

The Dawn of 5G

- LTE Today
- History from 1G to 4G
- 5G Technology
- Requirements: 1000x Data, true?

Seizo ONOE

**CTO, EVP and Member of the Board of
Directors**

NTT DOCOMO, INC.

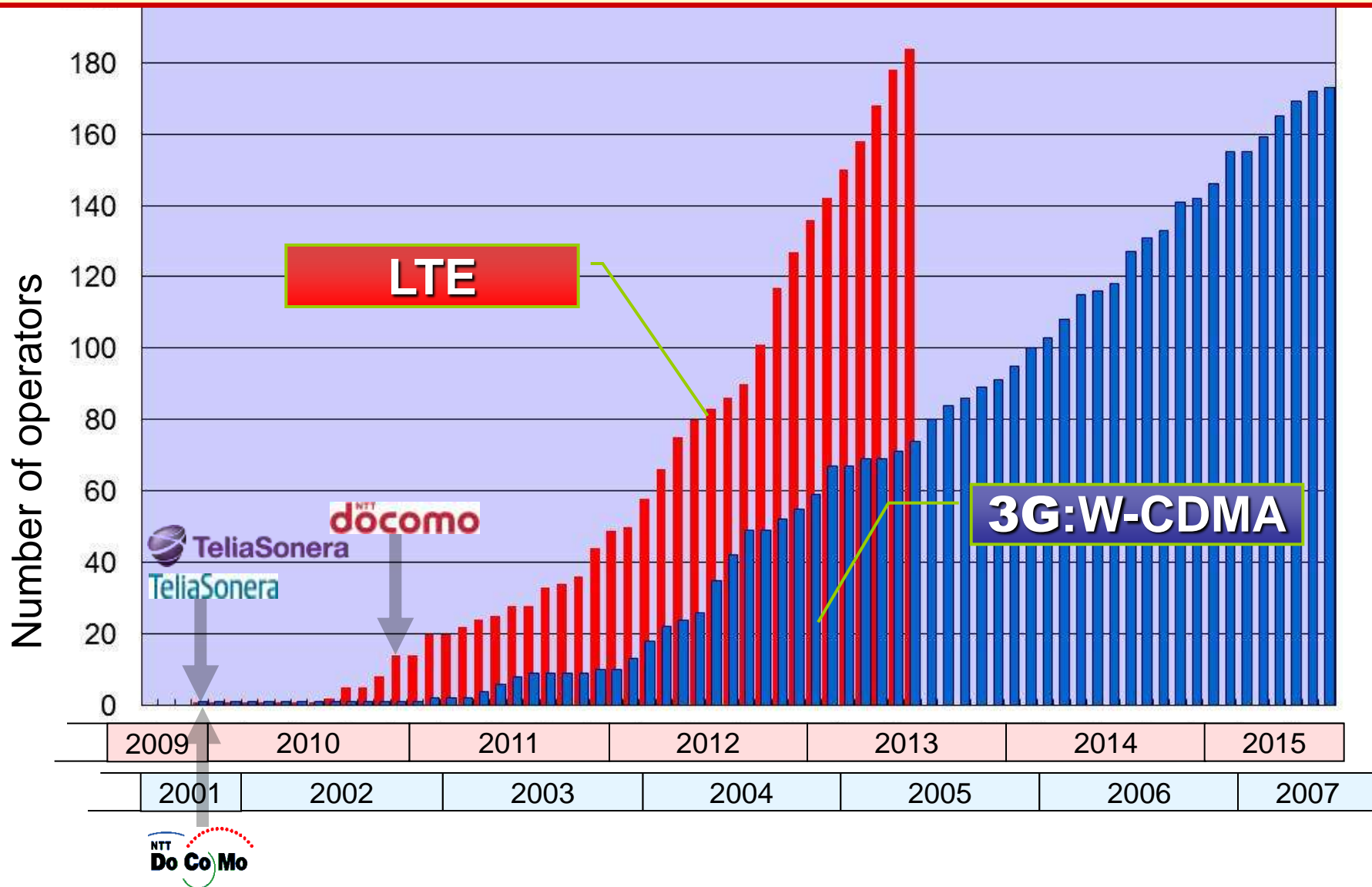


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LTE Today

Numbers of Operators (Global)

The global deployment of LTE is much quicker than that of 3G.

