

Feb. 18, 2021

The Dawn of the 5G Era and DOCOMO's R&D Activities

Naoki Tani

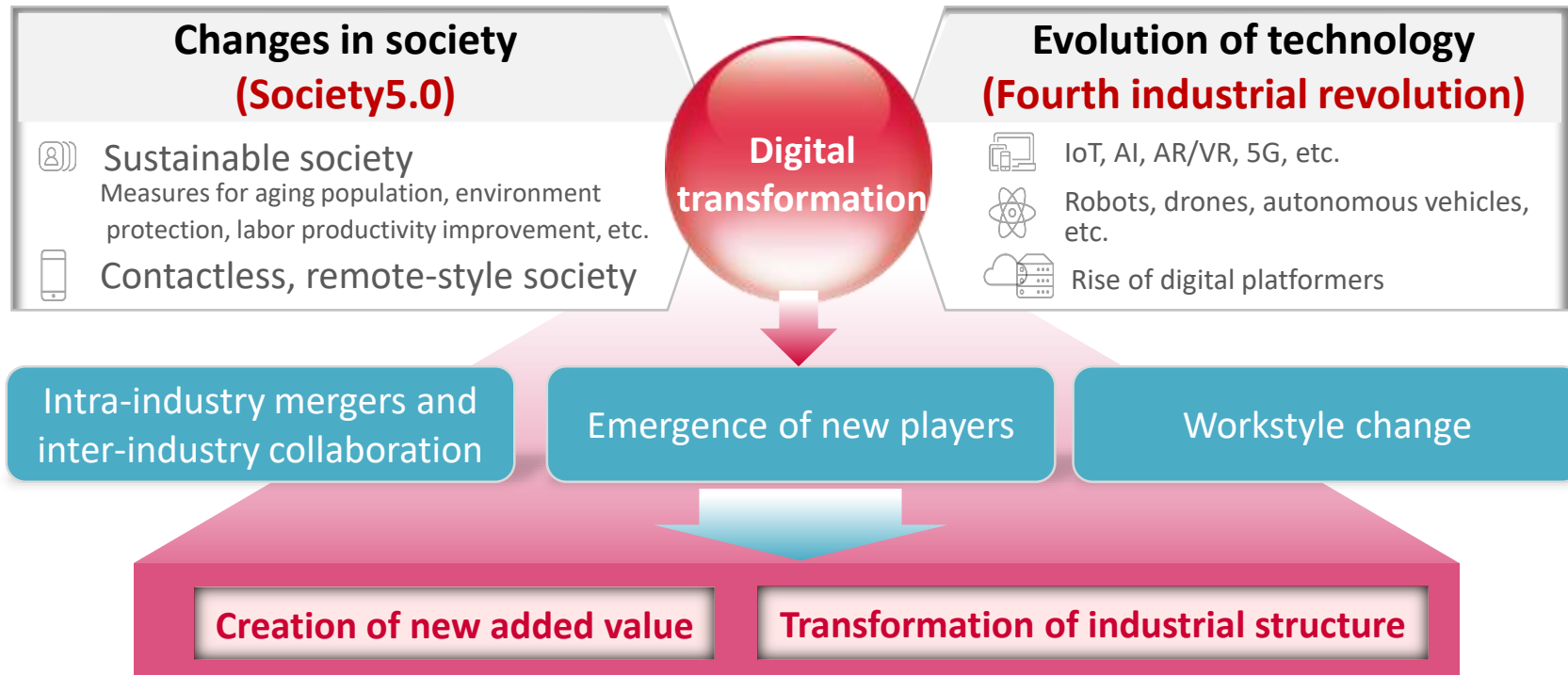
NTT DOCOMO, INC.

Executive Vice President

Chief Technology Officer

Executive General Manager of R&D Innovation Division

» Digital Transformation (DX) Gaining Traction



» DOCOMO's Approach to R&D

A society where everyone can shine and tap into a broad spectrum of possibilities by reaching out and connecting with others

