



**LIFI** ILLUMINATION TO  
COMMUNICATION

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A tall gentleman is standing at the center of the stage. Everyone's eyes are fixed on him.

They all are in a state of confusion and are little skeptical after what he just said.

There is pin drop silence around. One can hear the heartbeats of person sitting next to him.

Then he puts his hand to obstruct light of the lamp. All of a sudden, an HD video playing on the screen stops.

What follow next is the applause by audience, breaking the long three second silence.

“Once again, still don't believe”, says the gentleman who's slightly bent on his knees while moving his palm to obstruct the light again. An eye of a fly stretches over the screen as the video streaming pauses again.

The audience is still in awe.

He streamed an HD video using an LED. It was no less than magic. It happened first time in history.

The guy was indeed a magician. Not the one who tricks his audience; but the one who makes an LED do wonders.

But, how?

He is a scientist. An inventor. A real magician that tricks real world problems and not his audience.

Well, it's time to pull the curtains.

The stage was of TED. The gentleman was none other than Prof. Harald Haas.

He has just demonstrated how Li-Fi works. And how we can use a light bulb to illuminate as well as to communicate.

After his demonstration, the communication scientists around the globe were delighted. And why wouldn't they? Prof Haas gave them a whole new concept to work on.



Prof. Harald Haas demonstrating Li-Fi in his TED talk.

And since his TED Talk on Aug 2011, so much has been contributed by communication researchers around the globe to make this light see the light of a day.

And today in our brief time together, both of us, yes you and me, will be exploring how the research unfolded with time.

Hey, not only this, we will sneak peek into the future to explore how it will be unfolding.

So lean back and grab a cup of coffee as this is going to be quite a ride.

Let's start with what was happening before Aug 2011. Now to find that out, the goddess of research gave me two options. One, use all research papers of the Li-Fi domain and two, use the patents filed in LiFi.

The onus was on me to decide. I was in confusion on how to go about it.

[Research papers are good.](#) In fact they are awesome. But there is a catch. To collect all research papers of LiFi is one hell of a task.

The first problem is that there are multiple publishing platforms; second, many among them are still not available for public use; third, two research papers could demonstrate a single concept. So numbers of research papers published might not give me what I was looking for.

So I was left with patents that, on the contrary, can be accessed from a single database, are novel and are readily available.

That said, I created few key strings- a conventional method to mine patents- and executed them on Thomson.

And what I got was gold, but contaminated. So the next task I had in hand was to separate contaminates (junk data) from gold (insights).

And as soon as I finished, what I was left with was pure gold. Now the next task was to polish it and make it shine. In other word, to derive insights.

But before I let you know how I rolled, let's first discuss what exactly Li-Fi is, how it's better than its forefather and how it works.

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## WHAT IS LIFI?

You may be in a room – office, home, restaurant – or may be in a vehicle while reading this post. And I am sure that you can easily spot a light bulb around you.

And in the future, that light bulb could be your wireless hotspot. You and I will be in a world where billions of lightbulbs we use today for illumination purpose, will be used for communication, too.

And the wireless hotspots which these bulbs will create, provide you an internet speed that isn't possible with the current Wi-Fi router you have in your room.

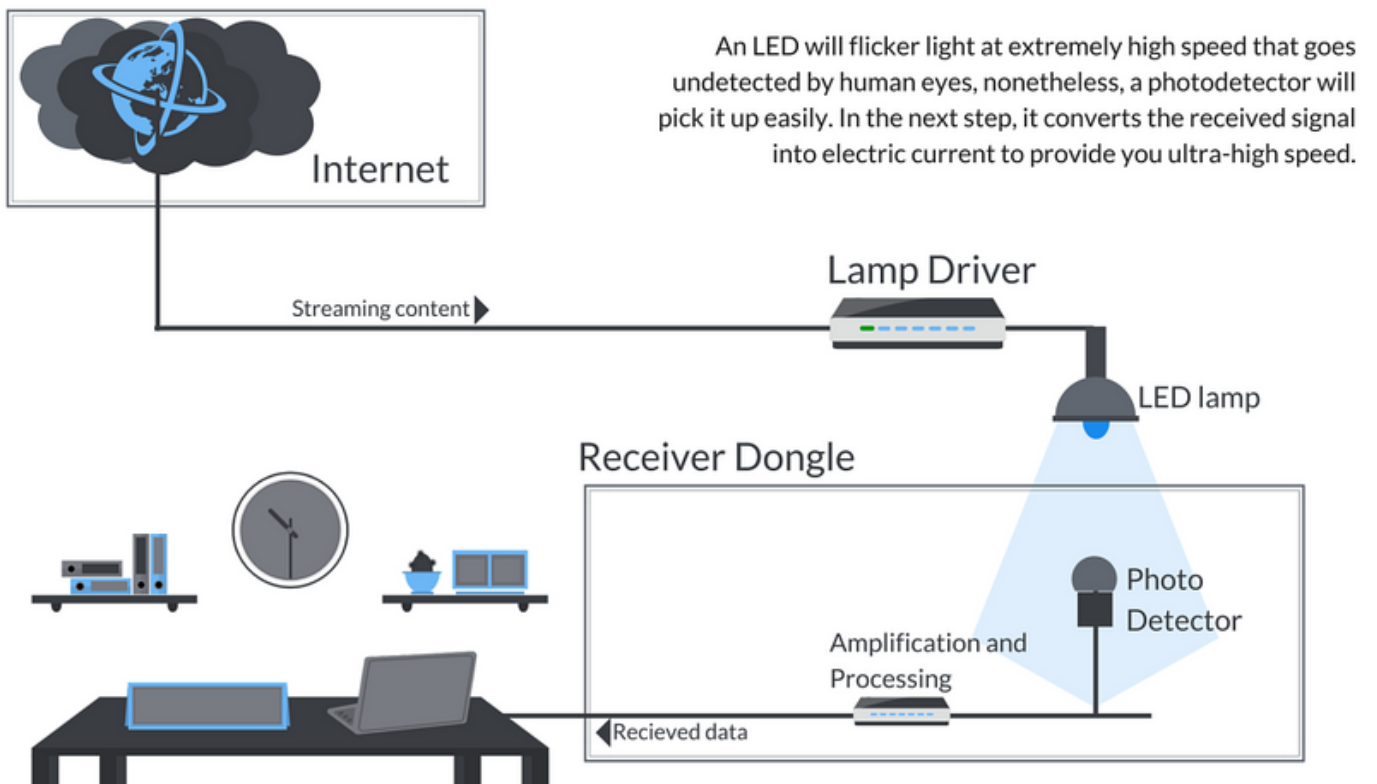
In February of 2015, researchers at Oxford University achieved a speed of 224 Gbps. You can download 20 HD movies with that speed, in just one second.

