LiFi

COMMUNICATION AT THE SPEED OF LIGHT AND THE EMERGENCE OF THE INTERNET OF PEOPLE

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GUNTER PAULI
WITH JURRIAAN KAMP

PROPOSED AS A REPORT TO THE CLUB OF ROME

Praise For The Book

"Congratulations: This books offers a solid base to popularize LiFi and the grand opportunities it offers to society."

—Prof. Dr. Suat Topsu, inventor of LiFi (France)

"LiFi, the exciting technology breakthrough that promises to light the way to a whole new global future, is about to create unimaginable opportunities. Finally we see a chance to bridge the digital gap between the North and the South."

—Ashok Khosla (India) Chairman Development Alternatives and Former Chair of the International Union for the Conservation of Nature

"Deploying LiFi at wide scale worldwide will be yet another a dream come true for humanity; and not the first one to be implemented soon thanks to these brilliant minds."

—Dr. Mariana Bozesan, Ph.D., Dipl.-Inform. (Germany)
AQAL Capital GmbH, Founder & Managing Director
Author of "The Making of a Consciousness Leader in Business"

"In the beginning there was light, LiFI challenges us to return to the beginning and leverage the power of light to sustain our connectivity!"

—Mamphele Ramphela (South Africa)
Former Managing Director of the World Bank,
Former Vice-Chancellor of the University of Cape Town

"When data transmission is no more by radio waves but over light, then we will massively save energy. LiFi presented in this book offers us the starting point to move from the present into the future where we can care for our common house while being connected."

—Rabino Sergio Bergman, Federal Minister of Environment and Sustainable Development of Argentina

"LiFi is big step ahead and opportunity to turn smarter and more efficient our sites and share a unique experience with our sport lovers & users."

—Olivier Colloc-Domancy (France)
Director of Research and Development of Decathlon Mountain Store & Sports

"At last, LiFi is becoming reality. We constantly seem to choose the wrong guy. Tesla would Have been a better choice than Edison now we have a chance to make the right choice. LiFi as described by Gunter is the future."

—John Hardy , Founder of the Green School (Bali)

"This book brings a sensational message. Through LIFi it seems possible to secure connectivity through light and thereby significantly reduce energy consumption, eliminate the risk of hacking and limit the power of large companies when it comes to who owns our data."

—The Rt. Hon Anders Wijkman (Sweden)
Co-President of the Club of Rome
Chairman of Climate - KIC

"LiFi is a game-changer: it will humanize the Internet."

—Carlos Moreira , Founder and CEO of WiseKey (Switzerland)

"LiFi presents a great opportunity to speedily and sustainably connect everyone in the developing countries, giving them access to customised information that they require to actively engage in changing their circumstances and bridge the gap that exists today."

—Chido Govera, Founder and Director of the
Future of Hope Foundation (Zimbabwe)

"Gunter Pauli, once again, brings transformative technologies to light, literally. For the Pacific Islands, LiFi has the potential to be a revolution to poor connectivity and providing access to Internet to all, while drastically reducing the costs, health risk and islands carbon footprint. LiFi, in the age of the Paris Agreement, must become the way of the future."

—François Martel, Secretary General
Pacific Islands Development Forum (Fiji)

"LiFi will contribute to make Internet serve humanity and the common good through faster, safer and healthier communications thanks to light."

—Christopher Wasserman, President Terolab Surface group
Founder Zermatt Summit

"Gunter Pauli has been one of the most influential system-entrepreneurs and positive social impact change makers in this century. His immense innovative knowledge, perseverance and creativity brings about the most positive disruptive project that exist today: LiFi."

—Laura Koch (USA) , Chair, Young Presidents Organization (YPO)
Social Impact Networks Council
—Jan-Olaf Willums, Founder of TINK

"Gunter's reflection on LiFi brings a new dimension to local action. Only innovative solutions can respond to the great challenges we face in the 21st century: finding the balance between jobs, environment and the wellbeing of citizens. The City of Roubaix is committed to pioneer to ensure we are part of the economy of tomorrow."

—Mayor of Roubaix, France

"Trust Gunter Pauli to not be satisfied with the status quo, and to always strive for better. LiFi is much faster and more accurate than WiFi, and uses existing infrastructure (public lighting networks) – opening up a range of new opportunities, of which we've only just scratched the surface. The future is bright, and it's coming to us, quite literally, at the speed of light!"

—Dr Vanessa Tamms
The University of Adelaide (Australia)

"Let there be light: the easiest way to connect people to each other. We can use a simple light ray to access a world of knowledge and sharing."

—Joel Glusman
CEO The Crystal Group (France)

"LiFi is a very innovative technology. It will create a new horizon of communication. Business and society should take note!"

—Yusuke Saraya
President Saraya Co., LTD (Japan)

Also by Gunter Pauli

Crusader for the Future: A Portrait of Aurelio Peccei, Founder of the Club of Rome (Pergamon Press, 1987)

Steering Business Toward Sustainability, edited with Fritjof Capra (United Nations University Press, 1995)

Breakthroughs: What Business can Offer Society (1997, Greenleaf Press)

Upsizing: The Road to Zero Emissions (1999, Riemann Verlag)

Out of the Box: 21 ways to be creative and innovative at work (2001)

Zen and the Art of Blue (Commonwealth Press, 2004)

The Blue Economy (USA, Paradigm Press, 2010)

The Blue Economy 2.0 (India, Academic Press, 2014)

The Blue Economy 3.0 (Australia, iXlibris, 2017)

The Third Dimension: 3D Farming and 11 More Unstoppable Trends that are Revolutionizing the Production of Food and Fuel, Regenerating Nature, and Rebuilding Communities (USA, JJK Books) www.jjkbooks.com

Plan A: The Transformation of Argentina's Economy www.jjkbooks.com

For more information consult

www.TheBlueEconomy.org
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For ordering fables by the same author
www.The FableShop.com

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Library of Congress Cataloging-in-Publication Data
Special PDF Edition ISBN 978-1-387-57453-7
Interior design: Rick Greer
Production service: Rick Greer

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LiFi

Thank you!

This book was never possible without the profound inspiration and guidance of Suat Topsu, the inventor of Visual Light Communication which was later translated into LiFi. We logged dozens of meetings, travels to the Far East, Latin America and across Europe to discover the potential and harness the opportunities.

Stan Shih, the founder of ACER and today the President of ID Capital, offered a strong encouragement introducing me to the Mayors of key cities, especially Taipei, the host of the Smart City Summit in 2019. When he labelled LiFi as the future, the message was clear.

Christopher Wasserman, entrepreneur and businessman, but pioneer of the Zermatt Summit and promoter of a strategy to humanize capitalism provided an outstanding platform for debate, exposing entrepreneurs and philosophers alike to grasp the potential of this breakthrough.

Mariana Bozesan, leading Europe's foremost ethical investment fund, secured the testing ground for LiFi among the angel investors of this world. That face to face with hard-nosed capital that wishes to do good, pushed us to crystallize the concepts and

the strategies in fewer words. Hence, the brevity of this book. It is to the point.

Parks Tau, the Executive Mayor of Johannesburg, for being the first mayor to fully support the introduction of LiFi, in spite of all internal opposition. And, Guillaume Delbar, the Mayor of Roubaix (France) who was the first to commit the implementation of a LiFi strategy for a city, was immediately ready to share with 6 other mayors in the North of France, a true leader focusing on getting the Internet for People in place.

Kirsten Dunlop, the CEO of Climate KIC who was keen from the first moment to engage with cities to turn this LiFi into a plan of action, finally going beyond promises and empty agreements, but clearly focusing on moving science, politics and communities in the right direction: dramatic reduction of emissions, healthy living environment and quality of democracy.

Chido Govera, the founder of the Future of Hope undertaking community work in Zimbabwe, offering a livelihood to orphan girls to reflect on the impact this technology should have on the communities of the Third World where Internet remains a luxury for a few.

Jean-François Garrec, the President of the Chamber of Commerce and Industry of Brittany, for setting up the first training programs on LiFi, demonstrating his pioneering and entrepreneurial role. And Didier Kling, the President of the Chamber of Commerce of Paris for offering a legitimacy for this technology that paved the way for many others to follow.

Shuji Nakamura, inventor of LED, and Nobel laureate, for the constructive discussions and the enthusiastic response. Tamio Ishibashi, the Executive Vice President of Daiwa House and an

early supporter of taking this innovative technology mainstream. Frans Otten, the great-grandson of the founder of Philips, for introducing me to the new science of the eye, light and business according to the new rules of the game.

A special thanks to Mr. CHONG Chan-yau, the President of Hong Kong Blind Union (HKBU), the first self-help organization of people with disability in Hong Kong who helped me understand the challenges faces by the visually impaired people and what they expect from innovations like LiFi. I thought I knew about the plight of the blind, but he put it in simple clear and unequivocal terms.

Of course, the book would not have come to fruition without the hands on support of Jurriaan Kamp who edited the rich content into a snappy book that has no other purpose than to offer a first insight into a platform technology that has the potential to change the quality of life.

To all member of my team including Charles van der Haegen, Patrick VanLeynseele, Yasmina Dahim, Nicolas de Quatrebarbes, François Nolet and many more that are not mentioned but important - thank you!

LiFi

Foreword

Pioneering communication

On April 7, 1997 Fritjof Capra and I presented our book "Steering Business Towards Sustainability" published by the United University Press per video over broadband internet connecting San Francisco with Tokyo. We were keen on demonstrating that the revolution of the Internet would transform us from citizens to netizens. The book presentation put us down in the history books of the Internet. We consumed 50 percent of the available bandwidth between Japan and the United States. Internet nerds at the time were wondering who were these pretenders pioneering the Cu-SeeMe technology developed by researchers at Cornell University with two powerful Solaris 2 computers purchased from Sun Microsystems. Bill Gates presented his book over the same channel eleven months later.

The experience emboldened Kazuhiko Nishi, the founder of ASCII and a first day partner of Bill Gates from Microsoft, and myself to take the two way experience to the next level. We decided to organize the first Global Conference on Broadband video internet connecting Nelson Mandela in Pretoria, Jimmy Carter in Atlanta, Shimon Perez in Jesusalem and a gathering of 12 Nobel laureates in Hiroshima under the leadership of Elie

Wiesel and coordinated by Ted Koppel, the anchor of ABC News. The first global gathering took place on December 5, 1995 and was reported on the front page of The New York Times.

From that early moment, I have witnessed the Internet revolution boom with great interest. However, my primary focus was on the fast track implementation of projects that provide water, food, health, housing, energy and jobs to the people and communities that needed it. I wanted to ensure that people who have hunger and suffer from diseases had a relief that was faster than the connectivity of the Internet. I was traveling the world, learning the science, funding the projects, monitoring the developments, ensuring that we finally reach the unreached. We were regenerating a rainforest in Colombia, farming mushrooms on coffee in Zimbabwe and Serbia emerging from civil wars, and we were learning about producing paper from crushed rocks. The Internet was nothing more than a tool.

That changed in 2007, when I learned during a visit to the Industrial Technology Research Institute in Taipei about the revolutionary technology of transmission of data and video with light. While the Taiwanese admitted it was not their invention, their reception hall showed this high definition video film projected on a screen without any wires … the transmission was secured through light. I was fascinated. As an ecologist I had followed the invention of LED lighting with great interest because it cuts the energy consumption of the incandescent light by 90 percent and the compact fluorescent lamp by 40 percent. I had also seen the projections of sales of LED explode thanks to the industrialization of Dr. Shuji Nakakura's invention of blocking blue light with phosphor to create white light, by leading global players as

Toshiba, Nichia, Panasonic, Samsung, Kingsun, Solstice, and Hoyol.

I realized that if we could combine this energy and light revolution with the transmission of data at the speed of light, we were looking at a disruptive technology that could serve the interests of billions of people around the world. I started dreaming: every light bulb could be converted into a high speed internet router? Soon it was clear that I had to go beyond my dream. There was better hiding under the logic of digital transmission at the speed of light.

I spoke about this revolutionary breakthrough at the Entrepreneur Summit in Berlin in 2014 where more than 2,000 eager business creators and angels had requested me to lay out the greenest innovations. I mentioned Light over the Internet. After my talk, I was approached by a representative of the French start-up Thomson Light that had decided to take visual light communication commercial and already had a catalogue with ready to order products. Soon, it became clear to me that these light bulb producers were dependent on the cutting-edge technology of Suat Topsu, professor at the University of Versailles, the founder and chairman of a French start-up company Oledcomm. As it turned out, Suat Topsu was the inventor of visual light communication using LED. He had avoided the lime light for nearly a decade focusing instead on solidifying the science behind this breakthrough, and building up hands-on experiences with cities, hospitals and companies.

When I connected with Suat Topsu, I began to see that this new technology followed the core principles of "The Blue Economy" which I had described in my Report to the Club of Rome in

2009. This economic development model proposes that (1) we use what we have, (2) we generate more value and do not focus blindly on cost, and (3) we have to respond to the basic needs of all. So, yes, light we have, and the wires to bring the power to the lamps have already been installed. And, if we can indeed create communications at the speed of light—and if time is money—then we can create an incredible amount of additional value.

Suat pushed my dreams further than I could ever imagine. He demonstrated convincingly that a simple streetlight or a lamp in the office now has the power to convert into a "satellite"—just as the processing capacity of an average car today is the multiple of the computing capacity needed to bring the first man to the moon in 1968. If we can communicate using light that is nearly everywhere, we can re-imagine hundreds perhaps even thousands of solutions for urgent societal needs. LiFi urgently deserves to become a new platform for technological, social and economic breakthroughs. It has the potential, it is missing … awareness. The world of technology and society at large are still amazingly ignorant about the opportunity and those who know have tiny pieces of information that offer no insight in the potential. We are so often missing a vision.

That is why this book—true to its message—was written at the speed of light. A cloud of ignorance blinded by routers, GPS technology and the promise of the coming 5G standard, has to be lifted fast to fully realize the potential of online communication for the benefit of humankind. We are fast approaching a dead-end in the world of computers and communications as we know it. There is the advent of LiFi and LED lamps. There is a breakthrough opportunity to transform the Internet beyond what

we have imagined to date. It provides a unique chance to even to get our democracy back.

Perhaps the most critical contribution that LiFi offers, is that it allows to shift from the race to bring "big data" under the control of a handful in an "Internet of Things" to design the "Internet of People", a network for the common good that serves the needs of all. Somehow, the Internet of Things has always seemed a poor perspective for the future. Technology—created by people—clearly, is meant to serve the needs of people, not of things. As we will show in this book LiFi is a tool to strengthen democracy and redistribute power—at the speed of light!

Join me in this quest to transform society. It is easier than we think.

—Gunter Pauli
Zoersel (Belgium) 5 February 2018

LiFi

Chapter 1

Seeing the light

Perhaps the LiFi revolution would have never started if Suat Topsu had not listened to his wife.

Since 2005, as a young academic researcher at the University of Versailles, Topsu had been involved with autonomous vehicle experiments using the LED lights of the cars for inter-vehicle communication. He knows that cars could be made to talk to each other only using headlamps and brake lights. His focus was clear: cars. But then, in 2009, he had had been appointed as a Professor of quantum physics, and his wife was pregnant with their third child, the French television aired a documentary on the dangers of radio waves. In response, Sara Topsu, decided to switch off the WiFi in their home, "It was a drama for me", recalls Suat Topsu, "I needed to work on my computer every day".

