Chapter

Introductory Chapter: An Overview to the Internet of Things

Manuel Domínguez-Morales, Ángel Varela-Vaca and Lourdes Miró-Amarante

1. Introduction

The Internet of Things (IoT) refers to the process of connecting everyday physical objects to the internet, from common household objects (lighting, appliances, etc.) to healthcare assets (such as medical devices), as well as wearables, smart devices and even smart cities.

These IoT-connected physical objects are visible within the created network itself, allowing them to be consulted and/or acted upon.

The great advantage of the IoT, which leads to its enormous importance today, centres on the ease of connecting new objects to this network. The interest in this technology is being increased year by year, as shown in **Figure 1**.

A few years ago, in order to connect a device to the network, it was necessary to deploy a multi-layered infrastructure to access its information. Nowadays, however, there are open-access projects that present a free and extensive network where end users can directly connect their objects (only needing a connection modem in the object itself).

With multiple connected objects over a large area, there is great potential for projects that focus on the population's well-being when applied to smart cities. This opens up endless possibilities, but not without challenges and concerns. Many of the latter focus on the devices and network's security and devices and how a malicious user can alter the information or undermine privacy.

All these issues and possibilities are addressed in the various chapters of this book, which attempt to cover all areas of the IoT.

So, the main aim of this introductory chapter is to serve as a justification for the book itself, presenting hard facts and data that prove the evolution of the use and deployment of IoT systems in society. To this end, a literature review will be carried out to show the increase in publications related to the subject in recent years.

2. Trend analysis

The methodology used corresponds to the classical systematic review process. The keywords used for the search process are "Internet of Things" and "IoT", including the operand "OR" between both. In order to observe the trend, the last 20 complete years are taken into account (from 2001 to 2021). Finally, the search engines used for it are Google Scholar, IEEE Xplore and Scopus. With the information obtained, the criteria used to analyse the works is mainly the applied field.

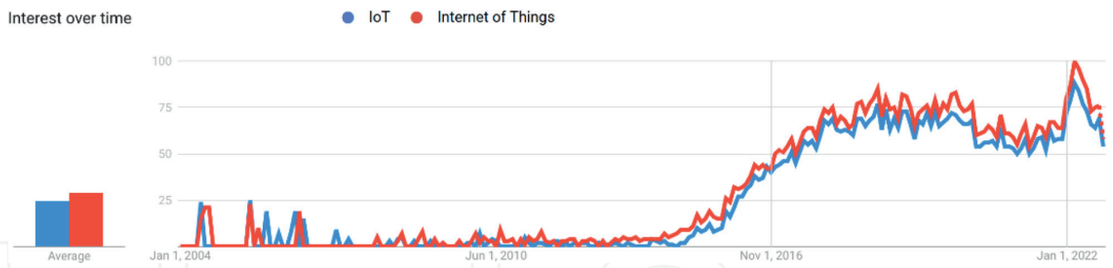

Figure 1.
Interest over time in the terms "IoT" and "Internet of Things" from 1st January 2004 to date (obtained from Google Trends). A strong increase can be observed in 2016 and in the beginning of 2022.

All the works found are used to obtain the distribution per year and observe the tendency. However, not all these works are analysed deeply to find their topic because of the great number of works found. Instead, we analyse only a subset of the most-cited works from each year.

The search results show a total of 339.804 works published between 1 January 2001 and 31 December 2021. The evolution of these publications for each year can be seen in **Figure 2**. It can be seen that the number of publications between 2001 and 2008 is not more than 100. The increase was maintained in subsequent years, but it was not until 2016 that a breakpoint was observed, with the number of papers doubling that of the previous year. This point coincides with the annotation observed in **Figure 1**.

From 2016, there was an exponential increase until 2020, when stagnation is observed (presumably due to the pandemic) with a subsequent upturn in 2021.

