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Presenting the (economic) value of patents nominated for the European Inventor Award 2012

Inventor file John O´Sullivan

1. The invention

1.1 Historic account

There is a general observation that only few universities and research organisations across the world are able to successfully commercialise their R&D by patenting and licensing their technologies, in particular to a scale of several hundred million dollars. One such exception is CSIRO, the Commonwealth Scientific and Industrial Research Organisation in Australia. A research team led by John O´Sullivan developed and patented the core technology of Wireless Lan ("WLAN") or Wireless Fidelity that is today in use in billions of devices. It is also an interesting story as it starts out with research on black holes and radio astronomy and ends up in a courtroom in Eastern Texas.

Stephen Hawking, the world famous physicist, postulated in 1974 that black holes might not be that black after all. Black holes are typically thought to develop when heavy objects such as stars gravitationally collapse. Under specific conditions, the internal pressure of the star cannot counter gravitational forces (e.g., when the star has run out of fuel at the end of its lifetime) and the star´s mass is crunched into an object of such little size that within a certain range nothing, not even light, can escape the gravitational attraction of the star. Any light that would hit a border region of the black star called event horizon would be absorbed. The hole would be hence not emitting any light or radiation and be perfectly black. However, Stephen Hawking´s theoretical work indicated that due to quantum effects at the event horizon there would be some radiation present, hereafter called the Hawking radiation.

The quest was now on to detect this characteristic radiation. It happened that exactly in the year Stephen Hawking postulated his theory about radiating black holes a young scientist by the name of John O`Sullivan received his PhD in electrical engineering at Sydney University, Australia. Following this, Dr. O´Sullivan accepted a position at the Netherland Foundation for Radio Astronomy (now ASTRON) and became head of the receiver group.[1]

Dr. O´Sullivan recounts these times:

> *"There were a number of research groups trying to find evidence for the Hawking radiation. We used complex technologies, finetuned radio telescopes, improved spectrometers and recorded hundred of meter of film….but although we looked at the characteristic traits of the signal, we did not find the smoking gun….however, while working with the data and the equipment it occurred to me that there should be ways to better, more effectively and efficiently process the data through a digital hardware which would perform Fast Fourier Transformation (FFT)"* (John O´Sullivan)

FFT was a possible solution to the need for a technique that sharpened and improved picture quality in radio astronomy pictures, which were hampered for example by multipath interference2.

In 1983, Dr. O´Sullivan returned to Australia to head the Signal Processing Group at CSIRO Radiophysics. CSIRO "…is Australia's national science agency and one of the

[1] http://www.csiro.au/people/John.Osullivan.aspx

[2] In radio transmission, *„…multipath refers to the simultaneous reception of two copies of the signal, that arrive via separate paths with different delays. A common example is when a signal bounces off a building or other object and is received along with the direct (unbounced) signal. In television reception, this causes "ghosting" -- one sees a faded echo on the screen horizontally displaced from the main image."* (see http://www.maxim-ic.com/glossary/definitions.mvp/term/multipath-interference/gpk/977)

largest and most diverse research agencies in the world." In FY 2010, the agency had some 6,500 staff and 57 research locations across Australia and abroad. The research topics are quite diverse but share a common goal system. These goals are defined by law and include *"…to carry out scientific research for assisting Australian industry, further the interests of the Australian community….and to encourage or facilitate the application or utilisation of the results of such research."*

This application-focus rationale of CSIRO led the then superior of Dr. John O´Sullivan to ask the scientist and his team to find commercial applications for their know-how and research results they had produced. The group consisted initially of five persons with an interdisciplinary background: Besides John O´Sullivan these were Graham Daniels, Terry Percival, Diethelm Ostry and John Deane. The team had thus specialists in physics, mathematics, signal processing, system and control systems, network protocols and, of course, radio astronomy. All these experts eventually became co-inventors of the WLAN patent and Dr. O´Sullivan underlines that "…the invention was above all a team effort."

