4 a.m. is the New Midnight

Steven Pemberton, CWI, Amsterdam

1   **Contents**

1   **A Print, 1790**

1   **Same view now**

1   **Jan Lievens (1607-74)**

"*Copied by E. Grosser, Esqr, from an Ancient Drawing said to have been made by*

1   **Indeed**

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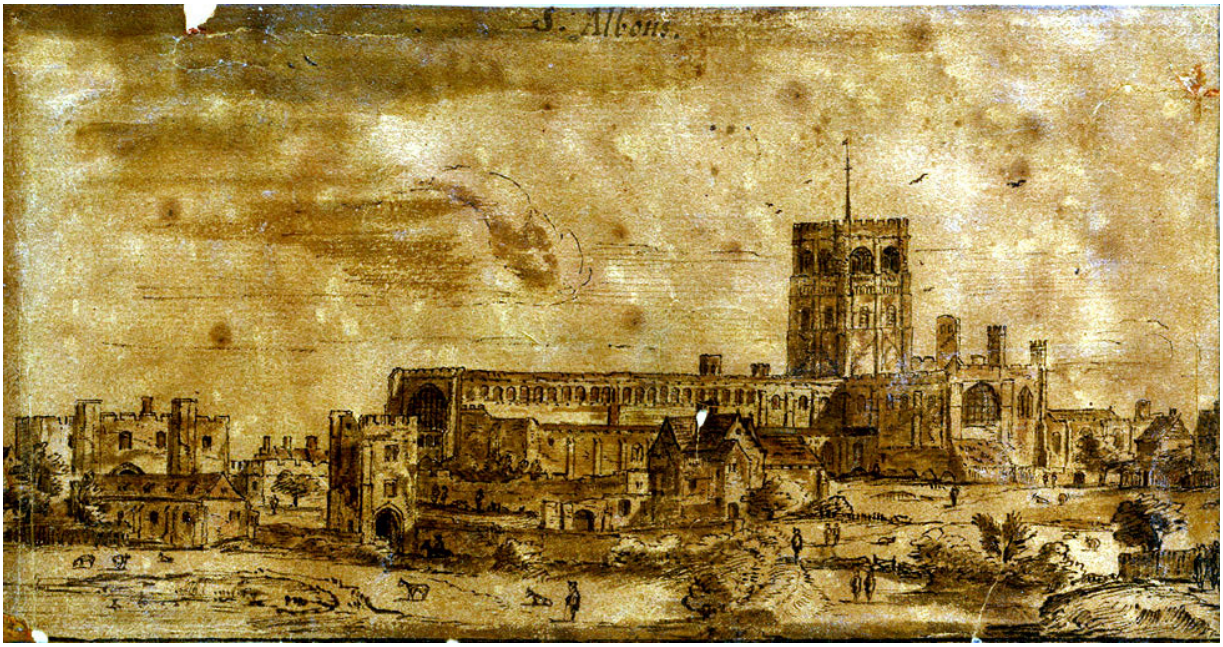
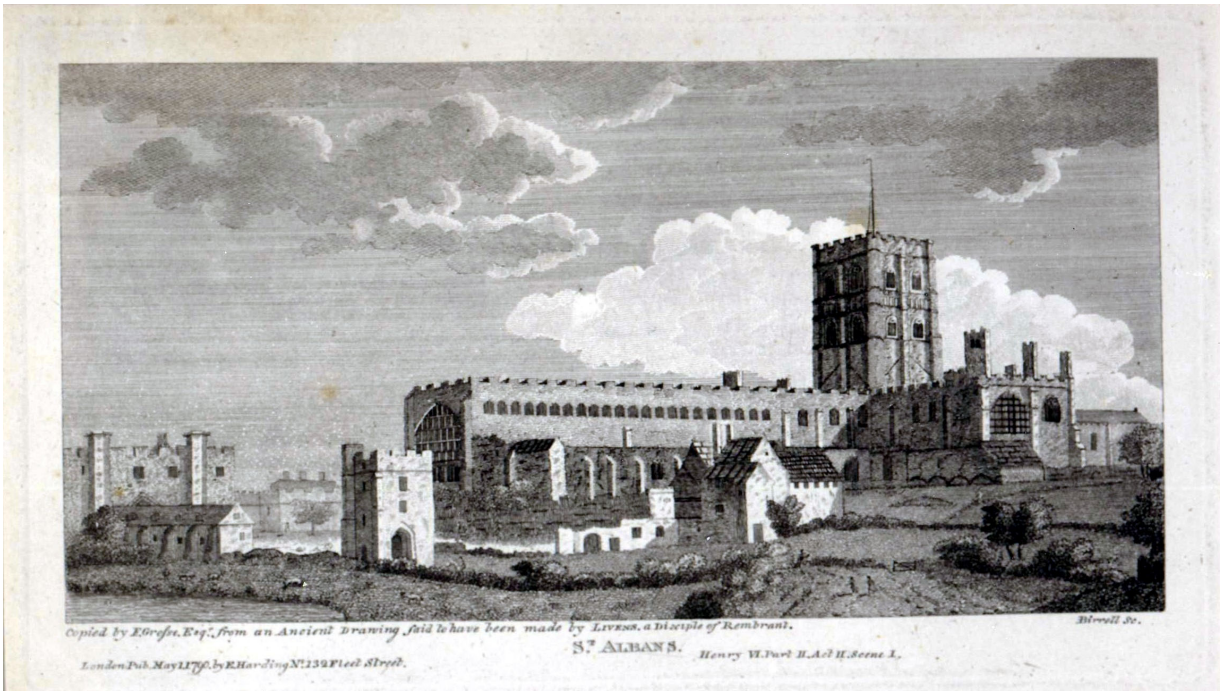