Initially, Suat tried to convince his wife that radio waves were not dangerous, as the documentary had argued. He studied a report of the World Health Organization (WHO) based on thousands of scientific studies on the effects of radio waves on living organisms. Unfortunately, the report stated that pregnant women were particularly susceptible to prolonged exposure to radio waves. Sara was not amused: "You're a researcher, find another solution".

Installing cables everywhere in their home, seemed a complex, expensive and time-consuming solution. So, Suat went to his lab and returned to his autonomous car research. His scientific mind was triggered: Why wasn't there a better way of communication with no health risks at all? The next day in his office he dove into the history of communication. Of course, he knew that Graham Bell had invented the telephone. Not so well-known is that Bell also invented a "photophone". In fact, Bell himself believed that the photophone was his most important invention ever. Of the 18 patents granted in his name, four were for the photophone.

The photophone was similar to a telephone, except that it used modulated light instead of modulated electricity as a means of wireless transmission of sound. On April 1, 1880 Bell communicated with a collaborator over some 80 meters. A few months later, they bridged a distance of more than 200 meters using plain sunlight as their light source. Bell used a system that was developed four decades earlier by Samuel Morse. Morse had demonstrated that it was possible to communicate over vast distances with light signals. By turning lights on and off messages could be communicated, through the "Morse code", to a distant observer. Bell had succeeded in adding an audio channel to the Morse system. Shortly before his death in 1922 Bell said in an interview that the photophone was "the greatest invention I have ever made, greater than the telephone". However, he never succeeded in realizing his dream to replace the mess of telephone wires along city boulevards. His design failed to protect the transmission from clouds, fog, rain and snow.

That next day in 2009, Suat Topsu realized that he could do now what Bell couldn't do in his day. Sunlight was not a reliable source for communication. Clouds would interfere and there would be no

communication at night. When Bell introduced his photophone, electrical light had only been just been introduced in the United States. But that light was not strong enough to transmit information—it wouldn't flicker fast enough. The finger of a human being could tap the Morse code much faster than a light could be switched on and off. Moreover, the flickering dramatically shortened the lifespan of the lamp and it dissipated more heat than light. That's why the telephone beat the photophone, and electricity and radio waves became the channels for communication for the next 100 years.

Meanwhile, light innovation continued as well. Two technological breakthroughs brought the perspective of the photophone back. First the invention of fiber optics by Corning Glass researchers Robert Maurer, Donald Keck, and Peter Schultz. Fiber optics can carry 65,000 times more information than copper wires. The second invention was LED (light-emitting diodes) that started in the early 1960s. The first LEDs were low-powered and only produced light in the low, red frequencies of the spectrum. The first high-brightness blue LED was demonstrated in 1994 by Dr. Shuji Nakamura, engineering professor at the University of California, Santa Barbara. The blue LEDs led to the development of the first 'white LED', which employed a phosphor coating to partially convert the emitted blue light to red and green frequencies creating a light that appears white. Nakamura, with Isamu Akasaki and Hiroshi Amano, was awarded the 2014 Nobel prize in physics for the invention of the blue LED.

LED light was the first light that didn't generate heat and therefore didn't consume a lot of energy that was wasted. It was cold light produced by a microprocessor—and that processor can make the light flicker at a speed invisible to the human eye without the need

for operating the on and off switch. Suat Topsu realized that he could take photonic communications to a new level and that "visible light communication" was a logical next step to add to the works of Morse, Bell and Nakamura. It was possible to multiply the speed of the blinking of light to 100 million times per second (100 MHz) and enormous amounts of information could be transmitted at the speed of light invisible to the human eye. It would solve the problem of his wife… Soon he succeeded in increasing the flickering to one billion times. Suat not only realized he observed the emergence of a new information transmission platform, he knew that this could one day change the way we connect to Internet.

However, before his invention was ready for widespread acceptance he needed a bit more help. That came from Professor Harald Haas, chair of the mobile communications department at the University of Edinburgh. In his research Haas became aware of the work of Topsu and he immediately saw the far-reaching potential. In 2011, Haas gave the TED talk 'Wireless data from every light bulb' presenting the future of optical wireless communications and he introduced the brilliant term "LiFi". Subsequently, LiFi was listed among the 50 best inventions in TIME Magazine in 2011, six years after it was invented.

In the past years, Suat Topsu and his company Oledcomm have introduced LiFi in museums across Europe, starting with the first one in Liège (Belgium), the metro of Paris, in a hospital in Perpignan and they have done experiments in businesses like supermarkets. The new French president Emmanuel Macron has embraced the technology as a spearhead of France's innovation. He was already convinced as Minister of Economics and presented the innovation as a breakthrough at the annual meeting of the World Economic

Forum in Davos in 2015. The world looked at it with unbelieving eyes. A French company and a French Minister could not be taken serious trying to change the world of Internet! The high profile presentation got buried in other more important mundane news.

Yet, today still very few people have heard of LiFi. Inventions take time to land and whenever there is breakthrough at hand that requires a fundamental shift, it will face ignorance and disbelief more than technical, marketing and legal obstacles. The story of Wi-Fi provides an interesting parallel. The radio wave based technology was invented in the early 1990s but would muddle through with limited applications for over a decade. It would take the arrival of the smart phone in 2007 for WiFi to become the communication it is today. The first generation of mobile phones didn't need WiFi since the service providers of the telecommunications contract had enough bandwidth to offer. However, the smart phone did. The capacity of transmission soon hit the wall for 3G and even 4G and the only way the users could enjoy the full potential of their expensive smart phones was the additional connectivity over WiFi to download audio and video, or play live games. Similarly, LiFi will only be used when there's a need for it. And that need is rapidly arising. Faster than we think even with the arrival of 5G in 2020.

We are entering a new era what has been coined as the "Internet of Things" and all information will be stored in "The Cloud", not on your computer. Today, most communication is still between people. People talking to each other on the phone. People are sending texts, emails and audio messages to other people. However, the communication is increasingly including all kinds of sensing and messaging with smart devices. It's estimated that a person in the industrialized world will own an average of 7 connected devices

in 2025. Most of us will have a computer, a cell phone, a camera, a smart fridge, intelligent keys, intelligent heating and cooling systems, security devices etc. Using artificial intelligence (AI), all these devices will talk to each other, receive instructions and act on the basis of an analysis of the information. That is "the Internet of Things". In your car, you will find a message that there's no more milk in your fridge. On your phone, you turn the heat off in your apartment when you leave the garage confirming your departure from home. The coffee machine will start roasting and brewing according to your preferences while you are in the shower. And we are not even talking about the millions of self-driving cars Google is proposing that will find their ways through constant communication over mobile networks. All that communication requires bandwidth. There are simply not enough frequencies below 10GHz—the spectrum used for all civil communication—to enable all this data traffic.

The 5G cellphone network, that has been in development for over a decade, promises broader bandwidths and faster speeds by 2020. It promises to take the present overloaded and clogged system that operates maximum at 100 Mbits per second to a new online universe at 1 Gigabit per second. An improvement of a factor 10 at the cost of billions of dollars, the installation of thousands of new antennas, and a massive increase of the radiowave exposure. However, some experts predict that the 5G network will already be saturated by 2022, two years after it will be launched. The industry claims this is not true, however why lose time defending the present technology that still has to be introduced to the market, why not embrace a complementary innovation that changes the rules of the game?

We need communication to push innovation to solve the challenges people and planet face. It doesn't make sense that necessary innovation is needlessly obstructed by technology. As the laws of physics tell us nothing moves faster than light. So, it adds up to organize innovation in an environment steered as much as possible by the speed of light.

Today, the fastest Internet wireless connection is about 100 megabits/second. We only need to look at the television or live Internet video to realize how frustrating it is that sound travels not as fast as light—someone's mouth is moving a split second before we hear the voice. It is impossible to play interactive video games in 3D because current Internet speeds are too low. Scientists in China have shown that LiFi can provide 252 gigabits/second. That is 2,500 times faster than the best today, and 250 times better than 5G. Light-based Internet, fiber optic networks combined with LiFi—will open door to a whole new dimension of content opportunities, and innovation.

Light, including the ultraviolet and infrared light that we cannot see, offers a very wide spectrum of frequencies. There are a few thousand frequencies available for radio based communication. As a result, even when there are only three or four licenses per country, today regularly several operators use the same frequencies. That means that the baby phone in your home could disturb the wireless phone of your neighbour. Providers try to overcome these problems with stronger signals which only invite other stronger, more energy-intensive signals leading to a cacophony and a waste of energy. The full spectrum of light, on the other hand, offers a billion frequencies. That basically means one specific frequency for each 8 people in the world. In other words: there are no limitations

and we are not going to run out of capacity if we begin using light-based communication. That is simple physics. It is even better. Radio communications are very tightly regulated. Communications of light is totally unregulated.

The laws of physics also guide the concept of triangulation that is used to determine a single point in space with the convergence of measurements taken from two other distinct points. Triangulation is the geometrical logic behind modern satellite-based Global Positioning System (GPS) location technology. We use more and more satellites in outer space to direct and navigate processes on Earth. The Internet of Things is increasingly dependent on GPS and Google will only be able to enhance its services when you disclose exactly where you are located. However, the system is hardly precise. Everyone, who uses a phone to find an exact location, knows that GPS can easily be some 10 meters or more off. That may not matter when you drive from the airport to the city, or you try to find a restaurant in a street ten blocks from your hotel; it becomes a matter of life and death in the case of self-driving cars which have to move forward in narrow lanes that are only a few meters wide, or the use of robots in surgery. We need more precise location services than GPS technology can provide. LiFi enables the necessary precision as we shall see in this book.

There is more. There are many important places where WiFi does not work. It does not work under the ground, in mines, or in tunnels. It also does not work when there's a lot of metal. The port of Antwerp in Belgium is the second busiest container terminal in Europe and processes some 10 million containers each year. The port has 2,400 kilometers of railways and two service centers that are connecting some 4,000 kilometers of fiber optic cables to run

the complex logistics. The port of Antwerp with all its industries, transportation and datacenters use 10 percent of the energy of Belgium. However, the extensive intranet of the port cannot use WiFi. Wireless communication does not work because the metal of the containers and the hangars, combined with railroad tracks, high voltage power lines and industrial complexes, causes too much interference. That means that QR codes of the containers can only be scanned with devices that are directly wired to the cables of the intranet. The headquarters of the Port of Antwerp, the emblematic last building designed by architect Zaha Hadid, is suffering from WiFi connectivity as well. Since the architect wanted to preserve the look and feel of the building in and outside, all the WiFi routers had to be placed in the floor. A building that is constructed with a complex mesh to stainless steel is most impressive to look at but most problematic to communicate from.

It goes without saying that the efficiency of one of the most modern container ports in the world would be tremendously served with a wireless communications system based on LiFi. As we shall see in this book, LiFi can vastly improve communications in parts of the economy that today cannot be served by WiFi. The fact that the Port has the lights on day and night, operates 24 hours a day all year round makes this the ideal LiFi site.

Finally, we need to go back to Sara Topsu who delivered a healthy third child to the Topsu family in 2009. As the cells in our bodies communicate through frequencies as well, there is no doubt that radio waves have an impact on our health. The question is how big that impact is? There is a lot of research and the results are not yet completely and convincingly clear for everyone, certainly not for the industry that is ready to defend its billions of dollars in

investments. But we do know that the World Health Organization (WHO) recommends a maximum exposure to radio wave frequency intensity below 620 milliVolts per meter. That limit was the result of substantial experts' consultation and there appears to be quite a clear scientific consensus about that level. In many places—hospitals, aircrafts—the exposure vastly exceeds the advised WHO norm.

It is tempting to draw a comparison with the tobacco industry of some 40 years ago. At that time people knew that smoking was bad for you. The question was: how bad? With the impact of radio waves, we find ourselves in a very similar situation. The millennials are the first generation that has grown up amidst today's intensity of radio wave exposure. Do we want to wait until we know in the coming decades what the impact of that exposure has been? Do we want to follow the traditional principle that one is not guilty until proven otherwise and that we should continue using something until it is proven that it is harmful? Or do we want to follow the principle of precaution and act like armies that are always preparing for a possible attack? Given that our health is at stake, the choice seems to be an easy one. Ask any mother or expecting mother and listen for a moment. Science needs time to make a unequivocal statement, society needs the layman's logic that it is better to be safe than to be sorry.

Sara Topsu made a choice that resonates with many of her peers. In return, she got more than protection of the health of her baby, she also got an even better and faster Internet connection at her home.

LiFi

Chapter 2

Let there be light

Light is the beginning of our existence. Without light, there is no life. Genesis is clear:'And God said: "Let there be light"'. These are the first words ever spoken by God! And it did not state let there be sun; the word light is explicitly chosen. It took the Cambrian Explosion, 541 million years to develop sight and ever since the challenge has been to have light so that we could see where we were, how we could protect ourselves and what we would like to eat, and who is there that wants to eat us. For the first time we could appreciate color, and produce pigments and light refraction in order to have desirable effects like blending into the environment or imitating a predator. Society transformed, not by volcanic eruptions or meteorite impact, but by the symbiosis of light sensing bacteria that put light sensitive rods and cones together connected to our brain. We never looked at reality with the same eyes again.

Then, some 400,000 years ago, we discovered how we could make fire so that we could even see at night. The next major breakthrough occurred in the 19th century when several inventors succeeded in capturing "fire" in a glass container: the light bulb. Thomas Edison subsequently succeeded in bringing this

innovation to mass production. He is recognized as the inventor of electricity and lamps even though he did not event it, rather he stood on the shoulders of dozens of creative minds and succeeded in taking this source of light at will to the mass market.

The light bulb changed the world. But it was only the beginning of a revolution that is still gathering speed. It took nearly a century to come to terms with the fact that a lot of energy was spent on the creation of heat and light, and we only valued the lumen, and wasted the heat. Then came the first oil crisis in 1972. It was a shock to wake up and realize the inefficiencies embedded in our light system. This triggered a new search for improvements. In the 1980s fluorescent light began replacing the old-fashioned light bulb and about 80 percent energy was saved. It had one caveat, it still required a minute amount of mercury in its production process. The European Union had banned all use of mercury due its is pervasive, invasive and permanent nauseous impact. While the compact fluorescent lamp was a commercial success and did cut energy consumption for illumination it was an interim solution.

In 2005, Shuji Nakamura, professor of material science at the University of California Santa Barbara, succeeded in turning the blue light of a cold light-emitting diode white with a good layer phosphorous coating. For his discovery—the phosphorous only let the white light rays through—he received a Nobel Prize. LED light was born and it saved another 50 percent energy.

LED lights are quickly replacing all other more energy intensive artificial light sources. LEDs are not only offering brightness that permits us to see with clarity in homes or offices where the sun cannot penetrate with full strength, or illuminate us all night at will. LEDs have penetrated in a decade everything. Before there

was talk about the Internet of Things with an antenna put inside to be able to scream "Here I am", all systems that were powered by electricity were equipped with a tiny light emitting diode, signaling on, off, standby, or offering an indication of volume, or strength of signal. LEDs light up all our screens. They are simply everywhere. If we had known what Suat had discovered inspired by the photophone of Bell, the Internet of Things would have used LEDs from the start instead of installing additional, costly antennas.

