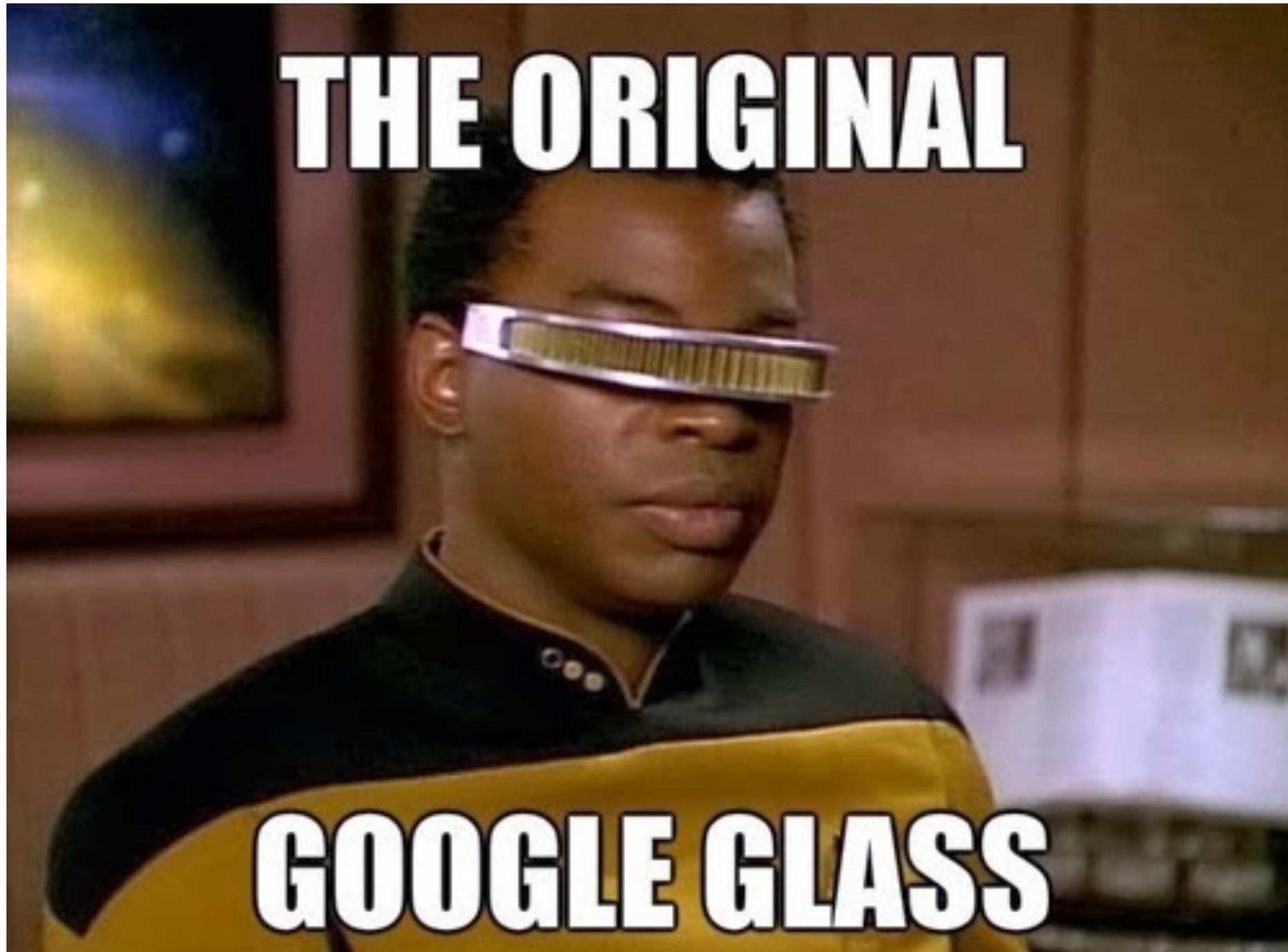


Proiectarea cu Microprocesoare

Wearable Computing

Facultatea de Automatică și Calculatoare
Universitatea Politehnica București

THE ORIGINAL



GOOGLE GLASS

A wearable device is a computer that is subsumed into the personal space of a user, controlled by the user, and has both operational and interactional constancy, i.e., is always on and always accessible.

Wearable History

Forms

Business case



- In 2013, investors poured \$458 million into 49 wearable company deals (*CB Insights*)
- \$139 Billion Industry in 2022
- Expected to triple in size by 2030
- Major tech companies like Apple, Google, Samsung and Intel investing heavily in wearables, with non-tech giants like Nike, Under Armour, Adidas, Fossil, Timex etc.

What makes wearables special?

