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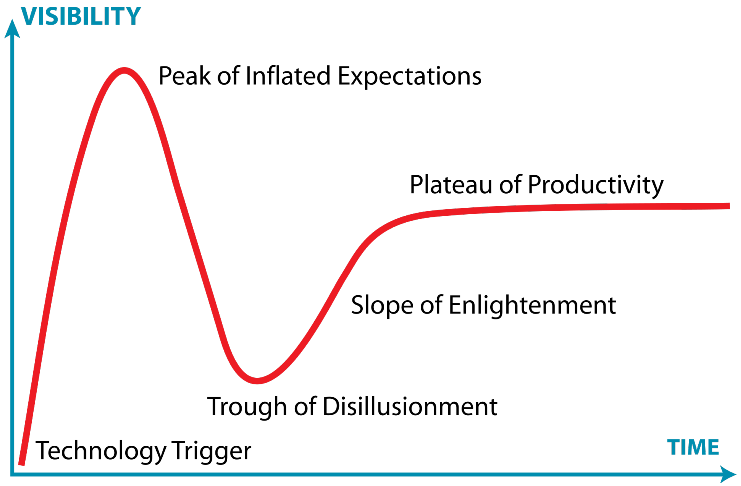
CITS 5506
The Internet of Things
Lecture 02

IoT Challenges, History, Evolution, Forecast

Dr Atif Mansoor
atif.mansoor@uwa.edu.au

Interpreting technology hype - Gartner Hype Cycle



Challenges for IoT

However, the Internet of Things raises significant challenges that could stand in the way of realizing its potential benefits.

Societal Challenges

- privacy fears
- surveillance concerns
- Security Concern (hacking of Internet-connected devices)

Example of Societal challenge: Google Glass

- The smart spectacles by Google unveiled in 2012.
- Introduction demo that featured skydivers streaming their jump through the device.

  https://youtu.be/uh-liQDE3cM
- Google shelved the product in 2015

Even the future King could not save it

Privacy concern kept it from going mainstream.

Challenges for IoT

Technical challenges

Constrained in storage, computing, energy source

- Sensors
- Power Consumption
- Security & Privacy → Less secure encryption
- Data Analytics
- Communication Technologies
- Interoperability / Standards
- Development Challenges/ Enabling Technologies

Challenges for IoT

- Enabling Technologies: The concept of combining computers, sensors, and networks to monitor and control devices has existed for decades.

- The recent confluence of several technology market trends, however, is bringing the Internet of Things closer to widespread reality.

- These include Ubiquitous Connectivity, Widespread Adoption of IP-based Networking, Computing Economics, Miniaturization, Advances in Data Analytics, and the Rise of Cloud Computing.

Challenges for IoT

Legal Challenges

The use of IoT devices raises many new regulatory and legal questions:

- Issues related to cross border data flows
- Data collected by IoT devices is sometimes susceptible to misuse, potentially causing discriminatory outcomes for some users.

Challenges for IoT

Legal Challenges

- Conflict between law enforcement surveillance and civil rights
- Data retention and destruction policies
- Legal liability for unintended uses → Weak legal framework related to such issue
- Security breaches or privacy lapses

It may force a shift in thinking about the implications and issues in a world where the most common interaction with the Internet comes from passive engagement with connected objects rather than active engagement with content.

Reading List

THE INTERNET OF THINGS: AN OVERVIEW
Understanding the Issues and Challenges of a More Connected World

https://www.internetsociety.org/wp-content/uploads/2017/08/ISOC-IoT-Overview-20151221-en.pdf

Reading List

Internet of Things: Concepts and System Design

Milenkovic, Milan

Publisher, Springer

Identifier

ISBN: 3030413454

ISBN: 9783030413453

EISBN: 9783030413460

EISBN: 3030413462

Reading List

From Machine-to-Machine to the Internet of Things : Introduction to a New Age of Intelligence.

