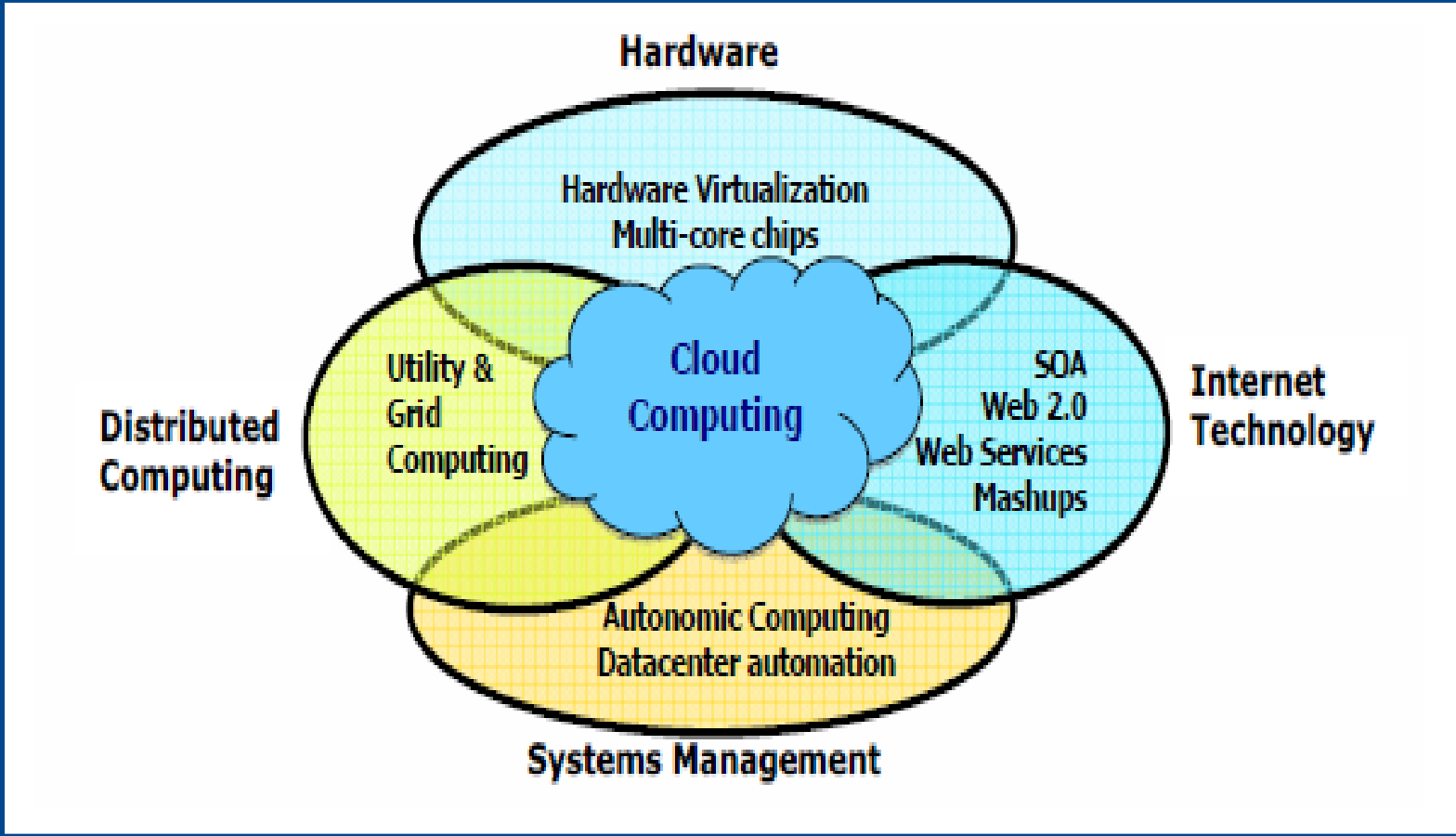
# Distributed and Cloud Computing

K. Hwang, G. Fox and J. Dongarra

## Lecture Note 1: Enabling Technologies and