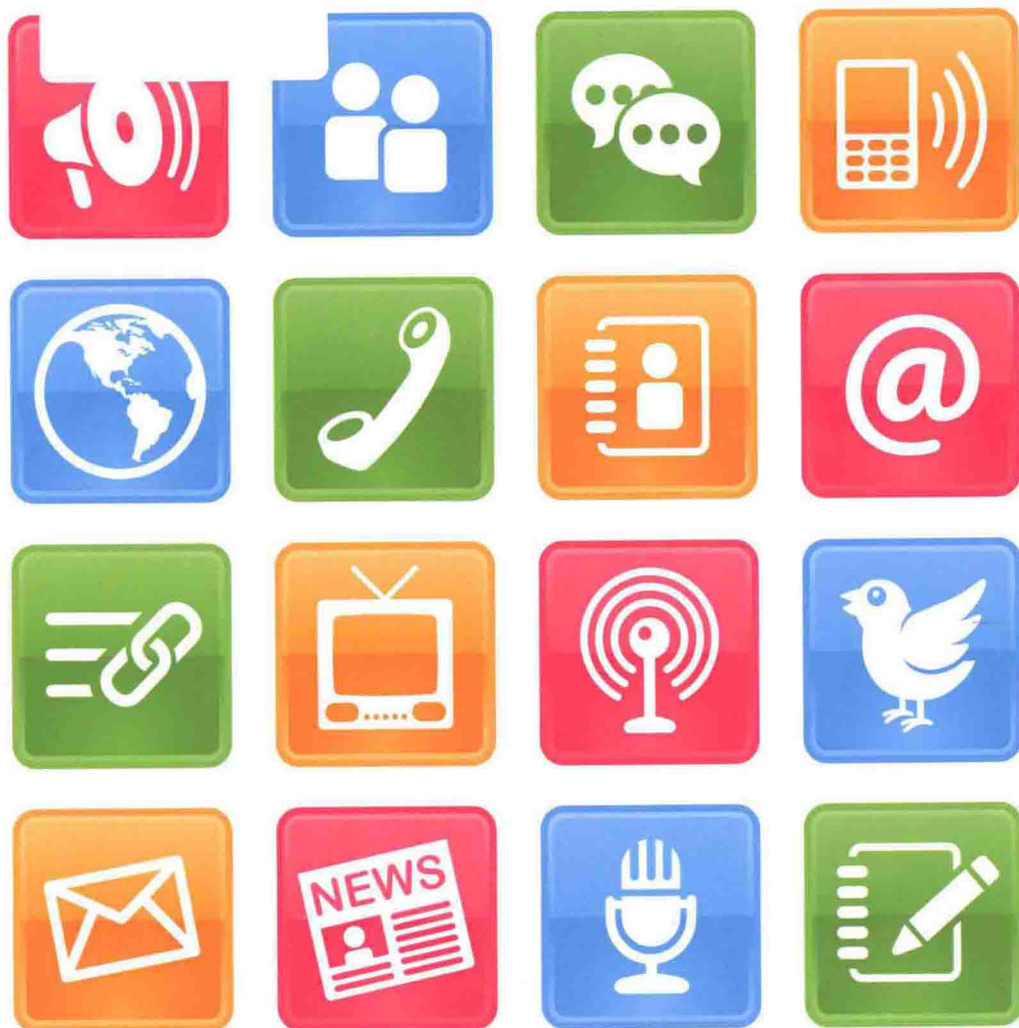


THE HANDBOOK OF Personal Area Networking Technologies and Protocols



Dean Anthony Gratton

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DEAN ANTHONY GRATTON



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The Handbook of Personal Area Networking Technologies and Protocols

This handbook offers an unparalleled view of wireless personal area networking technologies and their associated protocols. It lifts the lid on their growing adoption within the consumer electronics, home automation, sports, and health and well-being markets.

Bluetooth low energy, ZigBee, EnOcean, and ANT+ are comprehensively covered, along with other WPAN technologies including NFC, Wi-Fi, Bluetooth classic and high speed, and WHDI. It also features 802.11ac, the Internet of Things, Wireless USB, WiGig, and WirelessHD.

