

# 智慧整合感控系統概論

## Introduction to Cyber-Physical Systems

物聯網發展及機會  
(Development and Opportunity of the IoT)

國立臺北科技大學電子工程系

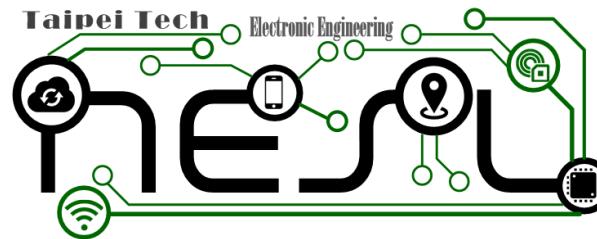
授課教師：李昭賢 副教授

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校內分機：2288



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# 學習目標

1

**Evolution of ICT Technologies**

2

**IoT / CPS/ M2M / WSN**

3

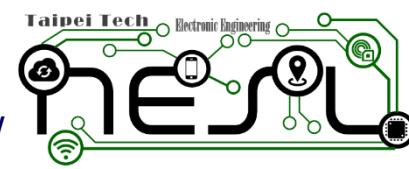
**Implementation**



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# 傳統個人電腦(Personal Computer , PC)

## ❖ 桌上型電腦/Desktop PC)

- 以馮·紐曼(Von Neumann)模型為基礎
  - 算術/邏輯單元(Arithmetic/Logic Unit , ALU)、控制單元(Control Unit)、記憶單元(Memory Unit)、輸入單元(Input Unit)、輸出單元(Output Unit)
- 支援有線網路(Wired Network)
  - 10/100/1000 BASE-T Ethernet



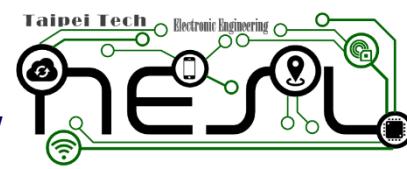
圖片來源：<https://www.emaze.com/@ALIZWLWI/Computer-Evolution>



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# 傳統個人電腦(Personal Computer , PC)

## ❖ 筆記型電腦(Notebook)

- 支援無線網路(Wireless Network)
  - Intel Centrino Platform : Intel首度將無線區域網路(Wireless Local Area Network , WLAN)介面納入其筆記型電腦晶片組內。



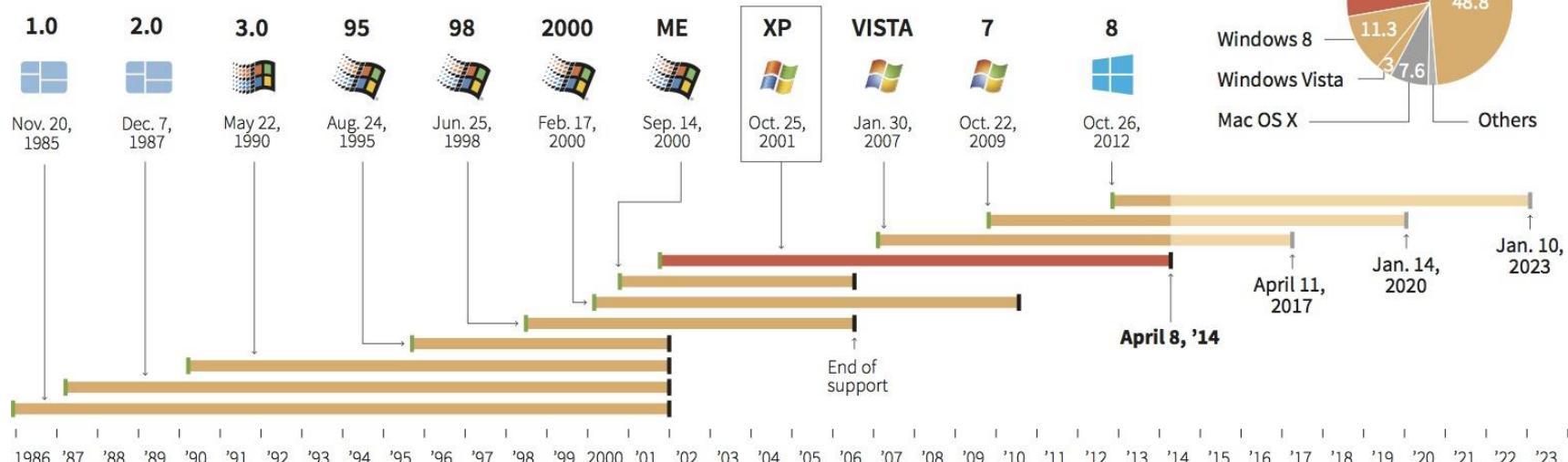
圖片來源：<http://images.tuxboard.com/d/15754-1/macbook+historique.jpg>

# 傳統個人電腦(Personal Computer , PC)

## Windows Operating Systems

PCs running the Windows XP operating system, which is no longer supported by Microsoft, are vulnerable to a recently disclosed Internet Explorer security bug.

### VERSION RELEASE DATE AND LIFECYCLE



Sources: Reuters; Microsoft; Net Market Share

Staff, F. Chan, 29/04/2014



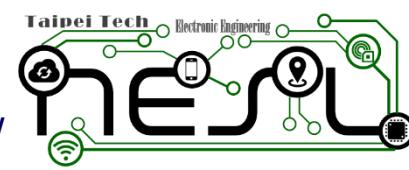
圖片來源：<http://blog.thomsonreuters.com/wp-content/uploads/2014/04/windows.jpg>



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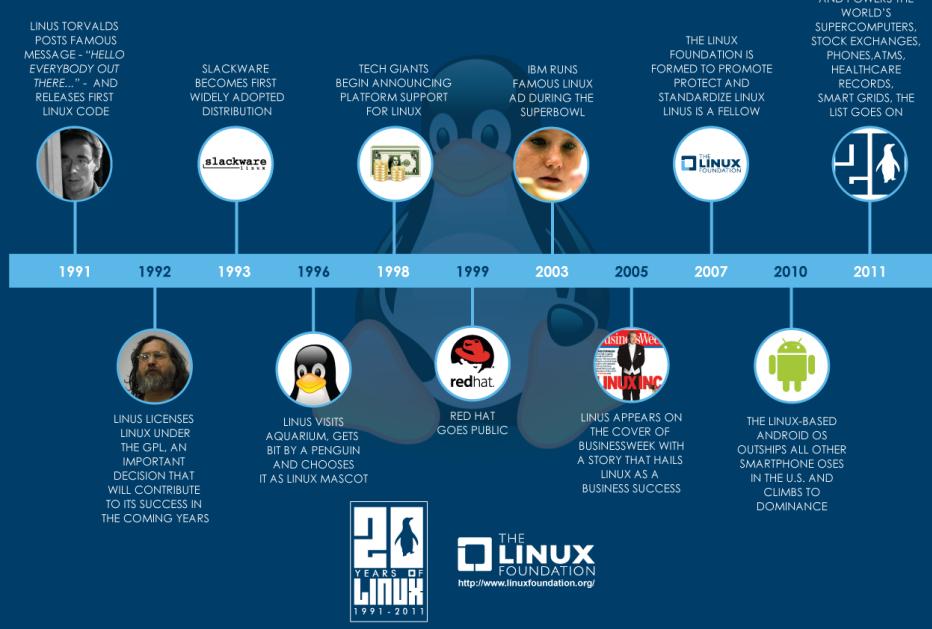


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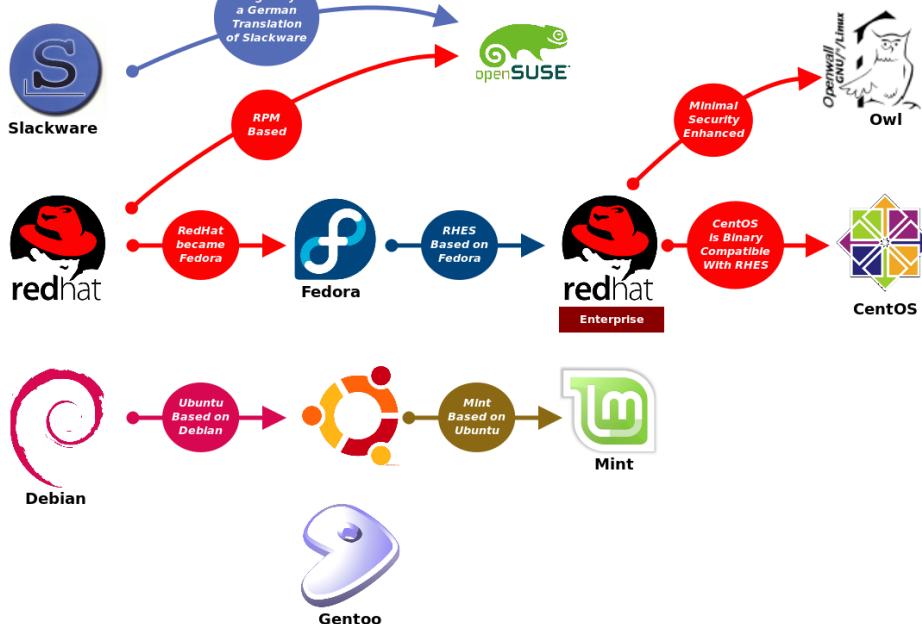
# 傳統個人電腦(Personal Computer , PC)

## MEMORABLE LINUX MILESTONES CELEBRATING 20 YEARS OF LINUX



圖片來源：<http://blogs.longwin.com.tw/wordpress/linux20infographic.png>

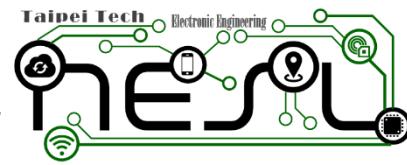
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# 手持式裝置(Handheld Device)

## ❖ 個人數位助理(Personal Digital Assistant，PDA)

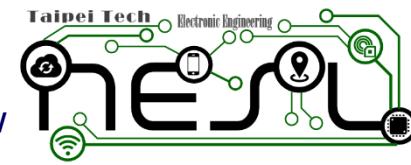
- 通常採用觸控筆(Stylus)作為輸入裝置
- 可隨身攜帶，主要功能是用作個人資訊管理系統
  - 例如：行事曆、電話簿、待辦事項、記事本...等



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# 手持式裝置(Handheld Device)



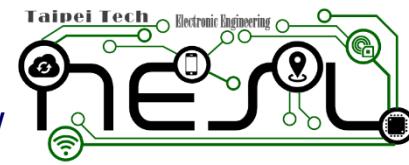
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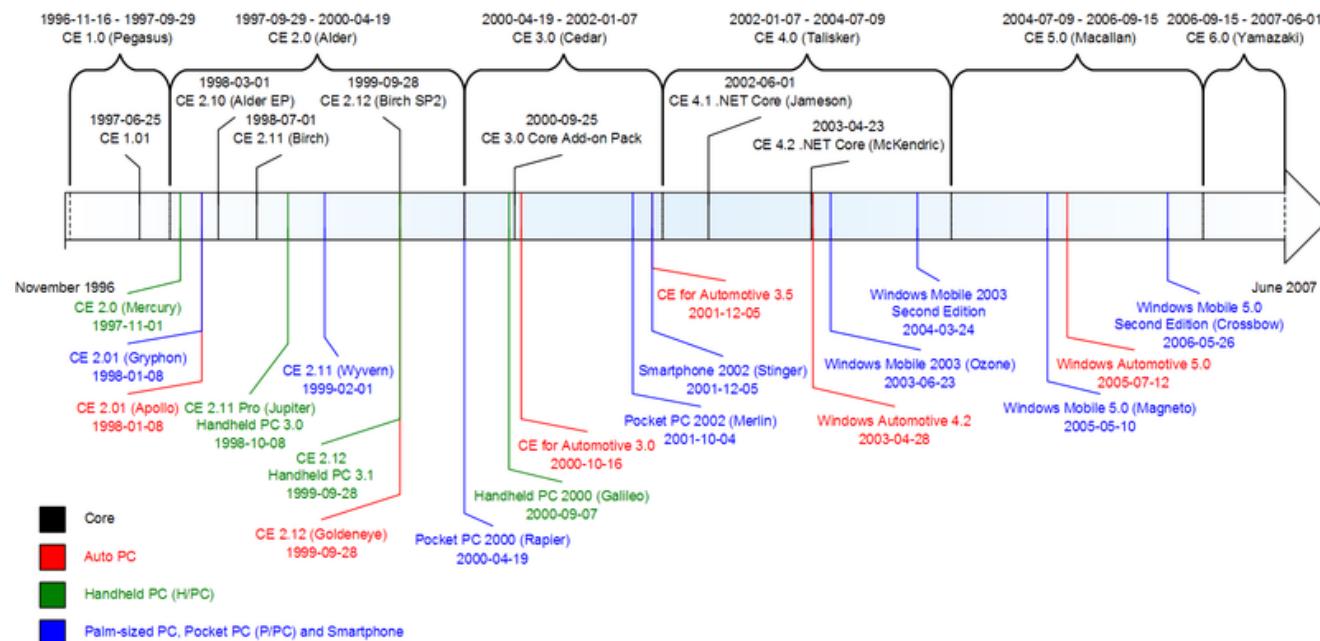
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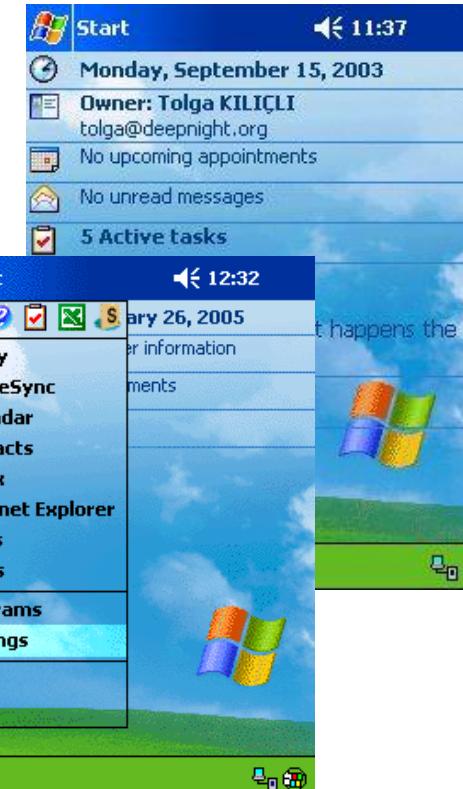
# 手持式裝置(Handheld Device)

## Windows CE Timeline

Source: "A Brief History of Windows CE" (<http://www.hpcfactor.com/support/windowsce/>), HPC.Factor, retrieved May 21, 2007



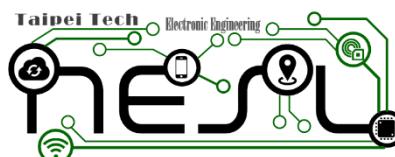
圖片來源：[https://upload.wikimedia.org/wikipedia/commons/thumb/c/cb/Windows\\_CE\\_Timeline.png/800px-Windows\\_CE\\_Timeline.png](https://upload.wikimedia.org/wikipedia/commons/thumb/c/cb/Windows_CE_Timeline.png/800px-Windows_CE_Timeline.png)



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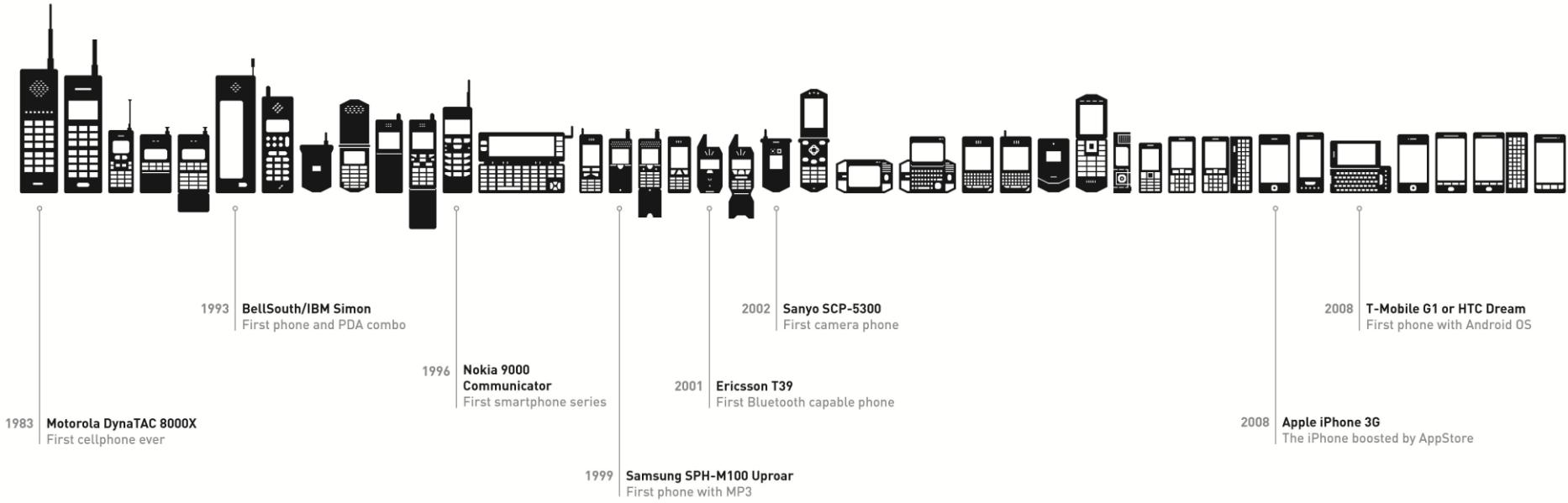


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# 行動裝置(Mobile Device)

## ❖ 手機(Cellphone)



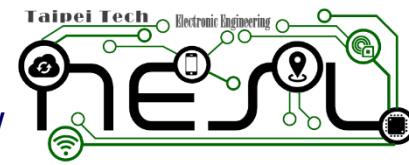
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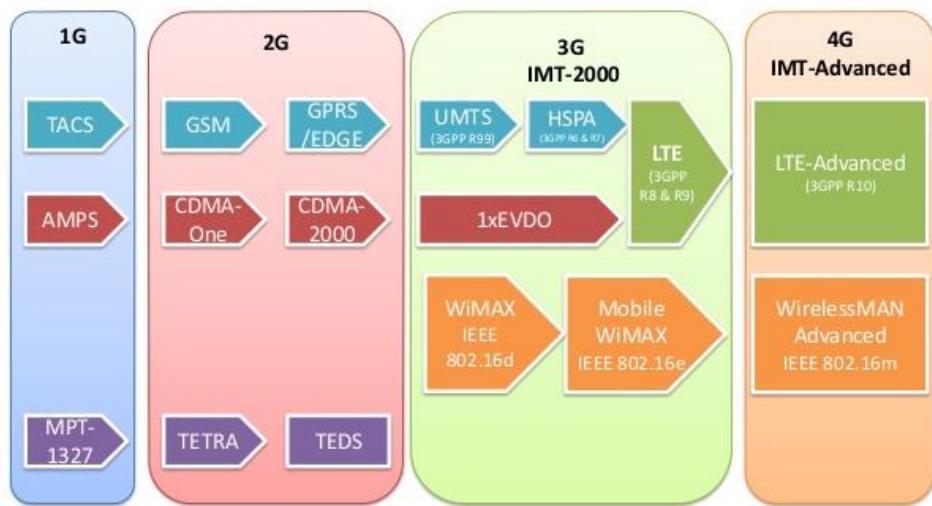


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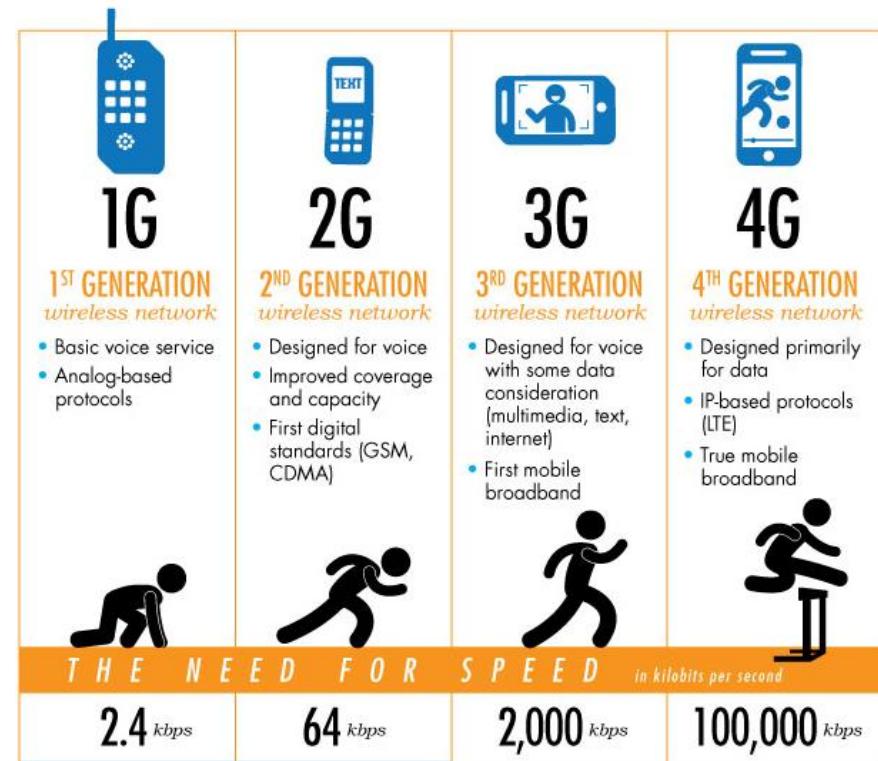


