

History of Mobile Communications with a Look Back at NTT DOCOMO R&D and Outlook for the Future

— The long and winding road —

Kota Kinoshita Former NTT DOCOMO CTO, former DOCOMO Technology President (front left)
Takanori Utano Former NTT DOCOMO CTO, former DOCOMO Technology President (front right)
Seizo Onoe Former NTT DOCOMO CTO, presently President of DOCOMO Technology (rear, second from left)
Kiyohito Nagata Former General Manager of NTT DOCOMO Communication Device Development Department, presently
President and Chief Executive Officer of Asurion Technology Japan (rear, first from right)
Koji Yamamoto Former General Manager of NTT DOCOMO Core Network Development Department, presently President
of NTC Technology (rear, second from right)
Chie Togawa Moderator (rear, first from left)

The logo for NTT docomo, with "NTT" in red above "docomo" in red lowercase letters.

—To begin with, let me thank all of you for taking time today to participate in this roundtable discussion. In the history of mobile phones, which today have become ubiquitous, there must have been all sorts of dramatic moments behind the scenes in technology and product development. Today, I would like to ask all of you about this story, from the early days to the present and into the future, divided into five generations.

■ 1st Generation (1980s, Analog System)~

Early Days

From car phones to mobile phones: birth of the compact mova handset

—Mr. Kinoshita, you were head of development in the early days. Can you tell us about the birth of the mobile phone?

Kinoshita Mobile communications originally appeared as a car phone system, not as mobile phones. The car phone was the first product to be commercialized.

Yamamoto December 3, 1979, to be exact.

Onoe/Nagata That's right, December 3, 1979.

Yamamoto Which was year 54 of the Showa era.
—Everyone remembers that well!

Nagata That's because it's a historic day. All NTT DOCOMO employees have that date in their head.

Kinoshita The first model weighed 8 kilograms occupying a volume of about 6 liters.

At that time, the chief technical engineer of Nippon Telegraph and Telephone Public Corporation was astonished at that weight and volume, and I remember him saying, "Redo it, soon!" With NTT Laboratories being newly organized, we puzzled over how to go about reducing the volume of this model from 6 liters. Then, on seeing a smaller prototype of a car phone, perhaps the second generation, the person in charge of this project com-



mented, "You know, if we were to attach a battery, the user would be able to walk around with the phone."

The word got around that "If we can do this, we get a mobile phone!" Certainly, this was the origin of the mobile phone concept. However, the radio band license here was assigned to car phones and could not be used for mobile phones. We therefore set our sights on commercializing a "removable mobile device that could be used outside the car." We succeeded in developing and commercializing a device that had the appearance of a mobile phone, but unfortunately, it was a system with limited connectivity with a terminal price tag of 1 million yen, so in the end, it came to be used by only a few people.

Utano That was certainly a time dominated by the development of car phones throughout the world. A full-fledged mobile phone was the MicroTAC manufactured by Motorola. Based on the car phone system, the idea at that time was to lower the terminal's transmission power and construct a terminal with the size and shape of a so-called mobile phone.

The problem here was that changing the form of the device from a car phone to a mobile phone made it difficult for radio signals to reach the base



Motorola MicroTAC

Extracted from the WIRED News article “The 12 Cellphones That Changed Our World Forever.”
https://wired.jp/2013/04/06/influential-cellphones/#galleryimage_61239-519_2

station. How to go about correcting this was the next major problem.

Kinoshita Here in Japan, we pursued a system design targeting a national system capacity of 100,000 subscribers with one unit of switching equipment installed in Tokyo and Osaka each.

Utano Having a car phone at that time gave a person some status. Against this background and taking international developments into account, we came to realize within the company that full-



scale downsizing was essential, and we kept this in mind while moving forward with system development. However, the “pocket bell,” or pager, had become a mainstream product by that time.

Kinoshita This created much anxiety for individuals on the development side leading the push for a first-generation mobile phone. The thinking at that time was that having a pager and access to a public telephone would make car phones unnecessary, so the implementation side was dismissive of mobile phones in general. I remember that the car-phone/mobile-phone business began with the view that 100,000 subscribers out of a population of about 100 million would be sufficient.

Onoe That being said, in 1982, the year I joined the company and three years after the car-phone business launch, the number of subscribers had reached only about 10,000, but the development of a so-called large-capacity system had begun. It was thought that perhaps we were “counting our chickens before they hatch.”

Utano As a result, in the ten-year period following the launch, the number of subscribers rapidly increased first to 100,000 and then to 1 million.