Wellbeing Society

Core technology evolution

Cyber-physical convergence

Data utilization

AI x data

2

Data acquisition/
accumulation

Future prediction/
knowledge discovery

3

Connectivity

5G/Next-gen network

NW

Cyber-Physical convergence

NW

Customer touchpoints

IoT/Devices

1

Informatization of people,
things and events

Actuate

4

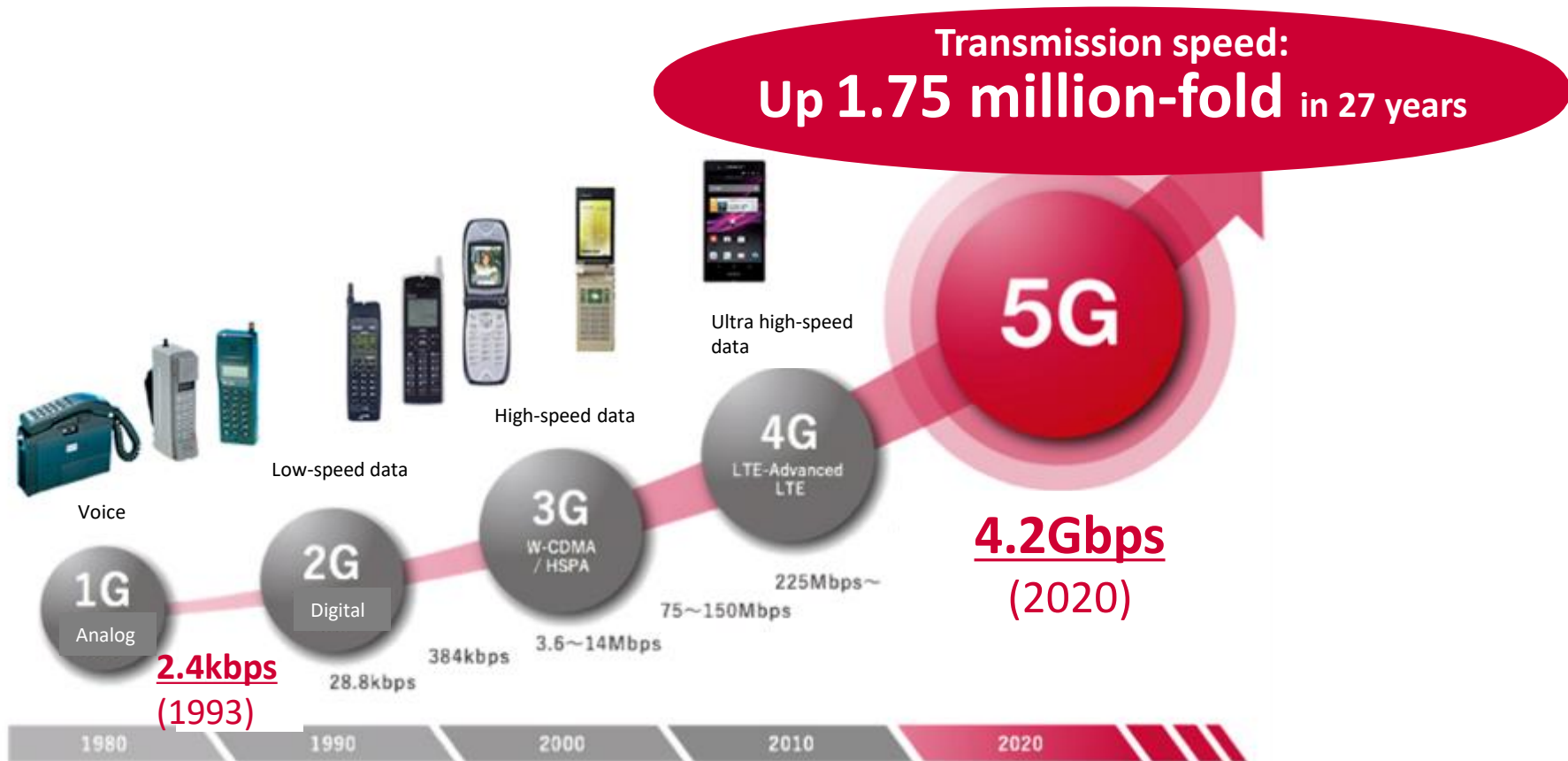
Physical space

Cyber space

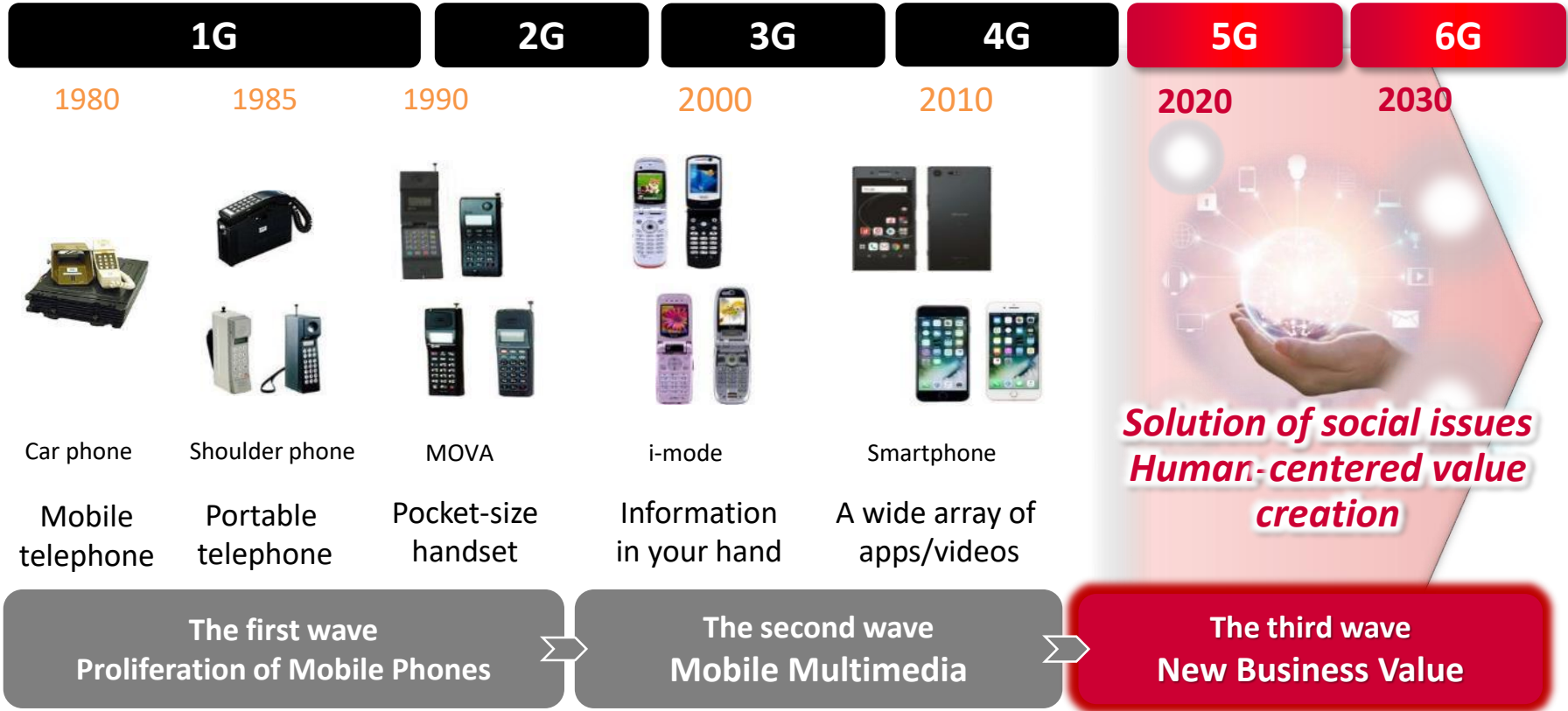


Technology Innovation -Network Technologies-

» Advancement of Mobile Networks



Creating a New History



»» DOCOMO's 5G: NOW

DOCOMO's 5G: Commercial service launched Mar. 25, 2020

5G subscriptions

Approx. **1.41 mil**



As of Dec. 31, 2020

5G area buildout

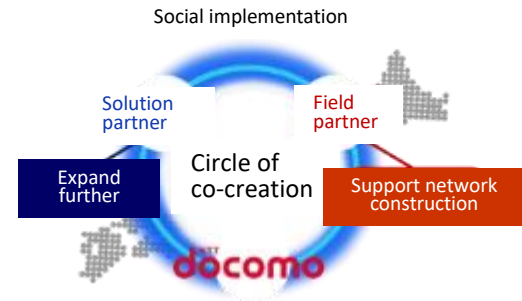
5G service available in
209 cities



As of Dec. 31, 2020

Participation in 5G Open Partner Program

Over **3,600** organizations



As of January 2021

» "Lightning Speed 5G" Coverage Expansion Using 3 New Spectrum Bands

3 New 5G spectrum bands

3.7GHz

4.5GHz

28GHz

瞬速5G

Lightning Speed 5G

500
cities

Including all ordinance-designated cities

Mar. 31, 2021

10,000
Base stations

Jun. 30, 2021

20,000
Base stations

High-speed, large-capacity
population coverage:

55%*

Mar. 31, 2022

32,000
Base stations

High-speed, large-capacity
population coverage:

Approx. 70%*

Mar. 31, 2023

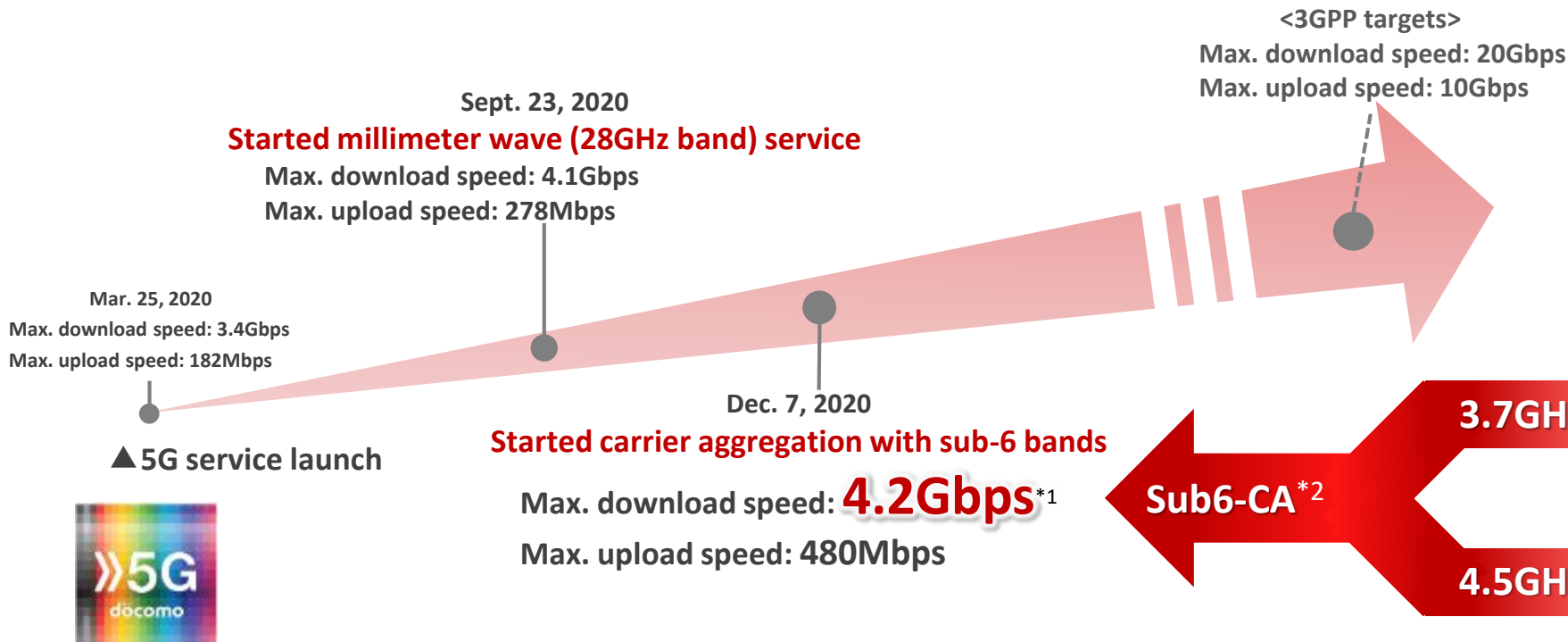


“Lightning Speed 5G” Roadmap for Speed/Capacity Enhancement

2020

...

202X



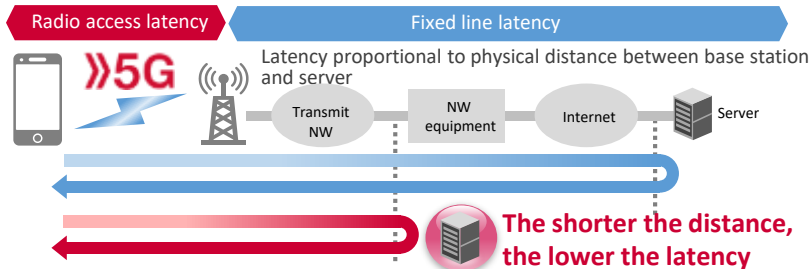
*1: Maximum value for applicable area coverage set forth in the technical standard of compatible devices.
*2: Carrier aggregation compliant with O-RAN specifications.

» Evolution of Network to Respond to Varying Needs

Lower latency (MEC*)

* Multi-Access Edge Computing

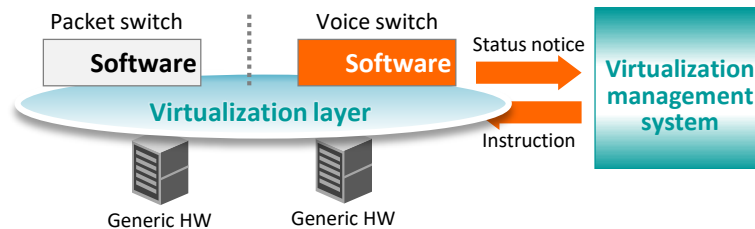
Further reduction of end-end latency



Software-based (virtualization)

Shared use of generic hardware to realize cost efficient network highly resilient against equipment failure and disasters

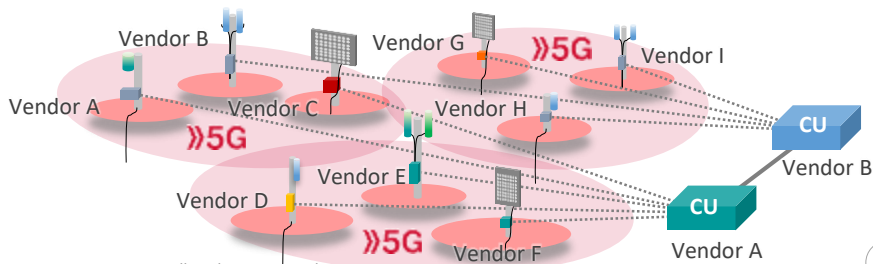
Various software can share common generic hardware



Open (O-RAN*)

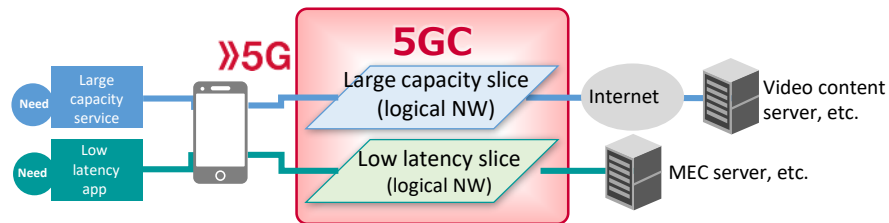
*O-RAN : Open Radio Access Network

Enable fast, flexible and efficient network construction through interconnectible open interface

