Deployment Realities of 5G

Seizo ONOE
CTO and EVP
NTT DOCOMO, INC.
Topics

- History and Future
  - What 5G provides and creates
  - Economics of 5G
  - Road to 5G Launch

- Extra Topic
  - Previous Generations’ Boom
  - Law of Great Success
## History from 1G to 4G and the Next

### Chronological Table

<table>
<thead>
<tr>
<th>Year</th>
<th>1G</th>
<th>2G</th>
<th>3G</th>
<th>4G</th>
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<td>TDMA Concept</td>
<td>2G GSM/PDC/TDMA</td>
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<td>1990s WCDMA 2Mbps Experiments</td>
<td>2000s CFDMA/SCFDMA 100M-1Gbps Experiments</td>
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<td>1990</td>
<td>1G</td>
<td>2G</td>
<td>3G</td>
<td>4G</td>
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</tbody>
</table>

- **1G (1980s)**: Analogue Cellular
  - **1985**: TDMA Concept, Paper by Dr. Kinoshita, ICC'81 and IEEE Trans. VT, 1982

- **2G (1990s)**: TDMA Concept
  - **1995**: WCDMA, 2Mbps Experiments

- **3G (2000s)**: CFDMA/SCFDMA
  - **2005**: 1Gbps Experiments at 11GHz

- **4G (2010s)**: LTE/LTE-Advanced

- **5G**: 10Gbps Experiments at 11GHz

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**Today**:

- 4G LTE/LTE-Advanced
- 5G
History of 4G Research at DOCOMO

Background: 4G research outcome of over 1Gbps data transmission

100Mbps in 2002-2003

1Gbps in 2004-2005

5Gbps in 2006
On the other hand, 3G services had not been well accepted by the market.

Lesson 2: Migration Scenario
Super3G Concept

Smooth path to the next generation was essential. ⇒In 2004, DoCoMo proposed Super3G concept for the smooth path to 4G.

Ideas on migration to 4G (3)

Scenario 3: First evolve 3G, then build 4G on top
- Extensibility is greater than Scenario 2
- Cost is lower than Scenario 1

((Innovative 4G evolution possible)

NOW 4G Launch
(2010s) 4G Evolution

3G Evolution

3G 4G

Super3G

※Super3G: The name of Enhanced3G called in DoCoMo

26th May 2004, ICB3G
Most people didn’t like the term “4G”.
In the RAN Future Evolution Workshop, many of the presentations pointed out the need of 3G long-term evolution to meet the future demand and to maintain its competitive position for coming decades. Several interesting new technology components such as OFDM with a flexible and broader RF bandwidth were presented as potential candidates for the evolution. It was pointed out such a technology enhancement should be applied to UTRAN architecture as well as the UTRA radio interface.

It is proposed that 3GPP should initiate the feasibility study of the long-term evolution accounting for the above situation. In this paper, a Study Item Description is presented for this study.

Concerning the time plan, we propose to complete the feasibility study by June 2006 and envisage all relevant core specifications by June 2007.
Secret Story of LTE Birth - a petit boast -
- Prehistory of LTE Standardization -
A Slide used for initiating the standardization

In early 2004, DOCOMO predicted the milestones, which actually happened.

March 8, 2004
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Usage scenarios of IMT for 2020 and beyond

- Gigabytes in a second
- Smart home/building
- Voice
- Smart city
- 3D video, UHD screens
- Work and play in the cloud
- Augmented reality
- Industry automation
- Mission critical application
- Self driving car

Future IMT

- Enhanced mobile broadband (eMBB)
- Massive machine type communications (mMTC)
- Ultra-reliable and low latency communications (uRLLC)
Another Aspect
Myths about 5G

People are trying to jump on the 5G bandwagon.

- For 5G, all things need something new.
- 5G needs significant investment.
Dr Seizo Onoe, CTO, NTT DoCoMo expresses interesting views on #5G bandwagon. #BKLYN5G  5G must be something new!
Let’s get on the 5G bandwagon and create new business models through the collaborations across industries.
DOCORO’s Case: Collaborations with various industries

Ongoing Collaborations for 5G Trials

- Broadcast
- Automotive and components
- Transportation
- Construction Machinery
- Security
- Devices
- Entertainment
- Others
IEEE Radio Frequency Integrated Circuits Symposium
4-6 June 2017
Honolulu, Hawaii

Catch the 5G Wave!
Let’s ride on the 5G wave!
And develop the 5G technologies.
And create new business through cross-industry collaborations!
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5G economics take away.

5G economical challenges.

Few Telco’s might be able to return on their 5G investment (at least initially). Massive demand for cell densification likely leading to substantial Capex & Opex pressures - Despite technology leapfrog in efficiency.
The data capacity enhancement with no increasing trend in CAPEX can be one of the 5G killer services.
Myths about 5G

- 5G is millimeter wave technology.
- 5G is a hot spot system.
- 5G launch needs new 5G spectra.
- 5G is IMT-2020 defined by ITU.
- 5G replaces 4G.
- For 5G, all things need something new.
- 5G needs significant investment.
5G provides Higher data speed and Higher capacity.

- Broader spectrum bandwidth
- Higher frequency spectrum
- Larger propagation loss
- Shorter coverage
- 5G is a Hotspot system for complementary use.