# 行動裝置(Mobile Device)

## ❖ 無線行動通訊的世代 (Generation)



圖片來源：<http://www.slideshare.net/ASanchoyerto/evolution-towards-tetralte-telronic-june2014-pub>

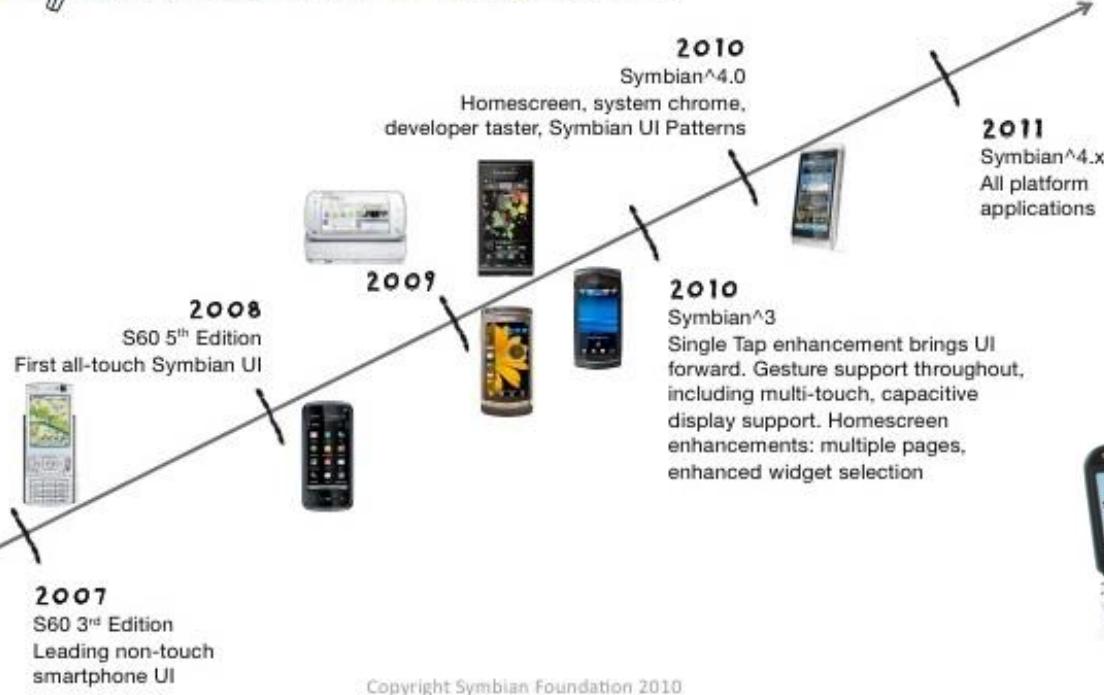


圖片來源：[http://www.phonearena.com/news/1G-2G-3G-4G-The-evolution-of-wireless-generations\\_id46952](http://www.phonearena.com/news/1G-2G-3G-4G-The-evolution-of-wireless-generations_id46952)



# 行動裝置(Mobile Device)

## Symbian UI Timeline



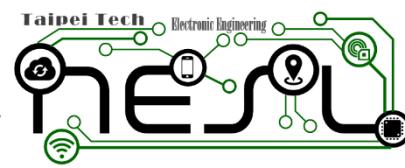
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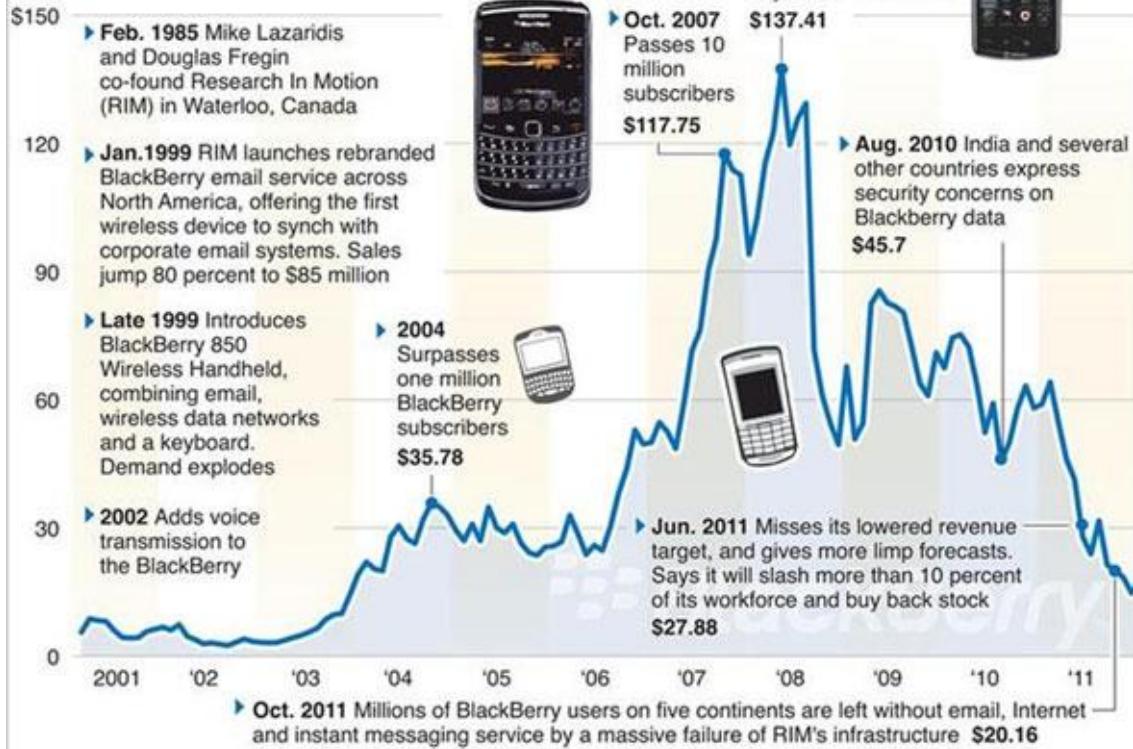
<http://www.cc.ntut.edu.tw/~chlee/>



# 行動裝置(Mobile Device)

## BLACKBERRY TIMELINE

RIM SHARE PRICES - Monthly close



Source: Thomson Reuters

REUTERS

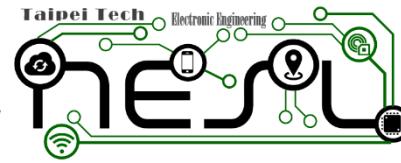
圖片來源：<http://mybroadband.co.za/news/wp-content/uploads/2012/01/BlackBerry-Timeline.jpg>



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# 智慧終端(Intelligent Device)

## ❖ 智慧型手機(Smart Phone)

- 具行動作業系統，可安裝應用軟體、遊戲等程式(App)來擴充功能，故其運算能力優於傳統功能型手機(非PDA類型的手機)
- 具多重連網能力(如：Wi-Fi、Bluetooth、3G/4G)、攝影機(Camera)、多點式觸碰螢幕(支援手勢)、各種感測器(如：加速規、陀螺儀、電子羅盤、GPS...等)



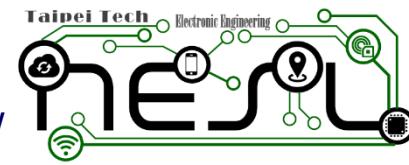
圖片來源：<http://www.gsmwarenhuis.nl/wp-content/uploads/2015/02/gratis-telefoon-bij-abonnement.jpg>



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# 智慧終端(Intelligent Device)

## ❖ 平板電腦(Tablet PC)

- 在外觀方面，觸碰螢幕比智慧型手機大
  - 常見平板電腦約7~12吋，智慧型手機的螢幕逐漸變大，多數小於6吋
- 在連網方面，多數預設不搭載3G/4G電信網路，亦不支援SMS簡訊服務。
  - 僅部分機型有支援
- 在電池方面，容量與續航力優於智慧型手機



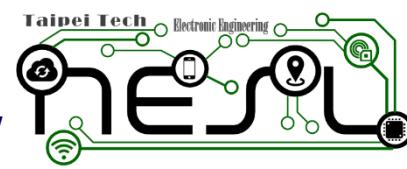
圖片來源：<http://irelandstechnologyblog.com/wp-content/uploads/2013/11/ipad-android-windows-8-tablet.jpg>



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# 智慧終端(Intelligent Device)



圖片來源：<https://yunmai.files.wordpress.com/2014/11/android-version-logo-history-watermarked.png>



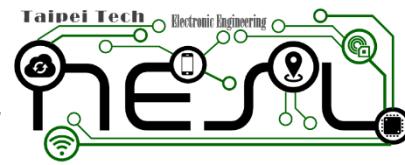
圖片來源：<http://www.techlevels.com/wp-content/uploads/2015/01/NexusFamily.png>



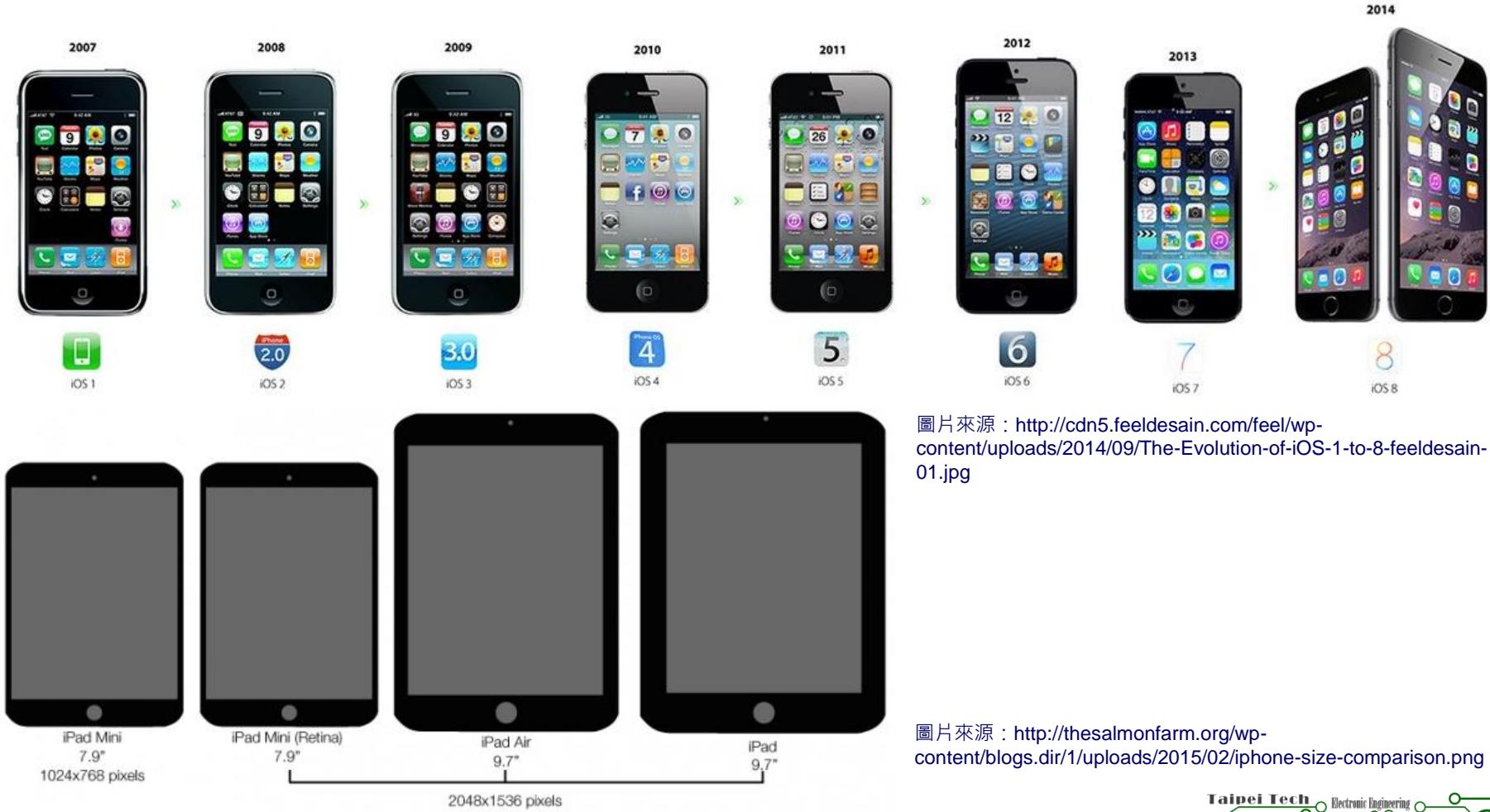
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# 智慧終端(Intelligent Device)



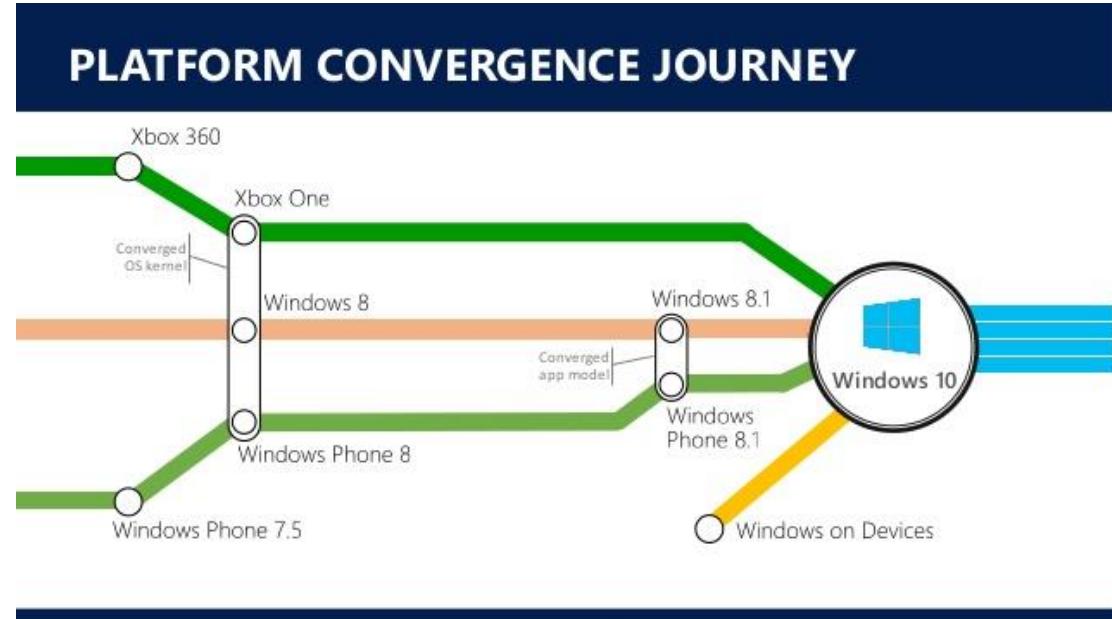
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圖片來源：<http://thesalmonfarm.org/wp-content/blogs.dir/1/uploads/2015/02/iphone-size-comparison.png>

# 智慧終端(Intelligent Device)



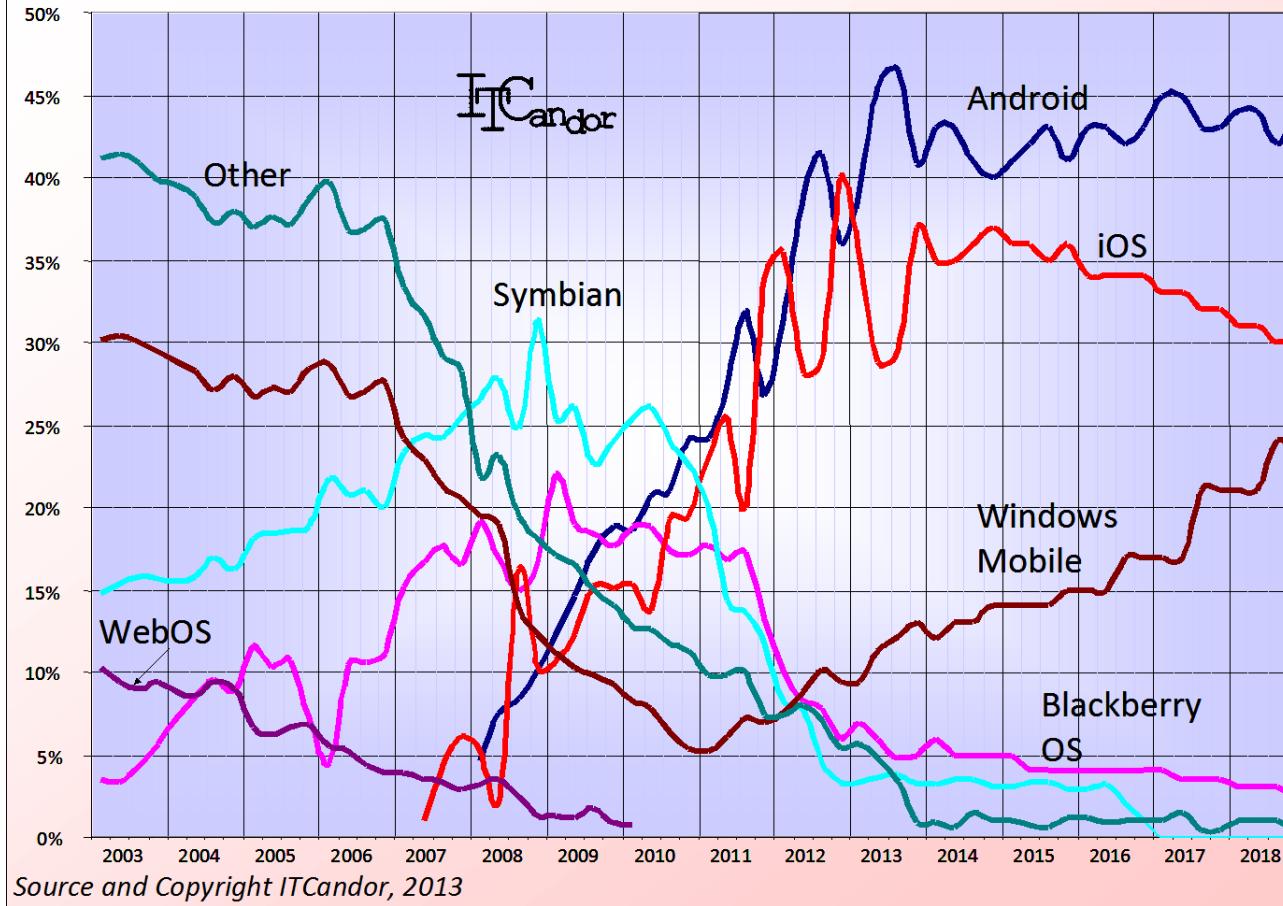
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圖片來源：<http://www.slideshare.net/MicrosoftAT/lumia-herbst14>

# 智慧終端(Intelligent Device)

Smart Phone Revenue (\$US) Forecast – Operating System Shares By Quarter – 2003-2018



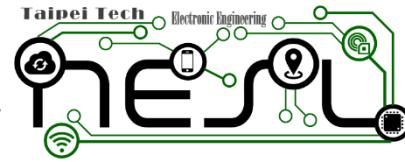
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# Evolution of ICT Technologies

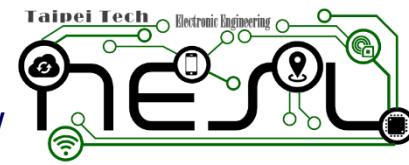
- ❖ Mainframe computing (60's – 70's)
  - Large computers to execute big data processing applications
- ❖ Desktop computing & Internet (80's – 90's)
  - One computer at every desk to do business/personal activities
- ❖ Ubiquitous computing (00's)
  - Numerous computing devices in every place/person
  - Millions for desktops vs. billions for embedded processors
- ❖ Cyber Physical Systems (10's)



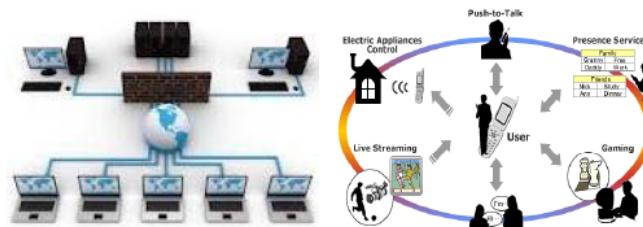
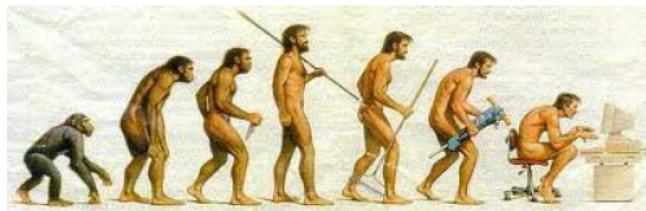
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# Evolution of ICT Technologies