Simply put, an LED will flicker light at extremely high speed that goes undetected by human eyes, nonetheless, a photo-detector will pick it up easily. In the next step, it converts the received signal into electric current to provide ultra-high speed. The image on the next page will help you grasp the concept better.

According to PureLiFi, a company by Prof Harald Haas, the working of Li-Fi is as follows:



When a constant current is applied to an LED [light-emitting-diode] light-bulb, a constant stream of photons is emitted from the bulb which is observed as visible light. If the current is varied slowly, the output intensity of the light dims up and down. Because LED bulbs are semiconductor devices, the current, and hence the optical output, can be modulated at extremely high speeds which can be detected by a photo-detector device and converted back to electrical current. The intensity modulation is imperceptible to the human eye, and thus communication is just as seamless as RF [radio frequency technology]. Using this technique, high-speed information can be transmitted from an LED light-bulb.





## WHY IT'S BETTER AND NOT BETTER THAN WI-FI?

Last year, after several lab tests, LiFi achieved record-breaking data transfer speed of 224Gbps. Even though it was an experiment and isn't possible in normal conditions, LiFi still has the potential to surpass WiFi in terms of data transfer rate.

The LiFi was publically disclosed in 2011 but researchers were working since 2006 to make it a household thing.

Now, even though it's been almost 5 years since the disclosure and the R&Ds efforts in this tech have doubled since then, LiFi isn't anywhere near in competition to the WiFi. Why are we not seeing it in the market?

Besides all the advantages of Li-Fi which has got everyone's eyes on it, LiFi has some serious drawbacks which are still to overcome and may stop it for another 5 years from becoming popular. Let's read few of them.

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A brief patent landscape study focusing on innovation taking place in 4G LTE technology and companies behind that. The study also reveals the top NPEs working in the same domain.



## THE TEMPORARY PROBLEMS

LiFi, as you may know, requires specialized LEDs in order to work flawlessly. Prof. Harald Haas claimed that LiFi can work with our existing LEDs but, this is just partially true.

There are a huge variety of LED bulbs floating in the market, each with different qualities. It's not necessary that your LED bulb is compatible with your choice of LiFi adapter. Also, as LiFi works in line of sight only, you will need to buy at least one LED bulb for each corner of your room.

Second, there's no public product with inbuilt hardware to support communication over LiFi. This means you'll need extra adapters for your devices, maybe at least one for every room. There goes the cost up again.

Even if you decide to deal with the cost of LEDs and LiFi adapters and are waiting eagerly to make you house conducive to use LiFi, there's still one major thing left which is going to cost you few hundred dollars more. That is your new network wiring settings.

As you know, your current LED bulbs are connected directly to electricity but, in the case of LiFi they need to be connected to your network. So, you may need to consider rewiring in your house again.

Currently, there are few products from Pure LiFi than can make it much less a pain in the head like, LiFi-X or Li-Flame which are much easy to setup than it sounds but they still needs extra wiring and adapters which you need to carry around with you if you're using it on laptop or smartphones.

## **THE NEARLY PERMANENT PROBLEMS**

All of the above problems are temporary, right? Once you set it up, you're good to go. Now let's read some other small but non-temporary problems.

### **Range**

The internet over LiFi is as restricted as light from that LED. It can't penetrate walls like WiFi. Just one obstacle and bam you'll get disconnected. You will also need to be in a defined range to use it efficiently as light intensity decreases with distance. You can't even turn your back against the LED bulb because that will again interfere with your signals.

### **Interference from other light sources**

LiFi is good for indoor purposes, as long as you are in enclosed area with minimum or no ambient light. If your room has windows or if you're sitting on your balcony, there are fair chances that light from outside may mess with your LiFi signals.

## Additional Devices

There's no consumer Smartphone or computer with built in LiFi support. You need additional devices to use it on your laptop. Two signal emitters on both ends (one for your device and other is your already existing LED), two signal receivers (again, one for your laptop and other hooked at your ceiling).

