From embedded systems to high performance computing

problems and solutions while waiting for the IOT

Speaker

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Summary

- General Computing challenges
- Drivers for the evolution
- Show-stoppers
- Application of the innovation to some fields of interest
- Examples from innovation projects (videos)
- Question time & Discussion

It’s cross related…it’s complicated

- **Applications are pushing**
  - Cost mass market compatible
  - Invasion in all the aspects of the life
  - Volumes

- **Technology evolve**
  - Integration scale
  - New materials and programming paradigms

- **What is making the meeting in the middle «complicated»?**
  - CMOS technology is arriving to the limit
  - Cost of new basic technologies is sometimes unaffordable
  - Power/energy wall
  - Data proliferation
  - Hard to move from invention to innovation
  - Design methodology is exploiting humans (fortunately)

Let’s start with an example: P3S project

- **Target groups**
  - – Children with cognitive and motor disability (e.g. autistic kids)
  - – Hospitalized Children
    - Their caregivers
    - Therapists
    - Educators
    - Parents
  - – Regular children and families (in the longer term)

TARGET GROUPS: Some numbers

Autism

1 in 68
children

The fastest growing disability in US: + 70% in the last 10 year
(US Center for Disease Control and Prevention, 2014)

Cognitive Disorder

25 M
children

(Developmental Disabilities Monitoring Network 2014)

Motor or intellectual disability

5-7%
world
population

(Annual Rep. US congress 2010)

NEEDS

1. Playful & Embodied Learning

– **play** and **bodily interaction** (tangible manipulation of objects, physical movements in space)
  - stimulates cognitive processes & sensor-motor capacities
  - in all contexts of children's life

