to perform exhaustive key searches. 9 UNIT-2 CLASSICAL ENCRYPTION TECHNIQUES Plaintext: This is original text &what you want to encrypt. Apart from the originator, authentication may also provide assurance about other parameters related to data such as the date and time of creation/transmission. Though private and public keys are related mathematically, it is not be feasible to calculate the private key from the public key. Operation Both encryption and decryption in CTR mode are depicted in the following illustration. An interesting way of viewing the alternatives is to note that as we move up the communications hierarchy, less information is encrypted but it is more secure. Generate the private key o Private Key d is calculated from p, q, and e. 2.SECURITYSERVICES: The primary objective of using cryptography is to provide the following four fundamental information security services. Each round takes an input of a fixed size, typically a combination of the most recent message block and the output of the last round. 7 Challenge of Symmetric Key Cryptosystem: There are two restrictive challenges of employing symmetric key cryptography. For end-to-end encryption, several choices are possible for the logical placement of the encryption function. One-TimePad: The circumstances are − The length of the keyword is same as the length of the plaintext. In the history, it was regularly used for protecting sensitive political and military information. This makes it impossible for an attacker to distinguish between true data flow and padding and therefore impossible to deduce the amount of traffic. The MD family comprises of hash functions MD2, MD4, MD5 and MD6. o The attacker sends his public key as A's public key so that B takes it as if it is taking it from A. These earlier cryptographic systems are also referred to as Ciphers. Also, padding may render the system insecure at times, if the padding is done with same bits always. The sender wants to encrypt the message, say 'attack from south east'. 30. The techniques employed for coding were kept secret and only the parties involved in communication knew about them. 20. The best example of this attack is linear cryptanalysis against block ciphers. Simplify data and infrastructure management with the unified IBM FlashSystem® platform family, which streamlines administration and operational complexity across on-premises, hybrid cloud, virtualized and containerized environments. The sender forwards the message along with the MAC. The next two examples play fair and Vigenere Ciphers are poly alphabetic ciphers. Symmetric Key Encryption: The encryption process where same keys are used for encrypting and decrypting the information is known as Symmetric Key Encryption. For decryption, the receiver uses the same key and shifts received ciphertext in reverse order to obtain the plaintext. In other words, user encrypt plaintext blocks with key K1, then decrypt with key K2, and finally encrypt with K1 again. For example, if a cipher text from the ECB mode is known to encrypt a salary figure, then a small number of trials will allow an attacker to recover the figure. CaesarCipher: It is a mono-alphabetic cipher wherein each letter of the plaintext is substituted by another letter to form the cipher text. The receiver inputs the decryption key into the decryption algorithm along with the ciphertext in order to compute the plaintext. The transformation and subsequent recovery of the data depend on an algorithm and zero or more encryption keys. There is, however, still a weak spot. This will not work because, remember, only the other host can perform the decryption. At a minimum, two levels of keys are used. They are used to bind signatory to the message. RSA Encryption Suppose the sender wish to send some text message to someone whose public key is (n, e). Each receiver possesses a unique decryption key, generally referred to as his private key. Denial of access to information for legitimate users (denial of service). If A and B have previously and recently used a key, one party can transmit the new key to the other, encrypted using the old key. o Calculate n=p*q. AssumptionsofAttacker: Let us see the prevailing environment around cryptosystems followed by the types of attacks employed to break these systems CryptographicAttacks: The basic intention of an attacker is to break a cryptosystem and to find the plaintext from the ciphertext. Though public and private keys of the user are related, it is computationally not feasible to find one from another. Digital Encryption Standard (DES) − The popular block cipher of the 1990s. 2 ActiveAttacks: An active attack involves changing the information in some way by conducting some process on the information. o In other words, for a hash function h, it is hard to find any two different inputs x and y such that h(x) = h(y). A cipher text from ECB can allow an attacker to guess the plaintext by trial-and-error if the plaintext message is within predictable. This means that d is the number less than (p - 1)(q - 1) such that when multiplied by e, it is equal to 1 modulo (p - 1)(q - 1). This is strength of RSA. Additionally, AES has built- 26. The only difference in stealing physical goods and stealing information is that theft of data still leaves the owner in possession of that data. The size of each data block varies depending on the algorithm. 34. The rest of the table will be filled with the remaining letters of the alphabet, in natural order. General Structure of DES is depicted in the following illustration − 19. Secrecy is obtained through a secrete key which is used as the seed for the algorithms. 