CASE STUDY

NTT DOCOMO

Gains a Go-to-Market Advantage in 5G with Flexible Channel Sounding

In pursuit of 5G's most extreme goals, developers are using a combination of millimeter-wave (mmWave) frequencies, ultra-wide bandwidths, and massive multiple-input/multiple-output (MIMO) methods. And while these add uncertainty to the design of transmitters and receivers, the biggest unknowns are in the resulting over-the-air (OTA) radio channels between 5G user equipment (UE) and base stations.

To fully characterize the channel, it is necessary to create mathematical models of channel performance and then use those models to define new air interface standards for 5G. A technique called channel sounding is an effective way to understand the channel and thereby enable the data rates, spectrum flexibility and bandwidth needed for 5G.

PATHWAVE

Organization

- NTT DOCOMO, Inc.

Challenges

- Characterize the mmWave in-the-air propagation channel interface
- Derive channel models for mobile and fixed wireless use cases
- Fulfill the 5G promise without overdesigning the network

Solution

- Keysight **Channel Sounding Reference** solution with PathWave
- Adapt and scale to meet measurement needs across multiple scenarios

Results

- Improved visibility in 12 key channel characteristics
- Reduced design risk and shortened development time 20%
- Gained 12-month go-to-market advantage

KEYSIGHT TECHNOLOGIES

This was the challenge facing NTT DOCOMO, Japan's largest mobile network operator. While its name is officially derived from the phrase "***do co***mmunications over the ***mo***bile network," it is also a contraction of the Japanese phrase "*doko ni demo*" which, in the spirit of wireless mobility, means "everywhere."

As one of the industry's leading innovators, NTT DOCOMO is working to deploy its 5G mobile network in time for a major athletic event in the summer of 2020 in Tokyo. To define and optimize a network that fulfills on the promise of 5G—without being overdesigned—NTT DOCOMO needed an accurate, reliable and repeatable way to characterize channel propagation.

The Challenge: Modeling Multiple mmWave Use Cases

For NTT DOCOMO's developers, the overarching driver is a 10-year plan aimed at creating an industry-leading communication platform. The major goals are to enable new subscriber services that include more bandwidth for human users, more capacity for machine-to-machine and Internet of Things (IoT) connectivity, and minimal latency for virtual reality (VR) and augmented reality (AR) applications (Figure 1).

To accelerate the commercialization of this platform, NTT DOCOMO's investigations focused on the 5G New Radio (NR) interface at 28 GHz for high-speed mobile scenarios and 67 GHz for fixed-wireless applications. That research revealed two crucial challenges: capturing data over the mmWave channel, and calculating a mathematical model that could be used in the design of mobile network cells.