Pure LiFi products claim to use a single AP (emitter) for multiple client side devices (laptops and Smartphones) but will you still need multiple receivers for each single device.

## Night problems

You may not be able to play your favorite game at nights by switching off your lights in the dark. There's a debate to use infrared light (almost invisible) instead of LEDs in LiFi to make it workable for nights as well. This, however, is prone to reduce the data speed. Other than that, IR radiation can be harmful for your skin.

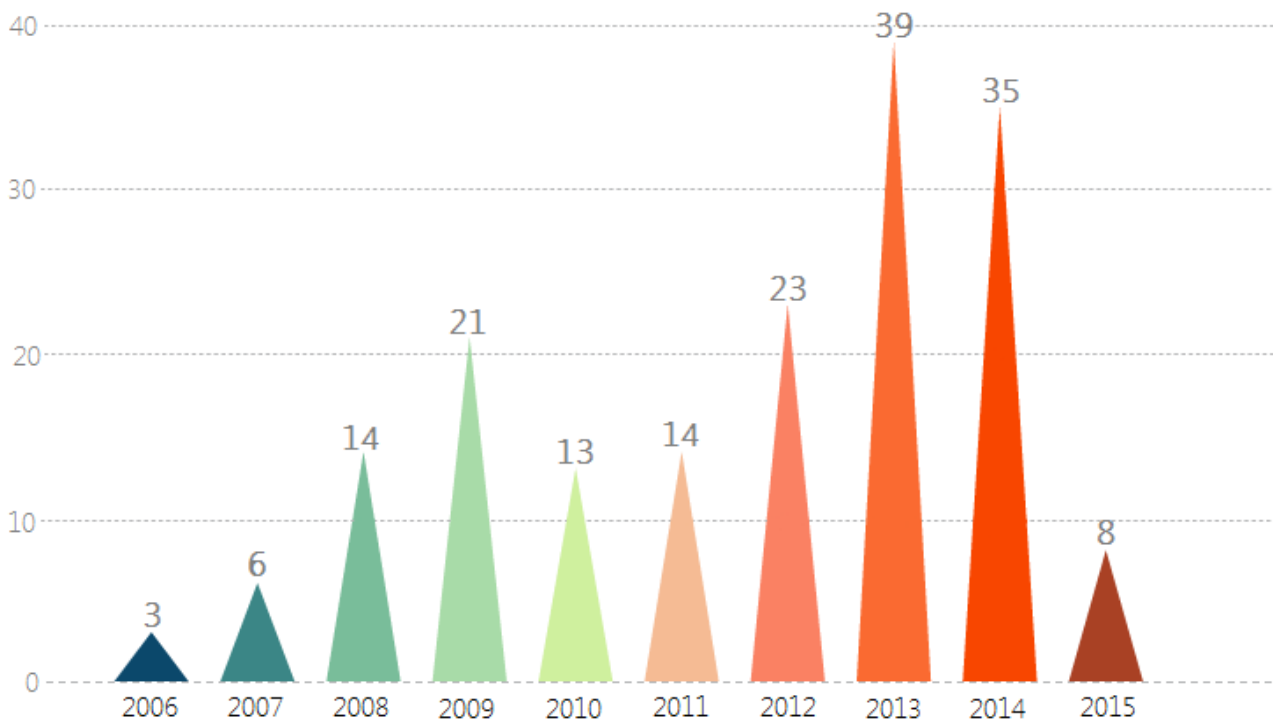
These actually are not problems, these are the limitations of a new communication network and almost all of these can be overcome as research in LiFi are growing every now and then.

LiFi can become a great communication method for home networks, for example, to transfer data from one computer to another or to stream high definition movies from your home media station. It's just another smartphone away from becoming popular; as soon as we see Li-Fi compatible smartphones in the market we can assume it to be entering our house in a flash.

# HOW LIFI EVOLVED IN THE LAST FEW YEARS

As I have mentioned, I used patent analytics to decipher how things have been moving for past few years in Li-Fi. In the below chart, I have plotted patent filing against year. The chart helps us know the state of research across the globe in the visible light communication or Li-Fi domain.

**LiFi**  
Patent Filing Trend



One thing worth noting is, that though first public disclosure of Li-Fi happened in Aug 2011, but the real game started way before in 2006.

If we divide the above chart into two phases: first before Prof. Haas' disclosure and second after his disclosure. We can see that in the first phase, the research activity in the domain was quite constant.

There is not any significant increase or decrease in patent filing activities in that phase. However, in the second phase, which is after 2011, there is significant increase in patent filing activities.

A 66% rise in patent filings was observed in 2012 as compared to 2011. Similarly when I compare all of the patents filed during 2012-2014 with 2006-2011, I find that 26% more patents were filed in former period than the latter.

Only 8 patents were filed in 2015. But this should not be considered as decrease in research activities. In general, a patent application takes 1-2 years to get published. And patents filed in 2015 haven't seen the light of a day yet.