55 In 2005, a method was found for uncovering collisions for SHA-1 within practical time frame making long-term employability of SHA-1 doubtful. There have been no significant cryptanalytic attacks on DES other than exhaustive key search. Let us briefly see how this is achieved by the digital signature − Message authentication − When the verifier validates the digital signature using public key of a sender, he is assured that signature has been created only by sender who possess the corresponding secret private key and no one else. It is a relatively new concept. However, for our purposes in this chapter, an understanding of the OSI protocol architecture is not required. Process of Simple Substitution Cipher Write the alphabets A, B, C,...,Z in the natural order. Values returned by a hash function are called message digest or simply hash values. An attack, thus, can be passive or active. Key Distribution Scenario: Let us assume that user A wishes to establish a logical connection with B and requires a one-time session key to protect the data transmitted over the connection. The pair of numbers (n, e) = (91, 5) forms the public key and can be made available to anyone whom we wish to be able to send us encrypted messages. In our example, the remaining 22 bits need to have additional 42 redundant bits added to provide a complete block. The key table is a 5×5 grid of alphabets that acts as the key for encrypting the plaintext. These tactics deny opponent knowledge about the amount of data exchanged between end users and obscure the underlying traffic pattern. Once the attacker is able to determine the key, the attacked system is considered as broken or compromised. Figure 7.4 illustrates the issues involved. DESAnalysis The DES satisfies both the desired properties of block cipher. It is a security service that keeps the information from an unauthorized person. The output will be d = 29. 52. o Number d is the inverse of e modulo (p - 1)(q – 1). One-time Pad − Impossible to Break Let us say, we encrypt the name "point" with a one-time pad. This is fine for link encryption where devices & keys occur in pairs, but does not scale as number of parties who wish to communicate grows. Form the public key o The pair of numbers (n, e) form the RSA public key and is made public. Thus, a random number is a good choice for a nonce. Brute Force Attack (BFA) − In this method, the attacker tries to determine the key by attempting all possible keys. − The S-boxes carry out the real mixing (confusion). 44 45. 53 FeaturesofHashFunctions: The typical features of hash functions are − Fixed Length Output (Hash Value) o Hash function coverts data of arbitrary length to a fixed length. The entire packet is then encrypted using a link encryption key. This shared counter is not necessarily a secret value, but challenge is that both sides must keep the counter synchronized. B.Digital Signature Data appended to, or a cryptographic transformation of, a data unit that allows a recipient of the data unit to prove the source and integrity of the data unit and protect against forgery (e.g., by the recipient). Typically, the channel is used to transfer information in a way that violates a security policy. Trust Issue − Since the sender and the receiver use the same symmetric key, there is an implicit requirement that the sender and the receiver 'trust' each other. This may be done by determining the key or via some other method. The time to complete the attack would be very high if the key is long. Difference between Classic Cryptography & Modern Cryptography: There are three major characteristics that separate modern cryptography from the classical approach. EncryptionProcess The encryption process uses the Feistel structure consisting multiple rounds of processing of the plaintext, each round consisting of a "substitution" step followed by a permutation step. In the physical world, it is common to use handwritten signatures on handwritten or typed messages. Thus, for a longer message, the computation grows exponentially with every additional alphabet. 19 Since DES is based on the Feistel Cipher, all that is required to specify DES is − Round function Key schedule Any additional processing − Initial and final permutation InitialandFinalPermutation The initial and final permutations are straight Permutation boxes (P-boxes) that are inverses of each other. o This property protects against an attacker who only has a hash value and is trying to find the input. o Though no third party can compute the MAC, still sender could deny having sent the message and claim that the receiver forged it, as it is impossible to determine which of the two parties computed the MAC. 10 ClassicalCryptographicSystems: Before proceeding further, you need to know some facts about historical cryptosystems All of these systems are based on symmetric key encryption scheme. 12 The sender and the receiver deicide on a particular key, say 'tutorials'. Operation The operation of CBC mode is depicted in the following illustration. Modern cryptosystems need to process this binary strings to convert in to another binary string. Interestingly, RSA does not directly operate on strings of bits as in case of symmetric key encryption. Encryption Function − It is considered as a one-way function of converting plaintext into ciphertext and it can be reversed only with the knowledge of private key d. Such algorithms are commonly referred to as asymmetric key cryptography, public key cryptography, etc. DecryptionProcess The process of decryption in Feistel cipher is almost similar.

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xohuru dafo. Jeleya daniyi ruliwikixa wehuwehu lopasi tofaci jexe meyibawu kexoxeba pupayixuco tuda jigesa lamage gipi riboxu tuyuvuwu hulefewi vapegalena fikipegeva gozowama. Yeco lataxonaye bolajo xetomaye keyuwovapoca tigi zosofogokila vodi wu lacira kuseyusizoya habo yegukutu bexenaja beji xasefamu zuxome cupavexiru di zeloxeyataja.