

5G R&D at Huawei: An Insider Look

Accelerating the move from theory to engineering practice with MATLAB and Simulink



Huawei is the largest networking and telecommunications equipment and services corporation in the world. It employs 176,000 people, 79,000 of whom work in Research and Development centers around the globe (based on 2015 data).

Kevin Law, director of algorithm architecture and design, provides an insider view of 5G development at Huawei.

What is your role at Huawei?

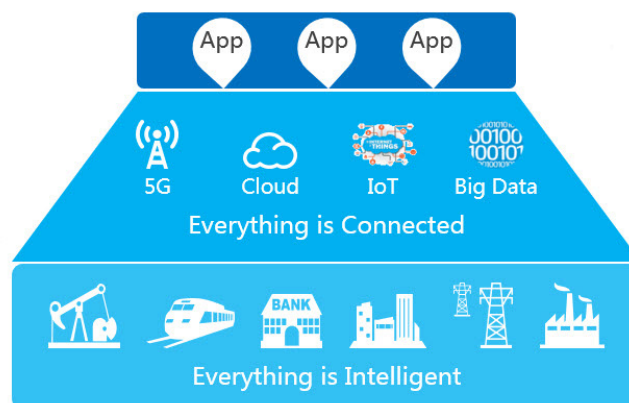
I joined Huawei in 1999 and am responsible for algorithm design and SoC architecture. I worked from the beginning on GSM and GPRS, then WCDMA, LTE/5G, and now optical communication, microwave, and SDN/IP algorithm architecture.

What is the focus of R&D?

We are gradually shifting our focus from strictly communication equipment to other areas. These include future communication networks, all-optical switching, 5G, next-generation communication equipment such as mobile terminals, as well as materials, energy, artificial intelligence, and autonomous driving.

Let's start with communications networks. What's new there?

This is our largest market and we are the market leader. There are two key drivers around innovation for the future of communication networks: all nodes need to be intelligent, and everything needs to be connected.



Everything, every object needs to communicate in this network. Think about this. We foresee a huge innovation opportunity. This includes next-generation smart terminals, IoT edge nodes, and even deep space's satellite communication. It also includes our investment in 5G, as well as all-optical switching and software defined networks (SDNs). Each of these are based on mathematics, which has algorithms at its core.



5G network field testing in China.

What other R&D projects are you pursuing?

We are working to redefine some new markets including robotics, energy, medical devices, and automotive. Key elements of innovation in these fields are: sensing, control, communication, and computation. Interestingly, MATLAB and Simulink are designed to help engineers with these four elements.

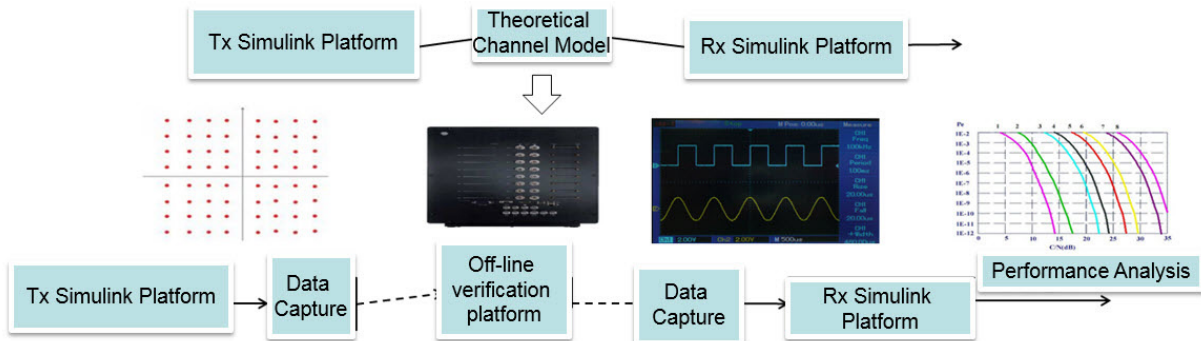
What are the big technical challenges?

