



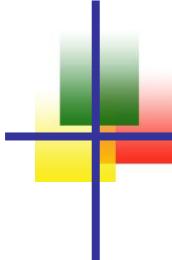
System On Chip

教育部商管學程系統晶片應用課程

Cellphone (iPhone 11 / Pro / Pro Max)



OUTLINE



■ Introduction

■ System Description

■ Technology Analysis

■ Industry Analysis

■ Applications

■ Conclusion

■ References



iPhone 11 Pro



iPhone 11 Pro Max



iPhone 11



iPhone Timeline (2007-2014)

- "Redefining" thinking about innovative applications
 - The first multi-touch screen (**keyboard and stylus**)
 - Build App Store Ecosystem (**Browser**)
 - Mobile Games
 - Change the photography behavior of ordinary people (**camera**)
 - amateur photographer
 - Accelerate 3G Internet access
 - mobile network business opportunities
 - The first high-resolution Retina screen
 - Virtual voice assistant Siri
 - iPhone 5s added Touch ID
 - iPhone 6 joins Apple Pay
 - iPhone 7 remove the headphone jack
 - iPhone X 3D structured light Face ID

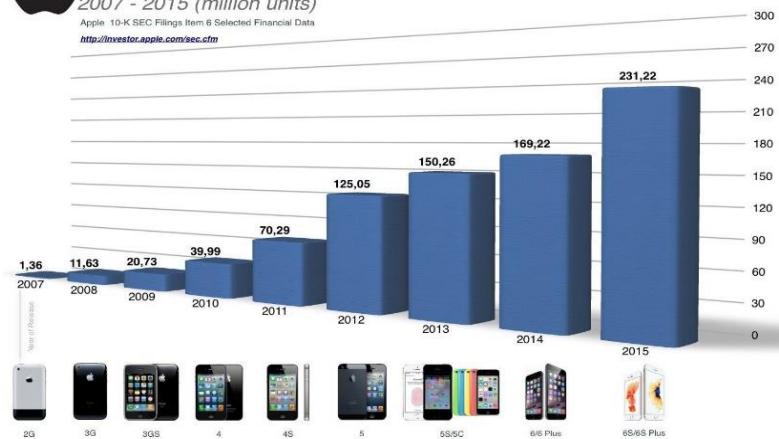


Smartphone Ecosystem

- 1.36 million units sold (iPhone 2G in 2007)
- 11.63 million units sold (iPhone 3G in 2008)
- 125.05 million units sold (iPhone 5 in 2012)
- 231.22 million units sold (2015 iPhone 6S)



Apple 10-K SEC Filings Item 8 Selected Financial Data
<http://investor.apple.com/sec.cfm>



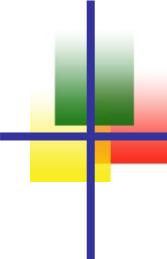
Devices

Infrastructural Components



Applications and Services

Third Party Applications and Services



OUTLINE

- Introduction
- **System Description**
- Technology Analysis
- Industry Analysis
- Applications
- Conclusion
- References



iPhone XI Spec

■ Cellular/Wireless

- FDD-LTE/TD-LTE/CDMA/GSM
- Gigabit class LTE with 2x2 MIMO
- 802.11ax Wi-Fi 6 2.4GHz 2x2 MIMO
- Bluetooth 5/Ultra Wide Band/NFC

■ Display

- 6.1" LCD Multi-touch display with IPS technology
- 1792x828 pixel resolution with 326ppi

■ Chip: A13 Bionic Chip

■ Camera: dual 12MP wide and Ultra wide cameras

■ Video recording: 4K video at 24/25/30/60fps

■ Truth Depth Camera

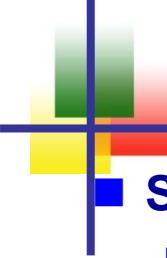
■ Location

- GPS/Wi-Fi/Beacons/Compass

■ Audio Playback: AAC-LC, HE-AAC, MP3

■ Video Playback: HEVC, H.264, MPEG-4

■ Siri:use video to send messages



iPhone XI Spec

■ Sensors

- Face ID
- Barometer
- Three-axis gyro
- Accelerometer
- Proximity sensor
- Ambient light sensor

■ Capacity

- 64G/128G

■ Apple Pay

■ Face ID

iPhone 11 other System Spec

Connectivity

Wi-Fi	Yes
Wi-Fi standards supported	802.11 a/b/g/n/ac/Yes

GPS	Yes
Bluetooth	Yes, v 5.00

NFC	Yes
-----	-----

Lightning	Yes
-----------	-----

Headphones	Lightning
------------	-----------

Number of SIMs	2
----------------	---

Sensors

Face unlock	Yes
-------------	-----

3D face recognition	Yes
---------------------	-----

Compass/ Magnetometer	Yes
--------------------------	-----

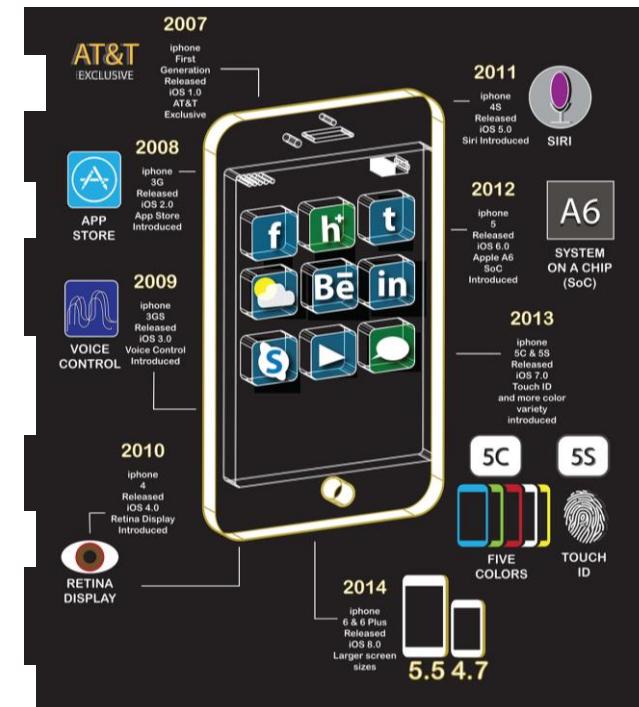
Proximity sensor	Yes
------------------	-----

Accelerometer	Yes
---------------	-----

Ambient light sensor	Yes
----------------------	-----

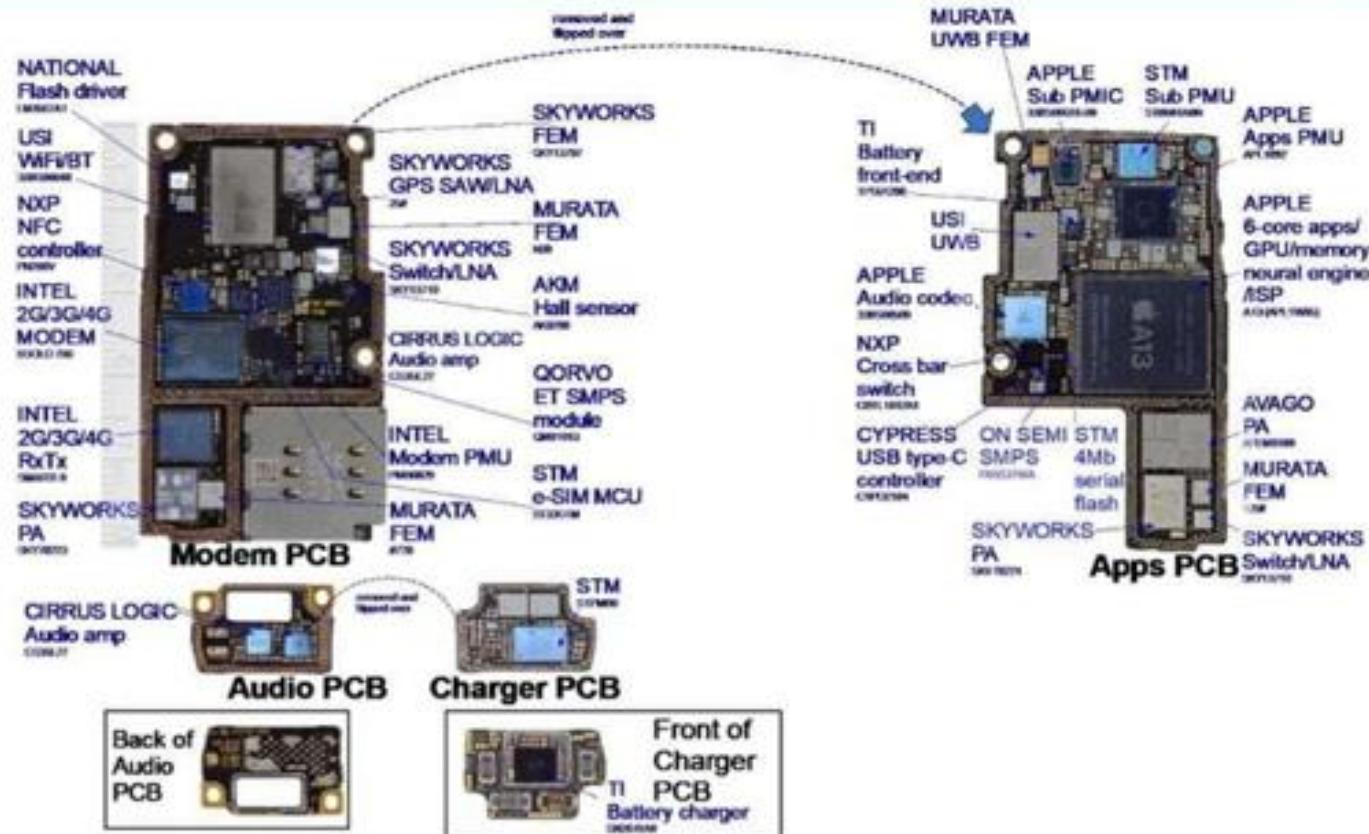
Gyroscope	Yes
-----------	-----

Barometer	Yes
-----------	-----



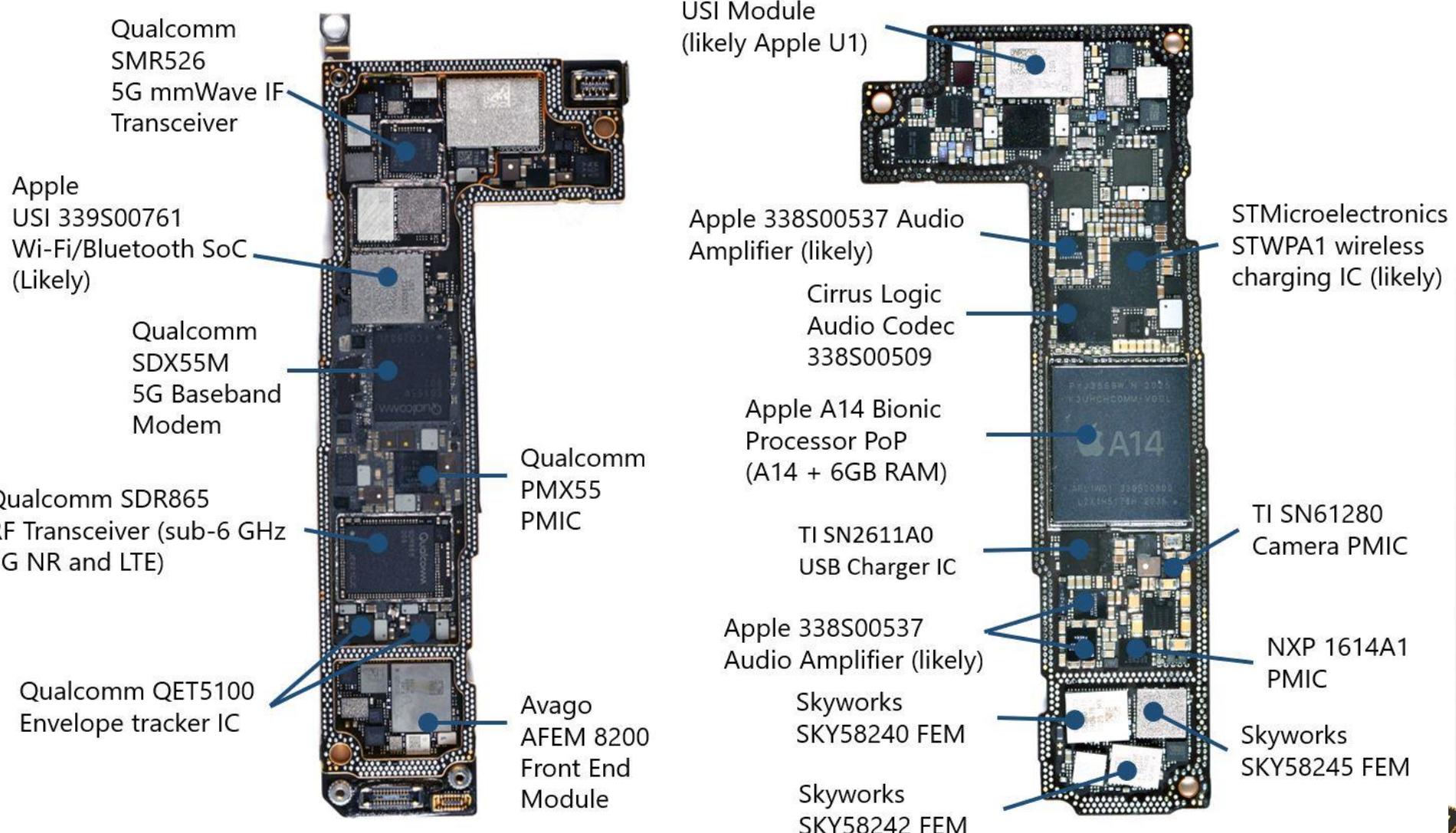
iPhone 11 System

iPhone 11 Pro Supplier Details



(Source: System Plus)