From 1983 on members of the team worked on a number of projects in areas such as underground mining, satellite communication, medical applications and also wireless communication. In 1988 the team had built, in collaboration with a private Australian chip manufacturer, a first chip for FFT. By 1990, the research group evaluated all on-going projects and decided that the WLAN project was the most promising:

> *"At that time, wireless LANs already existed, so we did not invent wireless networking per se. However, the performance of the available WLAN solutions was mediocre. We wanted to have a WLAN system that would be as powerful as the then existing cabled solutions. This meant that we would need to reach transmission rates of 100 mbit per second. Such transmission speeds were way off what could be achieved with the then available technology, it was a far stretched goal but it forced us, it challenged us to think out of the box. There were many problems that needed to be solved, but in essence it turned out that the problems we had to solve in radio astronomy back then with the black holes and later with the WLAN were remarkably similar, and FFT was a key component of the upcoming solution."* (John O´Sullivan)

Eventually, in 1992, CSIRO filed a provisional patent application in Australia for the invention and one year later, patent applications were filed in the U.S. and elsewhere. After the patent application was filed, two developments were pursued: On the one hand, CSIRO searched for a commercial partner for the technology. On the other hand, efforts were made to bring the solution closer to market. Collaboration with Macquarie University in Australia intensified on this topic (the research group was already collaborating with them before), and the CSIRO research group grew to eventually some 10 to 12 people. The focus of the research was the creation of a test bed and to eventually arrive at a functional chip, which would implement key components of the WLAN invention.

In 1995, Dr. O´Sullivan left CSIRO to work for News Limited as Technical Director. He eventually returned to the WLAN field when in 1997 the U.S.-Australian firm Radiata, Inc. was set up. Radiata Inc. had the specific task "…to turn the Intellectual Property and the results of the CSIRO testbeds into a workable chip." (Interview Nigel Poole from CSIRO) The establishment of Radiata followed a period of uncertainty, where all attempts to find a commercial partner failed. The agency had some non-disclosure agreements (NDAs) signed, but nothing really materialised. And while there was considerable interest in WLAN technology, there were around 20 research groups in the world hard at work on solving the problems surrounding wireless networking, and it was not that clear what would happen with technology developed by CSIRO. Backed by strong belief in the IP, the decision to push forward was an ambitious one.

Dr. O´Sullivan took the position of Vice President Systems Engineering at Radiata. CSIRO licensed their patents on a non-exclusive basis to Radiata as part of a

technology-development transaction, and between 1997 and 2000 the firm succeeded to build the first chips compliant with the newly ratified IEEE 802.11a standard. Radiata was eventually bought by Cisco in 2001 for a price of around US$ 300 million, while it still had only about 25 employees.[3] Against this backdrop, Dr. O´Sullivan found himself to become an employee of Cisco, where he had the position Director IC Systems Engineering.

At this point, the story behind the invention of Dr. O´Sullivan and his team could already be considered a big success. However, there followed a well-executed IP and licensing strategy, involving also the enforcement of the patent rights in the U.S. The rationales and background to these developments are explained in section 3.1 in greater detail. As far as Dr. O´Sullivan is concerned, he eventually moved on from Cisco to a firm called G2 Microsystems in 2004, only to return back to his roots at CSIRO in 2005 to work in the Australia Telescope National Facility on radio telescopes.

Throughout his career, Dr. O´Sullivan published more than 40 scientific and technical papers, was granted 12 patents in the area of wireless networking, FFT processors and antennas. In 2009, he received the CSIRO Chairman´s medal and the Australian Prime Minister´s Prize for Science for his achievements.