Before we start connecting every thing with light, we first need to unveil that the LED revolution comes with a new grand opportunity. To understand this we need to understand how our eyes work. We seem to grasp genetics and robotics better than we understand the eye. It is still being discovered as we write this book. Biologists have always studied the 5 million cones in our eyes. We have known for about a century that these cones capture light during the day and enable us to see.That is not when we need artificial light, that is when there is light.

However, we mostly use artificial lighting in the dark or in less bright situations. What we do with the light systems throughout history, is to attempt to recreate day light. But the moment our sensors and biorhythms of our bodies know that it is dark our eyes don't use the cones anymore to capture the scarce light. For that they use 120 million "rods".We know when we switch off the light before going to bed, we are in the dark, but a few moments later our rods start picking up every ray of light, to the point that we can see and recognize everything around us, even without light. The amazingly efficient working of the rods that bring the tiniest light source or reflection to our brain in the middle of darkness

has only recently been understood in the context of producing light to see.So instead of creating light that emulates the day, we should provide a modest shine that makes the best use of the physical structure of the eye where there are 24 times more rods than cones. So instead of artificially producing light, we should entice our eyes to use the built-in capacity of the eye to see more by creating conditions "to see in the dark".

Now, the lighting standards that regulators use around the world expressed in lumen and lux are based on what we knew in the 1920s about the workings of the cones in our eyes. In other words: we create the wrong light (daylight) for the wrong situation (night time). and fixed in an internationally agreed standard in 1931. We should empower the extraordinarily sophisticated eye to use its best, instead we create and still use today a standard of light that confuses our eye, by pumping more energy into the illumination than is needed.

And there is more: LED lights are mostly blue. The smart invention of Prof. Nakamura was blocking blue light with phosphor to only get white pass through. That was an easy - yet ingenious - solution. Still, looking at the full spectrum of light, to move blue to white requires the use of a lot of phosphor which will be consumed over time, limiting the life of an LED to approximately commercial 40,000 hours. So the choice was blue, and it was a good one at the time. Still, when we study the eye, we realize that there are other elements that could dramatically increase performance. Why and how?

Only 4 percent of the rods in our eyes are sensitive to blue light: 96 percent capture red and green light. But our eyes are not getting that light. So we are offering an overdose of blue, which

leads to insomnia and stress, while the widely available red and green |(but especially red) is not put to use to create hundreds of shades of white: yellow to be more relaxed, like the fire place, the bright white to concentrate on finishing a deadline. We would see much better and sharper if artificial light would match the physical capacity and the design preferences of our eyes for green and red light. We can provide better sight with less light. We are putting the eye to work to the best of its capabilities. That means we can save another 40 percent energy over and above the breakthrough of the introduction of LED while also proving light that better matches our natural rhythms and cycles.

We are confronted with the same logic of business where once a supply chain has been established, nothing—just about nothing but disruption—will move it from its beaten path. The focus is reducing costs, to have less warehousing, to speed up the turnaround, and the ensure that peripheral changes in design bring the same product anywhere in the market. That industry is not ready to change. Since LED goes by the book of a revolution in energy efficiency, few are aware that there is a window of opportunity to create yet another round of massive energy savings is here today.

The next step in LED lighting has been set by Ellipz Lighting and inventor John Rooijmans from The Netherlands. Rooijmans succeeded in creating white light through mixing blue, red and green light and Ellipz uses only the 4 percent blue the eye is used to, and on that tiny part the engineers put only a fraction of phosphor to block the blue rays. As phosphorous is reduced and sometimes even eliminated, the lifespan of LEDs increases dramatically to 25 years or more. That saves energy and materials

and turns into a remarkable product of efficiency. It is no surprise that Ellipz, established by two great-grandsons of the founder of Philips, the number one lighting company in the world is making quick inroads into the market. It is not about selling light, lux or lumen, it is not about renting light as a business model replacing the old concept of selling and moving boxes, it is about transforming a product that is now in harmony with the natural capacity of every eye. This is sustainable design.

In 1956, a 5 Megabit memory unit for an early computer weighed 2 tons. The Internet was born when faster and smaller computers merged with the telephone: The computer and communications "C&C" revolution. We are now witnessing another merger: LED and LiFi or "L&L". The insights gained in the functioning of the eye bring the level of performance to a hole new level. The reduced use of phosphorous improves the transmission capacity of data over light with a factor 20 over standard LEDs thanks to the meticulous use of the full light spectrum. LiFi is the fastest with Ellipz LED lights.

Forty years after the announcement of the microelectronics revolution on the back of the integration and merger of C&C, we are now witnessing an illumination revolution on the back of the integration and merger of L&L. C&C reinforced by L&L will transform the industry. We are talking about a fundamental redesign of our life style, our energy consumption, our communications, Big Data and much more. The next chapters will offer a glimpse of what we can expect.

The development of LED lighting in combination with a better understanding of the working of the human eye will first have to lead to new lighting standards. The industry is aware of this,

but the decision making in all public tenders is still driven by the science of the 1920s. Today, regulations require lighting intensity in certain places based on lumen—the total quantity of visible sight emitted by a source—and lux—the intensity of lumen per area. These standards were developed when lighting technology was still rather primitive and much less was known about the eye dynamics. Today, it is possible to create better lighting with much more clarity using far less lumen and lux that regulations require in public places at night and yet have more light, and have more depth in the illumination.

It is clear that we are only at the very beginning of the LED and LiFi revolution and it is hard to predict exactly where this will lead to. But LEDs—based on these new insights—are bound to be developed further as the technology will succeed in matching nature ever more closely. This will lead to further energy savings and healthier lighting that can support human beings according to their needs at any given time of the day and in any weather situation. The LED revolution has only just started and it will facilitate and perhaps even drive LiFi in the process. Let there be light!

LiFi

Chapter 3

Locks, screens, airplanes and supply chains

The word "LiFi" was inspired by "WiFi" which was in turn inspired by HiFi—or high fidelity. HiFi was the word used to describe the high quality audio systems that were introduced in the 1970s. The audio that HiFi provided was very close to original concert sound. The "fidelity" was very high. In the same way, WiFi is wireless communication very close to the original digital communication provided by cables. But the "fidelity" of WiFi is far from perfect. The Internet is a highly insecure environment. And that is something LiFi will correct.

Despite the complex systems with codes, response mechanisms with safe keys and firewalls that banks and other companies use to protect your accounts, every system can be hacked as happens from time to time. The Internet is far from a secure environment. The problem is that WiFi was never designed for security. It was designed for easy connectivity. WiFi works like a radio. Once you tune to the right station or hotspot, you get the music or connection you desire. Both systems are "one way". The radio station does not know who is tuning in and listening. The same

applies to hotspots, at best it gets an email address and that may be a fake one. Everyone can join a hotspot as long as you have the access code or password. That may seem like a major hurdle. If you are an experienced hacker working with a powerful super computer that can run a billion iterations per second, it is not. And radio waves pass through walls so that hackers can quietly work in their own space without being noticed. German chancellor Angela Merkel recently found out what that means when it became clear, through Wikileaks, that U.S. intelligent agents had been tapping all conversations on her secured cell phone from the U.S. embassy in Berlin a few hundred meters from her office.

In a traditional lock system, there is a two-way protection: you have a lock and a key. Only the key is useless and the lock without the key is useless too. WiFi only has a one-way code. Once you are in, you are in. The hacker who published the paintings of President George W. Bush only had to think creatively what code the former president would use based on his personality and personal data. It only took a few weeks to figure it out. Once in, always in, and no one even noticed that this hacker had been watching the artistic skills of the former president. This is an amazing total lack of seriousness in protecting data. Even with all the anecdotes, stories and personal experiences, things do not really change because it cannot be changed.

Let's compare the current protection of the Internet with the bank safe you may rent to safeguard your jewels. You have a key to your lockbox. That is: you have a key that fits a particular lock. You can only go to the safe with a bank manager who has another key to open a gate and then one more key to access a second

lock on your safe. The manager can't get in your safe without you. And you cannot get to or in your safe without the manager. That double lock provides tangible security.

LiFi has the potential to completely transform Internet security. We have already seen that the connection only works directly in the light beam. That direct light connection means that a hacker has to be standing next to you. However, LiFi security goes even further. Each light provides a unique connection point—or ISP address. Once the user connects, this connection is his and his alone. Each LED lamp consists of 5, 7 or 11 diodes that jointly produce the light. Each diode can provide a unique connection. That gives a connectivity density that, so far, has not been possible.

Here is what that means. Today, people like to share their experiences at big sports or music events with their friends on social media. So, when Lionel Messi is about to hit a penalty kick for FC Barcelona in a stadium with 100,000 people, many have their cameras ready to capture the moment. Subsequently, it is impossible for all these fans to upload their pictures. There is simply not enough bandwidth available. However, LiFi transmitted over the thousands of lights in the stadium could one day easily provide the bandwidth for all the fans.

From the office room to the sport stadium, the next user can connect to the next diode with the next unique connection. And because there are an estimated 14 billion lights in the world, and each of these lamps will have many diodes, there are billions of connections possible. This is the revolution in the making. Just as there is Moore's Law, there is going to be the LiFi connectivity law. Gordon Moore, the co-founder of Fairchild Semiconductor and Intel, argued in a paper in 1965 that the

number of transistors in a dense integrated circuit would double every two years. In a similar way, we now predict that the number of people connected to the Internet through light will double every year until every light bulb is used. So how long will it take before all are connected?

LiFi is not a radio station that anyone can tune in to. It can be designed to ensure that only those who should have access indeed can have access. This unique feature of LiFi makes it possible to develop perfect double lock software—a key with a lock, just like entering the bank safe. This type of security technology has already been developed by WiseKey, a company that specializes in Internet security. The double lock technology will be on of the compelling core features of LiFi as it will be deployed over the years. It is designed for security.

Another weak part in the current Internet technology consists of the "connectors". These are the pieces of technology to make the critical links: from your router to the communication cable, for instance, but also the antenna that makes the connection with a hotspot or the service tower of a cell phone company. These essential components have to be of a very high quality as billions of data run through them. They are also extremely sensitive. A dust particle on the connector between an antenna and a fibre optic line, or a lose connection between wires means a dropped call or an interruption in service. These connectors are in an urgent need of a fundamental transformation when we begin to transmit data at 10 Gigabits per second. LiFi can change that reality in partnership with the greatest quality producers of these devices. It provides seamless connections at tremendous speeds because LiFi has multiple "connectors" built in. Your phone has front and

back cameras that can connect you to a light source. Your phone also has a flashlight that can provide a connection and could even have a key embedded to your safe connection. And the backlit screen consists of 7 or 11 LED lamps as well. Each of these lights can provide connection. Each of these connectors could be transformed into a series of parallel ways to let information flow. That makes LiFi very reliable.

LiFi connectivity is going to be part of the new standard of mobile telephony. There are three European Union research programs that finance the seamless shift from one network to the other and this new super connectivity is scheduled for a launch in 2022. The LiFi option is already included. This hardware, firmware and software fine tuning will address a core aspect of the online experience. Users want speed and volume; they don't want a particular kind of connectivity. That is why the 5G architecture will integrate cellular service, WiFi, Bluetooth, hotspots and LiFi. Today when you have no cell phone service, you need to manually select a hotspot and connect. The new architecture will automate this process. The chip will switch your connection towards the best and fastest available wherever you are. That can be LiFi but in a forest on or the beach that will likely be a cellular connection.

There are environments where LiFi will beat all other options. In airplanes, for example. More and more airlines offer WiFi on board their planes. Ideally, airlines would offer all their entertainment through WiFi. There is a simple reason for that. Currently, the video screens in the passenger seats are connected to copper wires. That means that under the seats there is a lot of—heavy—copper wiring. Airlines want to reduce weight to save fuel. So, replacing existing hardwired connections with WiFi makes sense. At the

same time, it does not at all. This WiFi intensity within the metal walls of a plane will surely vastly exceed the WHO recommended maximum exposure to radio waves of 620 millivolts per meter. Moreover, radio waves cause interference with equipment too and that is something one would want to avoid on planes as well. LiFi eliminates the heavy cables and creates a healthier environment on board. TV, phones, tablets and phones can all be fed through the individual overhead light above each seat at speeds no one has experienced so far in the sky. Incidentally, that light also prevents wrong seating as in the future each boarding pass will connect a passenger with the right pre-assigned seat. LiFi provides a very compelling opportunity for airlines and several companies are eager to step into this opportunity. The question is not if the airlines will do this, it is rather the question how long it will take before the application will be approved. Now that WiFi has finally made its entry, it is unlikely that these service providers will make space for a much better service.

Warehouses provide yet another great opportunity for the introduction of LiFi. WiFi is often a problem in these places because radio waves are blocked by metal frames and walls. But there is more. Today, all products in a warehouse, packages at UPS, Fedex or DHL, containers at a terminal and parts of an assembly line have bar- or QR codes that are continuously scanned as products move through the supply chain. That scanning is a vast improvement over the manual supply management of a few decades ago. However, LiFi will further revolutionize this process. Instead of a QR code that can be scanned, all products will get a small "I am here" diode attached. That means that the products will be automatically recognized as they move under or next to

LED lights that illuminate the halls. There is no need for manual or automated scanning anymore. We can imagine the end of the bar codes and the QR codes, faster than anyone expected. It will always be exactly clear where any product is. Each single part can be tracked from its point of production, throughout its voyage using trucks, rail or flight, up to its transfer station and warehouse, and then to its final costumer or its integration into an assembly. Image the number of parts that need to be managed for assembling a plane. Each piece can be tracked each moment... provided there is light. Light based communication will make logistics infinitely easier and extremely more efficient as well as transparent in a way WiFi or any other technology available today would be able to.

In a very different way, LiFi will support family building. Many families today deal with the challenge that the very devices parents have give their children begin to dominate the relationships. Breakfast, dinners and other family-moments are disturbed by family members checking message on their devices. MyLiFi presents a great opportunity. This standalone lamp has been developed by Oledcomm, the company started by Suat Topsu. The lamp offers a LiFi connection but only in its light beams. And the light can be turned off! No light, no connection, yes family time. MyLiFi makes the Internet connection a local thing compared to WiFi that streams through out the home. MyLiFi enables parents to control Internet use. In many places, that is a highly desired functionality.

LiFi

Chapter 4

Hackers, gamers and the market entry of a new technology

New technologies face the challenge of entering the market and find initial acceptance. One can replace a light bulb with a new LiFi-enabled LED lamp, but that is not enough to get an online connection. There is a need to develop new software with new capabilities. This is a vast task and the work has only started. Engineering schools don't offer LiFi-programming courses. It is an innovation that few people know about so far! So the question is how do we fast track this innovation to the market?

The computer expert who comes to your home to update your laptop has never heard of LiFi. When you ask the electrical engineer, who fixes a short circuit in your kitchen, he will tell you that he is "not in the Internet business". The architects who design office buildings have lighting teams that have never thought about communication over light. The people who install the cables have always separated electricity and communication wires; now there is suddenly only one cable. The existing wires end in two different types on sockets in the

wall. With LiFi there is only one wire, but nobody has designed the supply chain for the subsequent integrated socket and plug yet. The hardware we have today can handle maximum data speeds of 100 megabytes per second. LiFi connected to an optic fibre cable will soon handle 252 gigabytes per second. That is 2,500 times faster than the best wireless connection today. We don't have the chips and computers to accommodate that speed, nor have the connectors been created.