1   **Indeed**



1   **Abbey Gateway, St. Albans**

1   **Clock Tower, 1400**

This is the only remaining mediaeval clock tower in England.

It contains a bell that was cast around 1350.

I used to walk past it every day on the way to school.

1   **Clock Tower**

1   **Why was the clocktower built?**

1   **1485 contract**

"*kepe, make and rewle the clokke, beyng in seid tenement, and to smyte and kepe his resonable howres, and dayly and nyghtly to rynge or do* ***rynge the bell*** *of the same clok by the space of half amyle wey* ***betwene the houres of viij*** *and ix of the same clok at* ***after noone,*** *and immediatly as he can or may* ***after the houre of iiij of the same clok before noone****, at hys owne propre costes, expenses, and labour, or hys assignes duryng the seid terme. And shall make and kepe all reparacons necessarye to the seid tenement and clokke Excepte the reparacons of the bell and the claper perteynyng to the seid bell, and excepte also the stone werk and lede werk of the seid tenement, etc.*"

1   **Curfew**

So one of the purposes of the Clock Tower was to sound the curfew (From French: Couvre Feu).

What this shows us is that in those days people slept from 8pm to 4 am: They still slept 8 hours, just from early evening to early morning.

Why?

1   **Light was REALLY expensive**

In those days, light was mostly provided by candles.

Candles were very important products.

In fact there were two guilds for chandlers: one for those who made wax candles, and one for those who made tallow candles.

And candles were very expensive. It was not uncommon for people in some jobs to be partly paid in fire wood and candles.

1   **"The Witching Hour"**

So people went to bed at 8, and got up at 4 for economic reasons: if you slept in the hours of darkness, you would use the least number of candles.

Which meant that Midnight was the time of the night furthest from daylight, furthest from waking, the darkest part of the night, when no one would be about.

Nowadays, Midnight is not as special, in fact the time of night furthest from sleep is likely to be around 4 a.m., when the least people are on the street, and when traffic is at its quietest.