Therapeutic Center

Hospital

School

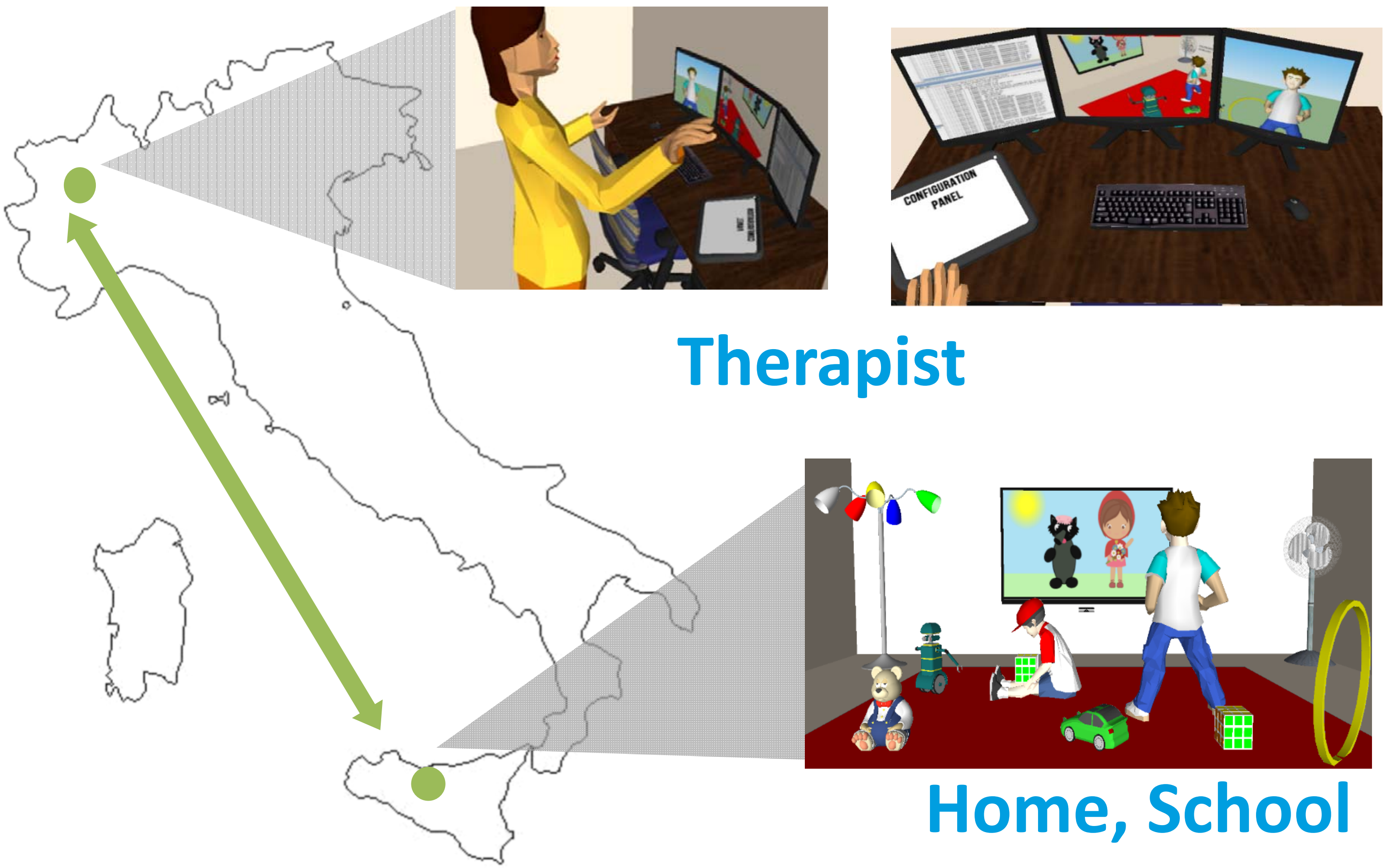
Home

Public Playground

2. New forms of therapy and learning

Need – remote therapy

Smart Spaces → Playful Smart Spaces → Playful Supervised Smart Spaces



P3S CONCEPT: Playful Smart Space

A multisensory "installation" integrated in children's living environments

