OCR Computer Science A Level

1.3.1 Compression, Encryption and Hashing

Intermediate Notes

<u>Specification:</u>

1.3.1 a)

- Lossy vs Lossless compression

1.3.1 b)

- Run length encoding and dictionary coding for lossless compression

1.3.1 c)

- Symmetric and asymmetric encryption

1.3.1 d)

- Different uses of hashing

Compression

Compression is used to reduce the storage space required by a file, meaning you can store more files with the same amount of storage space. Compression is particularly important for sharing files over networks or the Internet. The larger a file, the longer it takes to transfer and so compressing files increases the number of files that can be transferred in a given time.

Lossy vs Lossless Compression

There are two categories of compression: lossy and lossless. As the name suggests, lossy compression reduces the size of a file while also removing some of its information. On the other hand, lossless compression reduces the size of a file without losing any information.

When using lossless compression, the original file can be recovered from the compressed version. Something which is not possible when using lossy compression which reduces the size of the file by completely disregarding some information.

Run Length Encoding

Run length encoding is a method of lossless compression in which repeated values are removed and replaced with one occurrence of the data followed by the number of times it should be repeated.

For example, the string BBBBCCCDDDDDD could be represented as B4C3D6.

In order to work well, run length encoding relies on adjacent pieces of data being the same - if there's little repetition, run length encoding doesn't offer a great reduction in file size.

Dictionary Encoding

Dictionary encoding is another example of a method of lossless compression. Frequently occurring pieces of data are replaced with an index and the compressed data is stored alongside a dictionary which matches the frequently occurring data to an index. The original data can then be restored using the dictionary.

Take for example, the following passage.

We shall go on to the end.
We shall fight in France,
we shall fight on the seas and oceans,
we shall fight with growing confidence and growing strength in the air,
we shall defend our island, whatever the cost may be.

Frequently occurring phrases include “We shall”, “fight”, “the”, “on” and “in”. Placing these phrases in the dictionary below and replacing any occurrence with the phrase’s index, the size of the passage is substantially reduced.

Index	Phrase
1	We shall
2	fight
3	the
4	on
5	in
6	and

1 go on to 3 end.
1 2 5 France,
1 2 on 3 seas 6 oceans,
1 2 with growing confidence 6 growing strength 5 3 air,
1 defend our island, whatever 3 cost may be.

It’s important to remember that data compressed using dictionary compression must be transferred alongside its dictionary. Without a dictionary, the data cannot be used.

Encryption

Encryption is used to keep data secure when it’s being transmitted. There are a variety of different methods which can be used to scramble data before it’s transmitted and then decipher it once it arrives at its destination. We’re going to look at symmetric and asymmetric encryption.

Symmetric Encryption

In symmetric encryption, both the sender and receiver share the same private key, which they distribute to each other in a process called a key exchange. This key is used for both encrypting and decrypting data.

It's important that the private key is kept secret. If the key is intercepted during the key exchange then any communications sent can be intercepted and decrypted using the key. Asymmetric encryption gets around this issue.