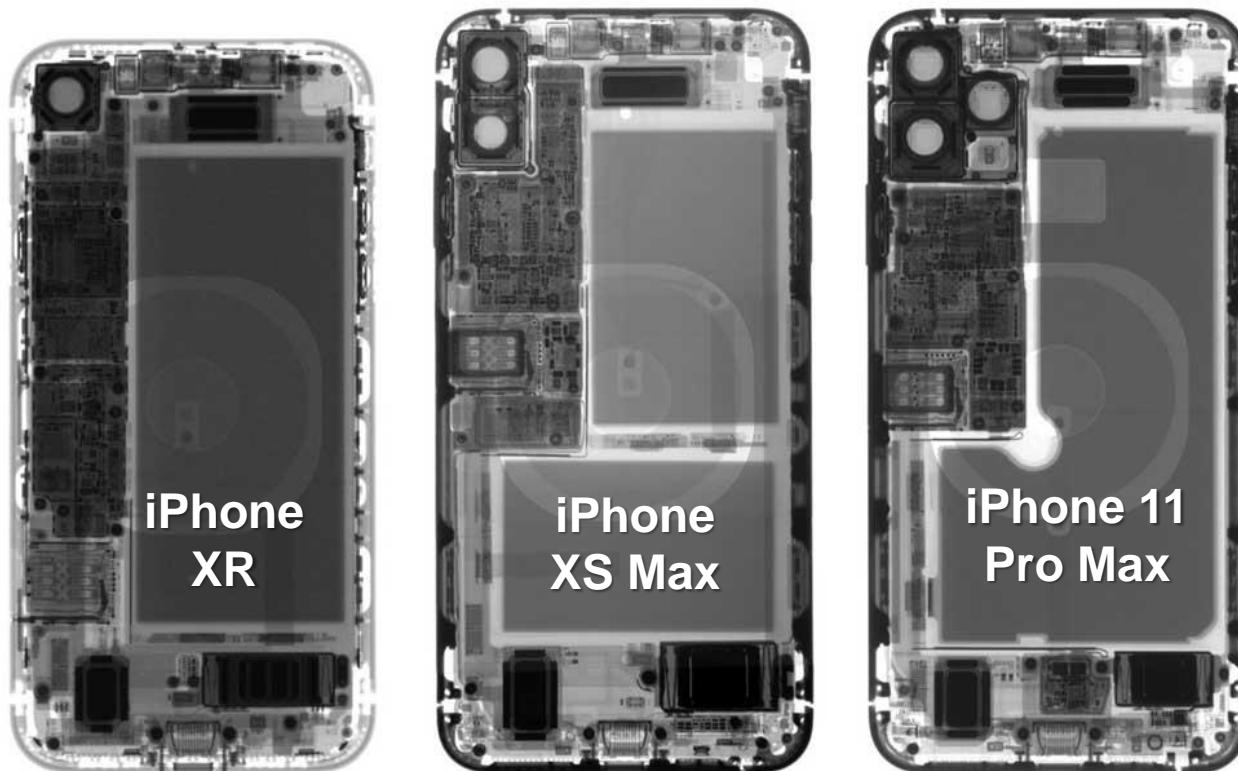
iPhone 12 System





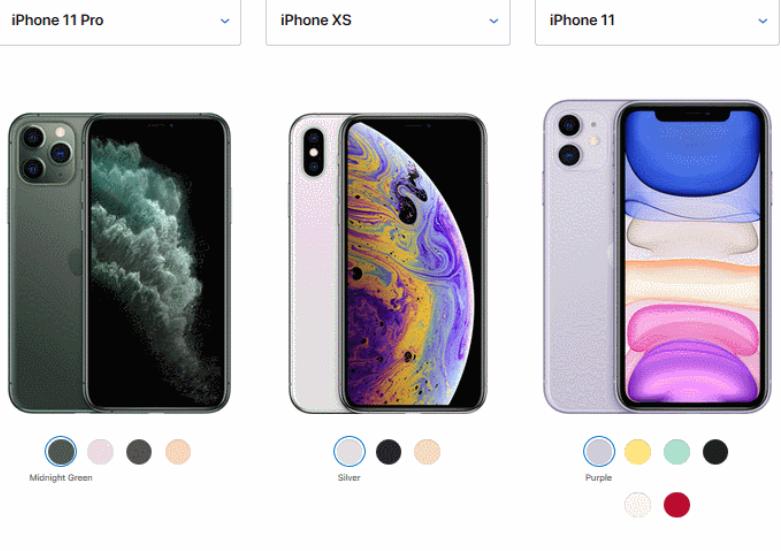
X-ray See Through iPhone

■ Camera、PCB、Battery、.....



System Spec comparison

	iPhone 11	iPhone 11 Pro	iPhone 11 Pro Max	iPhone 8	iPhone 11 Pro	iPhone XS	iPhone 11
Design	Glass + aluminum	Matte glass + stainless steel	Matte glass + stainless steel	Glass + aluminum			
Display	6.1-inch Liquid Retina (1792x828)	5.8-inch Super Retina XDR (2436x1125)	6.5-inch Super Retina XDR (2688x1242)	4.7-inch Retina HD (1334x750)			
PPI	326	458	458	326			
Processor	A13 Bionic + 3rd gen. Neural Engine — U1	A13 Bionic + 3rd gen. Neural Engine — U1	A13 Bionic + 3rd gen. Neural Engine — U1	A11 Bionic + 1st gen. Neural Engine			
RAM	4GB	4GB	4GB	2GB			
Storage	64GB, 128GB, 256GB	64GB/256GB/512GB	64GB/256GB/512GB	64GB/128GB			
Cameras	12MP Wide + 12MP Ultra Wide (rear) + 12MP (front)	12MP Wide + 12MP Ultra Wide + 12MP Telephoto (rear) + 12MP (front)	12MP Wide + 12MP Ultra Wide + 12MP Telephoto (rear) + 12MP (front)	12MP Wide (rear) + 7MP (front)			
Security	Face ID	Face ID	Face ID	Touch ID			
Other	Spacial audio with Dolby Atmos, HDR10 with Dolby Vision, wireless charging, fast charging, dual SIM, 2-meter water-resistance	Spacial audio with Dolby Atmos, HDR10 with Dolby Vision, wireless charging, fast charging, dual SIM, 4-meter water-resistance	Spacial audio with Dolby Atmos, HDR10 with Dolby Vision, wireless charging, fast charging, dual SIM, 4-meter water-resistance	Stereo audio, HDR10 with Dolby Vision, wireless charging, fast charging, dual SIM, 4-meter water-resistance	From \$24.95/mo. or \$599 with trade-in.*	Available at authorized resellers	From \$16.62/mo. or \$399 with trade-in.*
Battery	Up to 17 hours video	Up to 18 hours video	Up to 20 hours video	Up to 13 hours video	View pricing		View pricing
Weight	6.84 ounces (194 grams)	6.63 ounces (188 grams)	7.97 ounces (226 grams)	5.22 ounces (148 grams)			
Dimensions	150.9 x 75.7 x 8.3 mm	144 x 71.4 x 8.1 mm	158 x 77.8 x 8.1 mm	138.4 x 67.3 x 7.3 mm			
Price (MSRP, SIM-free)	From \$699	From \$999	From \$1,099	From \$449			



Quick Look

5.8"

Super Retina XDR display¹

5.8"

Super Retina HD display¹

6.1"

Liquid Retina HD display¹

Model	[hide]	iPhone 8	iPhone 8 Plus	iPhone XR	iPhone 11	iPhone 11 Pro	iPhone 11 Pro Max
Picture (not to scale)							
Initial release operating system		iOS 11.0		iOS 12.0		iOS 13.0	
Latest release operating system				iOS 13.1.2			
Display		4.7 in (120 mm), 4.1 in (100 mm) by 2.3 in (58 mm), 16:9 aspect ratio, aluminosilicate glass covered 16,777,216-color (24-bit), IPS LCD screen, 1,334 × 750 px screen resolution at 326 ppi, 1400:1 contrast ratio, 625 cd/m² max brightness, LED backlight and fingerprint-resistant oleophobic coating, True Tone Display	5.5 in (140 mm), 4.8 in (120 mm) by 2.7 in (69 mm), 16:9 aspect ratio, aluminosilicate glass covered 16,777,216-color (24-bit), IPS LCD screen, 1,920 × 1,080 px (Full HD) screen resolution at 401 ppi, 1300:1 contrast ratio, 625 cd/m² max brightness, LED backlight and fingerprint-resistant oleophobic coating, True Tone Display	6.06 in (154 mm), 5.54 in (141 mm) by 2.56 in (65 mm), ~19.5:9 aspect ratio, aluminosilicate glass covered 16,777,216-color (24-bit), IPS LCD screen, 1,792 × 828 px screen resolution at 326 ppi, 1,400:1 contrast ratio, 625 cd/m² max brightness, LED backlight and fingerprint-resistant oleophobic coating, True Tone display	6.06 in (154 mm), 5.54 in (141 mm) by 2.56 in (65 mm), ~19.5:9 aspect ratio, aluminosilicate glass covered 16,777,216-color (24-bit), AMOLED screen, 2,436 × 1,125 px screen resolution at 458 ppi, 2,000,000:1 contrast ratio, 800 cd/m² max brightness, fingerprint-resistant oleophobic coating, True Tone display, Dolby Vision and HDR10 support	6.06 in (154 mm), 5.54 in (141 mm) by 2.56 in (65 mm), ~19.5:9 aspect ratio, aluminosilicate glass covered 16,777,216-color (24-bit), AMOLED screen, 2,436 × 1,125 px screen resolution at 458 ppi, 2,000,000:1 contrast ratio, 800 cd/m² max brightness, fingerprint-resistant oleophobic coating, True Tone display, Dolby Vision and HDR10 support	6.46 in (164 mm), 5.9 in (150 mm) by 2.73 in (69 mm), ~19.5:9 aspect ratio, aluminosilicate glass covered 16,777,216-color (24-bit), AMOLED screen, 2,688 × 1,242 px screen resolution at 458 ppi, 2,000,000:1 contrast ratio, 800 cd/m² max brightness, fingerprint-resistant oleophobic coating, True Tone display, Dolby Vision and HDR10 support
Storage		64, 128 and 256 GB NAND flash driven by NVMe Express controller				64, 256 and 512 GB NAND flash driven by NVMe Express controller	
Processor		2.39 GHz hexa-core Apple-designed 64-bit Apple A11 Bionic (6-cores: 2 Monsoon high-performance, 4 Mistral high-efficiency) with embedded M11 motion coprocessor and dual-core Neural Engine	2.49 GHz hexa-core Apple-designed 64-bit Apple A12 Bionic (6-cores: 2 Vortex high-performance, 4 Tempest high-efficiency) with embedded M12 motion coprocessor and octa-core Neural Engine	2.65 GHz hexa-core Apple-designed 64-bit Apple A13 Bionic (6-cores: 2 Lightning high-performance, 4 Thunder high-efficiency) with embedded M13 motion coprocessor and octa-core Neural Engine			
Bus width				64-bit ^[7]			
Graphics		Apple designed tri-core GPU	Apple designed (1.1 GHz, quad-core) "G11P" GPU ^[8]				
RAM	2 GB LPDDR4X DRAM	3 GB LPDDR4X DRAM				4 GB LPDDR4X DRAM	
Connector				8-pin Lightning connector			
Connectivity		Wi-Fi (802.11 a/b/g/n/ac) with two spatial stream MIMO			Wi-Fi (802.11 a/b/g/n/ac) with two spatial stream MIMO		
SIM card form-factor		Nano-SIM			Nano-SIM and eSIM ^[9]	Dual Nano-SIM in China mainland, Hong Kong and Macau ^[10]	
Touch ID		Yes			No		
Face ID		No			Yes		
3D Touch		Yes			No		
GPS				Yes			
GLONASS				Yes			
Galileo				Yes			
QZSS				Yes			
Digital compass				Yes			
Barometer				Yes			
Bluetooth				Bluetooth 5.0 ^[11]			
Baseband / RF Transceiver		Qualcomm MDM9645M / Qualcomm WTR3925 / Qualcomm WTR4905 ^[12] or Intel XMM7360 / Intel PMB5750 ^[13]		Intel XMM7560 Modem ^[8]		Intel PMB9960 (XMM7660) Modem	
Additional features		In addition to 7/7 Plus: Fast charging (50% in 30 minutes), Qi wireless charging		IP67 dust and water-resistant Fast charging (50% in 30 minutes), Qi wireless charging		IP68 dust and water-resistant, Fast charging, Qi wireless charging	
Cameras	iSight	12 MP, quad-LED flash, autofocus, IR filter, Burst mode, f/1.8 aperture, 6-element lens, 4K video recording at 30 or 60 fps or 1080p at 30 or 60 fps, slow-motion video (1080p at 120 or 240 fps), timelapse with stabilization, panorama (up to 63 megapixels), facial recognition, digital image stabilization, optical image stabilization	Dual-camera 12 MP, quad-LED flash, f/1.8 aperture, optical image stabilization (wide-angle) quad-LED flash, autofocus, IR filter, Burst mode, 6-element lens, 4K video recording at 30 or 60 fps or 1080p at 30 or 60 fps, slow-motion video (1080p at 120 or 240 fps), timelapse with stabilization, panorama (up to 63 megapixels), Portrait Mode, Portrait Lighting, facial recognition, digital image stabilization, optical image stabilization	Dual-camera 12 MP, f/1.8 aperture, optical image stabilization (wide-angle) 12 MP, f/2.4 aperture (ultra wide angle 0.5X), quad-LED flash, autofocus, IR filter, Burst mode, 6-element lens, 4K video recording at 30 or 60 fps or 1080p at 30 or 60 fps, slow-motion video (1080p at 120 or 240 fps), timelapse with stabilization, panorama (up to 63 megapixels), Portrait Mode, Portrait Lighting, facial recognition, digital image stabilization, optical image stabilization		Triple-camera 12 MP, f/1.8 aperture, optical image stabilization (wide-angle) 12 MP, f/2.0 aperture (telephoto 2X), 12 MP, f/2.4 aperture (ultra wide angle 0.5X), quad-LED flash, autofocus, IR filter, Burst mode, 6-element lens, 4K video recording at 30 or 60 fps or 1080p at 30 or 60 fps, slow-motion video (1080p at 120 or 240 fps), timelapse with stabilization, panorama (up to 63 megapixels), Portrait Mode, Portrait Lighting, facial recognition, digital image stabilization, dual-optical image stabilization	
	FaceTime	7 MP FaceTime HD camera with deep trench isolation and auto image stabilization video recording at 1080p ^[14] 1080p HD video recording, Wide color capture for photos and Live Photos ^{[15][16]}	7 MP TrueDepth camera with deep trench isolation, auto image stabilization, Portrait Mode and Portrait Lighting video recording at 1080p	7 MP TrueDepth camera with deep trench isolation, auto image stabilization, Portrait Mode and Portrait Lighting video recording at 4K at 60fps or 1080p at 120fps	12 MP TrueDepth camera with deep trench isolation, auto image stabilization, Portrait Mode and Portrait Lighting video recording at 4K at 60fps or 1080p at 120fps		

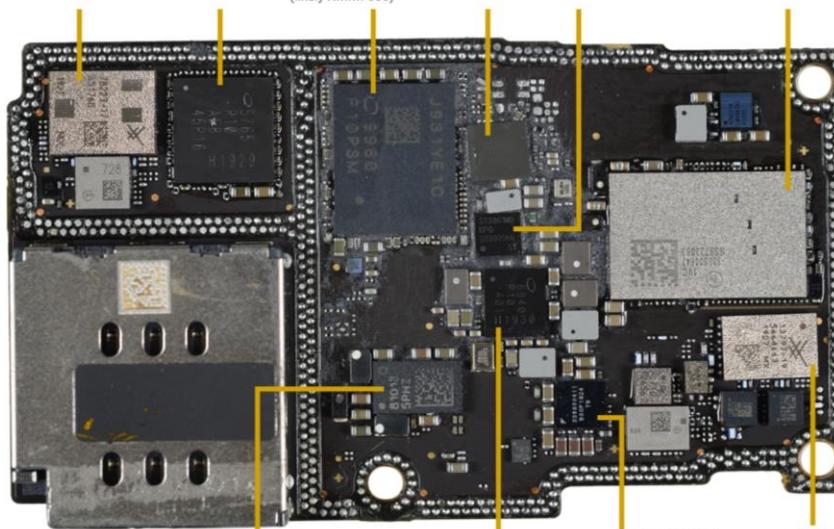
Iphone 11 Pro Max Disassemble

- STMicroelectronics) STPMB0 wireless charging IC
- Apple 338S00411 Audio Amplifier
- TI 97A8R78 SN261140 A0NOT

