5G:
FROM TECHNOLOGY TOWARD COMMERCIALIZATION

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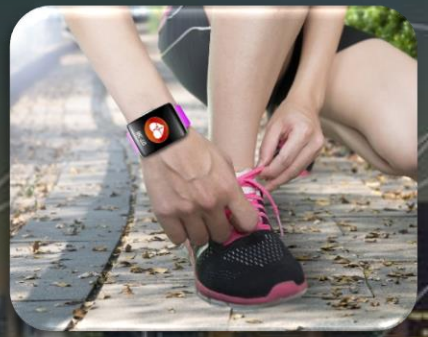
New Business Opportunities in 5G Era



Wearables

VR/AR/MR

Automotive

Smart City

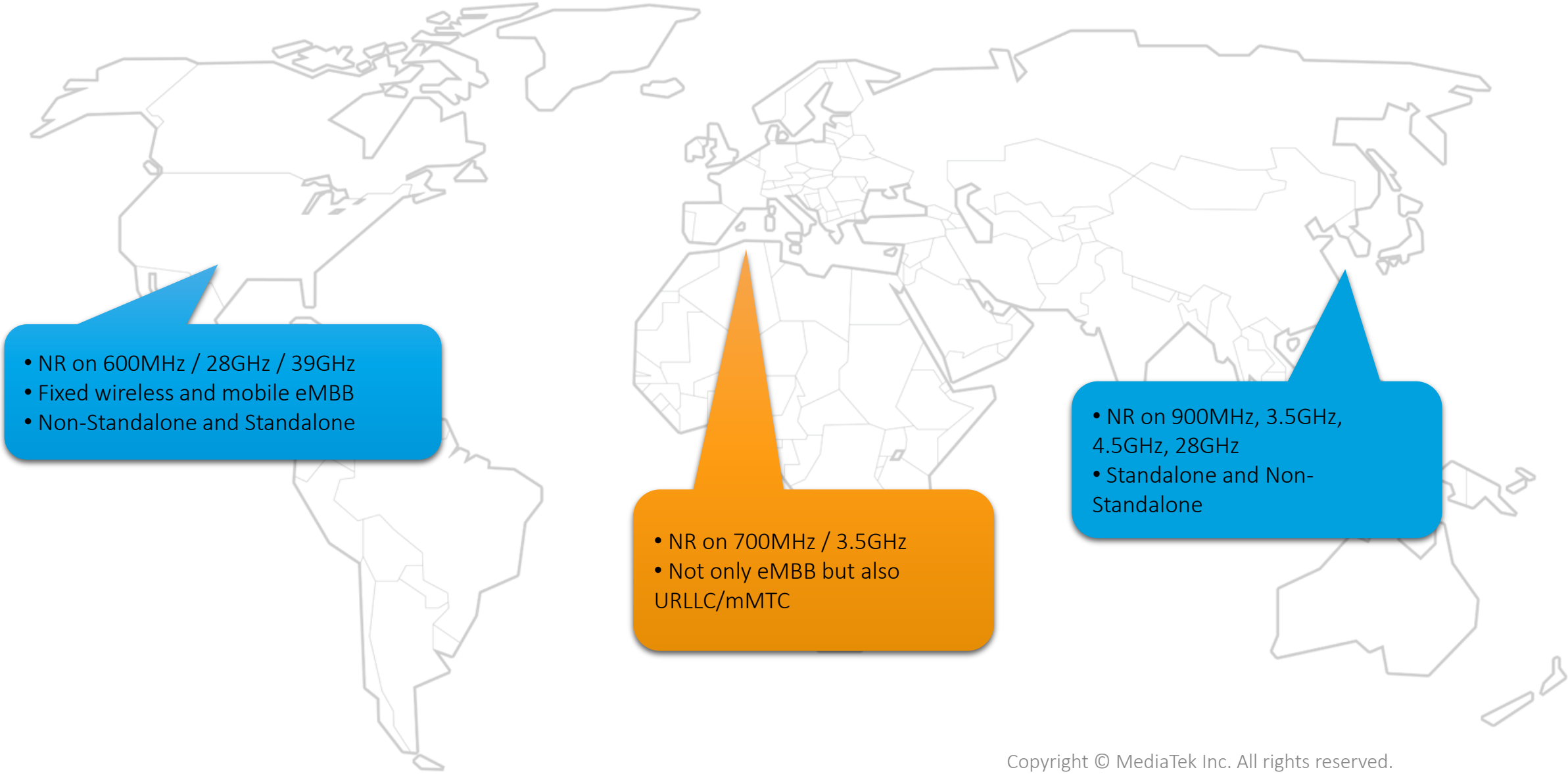
Data, …, Data, …, **Data**

2/3/4G establish the value of mobile data to human society

5G to further differentiate the data for various applications

- higher rate, lower latency, more reliable, larger capacity

Diverse 5G NR Requirements



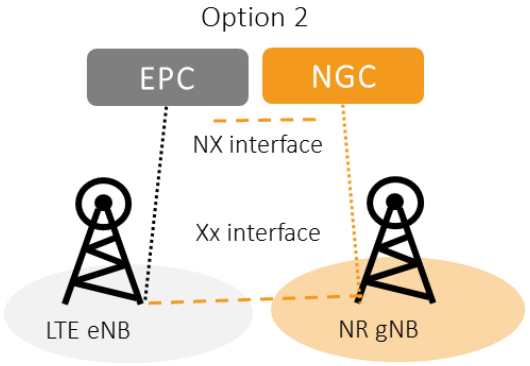
- NR on 600MHz / 28GHz / 39GHz
- Fixed wireless and mobile eMBB