60's-70's

Mainframe computing

*Computation facility in large institutions*

80's-90's

Desktop computing & Internet

*Computation facility in small office and home*

00's

Ubiquitous computing

*Computation facility for personal usage*

10's

Cyber-Physical Social Systems

*Computation facility for social use*

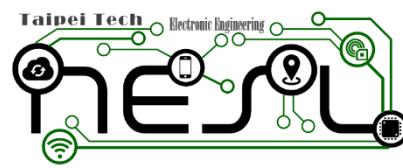
JEC-ECC2012, Alexandria, Egypt



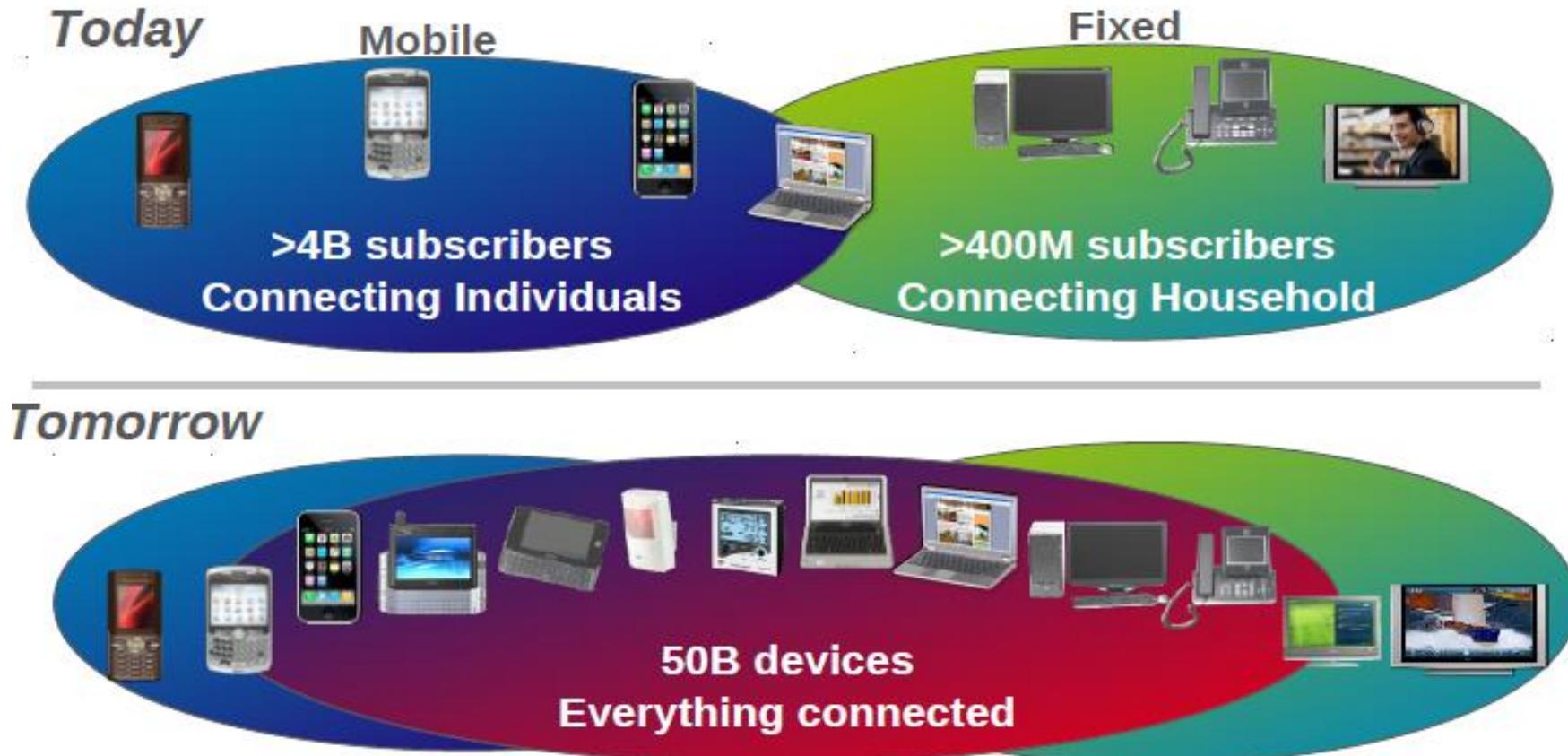
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# Evolution of ICT Technologies



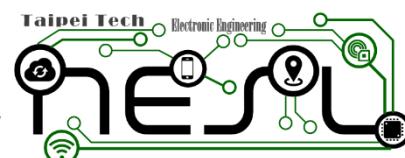
Source: Ericsson Research



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# Market Trends Driving IoT/M2M

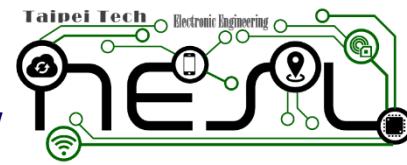
- ❖ Everything Connected (e.g. 50 billion devices by 2020)
- ❖ Processor/Memory Economics (e.g. Intel's announcement on Quark and Atom for wearable devices)
- ❖ Big Data and Analytics (e.g. machine learning embedded in Nest)



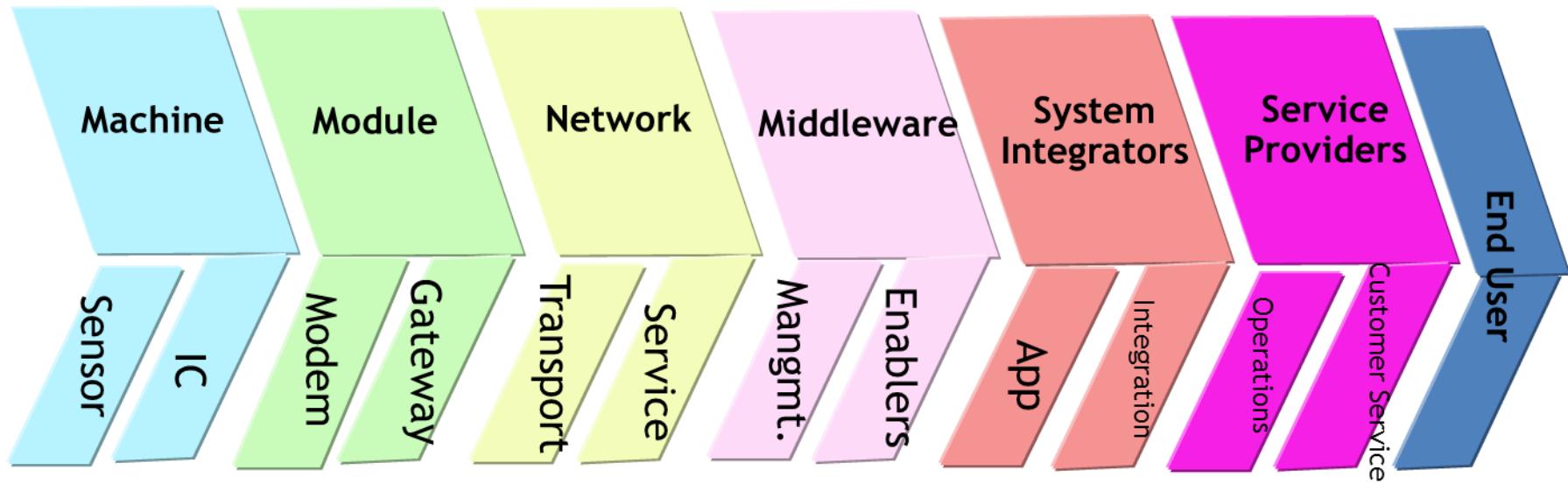
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# IoT/M2M Ecosystem



Middleware Providers

Machine & Device Manufacturers

Service Providers

Network Equipment Providers

Application Developers

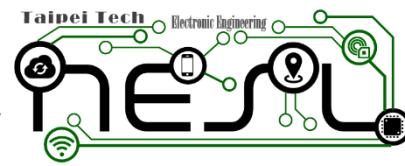
System Integrators



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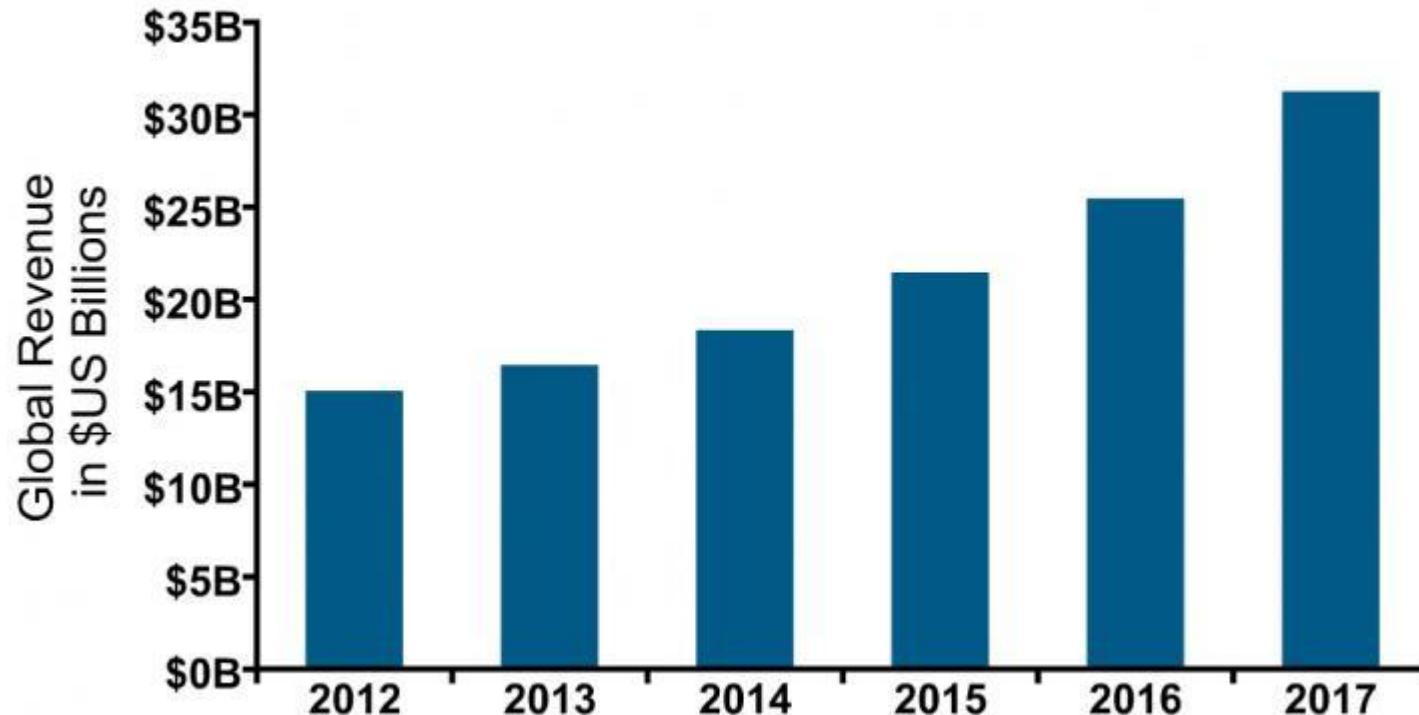
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# 2013 M2M Services Revenue Forecast

**Infonetics forecasts global M2M services revenue to more than double by 2017**



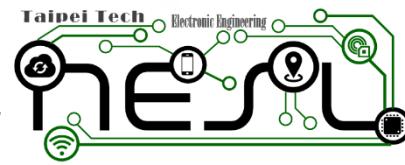
© Infonetics Research, *M2M Connections and Services by Vertical Annual Market Size and Forecasts*, Sept. 2013



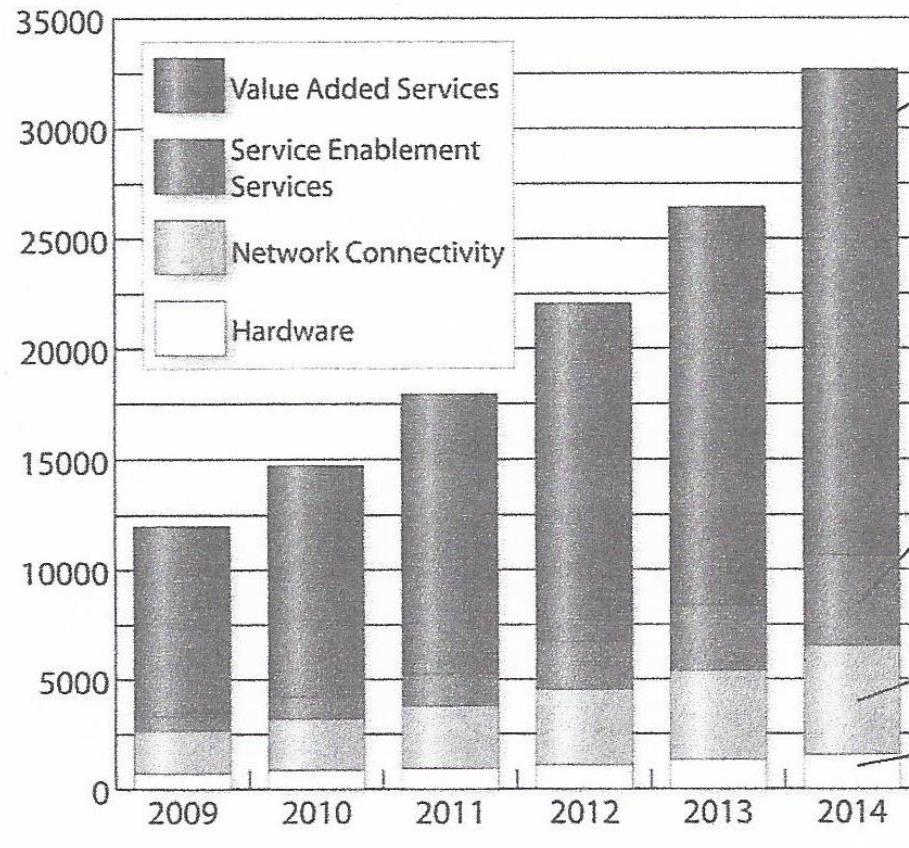
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# Market Size Projections



Application provider's share of what the end-user pays for the service in all sectors – transportation, healthcare etc. using any network

Middleware (device management, control, diagnostics, status and monitoring, location and tracking, storage) share of what the end user pays for the service in all sectors – transportation, healthcare etc. using any network

Data transfer portion of what end-user pays across all networks and application sectors

Wireless long range/short range and wireline communication modules market + engineering

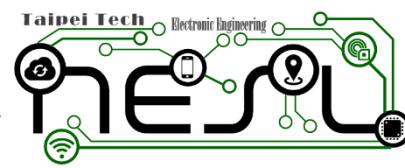
Source: "M2M COMMUNICATIONS - A SYSTEMS APPROACH", 2012, Wiley.



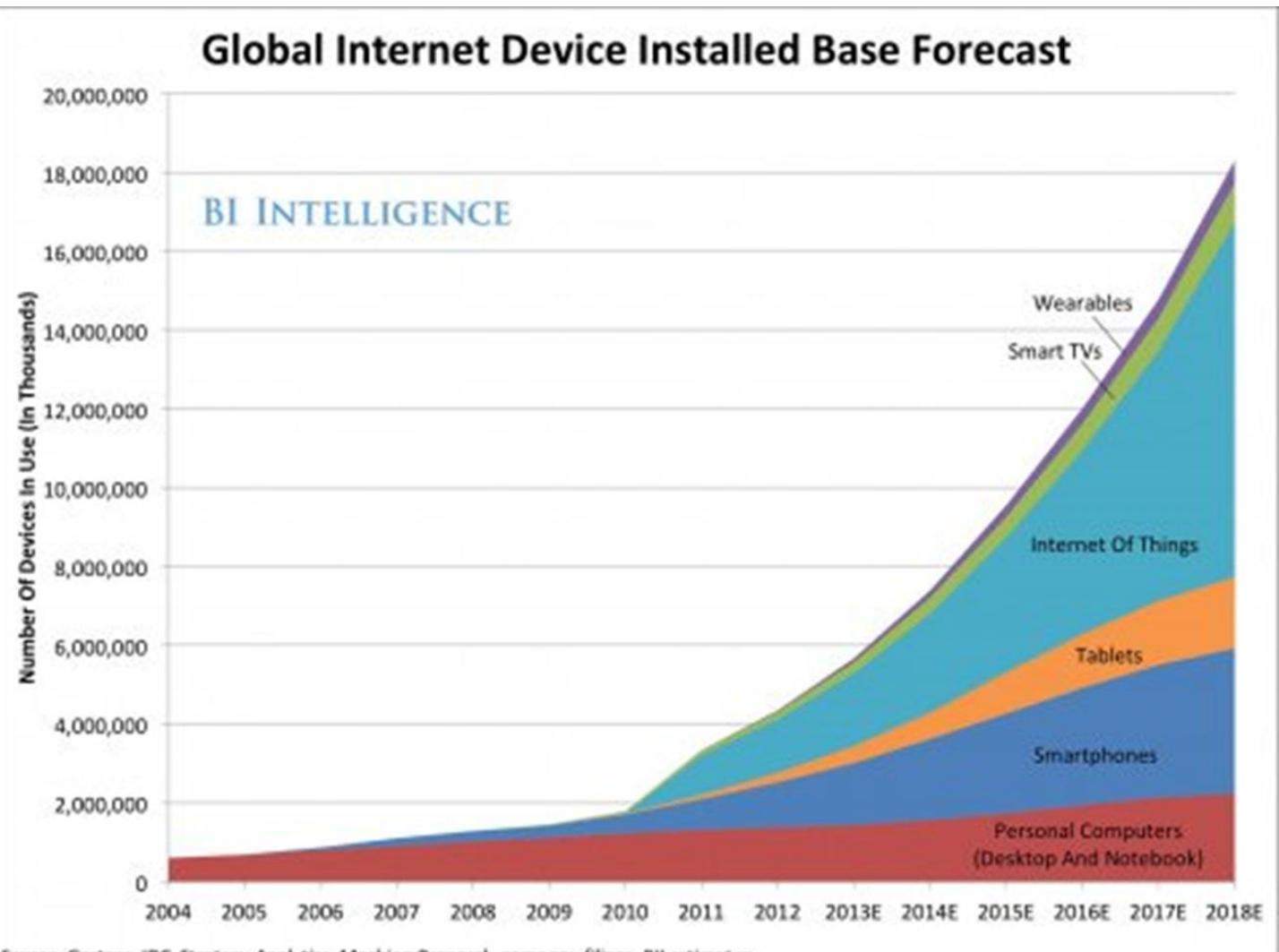
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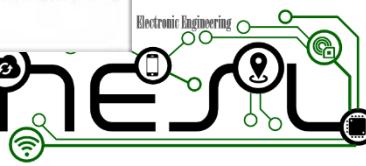
# Device Forecast



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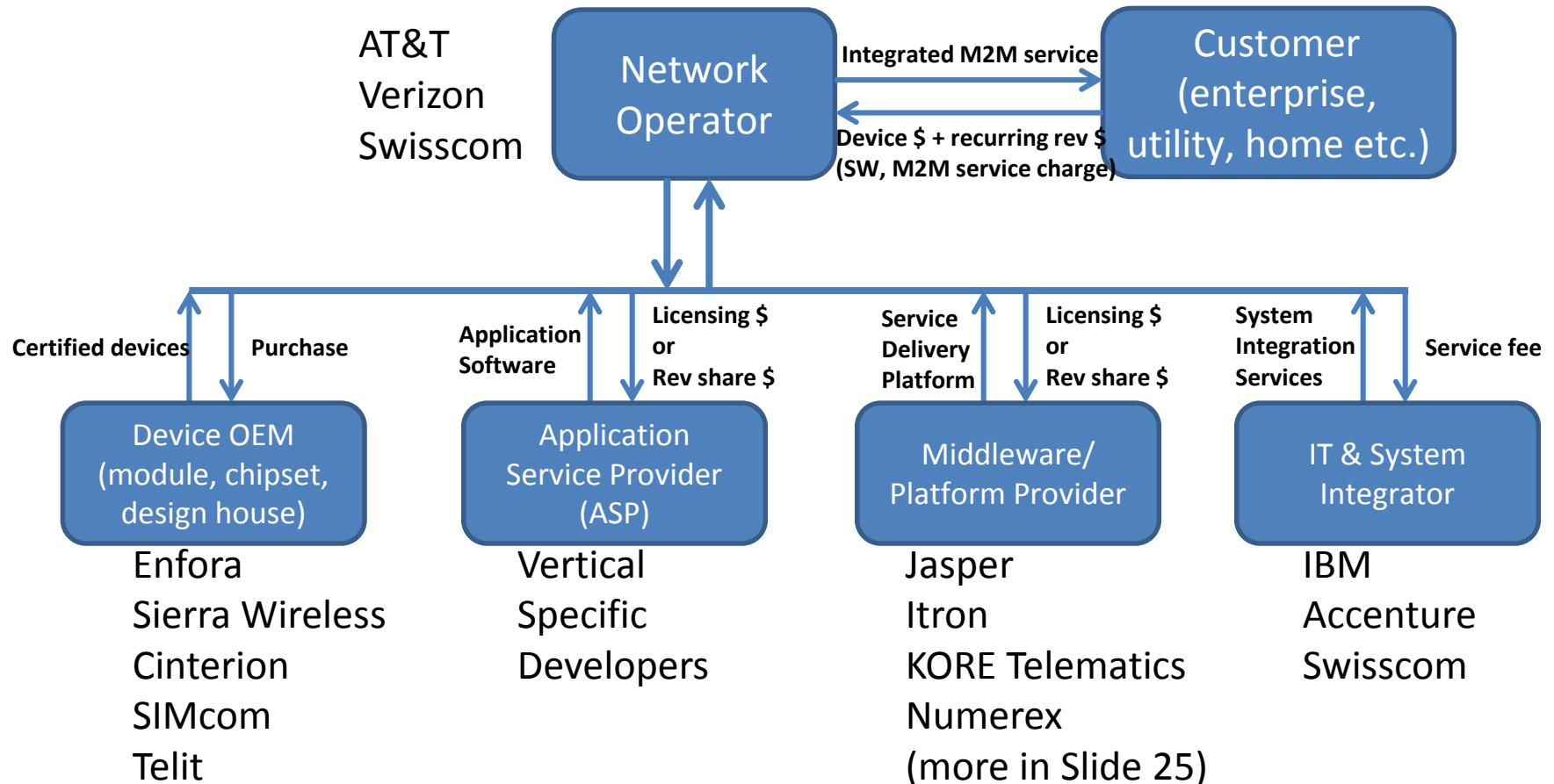


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# Service Providers & Network Operator

## ❖ Network Operator-led Business Model

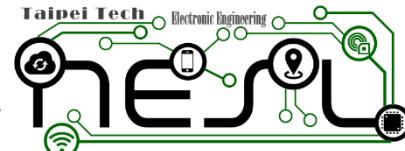


Source: "M2M COMMUNICATIONS - A SYSTEMS APPROACH", 2012, Wiley.