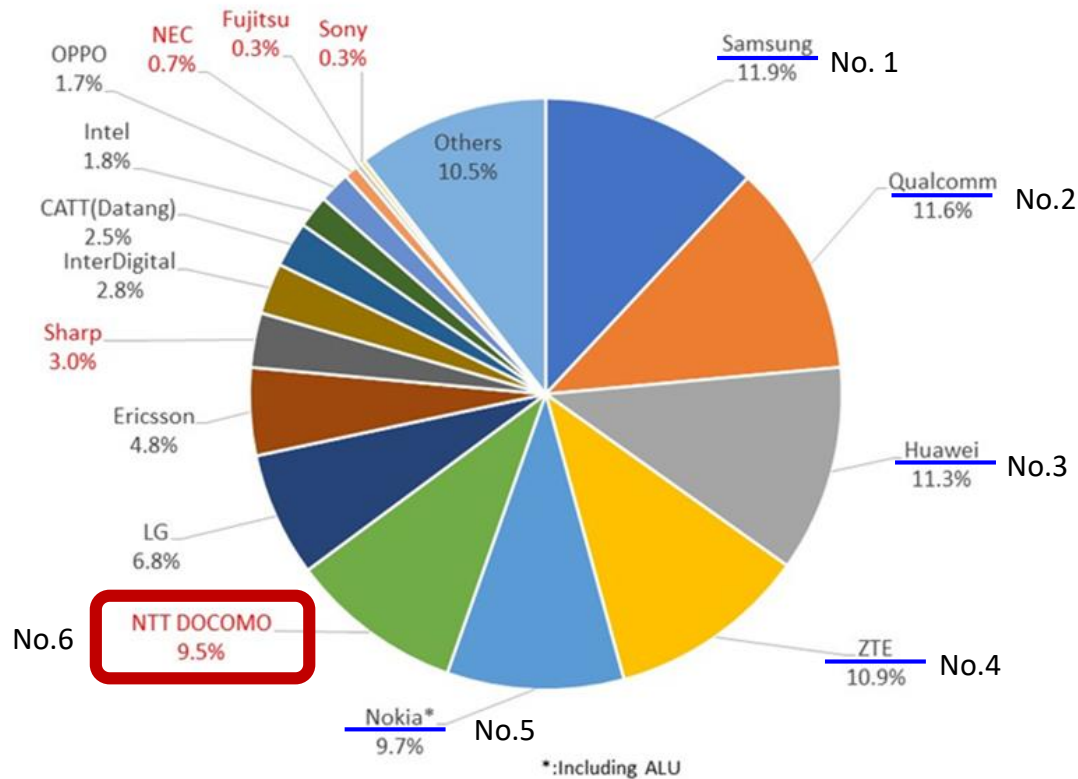


Slicing (5GC)