1   **The Cost of Light through the Ages**

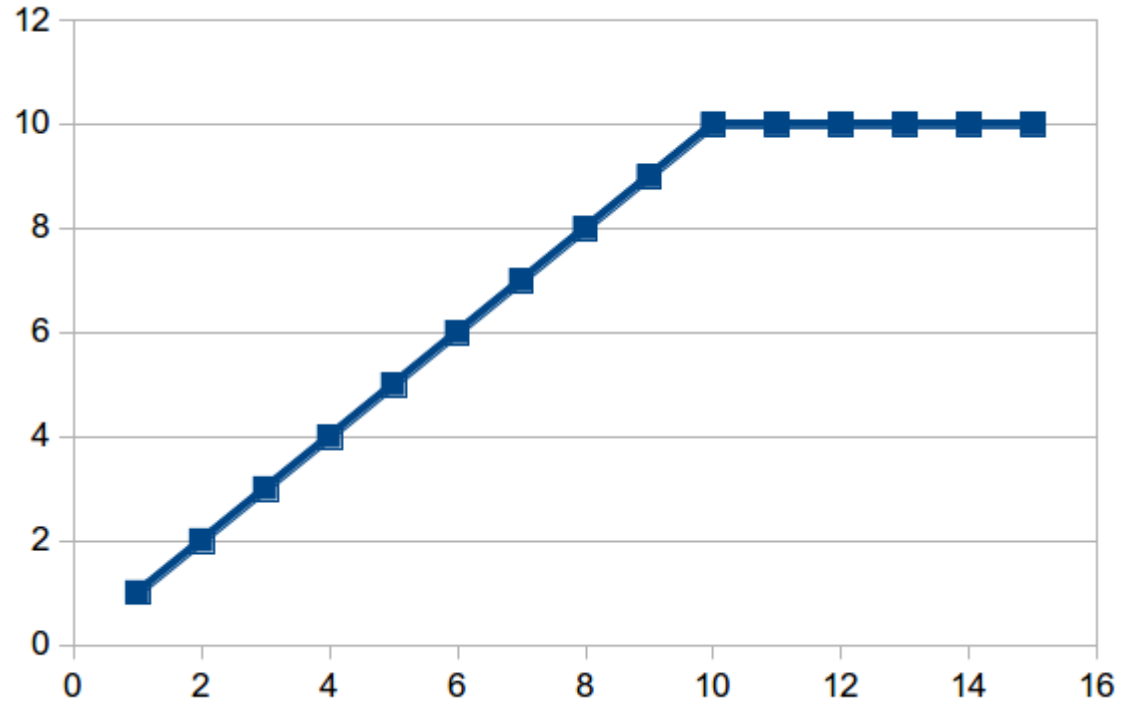
I am going to talk about the development of the cost of lighting over the years.

But first a reminder about graphs.

1   **Adding**

1   **Linear graph**

So if we



look at the graph of the bath filling, we get something like this:

1   **Multiplying**

However, for instance, when a bank gives you interest on a bank account, it is not adding a fixed amount every year, but an amount based on how much you already have in the bank.

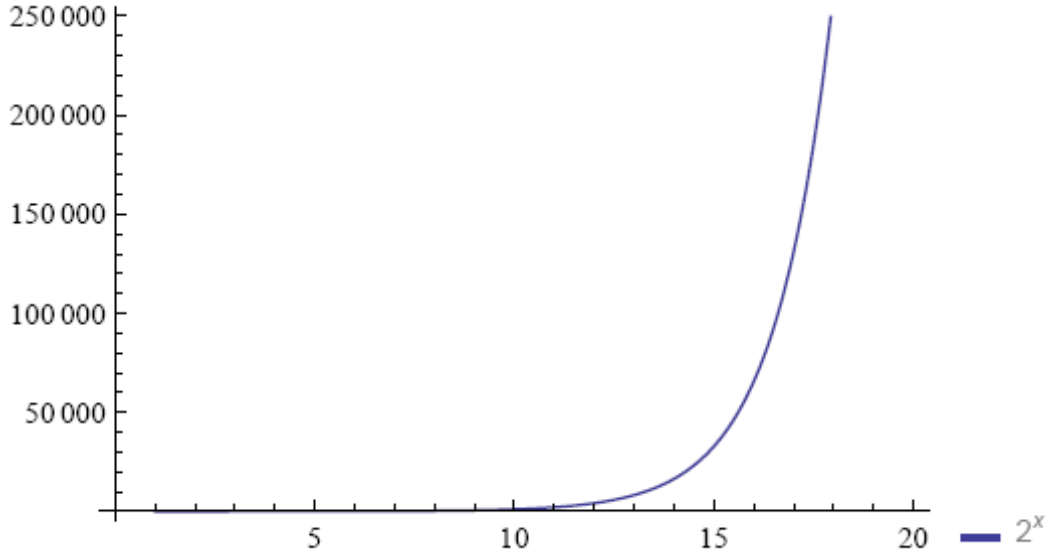
For instance, if they offer a 3% interest, then every year your money gets **multiplied** by 1.03.