Physical space enriched with

- Multimedia virtual worlds

  on large displays or projected on the floor/wall/ceiling

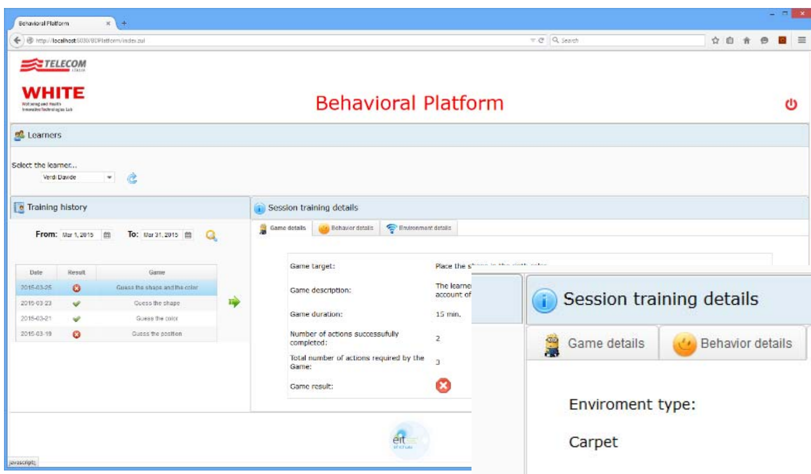
- "smart" objects (e.g. smart lights, smart toys, ...)

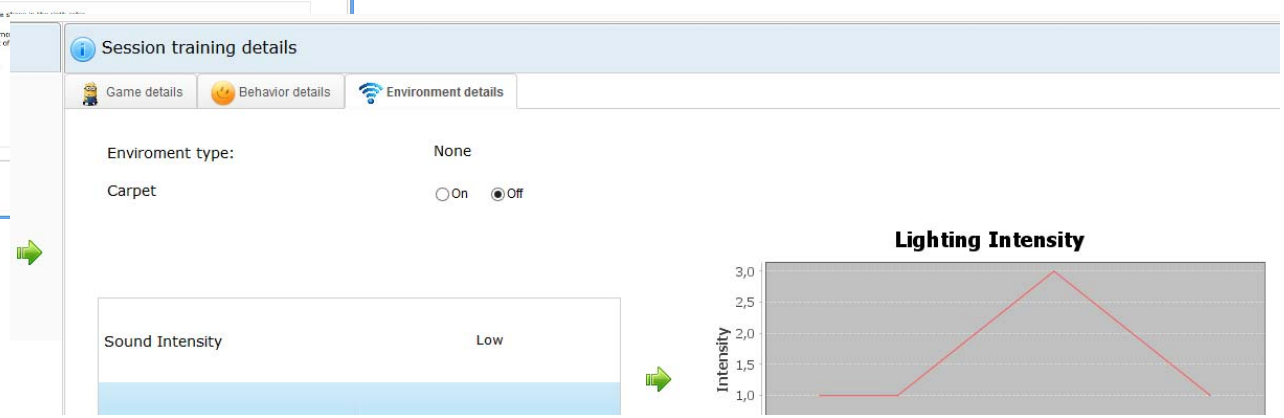
- multiple interaction paradigms (tangible, motion-based, full-body)

