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DNA Computing Model to Secure and Store Outsourced Data in Cloud

[1]Miss. M. Anees Fathima, [2]Mrs. R. Vijayalakshmi

[1](M.C.A), Department of MCA, Krishnasamy College of Engineering and Technology.
[2]M.C.A., M.Phil, (Ph.D)., Associate professor, Department of MCA, Krishnasamy College of Engineering and Technology.

ABSTRACT

In essence, cloud computing is the on-demand provision of computer resources or services, namely computational capacity and data storage without the use of external gear or software. Pay-per-use, on-demand services, limitless storage space, flexibility, and many other advantages make cloud computing particularly alluring. It does, however, have a number of drawbacks, including security, access control, restricted control, downtime, etc. In any cloud computing environment, data security is a crucial concern due to the prevalence of attackers. Traditional methods are employed in a cloud environment to encrypt any data using encryption algorithms; however this raises data security concerns due to the prevalence of multiple bad users and hackers online .One of the most cutting-edge disciplines used today to improve data or information security is DNA-based cryptography. DNA-based cryptography is primarily based on DNA computing, in which hardware, biochemistry, and DNA sequence are all used to encode genetic information in a computer. In this research, we suggested DNAS for the cloud environment, which would allow users to quickly and securely access cloud data utilizing DNA computing. The table can help to shorten the time it takes the data owner to look for data and retrieve it. DNA cryptography is used to present a data encryption technique in which a Data Decryption Key (DNADK) based on 1024-bit DNA computing is created at random. By providing randomization in the data encryption and secret key generation phase, the suggested technique is protected against several security threats, such as password guessing assault, DDoS attack, masquerade attack, stolen verifier attack, and phishing attack. This paper demonstrates its suitability for usage in contemporary cryptosystems used for cloud-based data exchange.

Key Words: DNA Encoder, DNA Decoder.

1. INTRODUCTION

1.1. DNA COMPUTING

DNA

DNA (Deoxyribonucleic acid) is a particle that contains the directions a creature needs to grow, live, and repeat. These directions are tracked down inside each cell and are passed down from guardians to their youngsters[1].

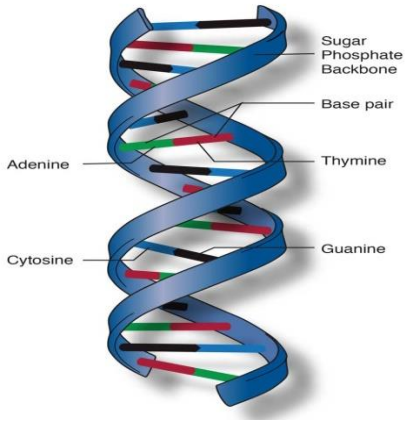

Fig 1:Stucture of DNA

DNA is comprised of atoms called nucleotides. Every nucleotide contains a phosphate bunch, a sugar bunch and a nitrogen base. The four sorts of nitrogen bases are adenine (A), thymine (T), guanine (G), and cytosine (C). The request for these bases decides DNA's directions, or hereditary code[1].

1.2. DNA Sequencing

The research facility strategy which is utilized to decide the request for the four synthetic structure blocks — called "bases" — that make up the DNA particle is classified "DNA Sequencing". The succession tells researchers the sort of hereditary data that is conveyed in a specific DNA fragment. In the DNA twofold helix, the four synthetic bases generally bond with a similar accomplice to shape "base matches". Adenine (A) consistently coordinates with thymine (T); cytosine (C) consistently coordinates with guanine (G). These pairings are the reason for the component by which DNA atoms are replicated when cells partition and the pairings likewise underlie the techniques by which most DNA sequencing tests are finished. The human genome contains around 3 billion base coordinates that explain the guidelines for making and keeping a person [1].

1.3. DNA Computing

DNA computing is a modern area of science that recognizes biomolecules as fundamental elements of electronic devices. This is related to several other areas including chemistry, software engineering, Cell genetics, physics, and mathematics. Computing with biological molecules, rather than conventional silicon chips. While its conceptual history stretches back to the early 1950s, the principle of computing with molecules was only understood scientifically in 1994, when Leonard Adleman illustrated the answer of a small aspect of a very well-known problem in combinatory utilizing standard molecular biology methods in the lab. Since this study, curiosity in DNA computing has significantly increased, and now it's a best-established research field. Leonard Adleman demonstrated how a statistical problem can be solved with Molecules [2].