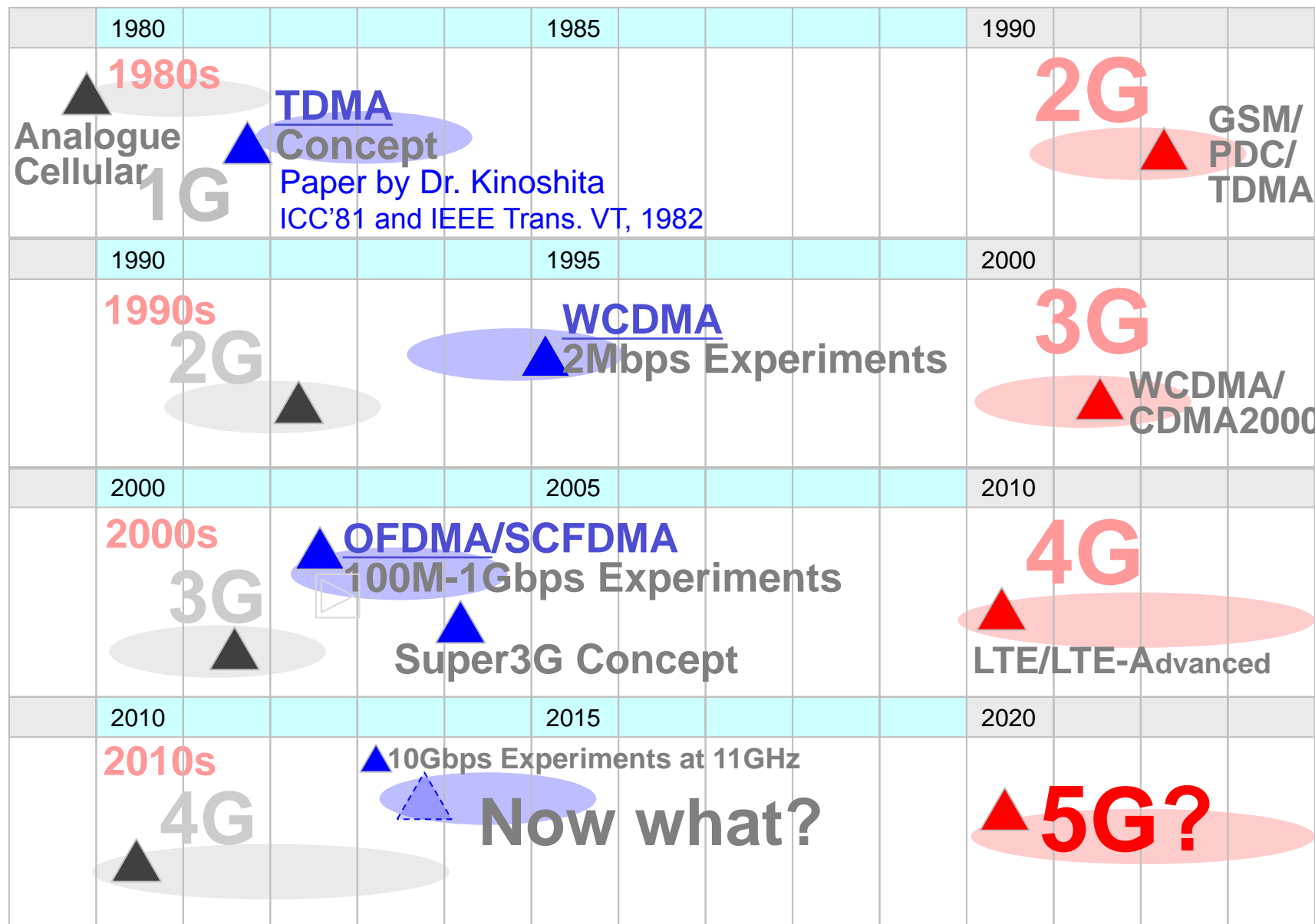


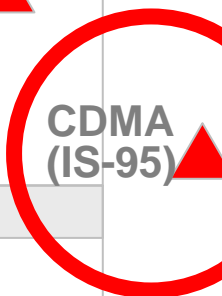
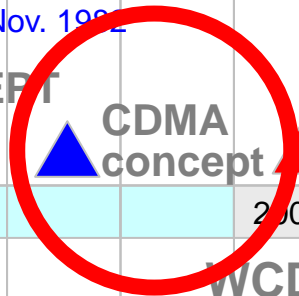
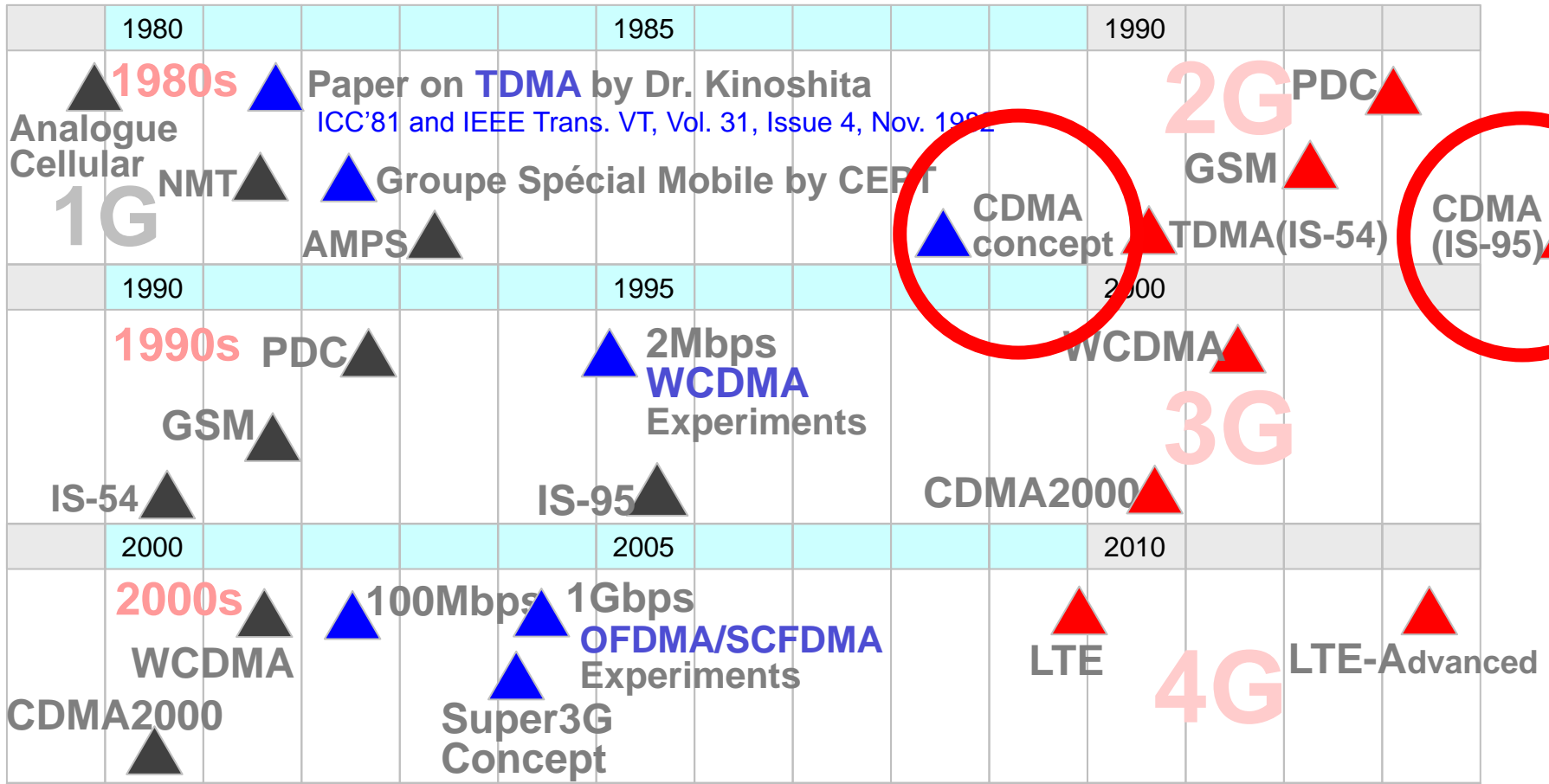
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History from 1G to 4G