- Non-Standalone and Standalone

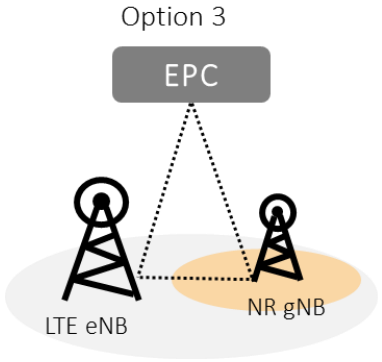
- NR on 700MHz / 3.5GHz
- Not only eMBB but also URLLC/mMTC

- NR on 900MHz, 3.5GHz, 4.5GHz, 28GHz
- Standalone and Non-Standalone

Tradeoff and Challenges

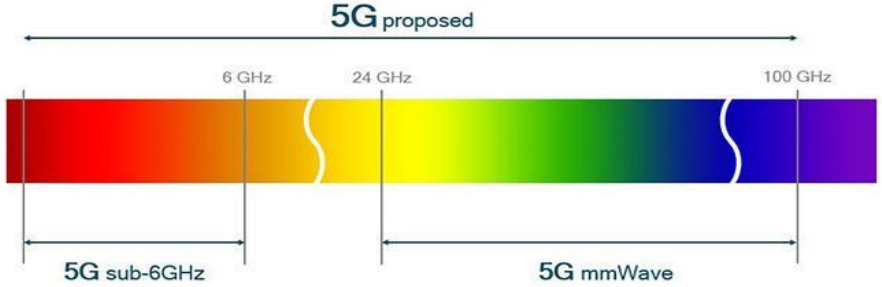
SA vs. NSA





	Standalone (SA)	Non-Standalone (NSA)
Spec	Op2 ready by 18'Q2	Op3 ready by 17'Q4
Advantage	- Simpler migration - Less overhead to LTE	- Leverage LTE coverage - Simpler solution (only NR UP)
Challenges	- NGCore for Day-1 - Higher CAPEX	- Extra signaling loading to LTE - Uncertain migration path