The handbook shows how white space radio, cellular, and femtocells have inadvertently blurred the boundaries between personal and wide area communications, creating disruptive topologies through technology convergence. It explores how pervasive WAN technologies have spawned a new generation of consumers through the Lawnmower Man Effect and explains how our personal space has become integral to social media streams, including Twitter, Facebook, and Pinterest.

An essential read for students, software engineers and developers, product planners, technical marketers, and analysts.

Dr. Dean Anthony Gratton is a bestselling author and columnist. Dean has worked extensively within the wireless communications R&D industry and has an accomplished career in software engineering. He was an Editor of the *Specification of the Bluetooth System: Profiles, v1.1*, and participated in defining the initial Bluetooth Personal Area Networking profiles. He was also active in the NFC technology and marketing committees. Dean is a contributor to several industry periodicals, where he has written many influential articles, sharing his thoughts and challenges on wireless industry news and opinions.

"Once again, Dean demonstrates his knowledge of the wireless standards landscape by providing a comparison of the many different technologies available. This is a valuable starting point for designers trying to unravel the complexities of the wireless world, helping them to determine the best option for their products."

Nick Hunn, independent consultant

**For Sarah, my darling wife and best friend,
“*you embody my hope and my immortality*”
– D.**

“You see, wire telegraph is a kind of a very, very long cat. You pull his tail in New York and his head is meowing in Los Angeles. Do you understand this? And radio operates exactly the same way: you send signals here, they receive them there. The only difference is that there is no cat.”

– Albert Einstein

“The future success of wireless technology rests upon it becoming as overlooked as electricity.”
– Dean Anthony Gratton

About the Author

Dr. Dean Anthony Gratton is a bestselling author and columnist.



Dean has worked extensively within the wireless communications R&D industry and has an accomplished career in software engineering. He has enjoyed a variety of roles and responsibilities in addition to being an Editor of the Specification of the Bluetooth System: Profiles, v1.1 (the original specification). He has participated in defining the initial Bluetooth Personal Area Networking profiles, and was active in the Near Field Communication (NFC) technology and marketing committees. His wireless research work has been patented.

Dean has developed, architected, and led teams across several new product developments for mobile phones, DigitalTV, Broadband (triple-play), femtocells, Bluetooth, Wi-Fi, ZigBee, NFC, and Private Mobile Radio.

Dean is a Community Editor-in-Chief for Eden (engageSimply.com) as well as being a popular columnist and contributor to a number of industry periodicals, where he has written many contentious articles sharing his thoughts and challenges on wireless industry news, opinions, and gossip. He continues to provide an authoritative published and vocal presence within the wireless communications industry.

Dean has become an influential social media persona (as @grattonboy), with an increasing Twitter following, and has been listed in the 50 “Top Dogs” of Twitter (bullsandbeavers.com). He is also listed as one of the “Top Marketing Book Authors on Twitter” in *Social Media Marketing Magazine* (smmmagazine.com), and is listed in the “Top 5” Twitter Elite in the United Kingdom, as rated by TweetGrader.com.

Dean holds a BSc (Hons) in Psychology and a Doctorate in Telecommunications.

You can contact Dean at thepanhandbook@deangratton.com and follow him on Twitter (@grattonboy) to enjoy his risqué humor, witty shenanigans, social media, and technology-related tweets. You can also read more about his work at deangratton.com and teamgratton.co.uk.

Making *My Book Social*

I have personally embraced social media for several years now and have been very fortunate in garnering some influential clout along the way. As such, I have become an influential social media persona myself as @grattonboy. I've been listed in the 50 "Top Dogs" of Twitter and have been regarded as one of the "Top Marketing Book Authors on Twitter" in *Social Media Marketing Magazine*.



Welcome to The Handbook of Personal Area
Networking Technologies and Protocols Twitter
account. Maintained by Dr Gratton aka
@grattonboy

↩ Reply 🗑 Delete ★ Favorite

Figure 1. The @ThePANHandbook Twitter account, where my book has its own brand, along with its own identity, to encourage engagement and to share thoughts, industry news, and gossip surrounding the technologies that are featured within.