If you have €1000 in your account, then at the end of the year you will have €1000 × 1.03, which is €1030. At the end of the second, you will have €1030 × 1.03, which is €1060.90.

This is called an **exponential** function.

1   **Exponential 20 iterations**

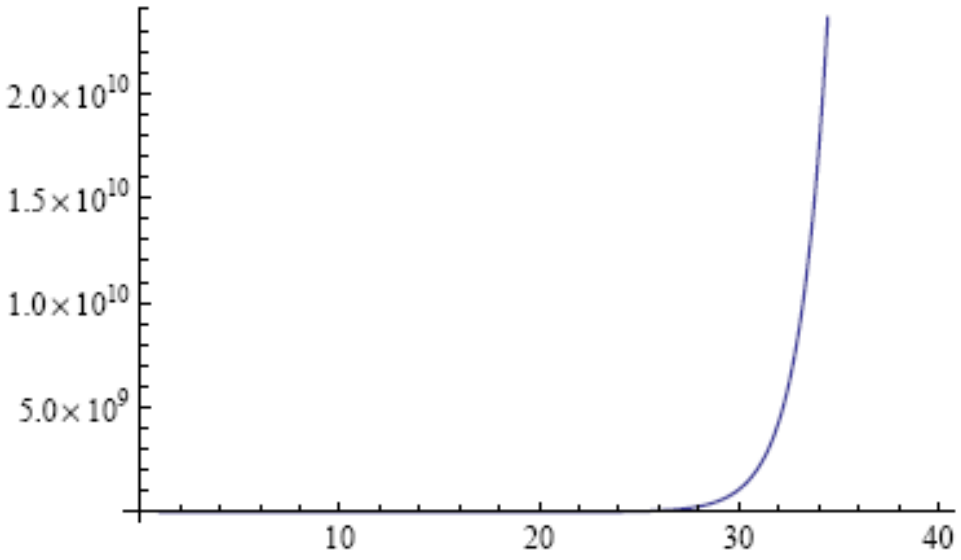
Note the 'knee' around iteration 15. People often talk about an



exponential function 'passing the knee'. This is a mistake.

1   **Scale, 40 iterations**

Note how there now seems to be nearly no action before iteration 26. The 'knee' is a fiction, a visual effect of the scaling used.