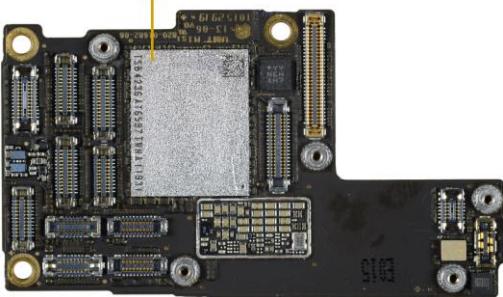
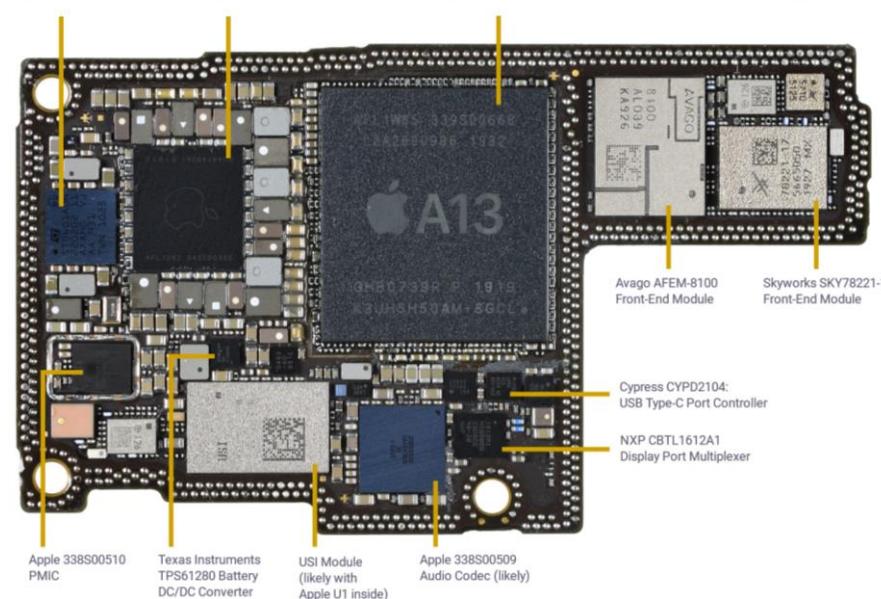


Chips

Skyworks SKY78223-17 Front-End Module Intel PMB5765 RF Transceiver Intel PMB9960 Baseband Processor (likely XMM7660) NXP SN200 NFC&SE Module STMicroelectronics ST33G1M2 MCU Murata 339S00647 Wi-Fi/BT Wireless Combo IC



STMicroelectronics STB601 PMIC Apple 343S00355/APL1092 PMIC Apple A13 APL1W85 PoP (A13 AP+Samsung K3UH5H50AM-SGCL 4GB LPDDR4X SDRAM)



Tech
Insight

Three lenses

Triple-camera system

Three cameras that feel like one.



超廣角鏡頭:

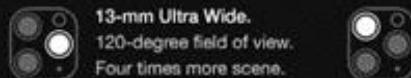
13 公釐焦距
 $f/2.4$ 光圈
5 枚鏡片組
120° 視角
4 倍寬廣取景範圍
1200 萬像素感光元件

廣角鏡頭

26 公釐焦距
 $f/1.8$ 光圈
6 枚鏡片組
光學影像穩定功能
100% Focus Pixels
全新 1200 萬像素感光元件

望遠鏡頭

52 公釐焦距
 $f/2.0$ 更大光圈
6 枚鏡片組
光學影像穩定功能
2 倍光學變焦
1200 萬像素感光元件



13-mm Ultra Wide.
120-degree field of view.
Four times more scene.



26-mm Wide.
Optical image stabilisation.
100 per cent Focus Pixels.



52-mm Telephoto.
 $f/2.0$ aperture.
2x optical zoom.

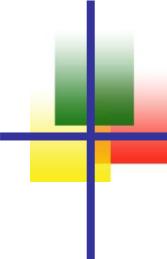
Comparison



品牌	APPLE	Samsung	Huawei
機型	iPhone 11/11 Pro Max	Note 10	Mate 20 Pro
處理器	A13 Bionic + U11	高通S855八核心	KIRIN 980八核心
第一主鏡頭(標準)	1200萬 f1.8 26mm OIS	1200萬 Dual f1.5/f2.4 77° OIS	4000萬 f1.8 27mm OIS
第二主相機(超廣角)	1200萬 f2.4 120° 13mm	1600萬 f2.2 123°	2000萬 f2.2 16mm
第三主相機(望遠)	1200萬 f2.2 52mm OIS	1200萬 f2.1 45° OIS	800萬 f2.4 27-80mm
第一前鏡頭	1200萬 f2.2	1200萬 f2.2	2400萬 f2.0 26mm

Vendor	Part Number	Product Common Name	Product Model Number	Front or Rear Facing?	Reported Resolution (MP)	Pixel Pitch (μm)	Die Size Length (mm) (Die Edge)	Die Size Width (mm) (Die Edge)	Die Area (mm²)
Sony	<Unknown> iPhone 11 TrueDepth selfie	iPhone 11	A2111	Front	12.0	1.00	4.04	5.53	22.3
STMicroelectronics	56G08A (TrueDepth Infrared Camera)	iPhone 11	A2111	Front	1.4	2.80	4.65	5.65	26.3
Sony	<Unknown> iPhone 11 Pro telephoto	iPhone 11 Pro Max	A2161	Rear	12.0	1.00	5.21	6.28	32.7
Sony	<Unknown> iPhone 11 Pro ultra wide-angle	iPhone 11 Pro Max	A2161	Rear	12.0	1.00	5.22	6.28	32.8
Sony	<Unknown> iPhone 11 Pro wide-angle	iPhone 11	A2161	Rear	12.0	1.40	5.78	7.01	40.5

OIS: Optical Image Stabilizer: capture sharp pictures at shutter speeds three, four, or five times slower than previously possible



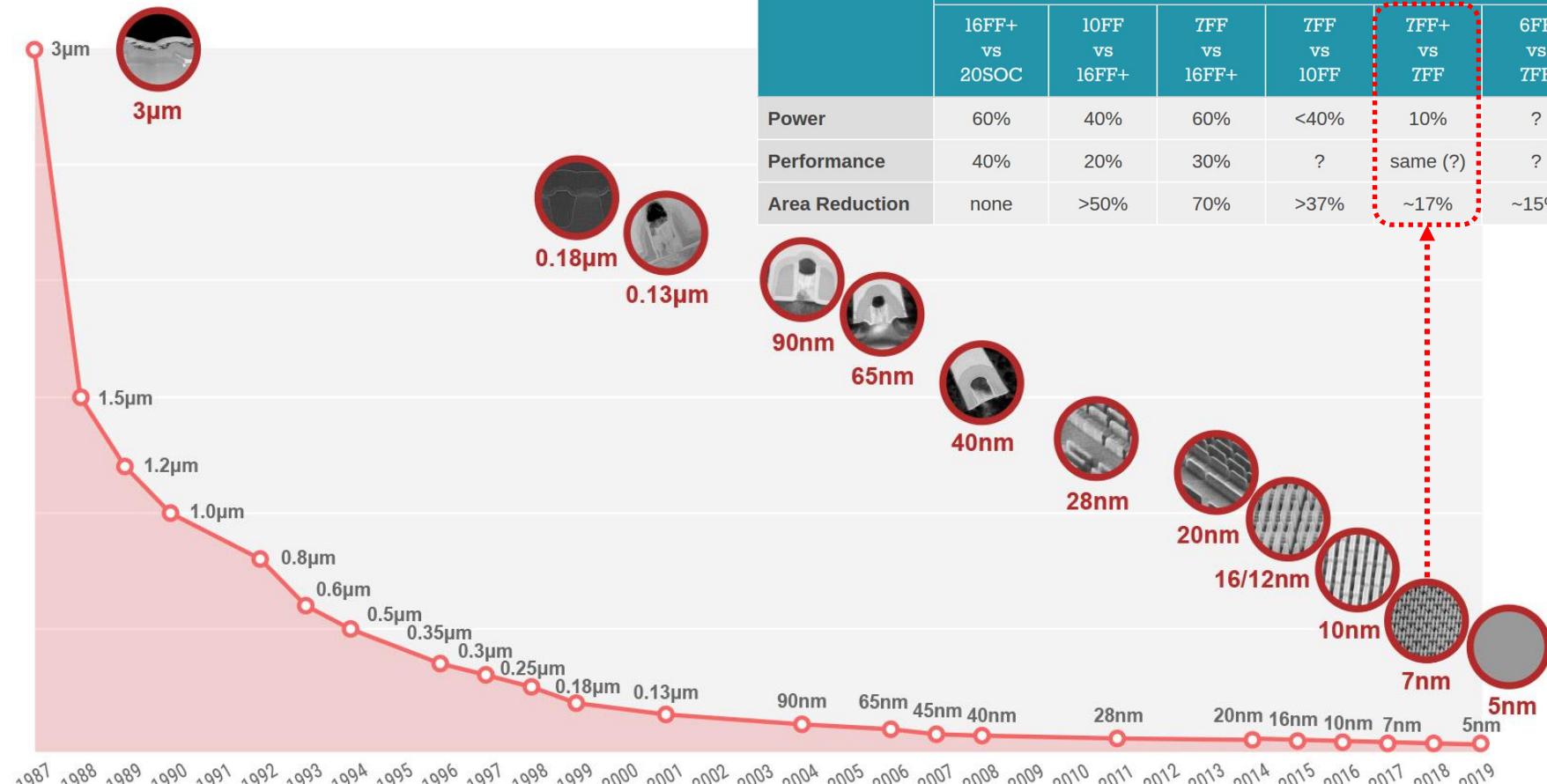
OUTLINE

- Introduction
- System Description
- **Technology Analysis**
 - A13 Processor
 - U1
 - Dolby Atoms
 - Taptic Engine
 - Baseband
 - RF
 - PA
- Industry Analysis
- Applications
- Conclusion
- References

List of Apple Processors

Name	Model no.	Image	Semiconductor technology	Die size	Transistor count	CPU ISA	CPU	CPU cache	GPU	AI accelerator	Memory technology	Introduced	Utilizing devices
A8X	APL1012		20 nm (TSMC) ^{[77][137]}	128 mm ² [77]	~3 billion	ARMv8.0-A	1.5 GHz triple-core Typhoon ^{[77][134]}	L1i: 64 KB L1d: 64 KB L2: 2 MB L3: 4 MB ^[77] (Inclusive) ^[130]	Custom PowerVR GXA6850 (octa-core) ^{[71][77][137]} @ ~450 MHz (230.4 GFLOPS)		64-bit Dual-channel 800 MHz LPDDR3-1600 ^[77] (25.6 GB/s) ^[131]	October 2014	• iPad Air 2
A9	APL0898		14 nm FinFET (Samsung) ^[138]	96 mm ² [139]	>2 billion	ARMv8.0-A	1.85 GHz dual-core Twister ^{[140][141]}	L1i: 64 KB L1d: 64 KB L2: 3 MB L3: 4 MB (Victim) ^{[130][142]}	Custom PowerVR GT7600 (hexa-core) ^{[71][143]} @ ~600 MHz (230.4 GFLOPS)		64-bit Single-channel 1600 MHz LPDDR4-3200 ^{[141][142]} (25.6 GB/s) ^[141]	September 2015	• iPhone 6S • iPhone 6S Plus • iPhone SE • iPad (2017)
	APL1022		16 nm FinFET (TSMC) ^[139]	104.5 mm ² [139]									
	APL1021		16 nm FinFET (TSMC) ^[144]	143.9 mm ² [144][84]									
A10 Fusion	APL1W24		16 nm FinFET (TSMC) ^[147]	125 mm ² [147]	3.3 billion	ARMv8.1-A	2.34 GHz quad-core (2x Hurricane + 2x Zephyr) ^[148]	L1i: 64 KB L1d: 64 KB L2: 3 MB L3: 4 MB	Custom PowerVR GT7600 Plus (hexa-core) ^{[71][149][150]} @ >650 MHz (>250 GFLOPS)		64-bit Single-channel 1600 MHz LPDDR4 (25.6 GB/s)	September 2016	• iPhone 7 • iPhone 7 Plus • iPad (2018) • iPod Touch (7th gen.) • iPad (2019)
A10X Fusion	APL1071 ^[151]		10 nm FinFET (TSMC) ^[84]	96.4 mm ² [84]	>4 billion	ARMv8.1-A	2.36 GHz hexa-core (3x Hurricane + 3x Zephyr) ^[152]	L1i: 64 KB L1d: 64 KB L2: 8 MB L3: none ^[152]	Custom PowerVR GT7600 Plus (12-core) ^{[71][83]}		64-bit Dual-channel 1600 MHz LPDDR4 ^{[152][151]} (51.2 GB/s)	June 2017	• iPad Pro (10.5-inch) • iPad Pro (12.9-inch) (2nd gen.) • Apple TV 4K
A11 Bionic	APL1W72		10 nm FinFET (TSMC)	87.66 mm ² [153]	4.3 billion	ARMv8.2-A ^[154]	2.39 GHz hexa-core (2x Monsoon + 4x Mistral)	L1i: 64 KB L1d: 64 KB L2: 8 MB L3: none ^[155]	Custom design (triple-core)	Neural Engine (dual-core)	64-bit Single-channel 2133 MHz LPDDR4X ^{[156][157]} (34.1 GB/s)	September 2017	• iPhone 8 • iPhone 8 Plus • iPhone X
A12 Bionic	APL1W81		7 nm FinFET (TSMC N7)	83.27 mm ² [158]	6.9 billion	ARMv8.3-A ^[159]	2.49 GHz hexa-core (2x Vortex + 4x Tempest) ^[160]	L1i: 128 KB L1d: 128 KB L2: 8 MB L3: none ^[160]	Custom design (quad-core)	Neural Engine (octa-core)	64-bit Single-channel 2133 MHz LPDDR4X ^{[161][162]} (34.1 GB/s)	September 2018	• iPhone XS • iPhone XS Max • iPhone XR • iPad Air (2019) • iPad Mini (5th gen.)
A12X Bionic	APL1083		7 nm FinFET (TSMC N7)	~135 mm ² [163]	10 billion	ARMv8.3-A ^[159]	2.49 GHz octa-core (4x Vortex + 4x Tempest)	L1i: 128 KB L1d: 128 KB L2: 8 MB L3: none ^[164]	Custom design (hepta-core)	Neural Engine (octa-core)	64-bit Dual-channel 2133 MHz LPDDR4X (68.2 GB/s)	October 2018	• iPad Pro (11.0-inch) • iPad Pro (12.9-inch) (3rd gen.)
A13 Bionic	APL1W85		7 nm FinFET (TSMC N7P)	98.48 mm ² [165]	8.5 billion	ARMv8.3-A ^[citation needed]	2.65 GHz hexa-core (2x Lightning + 4x Thunder)	L1i: 128 KB L1d: 128 KB L2: 8 MB L3: none ^[166]	Custom design (quad-core)	Neural Engine (octa-core) + AMX blocks (dual-core)		September 2019	• iPhone 11 • iPhone 11 Pro • iPhone 11 Pro Max