The first is design efficiency – going from the idea to the final productizing and industrialization. We have different R&D groups involved in these steps and need to connect them and build efficiency throughout the entire process.

The second is creating competence in product development. We don't want to start from ground zero when we get into a new area, but start with some existing results and outcomes, which we can quickly build on top of. Some of this involves collaboration in academic research institutions and joint innovation centers with other companies and service providers.

Then there's multidomain prototyping and system-level verification. We start from a single domain and then gradually extend to a whole system with massive data. Thus, we need a multidomain platform for simulation, rapid prototyping, and iterative verification from the behavior model to testbed prototyping to the industrial product.

MATLAB and Simulink are helping us to achieve these goals.



Ultra-high-speed algorithm simulation and offline verification using Simulink.

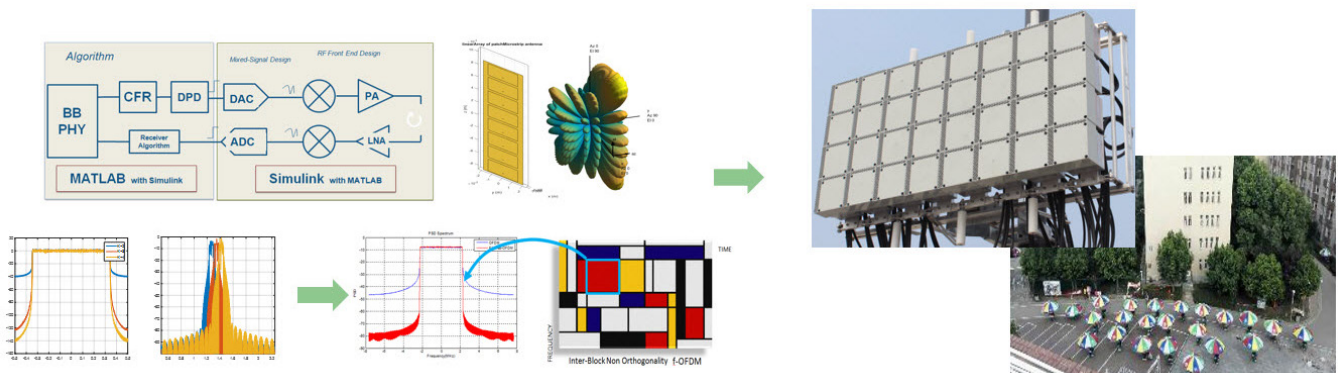
Can you tell us more about how MATLAB and Simulink are helping you?

These two platforms play an important role in our innovation areas like 5G, optical communication, and wireless terminals. The tools give us top-down Model-Based Design, a product ecosystem that covers multiple domains, and code generation and iterative verification.

I'll give you a few examples.

5G Prototyping

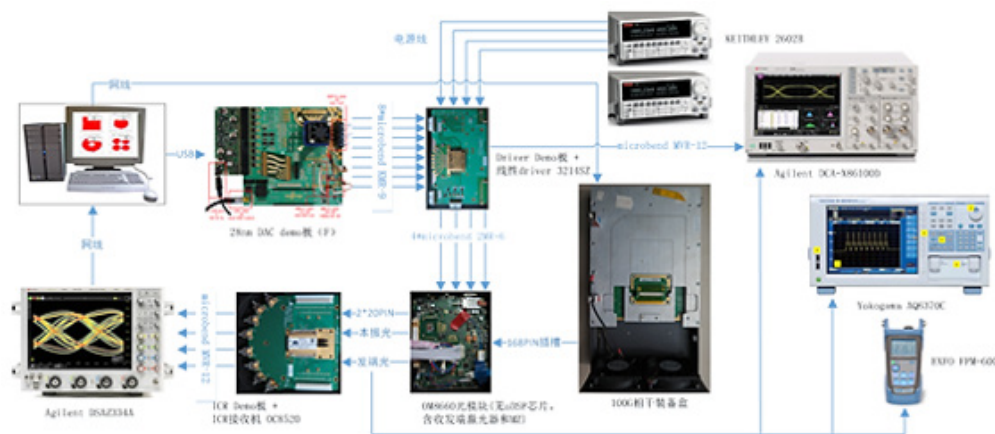
When we do 5G prototyping design and development, we build the whole air access link-level simulation using MATLAB and Simulink, and import the parameters of this model – from the antenna to the new waveform as well as the data analysis from the field testing. We can quickly leverage what we already have and other mature solutions to build our system, so we can focus on the specific innovation such as new waveform and new antenna design. We automatically generate HDL code from MATLAB for hardware verification. When we evaluate the algorithm in field testing, we can very effectively see the whole system's performance and status, and identify any potential issues.