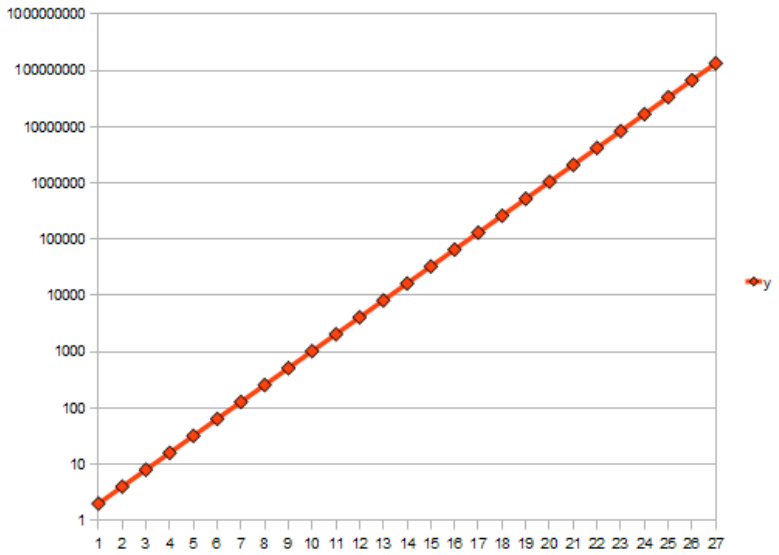


1   **Logarithmic scale**

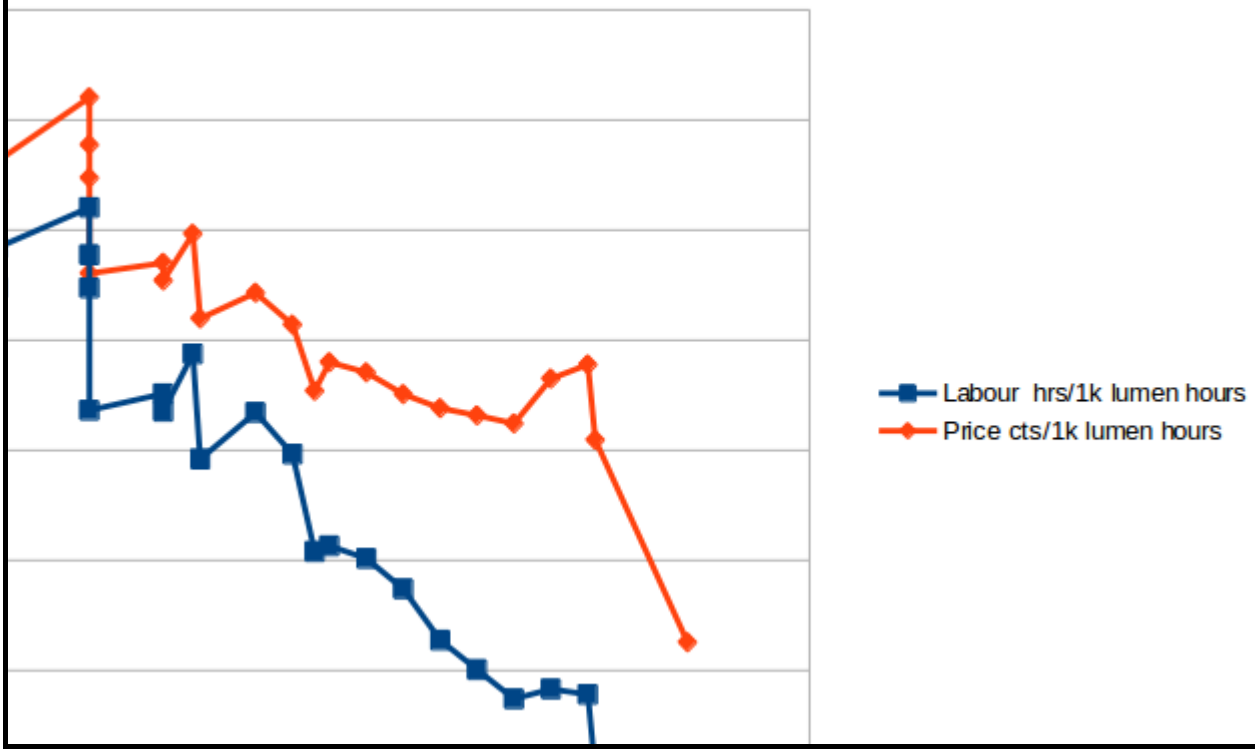
It is better to graph exponential functions in a different way.

On the vertical axis, rather than going in steps of 1, 2, 3, ... we use steps of 1, 10, 100, 1000, ... Then the exponential graph looks like this:

(It actually doesn't matter what the step size is, as long as it is a multiplication: the graph still ends up looking the same).