When Steve Jobs launched the iPhone he imagined applications that could be developed by anyone and before we knew it over a million apps were available online. In the same way, ever faster Internet over light waves will create a "self-organizing universe". There is no need to plan, and no need to control. Something that one day can hardly be imagined, will become indispensable the next day. In other words: LiFi is going to be fun, disruptive, creative, innovative, and game-changing. The question is: who will be the first one to push for adoption and market entry? It seems unlikely that this will be the government that always acts slow, nor the existing plethora of online players from the search companies to the network providers. It is a different crowd!

A new technology can only successfully enter the market with the support of an initial circle of passionate users. You can't force or push people to accept a new product or service. There has to be an alluring pull driven by curiosity and interest in new opportunities, while responding to an innate need that the present communication environment is not able to offer. When Apple began selling the first iPhone, the biggest fans were sleeping overnight in front of the stores. These are the highly motivated people, who introduce a new opportunity to the world. They will be the happy first users

whose enthusiasm will spread like wildfire. Can that same buzz be created for LiFi?

LiFi today has no such a group of fans yet. However, there is a group for which the technology opens a highly desirable new dimension: the gamers! An estimated one billion people in the world play video games, generating an annual global revenue of over 100 billion dollars. That is one in eight people. In the United States only, games are played in two out of three households. It all started with a few white blocks dropping down on a black screen. The game was called Tetris. Invented in the Soviet Union, commercialized by a Dutchman out of Japan, it took the world and continues to fascinate and relax people. The world of games has turned into an explosive billion dollar business.

Increasingly, people play video games online with their peers around the world. It's a global audience of tens of millions of people located anywhere where the online universe can reach. And, guess who has the chance to log the most often wins? The one who can make the next move the quickest: the one with the fastest connection! In Internet gaming speed is a critical asset. That means that the much broader bandwidth and much faster speeds, that LiFi has to offer, will have a massive appeal in this booming audience. If a gamer can access LiFi...

In fact, LiFi opens the door of the next dimension in interactive gaming that everyone is dreaming off but no one can really venture due to the lack of bandwidth and speed: 3D. Video games in 3D are the cutting edge for software developers. There is a race to introduce virtual reality in the games. But such games, so far, cannot be played interactively in cyberspace because Internet speeds cannot accommodate the need for fast connections to

process the online gamers simultaneously, While the photograph of Messi scoring can wait for an hour or so, the gamer will have lost a move. Today, the gamers have to settle for an oversimplified versions compared to what their minds can imagine and their softwares can create. However, gamers want to play. They have the imagination, the creativity and the dedication to find the ways to use LiFi in their games.

LiFi will mobilize the ever growing community of game developers and players who tend to cluster in certain places. In Japan, you will find them in the Akihabara district in Tokyo; in Argentina, they are in Rafaela in the province of Santa Fe; in the United Kingdom in Nottingham; and the best video game city in the United States is Orlando. These are the places where LiFi will not need to be introduced, the gamers—once aware of the opportunity—will want to be the first because their gaming will be the best. It will give a boost to the both the content and the scope of games with holograms passing from computer screens to span whole rooms. Gamers are not going to wait for an engineer to show up with an installation pack. They are not going to wait for the fiber optic cable to be equipped with the right connectors that can handle the speed that they consider the minimum, the ideal, the one that will happen. They will figure things out using what they have because they want to use LiFi now! While the blind will be offered guidance by light, the gamers will be the pioneers of the implementation of the LiFi technology.

There is a second market that is easily accessible: the companies that are investing in the new fiber optic networks. Some of these companies are big institutional players with bureaucratic decision-making processes. These are not prime candidates

for the adoption of a new technology. However, there also is an interesting group of smaller fiber optic network companies that have embraced the opportunity of providing this new service because they—rightly—expect fiber optic to be the transmission medium of the future. There are cities who have invested in fiber networks for certain (new) neighborhoods or for industrial or office quarters. Investments have been made with delivering faster Internet speed in mind. However, with existing technology the speeds that fiber optic networks offer can hardly be enjoyed. The last mile is missing, the last connection is not available. Let us not forget, fiber optics is the transmission of data over light, and if this has to get into your home or office, then it must abide by the power of WiFi which is only a fraction. In other words: these future-oriented investments can be made much more interesting and productive when LiFi service is added. There is a logical and ready audience for LiFi in the operators of fiber optic networks.

Finally, there is a third group of people that may lose its "profession" because of the arrival of LiFi and that prospect may make them interested in new opportunities that LiFi can provide. These are the "hackers". As we know, LiFi cannot be hacked when it connects from the light source to the computer or smart phone. If anyone attempts to come between the light emitting diode and the sender or receiver on the device, the connection drops. There only is a connection when people use devices in visible light. Hackers within their own right are creative and versatile people with an incredible mastery of algorithms. The game of hacking banking information, medical data and private information for extortion through malware placement are known impediments of the Internet. While some of the jobless hackers

could be invited to play a role in developing the emerging world of more energy efficient and healthier online universe, there is a new type of danger looming on the Internet that would indeed exploit this dramatic increase of speed.

The spreading of fake news is a new phenomenon. It is based on the capacity of special interest groups to play with the algorithms of Facebook and the likes. These "gamers" of information create news that is obviously false, but know how to package it in such a way that it is quickly picked up by the algorithms which forward the fake news to the people that may be open to receive this kind of information and resend it. This spread is amplified by a couple hundred addresses that have been created for this purpose and send minor iterations of the original fake news smartly adapted to the minute variations of the algorithms reaching quickly millions of people swinging public opinion in favor of one or distancing from another political candidate, pushing a separate agenda by causing confusion with truths that are unfounded and purposely created. It is obvious that this acceleration of the new hacking—filling people's minds and space with facts that are aberrations of reality—but that transform into an opinion which is hard to sway will benefit from this introduction of LiFi. We better be aware that there is nothing that is only good. Every new technological platform implies a series of pitfalls and dangers that may well lead to its success.

LiFi will be introduced into the market with bumps and boosts, it may well reach niche players at first but it has a vocation to evolve through the good and the bad to impose itself on a global scale. It will find its way on local levels through logical early adopters. Gamers, hackers and smaller fiber optic operators can

swiftly bring the revolutionary LiFi technology to the first local communities with users who will be passionate and determined that this will be their preferred technology. The first metro system in the world equipped with LiFi is in Paris, including the service to guide the visually impaired. The first hospital has been equipped in Perpignan, in France as well. The first museum in the world has been operating three years with LiFi is in Liège in Belgium. There will be many more "firsts". And they will evolve from the anecdote and the interesting case, to movements and platforms that in the end will transform societies. From there LiFi will tell her inspiring story to the wider world.

LiFi

Chapter 5

Tunnels, tourists and the blind

The story of David and Goliath continues to inspire many. David could not have won if he would have played according to the rules set by Goliath. David knew that Goliath was stronger. The same applies to emerging business coming to market. Newcomers who don't have a market position have to be creative and find their niches. The traditional competitive analysis following the SWOT—strengths, weaknesses, opportunities and threats—model does not work for innovative initiatives. It only makes sense when you are readying your company for the fight of the titans. The start-ups have limited strengths, mostly unknown and unrecognized technologies blended with enthusiasm and passion and their weaknesses particularly in marketing prowess and capital reserves are enormous. At that game, Goliaths will always crush Davids. Davids have to change the rules of the game in order to succeed.

Soichiro Honda, the Japanese engineer and industrialist, who started the Honda Motor Company in 1948, realized that very well. Initially, Honda produced only motorcycles from a wooden shack.

He succeeded because he sold his motorbikes with fuel that was in short supply in Japan after World War II. Honda made his fuel tapping turpentine from the pine trees that cover 70 percent of his country. After successfully selling motorbikes, Honda decided in 1956 that he would produce cars. Honda should never have become an automobile manufacturer and that's exactly what the Japanese government and the leaders of the established car companies Mitsubishi and Toyota told him in the 1950s. Honda never did a SWOT (strength and weaknesses opportunities and threats) analysis. His position was clear: his weaknesses were self-evident and the power of his future competitors overwhelming. The only way to take on the giants of the world was by making a list of all the weaknesses of the cars of his competitors. That list became so long that he began developing a car that addressed each of the weaknesses of his competitors. And he acted with speed and scale. He pushed the "go button" in 1956. In 1958 he opened his first assembly plant in Japan and already in 1962 he opened his first overseas assembly plant in Belgium while the other car makers where still debating if Honda was really making cars or just motorized bikes with a car body on top of it. The rest is history and today Honda is a successful fiercely independent multinational.

LiFi enters the market as a David following Soichiro Honda's strategy. LiFi cannot succeed when it wants to substitute WiFi in all cell phones and homes right away and if it wants to be connected to today's dominant platforms from Facebook and Google to Amazon and Microsoft as the preferred tool. A starting business should not aim to reach 100 million people to get to the market. A startup needs to provide proof of concept to demonstrate

resilience and focus on the development of human resources: from the entrepreneurs that envision the dramatic shifts to the engineers who can design safe systems and from the architect who sees how to save wires in an office building to the electrician who now can secure light and power over the same wire.

That is why LiFi starts its business by serving the needs of people that cannot be met with current WiFi and cellular networks technologies. The weakness of the other is the power of the newcomer. Based on these unique entry points the new technology can always successfully enter the market. It is a no risk, a beaten road approach provided the entrepreneurs focus on the real needs that have really not been met, and are not expected to be met anytime soon. This offers a degree of freedom to enjoy.

Today, the most obvious shortcoming of the WiFi connectivity is that it "ends" when we go underground. Even when you put in all the routers, drivers and repeaters in the underground world, you can't make calls underground, because there are no antennas powerful enough to pass through and there is too much metal that causes interferences. Radio waves can pass through most walls but they are blocked by the solid concrete and steel that frame underground structures from parking garages and tunnels to mining shafts and metro stations. GPS doesn't work either. That means that we cannot reach people when there is an accident in a mine or a terrorist attack in a metro, or in a tunnel going through a mountain where an overheated brake can cause a tire to catch fire.

LiFi, however, works as long as there is light. Every light in a tunnel or in the mine together with every hard hat can be equipped with LiFi and in emergency situations we can exactly

know where people are. Mines and tunnels have electricity lines and LiFi makes it possible to transform these existing power networks into life lines. It is no surprise that Chile that has recently struggled with several horrible mining disasters, has been the first country to embrace the LiFi technology for its mines. Thousands of kilometers of labyrinths require a change in a lightbulb to offer the communication and the geo-location that meet needs that are not served today.

Metro systems provide a next logical opportunity for LiFi and Paris is the first city that has begun implementing the technology. RATP, the company that manages the metro has signed the agreement to equip all 250 stations with LiFi. One and a half million people use the Paris Metro every day and they can be smoothly guided through the maze of underground tunnels with a cell phone and thousands of already existing lights that can exactly determine the location of the traveler. LiFi guides blind people through the metro since February 2018 in situations with a simple app with text to speech technology where a guidance dog, a baton stick or a regular GPS system are totally useless. The light can lead the blind. That is the groundbreaking change that LiFi offers.

And while underground mining would be an obvious start, there is a huge window to secure metro stations. Terrorists from Tokyo to Paris have made public transportation an easy target. Millions of people move through a maze of tunnels and when the worst happens, no one can communicate. The only viable form of information distribution today is the megaphone. All telephone networks will collapse under the demand for connectivity, just like you are not able to send your New Year's wishes over your phone exactly on the hour. Even the emergency exit signs are a poor

guidance to safety when there are thousands moving around at the same moment. When there are two exists like standard in a metro station, the emergency exit sign on one side may send people into the hands of the terrorists.

But the situations do not have to be as dramatic. Even in calm daily life, WiFi has not been able to be of real service to the blind. Visually impaired persons can be called VIPs but have certainly not been receiving a VIP treatment when it comes to communications and mobility. At best there is a converter to braille, or there is an application that translates text to audio. It is remarkable that the visually impaired—and their numbers are rapidly rising—have to continue to rely on a stick and a guiding dog. But these age-old systems do not work in a complex metro maze with escalators. Maybe for the first time a blind person can find the toilet, and know in which direction to stand or sit down. Can you imagine that we have still not taken care of this obvious need?

If LiFi can lead the blind, it can also guide tourists who arrive in a foreign city without any local knowledge. Just about anyone who arrived in Charles de Gaulle Airport in Paris for the first time and who does not speak any French is as much impaired as a visually impaired person. A LiFi driven app that exactly knows where the first time visitor is, can provide the relevant information at the relevant place and, with simple translation software, in any language. As soon as their cellphones connect to the light for free picking up a signal and pushing down a message through the infrared Sensor, the backlight screen, the cameras or the LED. Light is everywhere in the airport, from the illumination to the billboards that have long changed paper for LED boards. From the airport to the subway and the regional trains, everyone can

be guided and feel treated like a VIP. Guiding the blind with light, is the first step in the build up of an infrastructure that can expand over the years to have a full system ready by the Summer Olympics 2024 in Paris. Once Paris has implemented the complete "spiel" we can reasonably expect that others will follow - even before Paris has completed the task.

LiFi offers more safety too. Everyone is familiar with the green emergency "exit" signs in cinemas, hotel corridors, hospitals, schools, sports arenas et cetera. Worldwide, 80 percent of these signs are made by one (French) company Legrand. LiFi can turn these signs to red when that particular exit is not the one to look for safety. We can finally replace the megaphone! Legrand sells 500,000 of these systems per year and these can be converted into intelligent communication points, sending and receiving data. That means that in emergency situations through LiFi and LED communicating with exit signs and cell phones, people can easily be guided to the right exit.

LiFi can contribute to another safety dimension as well. Whatever the reader may think about the use of nuclear power in a rapidly emerging renewable energy reality, the fact of the matter is that, today, there are some 450 active nuclear power plants in the world that provide more than 10 percent of the electricity that is consumed globally. We know that very dangerous situations can develop when nuclear power plants fail. Japan—and the world—is still dealing with the aftermath of the Fukushima disaster that happened in 2011. The implosion of the Chernobyl nuclear power station in the Ukraine is another disaster that still has not been resolved. In the immediate aftermath of a nuclear crisis it would be ideal to send in robots—rather than people—to

deal with the reconnaissance and the first remediation. However, robots are useless in the case of a nuclear fallout. The nuclear radiation distorts the radiowave-based wireless signals that guide them. Seven years after the meltdown in Japan, it still has been impossible to enter the disaster zone! However, lightwave frequencies are not distorted by nuclear radiation. That means that strips of LED equipped with LiFi can safely guide robots that have a few light emitting diodes powerful enough to take pictures, and send visuals of the sinister area in case of nuclear disasters. Remember, go where others cannot go, perform where the standard fails, and the market will provide you entry.