It's time to start something for 2020s

Details 





History of 4G Research at DOCOMO

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

100Mbps
in 2002-2003



5Gbps
in 2006



1Gbps
in 2004-2005



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5G Technology

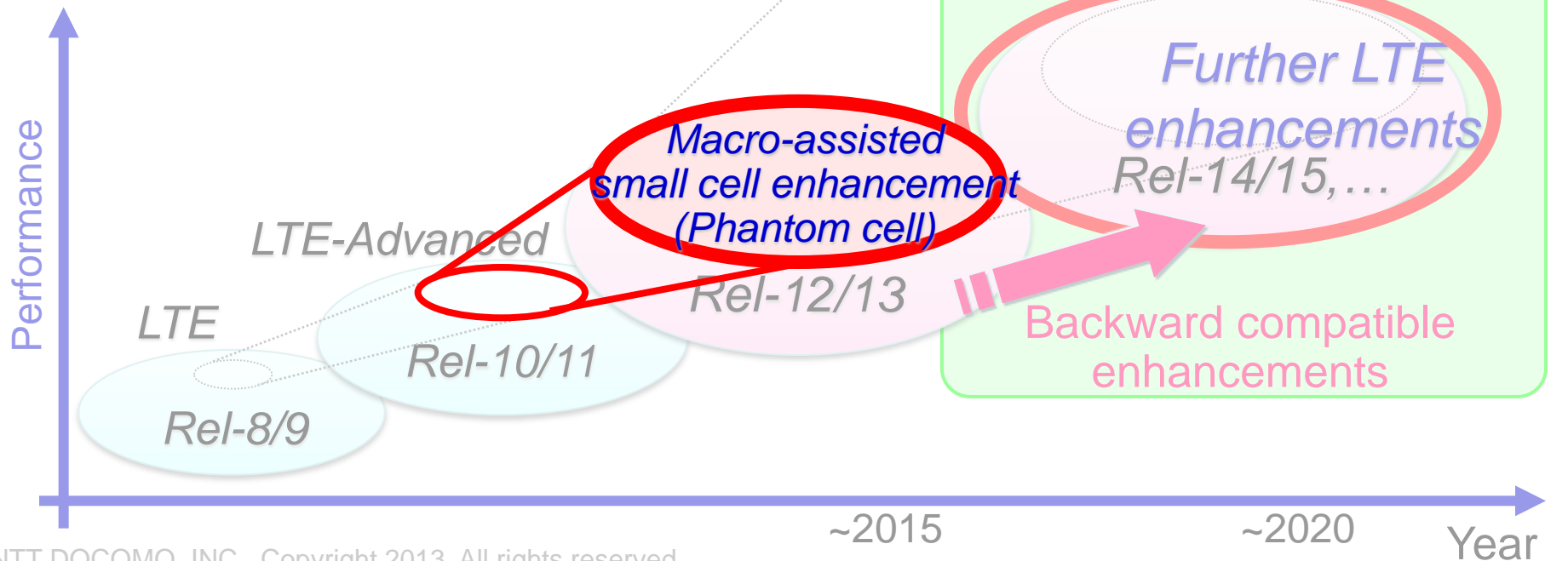
Evolution paths for Future Radio Access

Big gain vs. Backward compatibility

If we achieve “Big gain”, “New RAT” can be introduced.

Technology

- Phantom cell, Massive MIMO
- NOMA (Non-orthogonal Multiple Access)



Future Technology

● LTE-Advanced key features

➔ Carrier aggregation

➔ This is not so smart technology.

➔ HetNet/ Small cell

➔ This is old technology and may become buzzword.

“力業”

“Brute force”

● The combination of Carrier Aggregation and Small Cells with C-RAN will create new excellent features.

➔ **Advanced C-RAN** 

➔ Architectural evolution will be the possible area for a new technology.

Macro-assisted small cell enhancement

with current specs ➔ with new specs: **Phantom cell** 

Future Technology

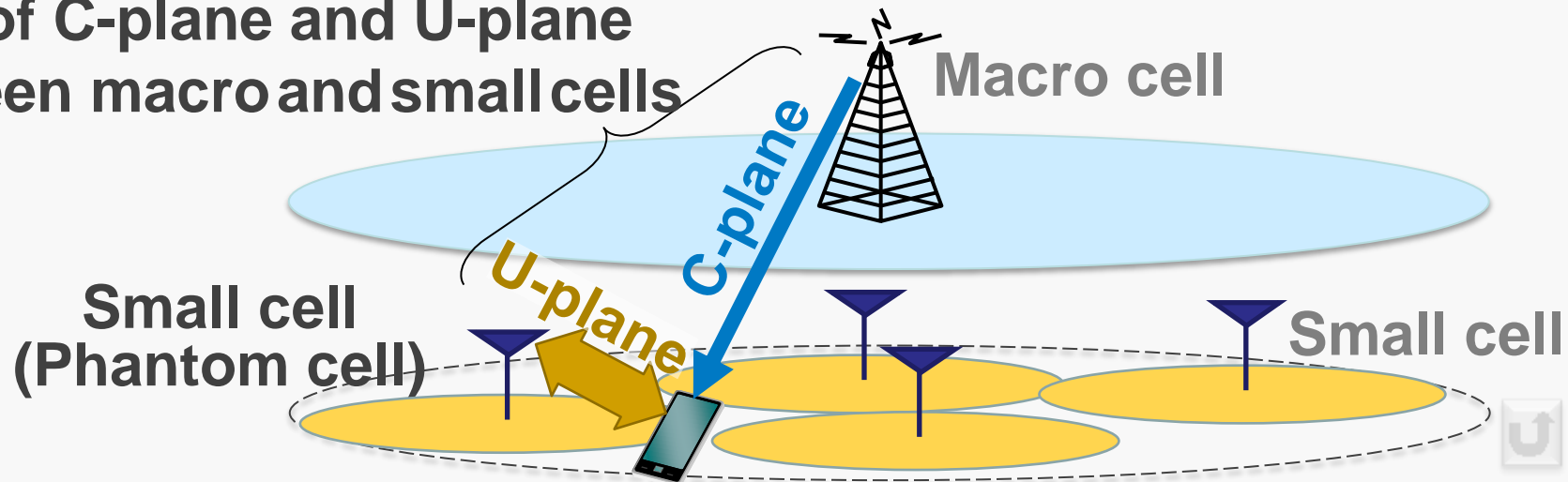
→ Architectural evolution will be the possible area for a new technology.

Macro-assisted small cell enhancement

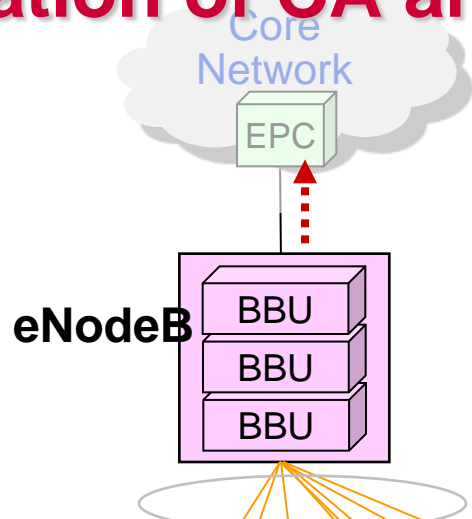
with current specs → with new specs: **Phantom cell**