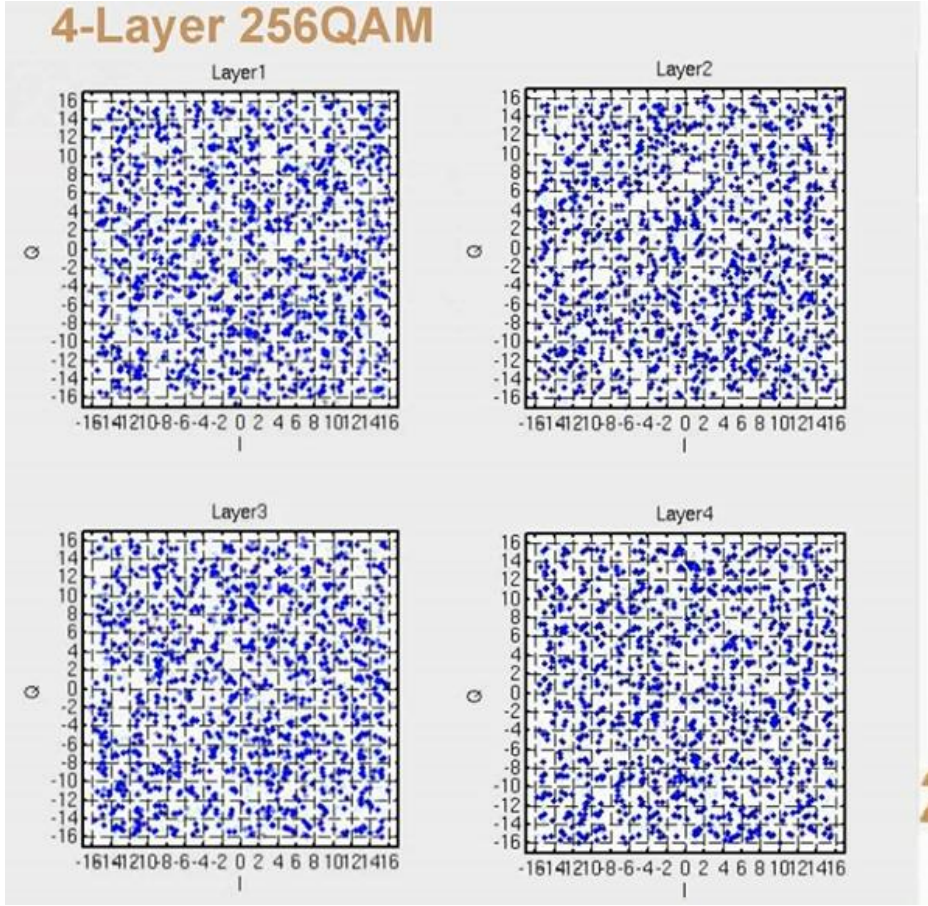
Sub-6GHz vs. mmW



	Sub-6GHz	mmWave
Advantage	- Better coverage - Mature ecosystem	- Much wider bandwidth
Challenges	- Limited bandwidth - 3.5/4.5GHz coverage	- Premature ecosystem - Very limited coverage - Unreliable signal quality

Peak Rate Challenge for Sub-6GHz

2Gbps can be achieved by 100MHz @ Band 42



MediaTek Pre-5G NR Prototype

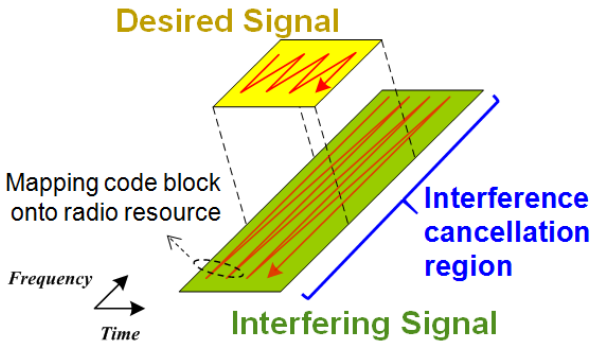
Example Experiment Configuration

Frequency	3.5 GHz
Carrier bandwidth	100 MHz
Peak data rate	4Gbps
Waveform	F-OFDM
Sub-carrier spacing	60 KHz
Modulation	256 QAM
MIMO [TxR]	4x4
Stream Number	4
Control channel coding	Polar
Data channel coding	LDPC

Spectral Efficiency Challenge for Sub-6GHz

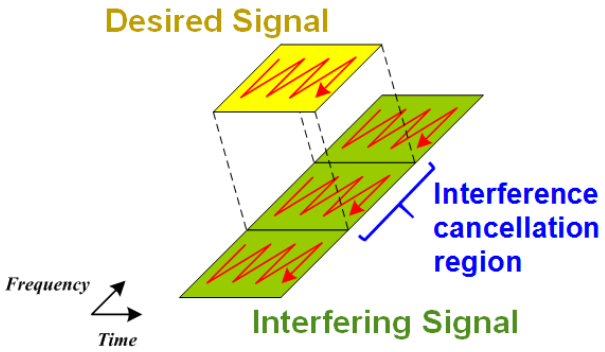
IC-Friendly Air Interface+ Non-Orthogonal Multiple Access (NOMA) is helpful

Legacy LTE Air Interface



Higher receiver complexity to perform interference cancellation (IC)

New 5G Air Interface



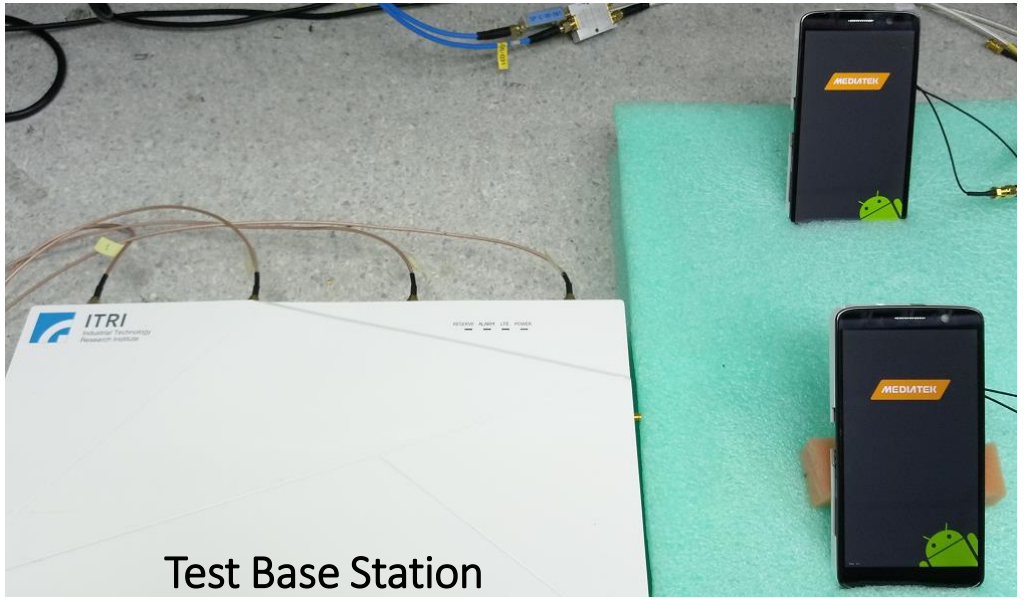
Lower receiver complexity to perform interference cancellation (IC)