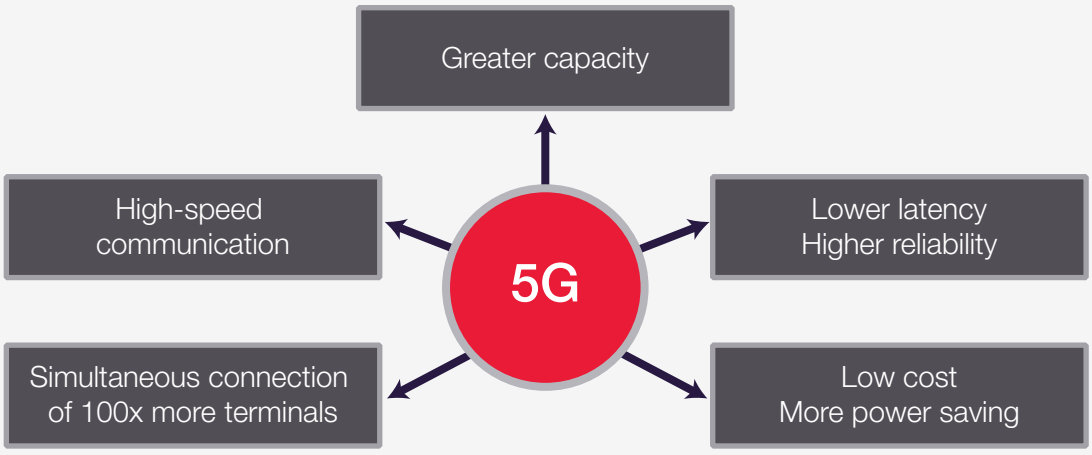

Figure 1. Expected performance and functions from 5G

To create the necessary models, signals must be captured within a 2x2 matrix of scenarios: urban and rural; fixed wireless and high-speed mobile (e.g., on a "bullet" train). Key measurements include frequency response, path loss, power-delay profile (PDP), Doppler shift, angle of arrival (AoA), and angle of departure (AoD). The various measurements present some daunting underlying challenges: generating and analyzing wideband mmWave MIMO signals; performing wideband system calibration; achieving precise transmit/receive timing; and managing data collection and storage.

Captured data is used as inputs to the channel model, which includes the effects of obstructions such as the human body or foliage, attenuation caused by precipitation or humidity, and multipath and reflections caused by buildings and other structures. Signal-analysis software must be capable of extracting a model of the wireless channel at all frequencies of interest. The resulting model is then used in the design of the mobile network, helping developers determine the optimum location and number of cell sites.

> **"One of our missions, as one of Japan's leading telecommunication carriers, is to provide a new communication platform that will lead the next era. We are developing advanced communication systems with the goal of practical application by 2020."**
>
> — Takehiro Nakamura
>
> Senior Vice President, General Manager of 5G Laboratories
>
> *NTT DOCOMO, Inc.*

The Solution: Adapting to Meet Specific Needs

Capturing time-varying, multi-path mmWave signals requires highly complex, multi-channel instrumentation that provides precise timing, razor-sharp synchronization, and advanced software. To meet these requirements, NTT DOCOMO turned to a trusted source: Keysight Technologies. Given the results of previous collaborations with Keysight, the research team easily envisioned the successful realization of a channel-sounding solution that would cover 28 GHz and 67 GHz.

The foundation was Keysight's Channel Sounding Reference Solution, which includes two types of core elements:

- Off-the-shelf, metrology-grade hardware for signal generation and acquisition
- PathWave software for instrument control, system-wide calibration, signal generation, signal analysis, and parameter extraction
- Multi-channel measurement with phased coherent

This architecture enables researchers to use, enhance, and modify the test platform to meet specific needs and implement advanced measurements (Figure 2). For example, the ability to use wideband MIMO data-capture techniques makes it possible to measure angular spread with fewer measurements and with higher resolution of multi-path parameters.