Yamamoto At the time of NTT DOCOMO’s founding, that is, in 1993, or year 4 of the Heisei era, the number of subscribers had reached 1.7 million!

Nagata This period also saw the birth of the “Shoulder phone” that was used by removing the receiver from the main unit hanging from the user’s shoulder. It became popular with news reporters for making on-site reports. In “Yoru No Hit Studio” (“Evening Hit Studio”), a popular music show of the time, the appearance of popular singer Masahiko Kondo walking down a flight of stairs using a shoulder phone helped to promote it among the general public.

Yamamoto The shoulder phone turned out to be extremely useful in providing behind-the-scenes support for rescue teams involved in the 1985 airplane crash on Mount Osutaka.



Shoulder phone

Nagata Before the actual launch of this service, we assembled and delivered what shoulder-phone equipment we had at Yokosuka R&D Center for this purpose.

Utano I remember that we would also lend out shoulder phones to Japan's Self-Defense Forces at that time for use in disaster recovery operations.

Nagata By the way, the mova[®] series of analog handsets only 150 cc in size made its appearance in 1991. However, that was an era in which we were receiving all sorts of comments from both inside and outside the company, such as "Why can pagers connect while mobile phones cannot?" This was the first generation of mobile phones.

■ 2nd Generation (1990s, Digital PDC System)~

Period of Explosive Growth

From voice to data communications: birth of i-mode

—With mova, terminal size contracted from 6 liters to 150 cc and the number of subscribers grew explosively. At long last, a transition was made to 2nd Generation mobile communications (2G).

Yamamoto In this era, the years 1998 and 1999 saw the birth of i-mode.

Nagata And that was preceded by the introduc-

tion of the Personal Digital Cellular (PDC) system, which allowed for data communications at 2,400 kbps or 1,200 kbps and facsimile communications too.

Kinoshita At that time, network digitization was a major trend, and a move toward developing a digital network for mobile communications had begun. I had received my orders, and thinking that, in the end, we had to enable clear and uninterrupted conversation during communications, we first changed the system so as to achieve a balance between the signal strength on the uplink (mobile terminal to base station) and that on the downlink, which was a problem in the first-generation system. In addition, instead of having the base-station side search for a base station to which a mobile terminal should be transferred, we made it so that the terminal itself would report on which base station it should move to, a scheme called Mobile Assisted Hand Off (MAHO). Thanks to this MAHO scheme and digital multiplexing effect, we were able to reduce base-station size significantly. In this way, call quality improved and system capacity increased, and the number of subscribers that could be accommodated by the digital PDC system at peak times increased to 40 million.

Utano In Europe and the United States, it was a period of vigorous studies on digital systems including efforts to achieve early standardization.

Onoe The Global System for Mobile communications, or GSM, centered in Europe was the first standard digital system in the world to be commercialized.

Kinoshita The PDC system, meanwhile, was initially commercialized only as a voice system.

Nagata And data communications in PDC was initially accomplished using voice-based circuit switching.

Kinoshita Data communications by circuit switching turned out to have a very complex



structure. Since the interface consisted only of analog modems, the mobile terminal would have to perform an analog-to-digital conversion on the up-link while the network side would have to convert that back to analog. Nevertheless, despite the complexity of this system, we really had no choice, so we endured much hardship. This was because the interface of the fixed network was analog while the mobile communications interval had been digitized creating a discrepancy between the fixed and mobile networks. We therefore had to find some way of eliminating this mismatch, which placed a burden on development.

Nagata Sales of a new system usually begin with the corporate world, so we naturally promoted FAX machines and modems to corporate enterprises that would likely have a need for them. However, there were times in which the system did not function as desired. Yet, right around the time that the system was starting to work for the most part, a transition to the packet-communications era and genuine data communications had begun.

It was decided on the executive level at that time that the network would move to packet com-

munications at an early stage, which made this technology available for use throughout the country ahead of services. While a variety of proposals had been set forth about implementing i-mode by circuit switching since a reasonably efficient platform had by that time been established for data communications, the talk eventually turned to running i-mode by packet communications.

Kinoshita At first, it was proposed from a telecom-operator point of view that X.25 be applied as a protocol for packet communications. However, as X.25 had yet to prove itself even in the fixed network, it was decided to look for a new protocol. Then, around 1995, people began to talk about something called the “Internet” that was gaining momentum in the United States, so we decided to look into this phenomenon.

Nagata At that time, probably no one really understood the structure of the Internet. But I think that catching up in the way that we did resulted in a dramatic leap in both technology and business.

Utano It was a time in which the use of e-mail made pagers no longer necessary.