	LTE	5G(*)	Gain
UE#1	2.71	3.57	31%
UE#2	0.23	0.29	26%

(*): IC-Friendly Air Interface + NOMA

UE#1

Rx SINR= 30dB



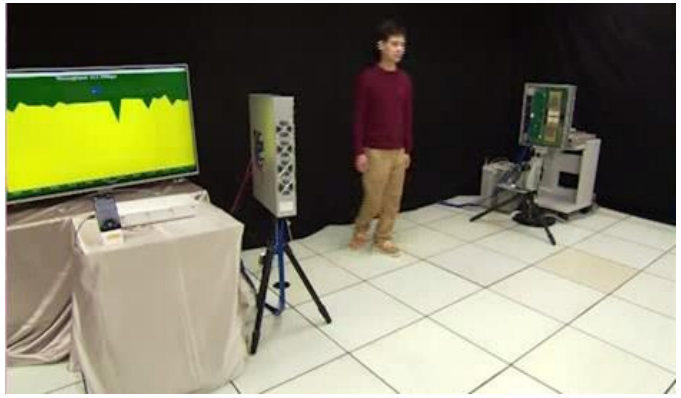
UE#2

Rx SINR= 0dB

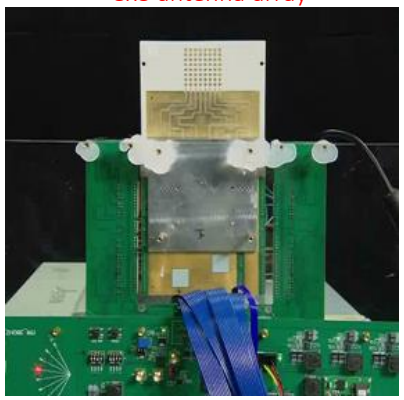
Spectral efficiency gain observed for both **cell center** and **cell edge** UEs

mmWave Link Reliability Challenge

Smart control between sub-6GHz and mmWave links can minimize the impact



8x8 antenna array



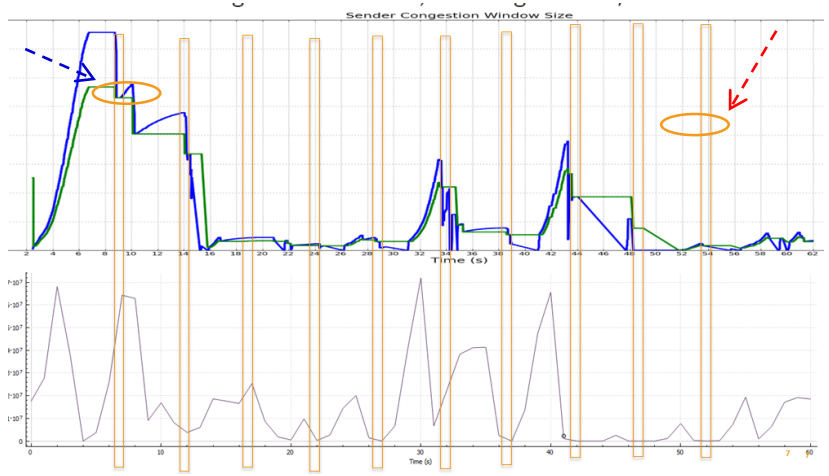
MediaTek LTE + 39GHz mmWave Dual-Connectivity Prototype

TCP congestion triggered
and window size reduced

Blockage to 5G channel
(16.7% of time)