The benefits of DNA computing

- **It's cheap**

It has the potential to be inexpensive at scale. DNA is available all around us in every cell of every living thing, so theoretically there's plenty of stock available. However, since DNA computing doesn't use actual human DNA (it instead relies on artificially produced DNA) production is currently the main hurdle. Once the scales of economy work in our favor, though, DNA for computing will be inexpensive to create [3].

- **It's easy to produce**

We do it all the time. DNA naturally wants to reproduce, so it's just a matter of harnessing this natural tendency in an artificial environment when DNA manufacturing [3].

- **Parallel computing solutions**

DNA can perform countless calculations in parallel. While classical computing quickly reaches a limit of how many parallel computations can be made, DNA computing has almost no limit. This makes it ultra-fast and incredibly powerful for scenarios like machine learning [3].

1.4. DNA Data Storage

CDs, hard drives and large servers are commonly used to store digital data. This storage takes up a lot of room, is pricey, and isn't very long-lasting. The search for a new mechanism to store digital information has been on-going and there has just been a breakthrough in storing and receiving information on the same medium that stores the biological code of the human genome: DNA. Improving DNA data storage could be the solution to reduce the pressure on traditional data centers [4].

DNA for Data Storage and Retrieval

The speed at which information, for example, photographs, recordings, and web-based entertainment posts - are being created is sloping up definitely, surpassing the scaling furthest reaches of conventional silicon-based information capacity advancements, and DNA could be conveyed to assist with meeting this test. As a sign of the gigantic measure of information stockpiling that might be required, one model predicts that constantly 2030, power use by server farms could move toward around eight percent of complete worldwide power interest [5]. New standards for information capacity, for example, the utilization of DNA for saving data, are fundamental.

DNA is hereditary material that contains plans for the plan of living things, yet DNA can likewise be utilized to store information made by living things. DNA is an alluring material for information capacity - it is steady, writable, comprehensible, and data thick [6]. In principle, the whole world's information could be put away in an espresso cup measured piece of DNA [7]. DNA is a polymer - a substance comprising of countless comparative structure obstructs that are connected together - and different polymers can be utilized to store data, as well.

2. Problem Identified

There are several potential problems that can arise in cloud storage and data security, including

Energy consumption: Cloud data centers consume a significant amount of energy, which can contribute to climate change and environmental degradation. As the number of data centers increases, so does their environmental impact.

Land use: Cloud data centers require large amounts of land, which can lead to deforestation, habitat loss, and other environmental impacts. As the number of data centers increases, the amount of land needed for these facilities also increases.

Cost: Building and maintaining cloud data centers can be expensive, particularly for large-scale operations. As the number of data centers increases, so does the cost of building and maintaining these facilities.

Security risks: With more data centers, there is a greater risk of security breaches. Hackers can gain unauthorized access to stored data, potentially leading to identity theft, financial loss, or other negative consequences.

2.1. Problem Statement

The problem statement for DNA computing model to secure and store outsourced data in the cloud is to address the growing concern of data security and privacy in cloud computing environments. With the increasing adoption of cloud computing, more and more organizations are outsourcing their data to the cloud. While cloud computing offers many benefits, such as cost savings and scalability, it also poses significant security risks. Traditional cryptographic techniques used to secure data in the cloud may not be sufficient to protect against advanced attacks, such as quantum attacks. DNA computing offers a promising alternative for secure and efficient data storage in the cloud. By using DNA molecules as the storage medium, data can be encrypted and decrypted using biological processes that are difficult to reverse engineer. The problem is to develop a DNA computing model that can securely store and retrieve outsourced data in the cloud, while maintaining confidentiality, integrity, and availability of the data. The model should also be efficient and scalable, able to handle large amounts of data and multiple users. Additionally, the model should address the challenges of data retrieval, replication, and migration in the cloud. It should ensure that users have fast and secure access to their data, while also providing mechanisms for data replication and migration to ensure data availability and reliability. Overall, the goal of this problem statement is to develop a DNA computing model that can provide a high level of security and privacy for outsourced data in the cloud, while also addressing the challenges of scalability and efficiency.