P3S Concept: Playful Supervised Smart Space

- **emote sensing and live monitoring of users' interactions**
- **automatic collection of behavioral data**
  - interaction logs
  - ECG monitoring via wearable devices
- **remote (manual or semi-automatic) customization of UX parameters**
- **data analysis (algorithms and interfaces)**





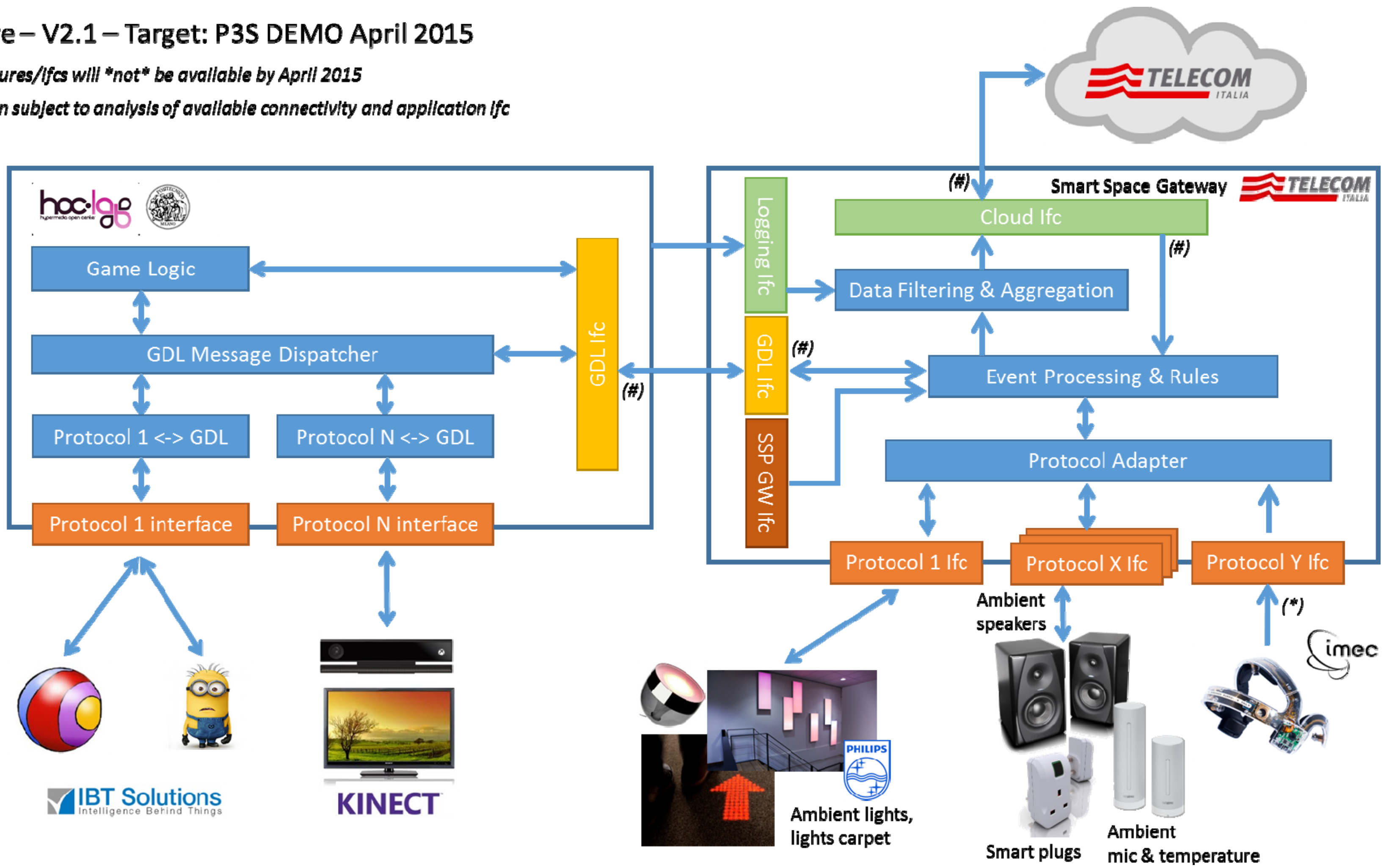


P3S architecture

Architecture – V2.1 – Target: P3S DEMO April 2015

*(#) = these features/Ifcs will *not* be available by April 2015*

(*) = integration subject to analysis of available connectivity and application Ifc

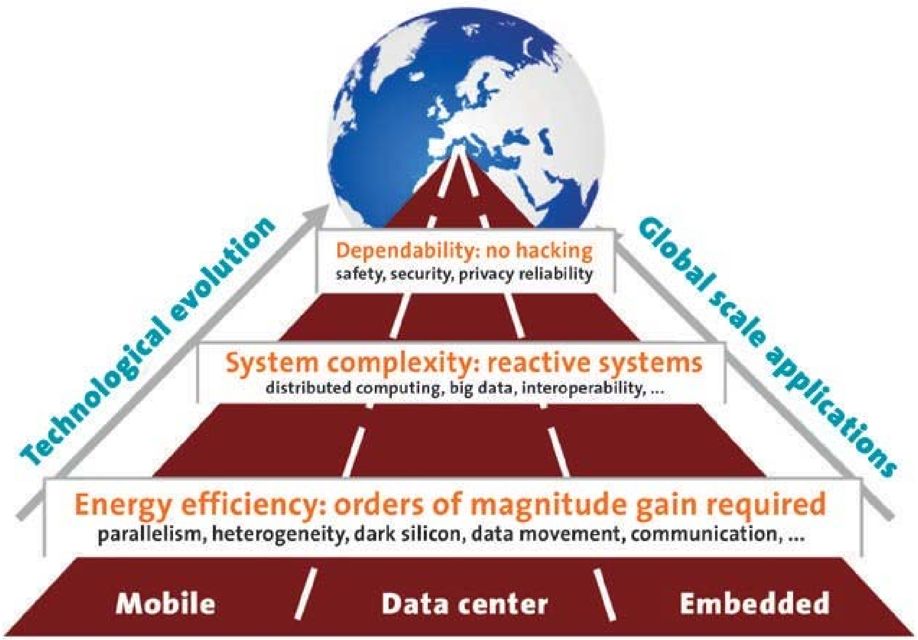


Requirements of a so vertical application

- Sensors possibly wearable
- Computing units
  - Low power for the sensors
  - High Performance Computing for data processing in the cloud
- Communication
  - Bandwidth to the cloud
  - Low power short range for wearable sensors
- Massive storage (in perspective)
- In-field experiments with prototypes and volunteers
- Customizability
- Standardization and compliance to regulations
- Affordable cost
- Design of interoperable software, distribuited architecture
- Hardware interoperability
- Players capable to enter into the market, from the concepts to the product it is a long way to come