As a result, it can be theorised that the trend in interest and use of IoT technologies has passed its exponential growth stage and is in the maintenance stage. It is at this point where it can be theorised that the research linked to this field is in its maturity stage, and therefore, we are in an ideal position to be able to publish a book of these characteristics.

In order to analyse the topic distribution, the most cited works from each year are extracted using the next criteria:

- From 2001 to 2008: in this period, there were less than 100 works per year (92 in 2008), so we extract the 10% most cited works for each year. In total, we obtain 25 works in this period.
- From 2009 to 2011: in this period, the number of works per year varied between 100 and 1000. As there is a big variation between these years, we extract the

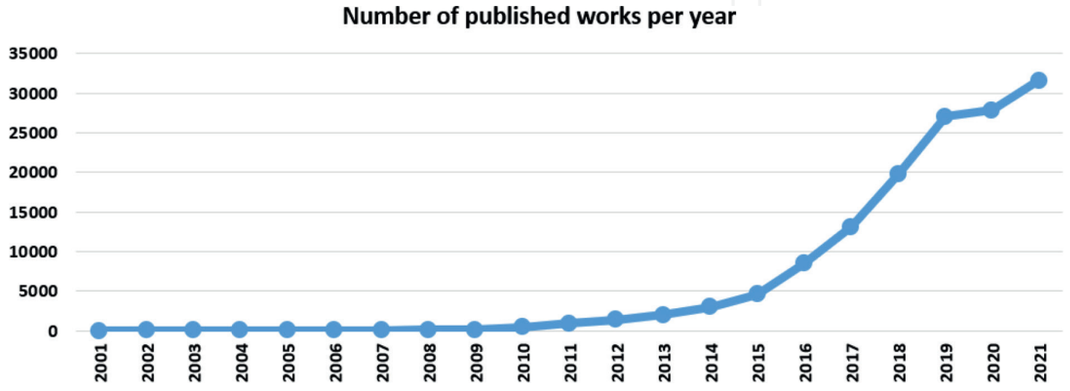

Figure 2.
Number of works published each year from 2001 to 2021 using the search phrase "IoT" OR "Internet of Things".

3% most cited works for each year with a minimum of 10. In total, we obtain 50 works in this period.

- From 2012 to 2015: in this period, the number of works per year varied between 1000 and 5000. For this case, we extract the 1% most cited works per year with a maximum of 40. In total, we obtain 102 works in this period.

- From 2016 to 2021: this is the period with the biggest number of published works (from 13 to 31 K works), so we need to reduce the number of analysed works in order to simplify the evaluation stage. So, we extract the 0.5% most cited works per year during this period. In total, we obtain 636 works in this period.

Finally, we obtained 813 works to be analysed. This amount of work is considerable and needs to be reduced. By discarding those works not published in international journals, the number of works is reduced to 391. Finally, discarding those published in non-JCR journals, the total amount of works is almost halved, obtaining a final number of 192 works.

With this final amount of work, the main topic distribution will be analysed. We will start by including the selected papers for the entire period (from 2001 to 2021).

If we look at the distribution of papers by each of the areas of interest (see **Figure 3**), we can see a high percentage of papers related with the field of computing (including those related with communications and security), which seems logical given the nature of the technology. In the second position is the field of Engineering, with 27% of the references observed. This is followed by pure sciences and health sciences with 16 and 15%, respectively. Lastly, the area least related with the subject of this book (social sciences) obtained 6%.