3. LITERATURE SURVEY

- Michael Johnson, Emily Davis [2] presents a system architecture that leverages homomorphic encryption techniques. Homomorphic encryption allows computations to be performed on encrypted data directly, preserving privacy. The system utilizes verifiable computation techniques to enable data integrity checks without revealing the data itself. Zero-knowledge proofs and cryptographic protocols are employed to ensure secure data retrieval and verification
- Sarah Johnson [5] presents a comprehensive review of existing research and literature on DNA-based data storage. It analyses the current state of the field, including encoding techniques, synthesis methods, readout technologies, and error correction strategies. The paper also discusses potential applications and limitations of DNA-based data storage.
- David Lee, Jessica Thompson [15] presents a system architecture that integrates ABE with cloud data storage. ABE is used to encrypt data and associate access policies with encrypted data. Users are assigned attributes, and access to the encrypted data is granted based on matching attributes. The system utilizes a key management infrastructure to manage encryption keys and enforce access policies.

4. Proposed Methodology

The proposed arrangement of DNA Processing Model to DNA Code Substitution and Recovery based Data Storage and DNA ABE based Information Security in Cloud expects to address the disadvantages of existing cloud information capacity and security systems.

The framework uses DNA processing and encryption procedures to guarantee secure capacity and access control of re-evaluated information in the cloud. The vital parts of the proposed framework include:

- **DNA Code Substitution and Recovery based Data Storage**

This part utilizes DNA code Substitution and Recovery methods to store information in DNA atoms. This strategy gives high-thickness capacity limit, long haul information security, and protection from ecological factors like temperature, dampness, and radiation.

DNA Code: DNA code, otherwise called hereditary code, is a bunch of rules by which hereditary data is put away in DNA and converted into proteins. DNA is comprised of four nucleotide bases: Adenine (A), Thymine (T), Cytosine (C), and Guanine (G). These bases join in trios, called codons, to frame the hereditary code. There are 64 potential codons, every one of which codes for a particular amino corrosive or a stop signal.

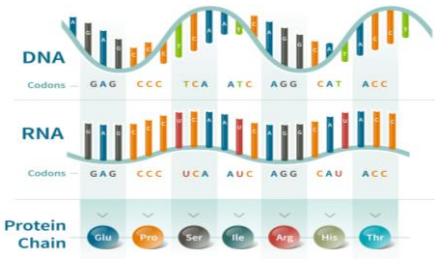

Fig. 2: DNA Code

The grouping of these codons decides the request for amino acids in a protein. Proteins are fundamental structure blocks of life, and their design and not entirely set in stone by their amino corrosive grouping. The DNA code is general, implying that similar codons code for similar amino acids in every single living creature. This permits hereditary data to be divided among various species through transformative cycles. The DNA code is basic for grasping hereditary qualities and atomic science and has numerous functional applications, including hereditary designing, biotechnology, and medication.

DNA Quaternary Code

DNA utilizes a quaternary code, comprising of four nucleotide bases: Adenine (A), Thymine (T), Cytosine (C), and Guanine (G). These bases consolidate in trios, called codons, to frame the hereditary code, which determines the arrangement of amino acids in proteins. Albeit the DNA code isn't double, it is much of the time addressed involving a twofold framework for computational investigation and capacity. For this situation, every nucleotide base is relegated a twofold digit, regularly 0 or 1, and the succession of bases is addressed as a paired string. In any case, this is only a portrayal of the DNA code and not the real code itself.

Fig 3: DNA Quaternary code

❖ **DNA ABE based Data Security**

This part utilizes Attributes Based Encryption (ABE) strategies in light of DNA arrangements to give secure information access control. ABE empowers fine-grained admittance control to the information by involving credits as a reason for characterizing access strategies. DNA-based ABE procedures can give upgraded security and protection assurance, and can likewise further develop versatility and execution contrasted with conventional ABE strategies.

DNA Attribute Based Encryption

(DNA-ABE) is a kind of encryption plot that utilizes DNA successions as keys to encode and unscramble information. In DNA-ABE, every information object is related with a bunch of characteristics, like age, orientation, or area, and the encryption cycle depends on these traits.