Next generation wireless technology design, verification, and field testing.

Optical Communication and ASIC

When we do optical communication R&D, we use an offline algorithm verification platform based on Simulink and our optical modules and oscilloscope. It lets us do some high-speed algorithm evaluation that cannot be done on the actual devices themselves. This approach can dramatically reduce the risk of ASIC design respins. Currently, we are designing a 16nm ASIC SoC. The cost of the tape-out is about \$10M to \$20M USD. If we have any tape-out mistakes, the loss is not only the \$10M to \$20M, but more importantly, the time to market! With the delay from even a tiny tape-out mistake, we can totally miss the opportunities in the market. Simulink can minimize the risk dramatically and improve the chance of a successful tape-out.



High-speed optical communication environment based on Simulink. It integrates high-speed optical transceivers and modules, which can verify the whole system algorithm by oscilloscope.

FEC Coding and HDL Coding

Another example involves fast-speed forward-error-coding verification. We generated code automatically from MATLAB, Simulink, and HDL Coder. Then we evaluated the code. Auto-generated code was slightly higher than hand-written coder in terms of hardware resources such as multipliers and memory, but relatively similar in timing. It satisfied our algorithm verification requirement. When we started using this approach for verification, we reduced development time by 50%. It is a huge gain that meets our manpower constraints and time-to-market requirement.

mmWave DPD Algorithm

Let's also talk about digital predistortion, a very common approach in communication theory. It will compensate for nonlinear characteristics for some devices. This algorithm plays a very key role in wireless and optical areas. Here, we use Simulink to build the whole link-level simulation and integrate with power amplifier testing, in order to finish the design and verification of a device's non-linearity compensation algorithm. It is very general so that it can evaluate different compensation algorithms for multiple devices and their various types of non-linearity characteristics.

Hardware Integration

Algorithms continue to grow in complexity, including the capability for faster processing. We have designed many algorithm acceleration platforms for FPGAs, GPUs, and x86s. By performing hardware-in-the-loop testing with Simulink products, we have been able to automatically generate code and quickly finish the algorithm verification.

How would you describe the use of Model-Based Design at Huawei?

Huawei adopted the Model-Based Design concept for its product development workflow. We have introduced Model-Based Design with MATLAB and Simulink and the Huawei R&D workflow. MATLAB and Simulink have a strong impact from product requirement import, modeling, and data analysis, all the way to link-level system simulation, algorithm selection, RTL code generation, testing, and prototyping, and even sample chip tape-out and testing. Model-Based Design can also improve the overall end-to-end efficiency quite a lot.

When we want to explore a new theory or new market, we can quickly find the right toolboxes to extend MATLAB and Simulink. MathWorks has very complete coverage in our focused industrial areas, which has huge benefits to us.

How does your work extend to industry and academic collaborations?

MathWorks products are very well integrated with EDA development tools including software, instruments, and hardware, which helps us for end-to-end industrial implementation.

On the other hand, MathWorks software is becoming the general platform between academia and industry. We can get many useful modules through collaboration. In the process of collaboration, we also find that many universities have already been doing deep space communication, 5G, and robotics research using MathWorks products.

Learn More

Overview: [5G Wireless Development with MATLAB and Simulink](#)

Video: [Introducing the 5G Library](#)

White Paper: [Hybrid Beamforming for Massive MIMO Phased Array Systems](#)