Distributed System Models

# Data Deluge Enabling New Challenges

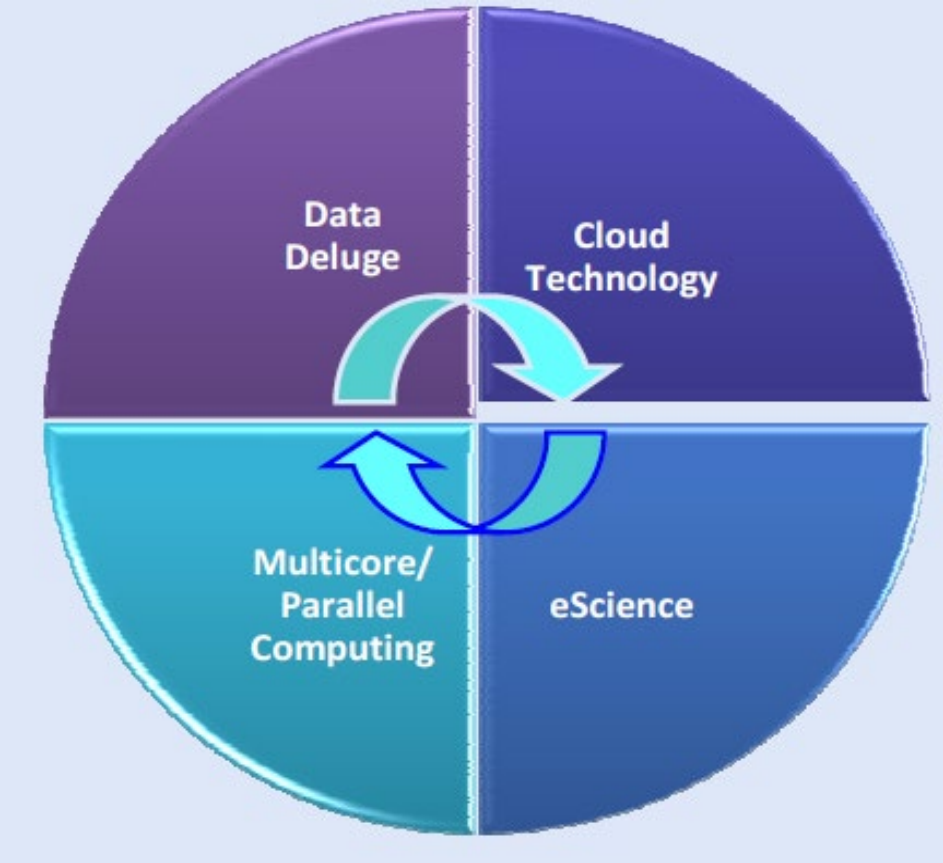



(Courtesy of Judy Qiu, Indiana University, 2011)