Split of C-plane and U-plane
between macro and small cells

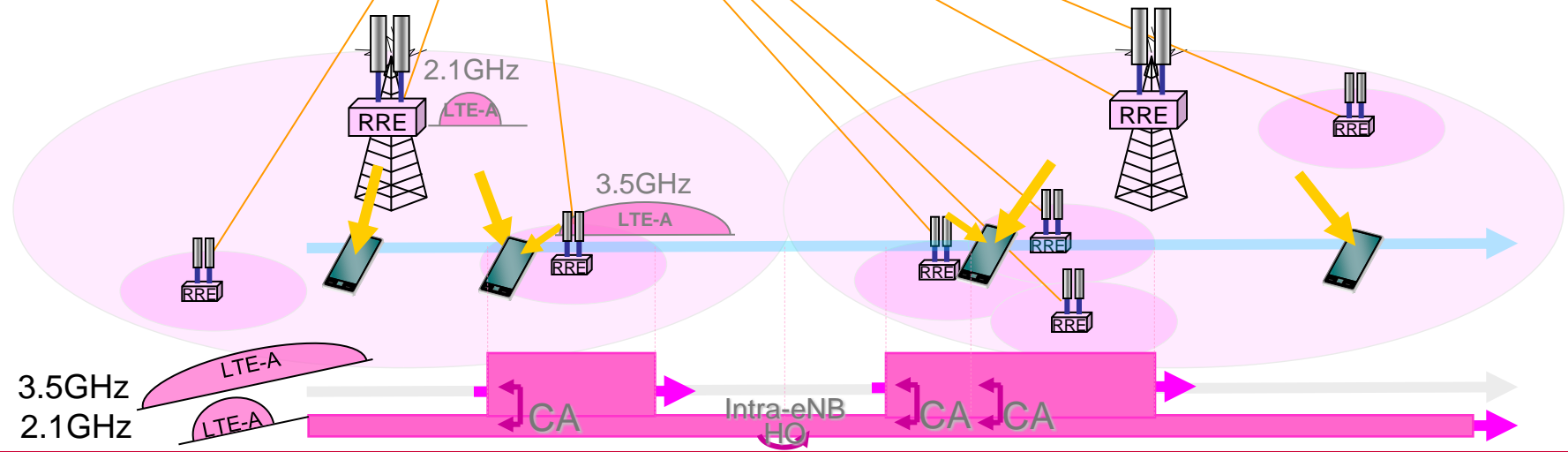


Advanced C-RAN Architecture -Combination of CA and Small-cell

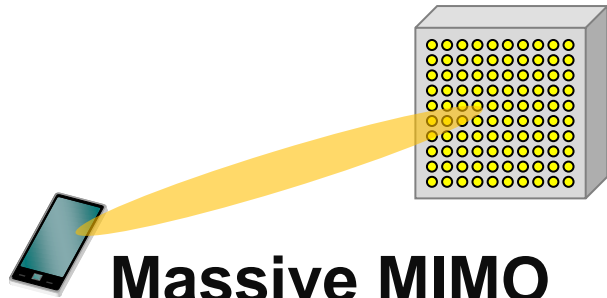


- Enhance data speed and capacity by small cells
- Small cell deployment without impact on mobility management
- Easy deployment of higher frequency bands
- Reduce signaling to core-network

- Carrier Aggregation between macro and small cell
- Maintain connectivity via macro cell
- All processing (CA and Hand-Over) within eNodeB



Massive MIMO and Macro-assisted Small cell



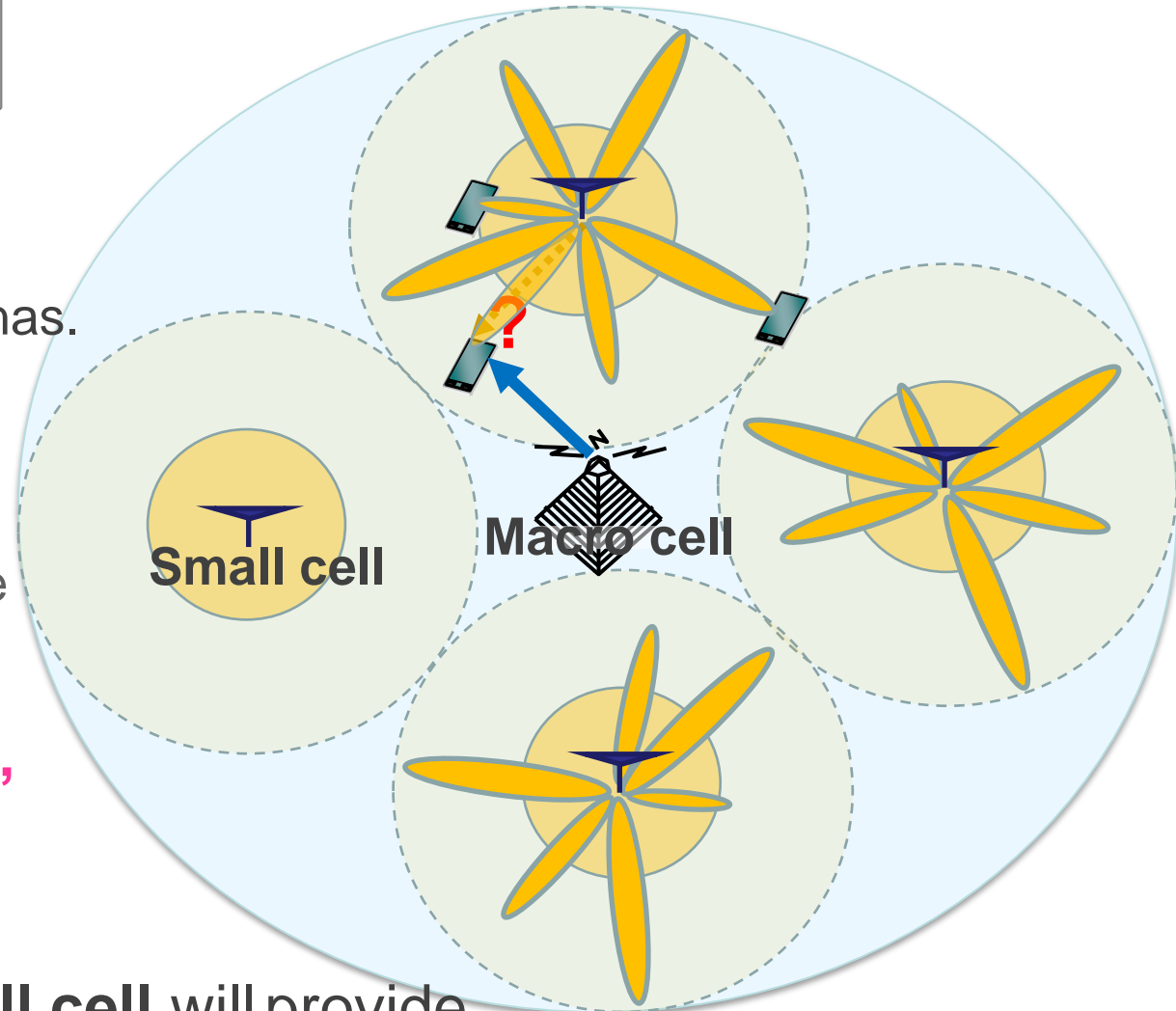
Massive MIMO
is about increasing
the number of antennas.