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#### The State of Innovation in Australia

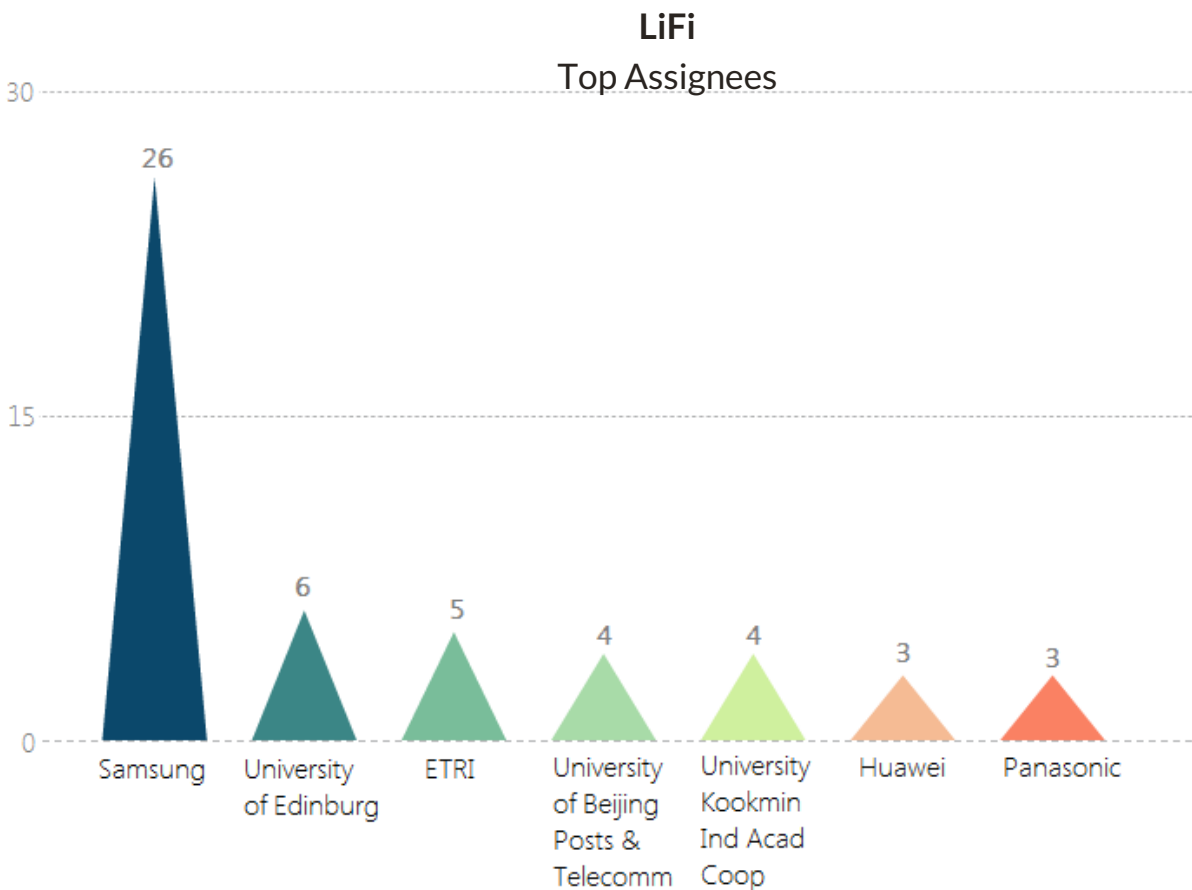
Traditionally, the Australian economy has been highly dependent on mining operations and farming. Although a consistent innovation is happening in the mining sector, the other sectors are being hugely neglected.



# WHICH COMPANIES ARE TRYING TO MAKE LI-FI A HOUSEHOLD THING OF THE FUTURE?

The visible light communication industry seems to have traveled long since its inception. It is expected to become a huge [\\$113bn industry by 2022](#). Without doubt, we are going to see tech Goliath and some new entities fighting to grab their share of the market.

This brings another question on to the table: who all are going to fight that Li-Fi war? And I again used the same patent data set to find the answer that is in the below chart.



Samsung, with 26 patents, is at the top spot followed by the University of Edinburgh that has filed 6 patents. ETRI is at the third spot which has developed visible light technology called LubiNet. LubiNet can deliver digital data via LED lights. The next two spots are occupied by Universities. This is something I was expecting as a university is the birth place of Li-Fi.

Professor Harald Haas, the father of LiFi, was associated with the university of Edinburgh, which is at 5th spot, is the inventor of many patents filed by the university. Other than that, Professor has filed few patents with NTT DOCOMO and Jacobs University Bremen as well.

Professor Haas has also established PureLiFi in 2012. His company focuses on development of visible light communications. Apart from tech goliaths – Samsung, NTT Docomo, Panasonic here – few ingenious startups– Koriist, SamsaraHQ and Sigfox, etc – are also making an effort to shine.

In the next post of this series, apart from the state of research before 2011, I will also be unveiling the top ten countries making efforts to convert your light bulb into a wireless hotspot. And you will not find either USA or Japan at the top.



## WHO INVENTED IN LIFI MUCH BEFORE ITS PUBLIC DISCLOSURE?

Whenever someone discusses Li-Fi, [the TED talk of Prof Harald Hass](#), the father of LiFi, hits the mind automatically. In Aug 2011, Prof Haas disclosed LiFi technology in public for the first time. Later on in 2013, his company Pure LiFi became the first company to manufacture a LiFi based product.

Does only Prof Haas or the Edinburgh University, was working on the technology before its first public disclosure in 2011? Read on to find the answer.