# From Desktop/HPC/Grids to Internet Clouds in 30 Years

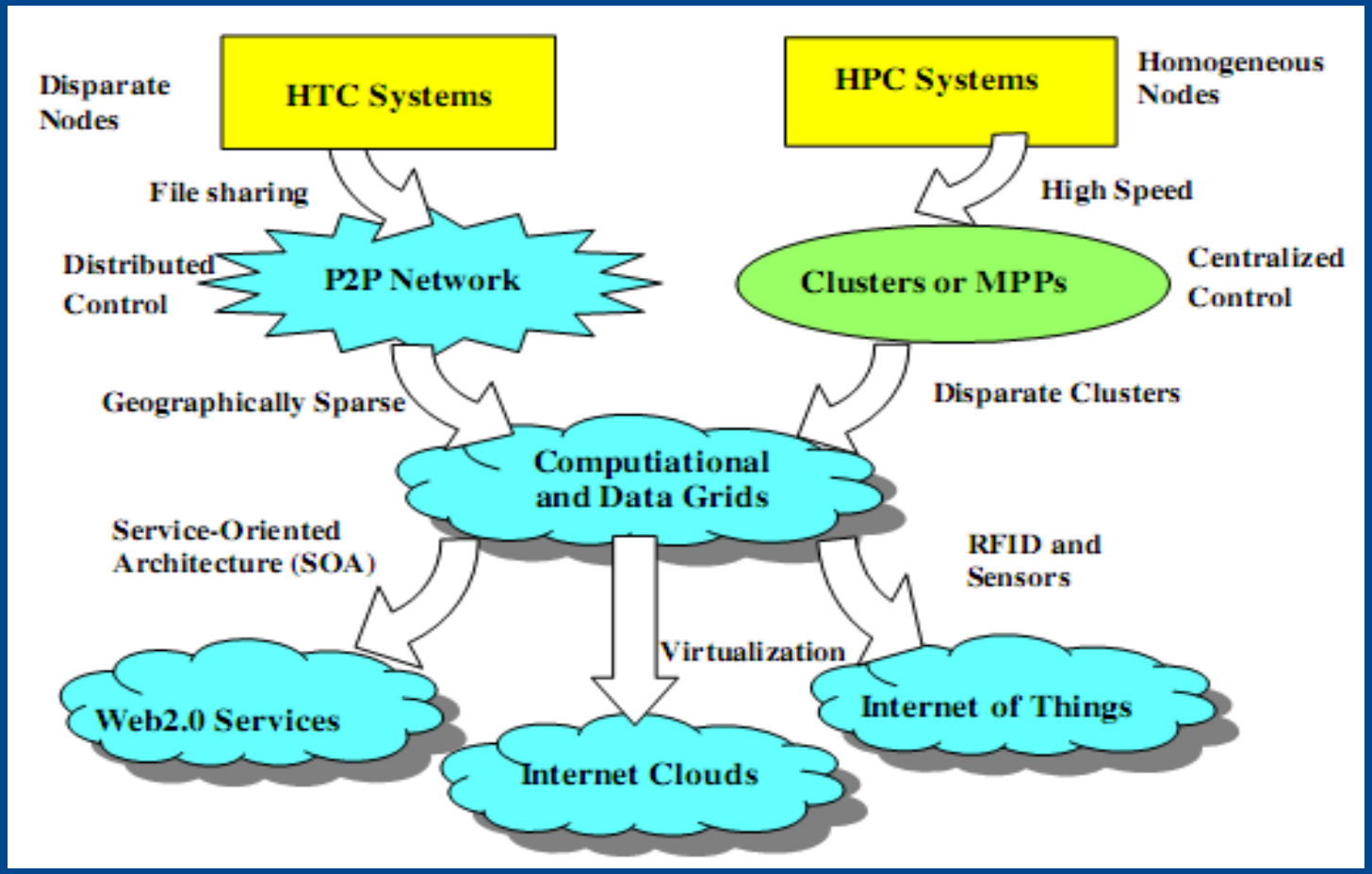
- HPC moving from centralized supercomputers to geographically distributed desktops, desksides, clusters, and grids to clouds over last 30 years
- R/D efforts on HPC, clusters, Grids, P2P, and virtual machines has laid the foundation of cloud computing that has been greatly advocated since 2007
- Location of computing infrastructure in areas with lower costs in hardware, software, datasets, space, and power requirements – moving from desktop computing to datacenter-based clouds

# Interactions among 4 technical challenges:
## Data Deluge, Cloud Technology, eScience, and Multicore/Pareallel Computing




(Courtesy of Judy Qiu, Indiana University, 2011)