1   **The Price of Light since 1800**



1   **Move to LED lights**

The data pre-dates LEDs

The cost of light produced by LEDs is decreasing exponentially.

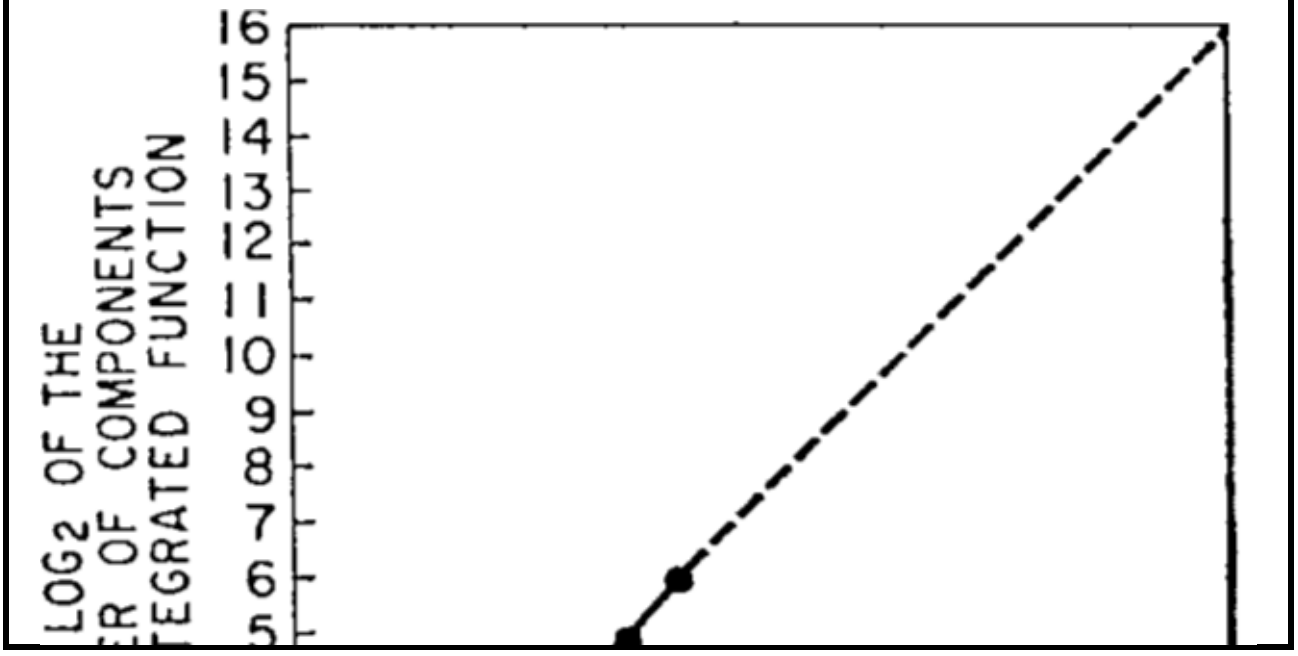
Haitz's 'law':

> **Every decade the price per lumen drops by a factor of ten.**

This is a halving rate of about 3 years.