TSMC Logic Technology



Advertised PPA Improvements of New Process Technologies							
	TSMC						
	16FF+ vs 20SOC	1OFF vs 16FF+	TFF vs 16FF+	TFF vs 1OFF	ZFF+ vs TFF	6FF vs TFF	5FF vs TFF
Power	60%	40%	60%	<40%	10%	?	20%
Performance	40%	20%	30%	?	same (?)	?	15%
Area Reduction	none	>50%	70%	>37%	~17%	~15%	45%



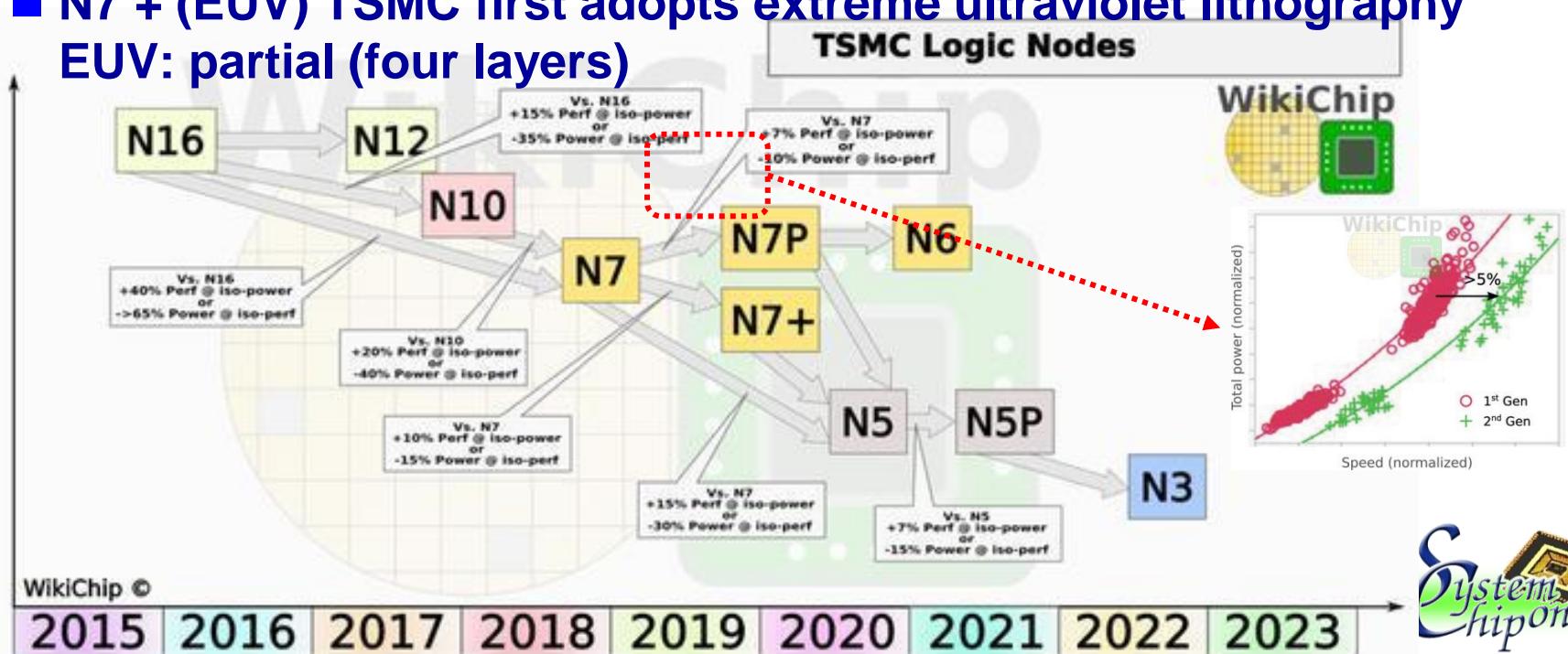
7奈米	製程節點	7+奈米
N7	製程代號	N7P (Plus)
浸潤式	微影技術	浸潤式及EUV
2018年上半年	量產時間	2019年上半年
中科Fab 15	量產基地	中科Fab 15
蘋果、超微、華為海思、高通、聯發科	主要客戶	華為海思、超微

TSMC N7 Pro

■ N7 Pro(DUV): A13 adopts 7nm 'enhanced version' deep ultraviolet lithography

- FEOL (front end of line): the first portion of IC fabrication where the individual devices (transistors, capacitors, resistors, etc.) are patterned in semiconductor
- MEOL (middle end of line)

■ N7 + (EUV) TSMC first adopts extreme ultraviolet lithography EUV: partial (four layers)

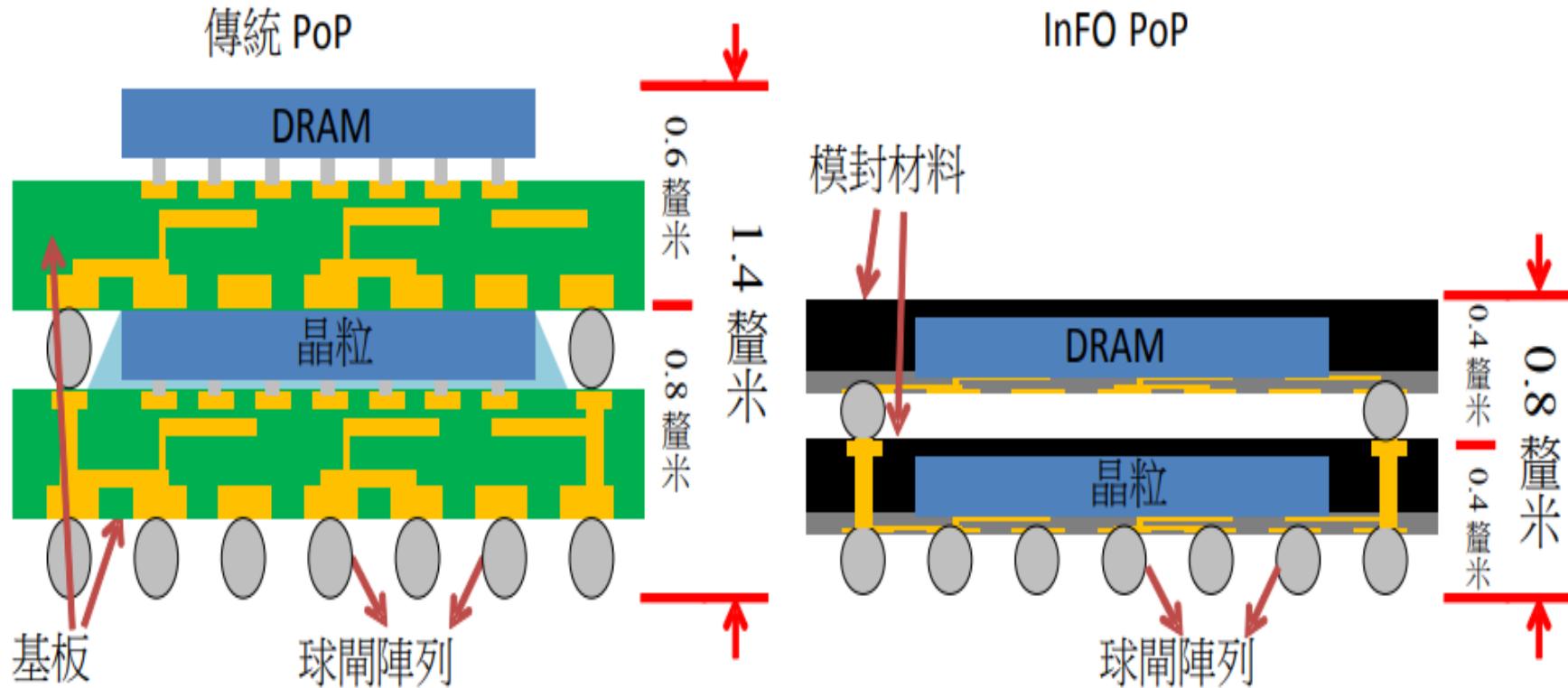


InFO PoP

InFO: Integrated Fan-out wafer level Packaging

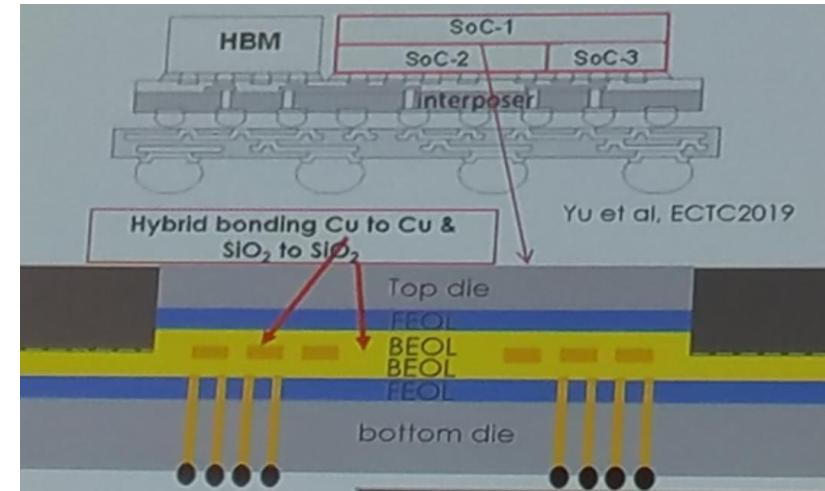
PoP: package on package

CSP:chip scale packaging



Wafer Level System Integration (WLSI)

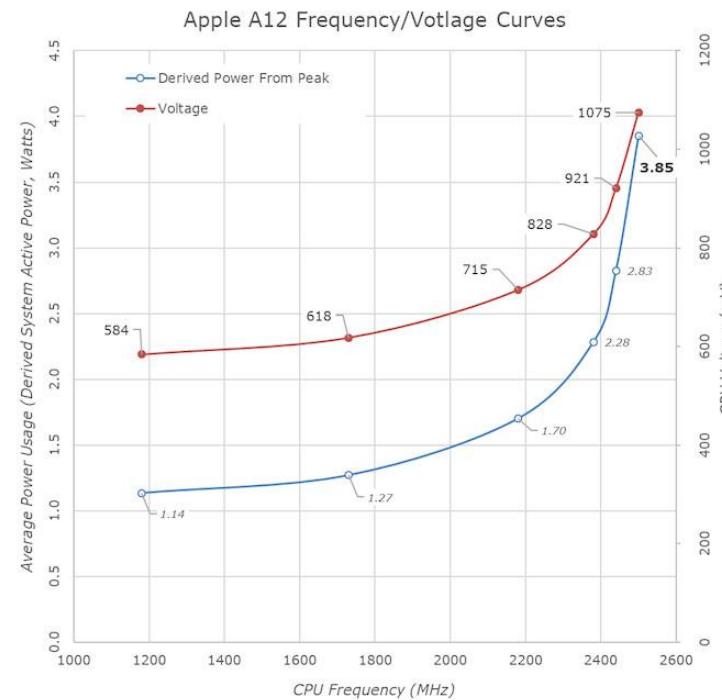
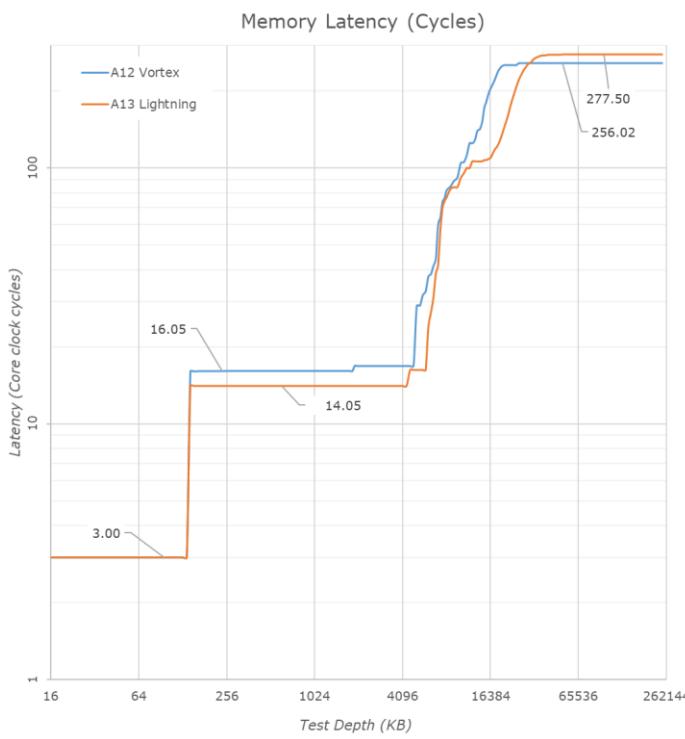
- Integrated Fan-out
- Chip-on-Wafer-on-Substrate
- System-on-Integrated-Chips
- Wafer on Wafer



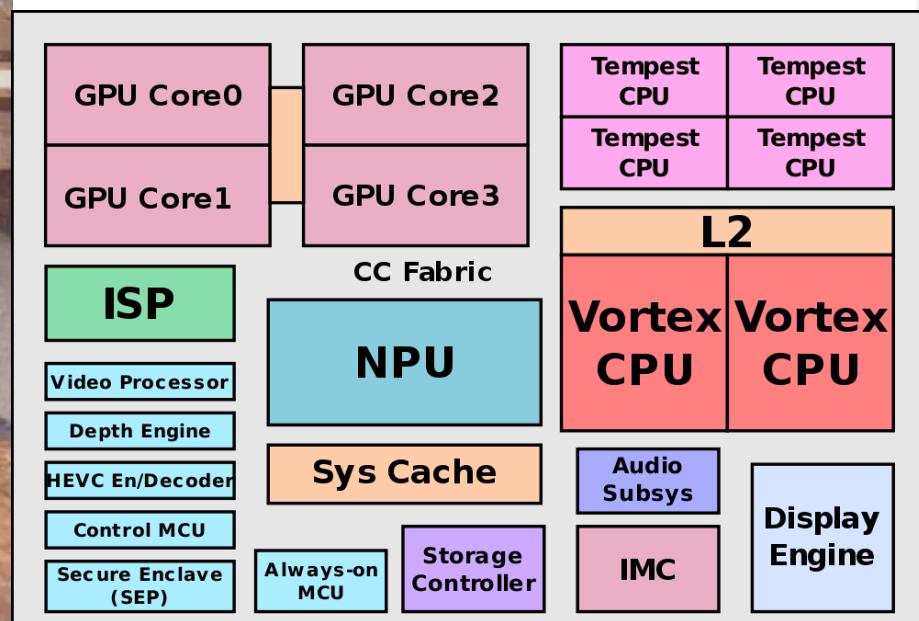
台積電先進封裝布局一覽				
先進封裝技術	InFO	CoWoS	SoIC	WoW
技術名稱	整合扇出型封裝	基板上晶圓上晶片封裝	系統整合晶片封裝	晶圓堆疊晶圓封裝
封裝結構分類	2.5D IC	2.5D IC	3D IC	3D IC
製程內容概要	晶圓級封裝，包括 InFO-PoP、InFO_oS、InFO_MS、InFO_AIP 等	將先進製程邏輯IC及 HBM/HBM2整合封裝在單一晶片	不同製程晶片與晶圓透過TSV堆疊封裝	兩片相同製程晶圓直接透過TSV堆疊封裝
量產時程	已量產	已量產	2021年後	2021年後
資料來源	業者提供			製表：涂志豪