# Evolutionary Trend
## toward Clouds and Internet of Things




**HPC:** High-Performance Computing

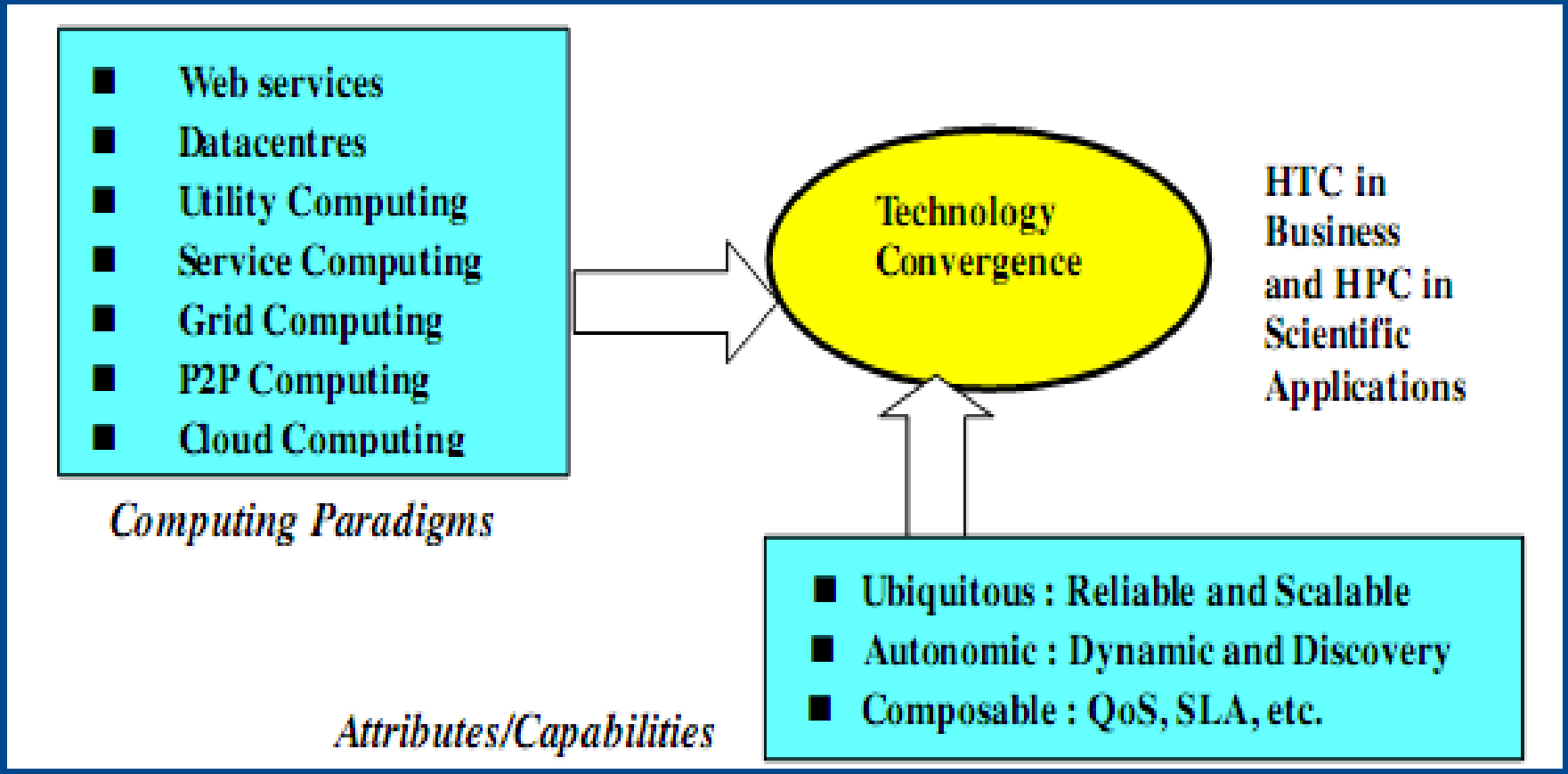
**HTC:** High-Throughput Computing

**P2P:** Peer to Peer

**MPP:** Massively Parallel Processors

Source: K. Hwang, G. Fox, and J. Dongarra, *Distributed and Cloud Computing,* Morgan Kaufmann, 2012.