- Used while the wearer is in motion
- Used while one or both hands are free or occupied with tasks
- Exist within the corporeal envelope of the user
 - Not merely attached to the body but becomes an integral part of the person's clothing
- Allows the user to maintain control
- (Should be) constantly available

Some interesting issues

Operating
Systems

Data
Transmission

Energy
Consumption

Security &
Confidentiality

Data
Management

Application
Development
Platform

Popularity Example

- Pebble
- Kickstarter Campaign
- Seeks : \$100K
- Raises : \$10+ Million



KICKSTARTER

Factors in Wearable Tech Today

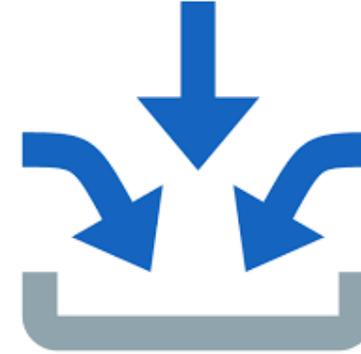
- Faster and Cheaper Hardware
- Cloud Storage
- Location Data
- Quantified Self Activity
- Gaming Industry
- Visual & Voice Technology
- User Experience



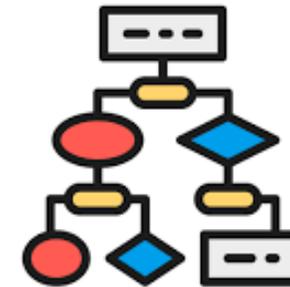
Devices



Applications



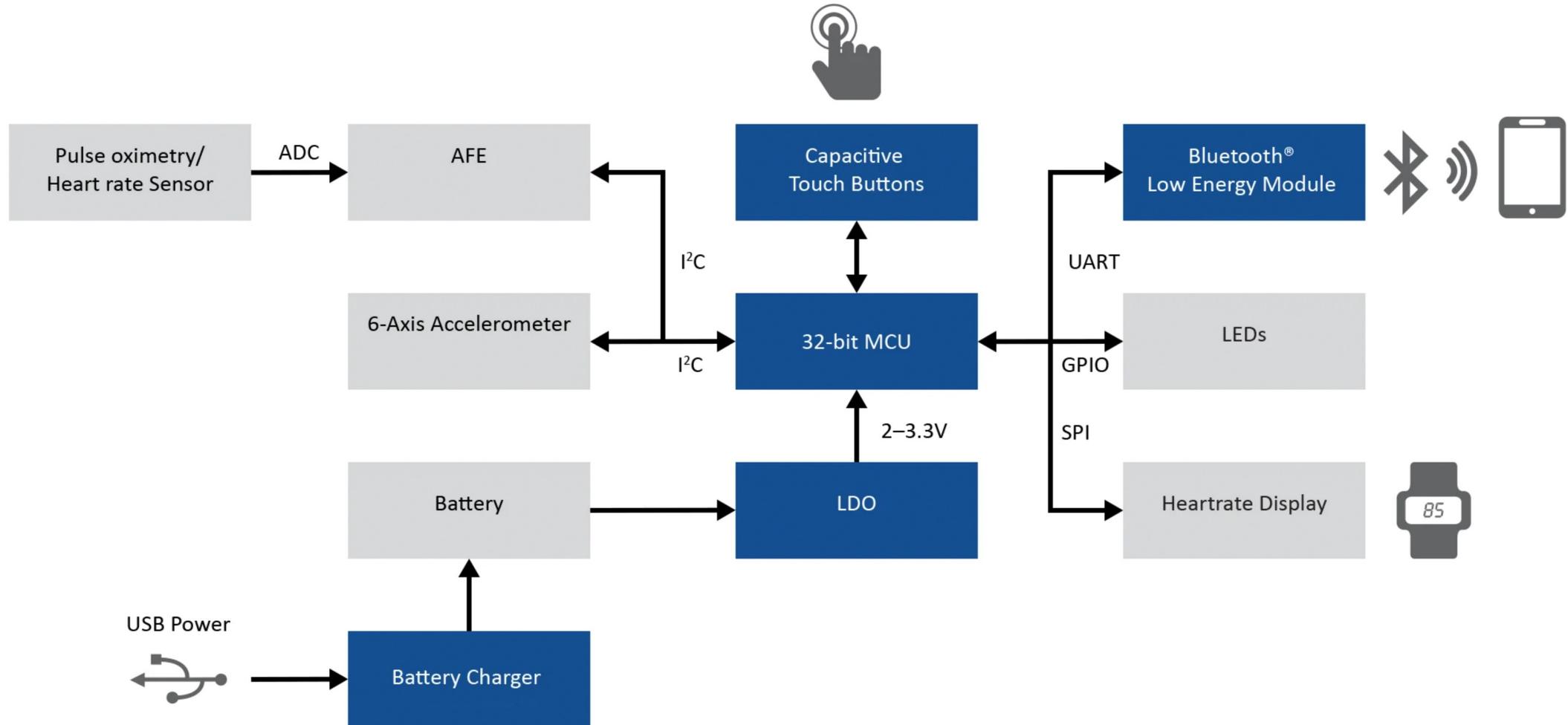
Inputs



Algorithms

Hardware

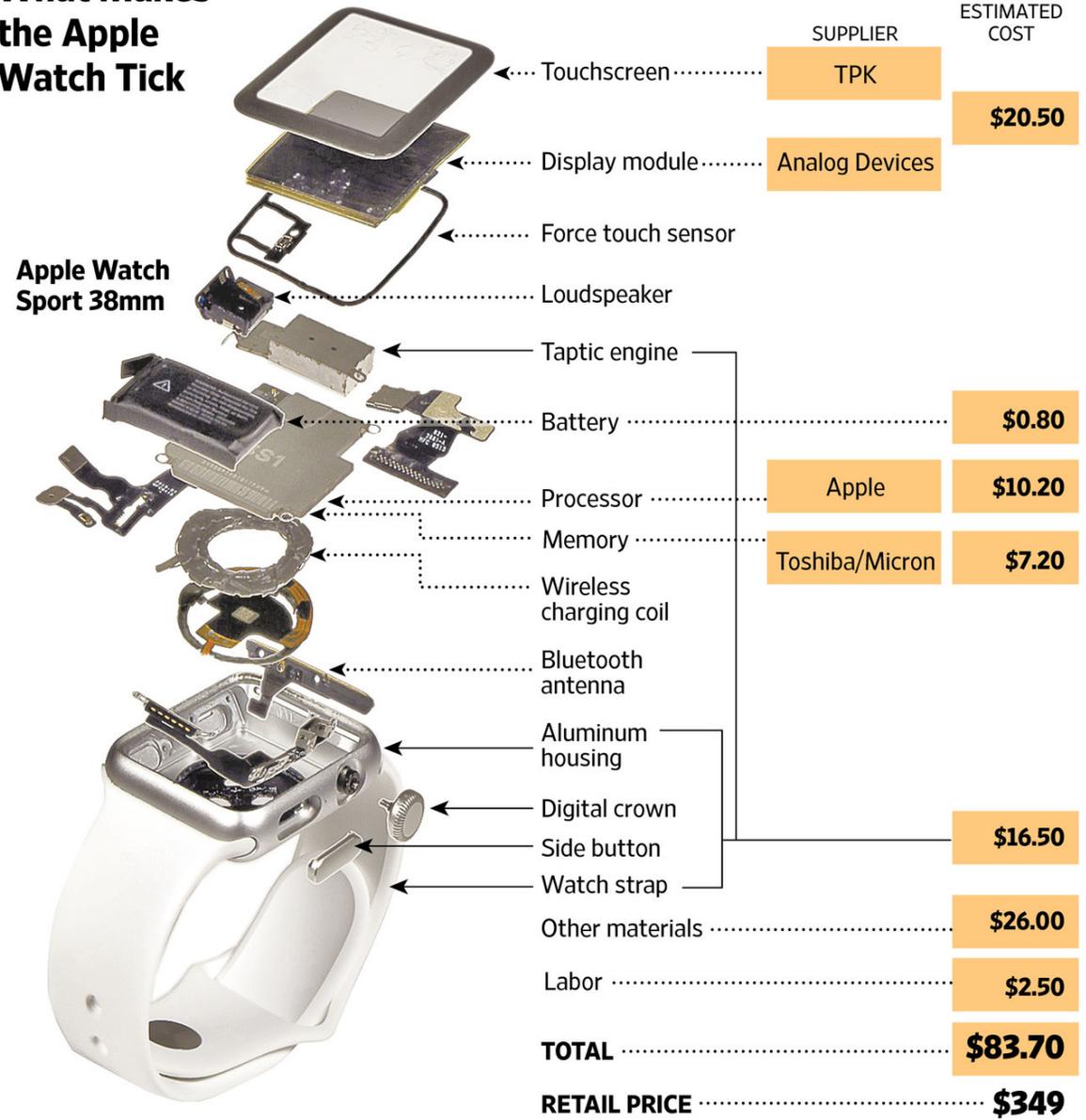
What is (typically) inside a wearable?



Apple Watch (Smartwatch)



What Makes the Apple Watch Tick

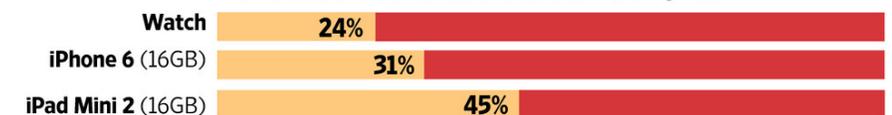


Note: Cost analysis excludes logistics, manufacturing, software and IP expenses.

Source and photo: IHS Technology

THE WALL STREET JOURNAL.