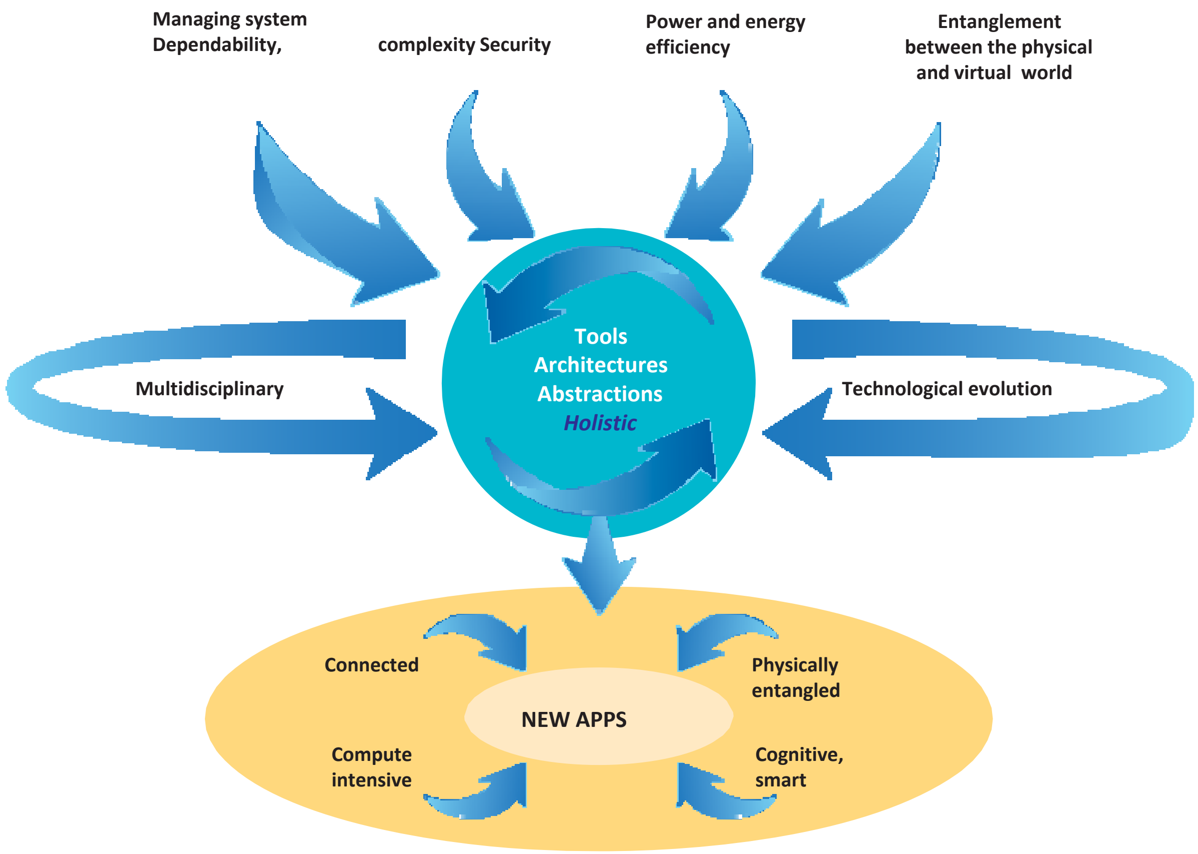
Is the current technology mature enough to substain the evolution of such type of systems/applications?

Main topics from the HiPEAC 2020 vision



- **Energy and power dissipation**: the newest technology nodes made things even worse
- **Dependability**, which affects security, safety and privacy, is a major concern
- **Complexity** is reaching a level where it is nearly unmanageable, and yet still grows due to applications that build on systems of systems

Application needs



Application needs (cont'd)

- They will be **compute-intensive**, i.e. they will require efficient hardware and software components, irrespective of their application domain: embedded, mobile or data center

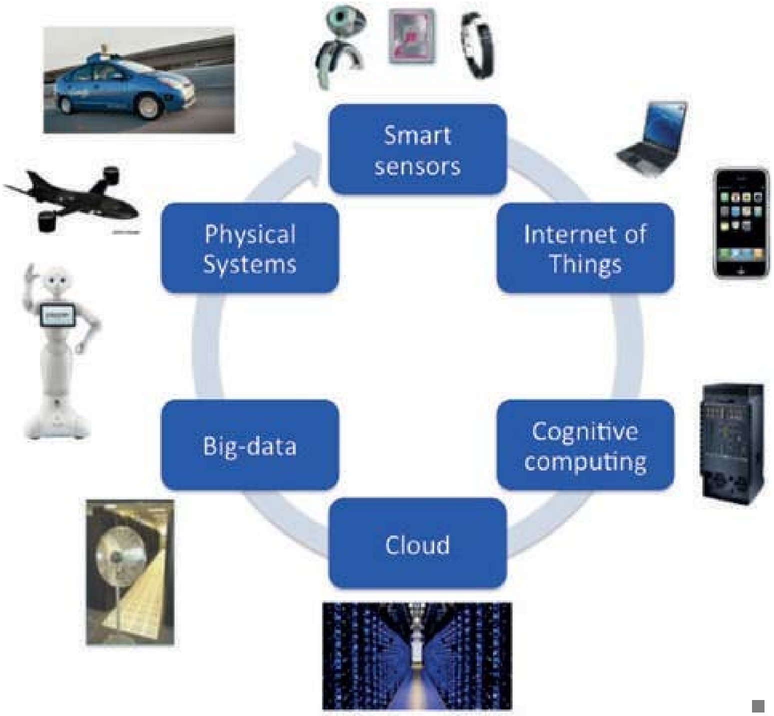
- They will be **connected** to other systems, wired or wireless, either always or intermittently online. In many cases they will be globally interconnected via the Internet