Yamamoto I think the vision we had and the

choices we made at that time were quite good all in all. For example, selecting protocol compatible with portable devices such as compact HTML for i-mode surely contributed to the expansion of mobile communications.

—However, wasn't the so-called Galápagos approach also a target at this time.

Kinoshita The system adopted by NTT DOCOMO as its 2G system was different from the international standards being studied in Europe and elsewhere. In other words, it came to be a system unique to Japan. Drawing an analogy with the Galápagos islands on which living things evolved independently of the outside world, the “Galápagos syndrome” was a term that disparaged the way in which Japan's unique system was isolated from the rest of the world.

Nagata Generally speaking, terminals with an abundance of functions have also been targets since the 3rd Generation (3G), but a contributing factor here was the rapid and super growth of i-mode. In contrast, true Internet services on mobile terminals were not provided in Europe and the United States until the smartphone era.

A chance to give shape to what we wanted to do—challenging ourselves to do what we thought we could not

—At this time, I would like to ask all of you about your thoughts at that time, when everyone was starting out from zero.

Kinoshita Honestly speaking, I did my work because it was very interesting. I did not ponder about anything grandiose like the future of mobile communications. However, I enjoyed giving form to totally new things.

Nagata Being in charge of device development, I was happy to see the actor Bruce Willis advertise mova handsets for us. It was quite a thrill to see people using this type of mobile phone inside a

train. We had quite a lot of freedom back then. Though it was said that there were few customers, that no one was paying attention, etc., this was a chance for those of us on the technology side to realize what we wanted to do with mobile phones.

Yamamoto I think that people associated with technology and engineering have a fundamental love of making and creating things. The road that we have traveled was sometimes painful, but nothing gave us more pleasure than the fruits of our labor. Even our way of thinking was sometimes rejected. Nevertheless, we persevered by becoming absorbed in our work and engaging with the “present” to constantly create better things. At the time of NTT DOCOMO's founding, I moved to the company for the simple reason that I found the work interesting. I had a dream that progress in mobile communications would make life more convenient and prosperous.

Onoe Doesn't everyone think that we should be proud of creating something that at one time we thought we couldn't? For example, there were many people who thought that a cellular system couldn't operate at high frequencies. I don't think there was anyone 20–30 years ago at the least that believed that cellular systems could be achieved at 2 GHz, but today, they are commonplace.

In the light of this story, I can give a more recent example. Though it's been said that radio signals at even higher frequencies such as millimeter waves won't propagate well in the 5th Generation mobile communications system (5G), I tell my subordinates, “Even if it cannot be done today, I want it doable in about ten years time.”

Yamamoto That's why it's important that we challenge ourselves to do not what can easily be done but what we may think cannot be done. This makes the world a more convenient place. Yes, it may be hard to try doing everything on one's

own, but I think that avoiding the challenge is bad.

Kinoshita It was often said at one time in the past that the world of R&D includes a “valley of death.” This refers to research and development that does not lead to commercial products. In this sense, there has thankfully been no valley of death in NTT DOCOMO development. Researchers, developers, and implementers would all cooperate closely enabling things created on the research side to move along after the development team has closely digested the requirements and conditions specified by the implementation side. We achieved a very effective workflow in this way.

Utano Since the number of people involved were not many, we could not help but do it that way. I would actually visit both development sites and business-implementation sites. In some cases, there was a division of labor as in operations, but here as well we would introduce the systems and add functions in an integrated manner. It’s exactly because of such an environment at NTT DOCOMO that it is not uncommon even today for people with development experience to visit business departments and conduct interdepartmental exchanges.



■ 3rd Generation (2000s, W-CDMA System)~

Multimedia era

Standardization and internationalization making international roaming possible

—We then entered the 2000s, an era of increasing globalization with the need for globally uniform standards.

Onoe By this time, mobile phones had already become popular, and we were forced to confront the fact that ordinary travelers would not be able to use their handsets elsewhere in the world without a uniform interface. Working to provide such an interface was the original idea behind 3G system. This was the period in which a globally uniform standard was discussed and established as an objective by the International Telecommunication Union-Radio communication sector (ITU-R). These discussions set a bit-rate target of 2 Mbps and promoted common recognition of this standard.

Nagata Manufacturers were naturally excited about 3G systems. Compared with second-generation PDC, 3G mobile communications represented a dramatic leap in technology. Although technology progressed in a continuous manner from ana-



log times to the PDC era, it made a big jump with the coming of 3G, and the considerable investment made by each manufacturer to accommodate 3G was likely due to their expectations of worldwide sales.