力業“Brute force”

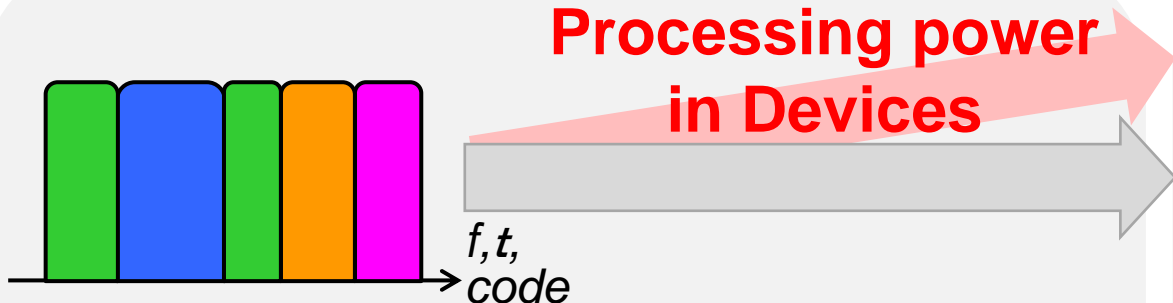
Adaptive Array Systems
had a problem in coverage
for common channels.

“an excellent feature”

The combination of
Massive MIMO and
Macro-assisted small cell will provide
adequate cell coverage even with higher frequency bands.



Non-Orthogonal Multiple Access (NOMA)



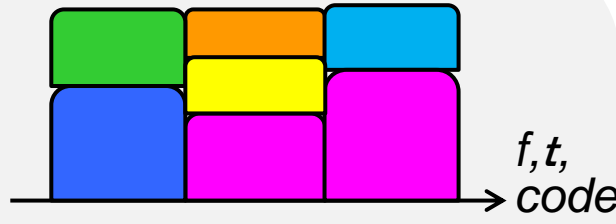
Effort for Orthogonality

Effort to Mitigate Interference

FDMA, TDMA, CDMA, OFDMA

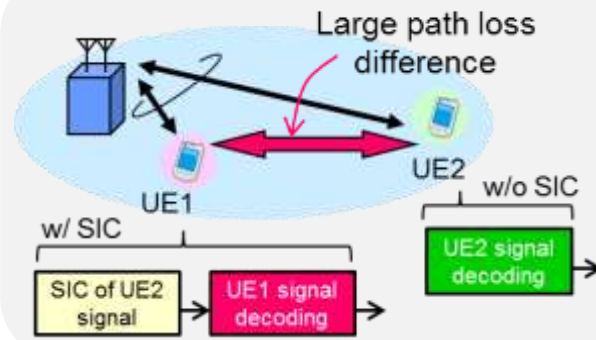
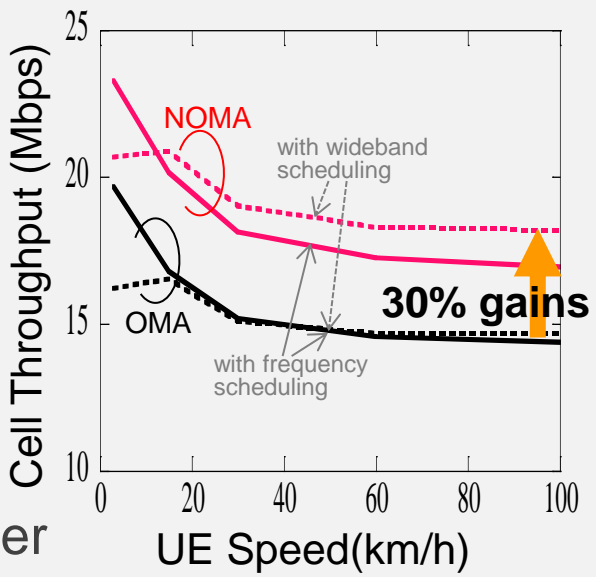
Equalizer, Cancellor

MIMO



Intentional Non-orthogonality

NOMA



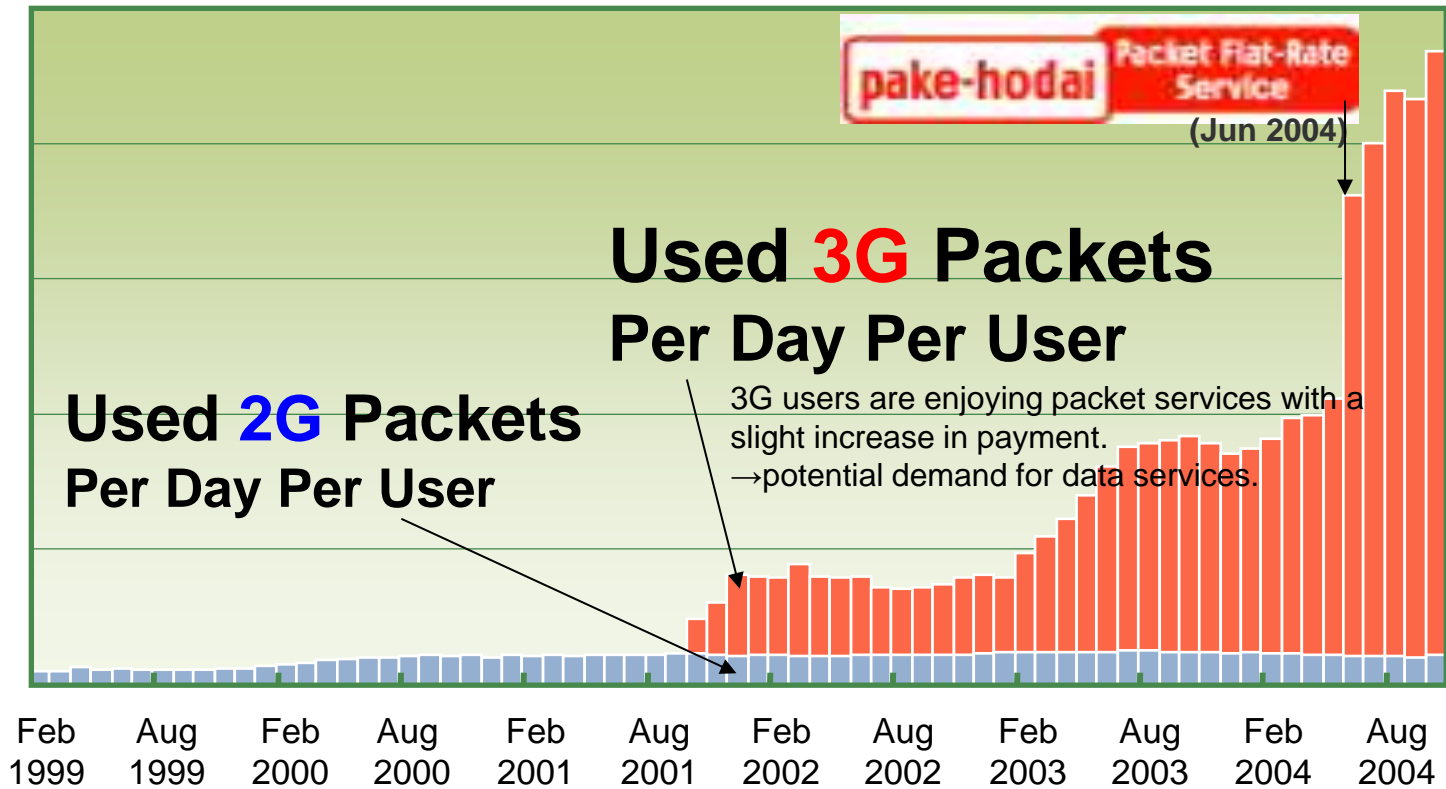
Exploitation of power-domain, path loss difference among users, and UE processing power