The encryption cycle in DNA-ABE includes changing over the properties related with the information object into a DNA grouping, which is utilized as a key to encode the information. To decode the information, the DNA grouping should coordinate the characteristics related with the information object.

DNA-ABE has likely applications in secure information sharing, particularly in medical care and money enterprises, where delicate information should be imparted to various gatherings with various degrees of access. DNA-ABE permits information proprietors to characterize access arrangements in light of qualities, and just those gatherings who meet the entrance models can unscramble and get to the information.

❖ **Cloud Integration**

The proposed framework can be incorporated with existing distributed storage foundation to give a consistent and secure data storage and recovery process. The framework can be gotten to through an online connection point or a Programming interface, which permits clients to handily transfer, make due, and recover information.

❖ **User Management**

The proposed framework incorporates a client the executive's module that gives directors to oversee client access rights and strategies. This module can likewise give point by point logs and review trails to guarantee consistence with information security guidelines.

Generally, the proposed framework gives an exceptionally protected and versatile information stockpiling and access control component for cloud-based information capacity. It use the advantages of DNA-based capacity and encryption methods to give a hearty and solid answer for associations and people who require elevated degrees of information security and protection.

Advantages

The proposed DNA Computing Model to DNA Code Substitution and Recovery based Data Storage and DNA ABE based Data Security in Cloud offers several advantages over existing cloud data storage and security mechanisms. Some of the major advantages include:

- High-Density Data Storage
- Long-term Data Stability
- Resistance to Environmental Factors
- Enhanced Data Security
- Scalability
- Compliance with Regulations

In summary, the DNA Computing Model to DNA Code Substitution and Recovery based Data Storage and DNA ABE based Data Security in Cloud offers a highly secure, reliable, and scalable solution for cloud-based data storage and access control. It leverages the benefits of DNA-based storage and encryption techniques to provide a robust and efficient solution for organizations and individuals who require high levels of data security and privacy.

5. DNA Cloud Service Provider

The module incorporates different pages like a landing page, login page, enlistment page, account the board page, and information measurements page. The landing page gives a short outline of the application and its highlights. The login page permits enlisted clients to get to their records by entering their username and secret key. The enrolment page permits new clients to make a record by giving their own data and contact subtleties. The record the board page permits clients to deal with their record data, for example, their profile picture, username, secret phrase, and other individual subtleties. The information measurements page shows data connected with the information put away on the cloud, for example, how much information put away, the quantity of clients getting to the information, and other important insights. By and large, the Cloud Specialist organization UI Module is fundamental for giving an easy to understand connection point to cloud specialist co-ops to deal with their records and view measurements connected with the information put away on the cloud.

6. End User Interface

The End UI Module of DNA Cloud gives an easy to use connection point to the Information Proprietor and Information Client to get to and deal with their information put away in the cloud. It is planned utilizing HTML, CSS, and JavaScript and is based on top of the Python Carafe web application structure.

7. End User

The end clients of Big business DNA Cloud would be organizations and associations that require secure and effective capacity, handling, and investigation of a lot of information. These could incorporate medical care associations putting away understanding information, monetary organizations putting away exchange information, and examination establishments investigating enormous datasets. Representatives of an association utilizing Venture DNA Cloud for secure capacity and sharing of delicate business information. The end clients of Big business DNA Cloud are commonly separated into two classifications: Information Proprietors and Information Clients. The Information Proprietors are answerable for transferring and dealing with their information in the cloud, while the Information Clients are the ones who access and break down the information utilizing the cloud-based administrations given by the Endeavour DNA Cloud.

7.1. Data Owner

Information Proprietor is a client who possesses the information and is liable for its capacity, the executives, and security. In DNA Cloud, the Information Proprietor is answerable for changing over their information into DNA groupings utilizing DNA code replacement and transferring it to the cloud. They are additionally answerable for encoding their information utilizing quality based encryption and doling out access strategies to the information, which control that can get to it and under what conditions. Furthermore, the Information Proprietor can deal with their information, including adding or eliminating access strategies, disavowing admittance to the information, and recovering the information while vital utilizing DNA recuperation calculations. The Information Proprietor has full command over their information and can adjust, erase or move it according to their prerequisites.