The A13's Memory Subsystem: Faster L2, More SLC BW

Architecture System Level Cache (SLC)



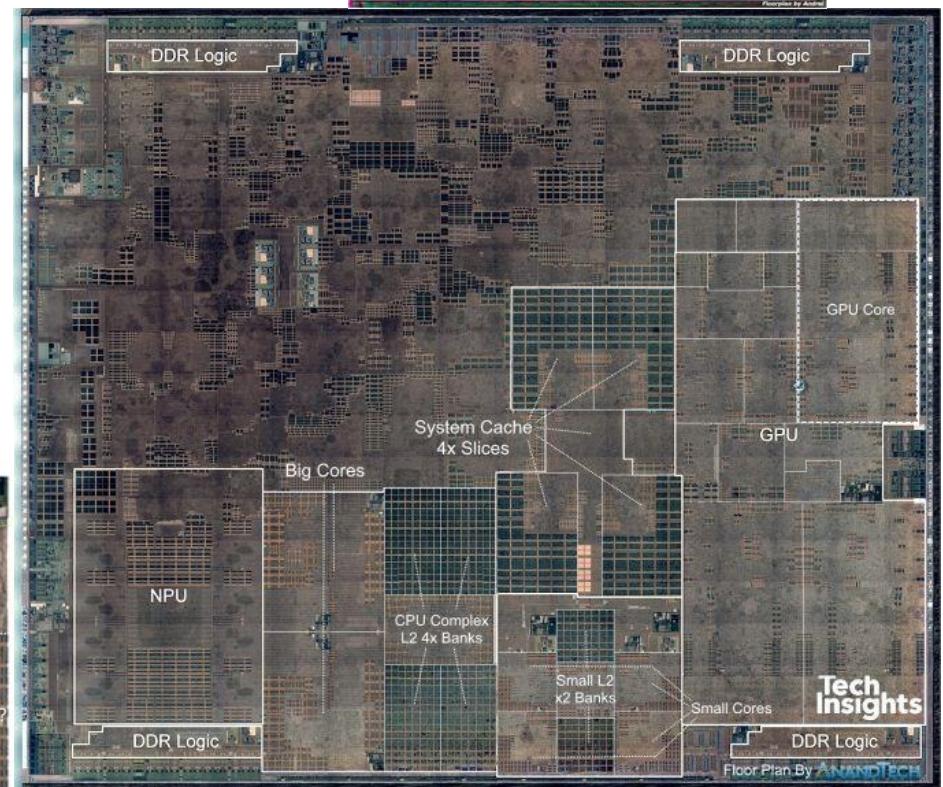
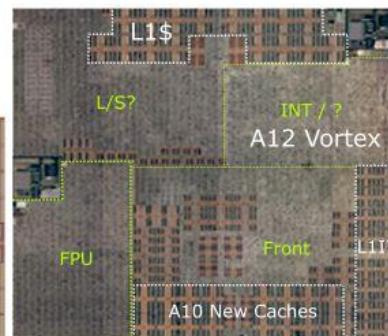
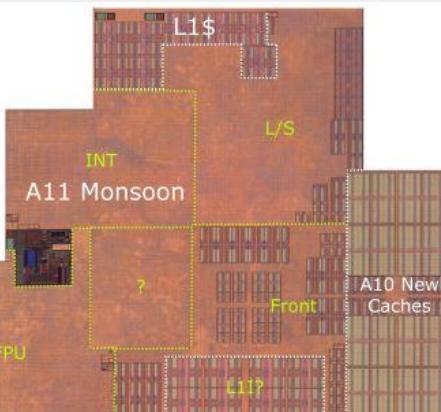
- FIB: Focused Ion Beam
- Reverse Engineering



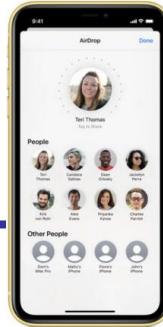
Die Block Comparison

Die Block Comparison (mm²)

SoC Process Node	Apple A11 TSMC 10FF	Apple A12 TSMC N7	Apple A13 TSMC N7P
Total Die	87.66	83.27	98.48
Big Core	2.68	2.07	2.61
Small Core	0.53	0.43	0.58
CPU Complex (incl. cores)	14.48	11.90	13.47
GPU Total	15.28	14.88	15.28
GPU Core	4.43	3.23	3.25
NPU	1.83	1.23	2.09

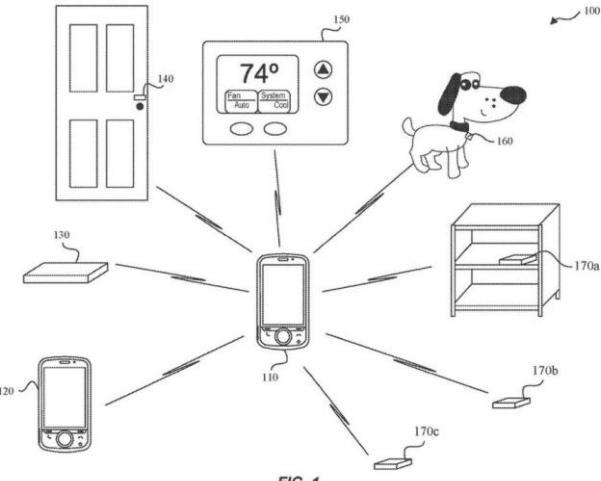


U1 Chip



Share. Find. Play.
More precisely
than ever.

Ultra Wideband technology comes to iPhone.
The new Apple-designed U1 chip uses
Ultra Wideband technology for spatial
awareness. It allows you to more precisely
locate other U1-equipped Apple devices. Think
GPS at the scale of your living room. So if you
want to share a file with your friend, just open
AirDrop, just point your iPhone at theirs, and
they'll be first on the list.*



■ Co-processor

- A, M, W, H, T and S series

■ U: Ultra-Wide Band

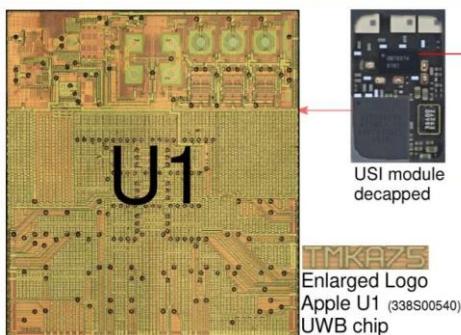
- Low-energy short-range radio technology for wireless data transmission

■ Strengthen the positioning function

■ More precise Air Drop (patent)

■ Apple Tags

USI UWB Module Details



SYSTEMPlus
CONSULTING

Technology	Accuracy	Price	Use cases	Installation
WiFi	5-15 m	€	做人 + 叉车	建筑物 + 工厂 easy
Bluetooth	1-3 m	€	做人 + 叉车	建筑物 + 工厂 easy
UWB	10-30 cm	€ € €	叉车	工厂 complex

Short-range wireless communication

●表 短距離無線通訊與新興通訊技術比較表

無線通訊 技術	Bluetooth 藍牙	ANT	ZigBee	NFC (Near Field Communication)	UWB (ultra-wideband)	TransferJet	IrDA (Infrared Data Association)	Li-Fi (Light Fidelity)
協會 Logo								
正式出道 時間	1999	2004	2005	2004	2002	2006	1993	2011
傳輸距離(米)	10~100 (一般模式) 10~30 (BLE)	0~30	10~75 (一般模式) 134 (降到 26kbps 時)	0~0.2	0~10	0~0.03	0.2~1 (Angle < 30°)	0~5
傳輸速度	1~3Mbps (一般模式) 24Mbps (Bluetooth HS)	20Kbps	10kbps~250Kbps	106Kbps 212Kbps 424Kbps	53.3~480Mbps	375~560Mbps	9.6K~115.2Kbps (SiR) 4M/16Mbps (FIR/VFIR) 1Gbps (Giga-IR)	1.6Gbps per 1-color LED
傳輸技術	無線電 射頻	無線電 射頻	無線電 射頻	無線電 射頻	無線電 射頻	電感磁場	光通路 (紅外線)	光通訊 (可見光)
使用頻段	2.4GHz	2.4GHz 1GHz (頻道降低時)	2.4GHz 915MHz (北美) 868MHz (歐洲)	13.56MHz	3.1GHz~10.6GHz	4.48GHz	300GHz~400THz (使用紅外線頻段，波長 850~900nm)	400~800THz (使用可見光頻譜，波長 375~700nm)
安全性	高	高	中	極高	高	極高	低	中
國際標準	IEEE 802.15.1	Proprietary	IEEE 802.15.4	ISO/IEC 18092 ECMA 340 ETSI TS 102 190	IEEE 802.15.3a ECMA 368 ISO/IEC 26907-8	Proprietary	Proprietary	Proprietary
延伸規格	Bluetooth Smart (BLE) Bluetooth HS	ANT+	ZigBee RF4CE (2009) ZigBee PRO	NFC 為 RFID 的延伸 分支	N/A	N/A	VFiR, UFIR, GigaR, 5/10GigaR	基於 VLC 技術的 IEEE 802.15.7
網路拓撲	樹狀、網狀、星狀、總線、點對點	廣播、網狀、星狀、總線、點對點	網狀、星狀、總線、點對點	點對點	點對點	點對點	點對點	星狀、點對點
應用範圍 (用途)	手機、平板、遊戲機、耳機、立體聲音頻串流、汽車、電腦及週邊、穿戴式裝置 (同步、資料傳輸、物聯網)	手錶、體育健身、醫療保健、穿戴式裝置 (同步、資料傳輸、物聯網)	遠端監控 (遙控、燈具控制)、各種自動化、無線感應開關、穿戴式裝置 (遙控、資料傳輸、物聯網)	手機、各式 ICT 產品、穿戴式裝置、電子錢包 (貨物辨識、認證、資料傳輸、電子支付)	電腦及週邊 (資料傳輸、同步、資訊串流)	相機、電腦週邊、行動裝置、手機、USB 同步底座 (同步、資料傳輸、視訊串流)	手機、平板、遊戲機、耳機、電視、電腦及週邊 (遙控、資料傳輸、上網、視訊串流)	各 ICT 產品、海底環境/低電磁波干擾環境 (資料傳輸、上網、視訊串流)
主管協會 /單位	Bluetooth SIG	ANT+ Alliance	ZigBee Alliance	NFC Forum	WiMedia Alliance (已解散，於 2009 年轉給 Bluetooth SIG, USB-IF)	TransferJet Consortium	Infrared Data Association	Li-Fi Consortium
網站	www.bluetooth.org	www.thisisanant.com	www.zigbee.org	www.nfc-forum.org	www.wimedia.org	www.transferjet.org	www.irda.org	www.lificonsortium.org

資料來源：DIGITIMES 整理 - 2014年

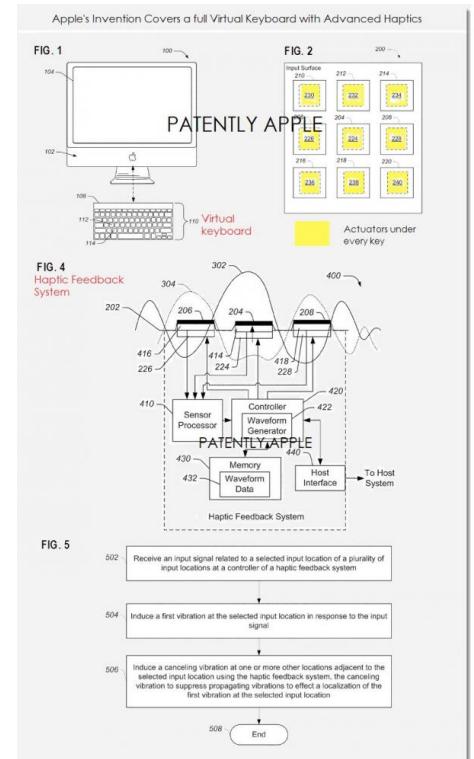
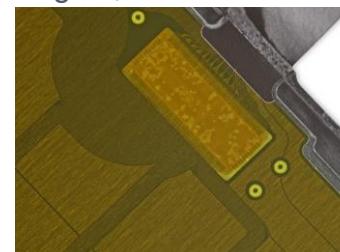
Taptic Engine

■ A new experience of human-computer interaction

Touch mode	Multi-Touch(2007)	Force Touch(2014)	3D Touch(2015)	Haptic Touch(2019)
Tap, slide, pinch with two fingers (zoom in and out)	✓	✓	✓	✓
Micro pressure	✗	✓	✓	✓
Press harder	✗	✗	✓	✓

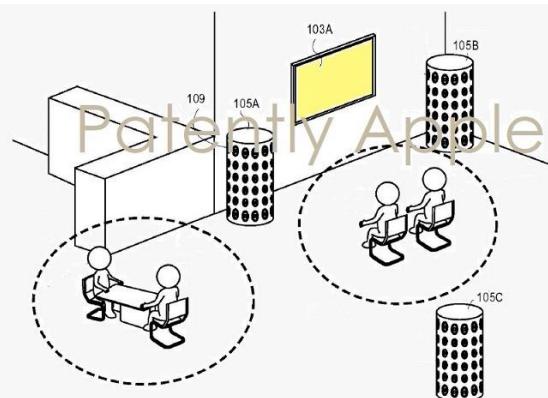
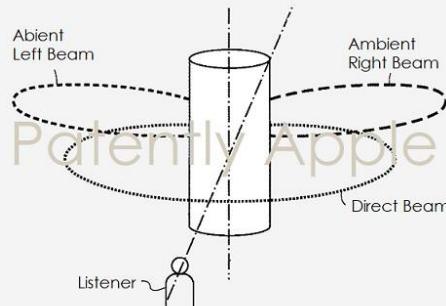
3D Touch

1. Press the application icon on the screen, etc., to bring up the secondary menu and realize direct function;
2. For a link, tap it to preview the link content, let go, and the preview content disappears (Peek); Continue to press again to open the link content and jump (Pop).
3. You can preview videos, emails, messages, etc. by pressing;
4. Give different feedback in different games according to different strengths;
5. Re-press the left edge of the screen to call out multitasking;