- They will be **entangled physically**, which means that they will not only be able to observe the physical environment that they are operating in, but also to control it. They will become part of our environment

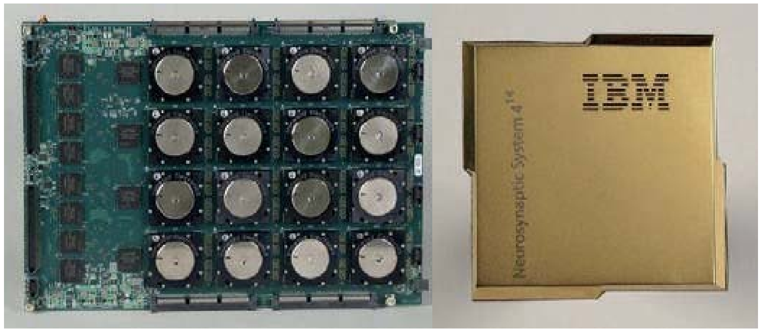
- They will be **smart, able to interpret data** from the physical world even if that data is noisy, incomplete, analog, remote, etc

All future killer applications will have these four characteristics, albeit not all to the same extent

Entanglement btw physical and virtual world



- The virtual, digital world and the real, physical world are being connected in the Internet of Things and in Cyber-Physical Systems
- Cognitive computing is making the interface, often driving big-data analytics and data mining



- SyNAPSE chip (IBM), a brain inspired computer architecture powered by 1 million neurons and 256 million synapses
- It is the largest chip IBM has ever built at 5.4 billion transistors and consists of 4096 neurosynaptic cores
- This architecture is meant to solve a wide class of problems from vision, audition and multi-sensory fusion at very low power

Small savings → great impact!

