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A4_17 All Your Storage Space is Porygon(e).

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Abstract
This paper looks at a system proposed by a video game, where by live creatures can be stored digitally on a computer system. Estimates are made as to the amount of data needed to store the information contained within one of these creatures. It is found that 2.32×10^{29} bytes of data are required to digitally store each creature. Under the storage system proposed in the game, the equivalent of over 19,000 Solar surface areas of storage material would be required per person subscribing to the service.

Introduction
In the video games associated with Nintendo's Pokémon franchise, a service is provided for the in-game character where he can store his Pokémon digitally on a computer [1]. This service comes in various configurations that have changed as sequels to the original game have been released. For this paper we will look at the original service, which in reference [1] is referred to as 'Bill's Computer'. In this configuration up to 20 Pokémon can be held in each of 12 boxes, making it possible to store a total of 240 creatures. In the games no reference is made to the amount of storage hardware required to store the digital information that describes each pokémon, as a result this paper will attempt to calculate the data required to store a digital image and arrive at a value of data required to provide this storage service. As the 1st generation computer system is being considered only Pokémon from the 1st generation will be considered in our calculations.

Theory
In order to store something digitally and physically reconstruct an object from this image technology would need to exist that can read and then position atoms in very specific locations and orientation. we will assume that within the Pokémon universe there exists such a technology. In order to calculate the data required to reconstruct something from individual atoms we must consider the parameters required to describe them. For each individual atom, data from the following parameters will need to be stored;

- Position - X, Y and Z.
- Rotation - *theta*, *phi*.
- Composition - Number of Protons, Neutrons and Electrons.
- Electron spin - Data for each Electron.

If we assume that a value for each parameter to the required accuracy can be stored within a single byte, it can be seen that a least 9 bytes will be needed to store the most basic atom, Hydrogen.

In order to determine how much data would be required to store the average Pokémon we must calculate the number of atoms that are needed to make the creature. In order to keep the model simple we will assume that the creatures are carbon based and thus will treat them as made up entirely of carbon-12 atoms. To calculate the number of atoms contained within the average Pokémon we can divide the average mass of a Pokémon by the mass of a carbon-12 atom. The mass of a single carbon atom is 1.99×10^{-23}g [2]. The most massive Pokémon in the 1st generation is Snorlax at 460kg and the least massive is Gastly at 0.1kg [3], this gives us an average mass of 230.05kg. Using this average with our mass for a carbon atom we can calculate the number of atoms present in an average pokémon,

$$\text{Total atoms} = \frac{230.05\text{kg}}{1.99 \times 10^{-23}\text{g}} = 1.16 \times 10^{28}. \quad (1)$$

Data Required
In the previous section we calculated that the average Pokémon contains 1.16×10^{28} atoms. In order to calculate the data required to store the information associated with these atoms we must first determine how much data a single atom of carbon-12 requires. We stated that there were 9 parameters that would need to be stored. Storing one of these parameters, electron spin, will require a separate piece of data for each electron present in the atom. This puts a carbon atom at 20 individual pieces of information, one for each parameter except electron spin which requires 12. We assume that the information for these parameters can be contained within a byte each, this puts the space required at 20 bytes per atom of carbon-12. Using this we can calculate the total amount of space required,

$$20 \text{ bytes} \times 1.16 \times 10^{28} \text{ atoms} = 2.32 \times 10^{29} \text{ bytes}. \quad (2)$$

Discussion
We have calculated the amount of data required to

store the average Pokémon digitally to be 2.32×10^{29} bytes. If a Pokémon trainer used his full allowance of 240 Pokémon, the amount of data required would rise to 5.74×10^{31} bytes. This is an unfeasibly large amount of data considering that in the Pokémon universe almost everyone has several Pokémon and may want to store them on the same system. To put this amount of data into context, in 2009 it was estimated that the entire worlds digital media content was around 500 billion gigabytes of data [4]. Using our calculation the data required to store our Pokémon is still over 5×10^{13} times larger than this amount. In 2010, Toshiba released an ultradense hard drive platter which could store 2.5 Terabits per square inch [5], this equates to 0.313 Terabytes per square inch. Using this material we can calculate what area would be required to store a Pokémon trainers full box of Pokémon,

$$\frac{5.74 \times 10^{31}}{0.313 \times 10^{12}} = 1.83 \times 10^{20} \text{ in}^2 = 1.18 \times 10^{17} \text{ m}^2. \quad (3)$$

Considering the surface area of the Sun is $6.08 \times 10^{12} \text{m}^2$ [6] the Sun's surface would need to be covered over 19,000 times to provide enough storage material to store the atomic data of a full box of Pokémon.

Conclusion

It is found that the data required to store the atomic data of the average Pokémon is of the order 10^{29} bytes. We consider a material announced by Toshiba that has one of the densest patterns of data storage and found that using this material we would require enough to cover an area equivalent to around 19,000 times the surface area of the Sun. Along with the large amount of material required, another drawback worth considering is that the material proposed is currently not able to be read as of yet, using commercially available drives the area would be around 4 times this [5]. In conclusion we find that the data required to digitally store a Pokémon trainers collection on the computer system proposed by the game, to be unfeasibly large especially when considering the storage materials currently available.

REFERENCES

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