Tsiatsis, Vlasios.; Mulligan, Catherine.; Avesand, Stefan.; Karnouskos, Stamatis.; Boyle, David.; Holler, Jan.Jordan Hill : Elsevier Science; 2014

ISBN : 9780080994017

OCLC : (OCoLC)905840122

ISBN : 9780124076846

Reading List

Internet of Things with ESP8266.

Schwartz, Marco.

ISBN : 9781786466679

Internet of Things with 8051 and ESP8266.

Gehlot, Anita.; Singh, Rajesh.; Malik, Praveen Kumar.; Gupta, Lovi Raj.; Singh, Bhupendra.

ISBN : 9781000258646

ISBN : 9780367534783

*ESP8266 is a low-cost Wi-Fi microchip, with a full TCP/IP stack and microcontroller capability

Reading List

Internet of Things : Integration and Security Challenges

Velliangiri, S. ,Kumar, Sathish A. P. ,Karthikeyan, P.

ISBN : 9781000291636

OCLC : (OCoLC)1204142479

ISBN : 9780367893873

Reading List

Internet of Things Security : Challenges, Advances, and Analytics.

Patel, Chintan.; Doshi, Nishant.

Milton : Auerbach Publishers, Incorporated; 2018

Identifier

ISBN : 9780429845734

Reading List

The Internet of Things : Technologies and Applications for a New Age of Intelligence.

Höller, Jan.; Tsiatsis, Vlasios.; Mulligan, Catherine.; Avesand, Stefan.; Karnouskos, Stamatis.; Boyle, David.

2nd ed.; San Diego : Elsevier Science & Technology; 2018

ISBN : 9780128144367

OCLC : (OCoLC)1076802386

ISBN : 9780128144350

IoT History

The term "Internet of Things" (IoT) was first used in 1999 by British technology pioneer Kevin Ashton to describe a system in which objects in the physical world could be connected to the Internet by sensors.

Ashton was working on RFID (radio-frequency identification) devices, and the close association of RFID and other sensor networks with the development of the IoT concept is reflected in the name of the RFID device company that Ashton joined later in his career: "ThingMagic."

http://www.thingmagic.com/ Now https://www.jadaktech.com/

IoT History

In 1977, work started on commercial automatic meter reading and load management for electrical services which led to the "smart grid" and "smart meter" over telephone lines[1].

In the 1990s, advances in wireless technology allowed "machine–to–machine" (M2M) enterprise and industrial solutions for equipment monitoring and operation to become widespread. Many of these early M2M solutions, however, were based on **closed purpose–built networks** and **proprietary or industry–specific standards**, rather than on Internet Protocol (IP) and Internet standards[2].

1. "Machine to Machine." Wikipedia, https://en.wikipedia.org/wiki/Machine_to_machine
2. Polsonetti, Chantal. "Know the Difference Between IoT and M2M." Automation World, July 15, 2014

IoT History

- The first Internet "device"—an IP–enabled toaster that could be turned on and off over the Internet—was featured at an Internet conference in 1990[1].
- Over the next several years, other "things" were IP–enabled, including a soda machine[2] at Carnegie Mellon University in the US and a coffee pot[3] in the Trojan Room at the University of Cambridge in the UK (which remained Internet–connected until 2001)

1. "The Internet Toaster." Living Internet, 7 Jan. 2000. Web. 06 Sept. 2015. http://www.livinginternet.com/i/ia_myths_toast.htm
2. "The "Only" Coke Machine on the Internet." Carnegie Mellon University Computer Science Department, n.d. Web. 06 Sept. 2015. https://www.cs.cmu.edu/~coke/history_long.txt
3. Stafford-Fraser, Quentin. "The Trojan Room Coffee Pot." N.p., May 1995. Web. 06 Sept. 2015. http://www.cl.cam.ac.uk/coffee/qsf/coffee.html

IoT Evolution

From a broad perspective, the confluence of several technology and market trends is making it possible to interconnect more and smaller devices cheaply and easily.