Flexible network rollout through software implementation



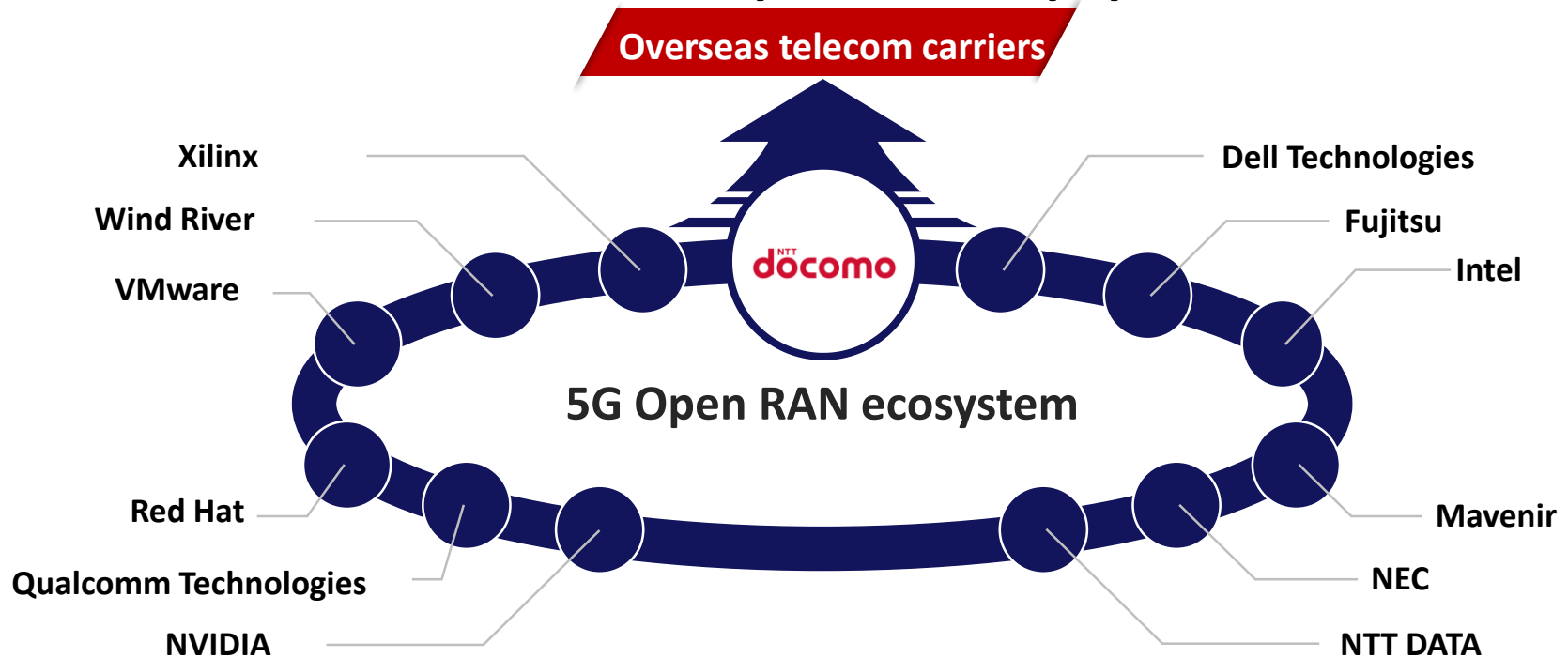
» 5G Essential Patent Ownership Share



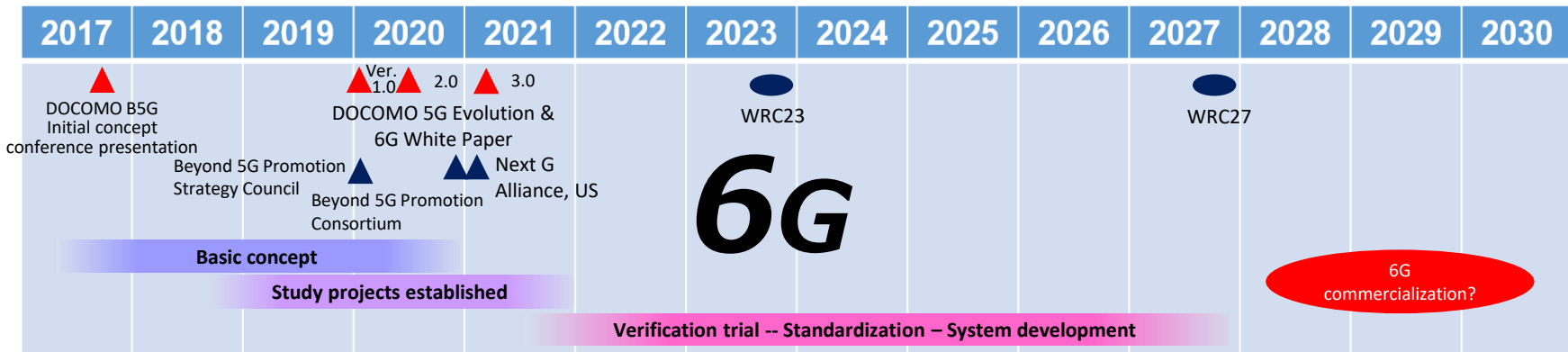
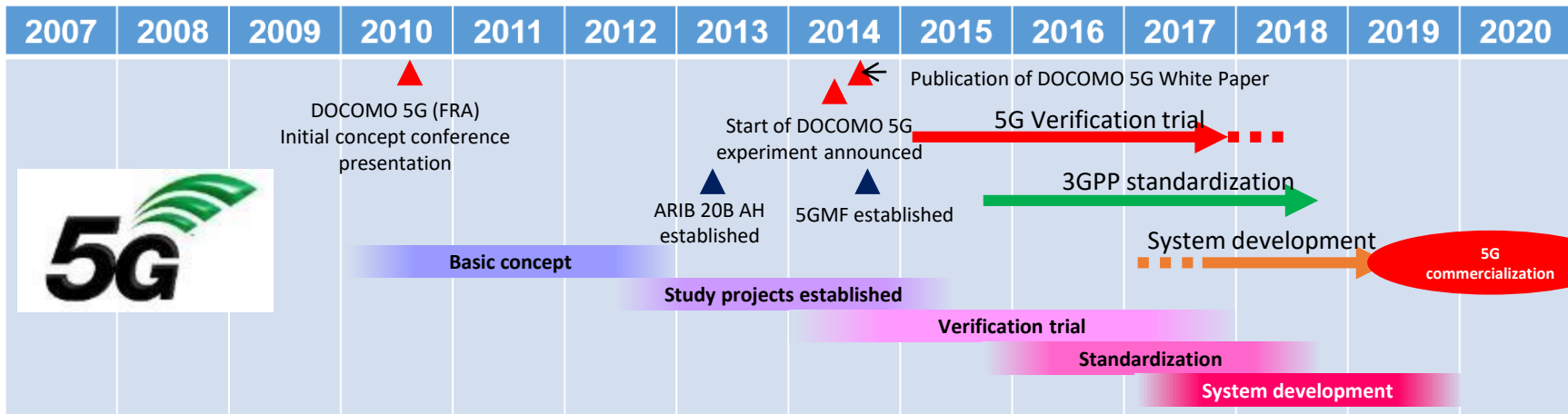
(Source) Cyber Creative Institute Co. Ltd. "Essentiality Evaluation of SEP Declared 5G Patents"
(Underlines in the chart were added by NTT DOCOMO, INC.)
<https://www.cybersoken.com/blog/topics/2020/10/12/2825/>

» 5G Open RAN Ecosystem

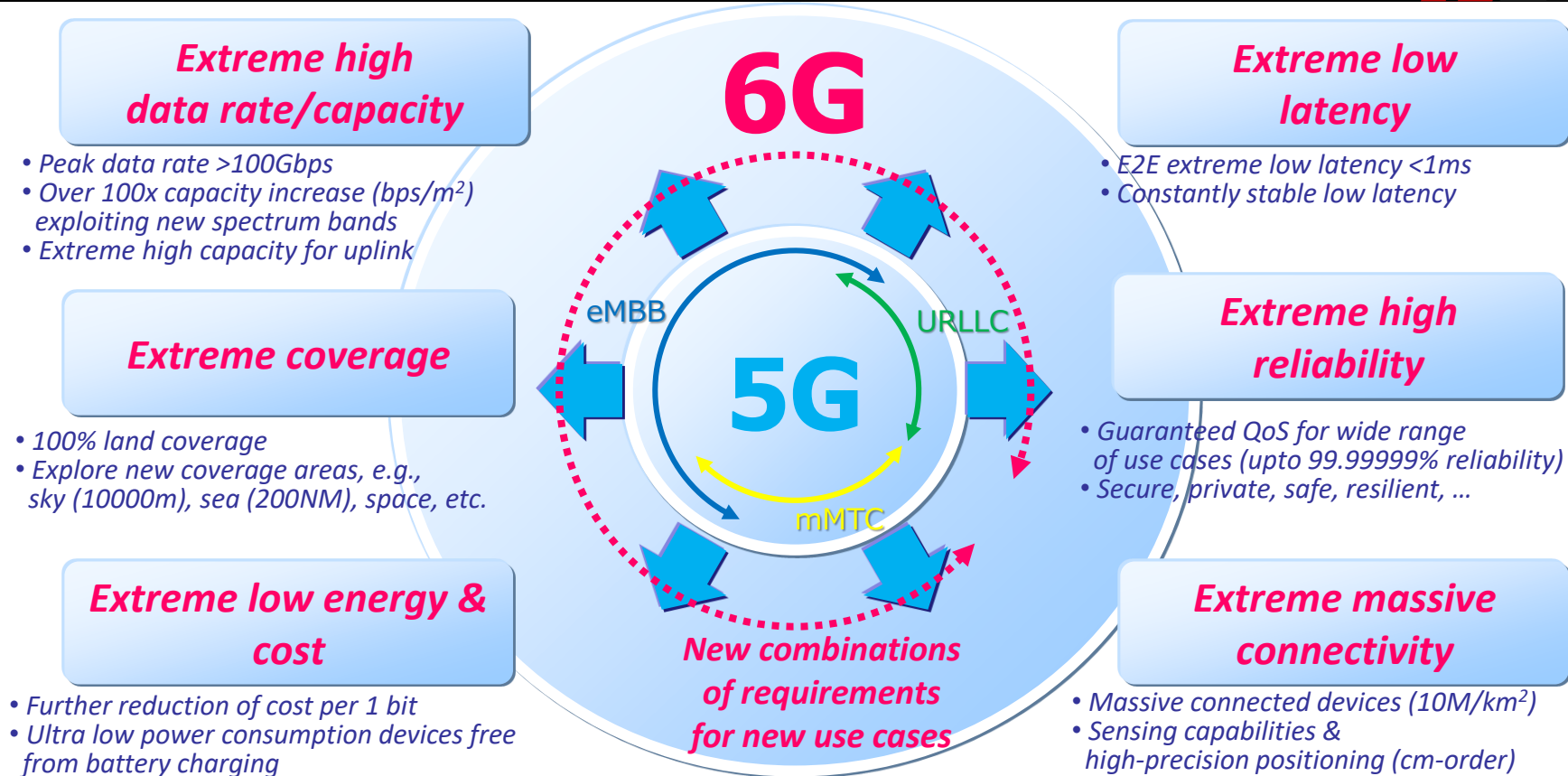
Started joint studies with partners to promote open intra-equipment interface in addition to open inter-equipment interface



» 5G Development Track Record and 6G Outlook



»»Challenging the “Extremes” toward 6G



World Envisaged by 5G Evolution & 6G



© 2021 NTT DOCOMO, INC. All Rights Reserved.