1   **Where else do we have exponential improvement?**

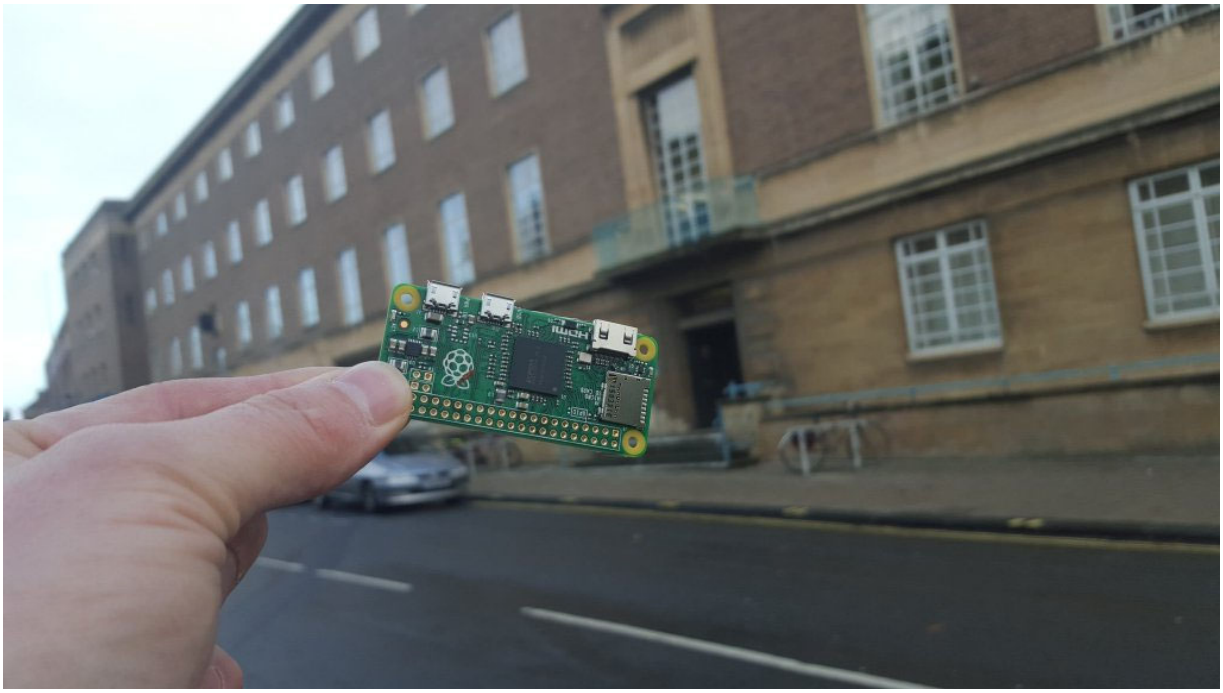
Computers: Moore's Law.



1   **1957: The first municipal computer (Norwich, UK)**

Just one of 21 cabinets making up the computer

1   **2015: The Raspberry Pi Zero**



The first general-purpose computer that was so cheap it was given away free on the

1   **How do they compare?**

The Elliot ran for about a decade, 24 hours a day.

How long do you think it would take the Raspberry Pi Zero to duplicate that amount of computing?

- 10 years?
- 1 year?
- 5 weeks?
- 5 days?
- 5 hours?
- 50 minutes?
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- **5 minutes!**

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The Raspberry Pi is not only one million times faster. It is also one millionth the price.

A factor of a million million.

A terabyte is a million million bytes: nowadays we talk in terms of very large numbers.

Want to guess how long a million million seconds is?

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Want to guess how long a million million seconds is?

30,000 years...

A *really* big number...

1   **Moore's Law**

In fact a million million times improvement is about what you would expect from Moore's Law over 58 years.

Except: the Raspberry Pi is two million times *smaller* as well, so it is *much* better than even that.