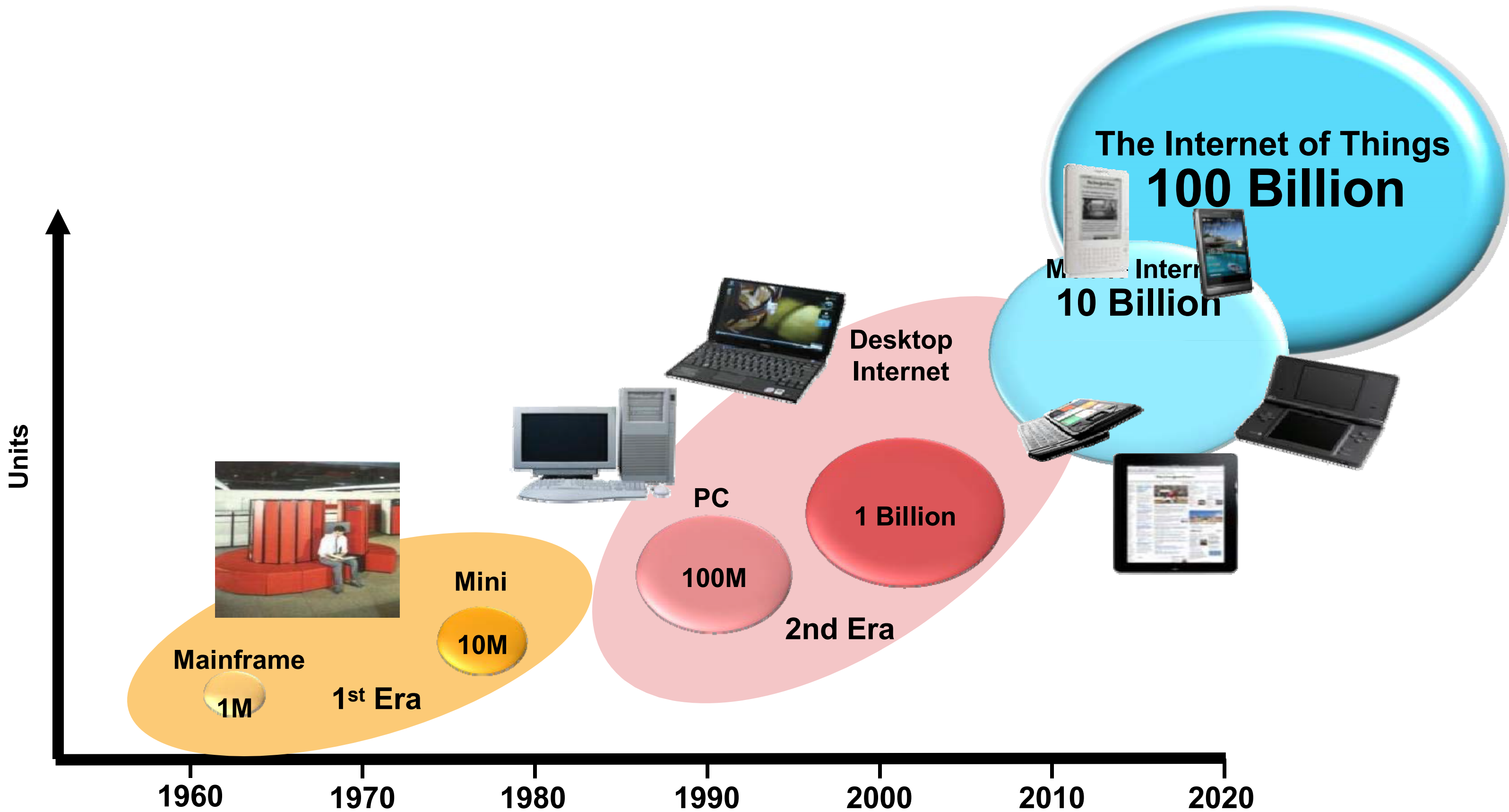
Industrial Internet: The Power of 1 Percent

