5G and Beyond
- 5G Myths and Realities -

Seizo ONOE
CTO and EVP
NTT DOCOMO, INC.
Tuesday, 24 May 2016

IF-01: Cellular Technologies in Shared Spectrum: LTE Unlicensed
Time: 14:00-15:30 (Room: Conference Hall 1, Level 3)

IF-02: 5G Architecture
Time: 14:00-15:30 (Room: Conference Hall 2, Level 3)

IF-03: 3GPP Standards Toward 5G
Time: 16:00-17:30 (Room: Conference Hall 1, Level 3)

IF-04: Dynamic Spectrum Access: The Ways Forward
Time: 16:00-17:30 (Room: Conference Hall 1, Level 3)

Wednesday, 25 May 2016

IF-05: Integrating Knowledge of Telecom Standards into Engineering Education
Time: 11:00-12:30 (Room: Conference Hall 1, Level 3)

IF-06: Rising Industrial IoT Applications
Time: 14:00-15:30 (Room: Conference Hall 1, Level 3)

IF-07: Toward 5G Mobile Network Softwarization
Time: 14:00-15:30 (Room: Conference Hall 2, Level 3)

IF-08: Accelerate 5G and LTE/WLAN Research and Development
Time: 16:00-17:30 (Room: Conference Hall 1, Level 3)

IF-09: 5G in Verticals - Game Changers, Catalysts, and New Players
Time: 18:00-19:30 (Room: Conference Hall 2, Level 3)

Thursday, 26 May 2016

IF-10: 5G - The PHY, the MAC, the Network, Anything Else: What will Make it Special?
Time: 11:00-12:30 (Room: Conference Hall 1, Level 3)

IF-11: IEEE 802.11 into 5G Landscape
Time: 11:00-12:30 (Room: Conference Hall 2, Level 3)

IF-12: mmWave for 5G - From Theory to Practice
Time: 14:00-17:30 (Room: Meeting Room S10, Level 3)

Time: 14:00-15:30 (Room: Conference Hall 1, Level 3)
"In early 2000s, there was a concrete 4G technology, but no one called it 4G. Today, there are no contents of 5G, but everyone talks about 5G."

No single representative technology, but there are several candidate technologies and the combinations of technologies create new technologies and solutions.
5G Myths and Realities
Myths about 5G

- 5G is millimeter wave technology.
- 5G is a hot spot system.
- 5G 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.
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Partially “Yes” and millimeter wave is a key for 5G.

However, it’s not all.
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A wrong story I don’t like

- 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.

Let’s tackle the challenge of achieving wide coverage as cellular systems even with higher spectrum.
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- Spectra are independent of technology generations. (ITU identifies IMT bands, not 5G bands.)
- 5G doesn’t necessarily need new bands, while new spectrum is key to extremely high performance.

5G uses new bands as well as existing bands with combinations from the beginning (and eventually by refarming).
• We don’t need to cry over the LTE spectrum fragmentation.
• Let’s use the existing bands for LTE and encourage enhancement of multi-band support in devices.
Effective Use of 2.1GHz band

**DOCOMO in Japan**

**Before LTE launch**
- 3G devices

**At LTE launch with 2.1GHz**
- 3G devices
- LTE1000 devices

**In the future**
- 3G devices
- LTE devices

**in Europe, Asia etc.**

**Before LTE launch**
- 3G devices

**After LTE launch with other than 2.1GHz**
- 3G devices

**In the future**
- 3G devices
- LTE devices (2100/2600 e.g.)

- After spread of LTE2100 devices, LTE2100 NW can be introduced easily.
- It is suggested to implement LTE2100 in devices even when the NW does not support LTE2100.
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ITU defines IMT-2020 but it does NOT define 5G in the recommendations.
Evolution of Mobile Technology

- **2010**
  - ITU IMT-2000
  - Evolution
  - LTE
  - LTE-Advanced

- **2020**
  - ITU IMT-Advanced
  - Evolution
  - 4G LTE
  - 5G
  - 5G+
  - mmW

5G could be started from IMT-Advanced 2000
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ITU Press Release may cause confusion, like 4G in the past.
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It may happen eventually but not in the short term. 5G will be overlaid over 4G. Some equipment could be upgraded by software.
Myths about 5G

People are trying to jump on the 5G bandwagon.

➢ For 5G, all things need something new.

➢ 5G needs significant investment.
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A vague sense of worry
CAPEX

Capital Expenditure at DOCOMO

3G launch
2001 Oct. 1

LTE launch
2010 Dec. 24

Billion Yen

2000
2005
2010
2015

R&D Expenses
3G launch
2001 Oct. 1

LTE launch
2010 Dec. 24

Data Traffic

Capital Expenditure at DOCOMO

Billion Yen


200X 6300X

200X

Log scale

2001 Oct. 1

3G launch

2010 Dec. 24

LTE launch

Billion Yen

200X

6300X

Data Traffic
5G Myths and Realities

- Time Plan
- Requirements
- Spectrum
- Technologies
- R&D activities
- Technology Convergence
Time Plan

- Myths
- Realities - Time Plan
- Requirements
- Spectrum
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- Technology Convergence
- Conclusion
DOCOMO’s Time Plan

|------|------|------|------|------|------|------|------|

Research, Experiments

Trial

Development

5G launch

5G

5G+

\[ \ldots \]

Study Item

Rel. 15

Rel. 16

Rel. X

ITU

3GPP

Requirements

Proposals

IMT-2020 Specifications

WRC15

WRC19
Worry about fragmentation due to early deployment of 5G
Numbers of Operators

Lesson 1: Launch timing

Number of operators

Years:
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007

3G: W-CDMA
To facilitate a widening array of advanced mobile broadband services, DOCOMO will construct a high-speed, low-latency, large-capacity network by implementing LTE from 2010.