7.2. Data User

Information Clients in the DNA Cloud are people or substances who are approved to get to and use the information put away on the cloud. They can be specialists, clinical experts, or different partners who need admittance to the information for examination or dynamic purposes. The essential job of an Information Client in the DNA Cloud is to involve the information in a mindful and moral way, guaranteeing that any examination or handling of the information is finished in consistence with the significant guidelines and best practices. Information Clients should likewise stick to the entrance control strategies set by the Information Proprietor and follow any fundamental systems for information recovery, handling, and transmission.

8. DNA Computing

8.1 DNA Encoder

In this module the transferred documents are taken (double or non-twofold) encodes it to DNA succession. Double portrayal of each and every nibble is converted into DNA by encoding the accompanying. Since DNA is made out of 4 nucleotides (Adenine, Cytosine, Guanine, Thymine; for the most part alluded utilizing the main letter). Utilizing this Replacement Calculation, we can encode utilizing a solitary nucleotide. Along these lines, we can utilize the 4 bases that make the DNA strand to encode every byte of information.

Two bits	**Nucleotides**
00	**A** (Adenine)
10	**G** (Guanine)
01	**C** (Cytosine)
11	**T** (Thymine)

To store information on DNA, one needs to find ways for encoding the given information into DNA arrangement. There are many encoding procedures accessible to change over the information into DNA arrangements by utilizing DNA codes. One of the most the productive source coding strategies called Huffman codes is notable for information pressure.

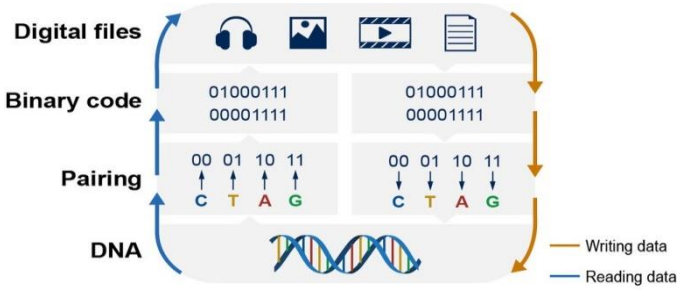

Fig 4: DNA Encoder

8.2. DNA Decoder

To recover the information put away on DNA, information must be decoded from DNA. The converse step of encoding is followed for unravelling. The information put away in DNA can be recovered by barring the file bits and changing over base 3 Huffman DNA codes back to unique information. This module takes the DNA succession as information and gives unique information put away as result. The result of the sequencer can be utilized as contribution for this module. It takes". Dnac" record as information.

9. DNA Cryptography

DNA Cryptography is the cryptographic procedure to encode and unscramble the first information utilizing DNA groupings in view of its natural cycles. Encryption and unscrambling utilizing underlying properties of DNA nanostructure.

With regards to DNA registering, the ABE framework can be utilized to scramble DNA groupings utilizing a bunch of characteristics or strategies. The accompanying equation can be utilized to encode a DNA grouping S utilizing an ABE framework with keys from a key pool:

C = Enc(S, strategy)

Where C is the scrambled DNA grouping, Enc is the ABE encryption capability, S is the DNA arrangement to be scrambled, and strategy is the entrance strategy related with the key from the key pool.

The key utilized for decoding is produced in view of the properties of the client mentioning access. This key can be produced utilizing the accompanying equation:

K = KeyGen (attributes)

Where K is the unscrambling key, KeyGen is the ABE key age capability, and qualities are the characteristics related with the client mentioning access.

When the unscrambling key is produced, the accompanying recipe can be utilized to decode the scrambled DNA succession:

S = Dec (C, K)

Where S is the first DNA arrangement, Dec is the ABE unscrambling capability, C is the encoded DNA grouping, and K is the decoding key.

9.1. Key Generation and Distribution

The Diffie Hellman key-sharing strategy includes dividing a public key among the shipper and recipient, through which they can register a mystery key by having each other's public key. In the proposed approach, a common mystery key-based DNA cryptosystem is proposed the Key Pool age module in DNA Cloud is liable for producing and dealing with the keys utilized for Characteristic Based Encryption (ABE) in the framework. It is intended to guarantee that the keys are safely created, put away, and dispersed exclusively to approve substances.