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1000x Data, true?

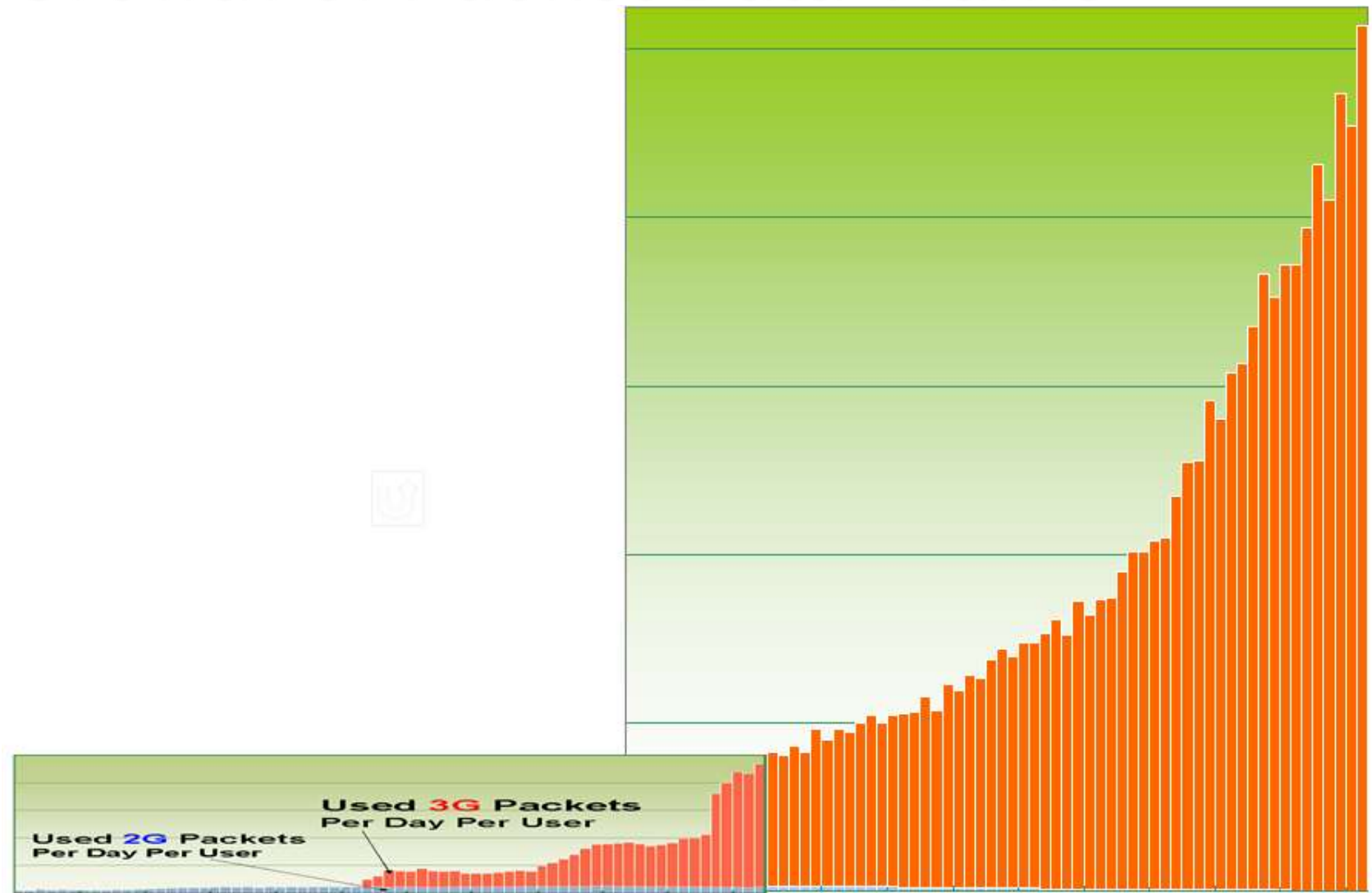
Growth of Packet Data Traffic

Number of Packets Per Day · User



- 3G has a much higher capacity than 2G.
- A potential demand is observed in the increasing traffic.