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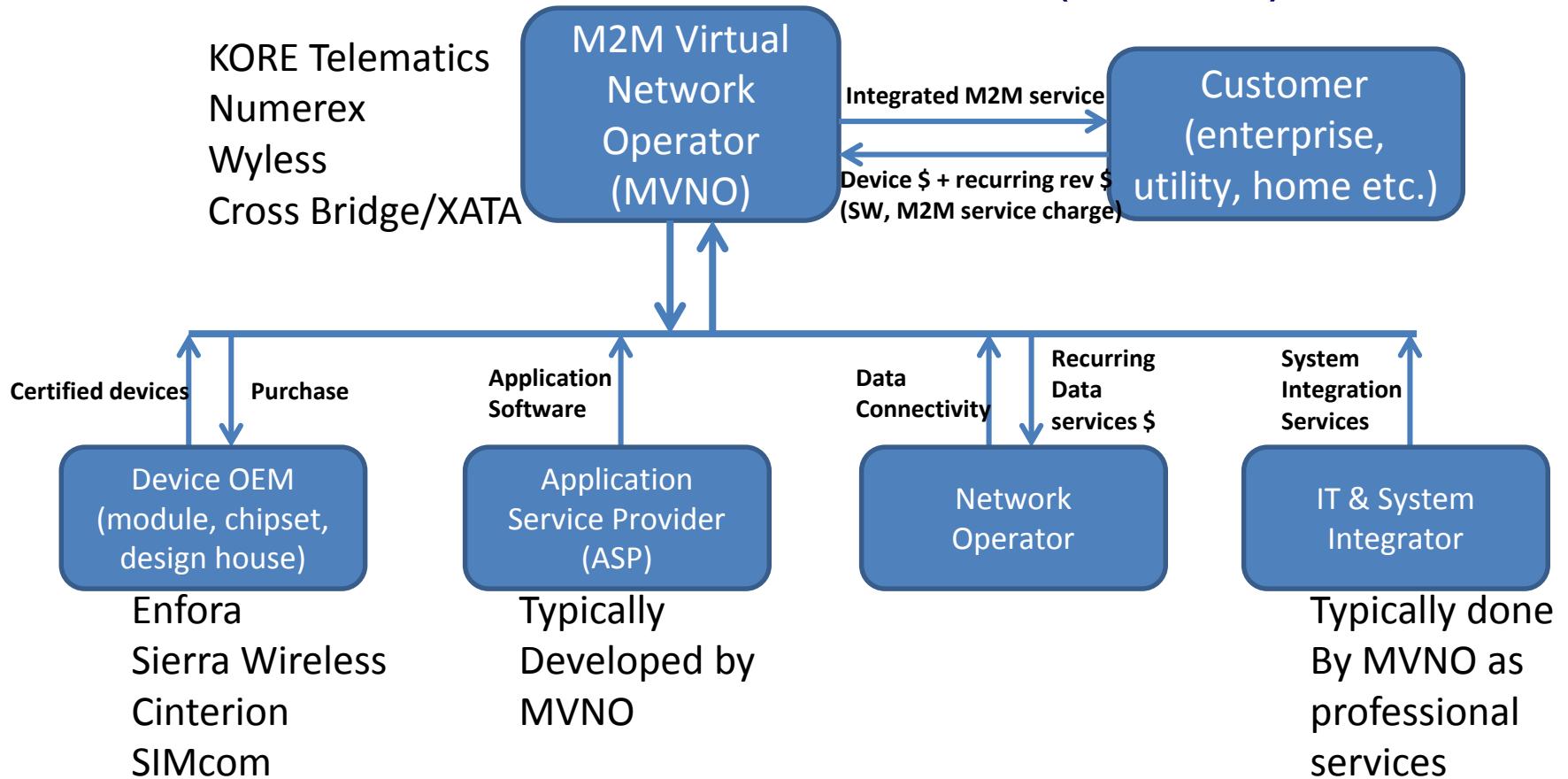


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# Service Providers & Network Operator

## ❖ M2M Virtual Network Provider (MVNO)-led Model



Telit

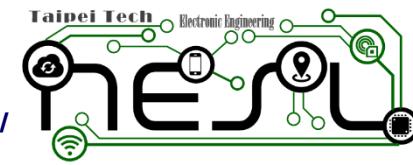
Source: "M2M COMMUNICATIONS - A SYSTEMS APPROACH", 2012, Wiley.



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# System Integrator

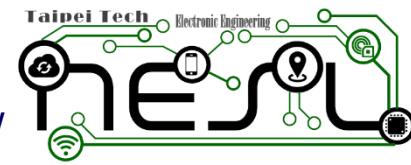
- ❖ IBM
- ❖ Accenture
- ❖ Swisscom
- ❖ ...
- ❖ etc.



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# Middleware/Platform Provider

## ❖ Commercial Offers

- OpenMTC (Licensed Source)
- Xively
- Nimbots
- Axeda
- Device Insight
- Thingworx
- Ninja Blocks platform
- ioBridge (Web Gateway)
- Thingvibe
- Digi
- Bosch
- SAP
- Etc.

## ❖ Open Source

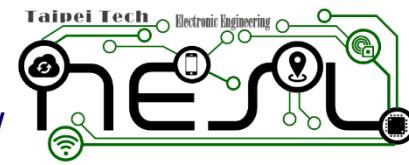
- OSIOT Interoperability Project
- Eclipse M2M Industry Group
- Koneki
- Paho
- Lua
- MQTT
- OM2M (Open Source)
- Contiki – IP-based open source operating system for the IoT
- Etc.



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# Device and Gateway Manufacturer

## ❖ Devices

- Withings
- Philips Hue
- Nike (FuelBand)
- Fitbit (Force)
- Apple (iWatch)
- Jawbone (UP 24)
- Misfit (Shine)
- Dropcam
- Kwikset Kevo E-Lock
- Honeywell Lyric Thermostat
- Etc.

## ❖ Gateways

- ECS
- Actility Cocoon
- AAEON
- Portwell
- Astar-tek
- Freescale
- NXP
- White Oak Canyon
- Axiomtek
- Kontron
- ADLINK
- Advantech
- Etc.

## ❖ Development Kits

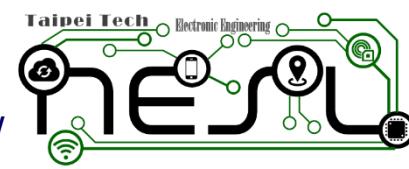
- Arduino
- Raspberry Pi
- BITalino
- WunderBar
- Intel's Galileo/Edison
  - Yocto Application Development Toolkit (ADT)
- TI's wireless connectivity
- Mediatek LinkIt
- Etc.



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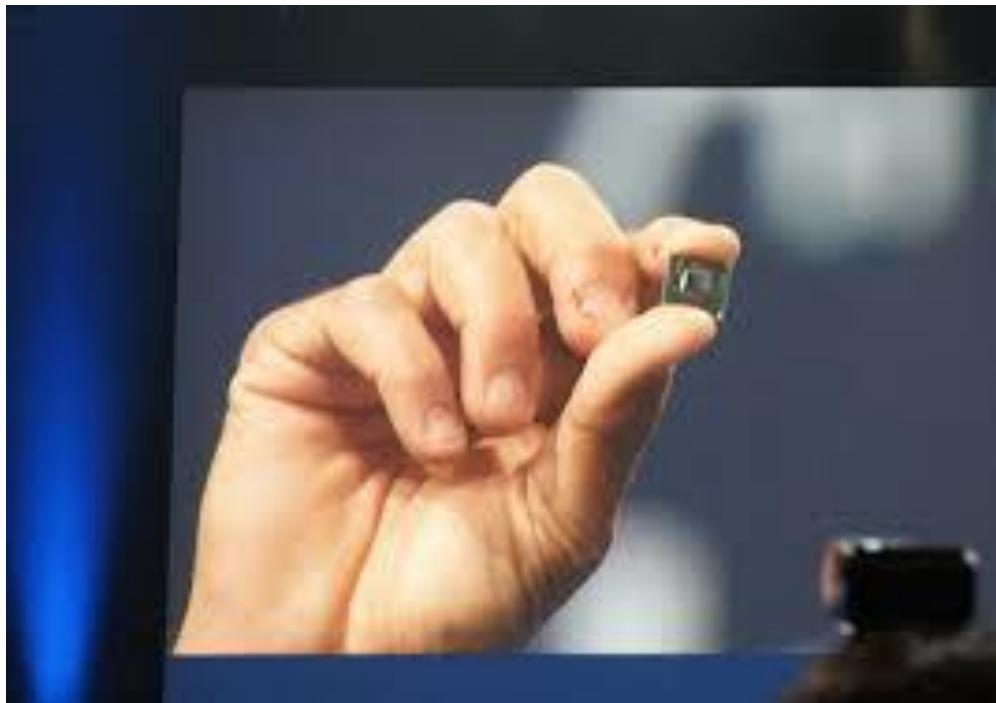


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# Just an example here

## ❖ Chip Manufacturer



Intel Quark



Intel Quark

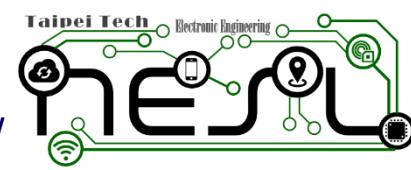
Mediatek, Marvel, ARM, Intel, TI, QUALCOMM etc.



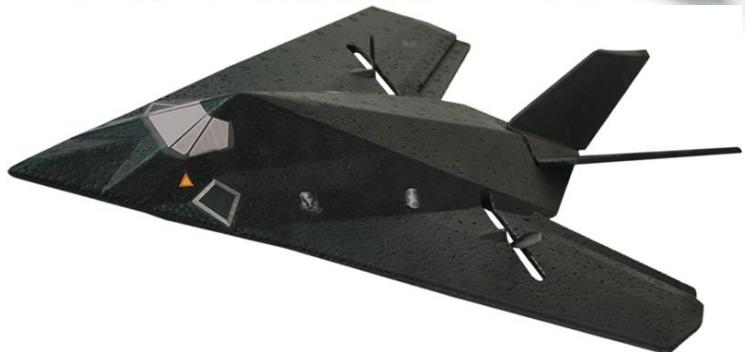
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# What are Embedded Systems?



# What are Embedded Systems?

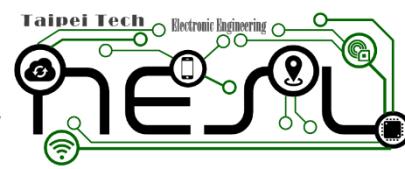
- ❖ Typical definition in a textbook
  - A computer that is a component in a larger system, and is not visible as a computer to a user of that system.
- ❖ But an embedded system may:
  - Look and function like a traditional computer,
  - Have a typical computer User Interface, or
  - Not contain a traditional CPU at all!



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# What are Embedded Systems?

## ❖ Better definition:

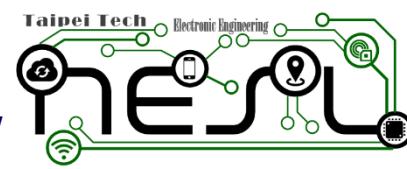
- A programmable component or subsystem providing some intelligence functions to the system of which it is a part.
- This can include:
  - Any device, or collection of devices, that contain one or more dedicated computers, microprocessors, or micro-controllers.
  - Microprocessor chips and Programmable logic elements (FPGA, ASIC etc.)
  - Device(s) may be local - Printer, automobile, etc.



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# What are Embedded Systems?

- Devices may be distributed - aircraft, ship, internet appliance.

## ❖ Key point:

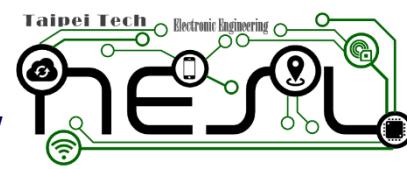
- Embedded computing devices have rigidly defined operational bounds.
- Not general purpose computers (PC, NB, etc.).



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# 嵌入式系統(Embedded System)

## ❖ 定義

- 在機械或電子式系統內嵌具專屬功能的電腦系統(A computer system with a dedicated function within a mechanical or electrical system).



圖片來源：[https://upload.wikimedia.org/wikipedia/commons/thumb/4/4c/Oxygen\\_devices.svg/2000px-Oxygen\\_devices.svg.png](https://upload.wikimedia.org/wikipedia/commons/thumb/4/4c/Oxygen_devices.svg/2000px-Oxygen_devices.svg.png)



# Characteristics of Embedded Systems

## ❖ Properties

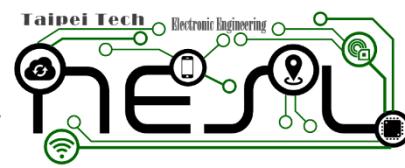
- No architectural link to standard platforms.
- Embedded systems may or may not have operating system (OS) services available.
- Tolerance for bugs is much lower in embedded systems than in desktop computers.
- Embedded systems are cost sensitive.



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# Characteristics of Embedded Systems

## ❖ Constraints

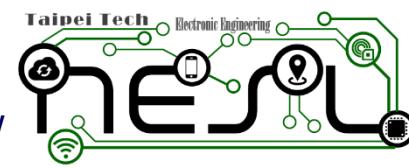
- Power/Energy constraints.
- Reliability
- Robust
- Moderate to severe real-time constraints.



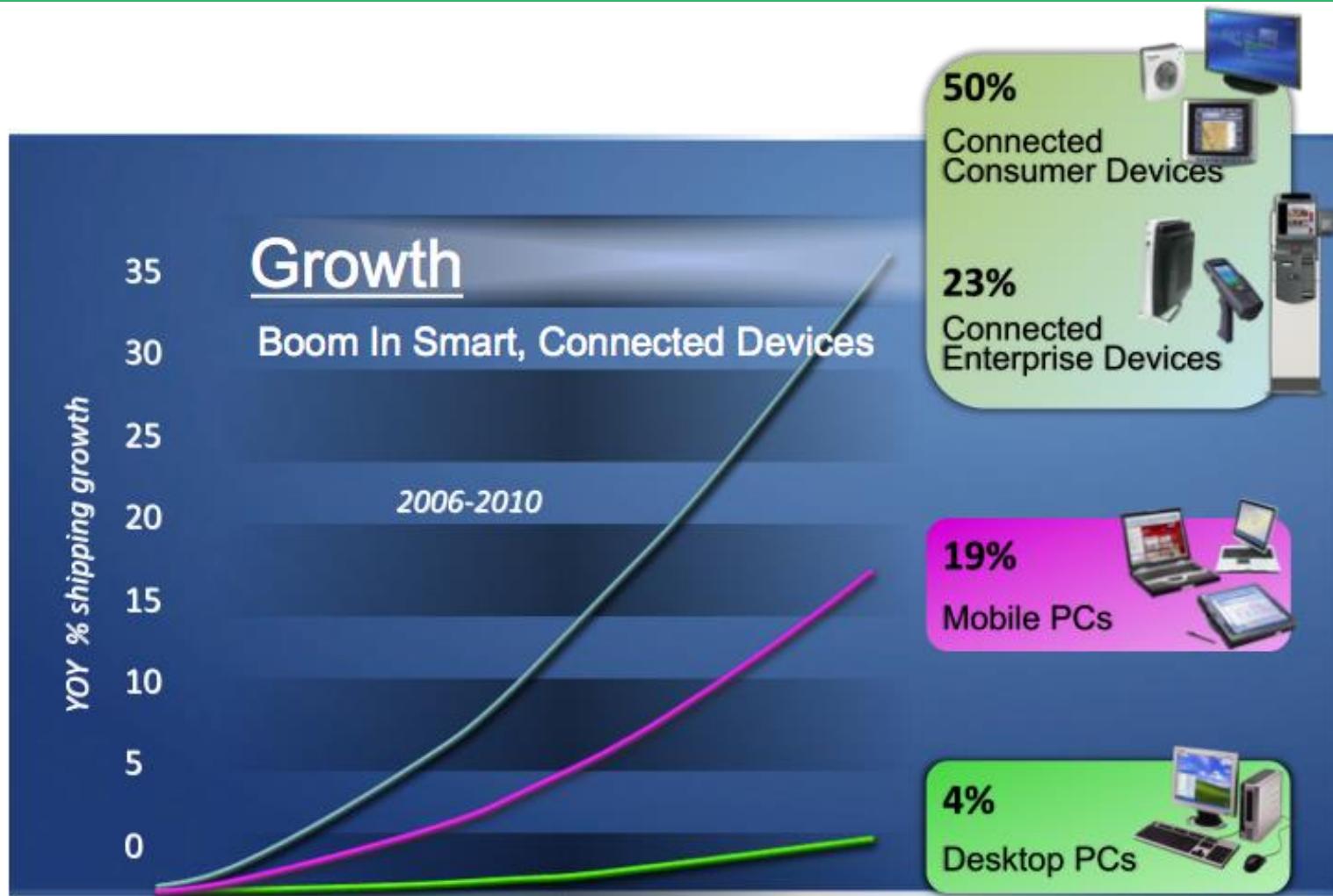
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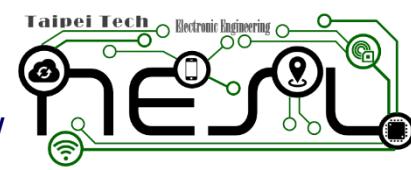
# Market Growth on Embedded Systems



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# Market Growth on Embedded Systems

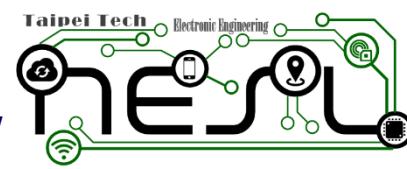
- ❖ The global market for embedded systems technologies was worth \$92.0 billion in 2008, i.e., 1/4 of Taiwan's GDP in 2008.
- ❖ The worldwide R&D in the field of embedded systems is expected to double over the next 10 years.
  - Total number of SW and HW developers will increase for 2.3% per year.
    - SW+HW: 471,000 at 2006 and 504,900 at 2009
    - SW: 312,000 at 2006 and 348,300 at 2008.