Yamamoto However, despite this uniform standard for 3G, it was said that there was a need overseas for incorporating not only 3G but GSM too, which placed additional pressure on development for Japanese manufacturers. It appeared that Europe with GSM already well entrenched was not eager to expand entirely into 3G.

Onoe As for the 3G system itself, the proposals made by Japan have made a big contribution. In a sense, these contributions have spread throughout the world. However, to what extent those contributions have been a plus for Japanese industry depends greatly on manufacturer and market circumstances, so I will not go into that here.

Kinoshita At the beginning of the 3G era, on being relieved that PDC development had come to an end and that we had managed in one way or another to get it working and to thrive, our development boss exclaimed, “It’s now time for Wideband Code Division Multiple Access (W-CDMA).” To make W-CDMA into a world standard, we decided to call various operators and manufacturers with the aim of developing some partnerships. At that time, on demonstrating to the Chief Technical Officer (CTO) of Nokia a transmission experiment of the system that the research group had been working on, he was surprised to see that we had made what appeared to be about two years’ worth of progress. Then, on returning to his country, he talked with the CTO of Ericsson. The result of this discussion was that wireless technology would unite Europe through NTT DOCOMO’s W-CDMA while control protocol would be left to GSM. This was the starting point for NTT DOCOMO in establishing a partnership with Europe.

Onoe In Europe, there were about five candi-



dates for a standard system, and one of those was W-CDMA. In this regard, the European Telecommunications Standards Institute (ETSI), a European standardization body, was the scene of intense discussions for about one year with a particular focus on the Time Division CDMA (TD-CDMA) system. Then, at the January 1998 meeting, it was decided that the European standard would be based on W-CDMA while incorporating TD-CDMA in part. With this concluded, our next challenge was the United States. On the American side, discussions centered on the CDMA2000 system, so the result was a “Japan and Europe versus the United States” scenario. This was not just a dispute centered on technology—it evolved into a struggle that included aspects of a trade dispute such as patent rights. After passionate discussions, a compromise was reached on some parameters, but W-CDMA for the most part became the standard. However, the end result was one standard with multiple modes including CDMA2000, so it was not a single standard in the truest sense.—So the reason for reaching this decision was not the superiority of a certain type of technology.

Onoe At that time, I didn’t think that 3G would last.

Utano Among European manufacturers at that

time, I remember clearly how some top executives would say, “The adoption of W-CDMA is not a question of its technical merits—for us, achieving W-CDMA from a technical perspective including intellectual property rights (IPR) is not realistic, so we oppose this standard.” Those manufacturers also stressed that, “There’s no way that we could adopt something that offers us no advantage at all.”

Utano That was because most European manufacturers providing mobile communications equipment at that time also had a large share of fixed communications. I think they were exploring to some extent what they could do to become major players in the next stage of mobile phones. This tug-of-war within Europe increased in severity, and I think that one major reason for this was that the market had increased in size against a backdrop of GSM and its success.

Onoe However, yesterday’s enemy is today’s friend, and I would like to say that it’s precisely because we were able to hold fruitful discussions on not just rights and interests but on technology too that we are today building good relationships.



■ 4th Generation (2010s, LTE/LTE-Advanced System)~

Smartphone era

Toward a more pleasant communications environment

—How did 3G that expanded the market come to change in the years that followed?

Kinoshita 3G was constructed independent of 2G. We made a considerable investment, but revenues for the several years after service launch were not that great. Under these circumstances, we could hardly be allowed to create a 4th generation (4G) anew, which is why we launched enhanced versions of 3G such as 3.9G and Super 3G (today’s LTE).

Onoe At that time, 4G research was progressing steadily, and data transmission speeds of 100 Mbps were being achieved in 2002–2003 along with 1 Gbps on the research-laboratory level. However, 3G business conditions were somewhat disastrous with initial investment yet to be recovered. This period overlapped with the drafting of NTT DOCOMO’s medium-term plan for R&D, and since we were hardly in a situation in which we could freely promote 4G development, in one week we repackaged our proposal in terms of “Super 3G,” which was subsequently reflected in the plan.





Of course, when it came time to deal with standardization, we did so in a careful and polite manner!

Utano That is to say, the question here was how to soften the resistance to new investment on the listening side. One way we did this was by making improvements within 3G a little at a time. For example, we increased bit rates gradually such as by High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA). Furthermore, if we advised that such extensions would comprise Super 3G, we thought that resistance on the listening side might become even smaller. We thought that mounting such an extension on existing infrastructure would not be a project requiring so much investment or present such a problem.