# Technology Convergence toward HPC for Science and HTC for Business

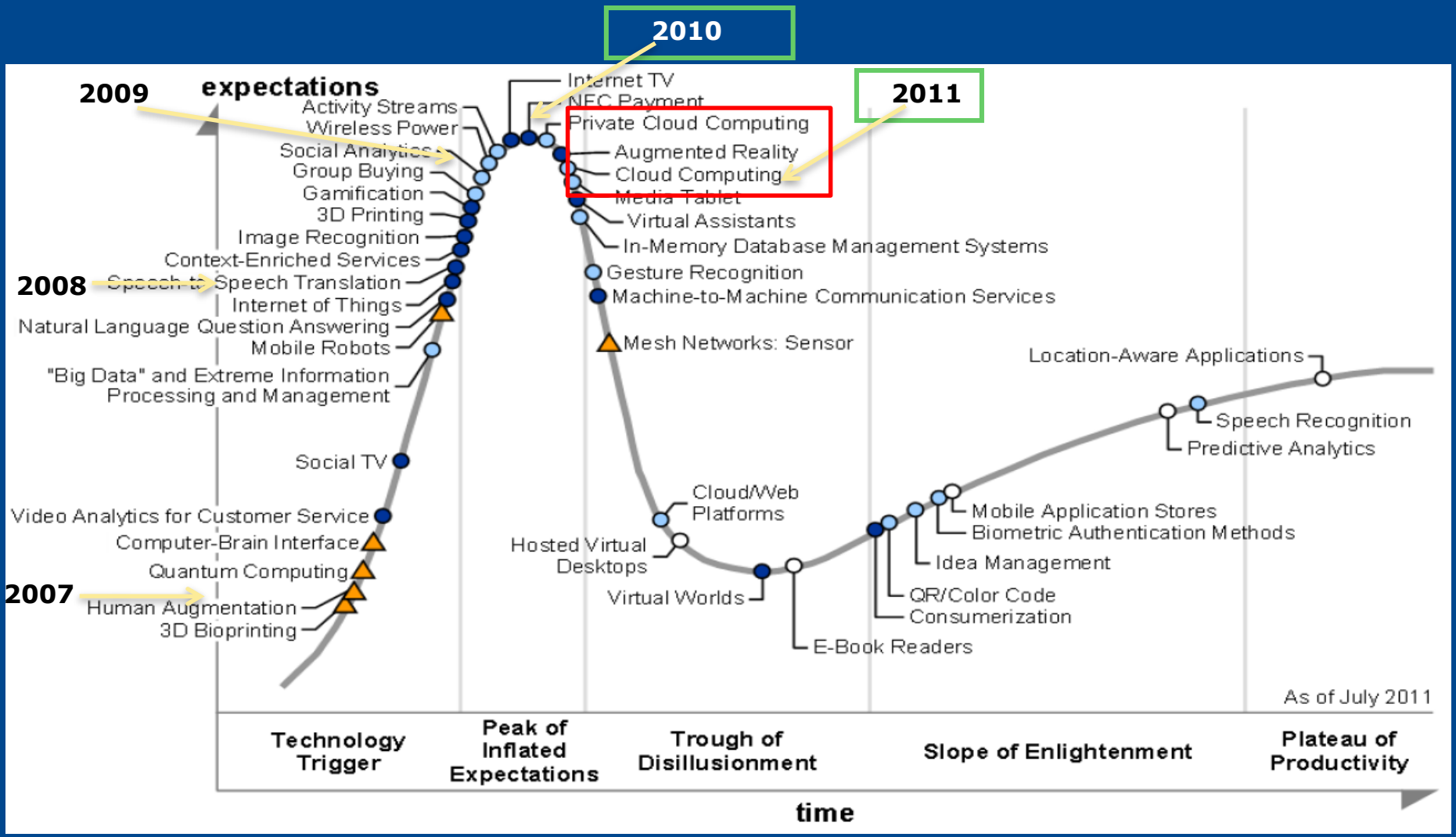



(Courtesy of Raj Buyya, University of Melbourne, 2011)

# Major technological challenges
## to build distributed system

1. New network-efficient processors
2. Scalable memory and storage schemes
3. Distributed OSes
4. Middleware for machine virtualization
5. New programming models
6. Efficient resource management
7. Application program development