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# 穿戴式裝置(Wearable Device)

## ❖ 常見之穿戴式裝置

- 眼鏡(Glass)
- 手錶(Watch)
- 手環(Wristband)



圖片來源：[http://i.nextmedia.com.au/News/20130502074733\\_how-to-use-google-glass.jpg](http://i.nextmedia.com.au/News/20130502074733_how-to-use-google-glass.jpg)

圖片來源：<https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcRusOfS-uPLmfYcgx-ZJvG7dUlnO6-xw1VHlkfgWI2S6IB65-4t>

圖片來源：[http://cdn.gsmarena.com/pics/14/02/samsung-gear-fit/gsmarena\\_001.jpg](http://cdn.gsmarena.com/pics/14/02/samsung-gear-fit/gsmarena_001.jpg)

# 穿戴式裝置(Wearable Device)

## ❖ Sensoria (智慧襪)



圖片來源：<http://www.sensoriafitness.com/Technology>

# 穿戴式裝置(Wearable Device)



圖片來源：<http://raconteur.net/public/img/articles/2014/09/WT-cover-crop.jpg>

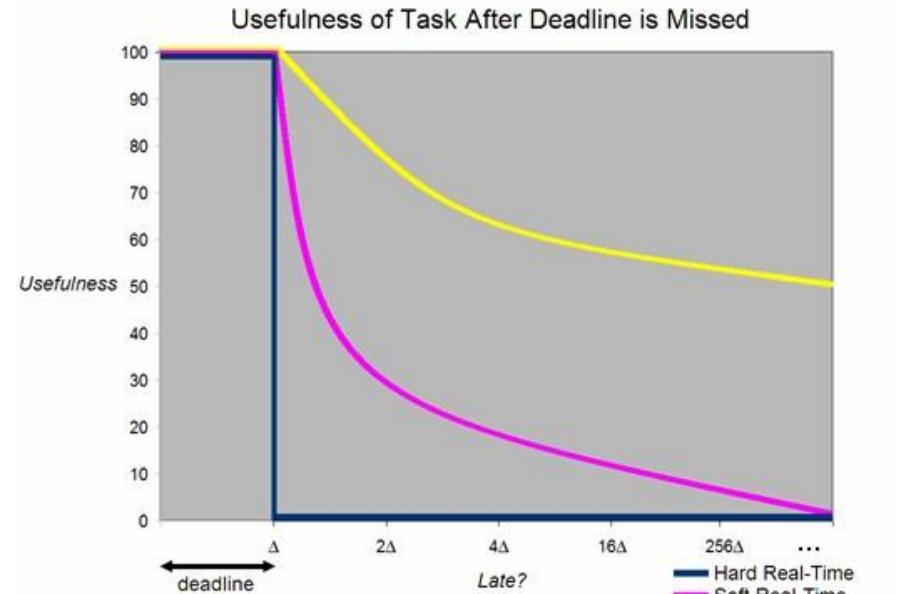
# 嵌入式系統(Embedded System)

## ❖ 朝向支援即時計算(Real-time Computing)

- 保證可在給定的時間限制內回應

## ❖ 即時作業系統(Real-time Operating System , RTOS)

- 軟式(Soft)：當超過期限後，系統可容忍某段誤差時間。
- 硬式(Hard)：不容許有任何延遲或誤差。



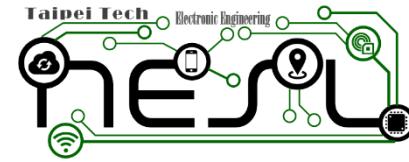
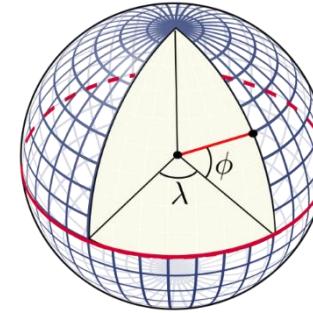
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# 新一代之資訊應用服務

## ❖ 適地性服務(Location Based Service · LBS)

- 定位(Positioning)
  - 地理位置(Geographical Location)
    - Longitude ( $\lambda$ ) (經度)
    - Latitude ( $\phi$ ) (緯度)
- 電子地圖(Electronic Map)
  - 如 : Google Map, Bing Map



# 新一代之資訊應用服務

## ❖ 擴增實境(Augmented Reality , AR)

- 在螢幕上把虛擬世界(Cyber World)套在現實世界(Physical World)並進行互動。
  - 利用攝影機(Camera)拍攝實景
  - 利用感測器(Sensor)察覺裝置、使用者與外在環境的相互關係
  - 將虛擬產生之文字和圖片重疊於實景之上



圖片來源：<http://7hc2m4pvp40gm4i1b4wnin7u.wpeengine.netdna-cdn.com/wp-content/uploads/sites/6/2013/08/augmented-reality-phone-app.png>

# What are Cyber-Physical Systems?

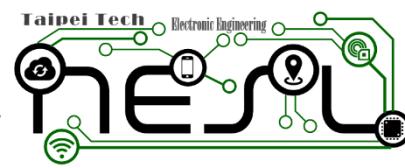
- ❖ Cyber-Physical System is a system featuring a tight combination of, and coordination between, the system's computational and physical elements.
- ❖ CPS uses computations and communication deeply embedded in and interacting with physical processes to add new capabilities to physical system.



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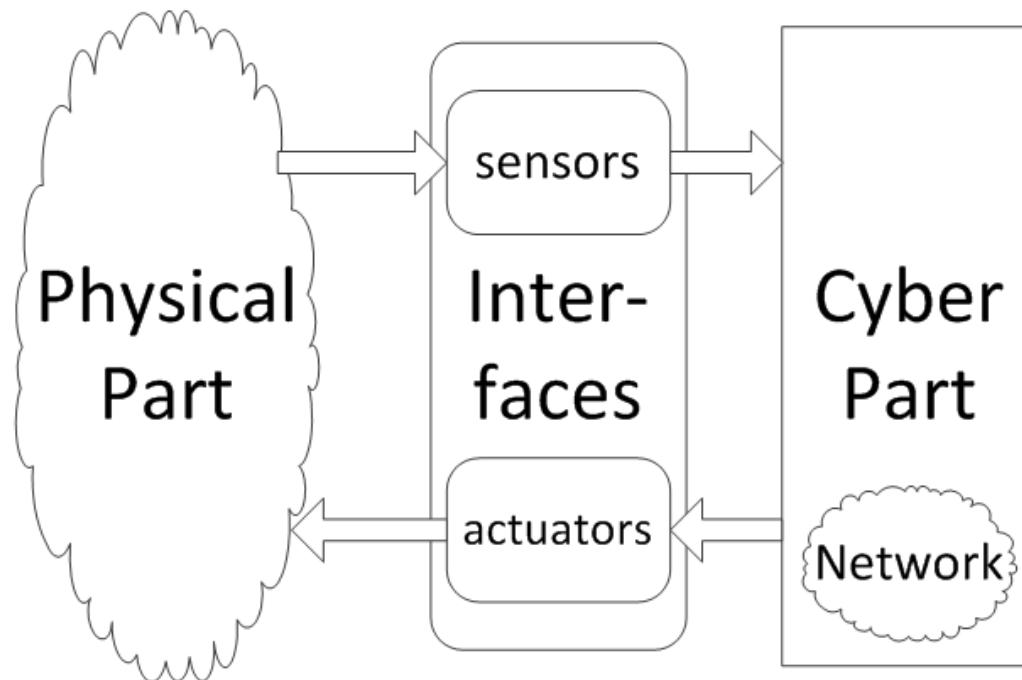


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# What are Cyber-Physical Systems?

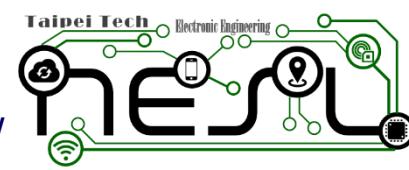
- ❖ Merging computing and networking with physical systems to create new revolutionary science, technical capabilities and better quality of life.



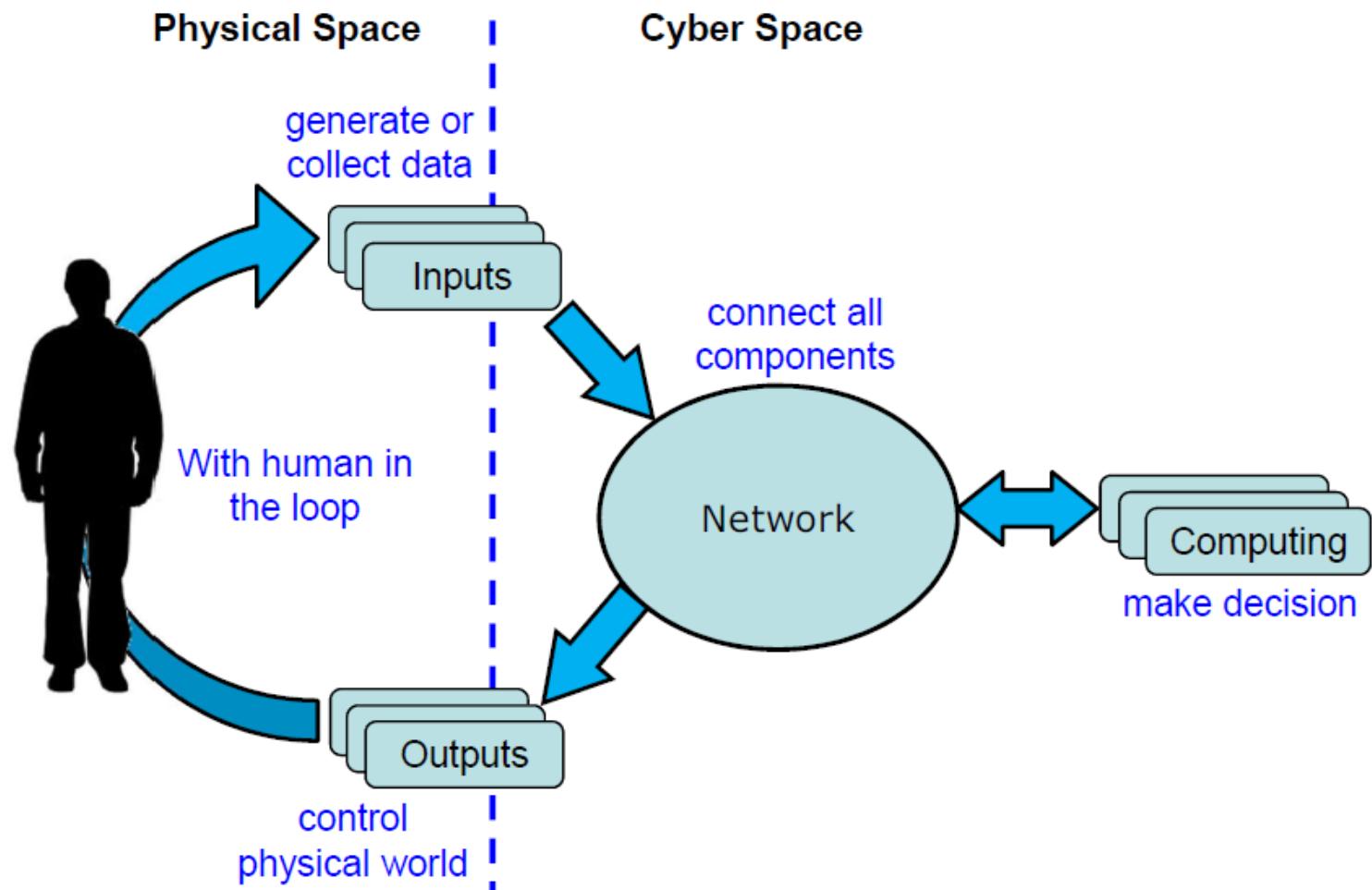
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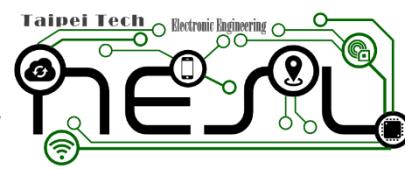
# What are Cyber-Physical Systems?



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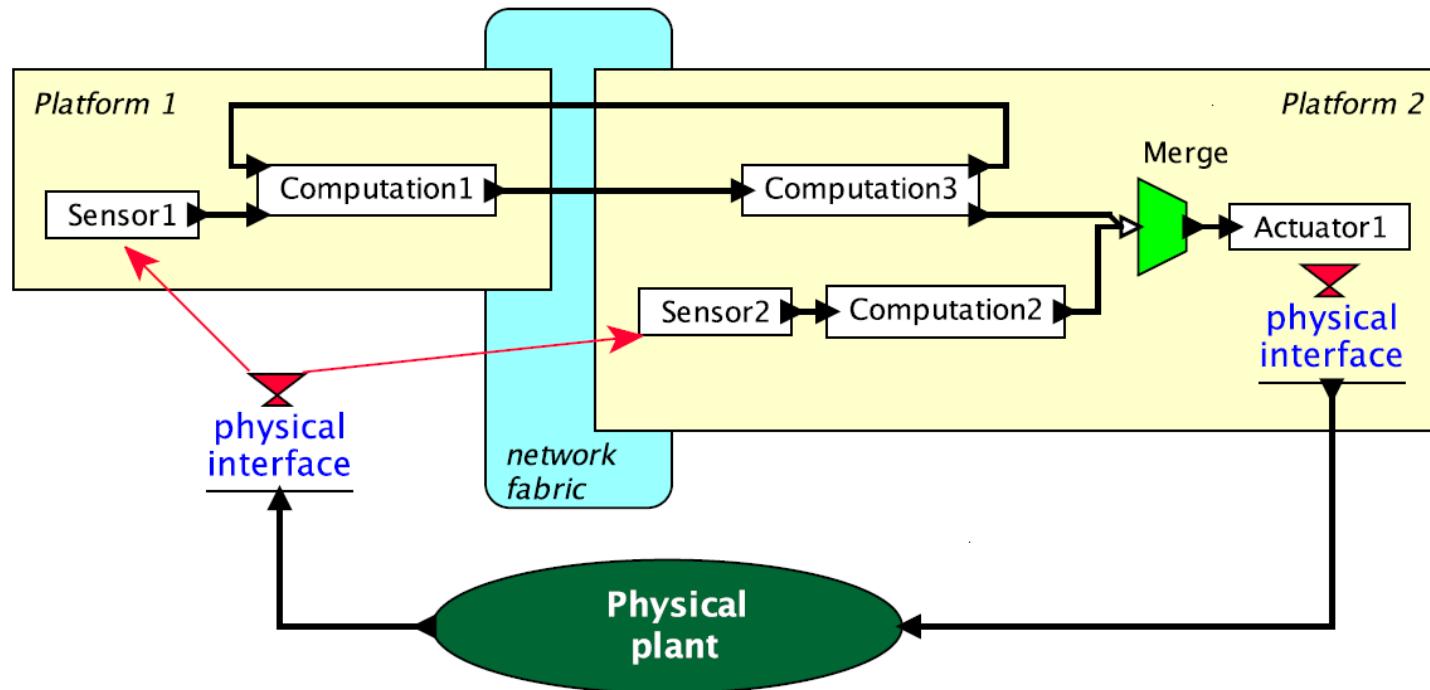


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# What are Cyber-Physical Systems?

- ❖ Convergence of computation, communication, and control.



# What are Cyber-Physical Systems?

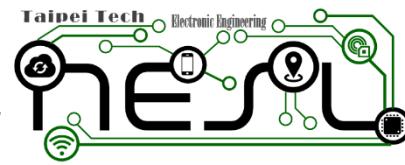
- ❖ Embedded computers allow us to add capabilities to physical systems.
- ❖ By merging computing and communication with physical processes, CPS brings many benefits:
  - Safer and more efficient systems
  - Reduce the cost of building and operating systems
  - Could form complex systems that provide new capabilities



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# Cyber-Physical System (CPS)

- ❖ Orchestrating networked computational resources with physical systems



Power generation and distribution



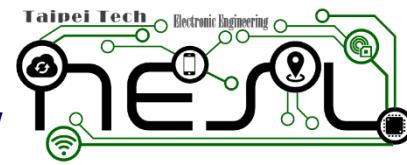
Factory automation



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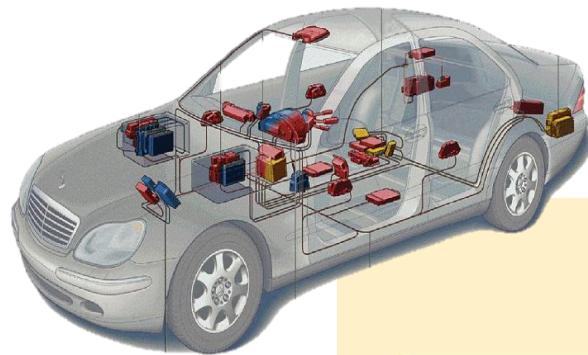
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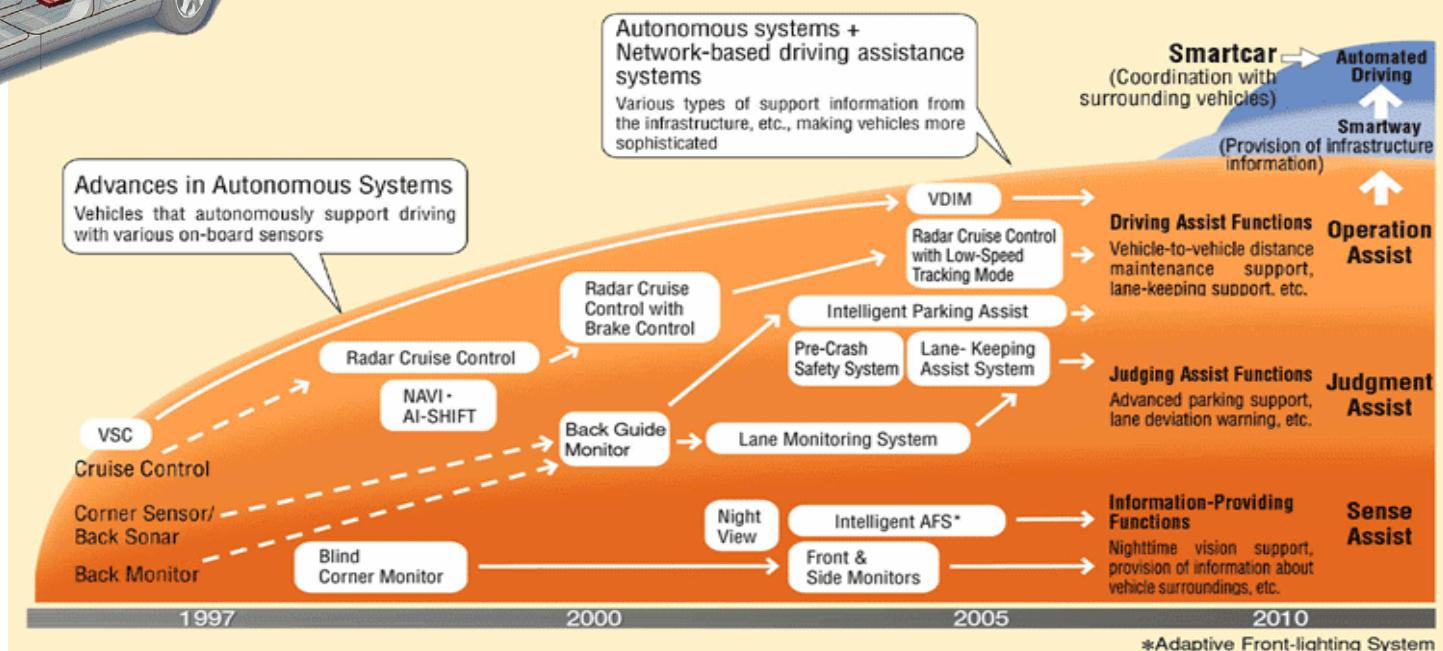
# Cyber-Physical System (CPS)

## ❖ Car Industry



Automotive

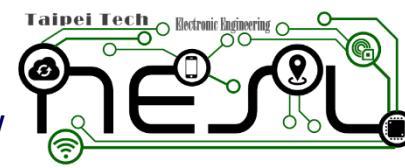
Toyota Autonomous Vehicle Roadmap (2007)



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# Cyber-Physical System (CPS)

Collecting data from the sensors on vehicles

Sending data to data centers via WAN

Analyzing data in data center

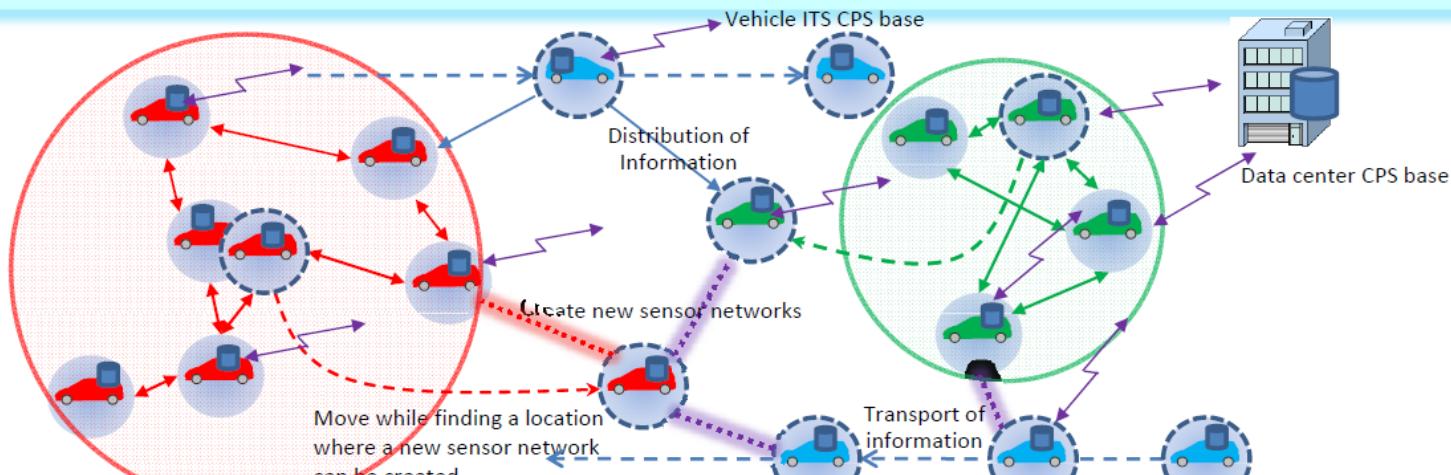
Guiding vehicles for efficiency and safety

The analyzed data in the data center is shared using vehicle to vehicle communication

→ to improve own traffic information, and traffic efficiency and safety!