- Ubiquitous Connectivity—Low cost, high–speed, pervasive network connectivity

- Widespread adoption of IP–based networking— IP has become the dominant global standard for networking,

IoT Evolution

- Computing Economics— Greater computing power at lower price and lower power consumption
- Miniaturization— Manufacturing advances allow cutting-edge computing and communications technology to be incorporated into very small objects & small and inexpensive sensor devices
- Advances in Data Analytics— New algorithms and rapid increases in computing power, data storage, and cloud services enable the analysis of vast quantities of data

IoT Evolution

- Rise of Cloud Computing– Cloud computing, which leverages remote, networked computing resources to process, manage, and store data, allows small and distributed devices to interact with powerful back-end analytic and control capabilities.

Economy and Development Issues

The Internet of Things holds significant promise for delivering social and economic benefits to emerging and developed economies.

This includes areas such as sustainable agriculture, water quality and use, healthcare, industrialization, and environmental management, among others.

Development Issues

The unique needs and challenges of implementation will need to be addressed, including :

- infrastructure readiness
- market and investment incentives
- technical skill requirements
- policy resources

IoT Forecast

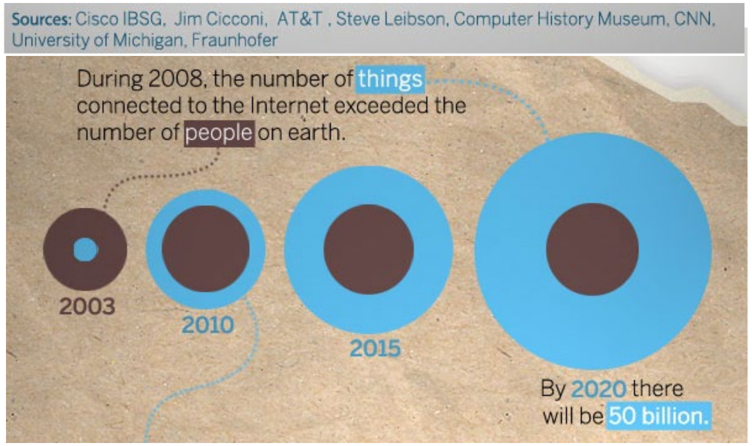
A number of companies and research organizations have offered a wide range of projections about the potential impact of IoT on the Internet and the economy during the next five to ten years.

- Morgan Stanley, a global financial services firm in 2013 projected 75 billion networked devices by 2020[1]
- Cisco says connected devices will be 3 x global population by 2023[2].

1. "Danova, Tony. "Morgan Stanley: 75 Billion Devices Will Be Connected To The Internet Of Things By 2020." Business Insider, October 2, 2013. http://www.businessinsider.com/75-billion-devices-will-be-connected-to-the-internet-by-2020-2013-10
2. https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.html

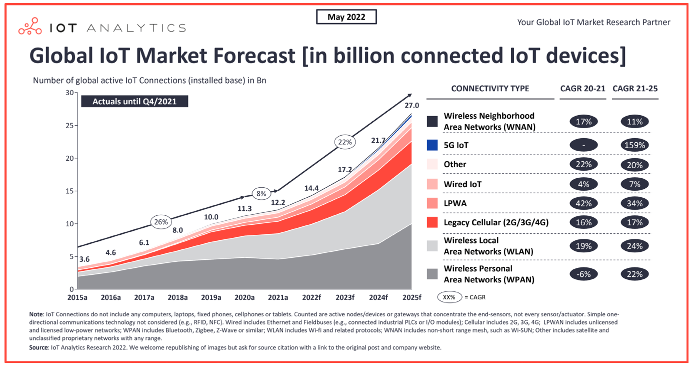
MacroEconomic Insight IoT

IoT Evolution



State of IoT 2022

State of IoT 2022: Number of connected IoT devices growing 18% to 14.4 billion globally[1]



1. https://iot-analytics.com/number-connected-iot-devices/

IoT Forecast

- Huawei forecasts 100 billion IoT connections by 2025[1]
- McKinsey Global Institute suggests that the financial impact of IoT on the global economy may be as much as $3.9 to $11.1 trillion by 2025[2]

While the variability in predictions makes any specific number questionable, collectively they paint a picture of significant growth and influence.