Growth of Packet Data Traffic

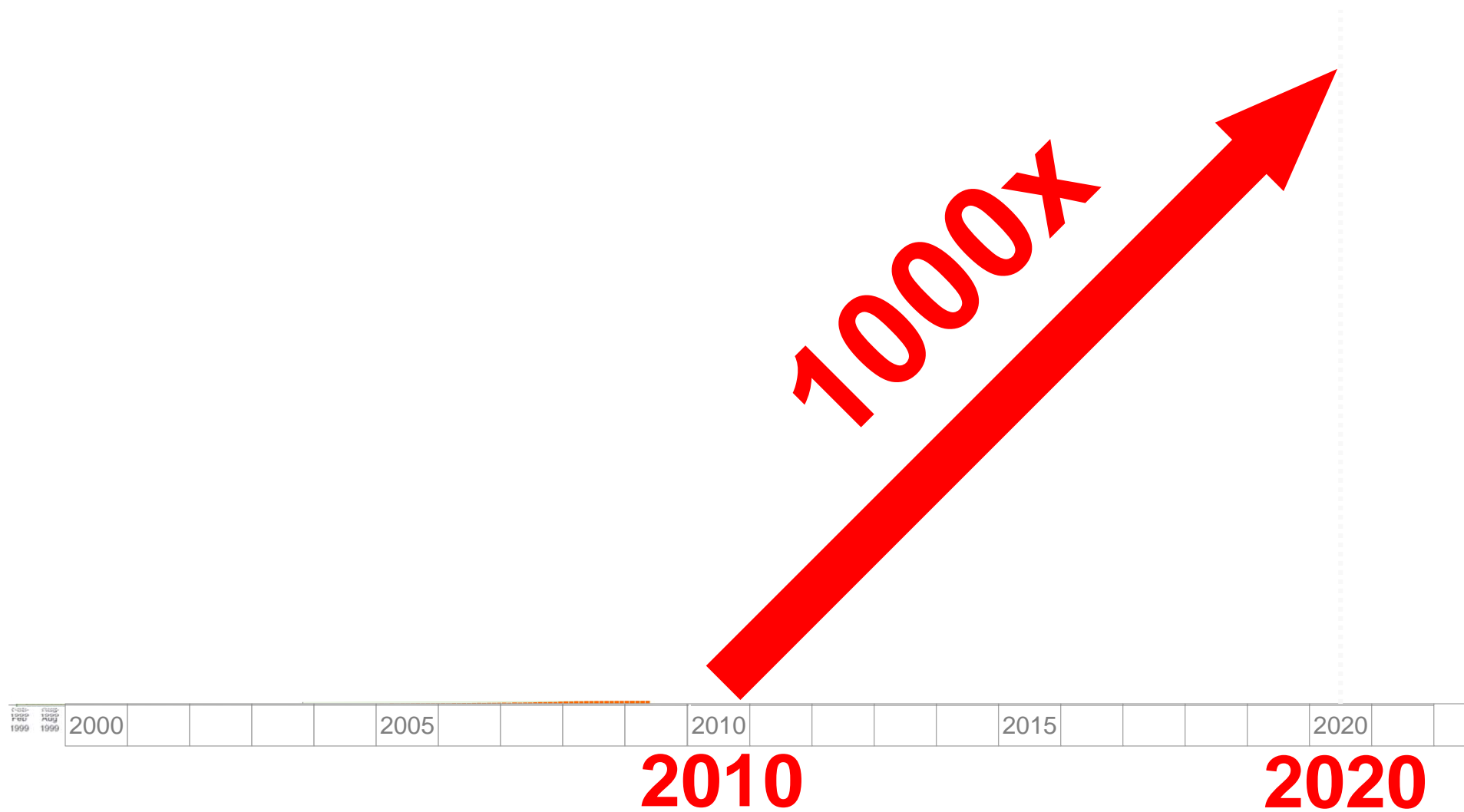


2000

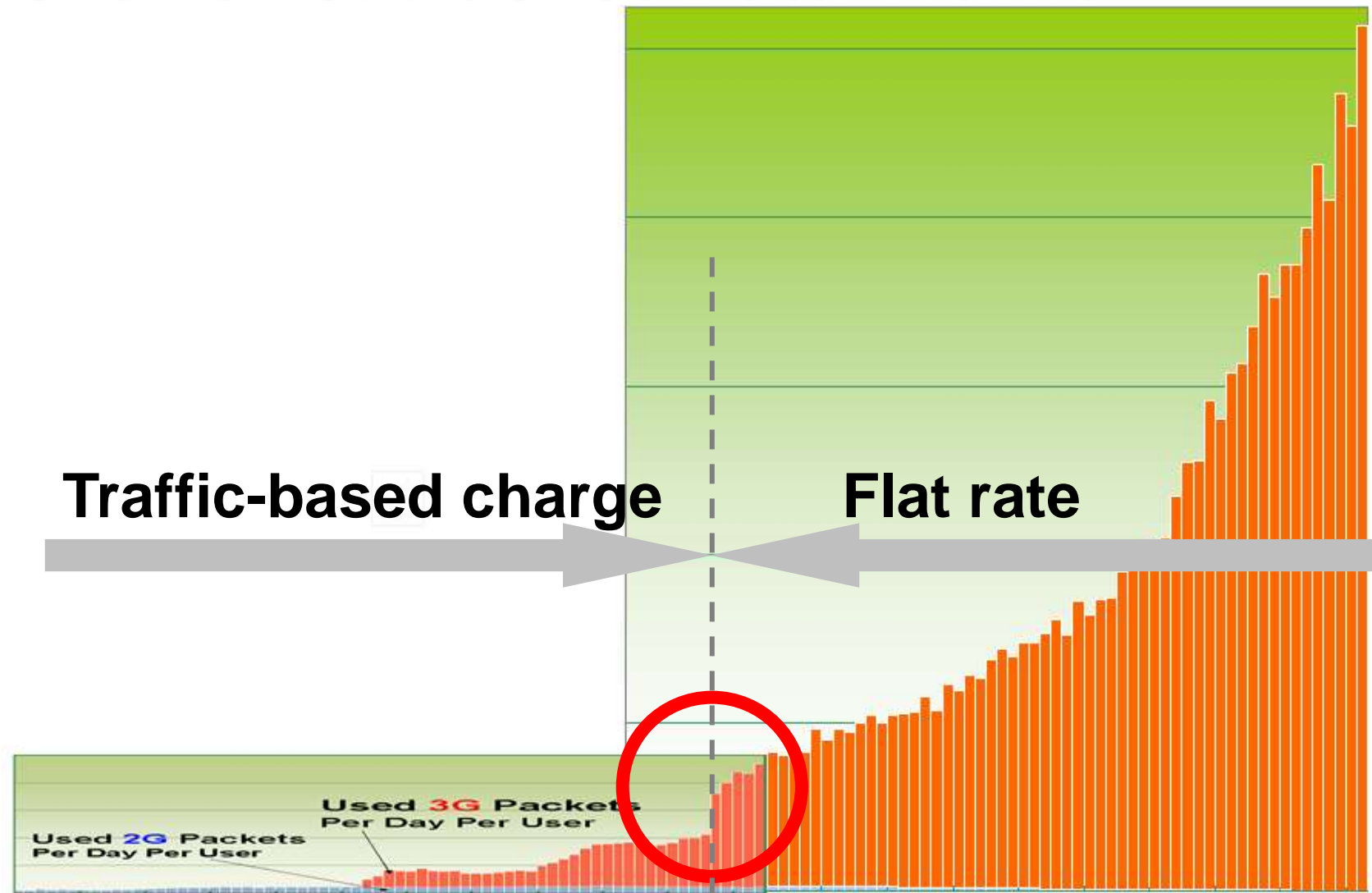
2005

2010

Growth of Packet Data Traffic



Growth of Packet Data Traffic



Traffic-based charge

Flat rate

Feb 1999 Aug 1999 Feb 2000 Aug 2000 Feb 2001 Aug 2001 Feb 2002 Aug 2002 Feb 2003 Aug 2003 Feb 2004 Aug 2004 Apr 2005 Oct 2005 Apr 2006 Oct 2006 Apr 2007 Oct 2007 Apr 2008 Oct 2008 Apr 2009