The vehicle-to-vehicle communication

→ for creating sensor network to provide min. communication capability in an emergency condition!



Vehicle sensing data: location, velocity, acceleration, load condition, temperature, rainfall, visual image, battery/fuel condition

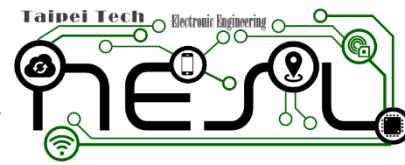
JEC-ECC2012, Alexandria, Egypt



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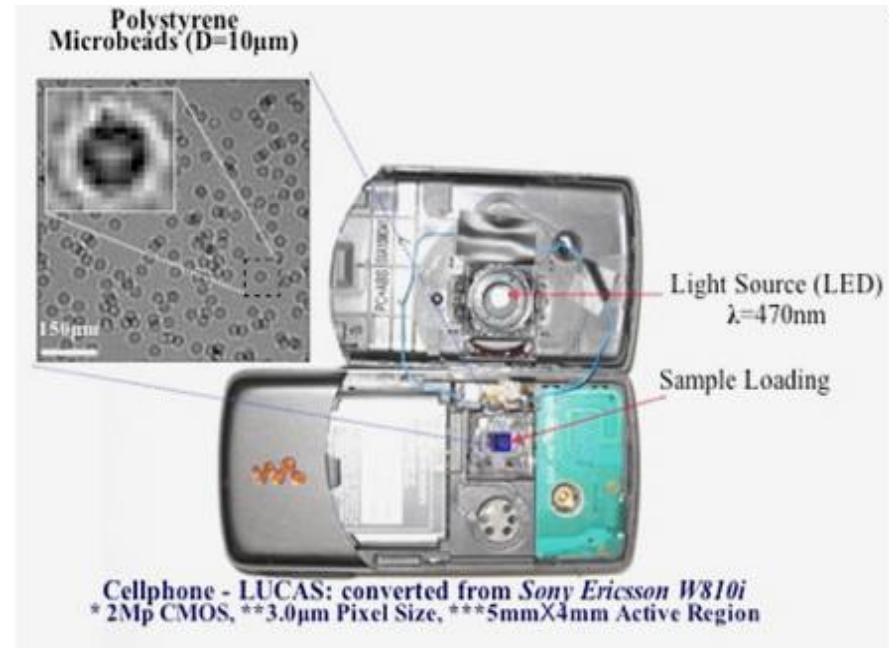


# Cyber-Physical System (CPS)

## ❖ Cell phones based on medical devices

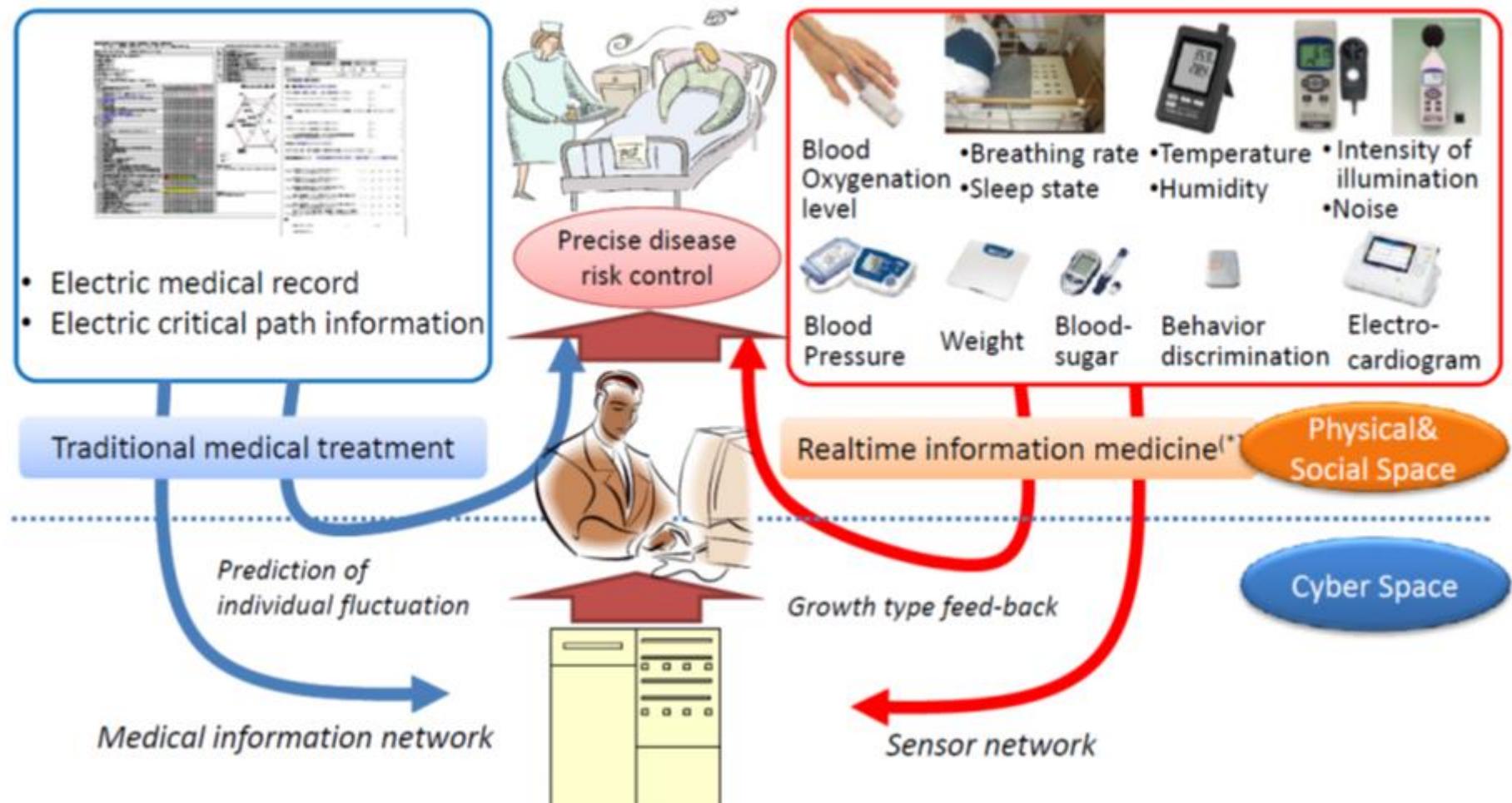


Telemicroscopy (Berkeley)



Blood testing (UCLA)

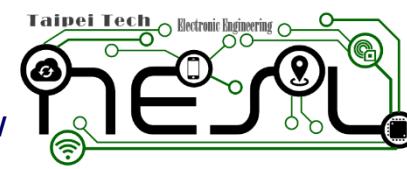
# Cyber-Physical System (CPS)



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# Cyber-Physical System (CPS)

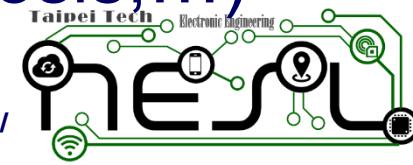
- ❖ telepresence
- ❖ distributed physical games
- ❖ traffic control and safety
- ❖ financial networks
- ❖ medical devices and systems
- ❖ assisted living
- ❖ advanced automotive systems
- ❖ energy conservation
- ❖ environmental control
- ❖ aviation systems
- ❖ critical infrastructure (power, water)
- ❖ distributed robotics
- ❖ military systems
- ❖ smart structures
- ❖ biosystems (morphogenesis,...)



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# Cyber-Physical System (CPS)

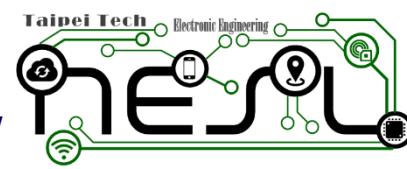
Sectors	Opportunities	
<i>Transportation</i>	Aircraft that fly faster and further on less energy. Air traffic control systems that make more efficient use of airspace. Automobiles that are more capable and safer but use less energy.	
<i>Defense</i>	More capable defense systems; defense systems that make better use of networked fleets of autonomous vehicles.	
<i>Energy and Industrial Automation</i>	New and renewable energy sources. Homes, office, buildings and vehicles that are more energy efficient and cheaper to operate.	
<i>Health and Biomedical</i>	In-home healthcare delivery. More capable biomedical devices for measuring health. New prosthetics for use within and outside the body. Networked biomedical systems that increase automation and extend the biomedical device beyond the body.	



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# Cyber-Physical System (CPS)

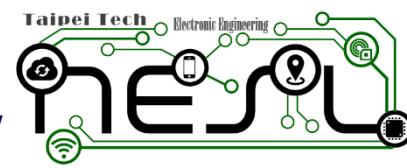
<i>Agriculture</i>	Energy efficient technologies. Increased automation. Closed-loop bioengineering processes. Resource and environmental impact optimization. Improved safety of food products.	
<i>Critical Infrastructure</i>	Highway systems that allow traffic to become denser while also operating more safely. A national power grid that is more reliable and efficient.	



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# ES v.s. CPS

## ❖ Embedded System (ES)

- Embedded system is software on small computers.
- The technical problem is one of optimization (coping with limited resources and extracting performance).

## ❖ Cyber-Physical System (CPS)

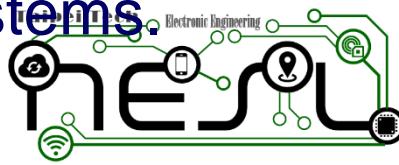
- Computation and networking integrated with physical processes.
- The technical problem is managing dynamics, time, and concurrency in networked computational + physical systems.



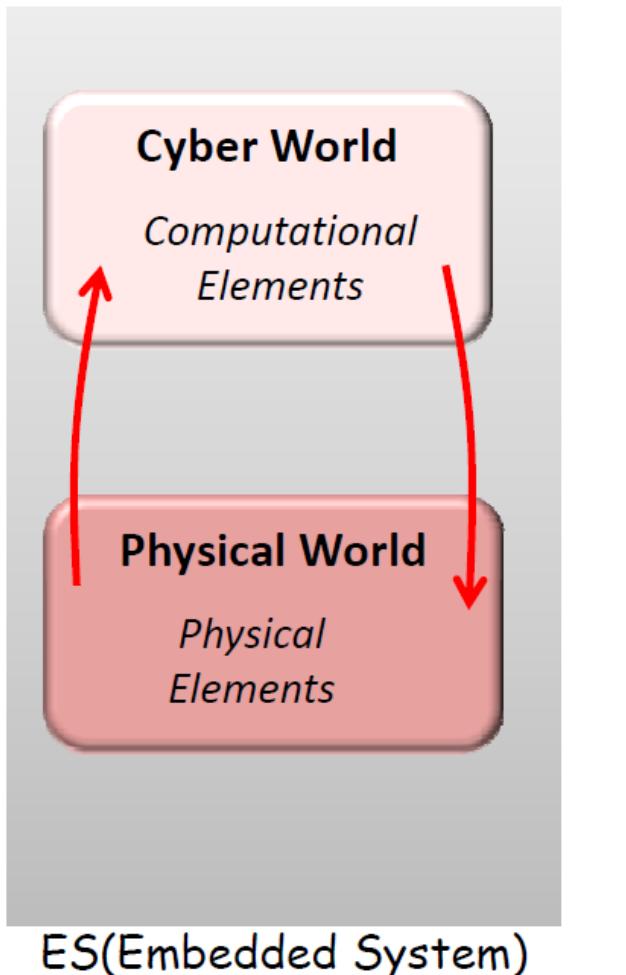
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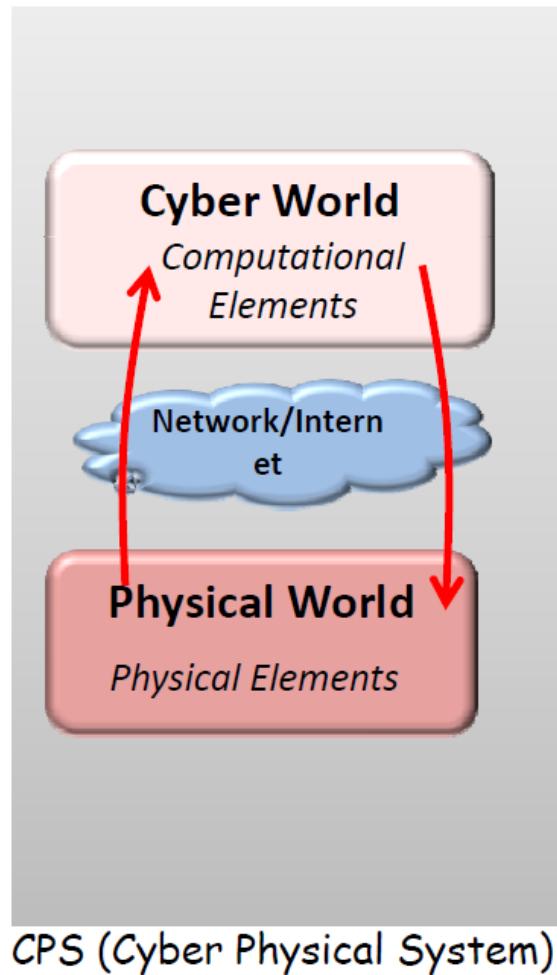
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# ES v.s. CPS



ES(Embedded System)



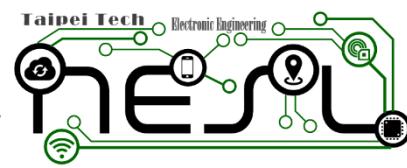
CPS (Cyber Physical System)



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# Characteristics of CPS

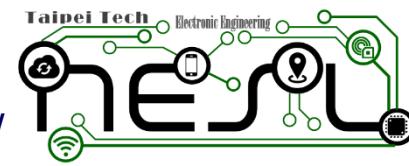
- ❖ Cyber – physical coupling driven by new demands and applications
  - Cyber capability in every physical component
  - Large scale wired and wireless networking
  - Networked at multiple and extreme scales
- ❖ Systems of systems
  - New spatial-temporal constraints
  - Complex at multiple temporal and spatial scales
  - Dynamically reorganizing/reconfiguring
  - Unconventional computational and physical substrates (Bio? Nano?)



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# Characteristics of CPS

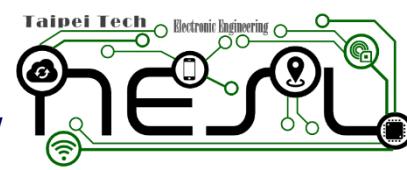
- ❖ Novel interactions between communications/computing/control
  - High degrees of automation, control loops must close at all scales
  - Large numbers of non-technical savvy users in the control loop
- ❖ Ubiquity drives unprecedented security and privacy needs
- ❖ Operation must be dependable, certified in some cases.



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# Real-time Operating System (RTOS)

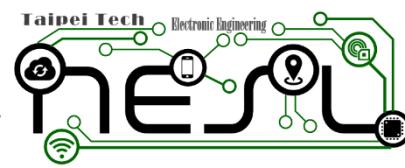
- ❖ Process data as it comes in, typically without buffering delays.
  - An RTOS has an advanced algorithm for scheduling.
  
- ❖ Key factors in an RTOS
  - minimal interrupt latency
  - minimal thread switching latency



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# Real-time Operating System (RTOS)

## ❖ Fast proprietary kernels

- For example, QNX, PDOS, VCOS, VTRX32, VxWORKS, etc.

## ❖ Standard OS with real-time extensions

- For example, RT-Linux

## ❖ Research systems

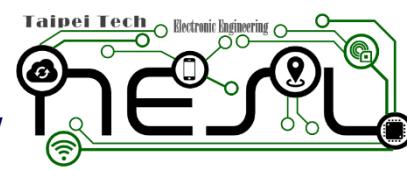
- For example, TinyOS, μC/OS II, eCos, etc.



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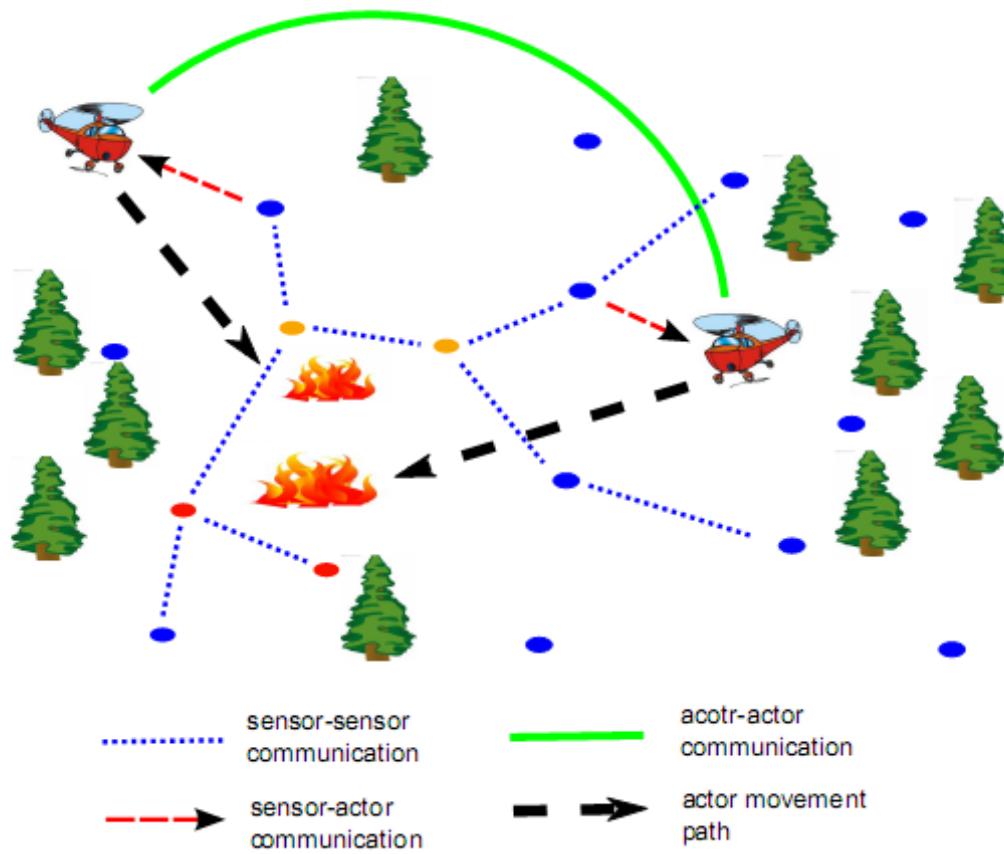


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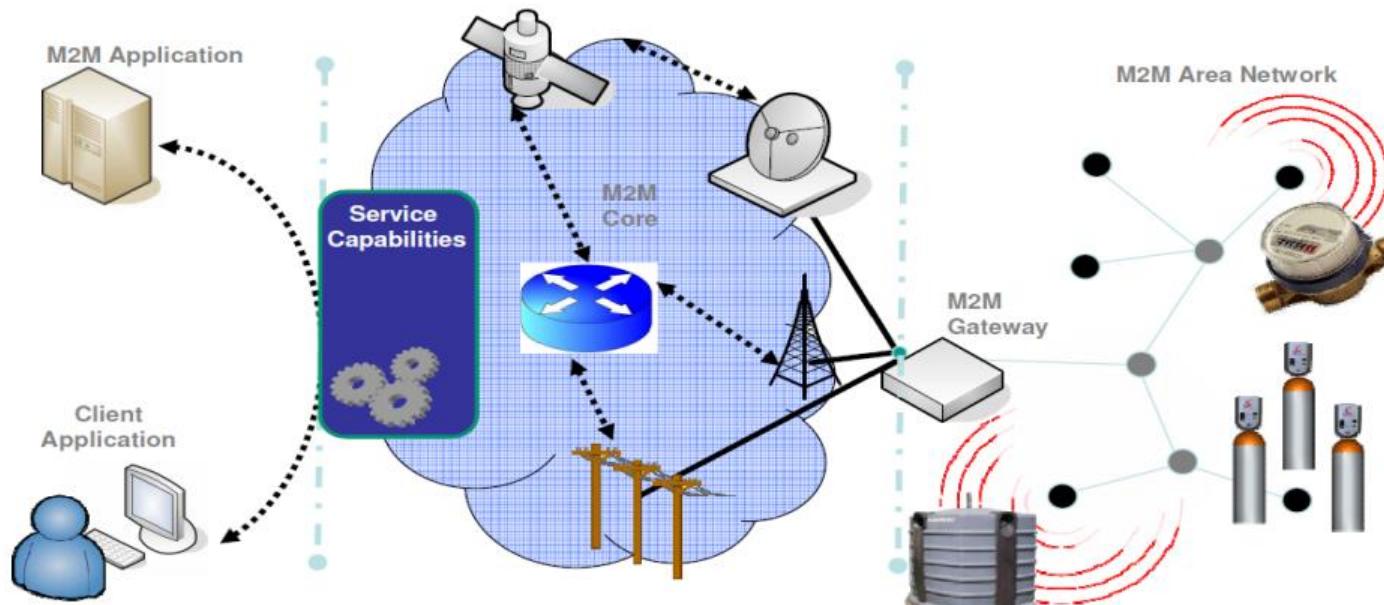
# Wireless Sensor Network (WSN)

- ❖ Spatially distributed autonomous sensors to monitor physical or environmental conditions.