Dolby Atmos

■ Spatial audio rendering for beamforming speaker arrays



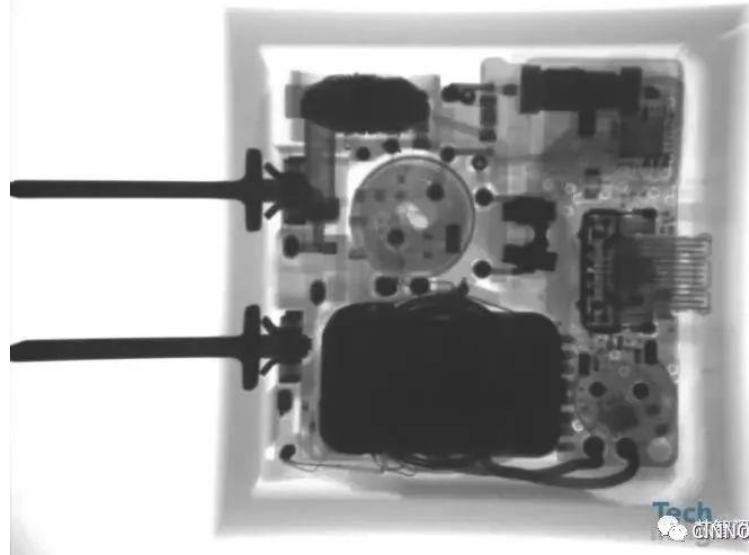
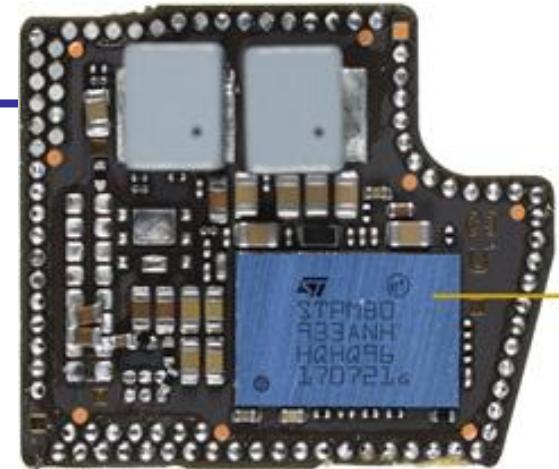
PD (power deleiver)

■ Power Delivery (PD) is for handling higher power and charge quickly over a USB connection.

■ **18W PD charger**

■ **USB-C to Lightning fast charging data cable**

Manufacturer	Part Number	Prominent Markings	Device Type	Item Description
Cypress Semiconductor	CYPD313532L-QXQQ	CYPD313532L-QXQQ 1919 TWN 6157	USB Controller	USB Type-C Port Controller.
Alpha & Omega	A032394E	(LOGO) 32394E GA9K1U	Power MOSFET	Alpha & Omega A032394E is a Power MOSFET.
Power Integrations Inc	SC1263K6	(LOGO) SC1263K6	CV/CC Flyback Switcher IC	Power Integrations Inc SC1263K6 is a CV/CC Flyback Switcher IC.
Infineon	BSZ096N10LS5	S10L RL21	Power MOSFET	Infineon BSZ096N10LS5 is N-channel, OptiMOS 5, Power-Transistor rated for 10A@55V



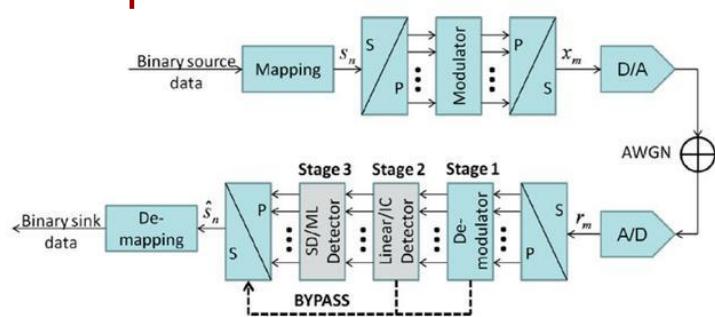
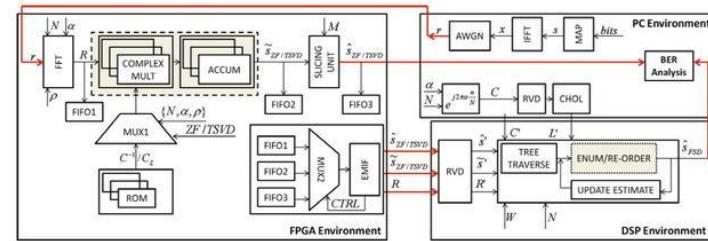
Baseband Processor

■ Intel PMB9960 (XMM7660)

- The 6th generation LTE modem of 3GPP Release 14.
- Supports speeds up to 1.6 Gbps in the downlink (Cat 19),
- Supports speeds up to 150 Mbps in the uplink.

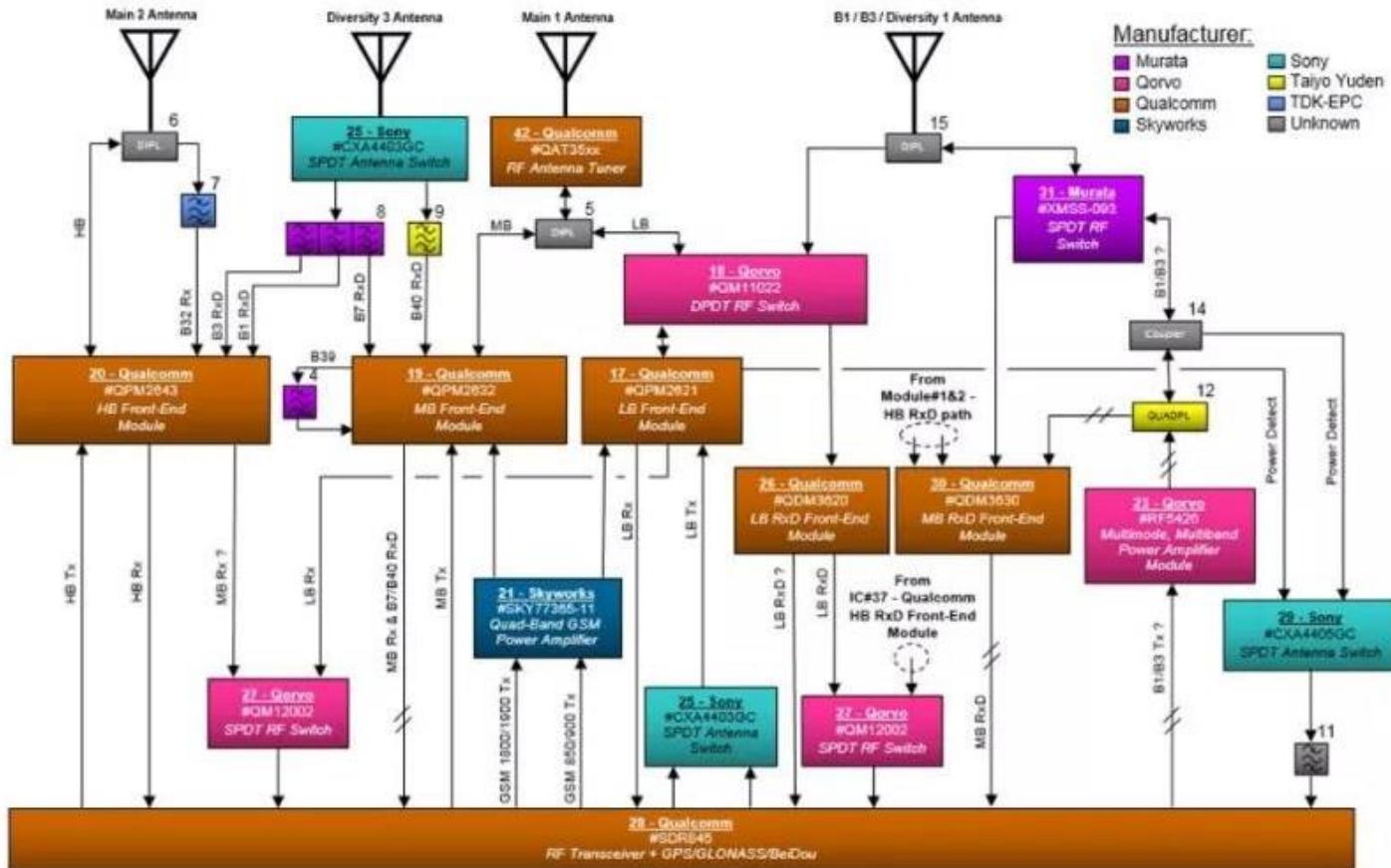
Technical Specifications

Baseband	Intel® X-GOLD™ 766 baseband
Transceiver	Intel® SMARTi™ 8 RF transceiver
Standards & Performance	3GPP Release 14 LTE FDD/TDD 1.6Gbps/150Mbps LAA Support TD-SCDMA 2.8/2.2 Mbps DC-HSPA+ Cat 24, 42Mbps GNSS – 4 Mode
Transceiver Capabilities	LTE-FDD LTE-TDD UMTS/WCDMA TD-SCDMA CDMA/EVDO GSM/EDGE
Carrier Aggregation	LTE FDD/TDD/Hybrid DL 7CA UL 2CA 4x4 MIMO
Modulation	LTE UL-64QAM; DL-256QAM
RF Bands	More than 45 LTE bands simultaneous; including 3.5GHz/5GHz
SIM Support	LTE/LTE Dual SIM Dual Standby (DSDS)

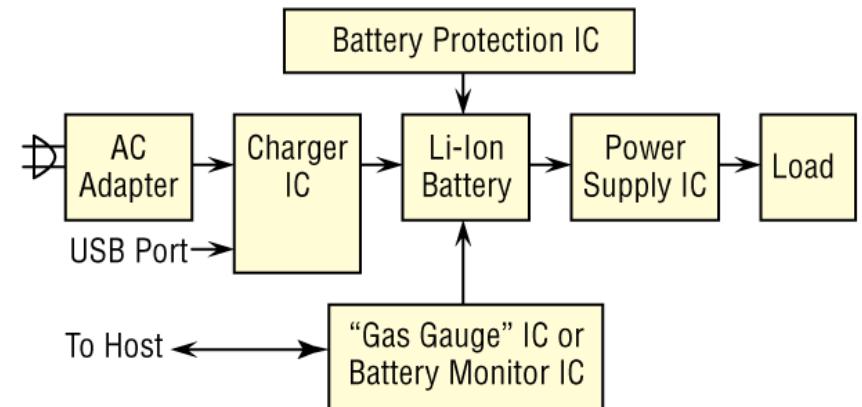
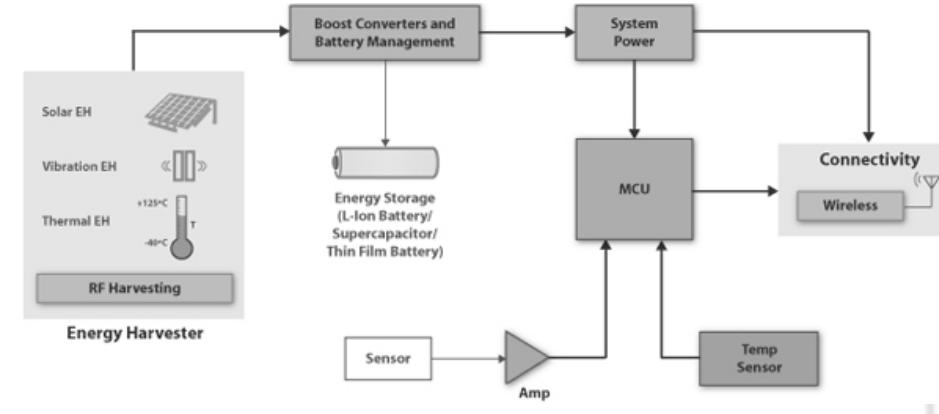
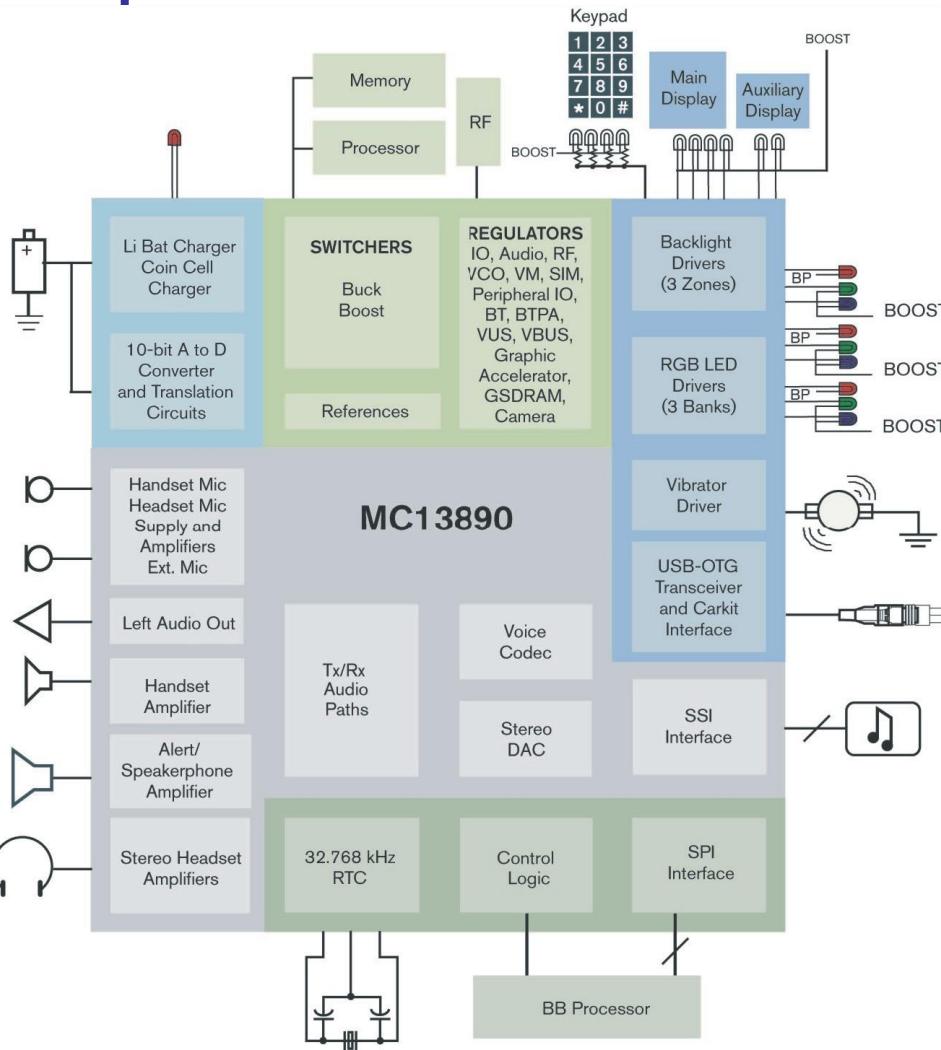