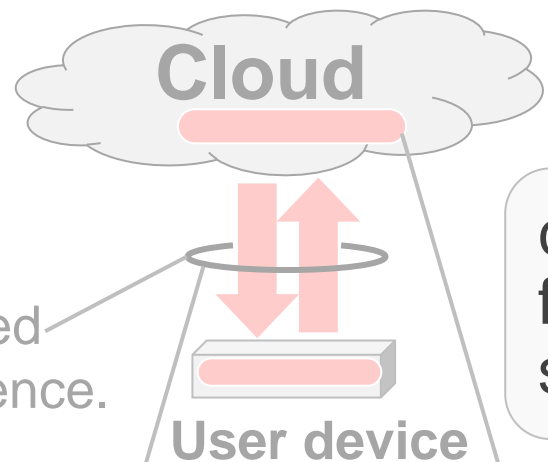
2000

2005

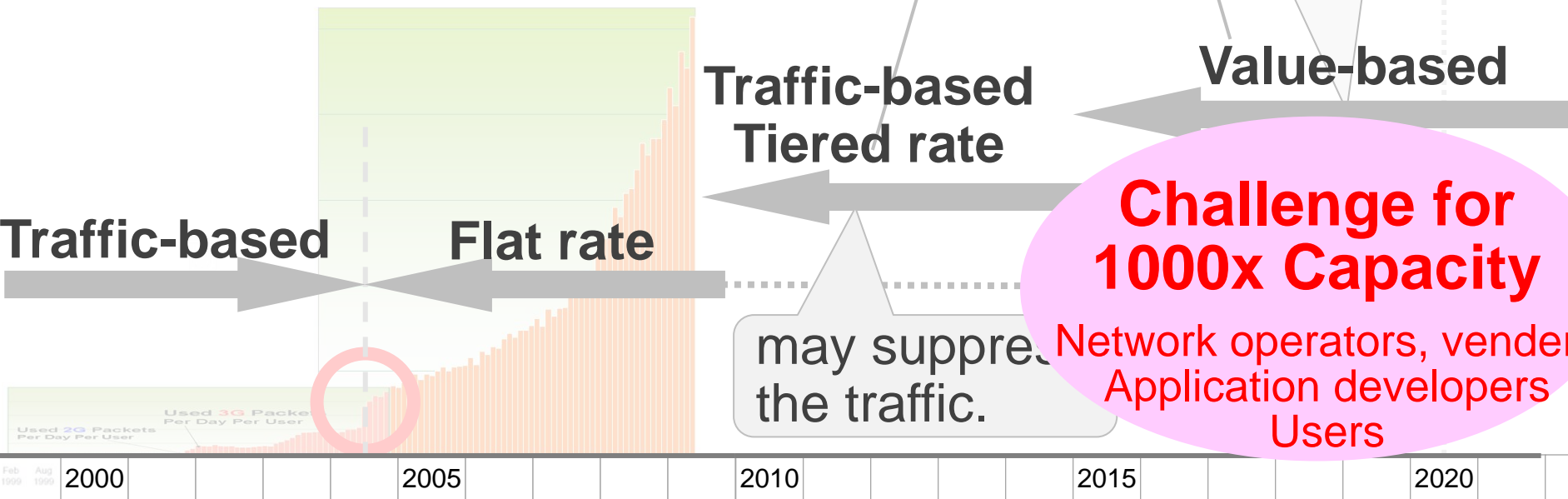
2010

Growth of Packet Data Traffic

Unused data may be transmitted by applications for user experience. Users cannot control the traffic.



challenges for customer satisfaction

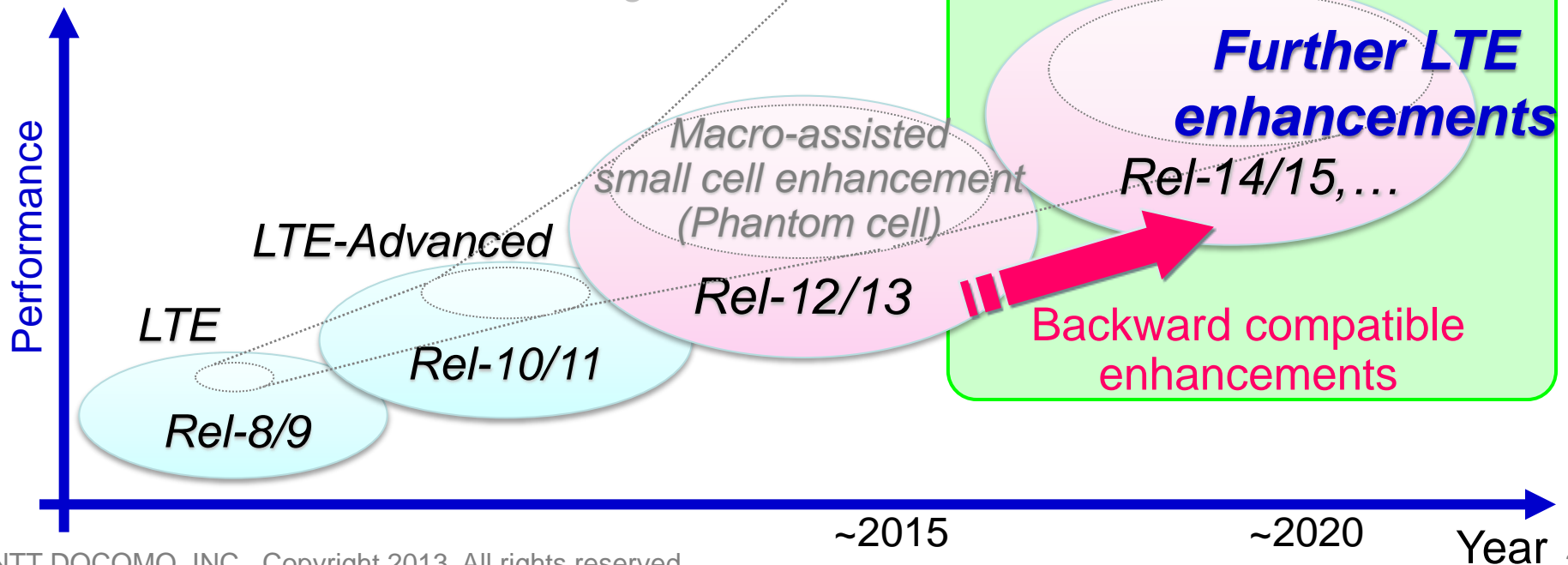


1000x Data happens for user experience in Cloud era.

Evolution paths for Future Radio Access

**Let's create a true 5G,
potential new RAT
with big gain.**

The terminology 5G will be used for all technologies created around 2020, for marketing.....



The logo for NTT docomo is displayed in red. The word "docomo" is written in a bold, lowercase, sans-serif font. Above the first letter 'd', the letters "NTT" are written in a smaller, uppercase, sans-serif font. The entire logo is centered horizontally and is partially overlaid by a large, light gray, semi-transparent triangle that points downwards from the top left corner of the image.

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