1.2 Technological features

While there are many aspects to the WLAN technology, the key patent in question is the technology described in U.S. patent number 5,487,069 filed on November, 23 1993 and granted on January 23, 1996. This patent *"…discloses a wireless LAN, a peer-to-peer wireless LAN, a wireless transceiver and a method of transmitting data, all of which are capable of operating at frequencies in excess of 10 GHz and in multipath transmission environments. This is achieved by a combination of techniques which enable adequate performance in the presence of multipath transmission paths where the reciprocal of the information bit rate of the transmission is short relative to the time delay differences between significant ones of the multipath transmission paths. In the LANs the mobile transceivers are each connected to, and powered by, a corresponding portable electronic device with computational ability."*[4]

Put in simple terms, the patent assesses that for high data transmission rates a number of problems such as multipath interference have to be overcome (a problem particularly paramount in indoor environments, where the radiowaves could reflect at various surfaces). The CSIRO researchers put the data on multiple frequency channels, at each of which the communication was slow enough so as not to be disturbed by the echoes caused by multipath interference. Breaking up the data across these streams and reassembling it at the receiver (such as a computer) would deliver high-speed wireless networking. This technology is used today by almost all Wireless LAN standards, except for the standard, which was originally the most successful (802.11b).

2. The market

The market for WLAN equipment[5] is large, and market analysts agree that further growth prospects are excellent. For example, market researcher ABI Researcher

[3] According to Nigel Pool from CSIRO, the exact value of the deal is hard to estimate because it involved the transfer of shares at a time when the dot.com bubble burst.

[4] Abstract from patent as indicated on http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=5,487,069.PN.&OS=PN/5,487,069&RS=PN/5,487,069

[5] The market for WLAN equipment addressed in this analysis includes access points, routers, gateways, wireless controllers and NICs such as PCI adapters, PC cards and USB cards)

expects a compound annual growth rate (CAGR) of 9% between 2011 and 2016.[6] The bulk of the growth is anticipated to stem from the enterprise segment (CAGR in the analysed timeframe: +21%), but even the consumer segment sector will see some 112 million units shipped by 2016. This corresponds to a 63% growth over 2010.

According to ABI Research in 2010, the number of WLAN Chips produced increased from 5.39 million in 2009 to 81.5 million in 2004, surpassed the 100 million mark in 2005 (158.8 million chips), surpassed the 200 million mark in 2006 (203.6 million units) and in 2009, 584.8 million ICs were produced. Forecasts between 2009 and 2015 anticipate a compound annual growth rate of 23%, leading to the production of eventually almost 2 billion ICs by 2015. Later industry research shows even higher numbers, estimating cumulative sales to date of WLAN products at about 3 billion units, rising to 5 billion units by the time CSIRO's WLAN patents expire in 2013.

In a white paper created by marketing research firm InStat, it is stated that

> *"…The quest for connectivity drives electronics manufacturers to enable their products with Wi-Fi technology. The next 5 years will see an increase in the number of Wi-Fi-enabled devices, from over 550 million in 2009 to nearly 1.7 billion in 2015. Devices that are leading adoption include mobile phones, Blu-ray players/recorders, e-readers, and digital televisions. New 802.11n-enabled devices will push the envelope in Wi-Fi capabilities, remedying many of the technical issues that constrained Wi-Fi adoption in video-centric CE devices in the past. As a result, we expect the adoption of Wi-Fi in the living room to accelerate. Across all "digital living room" consumer electronics, which includes set-top boxes, game consoles, Blu-ray players, digital picture frames, among other devices, Wi-Fi-enabled devices will exceed 200 million units by 2015. Mobile devices with Wi-Fi will still dominate shipments. In 2014, shipments of mobile phones with embedded Wi-Fi are projected to exceed 1/2 of a billion units. E-readers' Wi-Fi attach rates will increase from 3% in 2009 to 88% by 2014."*[7]

3. The role of patents and Intellectual Property Rights (IPR)

3.1 Motives and benefits of patenting and employed IPR strategy

3.1.1 The general approach

CSIRO has a central technology transfer office (TTO), which supports commercialisation of all research units. The office employs some 35 staff, 12 of which are concerned with licensing deals. The office follows a carefully drafted IP strategy, which has as goals a) to maximise the chances of the technology to succeed in the market place and b) to capture value for Australia. Against this backdrop, the TTO clearly states that there is no 'one-size-fits-all' approach for providing access to intellectual property, but has negotiated a wide range of licence types, as well as the sale or assignment of IP:

> *"The normal path is that a technology is jointly commercialised with a business partner, and we negotiate the terms and IPR ownership. Normally, this means that we own the patent and license to the partner exclusively…we have around 60 to 100 patents applied for per year, a*

[6] ABI Research (2011): Enterprise Demand Will Help Push Wi-Fi Equipment Market to 63% Growth in Five Years, April 26, 2011, http://www.abiresearch.com/press/3666-Enterprise+Demand+Will+Help+Push+Wi-Fi+Equipment+Market+to+63%25+Growth+in+Five+Years

[7] Kirstein, M. (2010): Wi-Fi Market Overview: Connectivity Becoming Ubiquitous, http://www.instat.com/promos/10/IN1005038WHT.pdf

> *figure, which has stayed constant for the last 20 years. Occasionally, commercialisation occurs also via start-up firms where we hold a share. Around 25 start-up firms have been set up over the past 10 years"* (Nigel Poole, CSIRO)

The TTO, however, only employs eight patent attorneys, and hence draws – where necessary – also on external patent attorneys. A key aspect of the tasks of the TTO is prioritising the IP. While some selected cases may be so valuable that several team members would work mostly on that case, other team members might deal with up to 10 different IP/licensing deals. A key decision in this context, which is reached together with the management of CSIRO, is to define the priorities according to the Australian needs (reflecting hence the goals of the organisation). For example, there would be a preference for collaborating with an established Australian business to ensure that technology is further developed and implemented both in Australia and through overseas operations. In the absence of any such partner, a start-up can be considered if it had the chance to drive the technology internationally and hence create Australian jobs. By contrast, if no considerable Australian market participation can be foreseen, it may be decided to license to a big multinational foreign firm, if this proves beneficial for the adoption of the technology. The return for Australia in this case would be in the form of scientific collaboration and potentially significant licensing revenue.

Against this backdrop, a key success factor is good IP awareness also at management level and the ability to decide on a case-by-case basis. Market know-how, i.e. knowledge of the relevant industry players, is the responsibility of the researchers as *"…they know their field best."* The success of the TTO work is measured only with a few, well balanced indicators such as number of patents filed, licensing agreements reached, adoption rate of technologies in the market.

The motives for patenting are not solely the creation of licensing revenue, according to Nigel Poole:

> *"There are two other important things to consider. First, it protects the downstream adoption of a technology to the market. If we were to produce for example a new drug, a big pharma firm, which we would license to, would have the time, opportunity and security to perform the necessary testing, validation, clinical trials necessary for market introduction which takes its time. And they would still be able to recover their expenses in the later patent life. The second reason is the signalling character of patents. It is, very much like a fence around a house, signalling competence, warning competitors to not enter the area and highlighting to industry partners that they have a professional partner to count on. This 'fence' is also a means to guarantee a long-term existence of competent research groups in our institution."*

3.1.2 The WLAN case

The case of the WLAN technology is intriguing, as this is one of the few examples where CSIRO did not have an existing Australian industry partner. There was considerable difficulty finding such a business partner for some time after the patents have been filed (see above). One of the reasons of lack of industry interest early into the process was that the technology was focussed on ambitious future applications. However, there was the explicit decision to further develop and commercialise the technology, despite this initial barrier. In 1997, the technology was non-exclusively licensed to the aforementioned start-up firm Radiata.