TCP window size

TCP throughput



- 5G Smart Link technology mitigates TCP throughput drop problem due to frequent channel blockage in 5G link
  - Experiment Results (5G TCP throughput)

    w/o blockage: 100%

    w blockage, w/o Smart Link: 30%

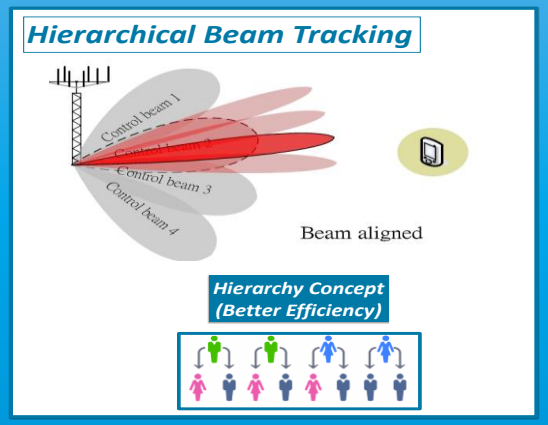
    w blockage, w Smart Link: 80%

mmWave Beam Forming/Tracking Challenge

Beam tracking is key to maintain mmWave signal reliability – efficiency vs. robustness

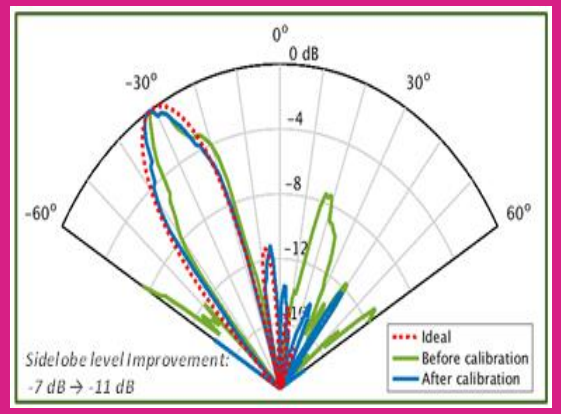
Hierarchical Beam Tracking (3GPP)

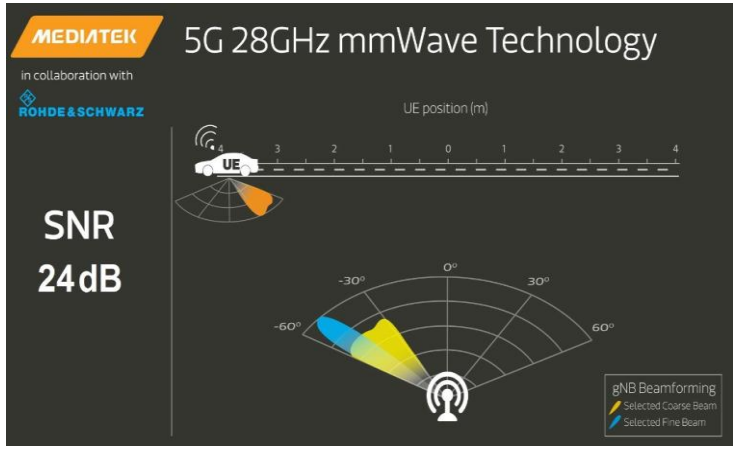
(Coarse/Fine beam)



Proprietary Cal./Char. Technique

(3~5dB sidelobe suppression)

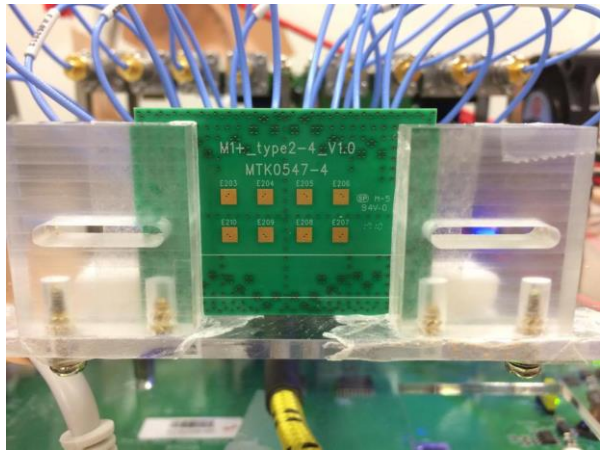




MediaTek 28GHz mmWave Prototype

mmWave Antenna Design Challenge

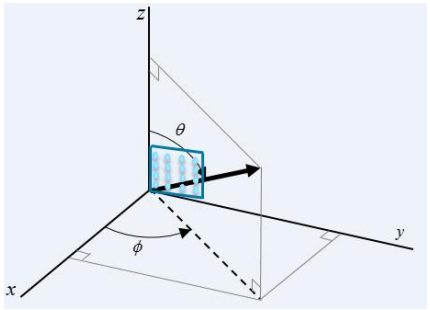
Beam reciprocity can be assumed after calibration