ホワイトペーパー

5G の高度化と 6G

株式会社 NTT ドコモ

2021年2月(第3版)



目次	
1 はじめに	3
2 進化の方向性「5G evolution and 6G」	4
2.1 5G evolution への考察	4
2.2 6G への考察	6
3 社会事件とユースケース	9
3.1 超高速・大容量通信	9
3.2 超カバレッジ拡張	10
3.3 超節約費電力・低コスト化	10
3.4 超広帯域	11
3.5 超遅延低遅延	11
3.6 超多接続とセンシング	12
4 技術革新と検討領域	13
4.1 広帯域域の分散ネットワーク高次元化 (New Radio Network Topology)	13
4.1.1 “波”による分散アンテナ展開	15
4.1.2 放射波 (RIS) 技術	15
4.1.3 端末間直達伝送技術	16
4.1.4 センシングや非ユースケースと Wi-Fi を分散アンテナ展開	16
4.2 閉鎖 (Non-Terrestrial Network) を含めたカバレッジ拡張技術	17
4.3 超広帯域域のさらなる広帯域化および超広帯域利用の高度化技術	18
4.4 Massive MIMO 技術および超広帯域技術のさらなる高度化	20
4.5 超遅延・超低遅延 (URLLC) の拡張および産業向けネットワーク	21
4.6 無線通信システムの多機能化およびあらゆる領域での AI 技術の活用	22
4.7 移動通信以外の無線通信技術のインテグレーション	23
4.8 ネットワーク・アーキテクチャ	24
4.8.1 フラットなネットワーク・トポロジー	24
4.8.2 フレキシブルなネットワーク機能配置	25
4.8.3 ネットワークのシンプル化	25
4.8.4 OAM (Operation and Maintenance) の高度化	25
4.8.5 複数のアクセス技術方式の統合運用技術	25
4.8.6 超広帯域を支えるコアネットワーク伝送/交換網技術	26
4.8.7 CPS を支える広帯域時延低減と広帯域セキュリティ通信	26
4.8.8 超カバレッジを支える位置・ベース移動網	26
4.8.9 セキュリティの高度化	27
4.8.10 分散するコンピューティングリソース	28
5 おわりに	30
参考文献	31
変更履歴	35

DOCOMO White Paper “5G Evolution and 6G”

Ver. 1.0 (Published Jan. 22, 2020)

Ver. 2.0 (Published Jul. 17, 2020)

Ver. 3.0 (Published Feb. 2, 2021)

https://www.nttdocomo.co.jp/corporate/technology/whitepaper_6g/?cid=CRP_CORP_to_CRP_CORP_tech_nology_whitepaper_6g

World Envisaged by 5G Evolution & 6G

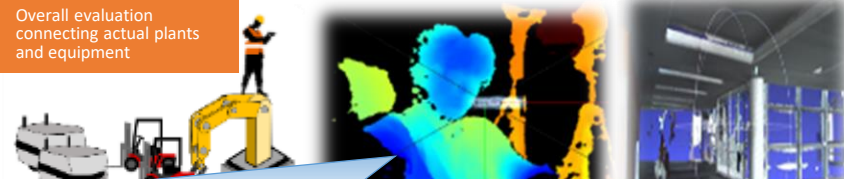
Coverage extension



Utilization of high altitude pseudo satellites (HAPS), satellite MIMO, underwater MIMO, millimeter wave performance verification for high-mobility environment, communication performance verification at 360km/h, flexible reflector films, metasurface lens, 5G relay node, Pinching antenna, smart surface

Explore industrial adoption

Overall evaluation connecting actual plants and equipment



Area estimation using point cloud data, definition of co-existence conditions with industrial equipment, various verifications using real environments/equipment, URLCC verification trial, etc.

Use of THz bands



6G simulator, 100GHz band high-output power amp, 150GHz band transmission system, 300 GHz band ultra high-speed IC, THz propagation tests, mobility performance verification using sensing

Future network



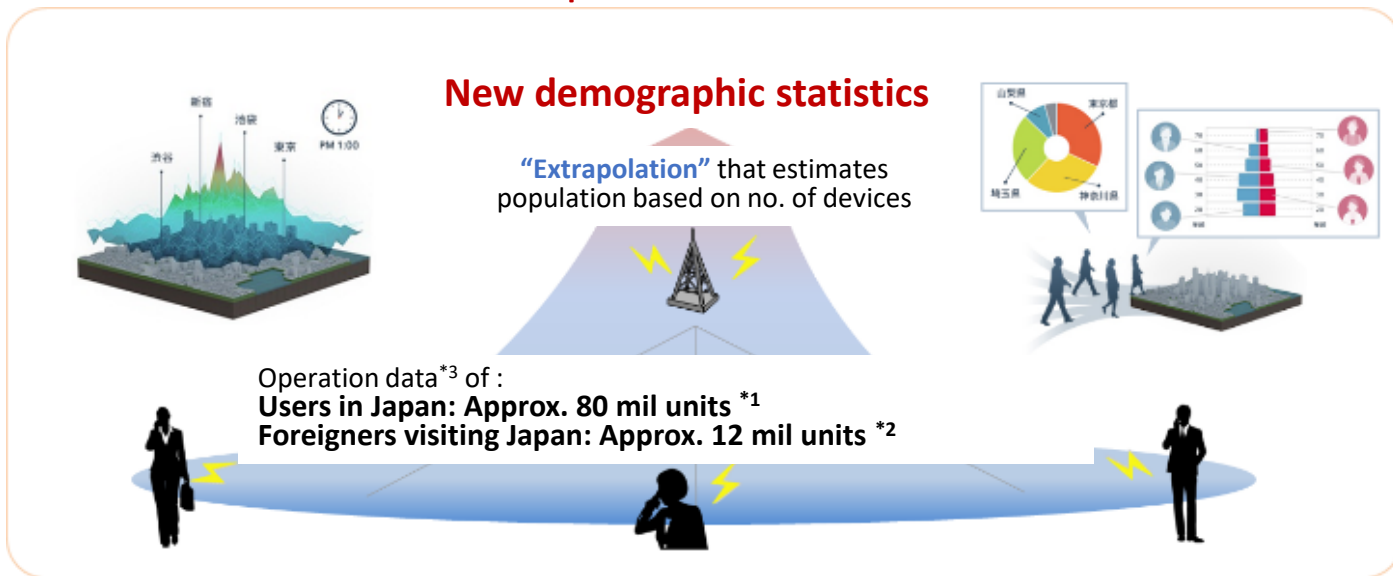
AI For RAN, Cradio®, VM-MIMO, OAM-MIMO, Analog-ROF, 6 G radio techniques (Mega-MIMO, etc.)