These chips in development by Radiata were supposed to implement the CSIRO technology, which was inherent in the then newly established IEEE standard 802.11a. Nigel Poole recounts:

> *"In the mid- to late 1990s, the standardisation body IEEE had working groups evaluate the existing technology for development of the 802.11a*

> *standard. They approached the patent holders of the technologies that were needed to implement the draft standard, including CSIRO. They sent us a letter asking whether we would grant upon written request a non-exclusive license under a non-discriminatory basis and on reasonable terms and conditions including its then-current royalties to entities wishing to implement the standard. Which is what we agreed to do."* (Nigel Poole and documentary evidence)

What the licensing terms meant was that whichever firm wanted to use the standard 802.11a, should have contacted CSIRO to take out a license and pay royalties at fair market value. What followed, however, did not meet the expectations of CSIRO from the agreement:

- Between 2002 and 2005, the first WLAN products (access points and cards to be plugged into notebook and desktop computers) hit the market. No firm approached CSIRO for a license in those years. Consequently, CSIRO decided to approach manufacturers with a copy of the IEEE letter, asking them *"…in a very friendly manner…"* that CSIRO wanted to talk to them about a license. The firms failed to take licenses, citing various reasons, many of which were not of a legal but commercial nature (such as that if they were to license from CSIRO, this would open the door for other patent owners who also would want to obtain royalties).
- By 2004, CSIRO became increasingly frustrated. There had been already tens of millions of WLAN devices sold, and projections indicated a steep upward trend with the possibility that WLAN would become an integral part of every notebook and mobile telephone. CSIRO reacted by writing a second letter to the various manufacturers asking them again to enter a licensing agreement. This time, the offer was that the earlier the firms would seal the deal, the less royalty was to be paid. Out of 28 approached firms, none agreed to license.
- In early 2005, CSIRO decided to take the matter to court and establish a principle and a precedent, preferably in the U.S., where most of the infringement was happening at the time. Eventually, in 2009, CSIRO was involved in patent litigation with 14 leading technology firms such as Intel, Dell, HP, Microsoft, Nintendo, D-Link and Netgear. Before the actual trial was concluded, the 14 firms agreed to settle, and around AUD$ 200 million were paid in licensing fees, mostly in upfront payments. With this settlement, CSIRO achieved that about one third of the industry licensed the technology.
- Since 2009, CSIRO has sued additional industry players making or selling infringing end products (such as computer makers and telecom and mobile phone service providers) and responded to suits from component makers (manufacturers of chipsets, which only partially implement the invention). By early 2012, CSIRO will have succeeded in totalling some AUD 450 million in licensing income from a series of patent litigation rounds and out-of-court settlements. 90% of the industry will have by then licensed the technology. This can be considered a tremendous success, not the least, as the U.S. Patent Office and courts have upheld the validity of the patent in their decisions.

There is still, according to Nigel Poole, *"…lots of leakage."* Some manufacturers, which integrate WLAN into their products, are so small that it is not worthwhile suing them. Another limitation is given by the fact that patent protection has been sought for only selected countries. There is hence no possibility to collect royalties from industry players operating only in countries like Russia, Canada, China or the Latin American countries. Yet another challenge is the complex international value chain in the industry, with manufacturers producing components or even end products in countries where CSIRO does not have patent protection. A partial solution to the latter problem was to sue those selling the end products in countries where CSIRO had a patent e.g. Telecom service providers which sell smartphones as part of their business model. However, CSIRO's license fee is charged only once per end product: *"Once one*

part of the value chain licenses the end product, all other elements become also licensed, either upstream or downstream." (Nigel Poole)

One may be intrigued to ask why CSIRO has been so successful in the Wi-Fi market and why so little additional litigation is seen, given that a) the electronics industry in general has a history of a considerable amount of patent litigation and b) the licensing terms proposed by the IEEE would also apply to other patent holders in the area. An answer to this question might be that the patent *"…is based on finding a non-trivial solution…based upon parameters set by the law of Physics over radio-wave propagation in this frequency range. "*[8] This means that the patent in question may be so fundamental that it is not possible to invent around it.[9]

Overall, Nigel Poole is satisfied with what CSIRO achieved with its patent:

> *"We believe that a public research organisation, despite being funded through public money, should not offer all of its research results to business for free. Doing that there would be some sort of 'free lunch' attitude, the firms would not value the technology, they would not consider the technology in all strategic aspects and they would engage in a behaviour where they would try to accumulate as much as possible for free….a good and fair price is a negotiated price…I believe we achieved a fair balance: Out of possibly 5 billion Wi-Fi enabled devices, we will have managed to obtain licenses for about 3 billion such devices….we did not achieve what we could have, but we have achieved something."*

By 2013, the patent in question will expire, closing this chapter of a successful story.

