AmiEs-2022

International Symposium on Ambient Intelligence and Embedded Systems

14 - 17 September, 2022
Antwerp, Belgium

AP UNIVERSITY OF APPLIED SCIENCES AND ARTS ANTWERP

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Kiel, Germany

The Legacy of Mark Weiser and the Evolution of IoT, AIoT, and BIoT

The link between the past and the future of a new group of interconnected innovative technologies.

AmiEs presentation:
A Retrospective and Critical Outlook

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Faculty of Computer Science and Electrical Engineering
Kiel, Germany

Content

- Introduction
- Advances in IT Technology
- Enabling Technology
- The origin of Ubiquitous Computing
- Mark Weiser, Xerox Parc
- Smart devices
- Development and important persons
- Internet of Things (IoT)
- Artificial Intelligence (AI)
- Blockchain (BC)
- Use Cases / Example Applications of IoT, AIoT, BIoT
- Critical Summary and Outlook
- Northern Germany: Research and Development, Cooperation

Disclaimer: This presentation makes no claim to completeness.

Location - Germany

Kiel

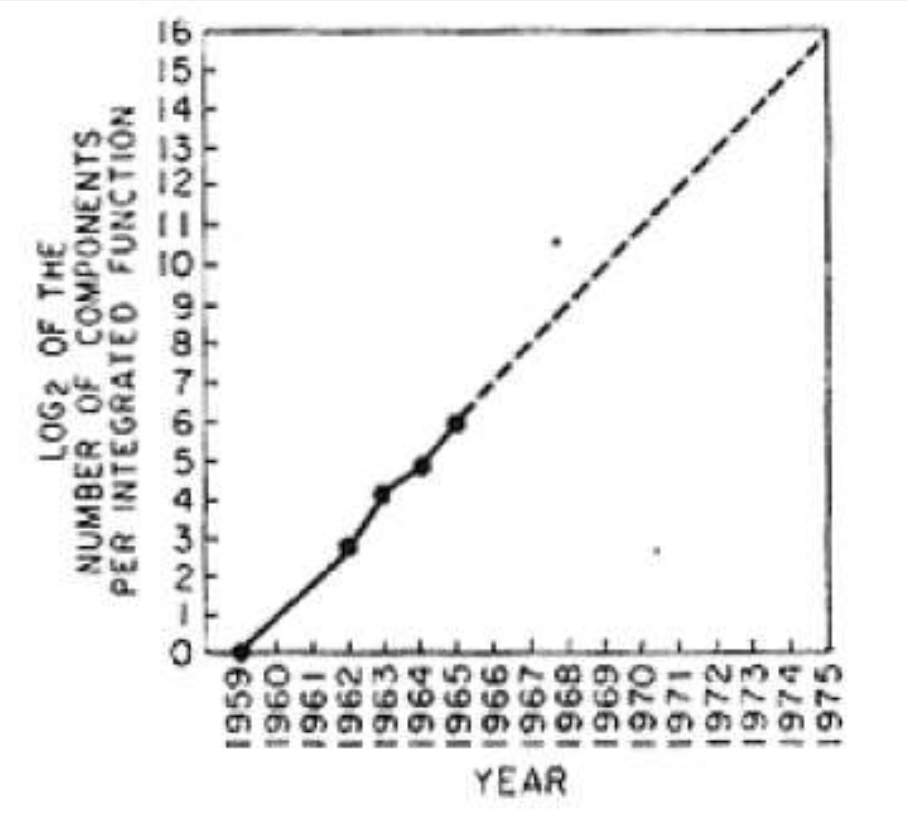
State Capital
of
Schleswig-Holstein

Institution:

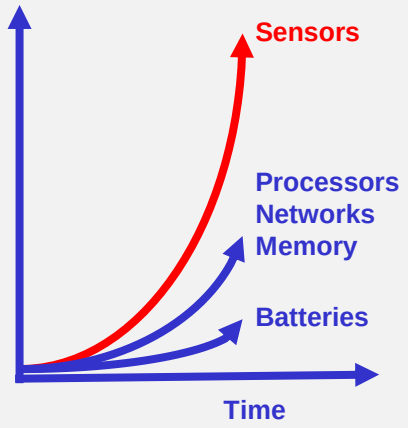
Kiel University of Applied Sciences (KUAS)

Maps Source: https://d-maps.com/

Moore's Law
(early version)



Gordon Moore
Co-founder of Intel in 1968.