Technology Innovation - Service Technologies -

» Mobile Spatial Statistics

Mobile spatial statistics is a **new form of demographic statistics** that can track **“when”** and **“what kind of person”** moved from **“where”** to **“where”**



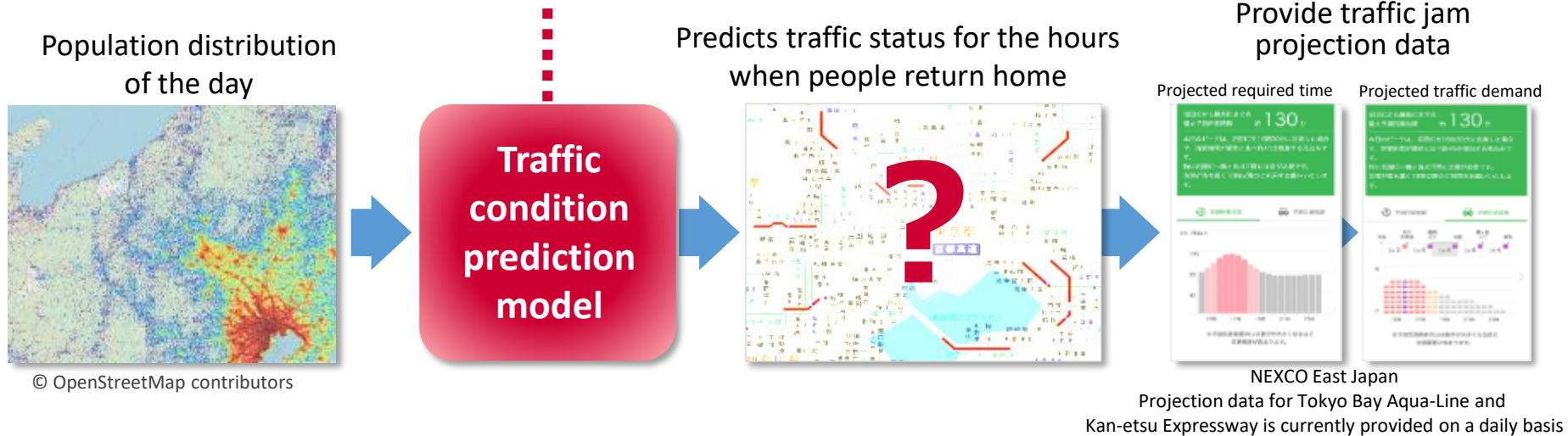
*1: Estimation is performed based on these units after eliminating the no. of enterprise and MVNO accounts, etc. (As of March 2020)

*2: Actual no. of visitors for 2019

*3: Data required to maintain mobile phones connectable all the time

» AI-based Traffic Jam Prediction

Traffic condition prediction model that patternizes the correlation between historical population data and traffic conditions



Values delivered

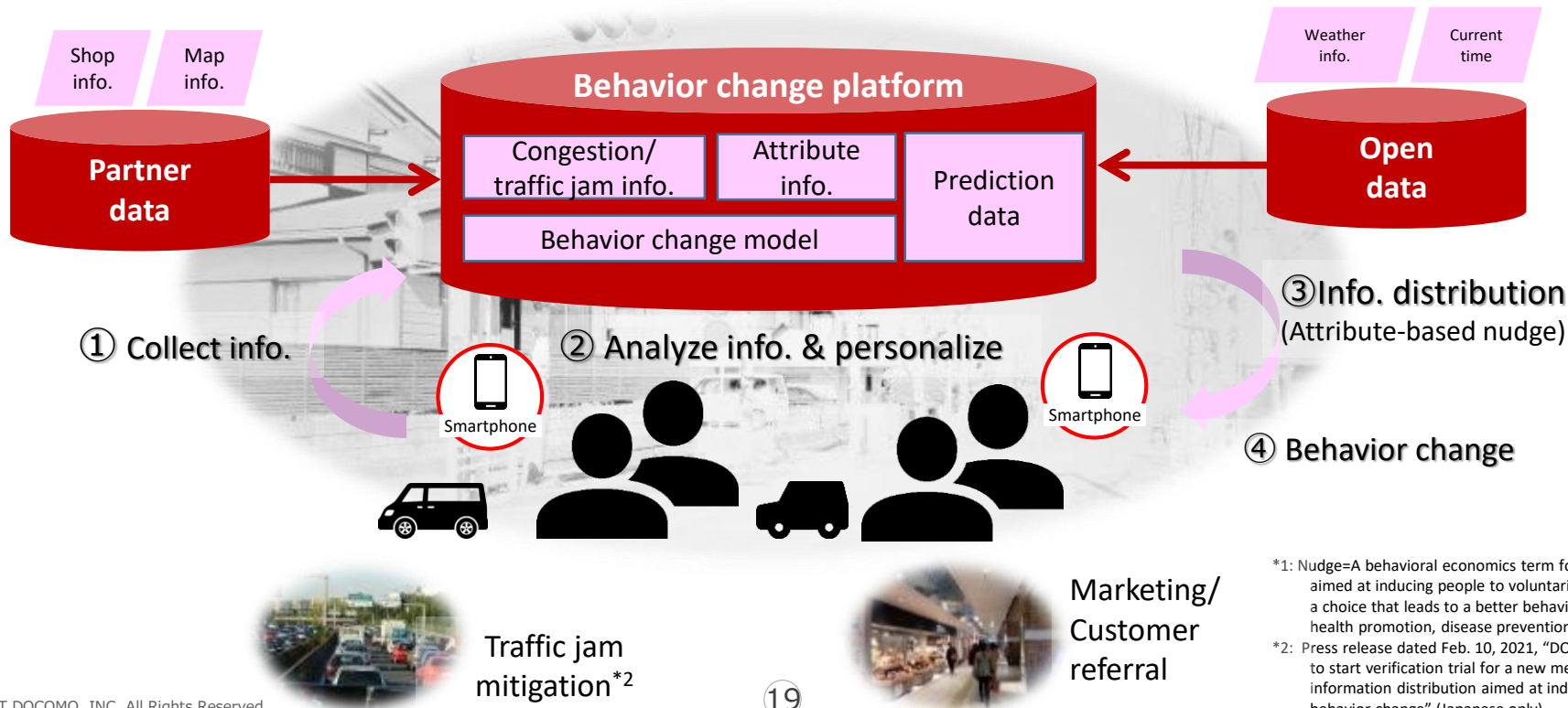
1 Improved satisfaction of expressway users

2 Traffic jam mitigation

3 Vitalization of regional economy

» Behavior Change Techniques

Development of a technique that powerfully induces people's **behavior change** through personalized **"nudge"***1 leveraging insights from **behavior economics**



*1: Nudge=A behavioral economics term for an act aimed at inducing people to voluntarily make a choice that leads to a better behavior (e.g., health promotion, disease prevention).

