

Zen and the Art of 6 GHz Wi-Fi Design

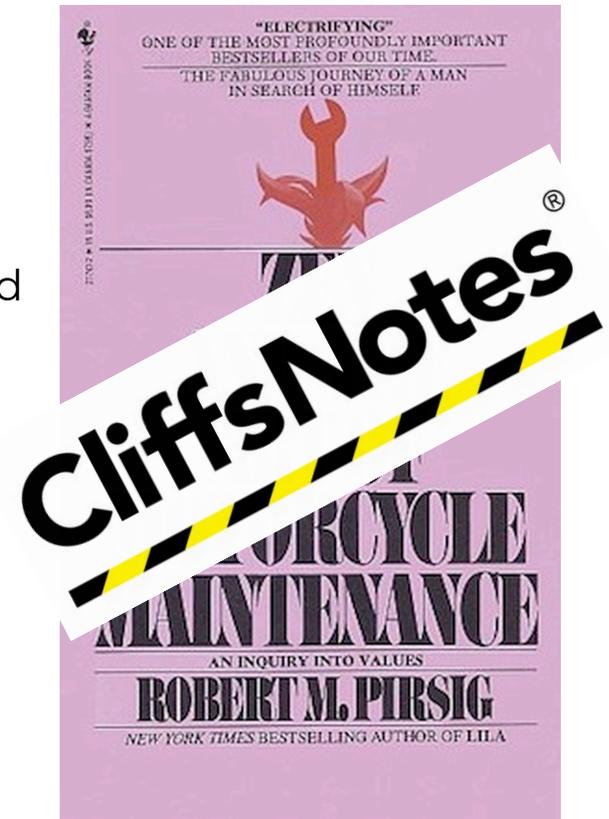
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Inspiration

- This talk is inspired by Zen and the Art of Motorcycle Maintenance: An Inquiry into Values by Robert M. Pirsig, published 1974.
- Zen and the Art of Motorcycle Maintenance is a physical and metaphysical journey that explores the philosophical concept of *quality* in the relationship between humanity and technology.
- A must read for any engineer!
- This talk contains @EmperorWiFi's philosophical interpretation of quality as it relates to Wi-Fi Design in general, and 6 GHz Wi-Fi Design in particular. *Quotes from the book are in red italics.*
- Alas, in 10 minutes, you're only getting the highlighted conclusions, not the journey!



Source: [https://larb-main-img-cdn.azureedge.net/unsafe/1280x0/filters.format\(jpeg\)/https%3A%2F%2Fdev.lareviewofbooks.org%2Fwp-content%2Fuploads%2F2018%2F07%2Fzenandtheartofmotorcyclemaintenance-1.jpg](https://larb-main-img-cdn.azureedge.net/unsafe/1280x0/filters.format(jpeg)/https%3A%2F%2Fdev.lareviewofbooks.org%2Fwp-content%2Fuploads%2F2018%2F07%2Fzenandtheartofmotorcyclemaintenance-1.jpg)

Is Wi-Fi Design an Art or a Science

- Answer: Yes (i.e. Both)
- The Wi-Fi Lifecycle is a dance between Art (*Qualitative*) and Science (*Quantitative*)
 - **Gather Requirements & Constraints:** Turn qualitative requirements and constraints into quantitative design metrics
 - **Design:** Use both quantitative metrics and qualitative guidelines to establish a design
 - **Deploy and Turn Up:** Quantitative procedures to install the design, mixed with qualitative on-the-fly judgment calls when reality does not match design assumptions
 - **Use:** The customer has a qualitative interpretation of how well the Wi-Fi performs



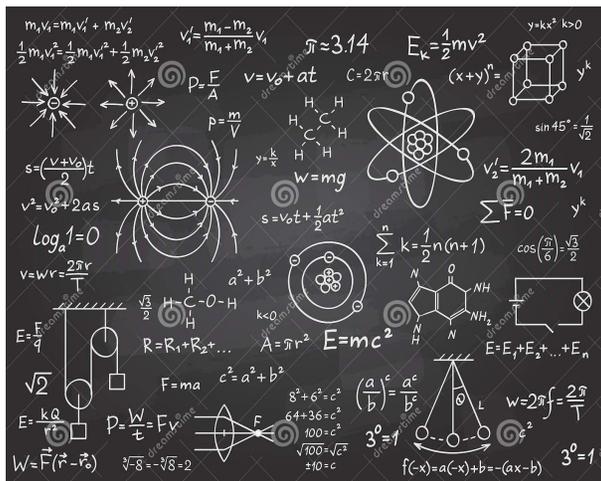
<https://www.ncfp.org/wp-content/uploads/2018/09/feature-head-vs-heart-scale-for-youth-by-youth-the-art-versus-science-of-grantmaking.jpg>

- We need both the quantitative scientific methods and the qualitative methods of art to produce a *high quality* design

“Two realities, one of immediate artistic appearance and the other of underlying scientific explanation, and they don’t match and don’t fit and don’t have anything to do with one another.”