# Machine-to-Machine (M2M)

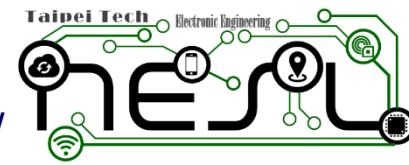
- ❖ Allow both wireless and wired systems to communicate with other devices of the same type.
  - M2M means no human intervention while devices are communicating end-to-end.



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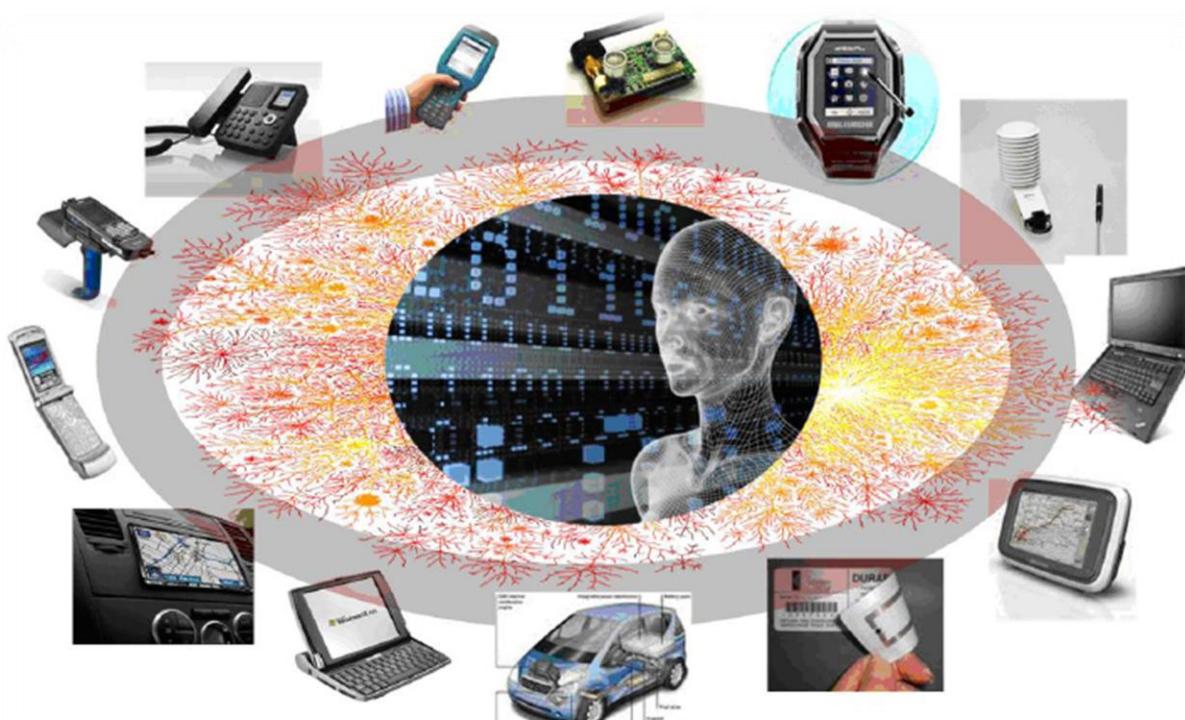
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# Internet of Things (IoT)

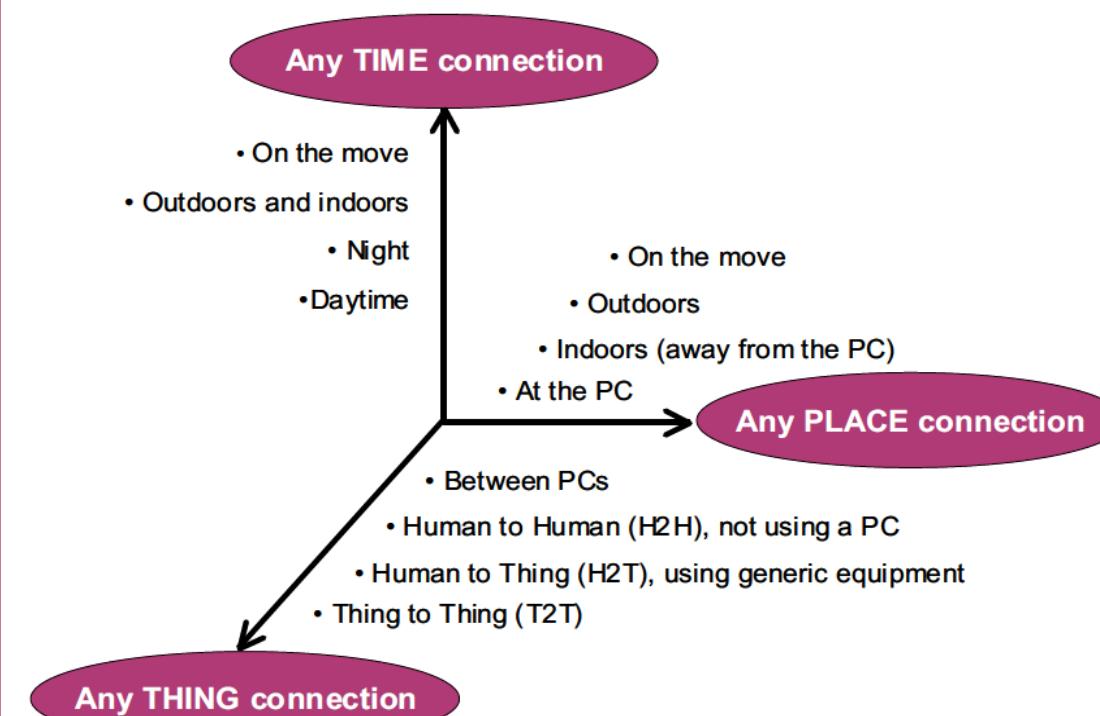
- ❖ A wireless network between objects, usually the network will be wireless and self-configuring, such as household appliances.



# Internet of Things (IoT)

❖ From any time ,any place connectivity for anyone, we will now have connectivity for anything!

Figure 1 – A new dimension

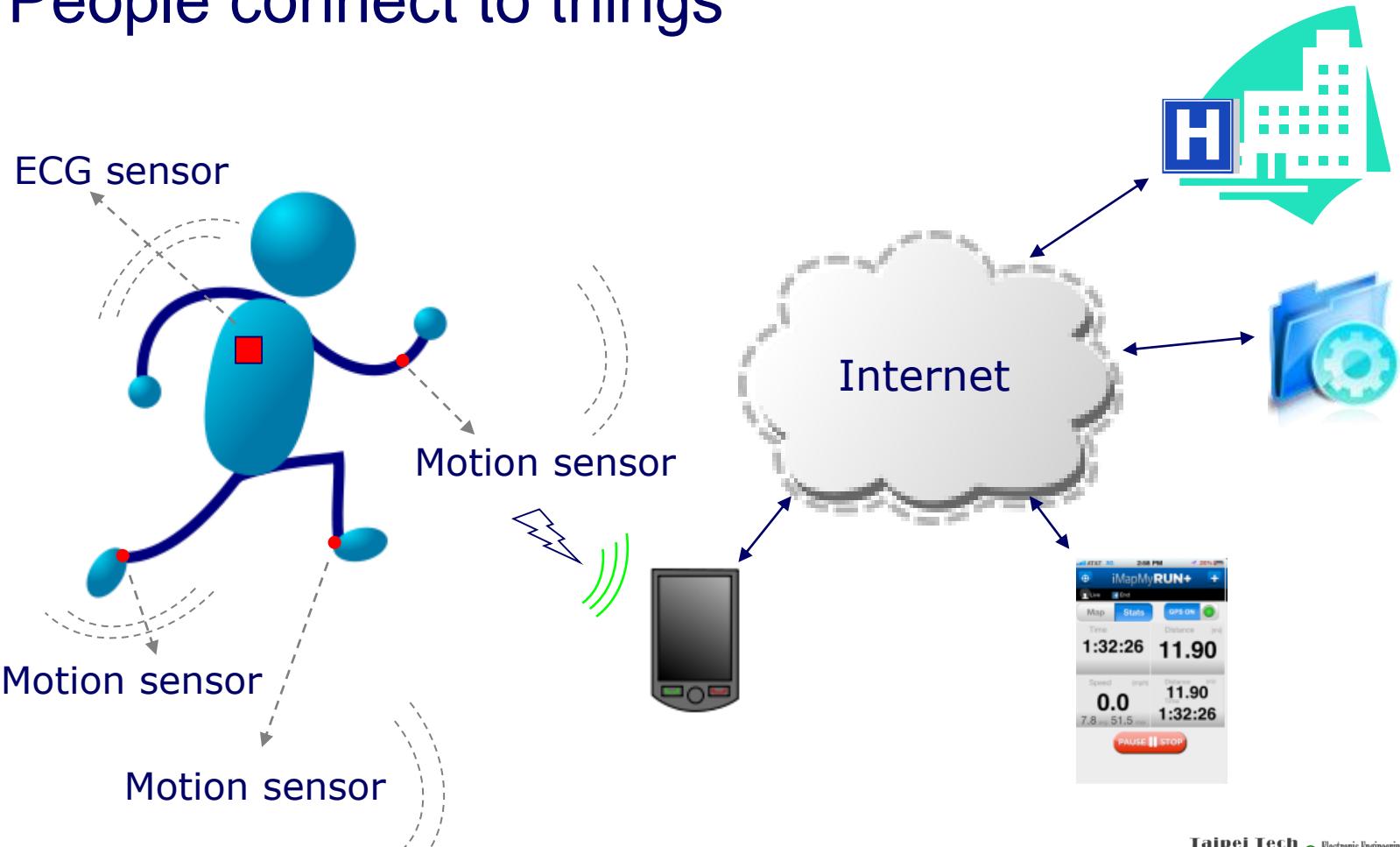


Source: ITU adapted from Nomura Research Institute



# Internet of Things (IoT)

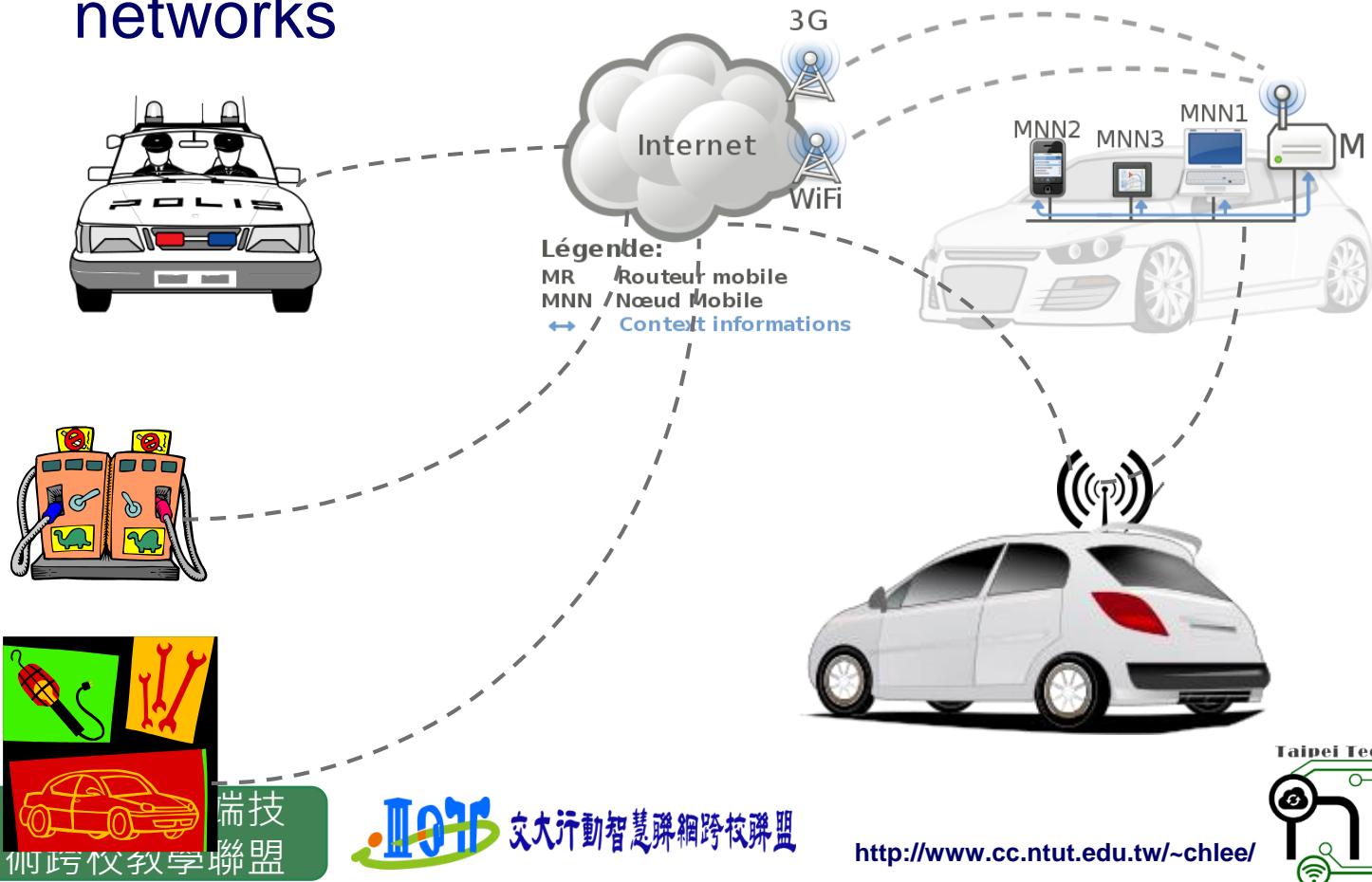
❖ People connect to things



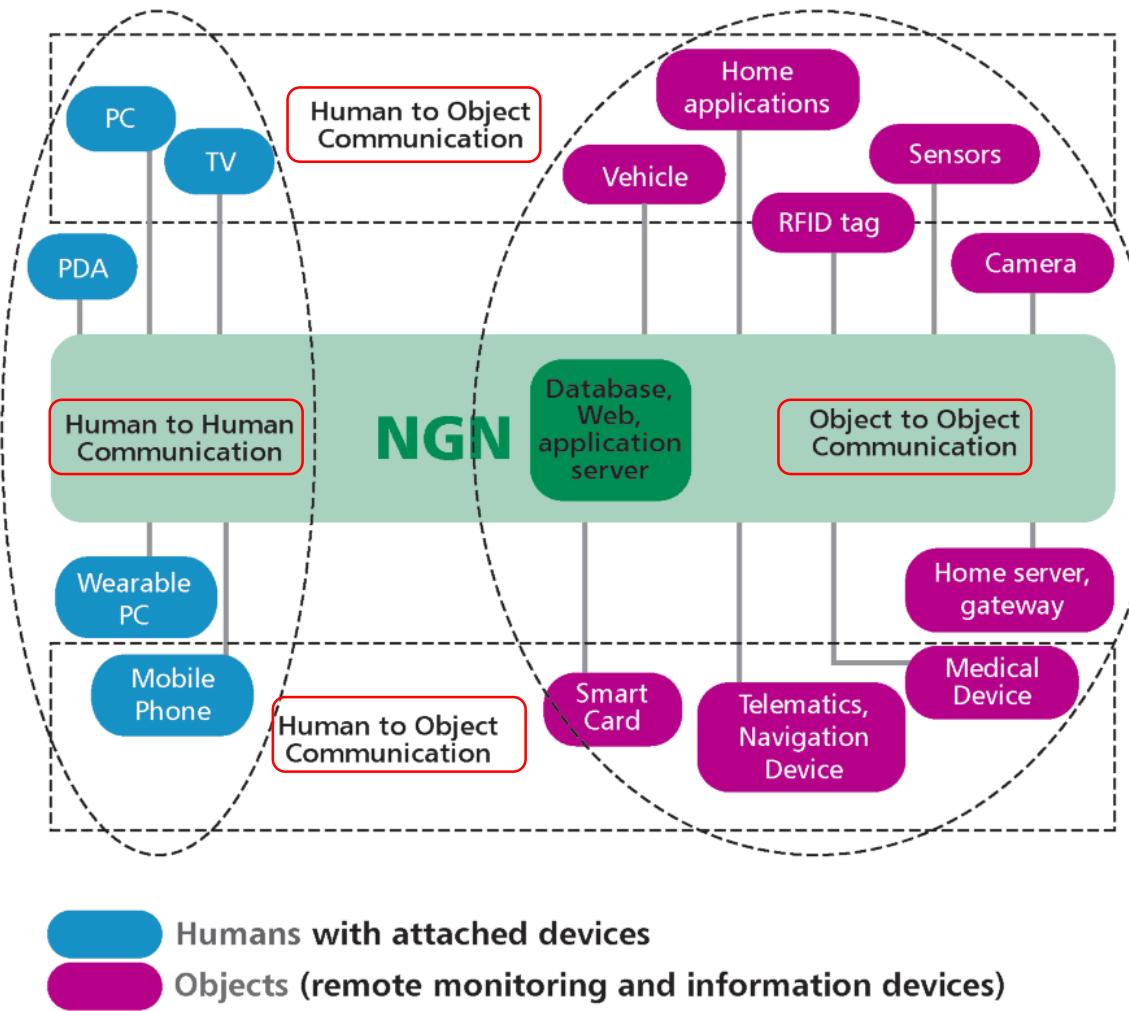
# Internet of Things (IoT)

## ❖ Things connects to things

- Complex and heterogeneous resources and networks



# Internet of Things (IoT)



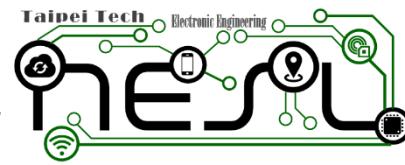
Figures from <http://www.rfidglobal.eu/userfiles/documents/white%20papers%204.pdf>



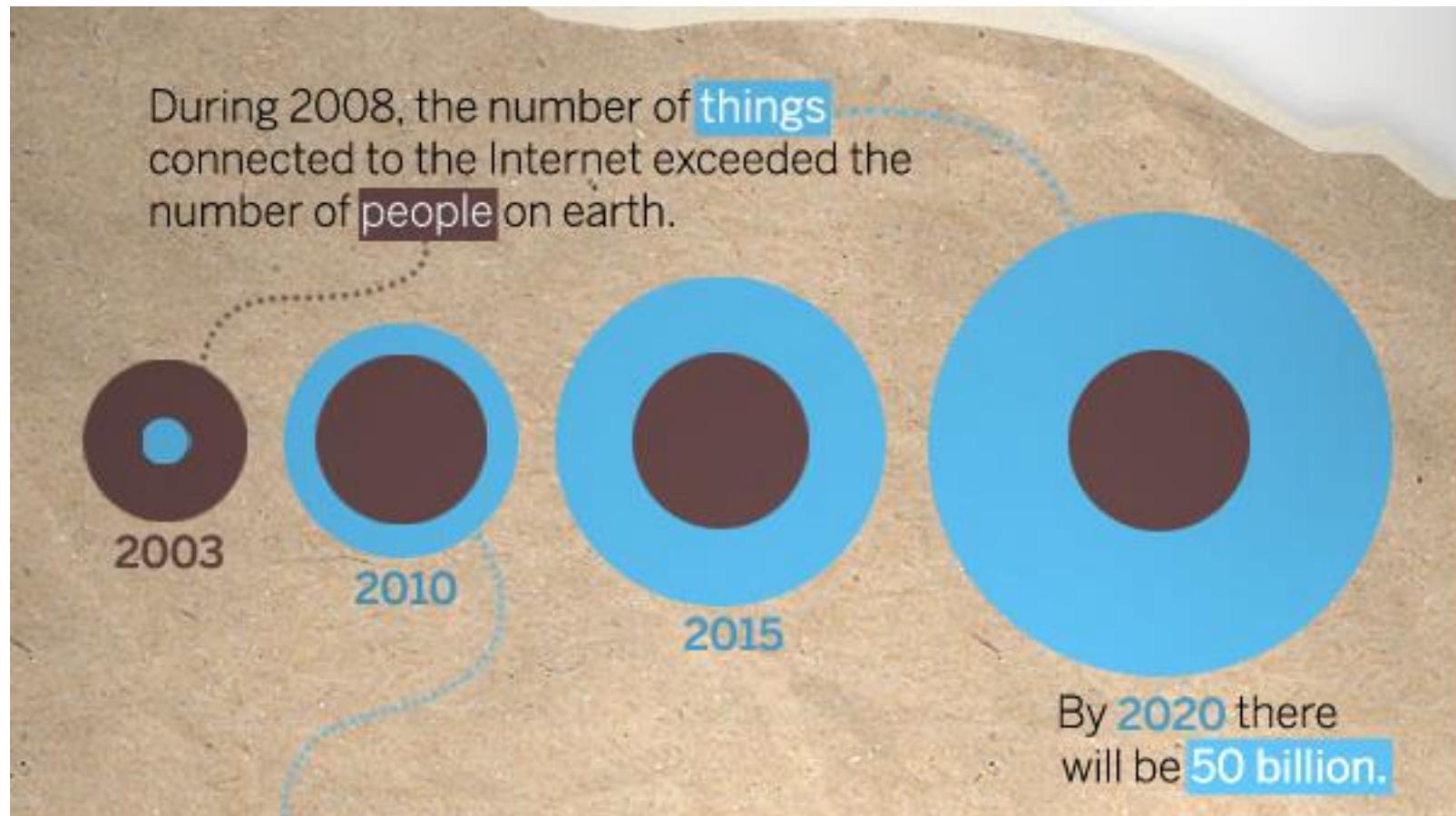
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# Internet of Things (IoT)