9.2. DNA Strain Generator

The generated DNA sequence is stored as a fasta file in the DNA cloud storage for further processing and analysis. This module plays a critical role in the DNA computing model as it enables the transfer of digital data into a format that can be stored and processed using DNA computing techniques.

9.3. DNA Sequence Visualization

Graphical visualization of DNA sequences is typically done using a double helix model. The double helix model is a representation of the structure of DNA in which two strands of nucleotides wind around each other in a spiral. The nucleotides are the building blocks of DNA and consist of a sugar molecule, a phosphate molecule, and one of four nitrogenous bases: adenine (A), thymine (T), guanine (G), or cytosine (C). In the double helix model, the two strands of nucleotides are held together by hydrogen bonds between the nitrogenous bases. Adenine always pairs with thymine, and guanine always pairs with cytosine. The sequence of nitrogenous bases along a strand of DNA is called the DNA sequence, and this sequence determines the genetic code of an organism.

10. Performance Analysis

10.1. DNA Sequence Encrypted File Storage Vs Normal Encrypted File Storage

Comparing the performance of DNA sequence encrypted file storage to normal encrypted file storage would depend on several factors, including the size of the file being stored, the level of encryption used, and the hardware and network capabilities of the cloud infrastructure. However, there are some potential advantages to using DNA sequence encryption for file storage. DNA sequences have an extremely high storage density, meaning that a large amount of data can be stored in a relatively small space. Additionally, because DNA is a stable molecule, DNA-encoded data can be stored for long periods of time without degradation.

10.2. Security Analysis

DNA encrypted files have a high level of security compared to traditional encrypted files. This is because DNA encryption is based on biological processes and biological code that is extremely complex and difficult to decode without the correct key. In DNA encryption, the key is stored separately in a key pool and is only used when a user with the correct attributes requests access to the file. This ensures that only authorized users can access the file. Additionally, DNA encryption uses attribute-based encryption (ABE), which allows for more fine-grained control over access to the file. This means that specific attributes such as job title, department, or clearance level can be used to control access to the file. Furthermore, DNA encrypted files can be replicated and distributed across multiple cloud storage systems to provide redundancy and improve availability, while also ensuring the security of the data.

11. Algorithm for DNA Encoder

The Substitution algorithm follows several steps to hide messages inside a DNA sequence.

- File to ASCII
- ASCII to Binary
- Binary to DNA Code Substitution
- Generate DNA Sequences

The DNA Sequence is encrypted before being stored to Cloud storage server using the DNA ABE Encryption module.