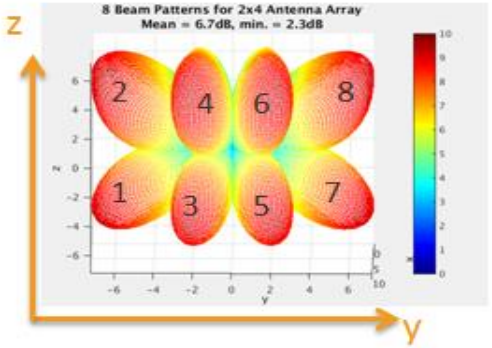
MediaTek 28GHz mmWave Prototype

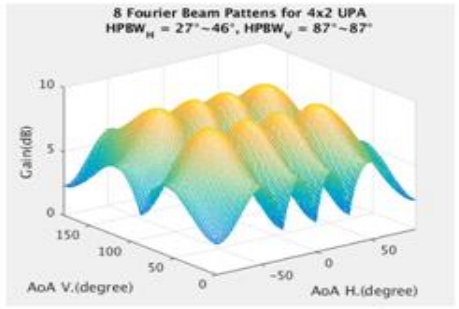
Beam 4

(ϕ, θ)=(-30°,60°)



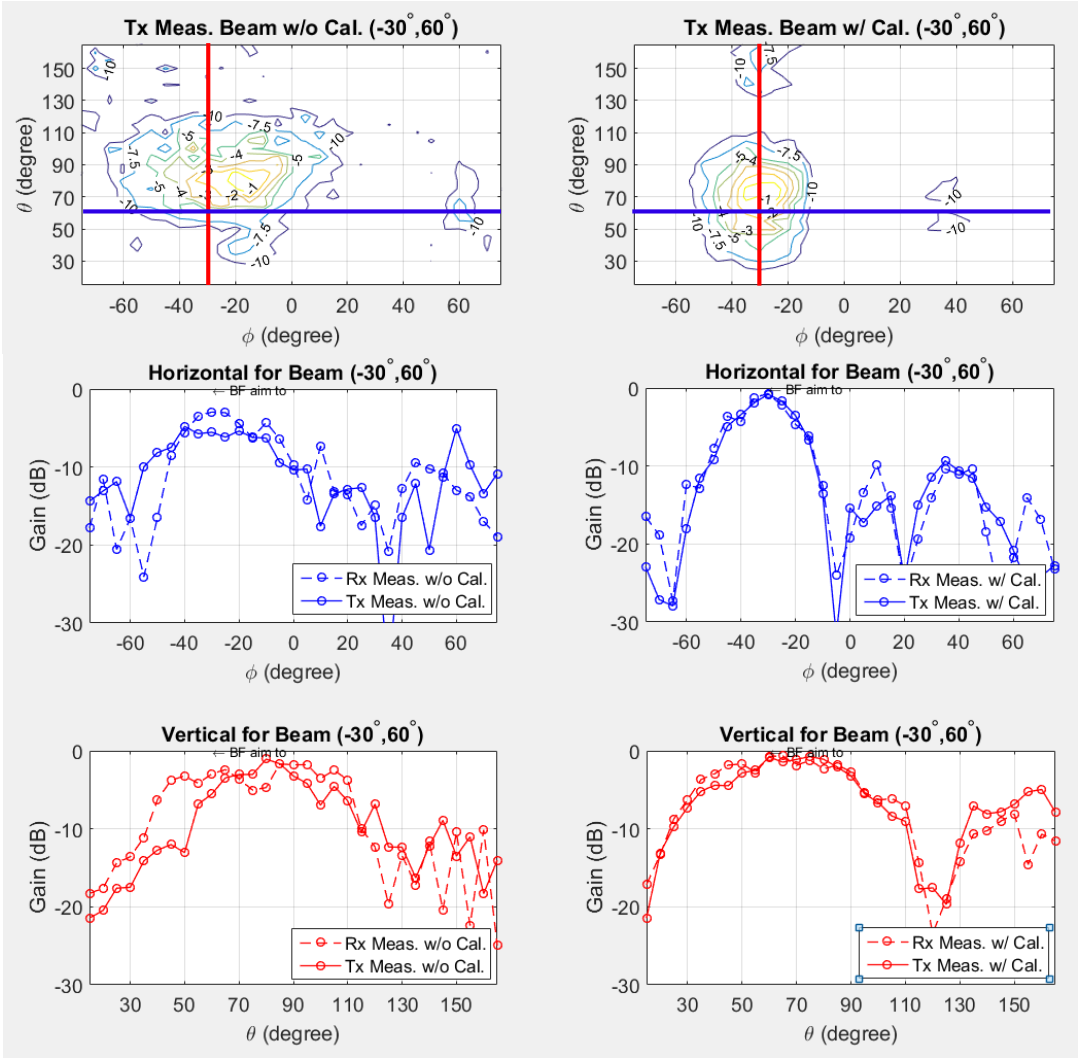
- UE codebook
  - 4x2 array is used
  - 4(H.) x 2(V.) = 8 beams