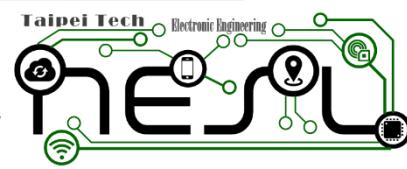
Sources: Cisco IBSG, Jim Cicconi, AT&T , Steve Leibson, Computer History Museum, CNN, University of Michigan, Fraunhofer



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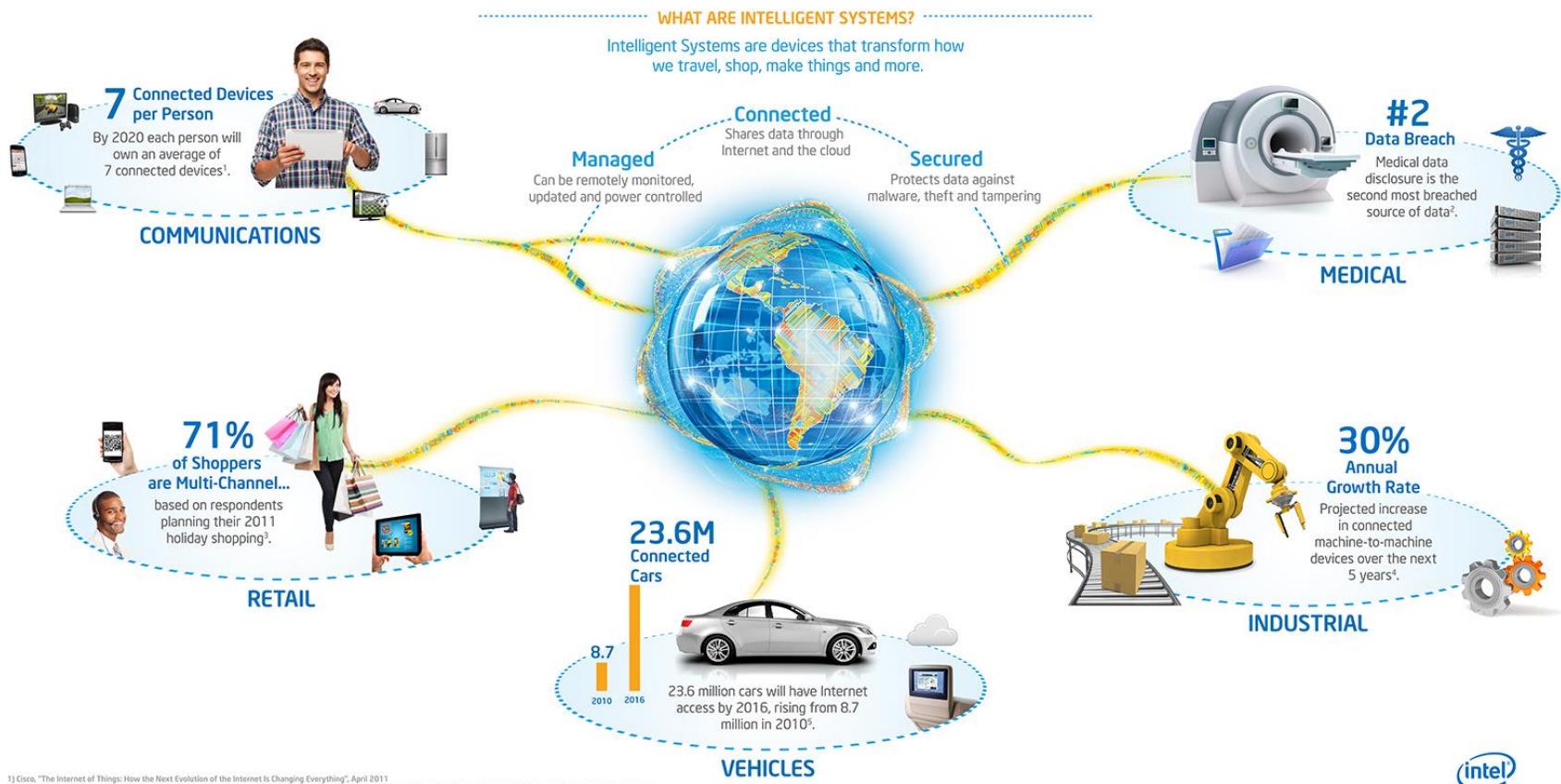


<http://www.cc.ntut.edu.tw/~chlee/>



# Internet of Things (IoT)

## Intelligent Systems for a More Connected World



1) Cisco, "The Internet of Things: How the Next Evolution of the Internet is Changing Everything", April 2011  
2) Bloor Research, "Security challenges in the US healthcare sector" White Paper, December 2010, <http://www.mcafee.com/us/resources/white-papers/vp-bloor-healthcare-security.pdf>  
3) Deloitte U.S., 2011 Annual Holiday Survey, [http://www2.deloitte.com/assets/Dcom-UnitedStates/LocalAssets/Documents/Consumer%20Business/us\\_retail\\_AnnualHolidaySurvey\\_2011\\_pr\\_102611.pdf](http://www2.deloitte.com/assets/Dcom-UnitedStates/LocalAssets/Documents/Consumer%20Business/us_retail_AnnualHolidaySurvey_2011_pr_102611.pdf)  
4) McKinsey Global Institute analysis, "Big data: The next frontier for innovation, competition, and productivity", June 2011  
5) Wall Street Journal, <http://online.wsj.com/article/SB1000142405270230496054576349763014933944.html>, estimate from research firm, Frost & Sullivan

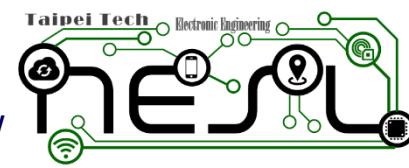
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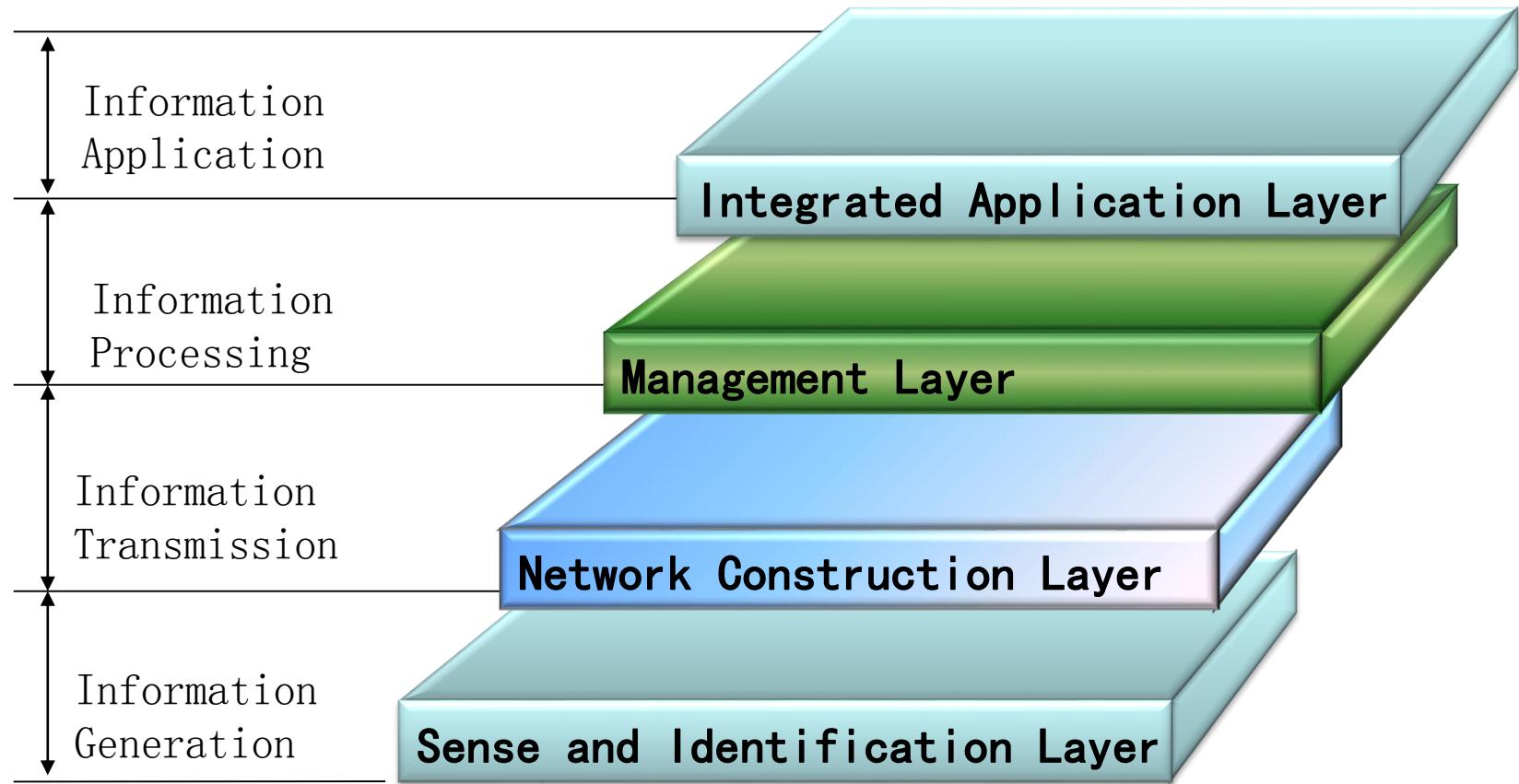
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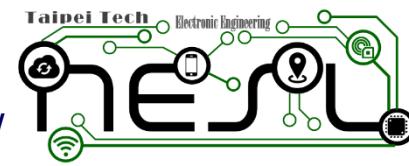
# Internet of Things (IoT)



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# 自由軟體 / 開放式原始碼

## ❖ Free Software / Open Source Code

- 軟體是由前人的經驗而發展出，而這些資產應該是開放的、可同享的。

## ❖ GNU Project

- Richard M. Stallman於1983年提出
- 目標在於建立一個完全相容於UNIX的自由軟體環境
  - GNU Compiler Collection (GCC)、GNU Binary Utilities (binutils)、Bash Shell、GNU C Library (glibc)、GNU Core Utilities (coreutils)



# 自由軟體 / 開放式原始碼

## ❖ 軟體授權(License)主要是確保軟體

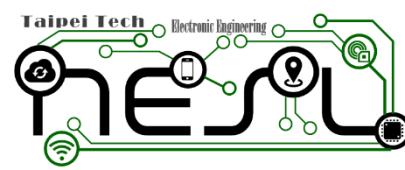
- 可任意使用的權利
- 可自由散佈的權利
- 可修改該軟體以符合自己用途的權利
- 散佈修改後軟體的權利

## ❖ GNU General Public License (GPL)

- 要求軟體在重新散佈或修改時，必需提供原始程式碼
- 修改後的軟體也要同樣以GPL授權



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## ❖ GNU Lesser General Public License (LGPL)

- 只在程式中引用採用LGPL授權的函式庫，而沒有針對該程式進行修改或衍生，則不需要公開程式碼。
- 若修改或衍生LGPL授權之軟體，則必須提供原始程式碼

## ❖ Apache、BSD、MIT License

- 當軟體重新散佈或修改程式碼後，不一定要提供原始程式碼。
- 經修改後的軟體可以改採其他授權。



# 黑客松(Hackathon)

## ❖ Hack (黑客) + Marathon (馬拉松)

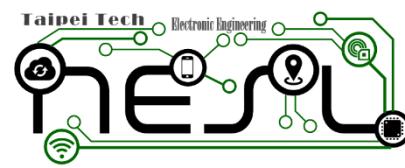
- 亦稱為Hack Day、Hackfest、Codefest
- 為了快速推動某項專案，號召相關不同專長的人員相聚在一起，緊密合作一段時間，進行馬拉松式的開發活動。



圖片來源：<https://hackathon.tw/>



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# 開放式硬體(Open-source Hardware)

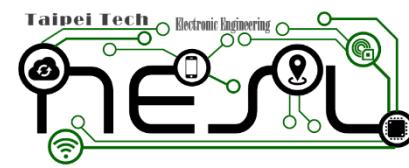
- ❖ 與自由軟體及開放式原始碼相同方式設計的電子硬體。
  - 釋放詳細的硬體設計，如：電路圖、元件清單和電路板布局



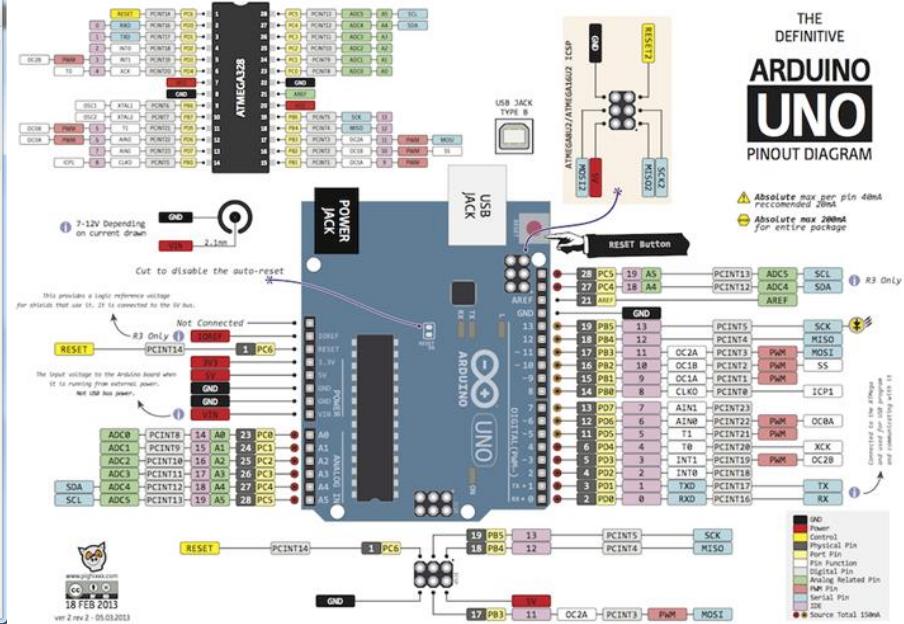
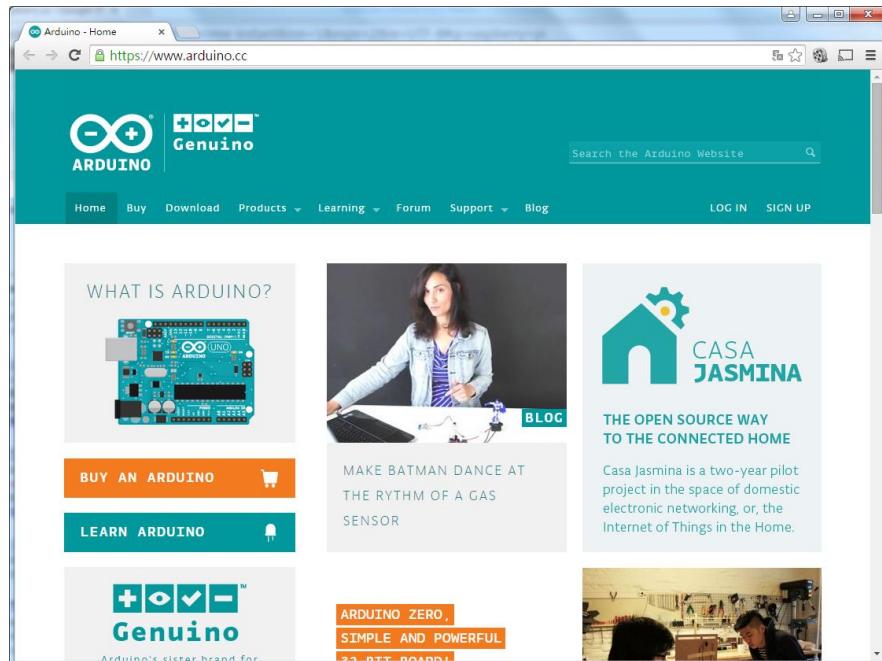
圖片來源：<http://www.in mojo.com/images/blog/oshw-logos.jpg>



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# Arduino

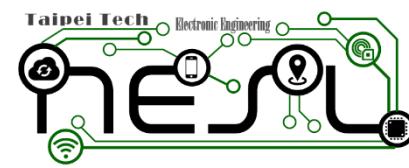


圖片來源：<https://www.arduino.cc/>

圖片來源：[http://lh6.ggpht.com/-PlsYLyLJ77E/UWdpseQBu3I/AAAAAAAACK-8/KFLzqBDyAi4/ARDUINO\\_V2\\_thumb%25255B2%25255D.png?imgmax=800](http://lh6.ggpht.com/-PlsYLyLJ77E/UWdpseQBu3I/AAAAAAAACK-8/KFLzqBDyAi4/ARDUINO_V2_thumb%25255B2%25255D.png?imgmax=800)



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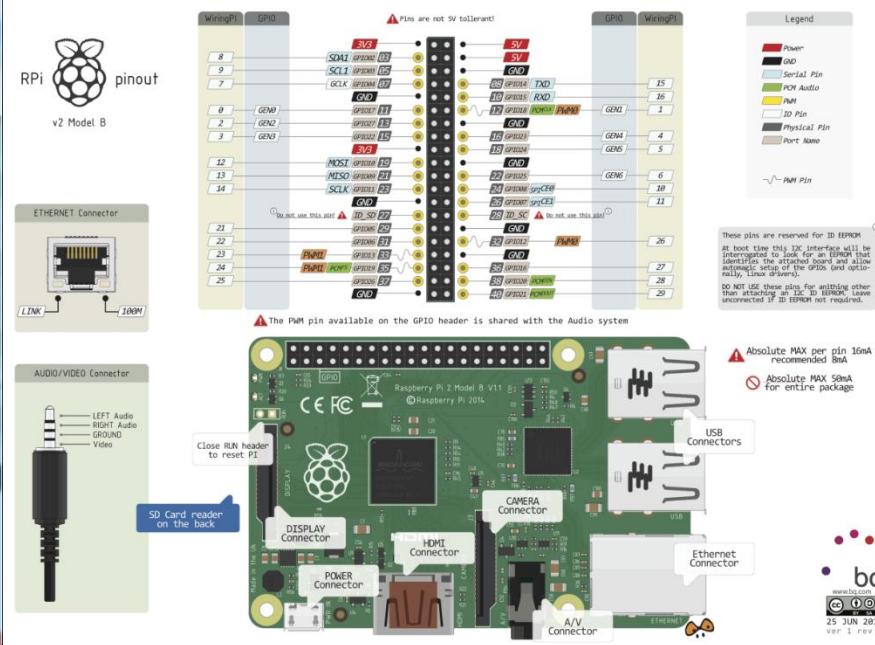


# Raspberry Pi

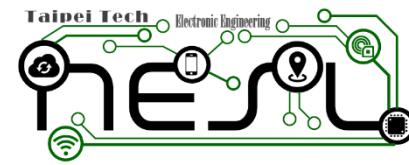
The screenshot shows the official Raspberry Pi website at <https://www.raspberrypi.org>. The header features navigation links for BLOG, DOWNLOADS, COMMUNITY, HELP, FORUMS, and RESOURCES. A search bar is also present. The main content area includes a cartoon illustration of a red crab on a beach with palm trees and a hammock, a "LATEST BLOG POST" section about a Picademy event, and a "WHAT IS A RASPBERRY PI?" button. Below this, there's a "MORE FROM THE BLOG..." section with thumbnails for projects like "PNEUMATIC TOOTH FAIRY", "PIGEON PI", "ROBERTS R300 REINVENTION", and "BEDBOT - FURNITURE WITH A TECH TWIST". At the bottom, there's a link to the "SFF THE BLOG ARCHIVE".

圖片來源：<https://www.raspberrypi.org/>

圖片來源：[http://41.media.tumblr.com/c16f74cfed11fdb70dde736b22ce99b0/tumblr\\_nr86vw9rci1s5t695o1\\_1280.png](http://41.media.tumblr.com/c16f74cfed11fdb70dde736b22ce99b0/tumblr_nr86vw9rci1s5t695o1_1280.png)



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# 自造者(Maker)

❖ 热衷於Do-It-Yourself (DIY)的爱好者

❖ Maker Faire

- 自造者運動(The Maker Movement)的慶典
- 結合全新元素的展覽，集結科技愛好者、工藝家、教育家、修補工、業餘愛好者、工程師、科學社團、作家、藝術家、學生、商業展示者展現、分享他們所作與所學

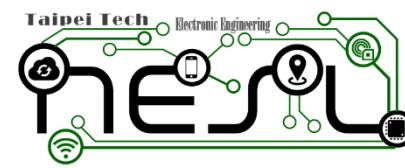


圖片來源：  
<http://exchangemyphone.com/blog/wp-content/uploads/2012/05/maker-faire.jpg>



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## ❖ IoT / CPS / M2M / WSN

- Convergence of computation, communication, and control.