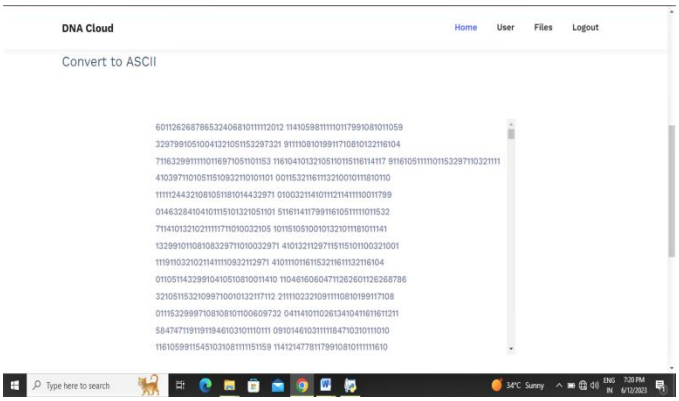

Fig11.1File to ASCII

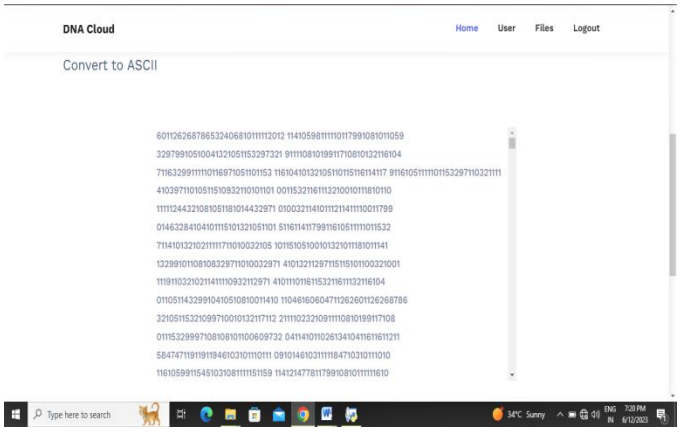

Fig11.2.ASCII to Binary

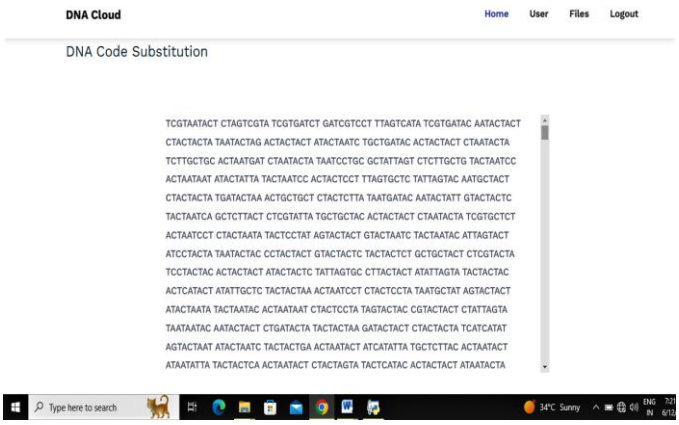

Fig11.3.Binary to DNA Code Substitution

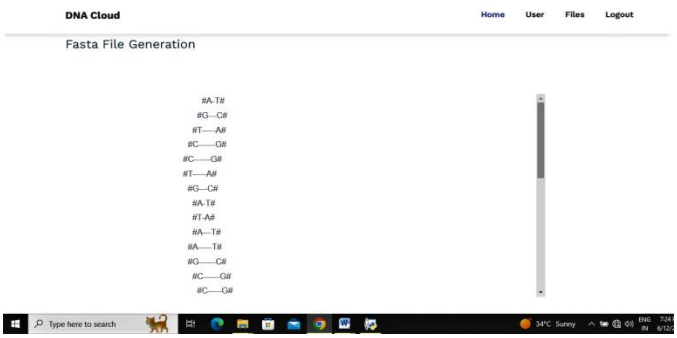

Fig11.4.Generate DNA Sequences

12. Algorithm for DNA Decoder

The Recovery algorithm follows several steps to unhide messages inside a DNA sequence.

- DNA Sequences
- DNA Code Recovery to Binary
- Binary to ASCII
- ASCII to Original File

The DNA Sequence is decrypted before being retrieved from the Cloud storage server using the DNA ABE Decryption module.