Is Wi-Fi Design an Art or a Science

The Argument for “Science”



<https://thumbs.dreamstime.com/z/scientific-formulas-mathematics-physics-calculus-class-chalkboard-algebra-physical-science-handwritten-vector-education-193610260.jpg>

- RF Physics (amplitude, wavelength, phase, channels, channel width, transmit power, free space path loss, Fresnel Zone)
- Signal attenuation (absorption, reflection, diffraction, etc.)
- 802.11 protocol (rules of operation)
- Computer modeling and measurement tools (Ekahau, iBWave, Hamina, Tamosoft, iPerf, etc.)
- Science indicates one optimal solution for every problem
- We know as Wi-Fi designers, however, that there is never one correct answer, just “better” and “worse” choices

“In context, the laws of physics and logic, the number system, the principles of [scientific Wi-Fi design] are ghosts... They contain no matter & have no energy, & therefore, according to the laws of science, do not exist except in people’s minds... Of course, the laws of science contain no matter & no energy either, & therefore only exist in people’s minds... We just believe in them so thoroughly they seem real.”

Is Wi-Fi Design an Art or a Science

The Argument for “Art”



https://lh6.ggpht.com/HlgucZ0yIJAfZgusynnUwxNlgIp5htNhShF559x3dRXiuy_UdP3UQVLYW6c=s1200

- Interpret customer’s requirements & constraints
 - Not stated quantitatively
 - Include unstated and avoid “stupid” requirements
- Artistic Elements of Wi-Fi Design
 - **Access Point:** Vendor, model, generation
 - **Location:** Where to place APs
 - **Channel and Tx Power Settings:** Balancing the APs to maximize coverage and capacity and minimize self-interference
 - **Other settings:** Judgements on whether to turn off lower basic speeds, fast roaming, and a whole host of other “nerd knobs”
- We euphemistically call these **“best practices”**
 - Alas, everybody watching this presentation has their own **best practices**, based on their experiences

“Art does not proceed by reason or by laws, but rather feeling, intuition, and aesthetic conscience.”

What Are Best Practices

- **Best Practices:** System of checks to indicate what works and what doesn't in practice, not just in theory

“One system or methodology of design is no more correct than another – it is merely what is ‘more convenient’.”

- **Establishing Best Practices**

- **Study:** Learn as much as you can on your own and from others. Get your certifications.
- **Experience:** Practice, practice, practice.
- **Make Mistakes:** We learn more from our failures than our successes
- **Focus:** Forget about multi-tasking. Turn off your email and your chat and your phone and focus on the problem at hand.
- **Care:** You must have gumption / passion for what you do. It must consume you. You cannot just clock in at 9 am and out at 5 pm.

“The right [best practices], the ones we really need, are not only passive, they are damned elusive, and we’re not going to sit back and just ‘observe’ them’. We’re going to have to be in there looking for them.”



<https://www.proofpoint.com/us/security-awareness/post/security-awareness-training-best-practices-consider>

So What Makes a Wi-Fi Design “Good”

- **Quality:** Everyone knows what it is, but nobody can define it.

Quality is what you like. Quality is scientific reality. Quality is the goal of Art.

- In Wi-Fi, we define the term **Quality of Experience (QoE)**
 - Attempt to define quantitative metrics of qualitative concepts
 - Measurement of how well the customer perceives the Wi-Fi works
- But what is “working” to the customer?
 - Wi-Fi is a utility, enabling other applications
 - Customers only notice the Wi-Fi when it is not working, i.e. the network has **low quality**
 - Therefore, **high quality** means it “just works”



<https://i.ytimg.com/vi/ZpFqneFTGA8/maxresdefault.jpg>

“Each [network] has its own personality, which probably can be described as the intuitive sum total of everything you know and feel about it... The test of the [network] is the satisfaction that it gives you. If the [network] produces tranquility, it is right. If the [network] disturbs you, it is wrong until either the [network] or your mind is changed.”

What About 6 GHz Design Specifically

6 GHz Band – Total Spectrum 1200 MHz



<https://2ezcjkljxcze2xqxl3jqvk4-wpengine.netdna-ssl.com/wp-content/uploads/2020/10/Picture1.png>

- New rules, same methodology
 - *Greenfield*: Take better advantage of deterministic aspects of 802.11ax
 - *Wider channels*: Constant power spectral density and large bandwidth → practical use of larger channel widths for higher throughput
 - *New use cases*: Mesh backhaul, high density client devices, high bandwidth
 - *New tools*: Improvements in modeling and measurement for 6 GHz
 - **Establish new “best practices” for 6 GHz**

“What your actual solution is is unimportant, as long as it has Quality... The solutions are all simple – once you have arrived at them. But they’re simple only when you know already what they are.”

Closing Moment of Zen

“The difference between a good [Wi-Fi designer] and a bad one is precisely this ability to select the good [best practices] from the bad one on the basis of quality. They have to care!”

“The way to see what looks good and understand the reasons it looks good, and to be at one with this goodness as the work proceeds, is to cultivate an inner quietness, a peace of mind so that goodness can shine through.”

“Gumption [i.e. passion for your work] is the psychic gasoline that keeps the whole thing going. If you haven’t got it, there’s no way the [network] can be [designed]. If you have got it and know how to keep it, there’s no way in this whole world that the [network] will keep from getting [designed]. It’s bound to happen.

“The way you live predisposes you to avoid the traps and see the right [best practices]. You want to know how to [design] a perfect [network]? It’s easy. Just make yourself perfect and then just [design] naturally... The real [network] that you’re working on is a [network] called yourself.”

Namaste

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