**“ The Li-Fi is more than a decade old technology.**



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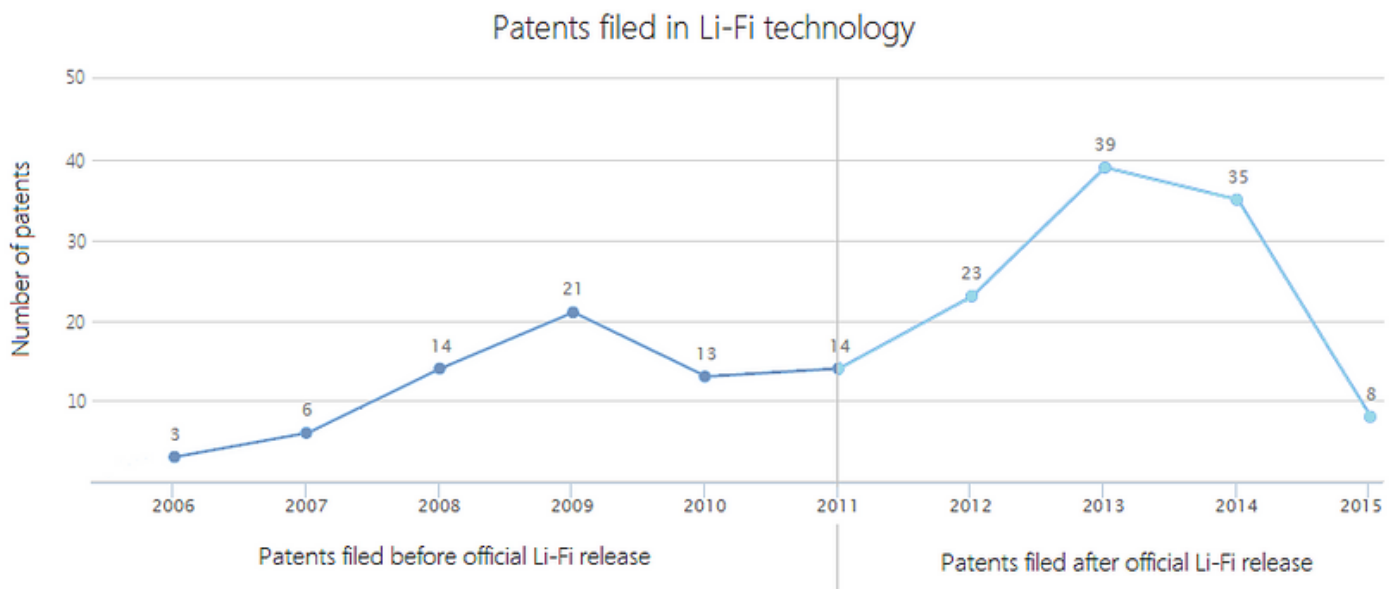


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# WHO WAS WORKING ON THE LIFI TECHNOLOGY BEFORE 2011?

To find the answer, I divided the patent data set into two parts. In the first part lies all of the patents filed after 2011 and the second part contains patents filed before Aug 2011.

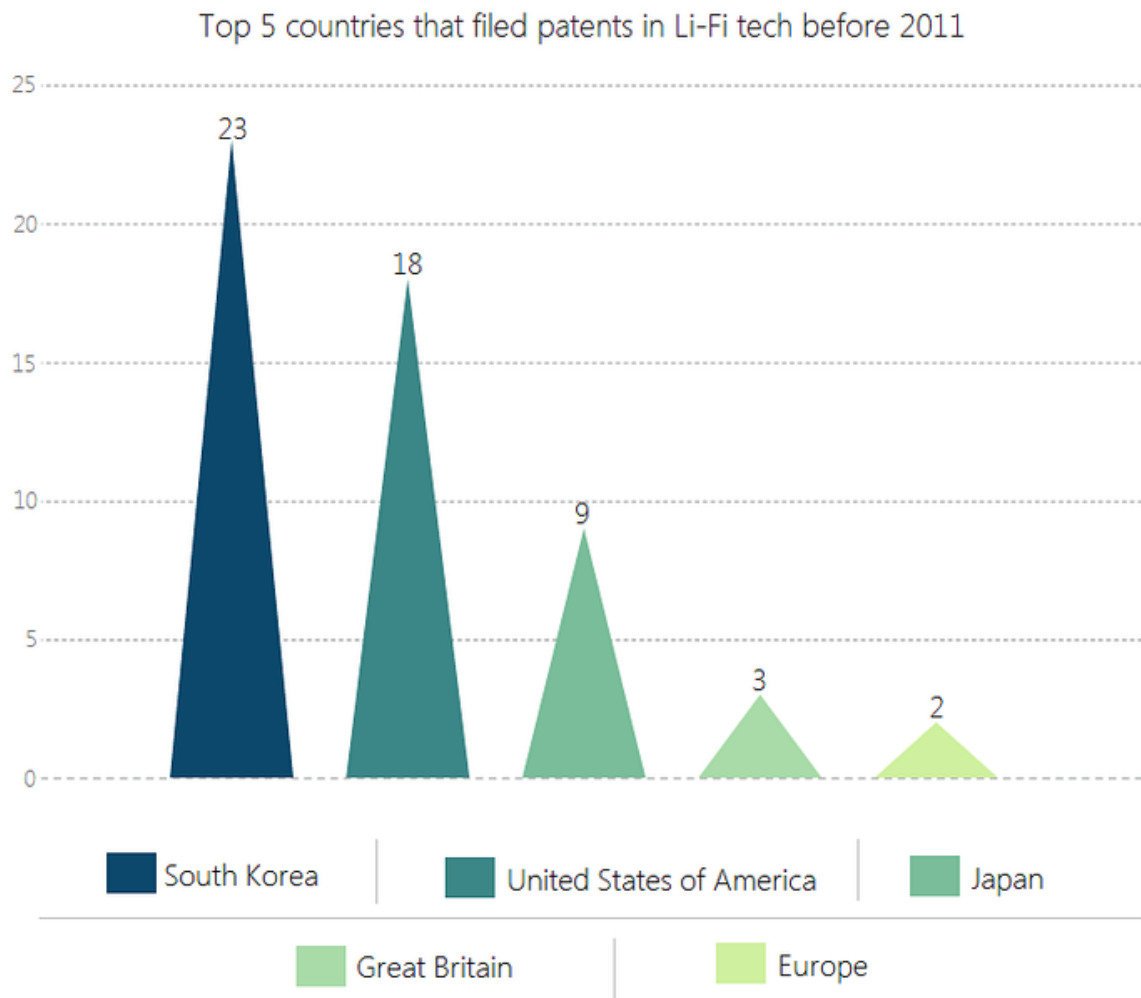
I analyzed the second part of the dataset which has patents filed for LiFi technologies way back from 2006. The patent filing trend below gives detail of the number of patents filed every year.