So, I want to make *my book social*; I mean social in terms of *social media*. If you like, I want to provide my book with its very own voice and I would like my readers to engage and correspond with my book. Those who are fans of social media will understand the associated benefits and holistically believe in the encouragement of *brand awareness* and *brand identity* – after all, it's consumers like *you* that define our brands today. You see, social media has inadvertently opened a door. In fact, I dare say it has knocked down walls and barriers that have normally closeted and protected big name brands. It has enabled everyday consumers to engage in two-way communication with them, preventing them from hiding behind the doors of traditional monolog-based promotion and filtering their consumer feedback into fan mail to bolster their corporate egos. What's more, these same brands can no longer afford a monolog engagement, but instead fundamentally need to embrace engagement with their consumer-base through social media. As consumers, we have become vocal about what we want, and social media has enabled us to engage with the brands that touch and shape our lives – now we are empowered through social media to touch and shape *them*! I'm introducing my book as a brand with its own identity to encourage engagement and to share thoughts, industry news, and gossip surrounding

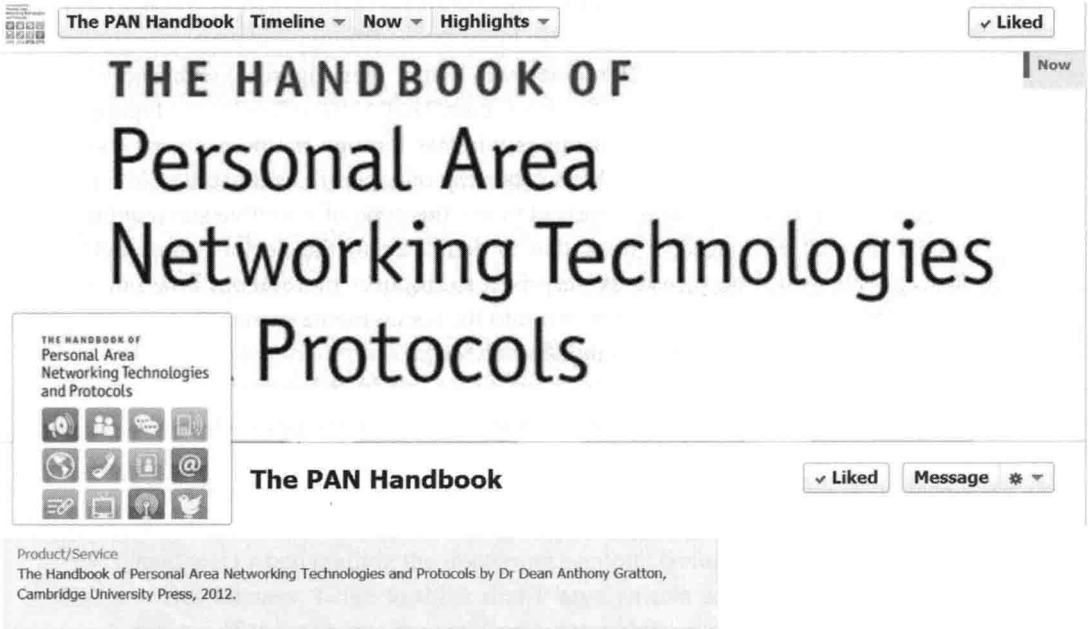


Figure 2. The PAN Handbook's Facebook Page (facebook.com/ThePANHandbook).

the technologies that are featured within. Incidentally, every technology that features in this book also has its very own brand identity on Twitter and Facebook – it's a perfect platform to engage your audience and build an army of *brand ambassadors*.

As such, *The Handbook of Personal Area Networking Technologies and Protocols* has its very own social media presence; after all, my book has an identity, a brand that you can engage with to learn more about its content and where you can discuss in general the technologies that uniquely form the wireless PAN. I've created these platforms to