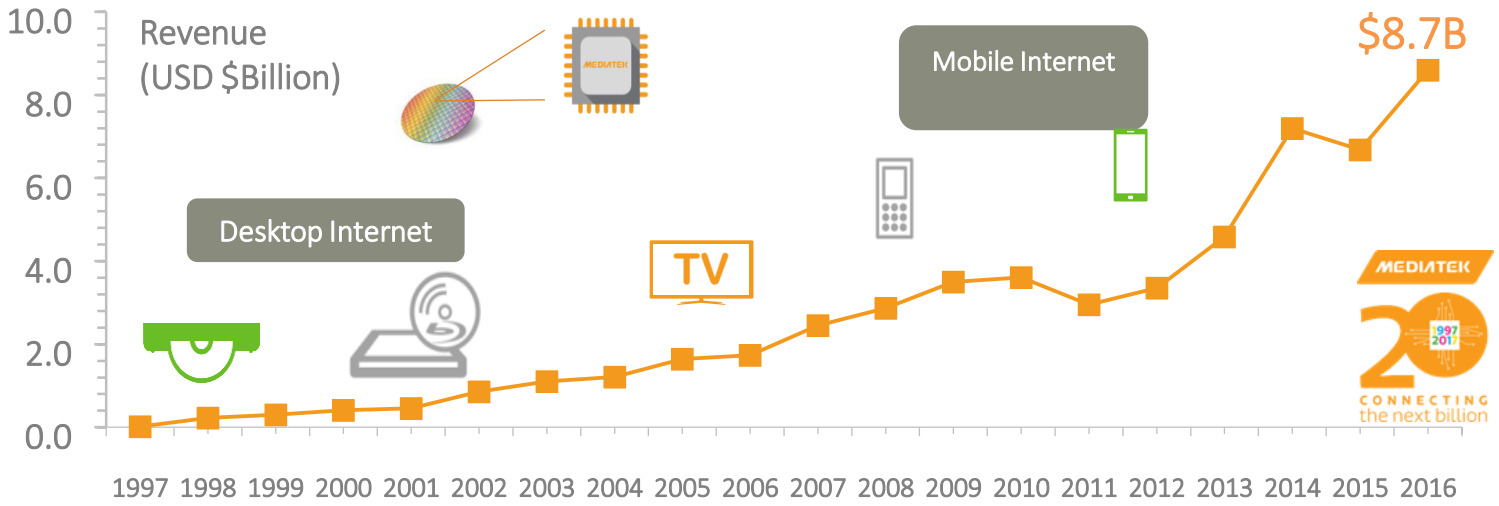
without cal./char.

with cal./char.

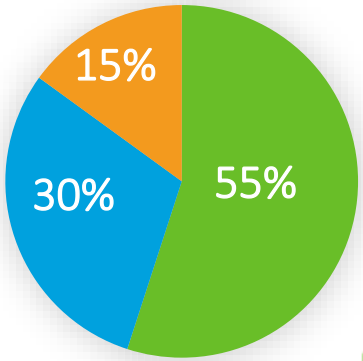


MediaTek's Portfolio for 5G Opportunities

#3	#1	#1	#2	#1	#1	#1
Connectivity network	Feature phone	Android Tablet	Smart phone	Digital TV*	DVD/BD player	Optical disc drive