It seems pretty clear now that research in LiFi started back in 2006, 5 years before its actual release. Nearly 33% of total patents on Li-Fi technologies were filed before 2011. This indicates that research on LiFi started almost a decade ago.

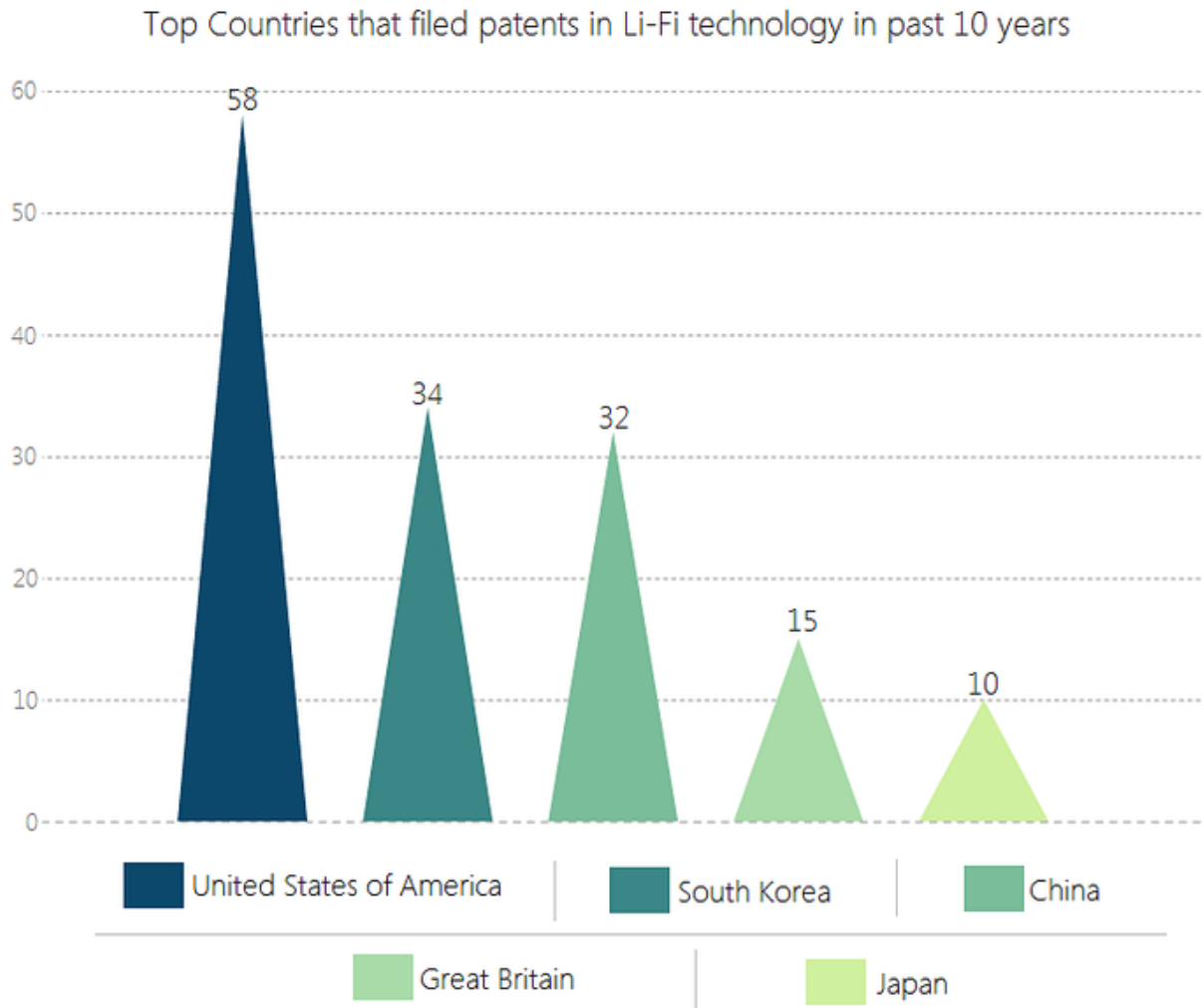
# TOP COUNTRIES INVOLVED IN LIFI RESEARCH BEFORE 2011

After analyzing the second dataset, I was able to find the top five countries that were actively researching in the LiFi domain. The chart below represents their patent filing.