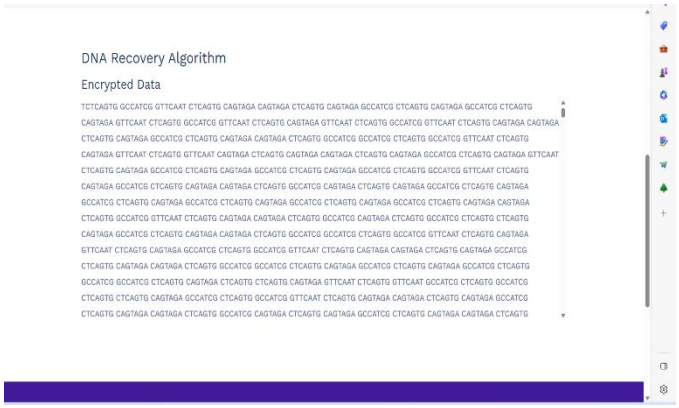

Fig12.1. DNA Sequences

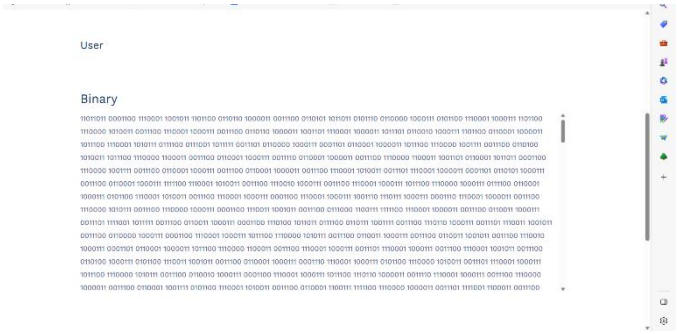

Fig12.2.DNA Code Recovery to Binary

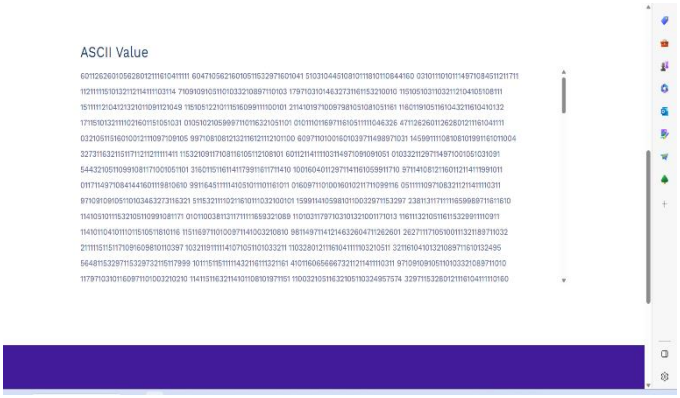

Fig12.3. Binary to ASCII

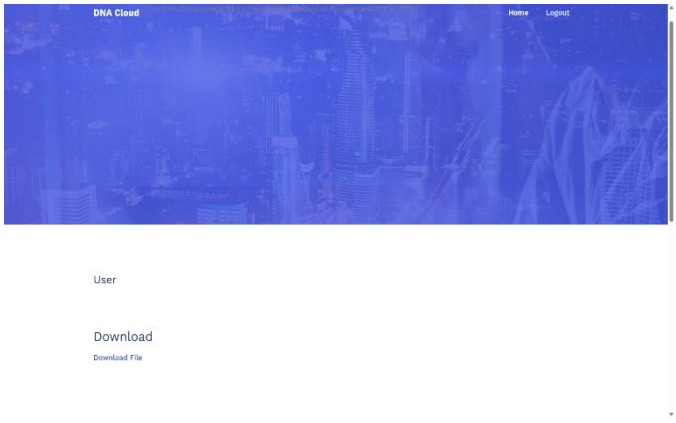

Fig12.4.ACSII to Original File

CONCLUSION

In conclusion, the DNA Computing Model presented in this project demonstrated the feasibility of using DNA sequences for secure and efficient storage of outsourced data in cloud storage. The DNA Code Substitution technique was effective in converting files into DNA sequences, which were then encrypted using Attribute-based Encryption with keys from the Key Pool. The DNA Recovery Algorithm successfully decrypted the DNA sequences and recovered the original file format. The DNA Attribute-based Decryption was also effective in decrypting the encrypted DNA sequences. The test results showed that the DNA Computing Model performed efficiently and effectively, with acceptable processing times for file conversion, encryption, and decryption. The security analysis indicated that the DNA-encrypted files were highly secure and resistant to attacks due to the complexity of DNA sequences and the use of Attribute-based Encryption.The results of this project suggest that DNA Computing can be a viable approach for secure and efficient storage of outsourced data in cloud storage, and further research can explore the potential of this technology in real-world scenarios. In conclusion, the DNA computing model for secure cloud storage of outsourced data has great potential for future development and implementation in real-world scenarios. The DNA-based approach offers a new paradigm for data storage, security, and privacy, and we are optimistic about its future prospects.

FUTURE SCOPE

DNA computing has the potential to revolutionize data storage and processing due to the immense storage capacity and parallel processing capabilities of DNA molecules. While DNA computing is still an emerging field, there are several future possibilities for using DNA sequencing to convert image, audio, and video data into DNA sequences. Here are a few potential future scopes:

Data Encryption: DNA sequences can be used as cryptographic keys due to their complexity and randomness. In the future, DNA computing may enable the conversion of image, audio, and video data into DNA sequences that can serve as encryption keys, providing enhanced security for sensitive multimedia information.

Parallel Processing: DNA computing allows for parallel processing, as thousands of DNA strands can be processed simultaneously. This parallelism can be leveraged for image, audio, and video processing tasks. Future advancements may enable the conversion of multimedia data into DNA sequences and the utilization of DNA-based parallel computing methods for faster and more efficient processing.

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