Materials and labor as a share of retail price

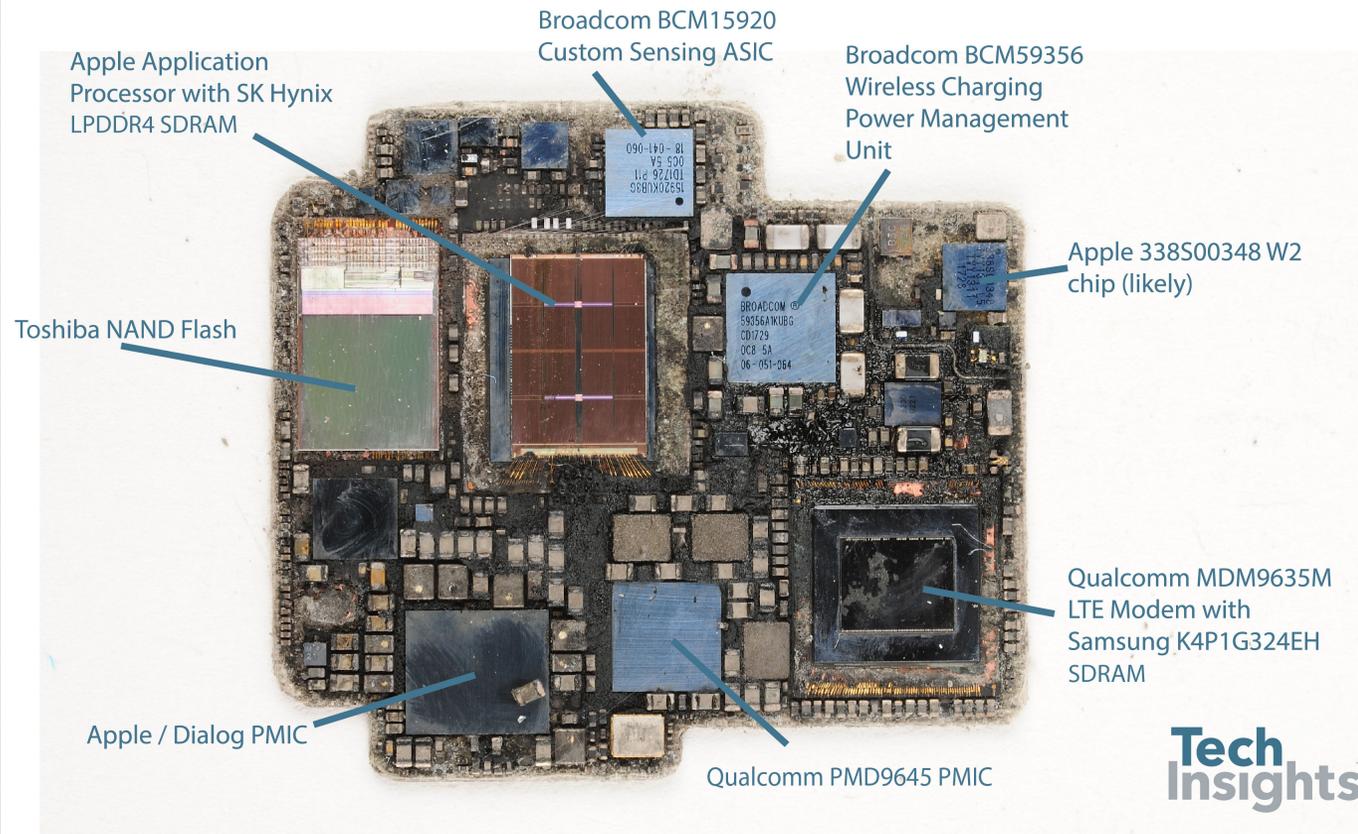
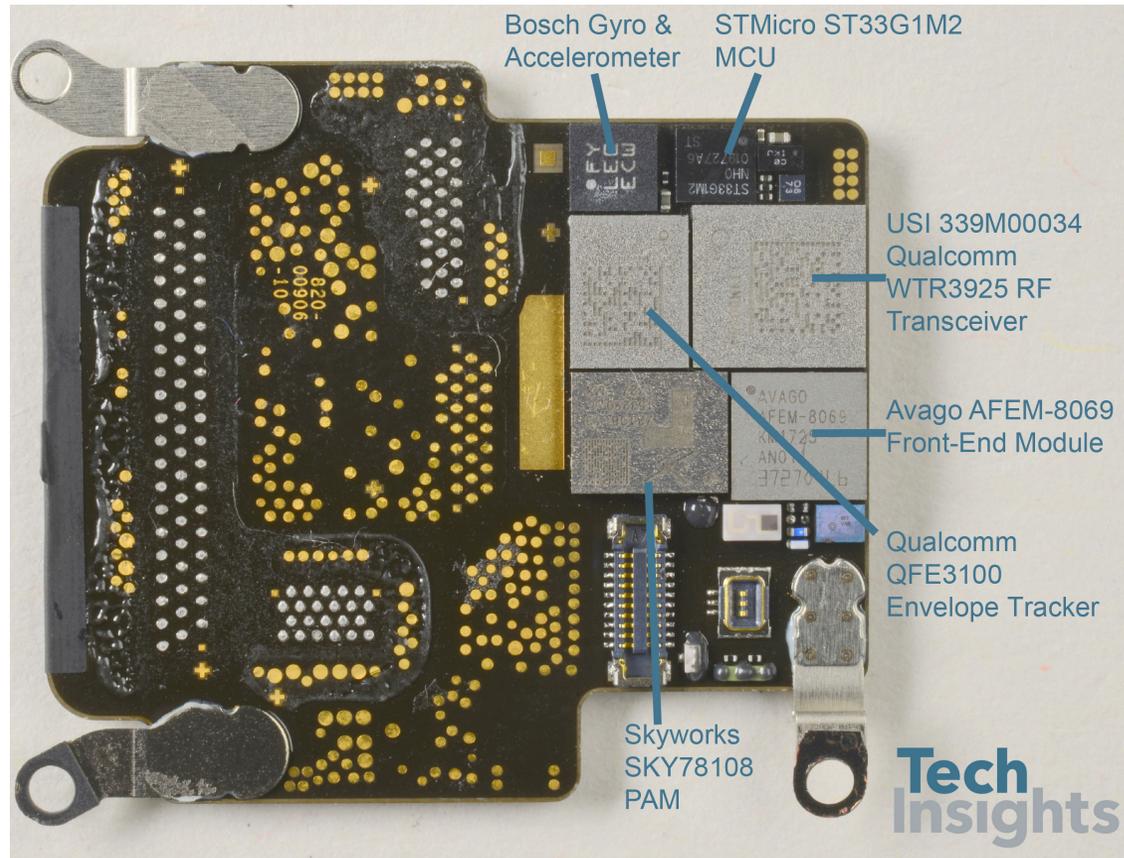