1. "Global Connectivity Index." Huawei Technologies Co., Ltd., 2015. Web. 6 Sept. 2015. http://www.huawei.com/minisite/gci/en/index.html
2. Manyika, James, Michael Chui, Peter Bisson, Jonathan Woetzel, Richard Dobbs, Jacques Bughin, and Dan Aharon. "The Internet of Things: Mapping the Value Beyond the Hype." McKinsey Global Institute, June 2015.

"Settings" for IoT Applications

Setting	Description	Examples
Human	Devices attached or inside the human body	Devices (wearables and ingestible) to monitor and maintain human health and wellness; disease management, increased fitness, higher productivity
Home	Buildings where people live	Home Controllers and Security Systems
Retail Environments	Spaces where consumers engage in commerce	Stores, banks, restaurants, arenas – anywhere consumers consider and buy; self-checkout, in-store offers, inventory optimization

“Settings” for IoT Applications

Setting	Description	Examples
Factories	Standardized production environments	Places with repetitive work routines, including hospitals and farms; operating efficiencies, optimizing equipment use and inventory
Worksites	Custom production environments	Mining, oil and gas, construction; operating efficiencies, predictive maintenance, health and safety
Vehicles	Systems inside moving vehicles	Vehicles including cars, trucks, ships, aircraft, and trains; condition-based maintenance, usage-based design,

“Settings” for IoT Applications

Setting	Description	Examples
Cities	Urban Environment	Public spaces and infrastructure in urban settings; adaptive traffic control, smart meters, environmental monitoring, resource management
Offices	Spaces where knowledge workers work	Energy management and security in office buildings; improved productivity, including for mobile employees

Manyika, James, Michael Chui, Peter Bisson, Jonathan Woetzel, Richard Dobbs, Jacques Bughin, and Dan Aharon. “The Internet of Things: Mapping the Value Beyond the Hype.” McKinsey Global Institute, June 2015. p.3. http://www.mckinsey.com/insights/business_technology/the_internet_of_things_the_value_of_digitizing_the_physical_world 25

IoT …………Conflicting Perceptions

IoT a revolutionary fully–interconnected “smart” world of progress, efficiency, and opportunity, with the potential for adding billions in value to industry and the global economy.

Others warn that the IoT represents a darker world of surveillance, privacy and security violations, and consumer lock–in.

Sensor Devices are widely available

- Programmable devices
- Off-the-shelf gadgets/tools

Technical Challenges for IoT

- Sensors Basic computing inside device itself
  - applications – edge computing and IoT, smart cities, smart manufacturing, hospitals, industrial, machine learning, and automotive.
  - chips to capture data about what is happening in our analog world, and then digitize the data so it can be processed, stored, combined, mined, correlated, and utilized by both humans and machines.
  - Energy and power efficiency are critical

Sensors

- Some type of always-on circuitry for faster boot-up or to detect motion, gestures, or specific keywords.
- In the past these types of functions typically were built into the central processor
  - wasteful of energy
- Developing a flexible system optimized with dedicated processors, as well as hardware accelerators offloading the host processor, seems to be emerging as a basic requirement
- Sensor data capture, fusion processing, and communication tasks, resulting in more power-efficient use of processing resources

Sensors

- Miniaturization of Sensor
  - "*Nanosensors are chemical or mechanical sensors that can be used to detect the presence of chemical species and nanoparticles, or monitor physical parameters such as temperature, on the nanoscale (10^{-9}). They find use in medical diagnostic applications, food and water quality sensing, and other chemicals.*"
    (Nature)

Miniaturization of Sensor

- Objects have characteristics of both particles and waves (wave–particle duality); and there are limits to how accurately the value of a physical quantity can be predicted prior to its measurement, given a complete set of initial conditions (the uncertainty principle).
- Quantum sensor utilizes properties of quantum mechanics, which have optimized precision and beat current limits in sensor technology.