The PAN Handbook News

Published by Dean Anthony Gratton – 67 news spotters today

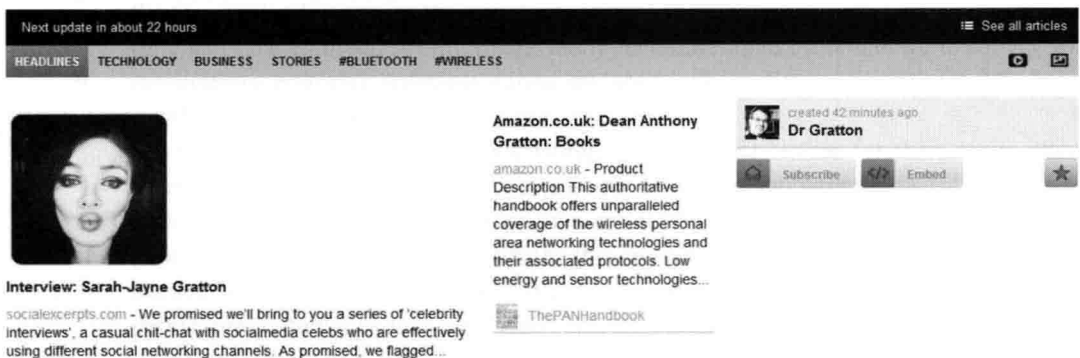


Figure 3. *The PAN Handbook News*. (Source: paper.li.)

offer you every opportunity to engage with me and to learn more about the book. I hope to dispel the rumors and hype that often beset the technology industry.

You can follow @ThePANHandbook via Twitter (see Figure 1) or become a fan of the book via its Facebook Page, facebook.com/ThePANHandbook (see Figure 2). You can even get your daily fix of all things wireless through the book's very own online newspaper, *The PAN Handbook News* (courtesy of paper.li), as illustrated in Figure 3.

Finally, you may be a little surprised to see this type of narrative surrounding social media in what is, indeed, a book that is dedicated to the personal area networking space. Well, you'll be pleasantly surprised to discover more about how our personal area networking space has been drawn into the social media domain later in Chapter 4, "Introducing the Lawnmower Man Effect (LME)."

Acknowledgements

Crikey, what was I thinking? Another book!

But who am I kidding? I love the challenge that the technology industry provides; I love the volatility, diversity, and inherent freedom of wireless technology. I romance with the notion of what wireless technology can potentially achieve and has achieved; and I just love the crafting process and seeing these pages fall into place – it's simply wonderful. You will soon discover more about my motivation and psyche (verging on madness) when reading the upcoming section "Before We Begin."

But for now, I like to think that I have written a book that encompasses a healthy review of the wireless personal area networking domain; one which I believe is long overdue. I've scanned Amazon and Barnes & Noble and I'm unable to discover similar books. After all, there's no other book which offers the density of all these technologies in one place – this is by far the most exhaustive coverage yet of the wireless personal area networking space!

Admittedly, I have had some highs and lows during this adventure, and, whilst at the keyboard, I have endured a breadth of emotions, which have been compounded by, on occasions, a need to do something else – damn Twitter! Nevertheless, I'm so pleased that these words have finally reached these pages. My journey hasn't been lonely – far from it: a large healthy glass of red wine (on occasions too much) has been in proximity whilst I've tapped my fingers skillfully across the keyboard listening to Elvis Presley, Neil Diamond and Dusty Springfield, who all made their respective guest appearances, albeit on my Windows Media Player playlist.

I should start by thanking Phil Meyler, Sabine Koch, Sarah Finlay, and Mia Balashova, the Cambridge University Press team, for their incredible patience – yes, it's taken some time and I have missed several (okay, many) deadlines, and I did manage to see my way through two editorial assistants during my seemingly endless overrun, with Mia being my third! So, so sorry, Phil!

I should also like to thank Nick Hunn and Bruno de Latour for their sanity check mechanisms – a prerequisite when tackling such a technical volume.

As usual, the content that follows has required the support of a number of amazing people and companies without whom this book would have never achieved what it needed to achieve for the wireless personal area networking space. So here goes: the people and companies that have made this short-range RF phenomenon become more than just a dream and, indeed, more than just a seemingly endless number of PowerPoint slides and empty promises.

In true Hollywood style, my guest stars all appear in alphabetical order . . .

AlertMe (alertme.com)

Jody Haskayne, Corporate Communications Director.

Amimon Incorporated (amimon.com)

Uri Kanonich, Senior Director Product Management at Amimon.

ANT Wireless (thisisant.com)

Catherine Gardiner Aylesworth, Marketing Manager at Dynastream Inc.;

Rod Morris, Director of ANT Wireless at Dynastream Inc.;

Sebastian Barnowski, Team Lead, Applications Engineering.

Barclays (barclays.co.uk)

Thomas Gregory, Head of Digital Payments at Barclaycard;

Louise Chan, Head of Commercial Management, Digital Payments at Barclaycard.