3.2 Patent statistics and patenting trends

The nominated patent EP0599632 – the European analogue to the U.S. patent described before – was applied for in 1993. In Europe, the patent has been granted for 13 countries. This was not the only patent family related to the invention filed by CSIRO or the Radiata team. The earliest application from 1987 was already concerned with the key component of the new technology, signal processing with FFT; this application was referenced in CSIRO's main WLAN patent specification.

Patent citations are one statistical indicator for patent value. The nominated patent family has been so far cited 96 times by other applicants. Citing applicants are AIRDEFENSE (U.S., 12 citations since 2003), Nokia (3 citations in 3 patent families between 1995 and 1997). 2002, one year after the patent was granted in Europe, had the maximum number of citations (14).

The IEEE 802.11x standard(s) have been created and constantly upgraded since 1999. The standard comprises a pool of more than 300 patents developed by 94 organisations. Contributing patentees include, for example, France Telecom (at least 12 EP patents), INRIA – Institut National de Recherche en Informatique et en Automatique (5 EP patents), TDF (4 EP patents), Panasonic (4), Nippon or Nokia. CSIRO accounts for only one patent – the one analysed – in the pool. Early patents are from the University of California (applied for first in 1979) or Apple (1985). Some belong to the founders of the Wi-FI alliance which was set up in 1999: 3Com, Alronet,

[8] Matthews, M. & Frater, B. (2003): Creating and Exploiting Intangible Networks: How Radiata was able to improve its odds of success in the risky process of innovation. Case Study prepared fort he Science and Innovation Mapping study oft he Department of Education, Science and Training

[9] Some people argue that because of this fundamental physical law aspect, there is only an indirect connection between the CSIRO work and the 802.11a WLAN standards. Eventually, the same solution would have been also found by someone else (Matthews et al., 2003). However, this argument is not quite clear because it is the very purpose of the patent system to reward the persons who come up with a solution to a problem first.

Intersil, Lucent Technologies, Nokia and Symbol Technologies. The alliance has now more than 300 members and has certified up until 2008 more than 5,000 products

Before the standard was created, in the timeframe of 1993 to 2000, there were 1,270 patent families applied for dealing with the subject of WLAN. After 2000, the number of applications dealing with WLAN – measured by counting the amount of documents citing WLAN in the titles, abstracts or claims of the patent specifications with different spelling – increased considerably. In 2005, there were 2,661 patent applications. In Europe, there are currently 1,132 patents on the subject of WLAN in force. The most important patent holders are Nokia (93 valid EP patents), Research in Motion (CA, 74 valid EP patents) and Siemens (71 patents).

4. Conclusions

The patent under consideration can be considered very valuable. Its success can be also measured in monetary terms and may be equalled to the amount of licensing revenue generated (AUD 450 million). The patent is also an example of successful public research commercialisation.

The following success factors proved vital for the success of the research:

- The team effort behind the invention and the inter-disciplinary nature of the team composition which triggered many fruitful discussions and led to the fact that problems could be viewed from different perspectives
- The trust provided to the researchers by their superiors Dr. Bob Frater and Dr. Stocker, as *"…they did not insist too much on pre-mature justification, despite of the undertaking being risky and needing considerable resources…hence the attitude of Bob Frater and John Stocker was a clear success factor"* (Dr. John O´Sullivan)
- The fact that the team set out with a very ambitious goal and has challenged itself to come up with something truly new.
- A well laid out and executed IPR strategy which did not fail at enforcing the IP rights