What if... Potential Performance Gains in Key Sectors

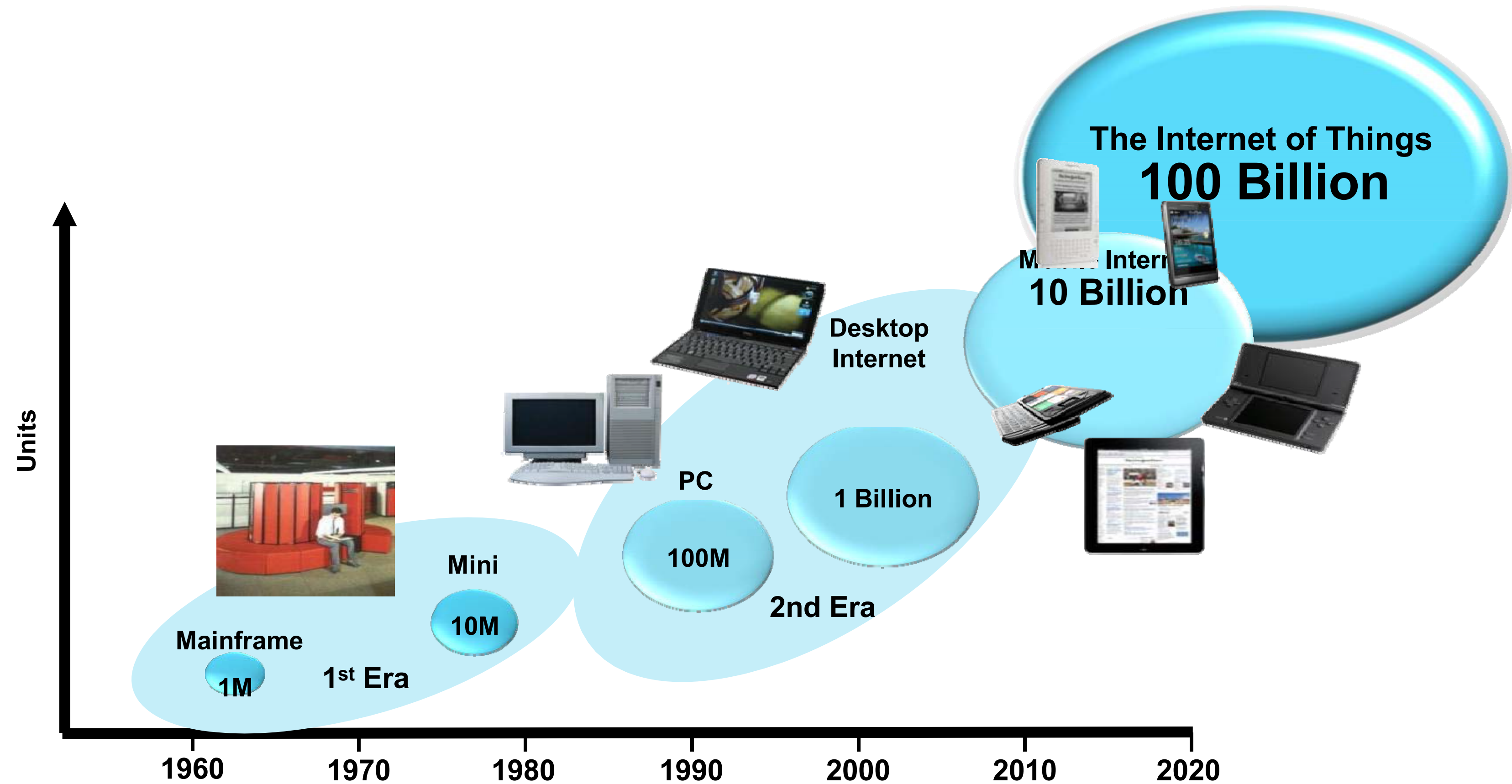
Industry	Segment	Type of Savings	Estimated Value over 15 Years (Billion nominal US dollars)
Aviation	Commercial	1% Fuel Savings	$30B
Power	Gas-fired Generation	1% Fuel Savings	$66B
Healthcare	System-wide	1% Reduction in System Inefficiency	$63B
Rail	Freight	1% Reduction in System Inefficiency	$27B
Oil & Gas	Exploration & Development	1% Reduction in Capital Expenditures	$90B

Note: Illustrative examples based on potential one percent savings applied across specific global industry sectors.
Source: GE estimates

The Eras of Computing



The Eras of Computing



Industry Changes in Requirements

Evolution of the industry-driving metric

Industry Changes in Requirements

Functionality

Evolution of the industry-driving metric

Up to 1980s

Supercomputers & mainframes

Industry Changes in Requirements

Evolution of the industry-driving metric

Functionality

Functionality
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Up to 1980s

Supercomputers & mainframes

1990s

The personal computer

Industry Changes in Requirements

Evolution of the industry-driving metric

Up to 1980s	1990s	2000s
Functionality	$\frac{\text{Functionality}}{\$}$	$\frac{\text{Functionality}}{\text{Power} \times \$}$
Up to 1980s **Supercomputers & mainframes**	**1990s** **The personal computer**	**2000s** **Notebooks**

Industry Changes in Requirements

Evolution of the industry-driving metric

Up to 1980s	1990s	2000s	2010s
Functionality	$\frac{\text{Functionality}}{\$}$	$\frac{\text{Functionality}}{\text{Power} \times \$}$	$\frac{\text{Functionality}}{\text{Energy} \times \$}$
Supercomputers & mainframes	The personal computer	Notebooks	Mobiles & mobility

Strategic Direction

The bad news: this is a very hard metric to optimize for

$$\frac{\text{Functionality}}{\text{Energy} \times \$}$$

The good news: if you crack it, you "own" the simpler metrics as well…

Cost of hardware versus cost of operation

- **1MW for one year costs ~1M$ (average in the US),**
- **increases 20% annually (J. Hamilton, Amazon, Google DC summit May 11**