# 2011 Gartner "IT Hype Cycle" for Emerging Technologies

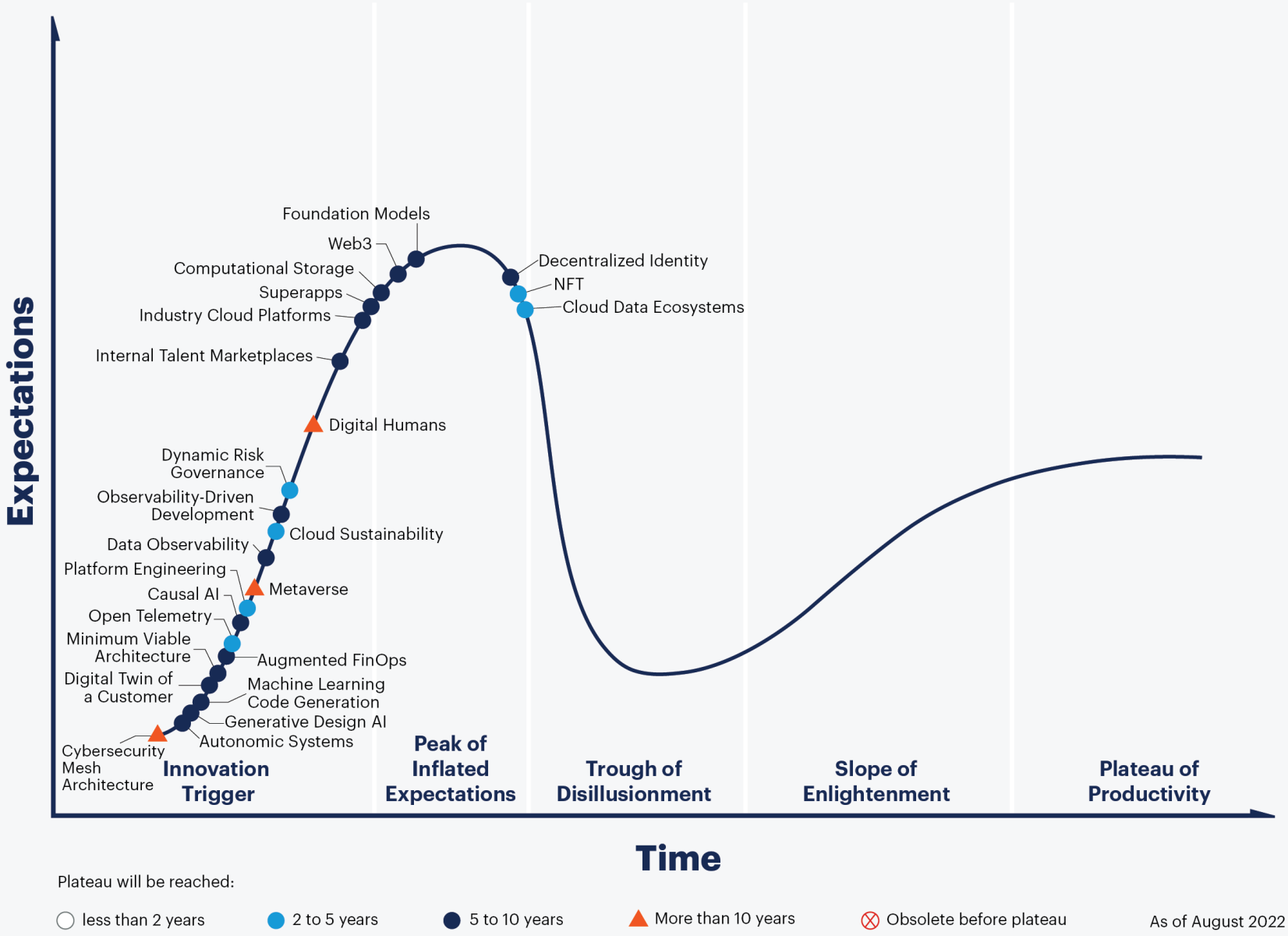



Years to mainstream adoption:

○ Less than 2 years ◎ 2 to 5 years ● 5 to 10 years ▲ More than 10 years ⊗ Obsolete before plateau

What is Gartner Hype cycle? https://en.wikipedia.org/wiki/Gartner_hype_cycle

# Hype Cycle for Emerging Tech, 2022




Plateau will be reached:

○ less than 2 years ● 2 to 5 years ● 5 to 10 years ▲ More than 10 years ⊗ Obsolete before plateau

As of August 2022

gartner.com

# Internet of Things (IoT)

- Introduced in 1999 at MIT

- What is IoT?
  - The networked interconnection of everyday objects, tools, devices, software, processing ability, sensors, computers, and other technologies.
  - A wireless network of sensors that interconnect all things in our daily life.

# Internet of Things (IoT)

- Idea of IoT
  - To tag every object using RFID or a related sensor or electronic technology such as GPS.
  - With IPv6 protocol, $2^{128}$ IP addresses are available to distinguish all the objects on Earth, including all computers and pervasive devices
- Let's review Computer Network Fundamental.
  - Lecture Notes 1-1, 1-2, 1-3

# Internet of Things (IoT)

- Requirements
  - Track 100 trillion static or moving object simultaneously.
  - Need universal addressability of all of the objects or things.
  - To reduce the complexity of identification, search, and storage, one can set the threshold to filter out fine-grain objects.
  - Now, we also have IoT which is not connected to the public Internet and just connected to a private network.
- All the objects and devices:
  - Instrumented, interconnected, and interacted with each other intelligently.

# Internet of Things (IoT)

- Communication Patterns
  - H2H (human-to-human)
  - H2T (human-to-thing)
  - T2T (thing-to-thing)
- What to achieve: a smart Earth
  - Intelligent cities
  - Clean water
  - Efficient power
  - Convenient transportation
  - Good food supplies
  - Responsible banks
  - Fast telecommunications
  - Green IT
  - Better schools
  - Good health care
  - Abundant resource
  - and so on

# Four Reference Books:


1. K. Hwang, G. Fox, and J. Dongarra, *Distributed and Cloud Computing: from Parallel Processing to the Internet of Things* *Morgan Kauffmann Publishers*, 2011

2. R. Buyya, J. Broberg, and A. Goscinski (eds), Cloud Computing: Principles and Paradigms, ISBN-13: 978-0470887998, Wiley Press, USA, February 2011.

3. T. Chou, *Introduction to Cloud Computing: Business and Technology,* Lecture Notes at Stanford University and at Tsinghua University, Active Book Press, 2010.

4. T. Hey, Tansley and Tolle (Editors), *The Fourth Paradigm : Data-Intensive Scientific Discovery,* Microsoft Research, 2009.