Bluetooth SIG (bluetooth.com)

Lindsay Peattie, Marketing Manager – Global Brand and Events;

Mike Foley, former Executive Director, Bluetooth SIG.

D-Link (dlink.com)

Andrew Mulholland, Marketing Manager (for Europe), D-Link UK.

Ember (ember.com)

Ravi Sharma, Director of Marketing.

EnOcean (enoecean.com)

Graham Martin, Chairman & CEO, EnOcean Alliance;

Dr. Wolfgang Heller, Product Line Manager, EnOcean GmbH;

Marián Hönsch, Software Applications Engineer, EnOcean GmbH;

Zeljko Angelkoski, Marketing Manager Global Communications, EnOcean GmbH;

Angelika Dester, PR Manager, EnOcean GmbH.

Garmin (garmin.com)

Justin McCarthy, Media Relations, Garmin International;

Jake Jacobson, Social Media Manager, Garmin International.

Hewlett Packard (hp.com)

Dean L. Sanderson, Product Manager at Hewlett Packard.

IPSO Alliance (ipso-alliance.org)

Geoff Mulligan, Chairman, IPSO Alliance;

Pete St. Pierre, President, IPSO Alliance;

Jessica Barnes, Director of Marketing and Management, IPSO Alliance;

Kate Easton, Marketing Director, IPSO Alliance.

Jabra (jabra.com)

Anja Brøgger Winther, Channel Marketing Manager at GN Netcom;

Suzaan Sauerman, Marketing Director at GN Netcom.

Netgear (netgear.co.uk)

Carly Hill, eCom Channel Manager, United Kingdom;

Sylvain Clemenz, Senior Retail, eCom Channel Manager, France.

NFC Forum (nfc-forum.org)

Ruth Cassidy, Vice President of Communications, Virtual Inc.

Nokia (nokia.com/press)

The Nokia Brand Clinic.

Nordic Semiconductor (nordicsemi.com)

Anne Strand, Marketing Communications Manager.

Orange UK (orange.co.uk)

The Orange Press Office at GolinHarris;

Chris Heeley, Project Delivery Manager, France Télécom Group.

RosettaStone (personalrosettastone.com)

John Bottorff, General Manager at Objects LLC.

Sony (sony.net)

Masayuki Takezawa, Deputy General Manager, FeliCa Business Division at Sony Corporation;

Yuka Matsudo, FeliCa Business Division at Sony Corporation.

Texas Instruments (ti.com)

Katrine Leander Brophy, Marketing Communications Manager at TI, Norway.

Weightless SIG (weightless.org)

Professor William Webb, CEO, Weightless SIG;

Alan Woolhouse, Director at Cambridge Startup Ltd.

WirelessHD (wirelesshd.org)

John Marshall, Chairman, WirelessHD.

Wireless Home Digital Interface (whdi.org)

Leslie Chard, President WHDI LLC;

Alexandra Crabb, Director of Media Relations at Ink Communications, Inc.;

Marta Twardowska, Relations Manager at Ink Communications, Inc.

Wi-Fi Alliance (wi-fi.org)

The Wi-Fi Alliance team.

WiGig Alliance (wirelessgigabitalliance.org)

Carlos Cordeiro, Chief Standards Architect at Intel Corporation;

Martyn Gettings, Account Manager, Proactive PR.

WirelessUSB (usb.org)

The USB-IF Administration Team.

Zeebox (zeebox.com)

Anthony Rose, Co-founder and CTO.

ZigBee Alliance (zigbee.org)

Joseph Reddy, Systems Architect, Texas Instruments;

Kevin Schader, Director of Communications, ZigBee Alliance.

Before We Begin

I've been writing books now for over ten years and I entered into this profession completely by accident following a heated discussion with the wife (Sarah). You know how people often say things happen at "the right place at the right time"? Well, for me that's exactly what happened and how I secured my first book contract with *Bluetooth Profiles: The Definitive Guide* back in September 2001. The amazement and sheer disbelief that I experienced – "Crikey, I did this!" – and seeing my first book pieced together in a bumper volume inspired me to write and want more. As for the heated discussion with the wife, I've been duly advised to save that story for another occasion, perhaps over several glasses of red!