LiFi will change business as well. The French corporation Decaux is the number one billboard company in the world. Decaux is increasingly replacing paper billboards with digital ones. Initially that was a simple efficiency strategy: it's easier to digitally to replaces ads than to send crews with paper posters through cities. But LiFi offers a new and additional opportunity for Decaux. These digital billboards have hundreds of small LED lamps that provide the back lighting, the large ones used in concerts of Beyoncé and the Rolling Stones use millions. The LEDs can turn the billboards in interactive communication instruments. Decaux billboards can offer travelers at a bus stop 3D video downloads in a few seconds, updates on the arrival, suggestions for the connections and permit to discover the area while waiting. The huge 3D space in front of a billboard can converted one day in full fledged holograms. Decaux will no longer be an advertising company. It is entering the communications industry. Their screens become active high-speed communication tools and soon could turn into virtual reality renditions that make the vision systems of today

look like early day IBM computers: bulky and slow, impractical and expensive.

LiFi becomes irresistible since it adds services and makes people create a vision that current communication technologies over cellphones, WiFi and satellites cannot provide. Here's another example. Many people regularly spend frustrating time touring parking garages searching for that one spot close to the elevators or that one "green" spot that -according to the sign—should be available on that higher floor. LiFi transforms that experience. As all parking lots have their own lights in an area where GPS basically shuts off, drivers that pass the gate and take a ticket, can immediately be guided to the one spot that is exclusively reserved for them. No one else will be guided there. That saves everyone time and frustration. LiFi also solves the problem of your "lost car". When you come in the parking garage at the airport after a two-week vacation your phone exactly knows where your car is parked.

As in the case of Mr. Honda, the list of weaknesses of the competition as well as opportunities for innovative new services becomes longer and longer. What is described now is but the very very low hanging fruits that everyone recognizes the moment it is spelled out. Today, all goods in warehouses need to be scanned so that they can be located and cashiers scan the products you buy in the supermarket. In the near future, a little diode will be added to all products and containers, instead of the bar- or the QR code. That means that all products will be able to communicate with the LED lights and there's no need to scan anymore.

LiFi can also vastly improve the consumer shopping experience. You never have to look for a product again. The shopping list

stored on your smart phone will have been picked up at the entrance of the store. The LiFi network quickly calculates the distance, checks the availability, verifies the sizes, etc. The LiFi system always knows where everything is and offers the best local guidance to take you from one point to the other securing the shortest distance. The cashier will already "know" the total you need to pay for your groceries the moment your shopping cart passes the checkout. A tiny battery will power the "Here I am" diode on the products for at least five years.

Research has shown that the installation of LiFi in a supermarket will immediately increase sales with 4 percent. As it turns out, 60 percent of the people leave the supermarket with one or two items on their shopping list that they have not been able to find. They were ready to buy the product but they could not locate it in the many aisles of the supermarket. LiFi solves that problem. It will not only save the consumer time, the system also ensures that she will find everything that is on her list—unless, of course, the item is out of stock. LiFi will increase consumer satisfaction as well as supermarket sales. Will big supermarket chains be interested in investing in LED lighting with LiFi in their stores to increase their sales while also saving on their electricity bills? We don't think this is going to be a hard investment decision for these chains to make… InterMarché, Lidl and E. Leclerc have already decided. The POC has been done and since not everyone has a smart phone equipped with LiFi, there is a small device on the shopping cart. Soon that will be designed out!

There are many early opportunities. However, users may wonder how they will be able to benefit from the LiFi experience before the arrival of the 5G technology that integrates a LiFi

connection in 2022. All smart phones have cameras that are designed to receive light (and images) in the front or the back and that are connected to the communication system to send the photographs over wireless communications to anyone. This is part of the firmware, solidly embedded in the phone, and carefully connected to the communication devices. There are hardly any phones left that do not have a flash light. This light can flicker a million times per second and could be embedded with an encrypted key, that must fit in a lock. This encryption cannot be hacked since anyone attempting to access it must stand in the direct sight of light which means that the privileged point to point connexion is interrupted and the code is not transmitted.

Moreover, smart phones are equipped with infrared sensors that turn screens lighter or darker. This IR sensor is sufficiently powerful today to transfer an SMS, WhatsApp or WeChat messages. The screens itself consist of 7 to 11 LED lights that provide the backlight of the phone. That whole screen can one day operate like a sender and a receiver at the speed of light. As the compelling opportunities for LiFi arise, early pioneers will find the ways to enable the technology with available hardware. It is perfectly possible today from the hardware point of view, but since the software is missing it is only possible to deliver the proof of concept in a laboratory. Otherwise, we could be jailed for hacking a phone!

LiFi

Chapter 6

Every light turns into a satellite

Almost every new technology requires new infrastructure, new firmware and new hardware to enter the market. A new software program with many attractive services can often only be run once these three preconditions are met. If Facebook goes from one to two billion users, it needs many more data service centers. An electric car requires a charging station. The arrival of the 5G cell phone network requires new and stronger antennas. Et cetera. These additional requirements often pose the greatest hurdles to the market entry of a new technology or service. Then, even before the infrastructure is decided, the underpinning standards will be fought over. The "videotape format war" of the 1980s provides a famous example. Most experts agree that the Betamax system was the better technology. However, ultimately VHS became the standard because that technology—led by Sony—offered users much more content, films on video, that they could use. In other words, Sony invested in the additional hardware that created the infrastructure (video stores) and even decided to buy Hollywood studios, that led to the winning market entry for the new technology

and securing a greater chunk of the cash generated in the whole supply chain.

Governments have sold licenses for the new 5G networks that will arrive in 2020 for billions of dollars. These are investments that very few players can afford. It is clear that no one who has put the cash on the table will appreciate a new competitor with a new infrastructure that first can complement, then bypass, and eventually overtake what those who paid the hard cash thought was an exclusive arrangement amongst a few. So these heavy capital investments are reserved for a few players in each country. And, perhaps the biggest monopoly, and a major obstacle of all mobile technology is the Global Positioning System (GPS) navigation technology. All GPS technology depends on American satellites. The United States capital markets guaranteed by a solid demand from the military are the only ones that succeeded in putting some 2,200 satellites in space. While most of them serve military purposes, civilian use is increasing and government contracts for the monitoring of climate change and its effects like rising sea levels and shifts in agriculture are in increased demand. However, each additional satellite requires an investment of anywhere between 50 and 400 million dollars. These are prohibitive amounts for new market players. There are a few players who suggest that they can do it with re-usable rockets, and focus on smaller satellites that cost ten times less. However, ten times less for 1,000 satellites is still more money than even the richest in the world can commit today. That is why the European Union has still not succeeded in uniting the forces to successfully launch and operate the European satellite program called Galileo to provide a competing alternative for the American GPS infrastructure.

Against this background, LiFi provides an extraordinary

opportunity. LiFi offers far more precise geolocation services than GPS but it does not need satellites.That is a revolution. In fact, there where there is too much density of users of GPS, like in cities characterized by traffic jams, and business districts with heavily connected multitasking offices, LiFi could turn all existing lights into satellites! LiFi does not need a new infrastructure. LiFi already has an infrastructure that was established over the past century: the public light network. There are an estimated 14 billion street lights. On top of that, there are one hundred times more light bulbs inside. We have the most connected society ever. We only did not realize that the merger of LED and LiFi will turn every single light into this magnificent satellite. The European Commission's incapacity to deliver on the budget for the 1,000 satellites was a blessing in disguise.

Governments worldwide provide public light in towns and cities and along streets and roads, even in shanty towns as an important public service. Light creates a sense of safety and helps to control criminal behavior. The costs of public light are never an issue. Governments that need to cut expenses don't turn the lights off in the cities.

There are electricity and communication cables along or under every street, in every home and office, and even under the oceans and across continents. In other words: the infrastructure required to make LiFi available to everyone already exists and has been paid for. We can use what we already have! This is perhaps the greatest contribution of the LiFi technology. There is no need to go through the massive expense of creating a new infrastructure.

LiFi could be distributed through old-fashioned copper electricity cables using current ADSL technology. Data can be transmitted at

even higher speeds through new optical fiber cables that can be used to supply power as well through "power over ethernet" (POE) technology. LiFi can use whatever distribution cable is available to connect devices through light into the world of hard wired networks.

This means that governments around the world can introduce LiFi as a public connectivity service—as the backbone of universal access to the Internet—on top of the existing lights, wires and cables without the need for any additional investments but the change of the lights and the build up a of server park to guide, process and perhaps even collect all the data. The breakthrough of LiFi is that it integrates high speed Internet into the public light system. Since these networks are nearly always connected to each home, which has its own local network the burden of entry is the lowest ever. In other words: There's an infrastructure that has already been paid for and there's a budget provided by the energy savings that will be generated.

Where the European Union has failed for now to establish an alternative for the commercial satellite infrastructure provided by the United States, Europe is a very favorable position to take the lead with the introduction of the LiFi technology. Europe has arguably the most-dense public lighting systems in the world. Instead of investing hundreds of billions to launch satellites, Europe can establish a very fast Internet infrastructure including superior geolocation technology for only fractions of such investments on the basis of which hundreds of thousands of new services will emerge. Millions of entrepreneurial ideas will emerge. The economy will get a boost, from the production of new firmware, hardware and software.

Attractive opportunities arise for developing countries as

well. The Internet infrastructure of many of these countries is lagging. Often only 50 percent—or even less—of the population is connected. As mentioned, the introduction of high-speed cell phone networks requires massive investments for which funding is not available in these countries. In addition, every router in a home costs at least 100 dollars and a connection to a new optical fiber cable is paid separately by those who can afford at least 1,000 dollars. Under these challenging circumstances, there is no way for developing countries to catch up with the Internet, and close the gap. There is a need to be able to leapfrog. LiFi is a game-changer for any country where the people are hungry for connectivity. Instead of facing the almost impossible challenge to upgrade an outdated infrastructure with billions of dollars that are not available, countries can now quickly and cheaply modernize their Internet structure that is critical to support much-needed economic development. LiFi offers the opportunity to reach billions of people at once through existing infrastructure. In other words: LiFi truly introduces the "Internet of the People" rather than the much discussed "Internet of Things".

The introduction of LiFi still requires changing the light bulbs. Existing light systems have to be replaced with LED lamps that have a driver and a modem. That means substantial investments. But here comes the best news of LiFi: the introduction of LiFi and LED reduces energy consumption with around 80 percent, you save on light and on the power consumed by the router. There are immediate power savings of 50 percent. A total savings of 80 percent can be achieved through intelligent energy management. Light and information are managed through the same network. That makes it, for instance, possible to dim street lights after

midnight. A mere 20 percent reduction in lumen saves 40 percent power. And when people leave buildings, light and data services are immediately shut down saving energy, improving security.

The massive energy savings make it possible to finance the conversion to LED and LiFi out of existing cash flow with a payback time between three and five years depending on the electricity rates clients are paying. After that period, a better combined electricity and data service can be offered ongoing at 20 percent of today's costs. And, yet, there is the initial bill upfront. Changing 100,000 streetlights will cost around 40 million dollars—even if that money can be recouped in three to five years. There are an estimated 14 billion lights in the world. That could mean an investment of trillions of dollars. This is an extraordinary stimulus of the economy, a redirection of the industry, a renewal of all software, and a bundle of services for the people we usually do not reach, and a pleasure for those who can afford.

The introduction of LiFi offers a very interesting investment opportunity. Investors always weigh risks against returns. The immediate energy savings of LiFi substantially reduce risks since the repayment of the bill is backed up by the energy savings. Then there is the risk that people won't use the new service. This is highly unlikely. Cities will not turn off the street lights. That risk is low as there is not much life today without artificial light and Internet. That means that income will be secure. There is another factor: LiFi turns public lights—that have essentially no value; they are considered and unavoidable and therefore acceptable cost—into an asset. The same light now becomes a distribution point for valuable additional services. For example: a street light becomes a "guide" for a blind person. That service has a value because

the European Union requires governments to provide mobility for visually handicapped people. Governments are fined when they don't make their infrastructure accessible for handicapped people. That fine is the value that LiFi generates.

LiFi turns a stranded asset into a source of multiple revenue streams which ensures that the asset value rises over time—and that is what investors are looking for as well. Something that, today, is valued at zero in the books becomes a critical component of the information infrastructure: what kind of an investment multiple is that? The LiFi investment is very solid because it combines low risk provided by energy savings of a critical service—secure cash flow—with increasing value of the asset over time.

In addition, LiFi investments offer popular carbon credits because of the energy savings generated as society and the planet gain. The Internet is a critical component of modernization. The online economy drives modern and emerging societies. And while this unbridled growth has been ongoing for 25 years, it does not seem that there is any sign of slowing down. The 24/7 communication driven by Internet and mobile communications on miniatured devices is one of the steadfast growth factors of the economy that cranks out ever higher sales and profits for companies like Apple, Google, Alibaba, Tencent, Softbank and Facebook. It is no surprise that the energy consumption of online communication has risen from one to two percent of global energy consumption and it may even reach six percent by 2030. Every router consumes the equivalent of three good old 60 watt lamps that are kept on 24 hours a day. There are buildings with hundreds of routers and new ones are installed every minute.

LiFi points the way to a cleaner, safer and cheaper infrastructure

that does not need routers, nor expensive satellites in space and antennas every five or ten kilometers. There are trillions of dollars available for investments at pension funds and impact investment funds in the world. It is hard to think about a more secure, attractive and more meaningful investment for institutions who want to contribute to progress for all. It gives us the confidence to state that any investment is a secure investment in the common good with a return that not even hedge funds dare to advertise, or risk appreciation that not even the government bonds can offer. With other words: too good to be true.

LiFi

Chapter 7

Healthy hospitals

We know that there are certain environments where we need to be careful with cell phones because they may cause dangerous interference. We know that we should not make calls while we are getting gas. There is a risk of explosion. We are requested to turn off our communication devices when we are on a plane. There is a risk of interference. Research shows that a concentration of radio waves can distort the migratory patterns of birds. They lose their age-old routes and end up in places where they have never been. Other research illustrates the impact of radio waves on the growth patterns of plants. When exposed to intense radio waves cells are not dividing according to healthy, natural and predictable patterns. In other words: radio waves can impact the behavior of machines, plants, and animals like us.

We also know that the intensity of radio waves continuously increases. In the center of big cities your phone can connect to dozens of hot spots. A verification in the center of London offered the average phone 65 antennas screaming for attention. More and more devices are connecting with each other in the "Internet of Things" which leads to a further increasing of the intensity of radio waves in smaller and smaller spaces. More and

more persons carry two or three phones, one from work, one from home and one with a local SIM card that is cheaper. With that intensity, we experience more and more interference and calls and connections regularly suddenly drop. The only response of the industry is more antennas, and stronger signals, this requires additional energy, and increases the intensity of the radio waves. Now that we are planning to increase the number of devices with antennas to as many as 10 for every household, we can only imagine what that means for the first generation of humanity that is exposed a complete lifetime to an intensity of radio frequencies that is considered above the safe limit. We have no idea what this will do to our bodies and our health. That is why it makes sense to apply the precautionary principle as if we are defending our borders against a possible invasion by an enemy. You do not wait until you have scientific proof that the enemy has attacked in order to prepare for defense. You get ready and do what is needed just in case the hard facts are confirmed: you do not want to be too late.