Apple Watch



<https://www.ifixit.com/News/53688/three-former-apple-engineers-helped-us-tear-down-apple-watch-series-7>

Apple Watch – main board



<https://www.techinsights.com/blog/apple-watch-series-3-teardown>

Jawbone (Activity Monitor)



MotionX[®]
Powered

RECHARGEABLE BATTERY

Up to 10 days of use on a single charge.

VIBRATION MOTOR

Powers your silent alarm clock & reminds you to move.

PRECISION MOTION SENSOR

Accurately tracks your movement and sleep activity.

3.5MM PLUG

Syncs your band with the app on your phone.

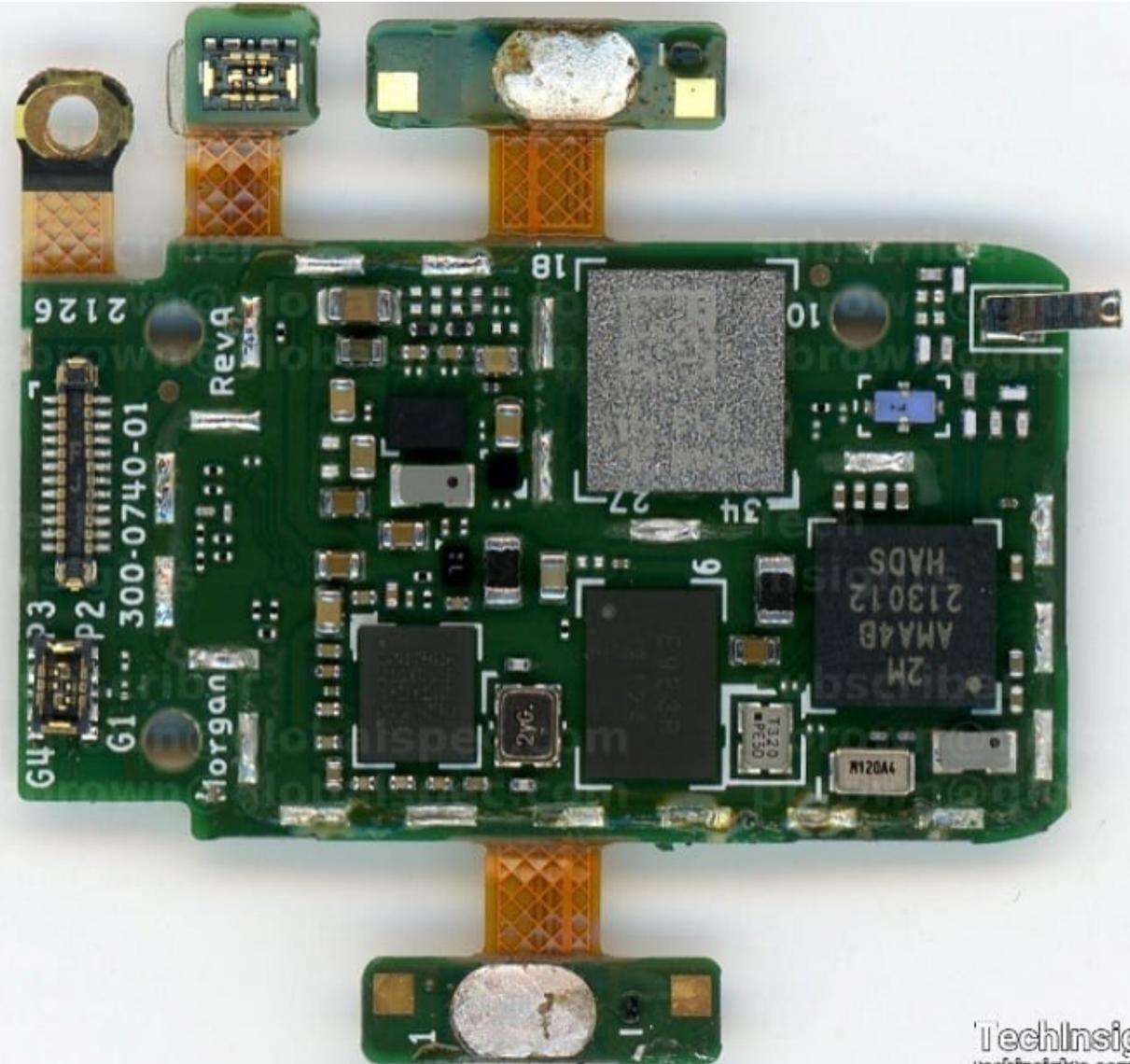
SWEAT-PROOF & WATER-RESISTANT*

Wear the band while showering or working out.

* Water-resistant up to 1m.

Fitbit Charge 5 – main board

- 1.02 inch OLED touchscreen
- ARM M-4 microprocessor
- Heart rate monitor and sensor
- TI AFE for heart rate monitor and bio-sensor
- TI's load switch, LDO regulator, haptic driver & 600 mA step-down converter
- Zinitix's DC-DC controller
- ST Microelectronics' 300 mA LDO regulator, three-axis MEMS accelerometer



Oura (Smart Ring)



Oura (Smart Ring)

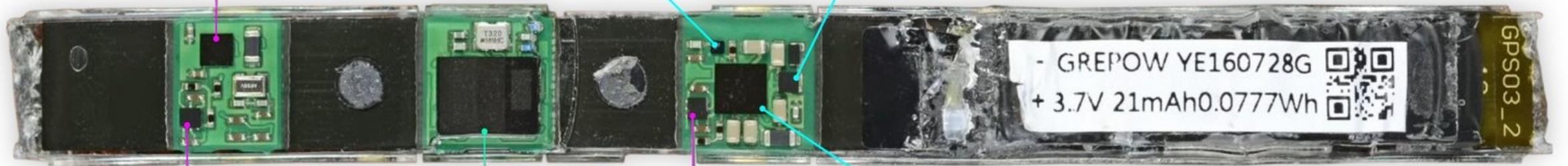
Unknown
Rohm (?)
Accelerometer/Gyroscope



Unknown
Unknown
Operational Amplifier (?)

Unknown
Unknown
Battery Fuel Gauge IC (?)

Unknown
Unknown
Wireless Charging IC (?)



Unknown
Unknown
IR LED Driver (?)