1   **The Orders of Magnitude Effect**

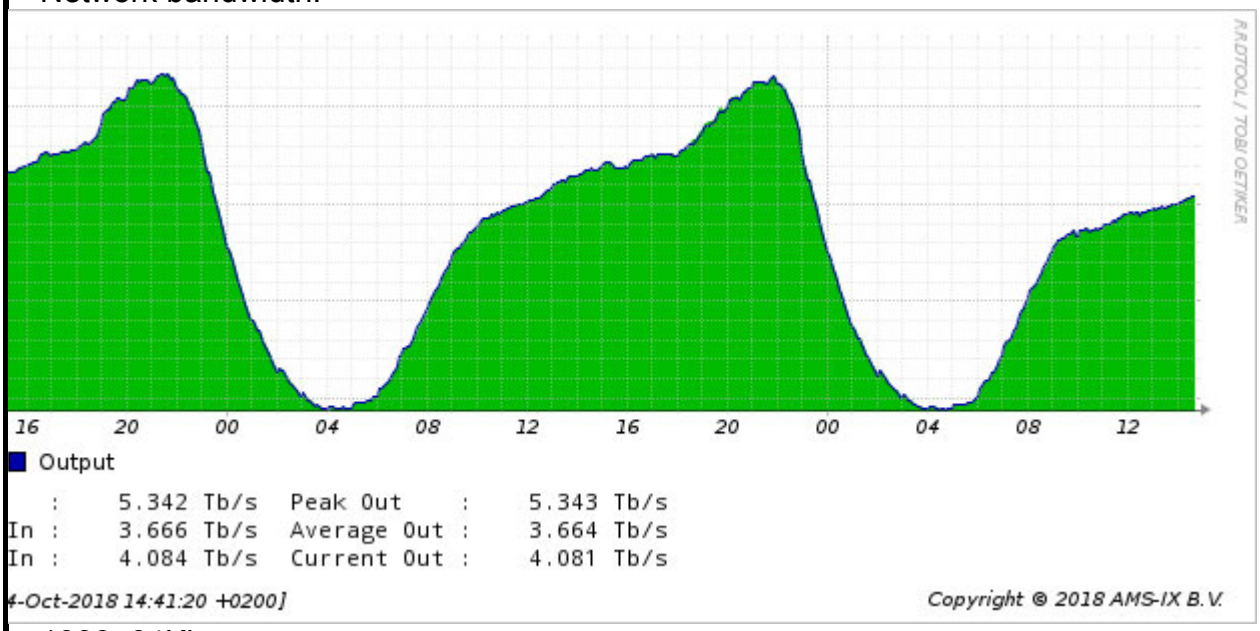
Each order of magnitude change in cost has meant we have used computers in a different way:

1,000,000	Mainframe
100,000	Minicomputer
10,000	Workstation
1,000	Home computer/Laptop
100	Netbook/Tablet
10	Project
1	Embedded

Similarly, the reduction in cost of lighting has meant that people have adapted their sleep behaviour (and by the way, that cyclists in Amsterdam actually use lights now).

1   **Where else do we have exponential improvement?**

Network bandwidth:



1988: 64Kbps

1   **Networks**

We have seen some effects of network cost reduction:

- In the early days of internet, with dial-up lines, people would log on, check their mail, and then log off again.
- When bandwidth became cheap enough not to have to meter, people went online continuously.
- We watch less television.
- We read fewer newspapers
- International communications are free, and by video.
- Landline telephones are disappearing.

But as uplink speeds start going above 1MBps, we have an opportunity to make other changes.

1   **Facebook**

What is Facebook?

It is a personalised website, with software that allows you to easily add items, photos, news items, links, and control who can see them.

Your friends are able to comment on your items, and you on theirs.

It then merges your items and your friends items into a stream that you can read and comment on as well.

And Facebook owns this content, and it owns you.

1   **Owning your own content**

How could we do better?

The amount of content you produce is fairly small.

In the ten years I have been on Facebook, I have produced about 100MB of data, most of which is pictures and videos. The text is about 3½MB.

It would be easy to produce the software that does the same thing, but serves them *from your home* (the server could be in your modem).

It would be fairly easy to restrict who could see what, using well known techniques.

Knowing who your friends are, it would also be easy to aggregate your friends items, and create a stream to comment on.

And you would own your data, and no one could spy on you.

And no one would be trying to sell you stuff.

1   **Other sites**

I pick on Facebook because of its size and presence, but the same techniques could apply for most other sites that exist thanks to its users providing its content.

In fact one of the big problems with such sites is that there are many of them, and you have to choose which to use, or duplicate your work. Examples are photo sharing sites, geneology sites, selling sites.

But in fact, if you kept your own data, and then allowed sharing sites to *aggregate* your data, you would only have to do the work once, and you could join and leave sites without any loss of data or work.

1   **Conclusion**

Orders of magnitude change can affect how we act.

The next step is to take advantage of the order of magnitude change in the uplink, and start making the internet a true two-way, distributed channel.

For example: Solid