I have historically titled this section of the book the "Preface" – maybe a hangover from my early days of writing. I don't personally think there's anything inappropriate with such a title, but I want to start anew by personalizing this section and sharing with you my motivation for writing this book. So, this is where I will now offer you an insight into my psyche and, on occasion, madness. Perhaps I will start by sharing more about me; you know, my specific experience and know-how, and ultimately what qualifies me to write such a book.

Okay. So, my experience spans over 25 years and I'll keep my account of it here brief! I have worked with networking technologies for around 22 years and have exclusively worked with wireless technology for close to 18. I have worked as a software engineer, developing products first-hand; as a software architect devising unique, creative, and effective methods for enabling networking and wireless technologies, which has led to some designs becoming patented; and I have managed and led teams for a host of consumer electronic products, including mobile phones, DigitalTV, broadband (triple-play), femtocells, Bluetooth, Wi-Fi, ZigBee, NFC, and Private Mobile Radio.

And it's still an ongoing adventure!

Incidentally, I initially didn't embark upon a career in software engineering, as my first passion was cooking, although I did dabble with computers and electronics at an early age – at 14, my first computer was an Oric-1 48k! I felt, at the time, that my destiny lay elsewhere, and I started work as a cook at my local Butlins' Barry Island holiday resort in the Vale of Glamorgan, South Wales, in the hope of following in my grandfather's footsteps as a culinary wizard. I know what you're thinking, "Butlins?", but everyone has to start somewhere, right? Anyway, it all came to an abrupt end and resulted in my first software engineering role, which I still have the fondest memories of. The position was with a small company based in Cardiff, South Wales – a world away from the wireless

communications saga I find myself relishing in today. In the late 1980s and early 1990s I was writing software for the gaming industry; in particular for *Amusement With Payout* (AWP) and *Skill With Payout* (SWP) machines for the United Kingdom, Europe, Africa, and Russia. I was primed to undertake a degree in computer science, but was offered the job on the condition that I withdraw my studies. Okay, so I took the cash! As such, my early career was nothing short of a steep learning curve, as I came to terms with my first software engineering role. But it was a time that was equally so rewarding, as I witnessed some of my crazy notions mature into real products – it was breathtaking. This was also a time sensationalized by Hollywood-like stories, for example when one of my subtle bugs resulted in the Chair of the company being held at gunpoint in Russia – I spent several days sifting through my source code realizing that the fraction of a fraction of a fraction was causing a miscalculation in the jackpot prize that, by the way, occurred over a year! Let's just say that the Chair escaped unscathed, made a safe return back to base, and was too exhausted and relieved to be angry, much to my relief. Oh, and the excitement over “fake bugs,” known as *Manufactured Malfunctioning Features* (MMFs). It was a craze in the early 1990s to write gaming machines that appeared to be faulty. I would write software that gave the impression to the player that the game was defective, but it was all part of the gambling experience. It seemed like a marvelous idea at the time, but it all backfired, as bars, clubs, and other venues were returning the machines to the operators, as they too saw the games as flawed.

It was such fun.

So, my first engineering role provided me with a sufficient foundation from which I could take on other challenges – I was ready, or so I thought. . . . I was eventually, after five years, wrenched from my role in Cardiff, and from what I considered to be my comfort blanket, kicking and screaming prior to moving to Cambridge, England, with my now wife in the mid-1990s. I managed to secure a number of software engineering roles in the Cambridgeshire area, which ultimately led me to some of my most diverse and challenging experiences in technology. But it wasn't until I secured my role at a North London company in 1999, where I was involved with some of the first Bluetooth products on the market, that my passion and innate belief in wireless technology was seeded. The potential I saw was huge and an enormous leap from the remote control, but fundamental questions needed to be addressed, such as “How should the consumer experience this freedom?” These were questions predominately surrounding the user experience, such as “What should the consumer see at the user interface level?” This had an impact across all consumer electronic products that undertook the wireless theme, and I wanted to encourage a simple, seamless, and transparent experience, especially when there wasn't an obvious user experience to share, such as for Bluetooth headsets, where you had to rely on a sequence of colored and blinking LEDs to pair and connect.

It proved to be an arduous task then and, unbelievably, it still is today.

Crikey, we took the cable away and introduced a new level of complexity to a product which, for all intents and purposes, worked just as well with a cable. A number of problems emerged as I tried to piece together a simpler and more transparent way of making sure wireless technology delivered on the promises the sales and marketing team