The research about the impact of all that radiation on human beings, so far, is not dramatic enough for industry to take bold decisions in favor of consumer and citizen's protection. Western Cartesian logic requires a clear cause and effect and that is—in these situations where there are many different influences—very difficult to determine. The Millennials are the first generation that has been growing up amidst the modern intensity of radio waves in their environment. We will know much more in a few decades when they begin to age. Nevertheless, the recommendation given by the World Health Organization (WHO) after consulting many of the world's leading experts, that we—especially more

vulnerable people like children, the elderly and the sick—should avoid exposure of radio waves beyond 620 milliVolts per square meter is hardly disputed.

It makes sense that sick people in hospitals whose cells and bodies need to heal should be exposed to as little radio wave interference as possible. However, as it turns out, exactly in hospitals—where more and more equipment and devices are connected to communicate via WiFi to better monitor medical processes and maintain inventory of all rolling beds and equipment—it is not uncommon to measure an intensity of radio wave frequencies at ten (!) times the WHO advisory. There are hundreds of routers in hospitals to connect devices like the intravenous IV drip that distributes fluid and medicine to patients and that has replaced the old manual model in many places. Such autonomous IV's are wirelessly monitored. They are effective, efficient and precise as nurses don't have to keep checking the patient. They also increase the radio wave intensity in the hospital and, with the hundreds of visitors equipped with cellphones, the risk of interference. A brief disturbance in an electrical system can change a critical dose of medicine fed through an automated drip.

Hospitals face a dilemma. More electronic and better-connected equipment allows them to better serve their patients, and save on staff that is more and more difficult to contract, and, at the same time, the wireless communication threatens their very health. There is an urgent need for a better solution. Three years ago, the Centre Hospitalier—a hospital in Perpignan, France—began installing LiFi throughout the entire building. At that time, the radio wave exposure often measured around 6,000 milliVolts per

meter. Today, the hospital measures a maximum intensity of 250 milliVolts per meter in every room. That is a dramatic reduction and brings the exposure well below the WHO recommendation of 620 milliVolts per meter. The hospital has eliminated many routers. Devices are connected through the LED lights in corridors and above the beds of patients. The remaining radio wave impact is mostly caused by antennas of cell phone companies in the vicinity that keep penetrating the premises.

The hospital in Perpignan is also saving a tremendous amount of energy. There used to be 700 routers in operation that each consume the power of three 60-Watt lamps 24 hours a day. Every light in the hospital is now a LED light that saves at least 50 percent energy while providing communication at the same time. That means that patients can easily be monitored through the lights above their bed. And, yes, the lights need to be switched on all the time. However, during the night the light only needs to shine at a fraction of intensity—enough for LiFi to work, not enough to disturb the healthy darkness in the room. It is also possible to use invisible light.

LiFi enables hospitals to increase efficiencies and generate more savings. Today, nurses after taking over shifts from their co-workers, lose substantial time going from room to room mapping, checking and monitoring, medicine, or even patients. When all devices, medicines, and hospital beds have their own little "I am here" diodes attached, everything can always be easily traced. The reports that nurses need to write to handover their duties can become much more simplified. Visitors can also be smoothly guided to their loved-ones and family members as nobody will get lost anymore in the extended labyrinths of hospitals. LiFi offers a

perfect and healthy solution for communication and connectivity within hospitals. To set up a LiFi network in the average hospital costs about 300,000 dollars. And that investment can be paid back in 3 to 5 years out of the energy savings without taking the operational savings into account.

The new LiFi infrastructure offers one more additional benefit as well. Today, when doctors prescribe medicines, they use devices like iPads that connect wirelessly with the pharmacies where patients can pick up their drugs. That is private and privileged information but somehow despite regulation that clearly prohibits sharing such information, the data—albeit anonymously—are collected through the search systems of Google et cetera. Medical files are worth fortunes to pharmaceutical and insurance companies. Medical information is one of the most sought after—and thus most hacked—data with a great resale value in the world of Big Data. While no serious industry leader will engage in illegal data gathering, the hard reality is that the business is solidly established and depends on the loopholes in the world of phone antennas, service providers, mobile electronics, search engines and soft hackers who secure access to data that is worth gold for the marketing experts of pharmaceutical companies and life insurance groups.

LiFi makes it possible for that communication to be turned completely private through an intranet connecting the doctor to the patient and the pharmacy in the hospital without any further connection to the world wide web. Every LED light has a unique ISP-connection. That means that the data that are shared are only available to the doctor, the patient and possibly a present nurse. There are no other people connected to the same light. That

means that no other people have any access to the information that is being shared. LiFi makes it possible for patient-doctor relationships to be brought back under the control of the ones who should control it.

Today, there is no choice yet. Expecting mothers, recovering patients and visiting family are all exposed to intense reading waves in hospitals without any real awareness about the issues at stake. Everyone in the hospital is the subject of special data gathering for the sake of information resale. Trackers can find out what websites are being consulted, about cancer research or alternative medicine. This can shape the strategy of companies, determine the lobbying efforts of pharmaceuticals that have been blocking insurance to reimburse homeopathy or alternative medicine. But as one can imagine, once people become aware, there will be no doubt that demand for this privacy will be explosive.

Whatever time it may take for a scientific consensus to emerge and for industry to respond, there is no doubt that the large majority of the expecting mothers would like to deliver their baby in a room that is free of excessive radiation over and above what the WHO has recommended. And which parents like their children to spend substantial time in creches or kindergartens that are located under a large cellphone antenna?

LiFi increases health, privacy, transparency as well as efficiency in one of the places where that is needed the most: the hospitals where people spend some of the most vulnerable moments of their lives. LiFi offers us a chance to get our life back where we do not want what we do, think and search be converted into commerce without any consideration of the common good.

LiFi

Chapter 8

Closing the gap

In the past 25 years, the Internet has been a major driver of economic development. Societies have been transformed by the online services offered by Amazon, Google, Facebook, Alibaba and Tencent and a long list of online giants. Whole industries—from hotels to taxis—are being overhauled by emerging Internet platforms. Mobile computers—cell phones—with geolocation (GPS) have added a new online dimension throughout our daily lives. In short: connectivity—the merger of computers and communications which was announced in 1982 by Koji Kobayashi, then chairman of the computer giant NEC (Japan) in a Report to the Club of Rome—has been driving growth and progress, and remakes society. Now there is another merger that seems unstoppable: light and Internet.

It is for the most part exiting news. But there is one challenge. While most people in the western world are speeding along the Internet highway, half of the world is still not connected. Accessing the Internet requires an infrastructure of satellites, antennas, cables, wires, routers and servers. These are expensive pieces of equipment that developing countries—struggling with improving supply of drinking water, providing food security, offering basic

health, education and infrastructure services—cannot afford. While the state has a hard time to deliver, poor people are incapable of mobilizing the cash to hop onto the Internet wave. At best, when a service provider who offers expensive subscriptions or, at least, prepaid cards that need to be replenished regularly is available, they can afford a few short messages. As a result, we face a situation where half of humanity is engaged in a fast-developing online socio-economic expansion while the other half seriously risks falling behind. It is easy to understand what that means for global cohesion. The geopolitical consequences of this trend—from terrorism to migration—are regular frontpage news. The gap is getting bigger and bigger.

There are glimmers of hope. When rice farmers in India can cut out the middlemen who were exploiting them and directly connect with the commodity exchange in Mumbai via a simple cell phone to know the real price on the market, the lives of their families improve. And, yes, it does help when Facebook launches balloons over rural areas in developing countries to provide connectivity which of course includes the caveat that they must use Facebook or face the reality of no connection. Still, the impact of these steps pales in comparison with the ongoing explosion of online innovation in other parts of the world.

The bottleneck is the lack of adequate infrastructure. And it is hard to see—after a quarter of a century of Internet and a decade of smart phones—how the unreached and the isolated will be able to catch up without major investments for which money is not available. Unless the existing infrastructure can be used.

As we saw in chapter 5, a major advantage of LiFi is that it can be introduced without massive investments. While it is a fact that

50 percent of the world does not have an Internet infrastructure, 90 percent of the world has a public light infrastructure. And, even where there is no public light yet, it is on the top of the agendas of development banks and governments to provide light to local schools, health care centers and stores. Through LiFi we can quickly bring another 40 percent of humanity online using the existing public lights. And, if it only takes a LiFi empowered light bulb and a solar panel to bring the rest of the world online, the remaining 10 percent does not need to remain far behind for too long. We know that light at night creates a sense of security and belonging, and that connectivity changes the livelihoods of people and speeds up economic development, facilitates learning and builds resilience. That means that the cluster of public street lights, renewable energy, and LiFi technology makes it possible to help close a dangerous socio-economic gap in our world.

The beauty of LiFi is that we can bring connectivity wherever there is light. That light can be a simple light bulb in the village square connected to an old-fashioned copper wire that distributes electricity to a dozen homes. The same wire can be used to carry information using 20-year old ADSL technology. The moment that light bulb is replaced with a LED lamp, the whole square can be connected. That means access to information; to better answers to medical needs; to better education; to better opportunities for business and trade; and for more sharing within the community. Remember: there are already billions of street lights in the world!

The connection can be made with a simple, second-hand cell phone or computer and there is no need any more to buy cellular services from the multinational providers that, today, are making

easy money providing service in developing countries even subsidized by donors. The free light of the street replaces the expensive subscription to a cellular company and provides a faster and better connection. It is clear that this local street light with LiFi only connects with the world if it can pick up an antenna, a cable or a satellite. Often this is not the case. While the system would not offer the chance to surf the world, it offers an introduction to the world through an intranet. The locals can come to a quick agreement what information should be available, what must be shared, and that could be posted on the local service, so that everyone has the opportunity to consult.

There is an important other dimension: LiFi also makes it possible to determine—once again from the start—which information is going to be shared and with whom. The worldwide web grew without a plan and led by an unlimited protection of the freedom of speech. As a result, an estimated 30 percent of today's Internet consists of porn. It is hard to see how that "freedom" serves the common good in society. How would we want to open up villages and communities to the world wide world of the Internet and provide this kind of accessibility. Most leadership around the world does not agree to the simple definition of freedom of speech that has been imposed by a few corporations with a North American legal framework, and does wish to have a layer of protection especially for those who have never been exposed.

Recently, a new unhealthy phenomenon has been added to the online world: "fake news", created to disturb and exploit society through clever algorithms. Whereas the world has been reeling about the danger of hacking, and the need to protect information that is privileged like medical data and creditworthiness the real

danger is a completely new one. A few experts have understood the algorithms of the Googles and the Facebooks and know exactly which kind of information will be forwarded by the system through automated programs to target groups based on their preferences, recent purchases, posts on Twitter and "likes". This fake news strategy is fueled by a few hundred fake email addresses and accounts and a boomerang effect is created on the web: millions of resends with minute adjustments reach tens or even hundreds of millions of people within hours or days. That false news circulates and gets recirculated through these automated systems and creates a new fake reality that is easily accepted in many places. Before the manual controls of Facebook or Google spot the fake news, it has already settled in the minds of people, shaped and changed their opinion, and the removal is not undoing the damage.

We are facing the challenge that the Internet, as we know it today, is creating a world that does not match with our reality nor does it respect the different cultures or vision of a healthy, happy and sustainable future. Therefore the way Internet operates today threatens that reality. It is against this background that the lack of connectivity for half of the world is perhaps a blessing in disguise, and provides an opportunity to design an Internet strategy and a service portfolio that is a true response to the need.

A few concrete examples can inspire people to take initiatives and create new businesses based on information that can be easily shared. Instead of pushing for synthetic shampoos and detergents in glittery packaging, anyone interested can learn how to take a kilo of citrus fruit peels, with one liter of water and seven spoons of sugar to create your own effective and fresh

smelling cleaning products. This information on hand in each village will save the skin of millions, water in the rivers, and avoid the dispersal of sachets into the environment littering the place for decades to come.

Similarly, information can be shared about how the waste from discarded fruits and vegetables, coffee and tea can be used to farm mushrooms, providing healthy food while the spent substrate becomes an ideal feed for chickens. Or how the roof of a house or a school could serve as an ideal spot for farming spirulina, a highly nutritious algae that only needs sun and warm water. The local production would provide the trace minerals all children need to grow up healthy. It makes sense that everyone knows this and can make a choice. This is what the real economy is about, this is how we can inspire people to keep cash in the local economy and spur development.

The lists of tested opportunities that have succeeded in other parts of the world and now can be shared globally is endless. The new online network will provide a discovery tour to develop local economies. Even the installation of the network itself through LiFi-enabled solar-powered street lights, could be explained in detail. And LiFi will grow faster serving the common good, and underpinning local growth with local entrepreneurship.

LiFi could be distributed over light networks that are mostly owned governments that are elected to serve the common good. This new information network can function completely separate from the World Wide Web and, as we shall see in chapter 10, out of the reach of Google, Facebook et cetera as well. A local server with all relevant information stored will secure accessibility to data that are important to enhance the resilience of the community

and the quality of life. At the same time it permits to learn how to operate and to create a culture of connectivity in phases. That provides a unique opportunity for a re-thinking of the online information infrastructure we want to create.

We envision that local rural schools and community health centers are the first to connect the surrounding community to an "intranet" that provides and exchanges information. That connection will change the way children learn while their parents can benefit from the access to information as well about health. Class rooms and homes can be connected providing more community and more safety. We already know what a simple light bulb powered by a solar panel can do in a village where there was no light after sunset. More reading, more information, means more change. Now the LED lamp with LiFi powered by the sun or the local electricity network can also bring step by step a connection to a wider world. Information, learning is the beginning of new possibilities, new habits that can improve and enrich lives. Better ideas to cook food or filter drinking water can travel faster and reach more people, solving more problems. LiFi connectivity can change the world and close the gap. This may very well be the most important contribution of this new technology.

LiFi

Chapter 9

Safe self-driving cars

Every year, in our world ….
… one million people die from malaria;
… half a million people get murdered;
… on average some 400,000 people die in wars;
… and cars kill 1.2 million people.

The fatality rate of the automobile is equivalent to having ten atomic bombs go off each year. That makes the car, by far, the deadliest "disease"of modern history. We worry about terrorism but we should really be concerned about the one instrument most of us use every day without even thinking about it: our car. We love our cars because we love our mobility—that's why we take the big risks and the high cost apparently for granted. We have tightened the rules for drinking and driving, the seat belt is compulsory in the front and in the back, the airbags give us a sense of protection, the brakes have an anti-blocking system, and tires do not spin anymore. A wealth of technologies have been integrated, and yet we do not seem to succeed in making a serious dent in those statistics of the killer car.

The problem with cars is that they have human beings at their wheels and human beings make mistakes. That is why mobile

robots—driverless cars—could make the world a much safer place. Many people question the safety of the driverless car and fear that technology may not be reliable. But most of us regularly sit on planes that fly mostly on autopilot. No technology will be one hundred percent failure proof, but it will be very easy for technology to beat human error. That's why the driverless car should save many, many lives.

We have been told that driverless car is coming fast. Most of us have become familiar with the images of the Google car that relies on very noticeable antennas on its roof and radar on the bumpers. That antenna on the roof connects to satellites in outer space to provide the car with GPS navigation. The self-driving car needs to communicate with outer space to avoid causing accidents. And that communication uses radio waves that—as we know—can be hacked. The radar is a sensing system that works at close range, a good tool to use that is already installed in many cars.