Secondly, only the selected set of works within the period from 2016 to 2021 (the period of exponential increase and stabilisation) will be analysed (see **Figure 4**). Analysing the results obtained, a very similar distribution to that obtained for the whole period can be observed. The only difference is that the first two branches (computer

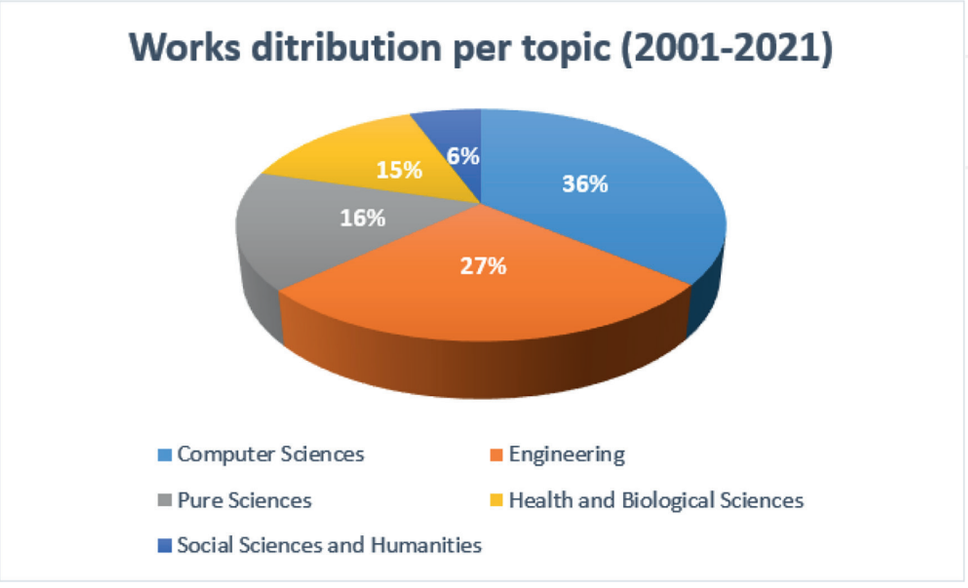

Figure 3.
Number of works published between 2001 and 2021 divided thematically.

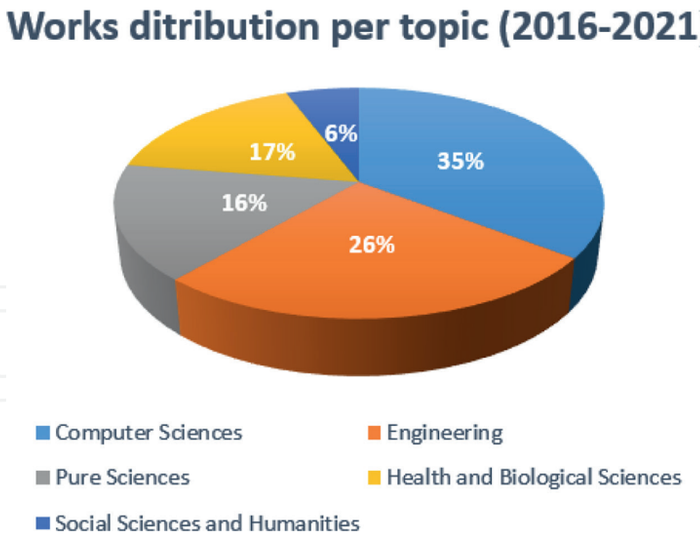

Figure 4.
Number of works published between 2016 and 2021 divided thematically.

Year	#	Work/s
2004	1	[1]
2005	1	[2]
2006	2	[3, 4]
2007	2	[5, 6]
2008	3	[7–9]
2009	4	[10–13]
2010	4	[14–17]
2011	9	[18–26]
2012	6	[27–33]
2013	6	[34–39]
2014	8	[40–47]
2015	10	[48–57]
2016	9	[58–66]
2017	12	[67–78]
2018	20	[79–98]
2019	24	[99–122]
2020	30	[107, 123–150]
2021	40	[151–188]

Table 1.
Selected works evaluated year by year.

science and engineering) slightly reduce their number in favour of health sciences (which increases from 15–17%).