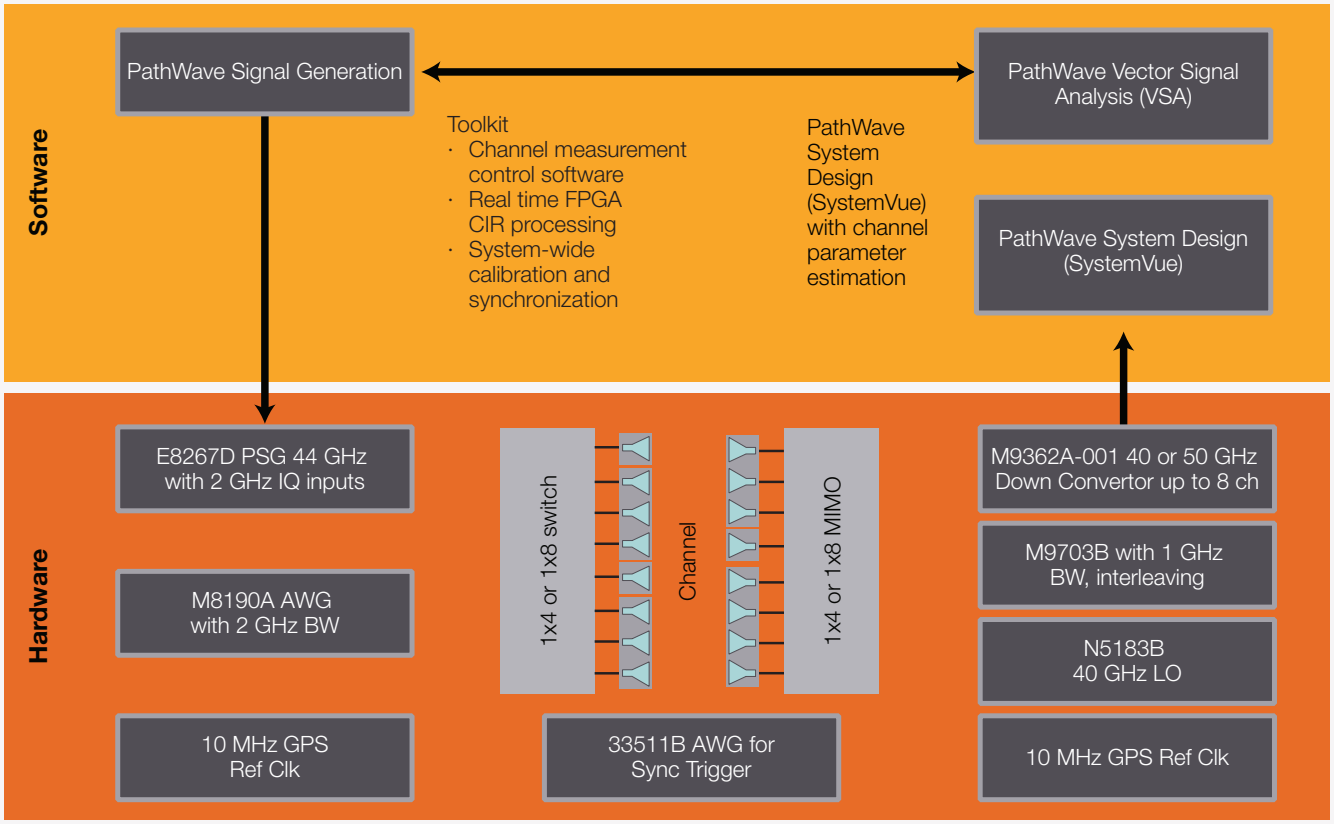

Figure 2. Architecture of Keysight's scalable channel-sounding reference solution

The Results: Gaining a Go-to-Market Advantage

With these capabilities, NTT DOCOMO was able to run twice as many tests on the air interface at 28 GHz and 67 GHz. Ultimately, the resulting models have enabled the development team to test more than a dozen critical channel characteristics, thus increasing its understanding of channel propagation across the matrix of scenarios: high-density fixed-wireless and high-speed mobile in urban and rural environments.

Through real-time interaction with Keysight, NTT DOCOMO quickly produced accurate channel models that helped minimize design risk and shorten overall development time at the network level by an estimated 20%. This is giving the company the opportunity to be first to market with a 12-month go-to-market advantage over its competitors.

> **"We knew that we needed a cooperative relationship with a test and measurement provider who specialized in high-frequency applications to develop and verify underlying technologies for 5G."**
>
> — Yukihiko Okumura
>
> Group Leader of 5G Radio Access Network Research Group
>
> *Research Laboratories*
>
> *NTT DOCOMO, Inc.*

Going Forward

As 5G technologies and standards continue to evolve, models of the air interface will require further refinement. That's why the reference solution is scalable and upgradeable, making it capable of measuring more channels at higher frequencies as 5G test specifications mature.

Because many of the constituent hardware and software elements are off-the-shelf Keysight products, they can be readily repurposed to other aspects of 5G research, development and verification: capture, demodulation and analysis of 5G signals; modulation and generation of 5G signals; chipset design, development and validation; UE design, analysis and validation; base station design, analysis and validation; and IoT device design, analysis, and validation.

Related Information

- Brochure: *5G Channel Sounding Reference Solution*, publication 5992-0983EN
- Application Note: *Defining a Channel Sounding Measurement System for Characterization of 5G Air Interfaces*, publication 5992-1064EN
- Webcast: *5G Channel Sounding Challenges and Test Approaches*
- User Report: *NTT DoCoMo accelerates technology development to commercialize 5G: Cooperation with Keysight in measurement of propagation characteristics at 60 GHz band (in Japanese)*, publication 5992-2325JAJP
- IEICE Transaction on Communications: *Scattering Characteristics of the Human Body in 67-GHz Band* (authored by NTT DOCOMO and Keysight Technologies)

www.keysight.com/find/5G

Learn more at: www.keysight.com

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

KEYSIGHT TECHNOLOGIES