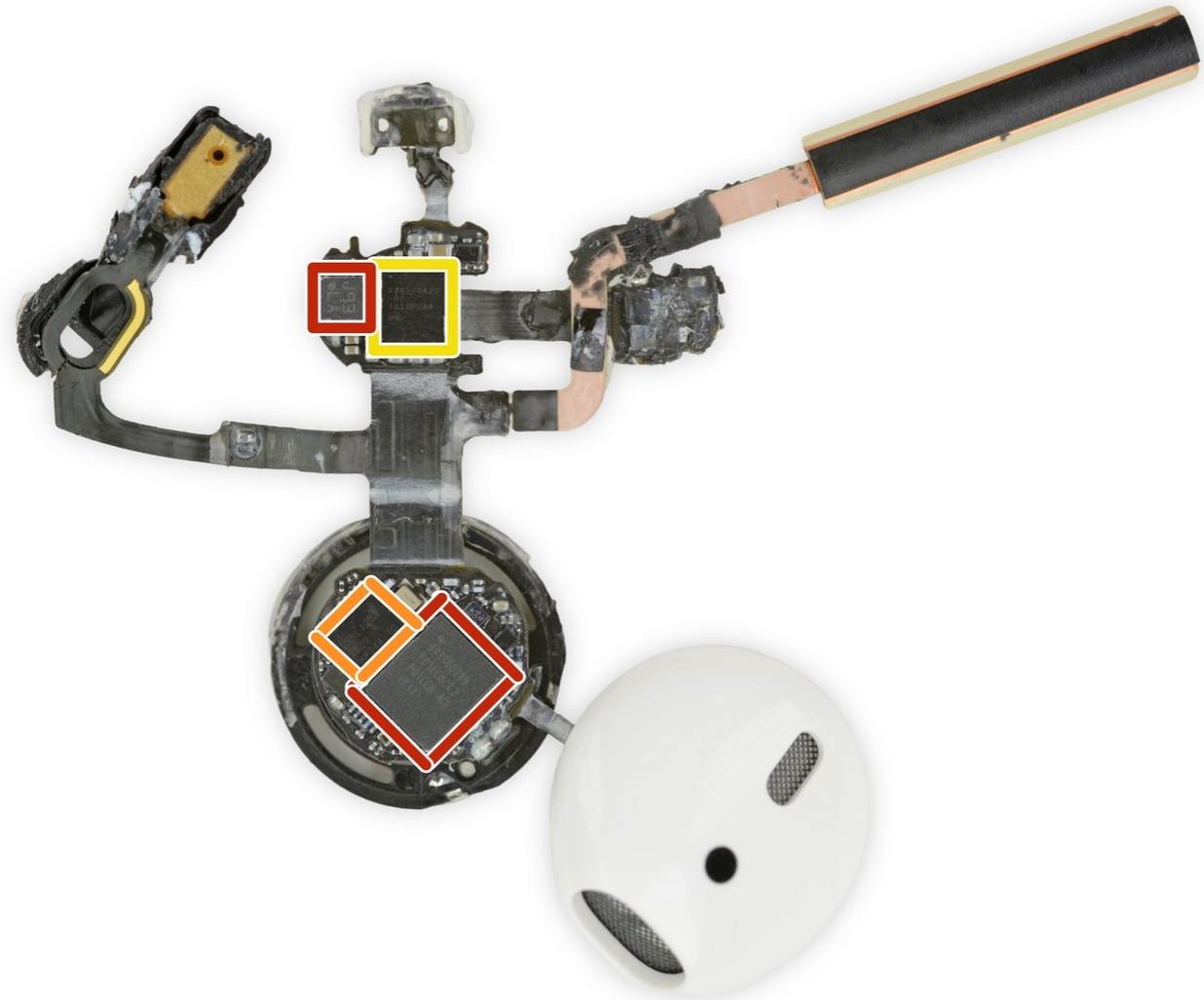
CY8C6336BZI (?)
Infineon
PSoC 6 MCU with BLE
Connectivity

Unknown
Unknown
IR LED Driver (?)

BQ25155 (?)
Texas Instruments
Battery Management IC

Apple AirPods (Smart Headphones)

- **Apple 343S00289** (likely Apple's new H1 chip)
- **Dialog Semiconductor** (Formerly Adesto) [AT25SL128](#) 128 Mb serial flash memory
- **Apple 338S00420** (likely a low-power stereo audio codec)
- **Bosch Sensortec** [BMA280](#) 3-axis accelerometer (likely)