South Korea with 23 patents is at the top spot because Samsung and ETRI were the early adopters of the technology and have been exploring the domain since 2007. The USA with 18 patents is at #2 spot followed by Japan where 9 patents were filed in LiFi technologies. Great Britain, where Prof. Haas' University is located, filed 3 patents and sits at the #4 position.

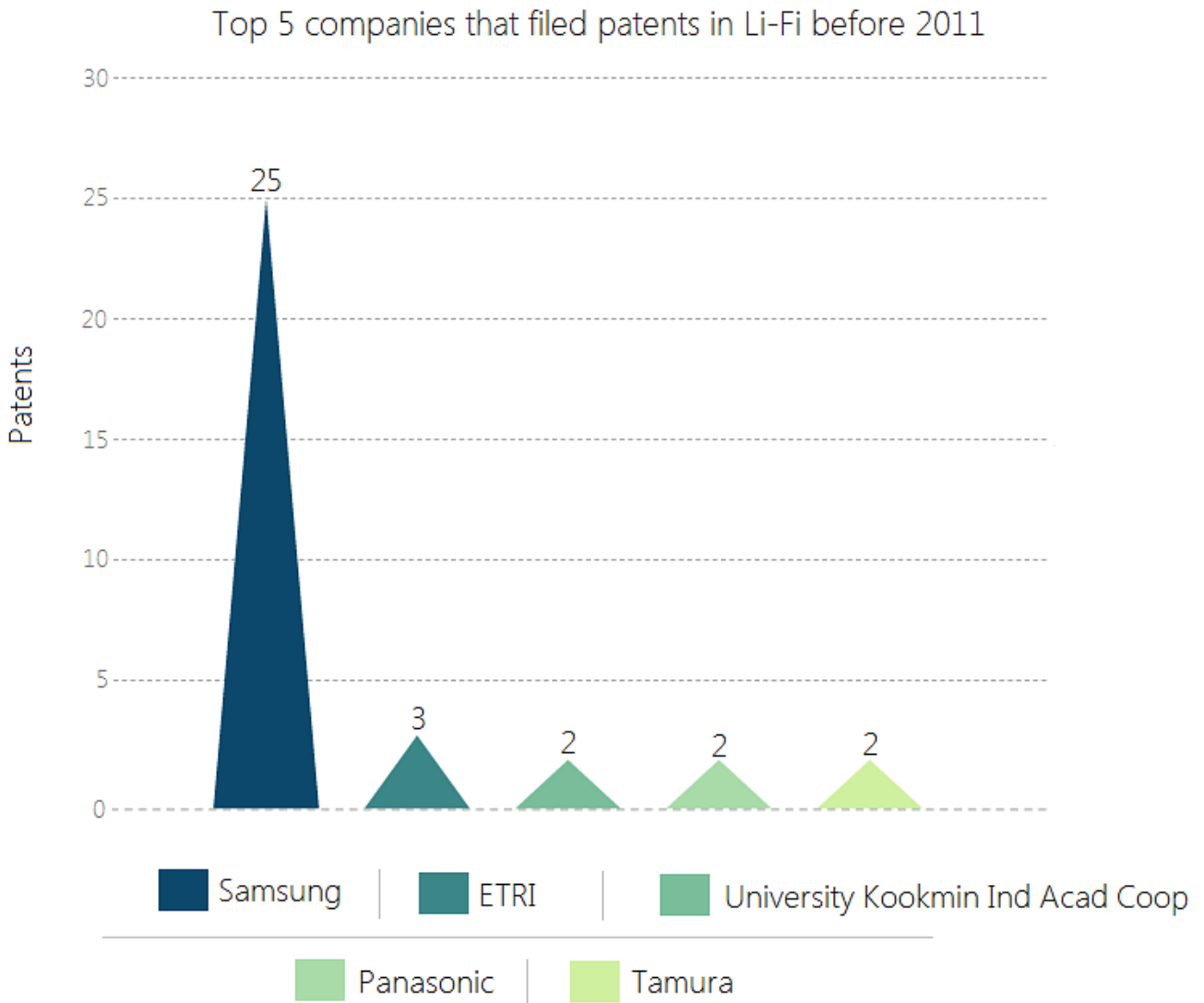
But the picture changes when we consider the overall patent filing in the last decade.



The USA with 58 patents tops the list and leaves South Korea behind which is now at the second spot. We can also see China joining the top league and is at the 3rd place. The graph above witnesses how innovation in LiFi got accelerated after 2011 and changed the tech landscape completely in just five years.

# THE TOP 5 COMPANIES THAT ARE EARLY ADOPTER OF LIFI TECHNOLOGIES

The graph below provides detail of the top five companies that are early adopters of the LiFi domain.



Samsung, with 25 patents, tops the list and leaves others behind by a great margin. It filed its first patent on LiFi technology in 2007. Its first three patents were on the basic working of LiFi equipment. These patents disclose how communication using an LED bulb is possible.

The first thing that surprised me a lot is finding the University of Edinburgh, where Prof Haas conducted research on LiFi, not making a place in top the five. The Second surprising thing was the first ever patent on LiFi technology which was filed by Huawei in 2006.