International standardization and network roll-out of LTE

- Customers’ demands for stress-free access to video and other rich content are expected to rise.
- Network traffic is expected to grow steadily due to widespread adoption of flat-rate services and increased availability of rich content.
- Many markets outside Japan are likely to follow similar trends.
- Adoption of LTE*1 is becoming the mainstream strategy.

DOCOMO plans to roll-out LTE from 2010, as one of the first operators to offer high-speed, large-capacity services at low costs in an efficient manner.
- Globally, many operators have launched LTE.
- DOCOMO launched LTE as one of the leading operators in the world.

<table>
<thead>
<tr>
<th>Japan</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
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<td>AXGP SoftBank (TD-LTE)</td>
<td>EN</td>
<td>KDDI</td>
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<table>
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<tbody>
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<td>Verizon, MetroPCS, TeliaSonera, TELE2</td>
<td>at&amp;t, Orange, SK Telecom, KT, LG U+</td>
<td>SMART</td>
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<td></td>
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</tbody>
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TSG-RAN meeting #11
Palm Springs, California 13th to 16th of March 2001

Agenda Item: X.Y

Source: DoCoMo, Hutchison 3G UK, Japan Telecom, Omnitel/Vodafone, Tellia, Telefonica, TIM/TILAB, Vodafone Group Plc, Alcatel, Ericsson, Fujitsu, Motorola, NEC, Nokia, Panasonic.

Title: Ensuring backward compatibility for Release 99 specifications
DOCOMO’s network handles both versions of Rel. 99 protocols, so that DOCOMO can continue to provide 3G services for initial users and global services for new users.

- Amendments to Release 99 will continue in 3GPP. NTT DoCoMo will also comply with these future changes, and will update network/handsets accordingly.
- DoCoMo will provide global roaming services with operators in Europe, etc. (whose 3G services start in 2002). Connectivity testing to take place prior to offering global roaming service.

The front runner should take responsibility for service continuity and global deployment avoiding fragmentation.
Requirements

What is 5G?

- Realities
  - Time Plan
- Requirements
- Spectrum
- Technologies
- R&D activities
- Technology Convergence
- Conclusion
5G Requirements and Capabilities

- Enhanced Mobile Broadband
- IoT
  - Massive machine type communications
  - Ultra-reliable and low latency communications
- New Business Models and Ecosystem across Industries
5G - IoT

2020

Enhanced Mobile Broadband

4G LTE/LTE-Advanced

5G Mobile Broadband

Low power

High performance

NB-IoT

4G LTE/Cat.0

5G-IoT

4G LTE/Cat.1

IoT

5G - IoT Enhanced Mobile Broadband

High performance

Low power

NB-IoT

4G LTE/Cat.0

5G-IoT

4G LTE/Cat.1

IoT
5G Technology

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A wrong story I don’t like

Let’s tackle the challenge of achieving wide coverage as cellular systems even with higher spectrum.
Massive MIMO: Coverage Extension

Evaluation assumptions:
- Tx power: 33 dBm
- Tx bandwidth: 100 MHz
- Target Rx SNR: -4 dB
- Antenna gain per antenna element: 5 dBi
- Path loss model: ITU-R Urban Micro NLOS
- BS antenna height: 10m
- Shadowing margin: 0 dB
- Penetration loss: 0 dB (outdoor user)
- Rx noise figure: 9 dB
Massive MIMO and Advanced C-RAN (Phantom cell)

Massive MIMO
is about increasing
the number of antennas.

The implementation
technology is key.

“Feat of strength”

“an excellent feature”

The combination of
Massive MIMO and
Advanced C-RAN Enhancement (Phantom cell)
will provide adequate cell coverage even with higher frequency bands.
Massive-MIMO and Advanced C-RAN (Phantom cell)
5G R&D Activities

- Myths
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5G Experimental Trials in DOCOMO with World-leading Vendors

UHF bands
Ex. 800MHz, 2GHz

Low SHF bands
3-6GHz

High SHF bands
6-30GHz

EHF bands
> 30GHz

HUawei
FUJITSU
NEC
ERICsson
SAMSUNG
MITSUBISHI ELECTRIC
NOKIA

Panasonic
Intel
MEDIATEK
QUALCOMM
KEYSiGHT TECHNOLOGIES
ROHDE & SCHWARZ
Ultra Wideband @ 70GHz band
Beam Tracking for Mobility
TOKYO, JAPAN, May 24, 2016—NTT DOCOMO, INC. announced today that it has achieved the world’s first wireless real-time transmission of 8K video deploying radio access technology for 5G mobile communications systems, in a trial jointly conducted with Nokia on May 19.
Multi-User MIMO @ 15GHz band (Outdoor)

- 10 Gbps user throughput
- 20 Gbps cell throughput
Cellular Technology Generations - the worldwide market

- 1G - AMPS
- 2G - GSM
- 3G - WCDMA
- 4G - LTE
- 5G -
- 6G -
- 7G -
The advanced market leads the technology then the technology penetrates the whole worldwide market.
Conclusion

- Myths
- Realities - Time Plan
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5G is a boom, creating some **myths** about 5G.

5G should not end up with hype. Instead, 5G should become **realities** of technology and capability in 2020 and beyond.
The new of today, the norm of tomorrow