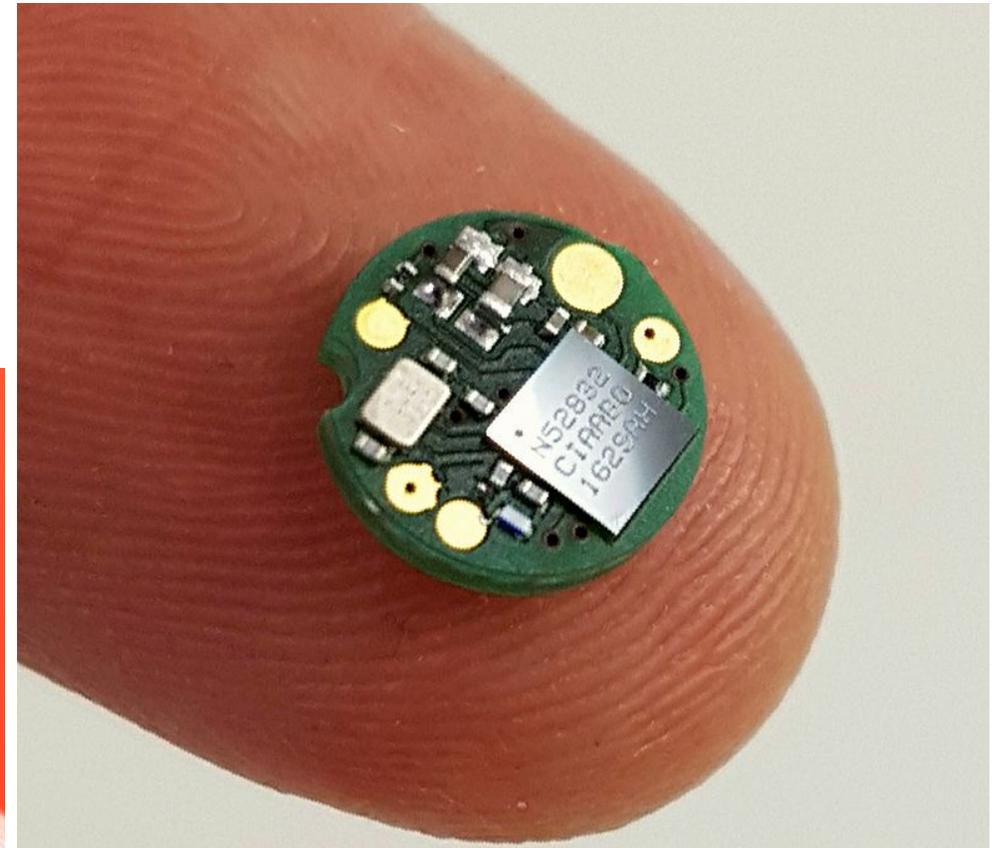
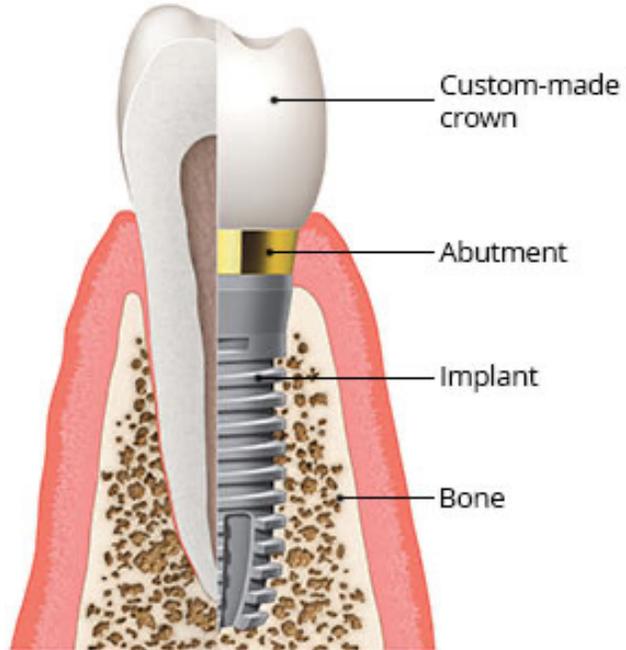


Apple AirPods (Smart Headphones)

- 93mWh battery
- T 8 36 (likely STMicroelectronics inertial sensor)



Microsal (Smart Dental Implant)



Software

watchOS

- Released 2015 exclusively for Apple Watch
- Limited open-source components
- WatchKIT API for developer use
- UNIX-like, slimmed down version of iOS
- Mostly closed ecosystem



apple.com/watchos/watchos-9

Tizen OS

- Open-source OS
- Developed by Intel, Vodafone, Orange, Samsung
- Not exclusively for wearables
- Native HTML5 app support
 - HTML, CSS and JS
- Tizen for wearable OS
 - Light version developed by Samsung
- Low footprint
- Optimized battery life



- Launched 2014, multiple HW platforms
 - 32-bit ARM, x86
- Open-source, closed source components
- Modified Linux kernel
- Multiple partners
 - LG, Asus, Samsung, Sony, Motorola



- Open-source RTOS
- Runs on a variety of HW platforms
 - From 8-bit AVR to 32-bit ARM
- UNIX-like, POSIX compliant
- Modified versions for trackers & watches
 - Fitbit, Xiaomi
- Growing user base and following



Concerns

- Wearables might lead to an improved, better life
- Putting your body online might not always benefit you
- Give whole level characteristics to the service provider not each user level specific information
- Ensure visibility for what the user is sharing
- Human agency and responsibility need to be in the loop

- Wearable Device can be hacked and attacked wirelessly. Patients may die.
- Spoofing and altering are dangerous phenomena which can actually derail the whole purpose. May create panic.
- Side channel attack through power trace analysis is possible.

Energy

- Main reason applications on wearables are limited
- A lot of R&D effort spent at all levels (HW+SW) to solve this issue
- Main trends
 - Processors become more and more efficient – smaller nm technologies for ICs
 - Software becomes more and more optimized – double-edged sword
 - New energy sources become attractive – wearable might end up powered by you

- Too much personalization or assistance will repel users
- Users will be overwhelmed by the huge amount of data and can easily be panicked by misinterpreting any vital health data
- May curb creativity and reduce recall rate

What comes next?

Deeper Integration?

- Move towards seamless integration with other systems
- Market becomes more consolidated and standardized
- Advanced sensing – neural link, health assessment
- Metaverse?

Edible Computers?

- "I expect to see edible computers pills, which will act like little medical monitors, downloading information about your state of health to a computer you wear."
 - Nicholas Negroponte, MIT Media Lab, 1999
- Technology already small enough to become implantable, only limitation is battery life