In this sense, the atmosphere at that time was completely different from now. Today, whether it's 4G or 5G, talking about new things one after the other turns into business. This is the era of looking for something new. The thinking here is that only what is fresh and original will turn into business.

Nagata As transmission speeds increase with 3G, 4G, and 5G, it is often said, "Let's think about what kind of services we can provide with higher

speeds." In recent years, however, faster transmission speeds have come to be used by all sorts of users resulting in the birth of new services and cultures. For example, while YouTube has been around for some time, users can now upload videos from their smartphones thanks to faster transmission speeds. This capability has given rise to "YouTubers" (YouTube celebrities) and has increased the use of Instagram while giving birth to the word "instagrammable."

Utano Users will use a system in line with communication capacity. This results in a cycle in which more usage requires a system that can accommodate that usage. Everyone has been using capacity liberally especially of late, so there is a need for the development side to consider how we are going to deal with such vigorous demand.

Onoe With each cycle, something new is born extending beyond previous discussions. Trust me, this is the path taken every time. 5G technology is a prime example. If we don't aim for more than what the customer wants or something slightly higher, that technology will soon be commonplace. That is, if we don't aim for something difficult, it's not going to go well. This may be in hindsight, but that's the type of cycle that occurs.

Utano In this sense, we are about to plunge into

a very difficult era. In the past, services in the fixed network generally came first and the task was to determine how best to incorporate those services in a mobile phone. From here on, however, we must think about what kinds of new business will be possible, which means a very different atmosphere from the past. I don't think the infrastructure will change, but I do think that the things that must be thought about will be very difficult compared with our times.

—The Tokyo Olympics is fast approaching. It appears that new things will again be in demand.

Onoe In the case of 5G, we have Internet of Things (IoT) technologies in mind, and we are working to lower latency and raise reliability. People outside the telecom industry have an eye on 5G, and new business opportunities will come to be born through partnering, that is, through various types of collaboration. It is being said that NTT DOCOMO will launch 5G services in 2020, and I think that this will become a reality.

**To future technology developers:
Use your abilities to give birth to “something slightly ahead of the times!”**

—It has come time to talk about the near future. Can you give some words of encouragement to your next-generation colleagues?

Nagata During my time as manager, I was allowed to use a considerable amount of money for development. And the most money I used was during a three-year period in which 3G had yet to be launched. In the sense of launching 3G terminals, we achieved our short-term goals, but these terminals were entirely different from Google's Android phones and the iPhone. That is to say, we probably made a mistake in where we used that money. Perhaps a sense of the global market would have been helpful, but at that time, we were not in such an environment. Today, an environment conducive to global consciousness has been established. I would like those that follow in our footsteps to focus on key technologies from a





global perspective or on leaving a legacy of prime technologies, and to think long-term in connecting those technologies to business opportunities.

Onoe But in a sense, this is also in hindsight. Our role has been to launch something totally from scratch. I think there is value in this. At the risk of repeating myself, I would like the next generation to achieve what they think cannot be done and to create new things not within the scope of their imagination but beyond it.

Nagata Yes, there is value there, but in the case of OSs and LSIs, Japan, in the end, lost the whole thing. I would like the next generation to dream of global activities and to leverage their ideas to the maximum to get on the path to success.

Yamamoto I was in charge of an area that was formerly called “circuit switching,” so while my advice may be different from that of the others here, my sincere request to my young colleagues

would be as follows. Given ten technologies, engage in world-leading, cutting-edge research and development for one of them, and for the remaining nine, combine them with things in the real world to create a NTT DOCOMO original network.

Utano I really don’t have any advice, but let me share this. I feel that our generation, while having little understanding of “mobile communications” at first, did what we had to do while deepening our knowledge of international conditions and technology thereby arriving at long last where we are today. So going forward, I would like to ask the next generation of developers to think carefully about what they need to improve and step up to the next level. Please search out what kind of abilities will become necessary. However, I’m afraid that what we have to say on this matter will not have much value. I believe that each of you must think about and find the understanding, knowledge, and technology that will be necessary in conjunction with changing times and environmental conditions. In this regard, I wish all of you much success.

Kinoshita Roughly speaking, I think it’s a good idea to set targets that provide clear benefits to operators, enterprises, and end users at the launch of the product or service. My advice is “Don’t do only what you can do now.” That is, begin by setting targets for things that have benefits and sale potential regardless of whether they can or cannot be done. You can then devote your efforts to meeting those targets. After all, it’s only communications, and just about anything can be accomplished here.

—Many diverse opinions! Let me thank all of you for your precious memories and valuable advice.