In summary, therefore, it can be seen that we are currently in a period of technological maturity after a few years of exponential growth in the number of jobs. And,

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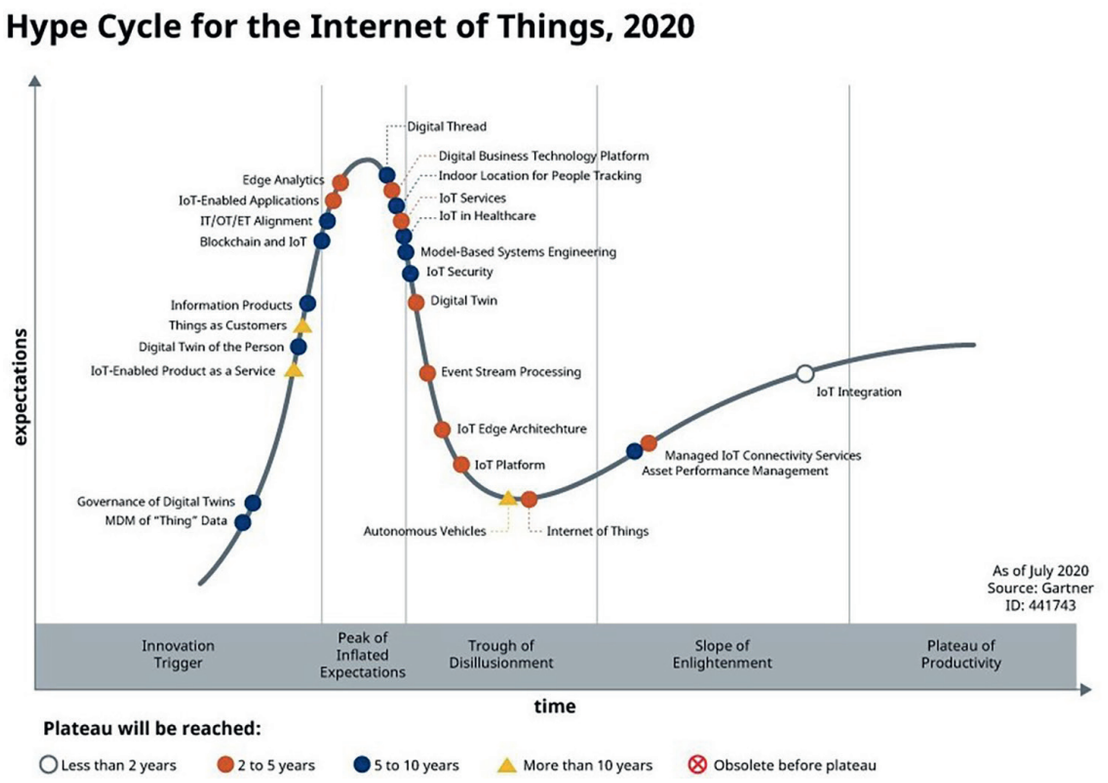

Figure 5.
Gartner's Hype Cycle of "Internet of Things".

with respect to the areas, a similar distribution is maintained throughout the period, although a continuous growth is observed in the field of health sciences.

These results have highlighted the importance and evolution of the Internet of Things in recent years. A significant increase in the number of publications has been observed since 2016, coinciding with the search trends provided by Google Trends.

This upward trend continues to increase exponentially until it stagnates in 2020, something that can also be seen in the search trends.

The summary of the most-representative works evaluated is presented in **Table 1**.

These data are directly related to the latest Gartner Hype Cycle of Internet of Things (published in 2020). It can be seen in **Figure 5** how the initial themes linked to the Internet of Things (including IoT Edge and IoT Platform) have already passed the crest of the wave and are in decline: these technologies were the fruit of the first upturn in 2016 (when both were at the crest of the wave). However, it can be seen that the technologies currently at their peak include those related with IoT in healthcare and smart homes, which may justify the increase in the proportion of publications in the health sciences in recent years.

Therefore, IoT systems and technologies have passed their initial curve of novelty and technology evolution and are now mature enough to be able to find innovative and useful work already implemented in society. It is therefore an ideal time to produce this book.

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