It comes as no surprise that governments have begun expressing concerns about the arrival of self-driving vehicles including drones. They fear that autonomous vehicles can be turned into "weapons". In their perspective any object that is capable of moving by itself is, by definition, a weapon. Google and the other autonomous car developers will counter that the cars will be programmed that they will not move when there is a human being in front of them—and that that code cannot be changed. Unfortunately driving on the car is more than responding code and law. The rules in many countries prescribe that as soon as passengers are preparing to cross the street on a zebra path, the car must stop and offer passage. However, if the pedestrians

simply stand there, then the car cannot move forward - if it respects the law and should not be programmed to any different. But if the car waits until the duo decides where to go, it creates a traffic jam. A human driver will quickly make up his mind and conclude that it is fine to break the rule, and drive on. That is why the self-driving car will take decades to operate in the city.

There is another hard reality: radio wave-based GPS navigation systems and software codes can be hacked. That means driverless cars empty or full with passengers can be taken over by someone who wants to cause harm. Yes, technology could avoid the human error, and prevent traffic accidents and make driving safer and, at the same time, technology can never be 100 percent protected against human evil. Trucks have been diverted by thieves that just change the GPS coordinates and arrange for a stop at a lonely parking. Even cargo ships have seen their GPS guidance system hacked, ensuring that these are located in a space in the sea where the pirates can act in impunity. The industry must come to terms that wireless communications as it is designed and operated today is embarrassingly easy to exploit.

However, it is interesting to note that the driverless car future is very much planned in a "car-centric-way. The message of the autonomous car is clear: "Here I am. I know where I'm going and I'm going to avoid accidents. I'm going to follow the white lines and I'm going to stick to my lane and my car will brake automatically for any danger on the road. And by the way, I will respect all traffic rules." We are planning traffic from the perspective of the individual car. Each car is subsequently connected with its surroundings via a satellite in outer space. It is the very same "top-down" approach that characterizes most of the structures

and organizations in society. We know there are better, and more efficient ways to organize.

If one observes traffic in cities from the sky, the movements of the cars resemble the flows of swarms of, for instance, ants. Let us grasp the essence of swarms from locusts to fish, from krill and butterflies to reindeer. We know that nature does not use satellites to organize "traffic". The ants have other ways to communicate. Flocks of birds rise from a lake without a central command and move into the ideal direction. Subtle signaling between the birds creates a harmonious clapping of the wings in an instant. And there are no collisions, neither are there traffic jams. And while some scientists believe that migratory birds can read the stars, follow the position of the moon, or perhaps use their sense of magnetism with a compass, it is clear that for a voyage of the magnitude that swarms and flocks undertake, the key is the constant and tacit exchange of information amongst the members of the crowd.

How would it be if cars could "talk" to each other in the same way? Biomimicry is the science that looks at how manmade systems can be inspired by natural patterns. The approach generates more far efficient and sustainable frameworks based on systems and logic that has proven its functionality in nature for thousands, if not millions of years. If anything did not work well, then it would have been long eliminated. In that respect, it is interesting to note that technology giants like Google and Tesla that pioneer the development of the driverless car, still focus on GPS navigation and WiFi in their designs. While Tesla eliminated wires out of the car using WiFi, we know now that this is only the beginning and a new technology will perform better, with less energy while creating a space where the impact of radio waves is eliminated.

We know that for almost 10 years, there is a new technology available that allows for a very different—and far more direct and precise—communication between cars. Lights are a critical feature of cars. Many countries like Sweden, Norway and Finland have been enforcing for several decades that car lights should be kept on even in bright daylight. The introduction of LiFi makes it possible for cars to talk to each other with their lights—faster, more direct and without the risk of hacking. LiFi car design means integrating LEDs everywhere—from the indoor creation of atmosphere to the dashboard and the floor guidance system, the headlights with beams that penetrate darkness and fog over 10 to 25 meters. The rear mirrors have LEDs, as well as the door safety lights and even the dozens of sensors and the phone communications: all of it can be managed by light. This will reduce consumption of power, an important feature for the electric vehicle, and transforms the car into a migratory bird in a flock that is in constant communication with everyone around.

LiFi will allow for natural traffic flows that follow natural patterns. One would have expected one of the technology leaders to jump on this tremendous opportunity sooner… The first test of the viability of LiFi empowered LEDs in vehicles was already proven in 2009 through a cooperation of the University of Versailles and Renault. The tests are very promising even though in these tests the street lights were not yet integrated.

The combination of the lights of the cars with street lights, that can be invisibly "on" during the day, and strategically placed reflectors creates the perfect light infrastructure for reliable high-speed communication and a guidance system.

LiFi does not pretend to replace any time soon the existing

communications infrastructure. However, in the "light" of the fascinating portfolio of new services and the unparalleled opportunity to cut accident and mortality rates on the road, the LiFi technology vastly improves the GPS and radar-based systems. Let us start with the geolocation. The GPS can never turn into a centimeter precise positioning tool. The cell phone tower antennas are at least 3-4 kilometers apart, and the satellite is at least 20 km above, and taking into account that the Earth is round, the often forgotten Mercator effect that distorts a line when drawn on a geolocation system that is 2D, while the reality is 3D implies that GPS is … what it is: a revolutionary tool that is up for dramatic improvements thanks to innovations in technology and infrastructure design. Here is where LiFi can have big consequences in traffic situations. Radar also helps. However, radar communication only warns a vehicle that there is a problem ahead; radar does not provide communication between the cars in a swarm logic.

Here is an example of the difference. If one driver slows down, GPS and radar tell the next car to slow down as well. Subsequently, the next car gets the same message from the car in front and so the signal travels through the lane of cars on the highway. It is more efficient than with human drivers at the wheel. But it is still a step-by-step response to an incident. LiFi communication is very different: the moment that one car has to brake because a deer crosses the road, that car instantly communicates—at the speed of light—to all cars behind and around. All cars know at the same time what is going on and can adjust their course. That is exactly how we see flocks of birds instantly change their patterns. LiFi also realizes every child's dream: all cars waiting at the red light

can instantly, at the same time, accelerate when it gets green. Imagine how much efficiency that brings to city traffic!

Because LiFi systems can receive and send all relevant information can also help manage the danger of moving vehicles in tunnels in the mountains or under rivers. It is not unusual for the engines or the brakes of trucks and buses to overheat in the mountains. That can lead to tires catching fire and, when that happens in tunnels, it creates very dangerous situations. Tunnels suffer from a shortage of oxygen, that means that any heat source turns into a charcoal production unit, creating havoc inside at 1,000 degrees Celsius. It happened before in the Swiss mountains, and it will happen again. For example: trucks and buses are obliged to have their brakes checked before they drive through the long tunnel under the Mont Blanc connecting France with Italy. The drivers may be requested to wait for hours to cool down the brakes, and to ensure that the risk inside is managed with a limited number of heavy vehicles. It is very easy to install heat sensors in addition to any LED with LiFi drivers and models in tunnels connected over the existing cable system and trucks and buses can be swiftly informed long before a dangerous situation arises. On top of that, the exact position of each vehicle is known thanks to the LiFi geolocation in a space where everyone agrees: GPS is not practical. In emergencies, cars can easily be directed to move people out of dangerous situations.

LiFi brings more efficiency and safety to the emerging world of the driverless cars but ultimately the technology offers a different and more human way of organizing society. Today, Uber-kind of apps show where cars are and how quickly they can come and help you to get from one place to another. In a LiFi environment

these services can be integrated with information of traffic situations, but also with the needs of people. In emergencies, cars can easily be directed to move people out of dangerous situations. The integration of all information in one network for the common good, will not only reduce fatalities in traffic and increase efficiency, it will also improve mobility and better serve the needs of the people.

LiFi

Chapter 10

The Internet of people

25 years ago, the Internet was an inspiring experiment in democracy. The technology to link computers to communication cables had been developed for military purposes. However, the marriage of the computer and the telephone turned into a revolutionary new platform of the people, by the people and for the people. Pioneers everywhere developed connections and software to link people. If you had a computer and a telephone line you could "dial up" and participate in a booming conversation around the world. People started to post their research papers, offered their products and shared their visions and dreams. It was a remarkable example of democratic co-creation. The World Wide Web was born.

In the early 1990s already some 1,000 research institutions around the world had powerful enough connections to allow for online video conferencing. By 1995 that number had grown to about 10,000. That rapid growth turned into an explosion in 2003 when Skype was introduced as a platform that everyone could use at no cost provided you had an Internet connection. Video conferencing allowed us to add our visual selves to the exchange.

With more and more information as text, data, photo and video

posted in the new online universe, the need for some kind of organization structure arose. People wanted to be able to find the information they needed. The wanted to "search". Early pioneers jumped on the opportunity to offer that service. In 1990, Archie was introduced at McGill University in the United States as the first "search engine". Then came, among others, well-known names as Alta Vista and Yahoo. And in 1998, two entrepreneurs in Silicon Valley founded a company with a strange name: Google.

At first, the search service seemed simply useful, helpful and efficient. But then clever entrepreneurs began collecting the data. We could have realized what was going on when Yahoo and Google began offering free email accounts with abundant storage. In the early Internet days, we bought monthly subscriptions to go online. We had to pay! Suddenly, access to the Internet became free. Or, at least, it seemed like that. We were going to pay in a different way: with our data. The search companies turned our data into their revenue. Initially, we were unaware of the process but our behavior began to be deeply studied and intensely analyzed. Data mining became a science.

The arrival of the smart phone in 2007, accelerated the trend. It allowed the search companies—by now Google already dominated the market—to follow users with their targeted advertising 16 hours or more a day. They used "algorithms"—a set of rules that precisely defines a sequence of operations, according to Wikipedia—to make sure that they would personalize content as much as possible to our liking. If we like one story, Google would make sure that we would see a similar story to keep our attention and to make sure that we keep seeing their ads. The age of distortion had begun. From the "objective" newspaper front

page that presented the news selected by a group of editors, we had arrived in a world where the news was presented as a confirmation of our already held views. What we think is today's news, in many ways has become Google's selection of the news we like. Including the always available opportunities to hack—as discussed earlier in this book—election outcomes are now at risk as we have seen.

Meanwhile, Google and platforms like Facebook and Amazon that copied the algorithm magic became outrageously wealthy using our personal information as well as public information that is not theirs either. Google does not know when an airline flies from New York to Tokyo, nor does the search company know which hotels there are in Tokyo or what is the best metro line to get from the airport to that hotel. Google does not know either what is a good restaurant close to your hotel. In short: Google hardly knows anything. However, the search engine knows one thing very well: how to find the right information. The company uses a process called "API" (application programming interface) to automatically access information wherever that is available. Google went to the airlines and said: give us access to your schedules and we make sure that people book more flights with you. They went to hotel chains and to towns and cities. They got automatic, unlimited access to schedules, maps, lists, opening times of offices, names of doctors in hospitals, schools that welcome applications, etc. And Google does not pay for all that information. It "pays" with the story that all institutions that provide information will benefit from doing so: airlines get more customers, restaurants more clients, cities more tourists… It is a true story but it is strange that, in the process, Google makes

massive money using data that is not theirs. The multinational company does not even pay (sales) taxes in most countries!

A frightening future is rapidly arising where a handful of companies will control 90 percent and more of all available information. Whenever a new online initiative emerges that show some success in capturing part of the market with a new service, it is quickly bought by one of the giants bulking in cash. The old days of seed money, first and second round investment in a start-up is cut short: millions and even billions are offered so that everything that could create a dent in this hegemony is put under one of the few roofs.

The very World Wide Web that started as bottom up people's initiative has become a top down structure dominated by a few corporate giants. We used to have steel and railway barons, now we have online kings that are even more powerful. In that respect, the current political debate in the United States about "net neutrality" is of critical importance. There is much at stake. When lawmakers give in to the wishes of telecom and online corporations and allow them to manipulate the ranking of search results based on which advertiser pays the most, democracy is completely in peril. Then the experiment in democracy that started 25 years ago will have ultimately failed.

Even if lawmakers do the right thing and protect the privacy of the public with regulation, the Internet giants find their ways around them. The European Union offers its citizens privacy and protection of their data. However, everyone who uses Google in the EU "clicks" these rights away when they accept that long screen of "terms and conditions" in small type. The mining of data that belong to people and to the common good continues

in the interest of a few billionaires while, in the process, no taxes are being paid.

Many people don't care. They are happy with all the online services and opportunities, and information and music at their fingertips. However, there are growing concerns. Edward Snowden and Wikileaks have shown that information gathering goes well beyond what a reasonable citizen expects to be necessary to maintain security in society. Increasingly, in surveys people rank privacy as a higher concern than nuclear war.

Against this background, LiFi offers a big opportunity to go back to the drawing board and determine how we want to share what when we connect online. Today we cannot imagine any other online environment than the World Wide Web. Information "lives" on a website that is hosted by companies that are part of or related to the emerging data monopoly. But if we begin to re-imagine online communication, it is quite possible to design a different digital experience. It is possible to rethink Big Data, and perhaps even be as ambitious to imagine a democracy free of the mingling of special interest groups that operate within the algorithms to gain an election.

Most information people use and search for is local. Where is the hospital? Until what time is that store open? Which metro line brings me to the football stadium? More than 90 percent of search queries is purely local. Why is it necessary to access that kind of information through servers and a global online structure operated and dominated by multinational companies? How would it be if cities brought the information of local services and businesses together in a local information network that is based on the existing public light infrastructure? Why would not local

networks serve local needs and make sure that money stays in the community instead of flowing out to Internet companies in other countries?

The answer is, of course, that until now there was no alternative. The World Wide Web is the only thing we have and it is good. If it helps local business to increase revenue, then why bother? But with the emergence of LiFi the situation changes: there is an alternative. And it works! Cities can provide a publicly owned information network based on the existing public light infrastructure and local software entrepreneurs can use that network to offer local services to local businesses. If in Paris, ask the Parisians which is the best restaurant and if Alain Ducasse wants to promote his three Michelin star places, then let him pay to be ranked first. That money can be made in and stay in the community, and it will even be self-evident to charge taxes on the value added to income. There is no deal with Ireland, or tax shelter in the Caribbean. That local network only works when you are, literally, in the light of the city. Your smart phone connects to the LiFi network as a separate network that is not connected to your regular cell phone service network. You cannot access that network when you are in another country. But that is not a problem: when you are in another country—or even in another city—you don't need to know how which metro line takes you from the railway station to the football stadium.

The new LiFi network will be very attractive to local business. As we saw before, LiFi's highly precise geolocation services make it possible to direct people much more efficiently than current GPS based services. And the local entrepreneurs who would create the software to open up the LiFi network, will make sure that they

offer their better services at a lower fee than Google. It is will not be hard for local stores to discover the advantages of the new network. Imagine for a moment that Paris and a few other cities offer this in parallel. Google should welcome this local competition that will stimulate citizens to choose and will offer opportunities to differentiate.

Moreover, the local LiFi network is set up with new local government rules that protect your privacy and safeguards that your personal data remain yours. That means that when a doctor sends your prescription to the local pharmacy that your health data will not become available to pharmaceutical companies, exactly as the data protection law intends to do. We should keep matters very clear in mind: if the data flows from any device over light, there is no Big Data. It will not take long for this to work, with a smart David-like approach: change the rules of the game.