品牌	Intel	Qualcomm	Qualcomm
處理器	XMM 7560 LTE	Snapdragon X20 LTE	Snapdragon X16 LTE
晶圓製程	14nm Intel	10nm LPE	10nm LPE / 14nm LPP
處理器	APPLE A12	Qualcomm S845	Qualcomm S835
LTE類別	LTE CAT.16 (下行) LTE CAT.13 (上行)	LTE CAT.18 (下行) LTE CAT.13 (上行)	LTE CAT.16 (下行) LTE CAT.13 (上行)
下行功能	5*20 MHz CA 最高256-QAM 4X4 MIMO 最多10個Downlink Streams	5x20 MHz CA 最高256-QAM 4x4 MIMO(3CA) 最多12個Downlink Streams	4x20 MHz CA 最高256-QAM 4x4 MIMO(2CA)+2*2(1CA) 最多10個Downlink Streams
上行功能	3x20Mhz 最高64-QAM	2x20 MHz CA 最高64-QAM	2x20 MHz CA 最高64-QAM
峰值下載速度	1 Gbps	1.2 Gbps	1 Gbps
峰值上傳速度	225 Mbps	150 Mbps	150 Mbps

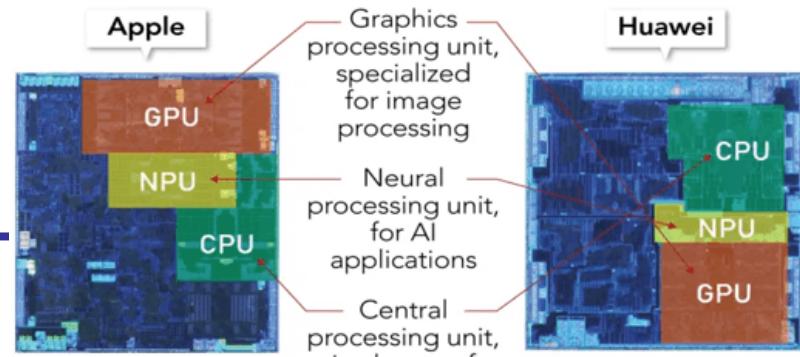
Block Diagram – Radio Design



Power Management Ics (gather energy for use in parts)



Comparison

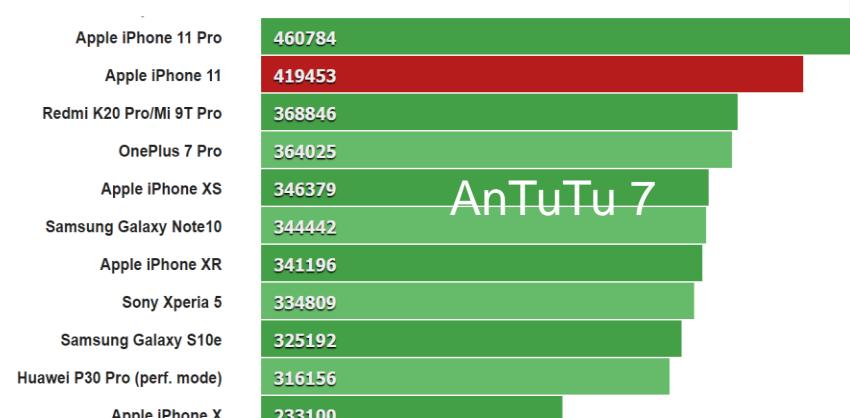
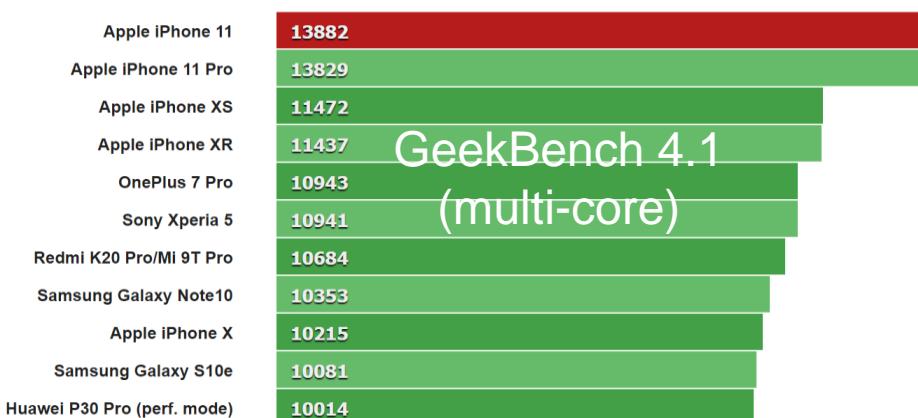
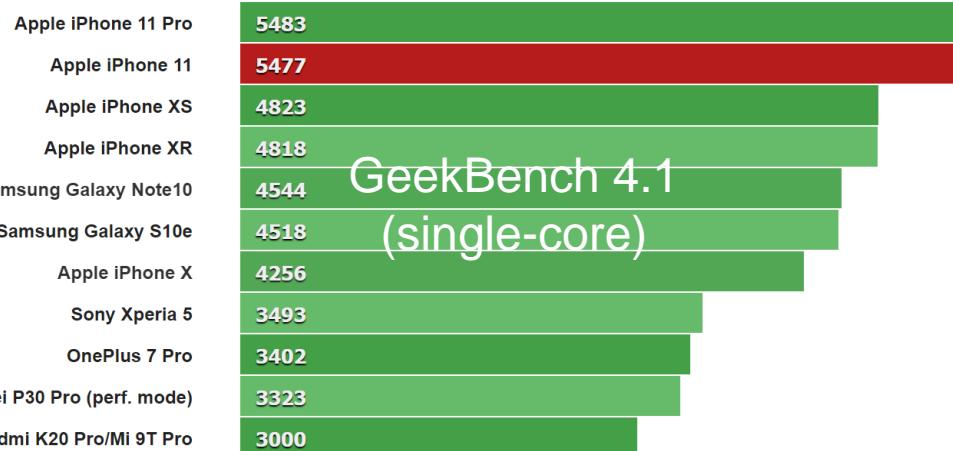


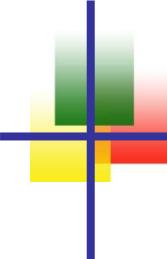
圖片來源：Courtesy of Techanalyse
Source : 科技政策研究與資訊中心—
科技產業資訊室(iKnow)整理，2019/04

A series processor

	System-on-chip (SoC)	A12 Bionic	A13 Bionic	Kirin 980	Kirin990 5G
Design	Supplier	Apple		Hisillicon	
	Released date	9.12.2018	9.10.2019	8.31.2018	9.6.2019
	64 Bit	Yes			
	Manufacturing process	7nm TSMC	7nm TSMC	7nm TSMC	7nm TSMC EUV
CPU	Transistors	6.9 billion	8.5 billion	6.9 billion	10.3 billion
	CPU Cores	2+4	2+4	2+2+4	2+2+4
	Performance CPU	2 Vortex CPUs (2.49 GHz)	2 performance CPUs with 20% faster and 30% lower power	Cortex-A76 (2.6GHz) × 2 + Cortex-A76 (1.92GHz) × 2	Cortex-A76 (2.86GHz) × 2 + Cortex-A76 (2.36GHz) × 2 +
	Efficiency CPU	4 Tempest CPUs	4 efficiency CPUs with 20% faster and 40% lower power	Cortex-A55 × 4	Cortex-A55 (1.96GHz) × 4
GPU	Max Clock (GHz)	2.49	N/A	2.6	2.86
	GPU	Internally-designed GPU	Fastest GPU ever for smartphone	Mali-G76	Mali-G76
AI Accelerator	GPU Cores	4	4	10	16
	AI Processor	8-core Neural Engine	8-core Neural Engine	Dual NPU	Three NPU
5G	5G Modem	No	No	No	Balong 5000 modem
Memory	Ram Interface	LPDDR4X	LPDDR4X	LPDDR4X	LPDDR4X
	Ram Frequency	2,490	N/A	2,133	2,133
	Max Bandwidth	N/A	N/A	34.1	34.1

Benchmark



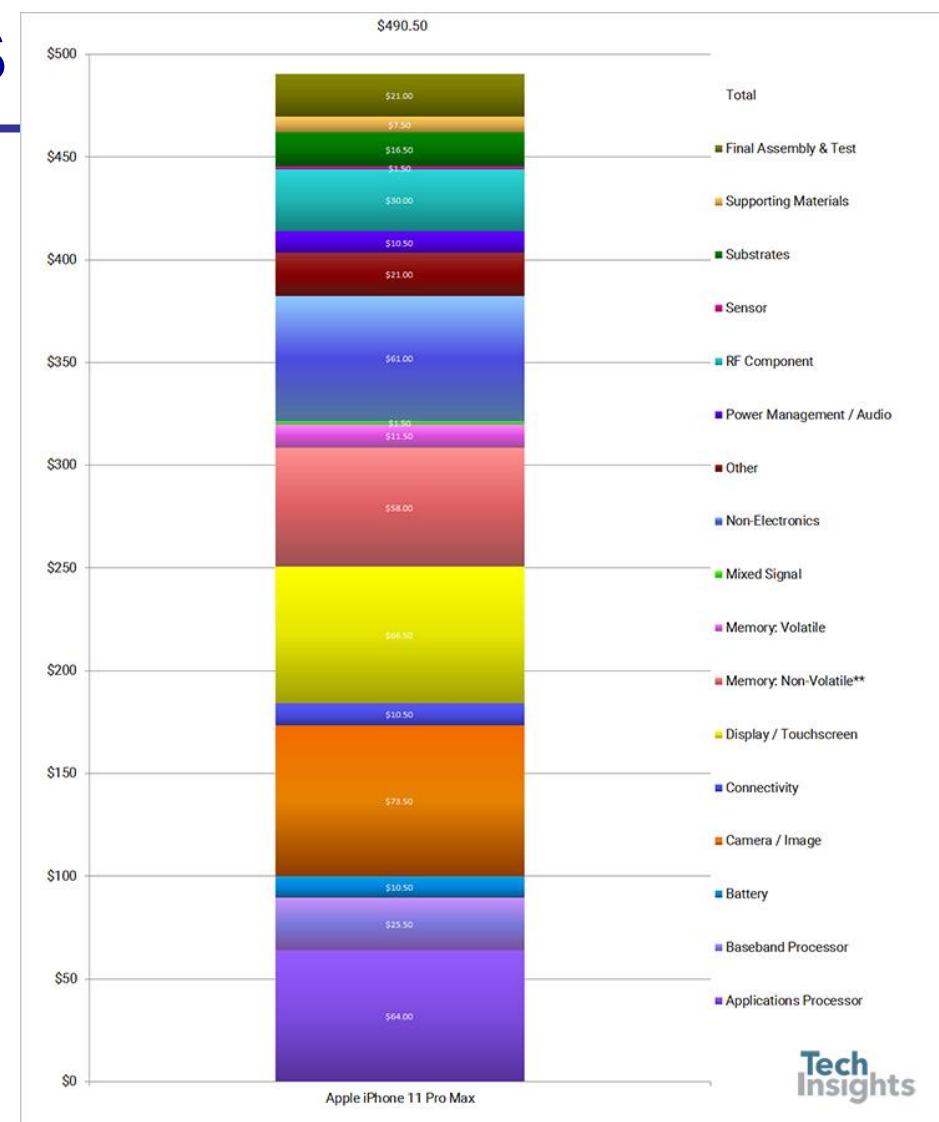


OUTLINE

- Introduction
- System Description
- Technology Analysis
- Industry Analysis**
- Applications
- Conclusion
- References

Bill of Materials

Apple iPhone 11 Pro Max	
Applications Processor	\$64.00
Baseband Processor	\$25.50
Battery	\$10.50
Camera / Image	\$73.50
Connectivity	\$10.50
Display / Touchscreen	\$66.50
Memory: Non-Volatile**	\$58.00
Memory: Volatile	\$11.50
Mixed Signal	\$1.50
Non-Electronics	\$61.00
Other	\$21.00
Power Management / Audio	\$10.50
RF Component	\$30.00
Sensor	\$1.50
Substrates	\$16.50
Supporting Materials	\$7.50
Final Assembly & Test	\$21.00
Total	\$490.50



Tech
Insights



Supply chain

iPhone 11 Pro Max零件供應商



資料來源：iFixit、業界

Business Model

THE APPLE GDP: THE IOS ECOSYSTEM HAS GROWN TO \$163B

Apple captures most of this revenue



Source: VisionMobile analysis
Figures for 2012

© 2013 VisionMobile Inc.



Porter's 5 Forces Analysis





SWOT

Here's Why Apple is still the best

- ✓ Advertising capabilities
- ✓ U.S. distribution channels
- ✓ Vertical integration
- ✓ Brand awareness and reputation
- ✓ Sound financial performance

Did you know? Apple's brand is worth over \$170 billion.

Apple's competitive disadvantages

- ✗ Overdependence on iPhone sales
- ✗ Weak direct distribution channels in India
- ✗ Low expenditure on R&D
- ✗ Incompatibility with other OS

Did you know? iPhone generates 2/3 of Apple's sales.

Possible pursuits

- ?] The Internet of Things (IoT) market
- ?] Health-related wearable gadgets
- ?] Expanding mobile payments market
- ?] The mobile enterprise app market

Did you know? Only 1 person in 20 is using Apple Pay.

Dangers to avoid

- ?] Intensifying competition
- ?] The rising U.S. dollar exchange rate
- ?] Lawsuits over patent infringements
- ?] Risk of data breaches

Did you know? Apple is the most targeted company for patent infringements.