A wrong story I don’t like

Let’s tackle the challenge of achieving wide coverage as cellular systems even with higher spectrum.
Challenges of RFIC

- RF devices for wide-range frequency bands and bandwidths (0 to 100GHz)
- **High density implementation** of RF and power devices

Macro cell
- e.g. <6GHz, mmW
- e.g. 2.1GHz
- e.g. 3.5GHz

Small cell/Semi-macro cell

Massive MIMO and Advanced C-RAN
We achieved many things we had thought impossible. In the future, we can make what we think impossible today.
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DOCOMO’s Time Plan

**Research, Experiments**
- 5GTSA

**Development**
- 5G NR Non-Standalone
- 5G NR Standalone

**System Trial**

**5G**
- Launch

**5G NR**
- Non-Standalone
- Standalone

**Study Item**
- Rel. 15
- Rel. 16
- Rel. X

**Requirements**
- IMT-2020

**Proposals**
- WRC15
- WRC19

**Specifications**
We should avoid fragmentation due to the early deployment.

I can talk about DOCOMO’s experience in 3G. The front runner should take risks.
Lesson 1: Launch timing

Numbers of Operators

- 3G: W-CDMA
DOCOMO’s network handles both versions of Rel. 99 protocols.

DOCOMO does NOT intend to repeat this for 5G. We, as one of the front runners, will continue the effort to accelerate the 3GPP work and implementation with stable specifications.

The front runner should take responsibility for coping with fragmentation.
DOCOMO’s Time Plan

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<td>IMT-2020 Specifications</td>
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</tbody>
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- **Research, Experiments**
- **System Trial**
- **Development**
- **5G launch**
- **5G NR NSA**
- **5G NR SA**
- **5G NR SA**
- **5G**
- **5G+**
- **Rel. 15**
- **Rel. 16**
- **Rel. X**
- **WRC15**
- **WRC19**
Beam Visualization
High-Speed Drive Test at Fuji Speedway

- Max speed: 150+ km/h
- Max data rate: 2.58 Gbps
Launch of ‘5G Trial Site’

TOBU Railway Co., LTD. and NTT DOCOMO, INC. started technical collaboration on 5G service creation

<May 22, 2017>

As per agreement on collaborative 5G service creation signed in November 2016, a ‘5G Trial Site’ was started today at TOKYO SKYTREE TOWN®, in which visitors can experience services employing 5G technologies.
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Previous Generations’ Boom
Just Before the Launch of Next Generation

Law of Great Success
This actually happened in previous generations.
- HSPA+ (enhanced 3G) was booming just before 4G (LTE) launch.
- EDGE (enhanced 2G GSM) flourished just before 3G (W-CDMA) launch.

2009 (1.5 years before LTE launch)

HSPA+ Plays The Leading Part, LTE Be a Minority.

Nikkei Communications, 2009/03/15
Evolution paths to 4G

Big gain vs. Backward compatibility

Introducing halfway improved technologies is inefficient in investment. Evolution of old technologies must be stopped after a new and better technology is standardized.
Big gain vs. Backward compatibility

Introducing halfway improved technologies is inefficient in investment. Evolution of old technologies must be stopped after a new and better technology is standardized. However, the LTE/5G relationship is tricky.

5G is the interworking of New Radio and eLTE.
This actually happened in previous generations.

- HSPA+ (enhanced 3G) was booming just before 4G (LTE) launch.
- EDGE (enhanced 2G GSM) flourished just before 3G (W-CDMA) launch.

3GPP Work items trying to adopt the technologies designed for 5G NR for LTE.

It’s tricky. 5G is the interworking of 5G New Radio and eLTE.

As a marketing gimmick, evolved 4G will likely be called “5G.”
Law of Great Success
Only in Even-Numbered Generations
Law of Great Success Only in Even-Numbered Generations

- A de-facto global standard
- More-than-expected demand

Rapid global deployment. LTE is the single global standard (no other standard implemented). More-than expected demand.

1G
Fragmented standards
Limited deployment

2G

3G
Slow deployment
Spectrum auctions & economic situation
Less-than-expected demand

4G

5G

6G
???
 LTE-based technology

???
Numbers of Operators

<table>
<thead>
<tr>
<th>Year</th>
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<td>2001</td>
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<td>2006</td>
<td>50</td>
</tr>
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<td>2007</td>
<td>60</td>
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- **LTE**: Starting from 2010, the number of operators using LTE technology has significantly increased.
- **3G: W-CDMA**: The number of operators using 3G technology has also increased, especially from 2007 onwards.

The chart shows a steady increase in the number of operators over the years, with a sharp rise in 2015.
We have to wait until 6G to see our expectations for 5G fulfilled. 6G will be the complete form of 5G, or 5G will be the final generation that will keep evolving ever after 2030.

Regardless of technological generations, cross-industry collaboration will create new business models and ecosystems.
4. Will 5G live up to the hype?
Over the past few years, engineers and executives have set sky-high expectations for 5G. They’ve spoken of 5G as the wireless network that will unleash radical new technological advances in every possible realm, and promised that it will enable autonomous cars, streaming virtual reality, and remote surgeries.

Much of the talk at this year’s summit was as bold as ever. In a keynote about how 5G would improve industrial systems, Kenneth Budka of Bell Labs predicted that 5G technologies would “fundamentally transform human existence.”

This year, though, such grandiose statements were also punctuated with more sobering analyses. A generous helping came from Seizo Onoe, chief technology officer of NTT DOCOMO, who has developed something of a reputation for pouring cold water on 5G expectations.

During his keynote, Onoe said he has noticed an informal law during his time at DOCOMO: The wireless industry manages to achieve great leaps of success only in even-numbered generations. By his measure, 2G and 4G were truly transformational, while the improvements that came with 1G and 3G were mostly incremental.

“Applying this law to 5G, I would say we have to wait until 6G to fill all the expectations of 5G,” he said. Stay tuned.
Conclusion

➢ 5G will be successful.

➢ 5G is attracting interest from a wide variety of industries.  
   - Let’s get on the 5G Bandwagon!

➢ RFICs are key to realize 5G technologies, and will enable what we think impossible.  
   - Let’s ride on the 5G wave!
The new of today, the norm of tomorrow