Asymmetric Encryption

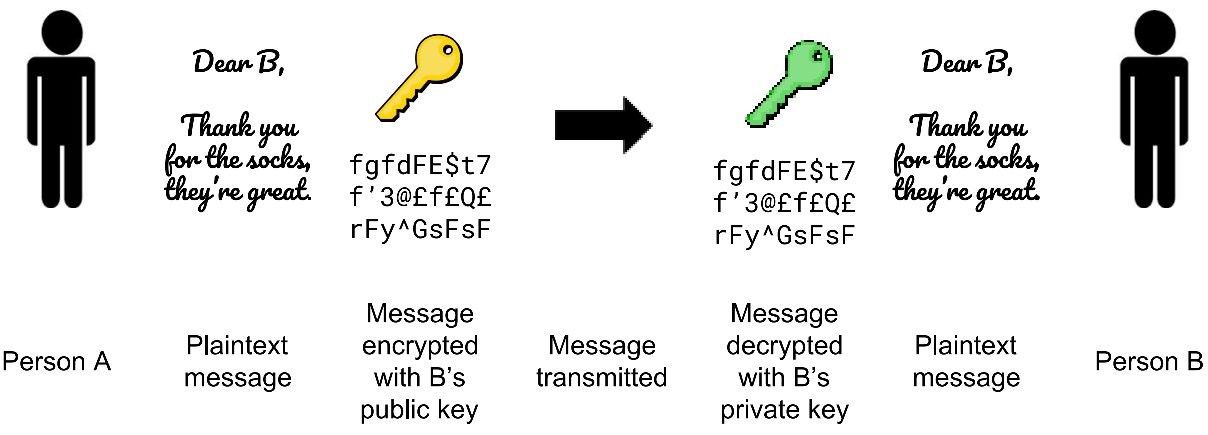
When sending information using asymmetric encryption, two keys are used: one public and a second, private, key. Something which is encrypted with one of the keys can only be decrypted with the other key. For example, if a document is encrypted with the public key, only the private key could be used to decrypt the document.

The public key can be published anywhere, free for the world to see, while the private key must be kept secret. Together, these keys are known as a key pair.

Asymmetric encryption is based on everyone having their own key pair. They publish their public keys online on a special website and keep their private key to themselves.

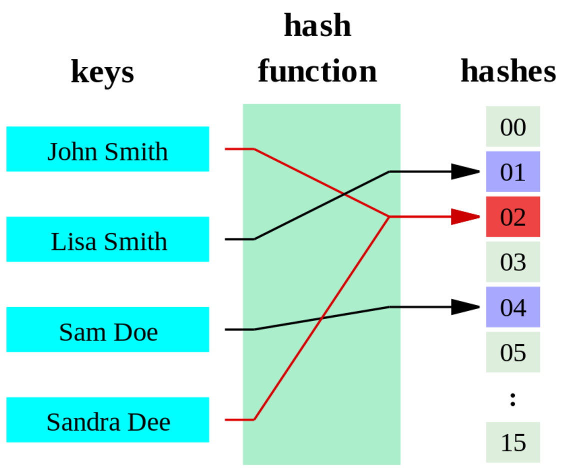
If someone wants to send you a message, they must first find your public key. The message is then encrypted with your public key meaning that only you can decrypt it, using your private key.

In the diagram below, person A needs to send a message to person B.


Dear B,
Thank you for the socks, they're great.
fgfdFE$t7 f'3@£f£Q£ rFy^GsFsF
fgfdFE$t7 f'3@£f£Q£ rFy^GsFsF
Dear B,
Thank you for the socks, they're great.
Person A
Plaintext message
Message encrypted with B's public key
Message transmitted
Message decrypted with B's private key
Plaintext message
Person B

Hashing

Hashing is the name given to a process in which an input (called a key) is turned into a fixed size value (called a hash). There are a vast number of algorithms, called hash functions, which do this.



Unlike encryption, the output of a hash function can't be reversed to form the key. This quality makes hashing useful for storing passwords. A password entered by a user can be hashed and checked against the key to see if it is correct, but a successful hacker would only gain access to the keys, which can't be reversed to gain the passwords.

Synoptic Link

Hashing is used in a type of data structure called **Hash tables**

Hash tables are covered in **1.4.2 Data Structures**

Another use of hashing is hash tables. A hash table is a data structure which holds key-value pairs. Formed from an array and a hash function, hash tables can be used to lookup data in an array in the same amount of time, regardless of how many values are in the table. When data needs to be inserted, it is used as the key for the hash function and stored in the bucket corresponding to the hash.

Hash tables are used extensively in situations where a lot of data needs to be stored with constant access times. For example, in databases.

If two pieces of data (keys) produce the same hash, a collision is said to have occurred. For example, in the image above the keys `John` and `Sandra` both hash to `02`.

A good hash function should have a low chance of collision and should be quick to calculate.