More information at:
www.strategicmanagementinsight.com/swot-analyses/apple-swot-analysis.html



SWOT Analysis

STRENGTHS

Style/Brand

Rich UI

User Base

Hype

First Mover

Migrate people to Apple

Port existing apps

New social device

Distribute iTunes content

OPPORTUNITIES

WEAKNESSES

High price/ High end

Limited distribution channels

Missing features

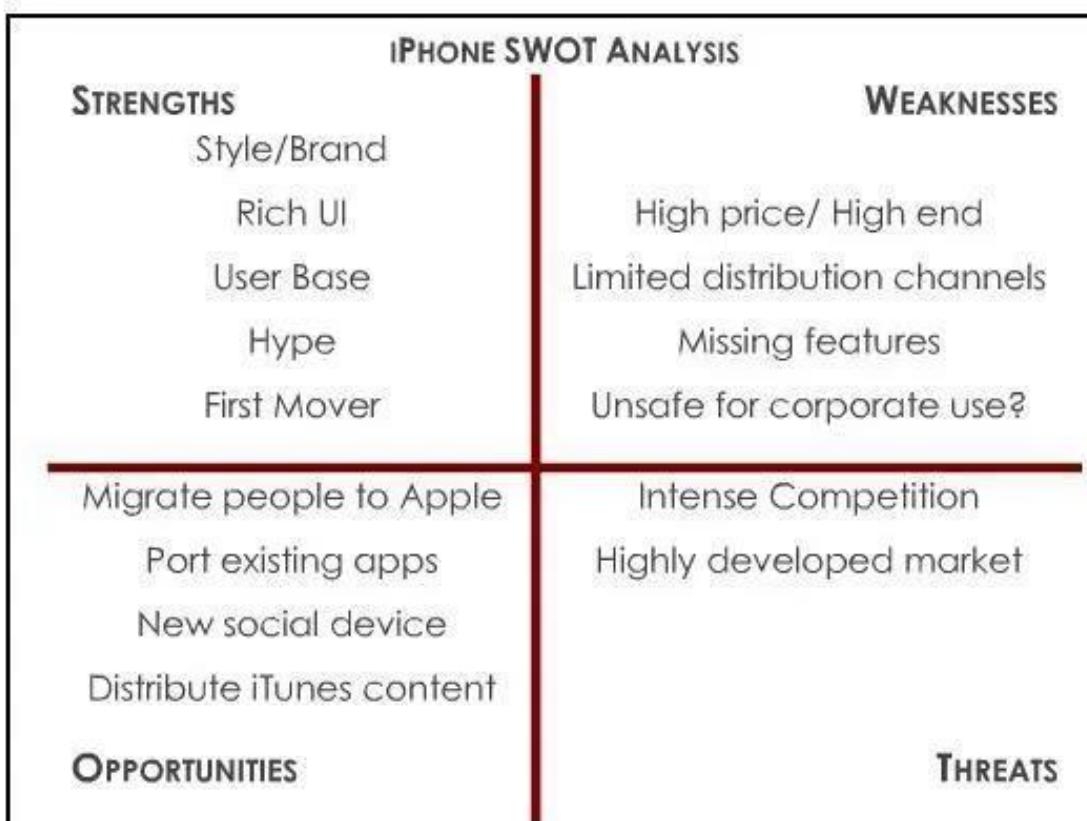
Unsafe for corporate use?

Intense Competition

Highly developed market

THREATS

IPHONE SWOT ANALYSIS





OUTLINE

- Introduction
- System Description
- Technology Analysis
- Industry Analysis
- Applications**
- Conclusion
- References

Deep Fusion (iOS 13.2)

- **Synthesize multiple photos through AI to improve resolution and reduce photo noise**

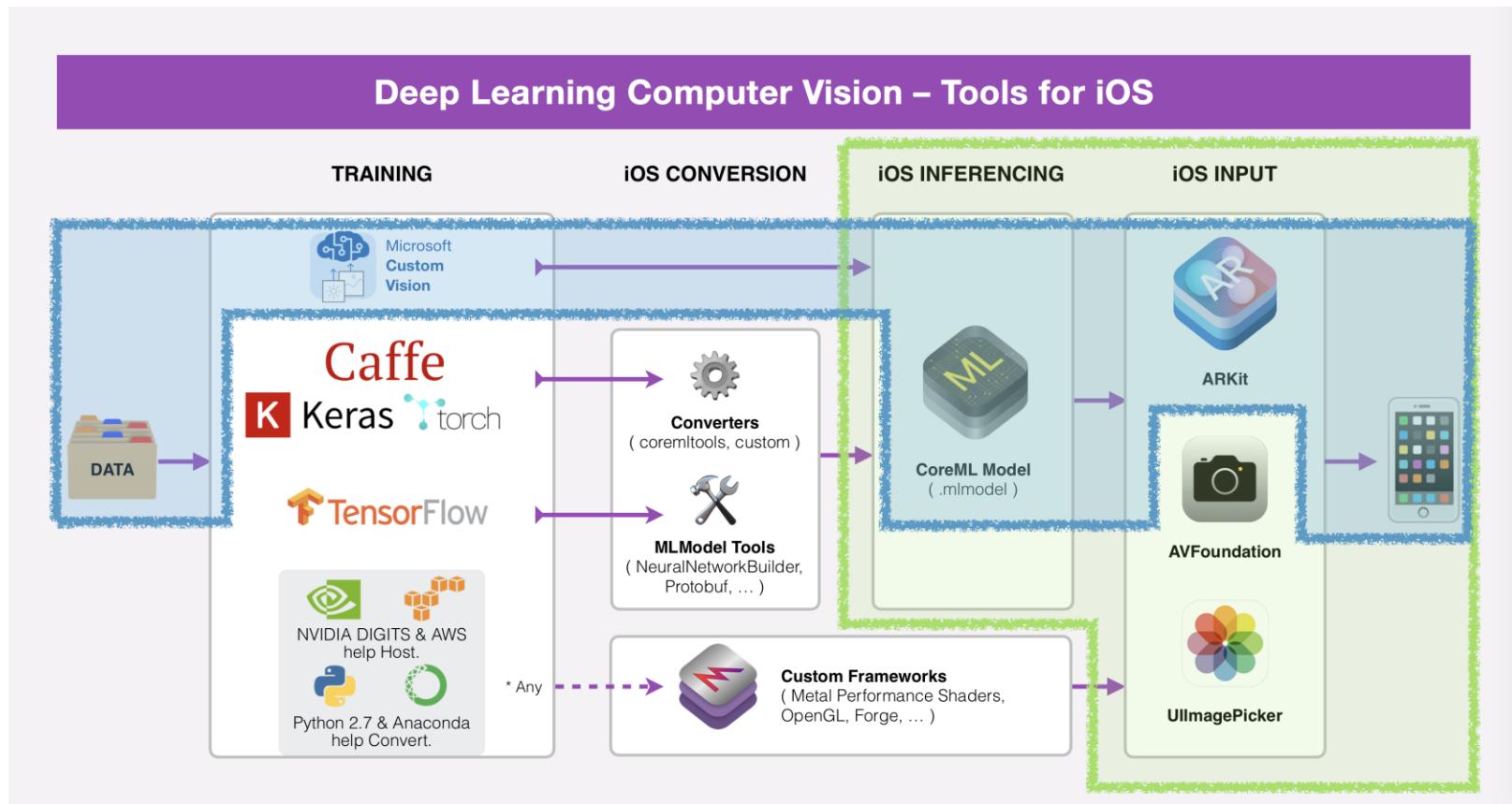
- When the iPhone shutter "before" is pressed, 8 consecutive photos will be taken and temporarily stored
 - Four of them are short exposure and four are medium exposure.
- And when you press the shutter button, long exposure photos will start
- Through Deep Fusion technology, 9 photos are combined with photos of different exposure times, to synthesize a photo with high resolution and low noise
- With Apple A13 Bionic's neural engine and machine learning, it only takes one second



Apple Chip

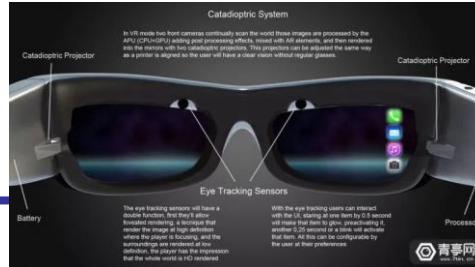
Core ML

Machine Learning Framework

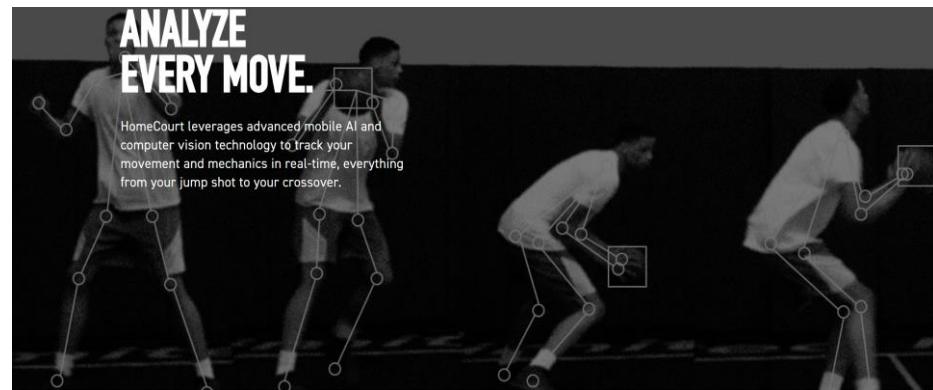
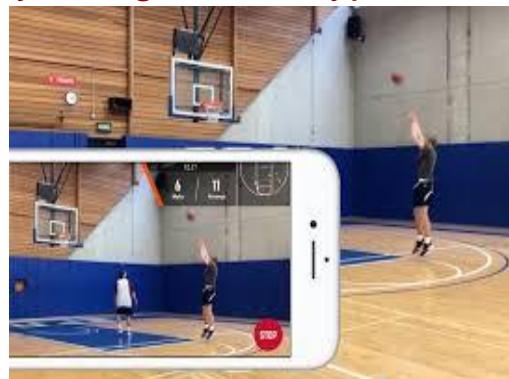
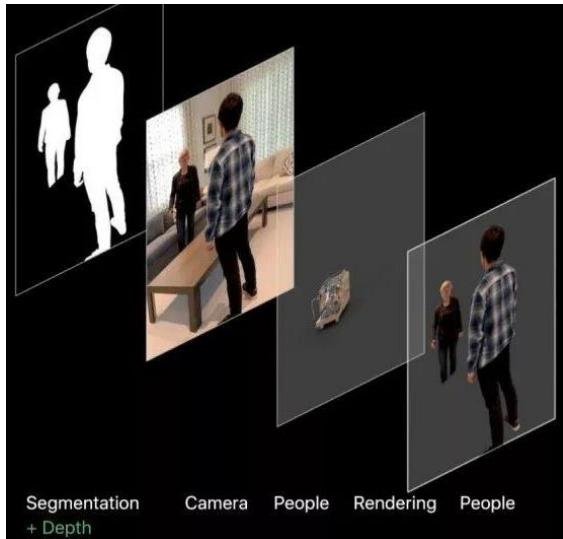




ARKit 3



- Real-time occlusion, gesture recognition, collaborative meeting, multi-face tracking, physical size
 - HomeCourt: Automatically recognize the type of shot, arm angle, running speed, shooting angle
- CPU, GPU: rendering
- Neural Engine
- ISP: Optical Flow



System Chip on

Differences between iOS and Android systems

ios android compare

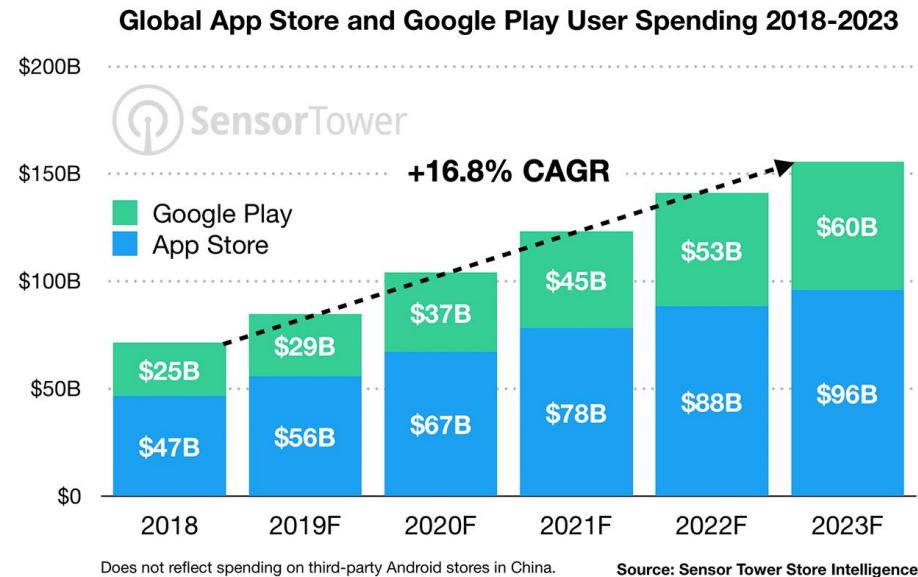


	iOS (iPhone)	Android
Developer	Apple	Google
Copy/Paste	✓	✓
Multitasking	✓	✓
Flash Support	✗	✓
Silverlight Support	✗	✗
HTML5 Support	✓	✓
Unified Inbox	✓	✓
Exchange Support	✓	✓
Threaded Email	✓	✓
Visual Voicemail	✓	✓
Video Calling	✓	✓ Third Party App
Universal Search	✓	✓
Internet Tethering	✓	✓
Removable Storage	✗	✓
Facebook Integration	✗ (Third Party App)	✓ (Third Party Integration)
Twitter Integration	✗ (Third Party App)	✓ (Third Party Integration)
Folders	✓	✓
Apps Organization	Customizable	Customizable
App Store	300,000+ Apps	90,000+ Apps
Microsoft Office Support	Third Party App	Third Party App
Widgets	✗	✓
Media Sync	iTunes Mac & PC	Direct File Transfer + Third Party Software
X-Box Live Integration	Via Third Party App	Via Third Party App



How to make money through Apps

- App
- Credit card fees
- telecommunications



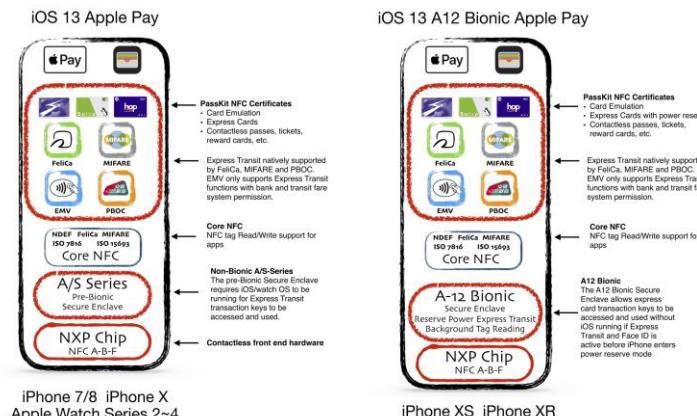
SensorTower Data That Drives App Growth

sensortower.com



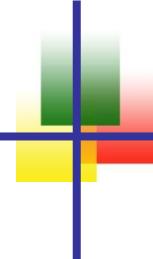
NFC

- NFC gets a lot more powerful in iOS 13.
- Not just an easy way to check out at the point of sale in a traditional retail environment such as Apple Pay.
- With iOS 13 (on iPhone 7 and later), users will be able to read a range of contactless smart cards and tags, including NFC-enabled passports and other government IDs.
- Write NFC tags (that is, NDEF write), and even lock tags.



iOS 13





OUTLINE

- Introduction
- System Description
- Technology Analysis
- Industry Analysis
- Applications
- Conclusion
- References

Expect Great Things from the Apple A14 processor

- First iOS handset with 5G
- 5nm process (A14 chip)
- Reverse wireless charging function
- 3D sensing ToF (time-of-flight ranging)
- "No bangs" design





OUTLINE

- Introduction
- System Description
- Technology Analysis
- Industry Analysis
- Applications
- Conclusion
- References



References

- <https://www.cultofmac.com/651258/iphone-11-pro-max-comparison/>
- <https://mrmad.com.tw/iphone-11-pro-max-ifixit-teardown>
- https://en.wikipedia.org/wiki/Apple-designed_processors