*2: Press release dated Feb. 10, 2021, "DOCOMO to start verification trial for a new method of information distribution aimed at inducing behavior change" (Japanese only).

» New Experiences Enabled by XR (VR/AR/MR)

docomo XR



Virtual Reality

Experience in a virtual space that is completely detached from real world



Augmented Reality

Superimposition of content on to real world

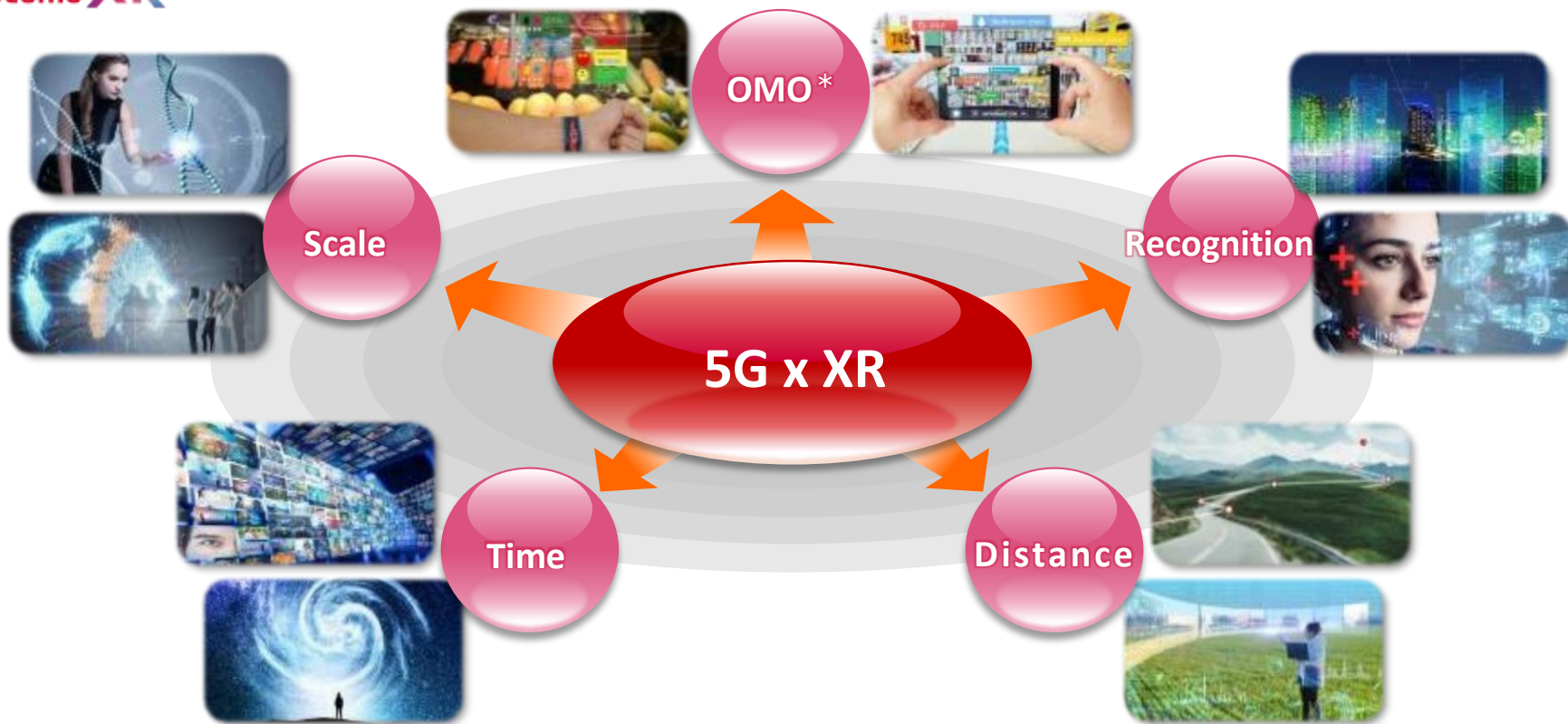


Mixed Reality

Experience in a world where real world and virtually displayed objects are converged and made indistinguishable

» Transcendence in 5 Areas Realized by 5G x XR

docomoXR



» World DOCOMO Aspires to Create with XR and Technical Developments

docomo XR

Bring fun & convenient places, or other places you want to go to your living room



Discovery of new value and attractiveness of communities & tourist destinations



Remote operations & customer experience with a rich sense of reality



Front/portal

Device/UI

XR technologies

3D content

Spatial platform

» Enhanced Spatial Value through Virtual Event Platform

docomoXR

A platform that delivers “real” events as a new “digital” experience

New forms of seminar/exhibition



New forms of city/community



New forms of music/sport



New forms of education

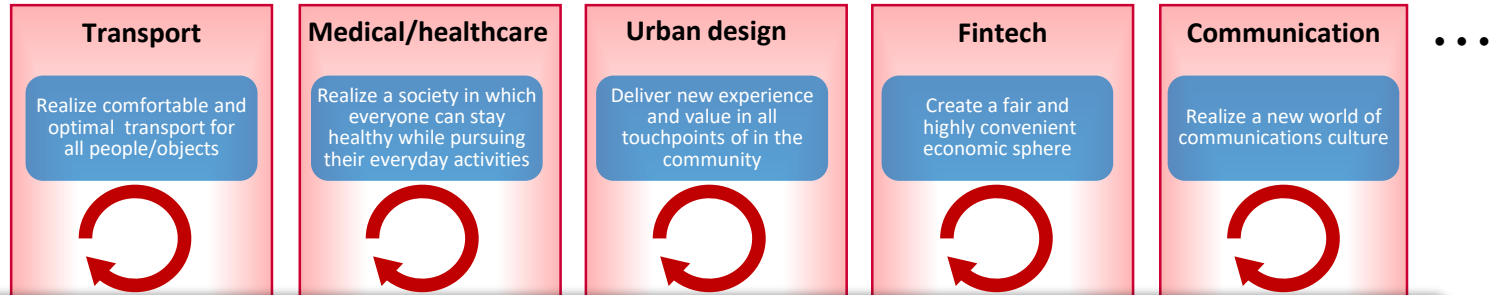


» New Society Brought About by Digital

A society where everyone can shine and tap into a broad spectrum of possibilities by reaching out and connecting with others

Wellbeing Society

Construct a smart city leveraging cross-sectoral DX



AI x Data



AI traffic jam prediction ...

モバイル空間統計

5G/Next-gen NW

»5G

5G & EVO 6G™

Technical development coupled with business

IoT/Devices

行動変容基盤

docomo XR ...

The new of today, the norm of tomorrow

NTT
docomo