Other/Connect



Home/MM

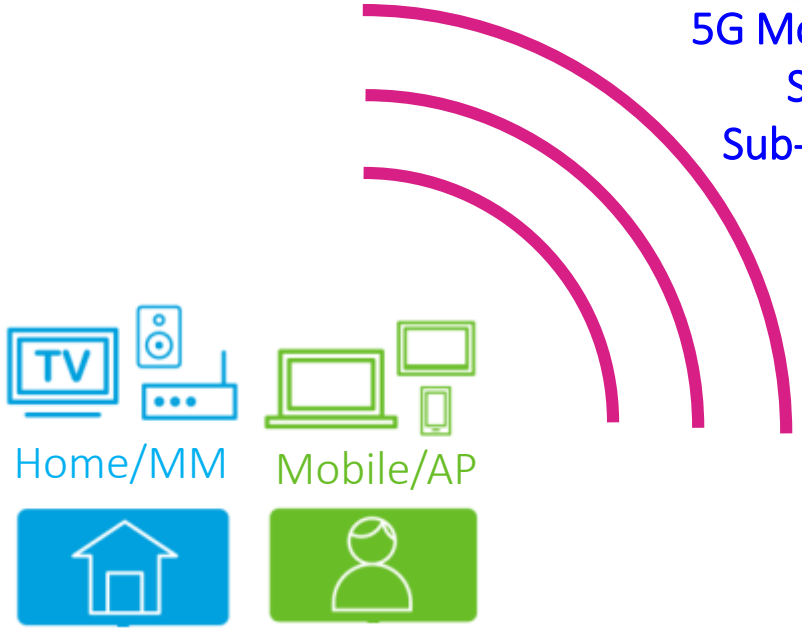
Mobile/AP

Collaboration to Make 5G Success

5G Mobile Device
SA/NSA
Sub-6G/mmW

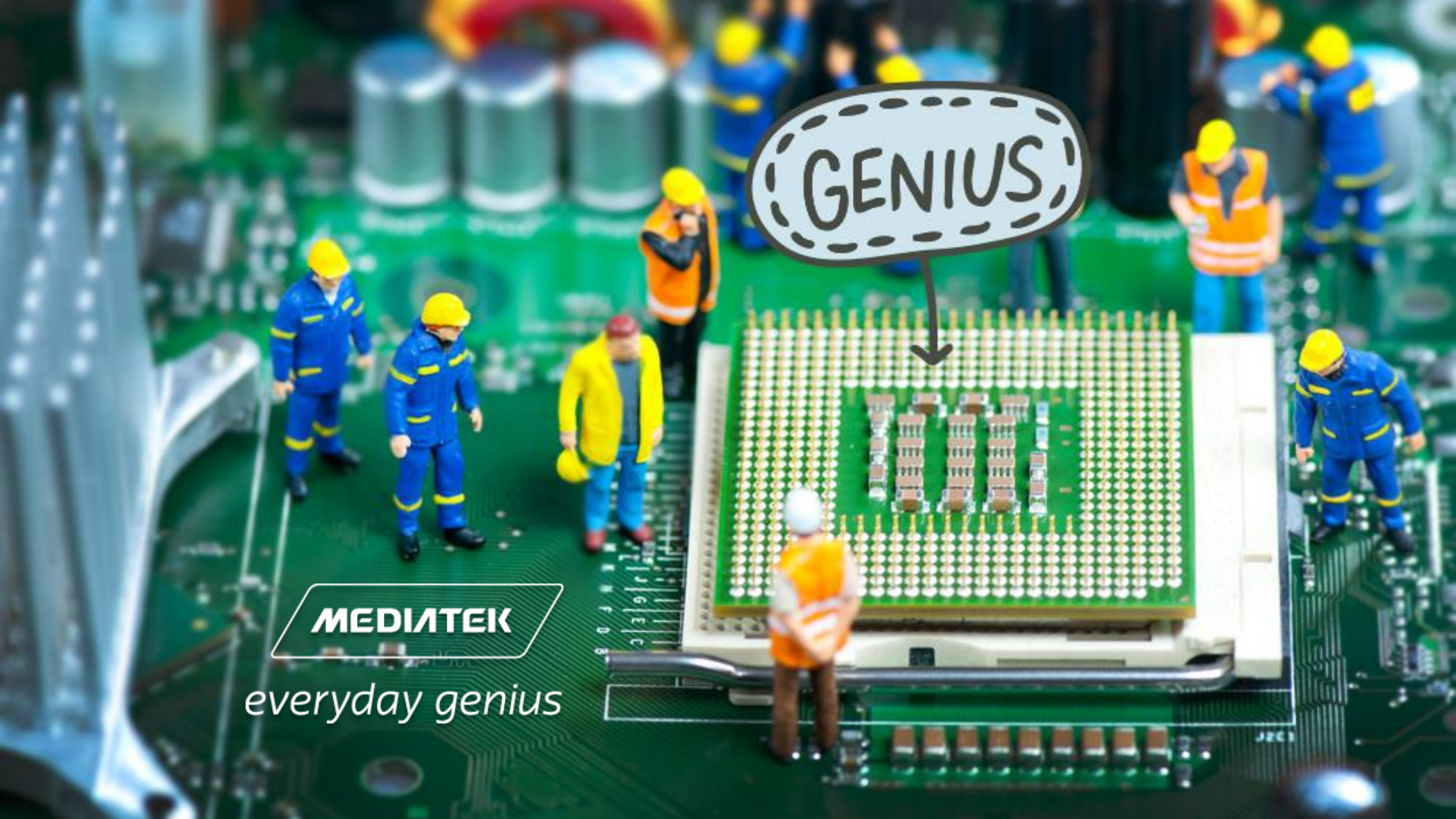
VR/AR/MR

Autonomous
Driving/Networking



IoT

Industry 4.0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