LiFi opens the door to an online renaissance. Based on the public light infrastructure owned by and governed by the local government, local businesses and facilities can be supported with new local entrepreneurship. That leads to more local economic development and money that circulates in the local economy. More local connections means more sharing and more participation and more democracy. That means a healthier community energized by more democracy. LiFi can revitalize the original online dream.

LiFi

Chapter 11

The first 100 cities

Throughout history monopolies have collapsed as new spheres of influence and new technologies emerged. Emperors and kings have experienced that truth. Steel barons and landline phone companies no less. Today we live in an online communications universe dominated by a handful of giant corporations. When we look into the future we can see a continuation of mergers of technologies. We can begin to imagine the blending of smart phones, virtual reality, blockchain and artificial intelligence will transform society. And we can easily think that that transformation will be led by the same online superpowers that already dominate our lives today. But that may be a mistake.

A new technology is rising and with it a void that is waiting to be filled. The merger of LiFi communications with LED lighting technology provides a tremendous opportunity for a new wave of bottom-up economic development led by a new breed of entrepreneurs. As we have seen, there is one outstanding feature that marks this new trend: the infrastructure is already available and paid for. There is no need for massive infrastructural investments that drive concentration of power from the start like hundred of

thousands of antennas or thousands of satellites. And, precisely because the infrastructure already exists, there is an opportunity for a well-known institution—that is traditionally hardly expected to drive major change—to play a key role and unleash an entrepreneurial wave of local economic development.

Most public light infrastructure is owned by cities. In recent decades, cities have lost much appeal as confidence in government declined around the world. Today, most people trust companies more to deliver the services they require than they expect their governments to serve them well. LiFi offers cities the opportunity to re-energize communities and rethink how to ensure citizens' participation, even inspire them and involve them. Using the existing public light infrastructure, local services and local businesses can be connected in a city-owned communications network that serves citizens better and cheaper than the current global advertising and Big Data driven World Wide Web.

The start is easier than we think, provided there is a political will to upset the status quo and embark on programs that are the design and the building of real Smart Cities that can do more than put a WiFi antenna on a public light pole in order to read the water and power meters in the houses. Cities around the world can easily embrace LiFi and roll out initiatives that have been proven to save energy, to improve health, to speed up Internet and to redefine the concept of Big Data at the service of citizens and the common good.

The system has been tested. A city can begin—like Paris has already started doing—to offer LiFi in an underground metro system. How many metros are not urgently in need of changing their lights? How many undergrounds are not capable of guiding

a newcomer (like a tourist) or a visually impaired through the maize of tunnels, and elevators? Paris has proven that it is possible to allow blind people to travel, find a toilet when needed without asking anyone, and even facilitate them to get in an elevator. There are 160 metro systems around the world, New York has the most stations, Beijing the most passengers, and Shanghai the longest lines. If the Metro of Paris has embraced LiFi, one could expect that at least ten percent will be keen on following this example. That requires an investment of approximately 500 million dollars.

Cities should take the lead in offering all citizens an exciting new online experience. Gamers will declare the cities that lead this, their favorite place to live, work and play. Gamers who may have been known for a rather reclusive life style, will come out of their comfort zones and share the space that is public, and yet thrilling fast. Installing LiFi in local hospitals protecting ill people in need of healing from excessive radio waves is another logical early step for any city. The example has been set in a hospital in Perpignan, France. In other words: cities around the world can copy technologies that have already been proven to work. So how many cities would be prepared to embark on the hospital conversion? Could we imagine a thousand? Actually the strategy to convert the hospital into one that is within the WHO standards is a "plain vanilla deal", or should we call it a "copy paste" situation. Ideal, since anyone who is keen to learn how it does work, simply goes to Perpignan and talks to the pioneer customers who have done it.

The challenge will be that there are no clear standards and no regulations for a new technology like LiFi. Cities are expected to offer tenders for new projects but tendering does not work when there are no clear specifications yet. These specifications are the

reason why often innovations do not go to market fast enough since some technical code has been written into the process and changing that would be tough especially since the experts themselves have no experience in the innovative technology. Now that the RATP, the company managing the Metro of Paris has decided to equip all 250 plus subway stations with LiFi and is replacing 200,000 lights with LiFi enabling LEDs, why would any other city have to repeat the learning process?

The best way for LiFi to cut through this obstacle is by focusing on delivering the services that cities should be delivering but are not delivering. Guidance for the blind in metro systems, for instance. LiFi offers a great solution for that need and that may help overcome the administrative challenges.

However, when services are not being delivered—in most cases—that also means that cities do not have a budget for them. The good news is that the investments in the creation of LiFi networks for public service has two sources of revenue: first a major chunk (if not all) can be paid for out of the energy savings of replacing existing public lighting with LED lamps. The calculation can be done by anyone: how many lamps, what is the cost per lamp and the cost of the installation, the energy savings in kWh, and when we know the rate to be paid to the power company then there is a budget. Still, there is a hurdle to overcome: the initial payment for the installation of the LED lamps implies cash up front. The savings trickle in over the years. It is an investment that is easily earned back but it begins with the payment of some substantial bills. The Metro of Paris looks at an initial bill of €25 million. Now Paris has enough cash reserves and funding to undertake this, but still, if there is another way to get the process moving without having

the impact the balance sheet, then the decision will be quick and pragmatic.

That is where the "100 Cities LiFi Project" comes in. Don't worry: this is not the next global initiative that will fail under the heavy burden of administration and bureaucracy.

LiFi is a people's technology that will find acceptance and enthusiasm through their bottom-up people driven initiatives delivering essential community services. But one city is only one city. And even a 25 million contract does not mobilize large, solid and patience capital. And the financial challenge will be the same regardless which city is involved. As we have noted, the energy savings of a LiFi-enabled LED infrastructure are up to 70 percent, and with the new services added that can increase to 90 percent. That makes the installation of LED lamps a priority in the response of (local) governments to climate change. After all, cities are keen to implement the Paris Accords which were agreed by nations, but which has no concrete strategy, and certainly no chance to enforce anything.

The European Union recently established a public-private innovation partnership—Climate-KIC (Knowledge and Innovation Community)—to support local governments with the transformation of energy policies to mitigate the impact of global warming. LiFi offers Climate-KIC a very concrete platform to serve its mission. And Climate-KIC has already started conversations with a dozen cities in Europe about the short-term installation of LiFi networks. Please note: short term. Installing LiFi networks can be done within months rather than in years. That fact leads to a major additional advantage: the benefits of LiFI can be experienced in a year or so after the initial decision to instal a network. That means that local

politicians—who are always facing a next election soon—can show short term results. That will be a powerful driver for the success of LiFi. The focus is not on the installation of a technology, the focus is on the provision of services.

And this is the second source of financing. Subways have agreements for advertising and that is likely to continue. Subways have busy networks of shops in and around the metro that provide services. The LiFi network permits all of these services to go online, without having to pass through a service provider, without having to use any search engine. It goes direct and personal and secure over the light system. With more than one and a half million commuters traveling through the Paris Metro every day, and an estimated minimum of 100 connections of the personal device from a headset, to a tablet or smart phone, offers an insight in the amount of Big Data collected just from the basic movements. Apart from the energy savings, there is a vast array of new services which will be deployed over time creating an entrepreneurial culture that will transform public transport as we know it. This offers multiple revenues for the Metro provided it invests in the server network and the software systems.

There is a third source of funding: the increase in asset value. Indeed, street lights are a cost, and tax payers are ultimately responsible for the financing. Public transport is a cost, and the investment in subsidies per passenger is high, and yet it is done because if people would not sit in the metro, train or bus, they would be clogging the roads to the point of collapse. However, thanks to LiFi, there is a new value that can be given. Public light becomes an asset instead of a cost. And when you have assets, you can get financing.

Cities brought together through initiatives like Climate-KIC enjoy opportunities to meet the financial challenge. As we have described, LiFi provides a solid investment without risk on the technology side, without doubts on the performance and the platform for revenues. And, LiFi offers a long term stable return backed up by energy savings with lamps that will last a quarter of a century. This is ideal for institutions like pension and impact investment funds. Risks are low as the proof of concept has already been established. It becomes even easier when cities jointly team up for the financing of the investment.

Many big financial institutions do not want to undertake one-off projects they know very little, or even nothing about. They prefer to make one decision of 500 million than two decisions of 25 million. After all the process is exactly the same, just add a zero. So financiers like bigger investments better than smaller ones. They like deal flow—one project after the other executed under the same conditions. Instead of one city needing 20 million dollars to install LiFi in a metro and/or in hospitals, 100 cities may need 2 billion dollars. And that could very well be an easier investment because the investing fund can now claim that major carbon emissions—and financial—savings can be realized. It cuts on red tape, and reduces the cost of administration.

LiFi will find its way into the world through a lose global network of cities that will lead the introduction of the technology with a clear focus on the common good. The early leaders are already lining up from Roubaix in France and Kortrijk in Belgium to Taipei in Taiwan, Sydney in Australia and Rafaela in Argentina.

The introduction of LiFi networks allows local governments to revitalize their communities. The emerging new technology will

unleash a new wave of entrepreneurship as cities open a new public network to offer new services and the pioneers may well be the gamers and the hackers whose skills have now found the common good as a purpose in life, and a profession for the future. The visually impaired will be integrated more as they will be able to use public transportation, and that sends a positive signal to every household. Public lighting will become such an important component of the city's services that it will be installed everywhere making the city more accessible, peaceful and safe. The city will be more interesting and easier to navigate as information for travelers and consumers will be always readily available. The socio-economic cohesion of the city will increase as the new LiFi network strengthens local businesses and services. Cash circulates locally.

Local LiFi networks will create and support community through connecting citizens and local businesses in new and more direct ways. People in LiFi cities will discover that there are other ways to connect than through the online services of giant multinational companies. They will discover that they can protect their privacy while still enjoy the benefits of online communication. The ultimate message of LiFi is the reawakening of the original online dream of networks operated by people and for people in the interest of the common good. This allows citizens to tackle vast problems that were not resolved, This permits everyone to participate actively, This permits us to transform 100 cities at a time. Welcome, the Internet of People.

LiFi

EPILOGUE

This book is only the very beginning, but it sets the stage. It started with a re-discovery of an invention of the 19th century, and ends with a view of a horizon beyond anything that we can grasp today.

The goal is not to predict the next unicorn. Certainly, the strategy is not wealth accumulation. The opportunity is to serve the common good through doing good business with a great new technological platform. The way forward is to inspire city mothers and fathers and young entrepreneurs to create an environment that is conducive to serving progress for all. That is the success we plan for.

A special effort will be made to cluster and pool technologies of all sorts into a hub of innovation that will change the way we communicate. The objective is to communicate and connect with a conscience about the impact on people and planet, with a clarity of the benefits LiFi can bring and an awareness of the opposition this new platform will face.

There is no doubt that LiFi will serve the unreached—from the blind in our societies to the orphans in Africa, and the schools without electricity or Internet in Latin America. The LiFi opportunity requires an exceptional generation of social entrepreneurs who believe in the common good.

LiFi has to power to reach the unreached, but it also carries the potential to change the course of Big Data. We need people who will join to make change happen. So let us connect and unite our efforts. We have a long walk ahead: it is better to proceed hand in hand.

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The Fable of LiFi

Over the past 25 years of engagements in innovations I have taken the habit of translating each transformative breakthrough into a fable. If we do not inspire children, then it will be impossible to mobilize the next generation to pursue the work that we have initiated but can never complete.

Here is the fable on LiFi, that is available to all Chinese students as of 2018. Now that the Chinese children know that Internet over light is a fact of life, it is our duty to expose children everywhere else to imagine their novel internet service. If their parents to not facilitate it, then the next generation will simply do it!

At the Speed of Light

A family of fireflies gathers in the evening, happily showing off their power to create light. An owl is watching this spectacle.

"Did you know that people are now making light that does not make any heat?" Owl asks the fireflies. "They call it 'el-ee-dee' light, or LED."

"What is so new about that?" asks a firefly elder. "We have been making cold light from the time we first came into this world."

"Well, that may be true," Owl responds. "But you do not use it to illuminate streets and homes. Now people even use light to send information."

"So, what is new about that? Before there were radios and phones, people already knew how to send information by using light."

"Yes, but the beauty of it is that now people can have cold light and access to lots of information – at the same time."

"Now it is getting interesting," the firefly elder says. "Does this mean that when people go to sleep at night and switch off the lights, they will also switch off the internet?"

"Absolutely, and that will put a stop to harmful internet pollution. At least people are now doing more than one thing with what they have," Owl replies.

"This means that people now use light in a way that is cheap, safe and uses very little energy. On top of that it is also used for sending information. Yes, they are getting smarter all the time."

"Just imagine, a movie of two hours long being sent to your computer through a ray of light in only thirty seconds!"

"That much? And so fast? Does it not cause a lot of pollution?"

"Pollution is when there is harm caused by having too much of the same. You can have noise pollution when there is too much sound, like making lots of noise playing the radio and sending out information. This would be stressful for those who do not want to listen to it. But light, it is hard to have too much light."

"How much light can you see, Mr Owl?" the firefly asks.

"What a strange question. Of course I can see only what you can see."

"Not true! Here is a surprising fact for you: There is light that you cannot see, but it can still transmit data."

"Light that I cannot see? That must be very efficient. The best thing about this is that I can go to bed and sleep in peace – while there is information swirling around my head at the speed of light!"

Without light there would not be life. But light will change the world once more. In 1880 Graham Bell made—in his own words—his greatest discovery: the photophone. Bell succeeded in transmitting sound over the waves of sun light. Bell's problem: the sun does not always shine. 125 years later French physicist Suat Topsu was able to apply Bell's innovation to LED lighting and LiFi—Internet over light waves—was born.

LiFi is much faster. It is healthier because it does not interfere with our bodies. LiFi cannot be hacked and it does not require massive investments: the public light infrastructure already exists! Cities can save money replacing lights with LiFi enabling LED lights. LiFi also offers an opportunity to redesign online communication in the interest of the common good. While the Internet of Things is fast emerging, LiFi points the way to an even more exciting future: the Internet of People.
More information: www.theblueeconomy.org
To order books: www.jjkbooks.com

GUNTER PAULI (1956) is an entrepreneur and author who embraces groundbreaking and pioneering initiatives. His latest book, The Blue Economy, has been translated into 43 languages and has reached over a million readers. While The Huffington Post named him the Steve Jobs of sustainability, his Latin American friends often refer to him as the Che Guevara of sustainability. The 12 trends in The Third Dimension are based on his work with over 200 projects in every corner of the world in the past 25 years. Pauli surfs the waves, intuitively thriving on the transformative and unstoppable trends that no statistics or big data seem to identify

JURRIAAN KAMP (1959) left a successful career as South Asia correspondent and chief economics editor at the leading Dutch newspaper, NRC Handelsblad, to found the "solutions journalism" magazine Ode which was later re-named The Intelligent Optimist. In 2015, Kamp launched a daily online solutions news service, The Optimist Daily. Kamp has regularly come in ahead of the curve on stories that advance new visions of our world including a solutions-oriented, optimistic approach of the challenges of sustainability.