How are the Network changing

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Extensions
- More nodes, more connections, IPv6 (128-bit addresses) as compared to IPv4 (32-bit address space)
- Any TIME, Any PLACE + Any THING
- M2M, IoT
  - Billions of interconnected devices,
  - Everybody connected.

Expansions
- Broadband & LPWAN

Enhancements
- Data-centric and content-oriented networking
- Context-aware (autonomous) systems (knowing the surrounding environment through sensors)

Future Networks

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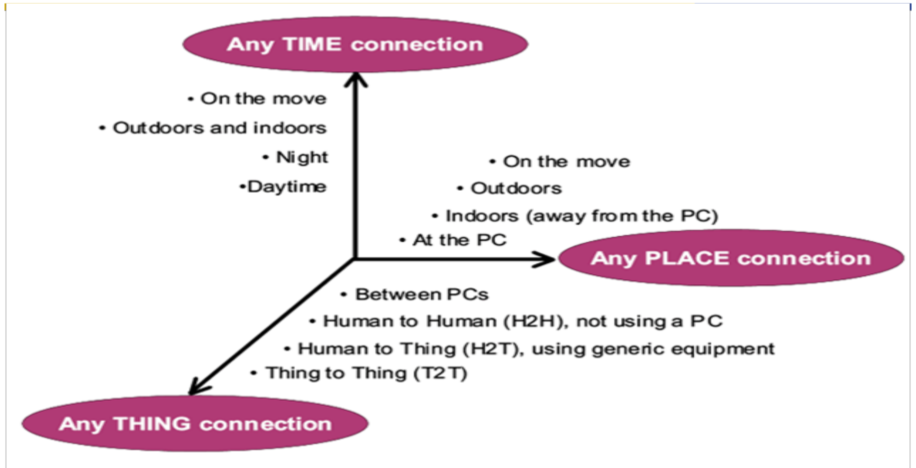

Source: ITU adapted from Nomura Research Institute

Interpreting technology hype - Gartner Hype Cycle

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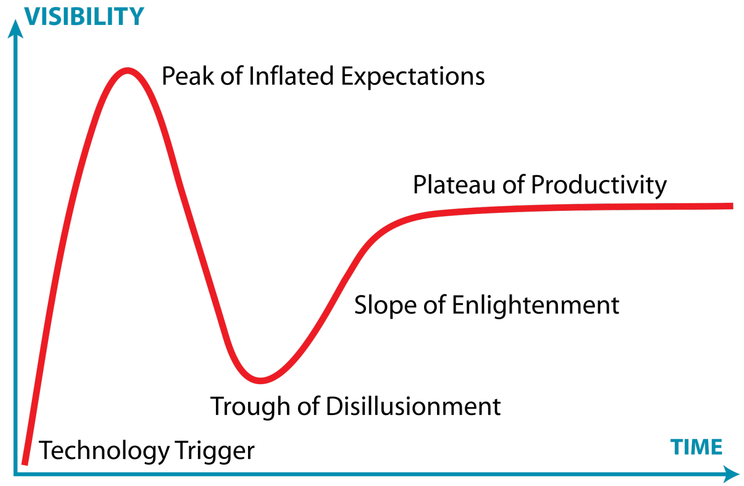

Communication

IoT Requirements for Various Applications

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Requirements	Health	Aviation	Home Automation	Smart Cars	Wearables	Industrial Control
Reliability	high	high	high	high	low	high
Latency	long	low	long	low	long	low
Mobility	low	high	no	high	low	low
Security	high	high	high	high	mixed	high
Power	low	low/mix	mix	mix	low	mix
Protocol Message Size	short	mix	short	mix	mix	mix
Frequency of Interactions	low	high	Low	high	low	high

Data Behaviour