There are total 3 patents filed in 2006 out of which, one if filed by Huawei, second is filed by Panasonic and the third one is the result of collaboration between Elta System and Optigo.

After 2006, the research in LiFi accelerated with every year which is quite evident from the increasing in the patent filing. This happened because many other research institutes started pushing the envelope ahead. ETRI was one among them. It filed its first Li-Fi patent in 2007, then after a hiatus of three years, it resumed filing from 2010.

## **THE TOP FIVE EARLY INVENTORS OF LIFI BEFORE 2011**

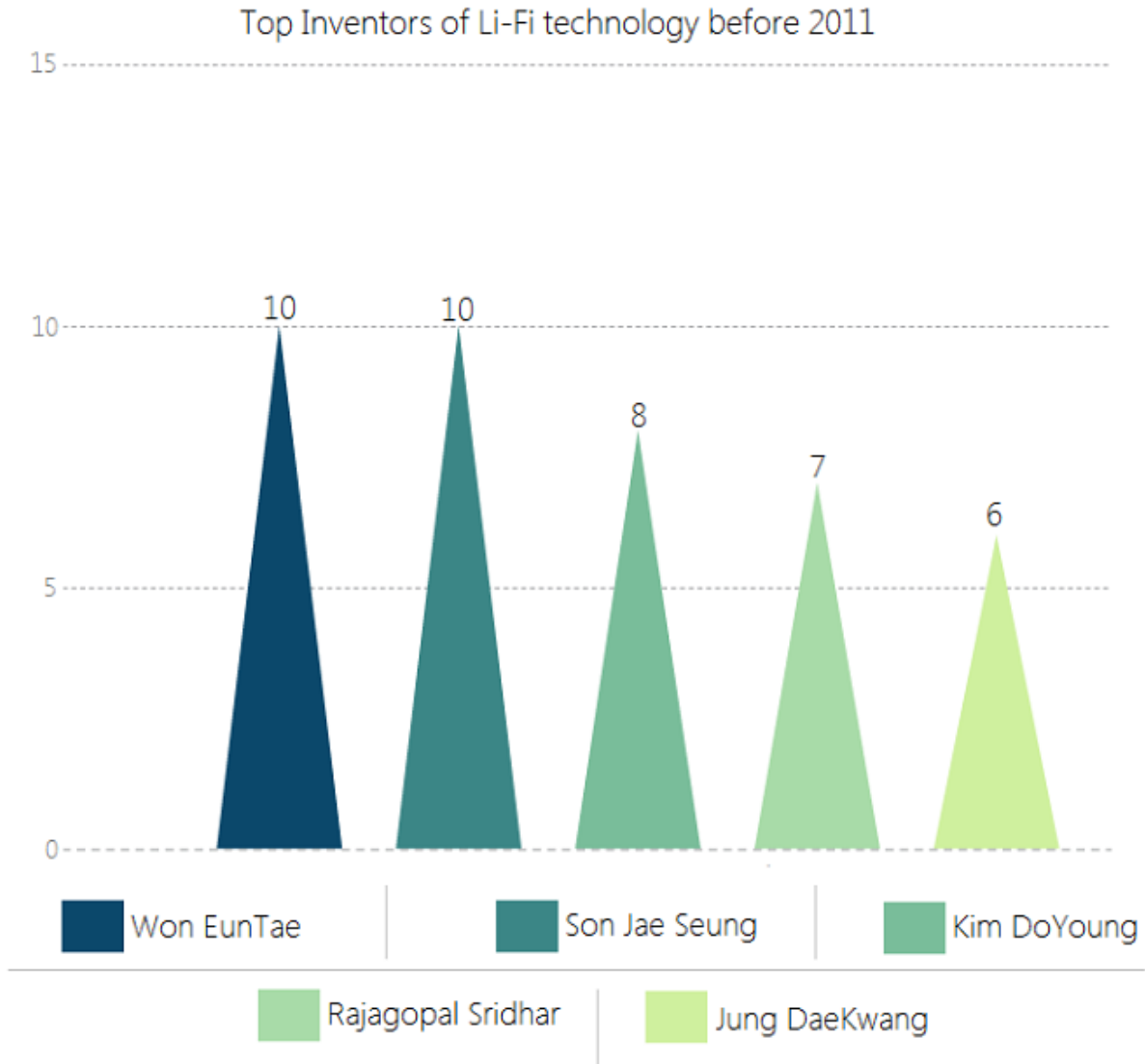
Like top companies/institutes, the list of top five inventors came as a surprise, too. All of the top five inventors were from Samsung.

### **Download Also:**

#### **Top Patent Prosecution Firms of Germany**

Where there are patent filings, there are law firms and attorneys involved. We conducted a patent landscape study to find what they are up to and how the state of patent prosecution looks like in Germany.





If we look at before 2011 stats, Prof Haas name didn't show up in the top five and he is at the 6th spot. This indicates that Professor chose to publish research papers instead of filing patents. The father of LiFi, for example, published his first research paper on LiFi – [First paper on practical OFDM implementation for VLC](#) – early in 2006.

If we look at the total patents filed during 2006-15, Prof. Haas makes in the top five and is the top 3rd prolific inventor filing patents. Son Jae Seung of Samsung managed to clinch the top spot.

THANKS FOR READING



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