Ref.: http://www.intel.com/research/silicon/mooreslaw.htm

“Prediction is very difficult, especially about the future”

(?) Niels Bohr (1885-1962)

Predictions

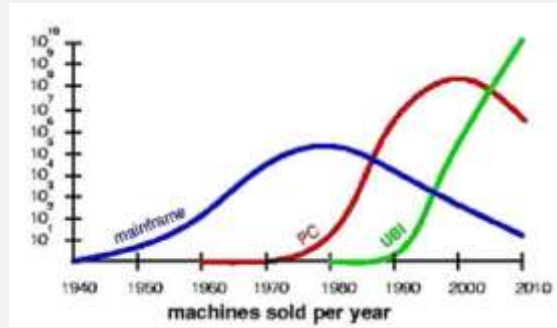
“I think there is a world market for maybe five computers”

Thomas Watson, CEO IBM, **1943**

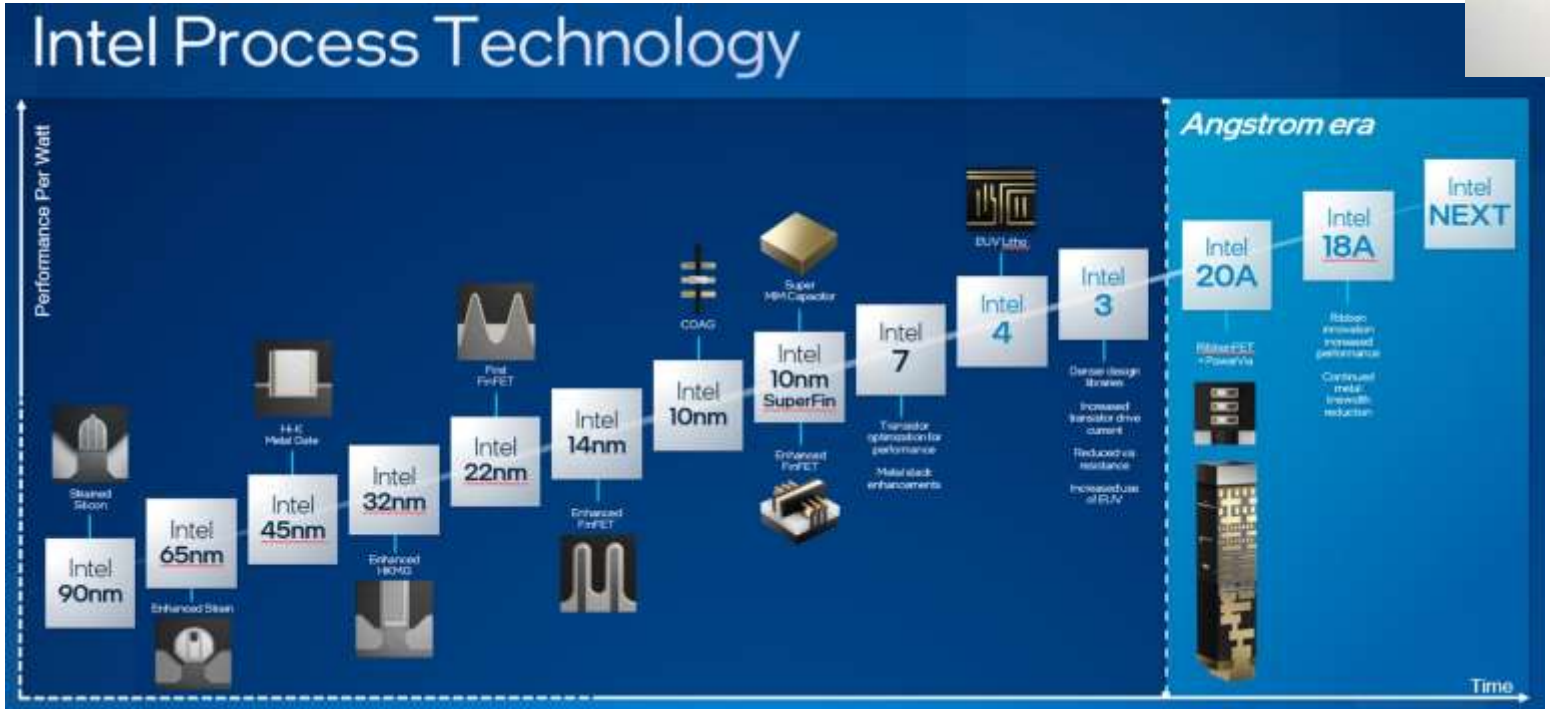
"Picture a day when a billion people will interact with a million e-businesses via a trillion interconnected, intelligent devices"

Louis V. Gerstner Jr., CEO IBM, **2005**

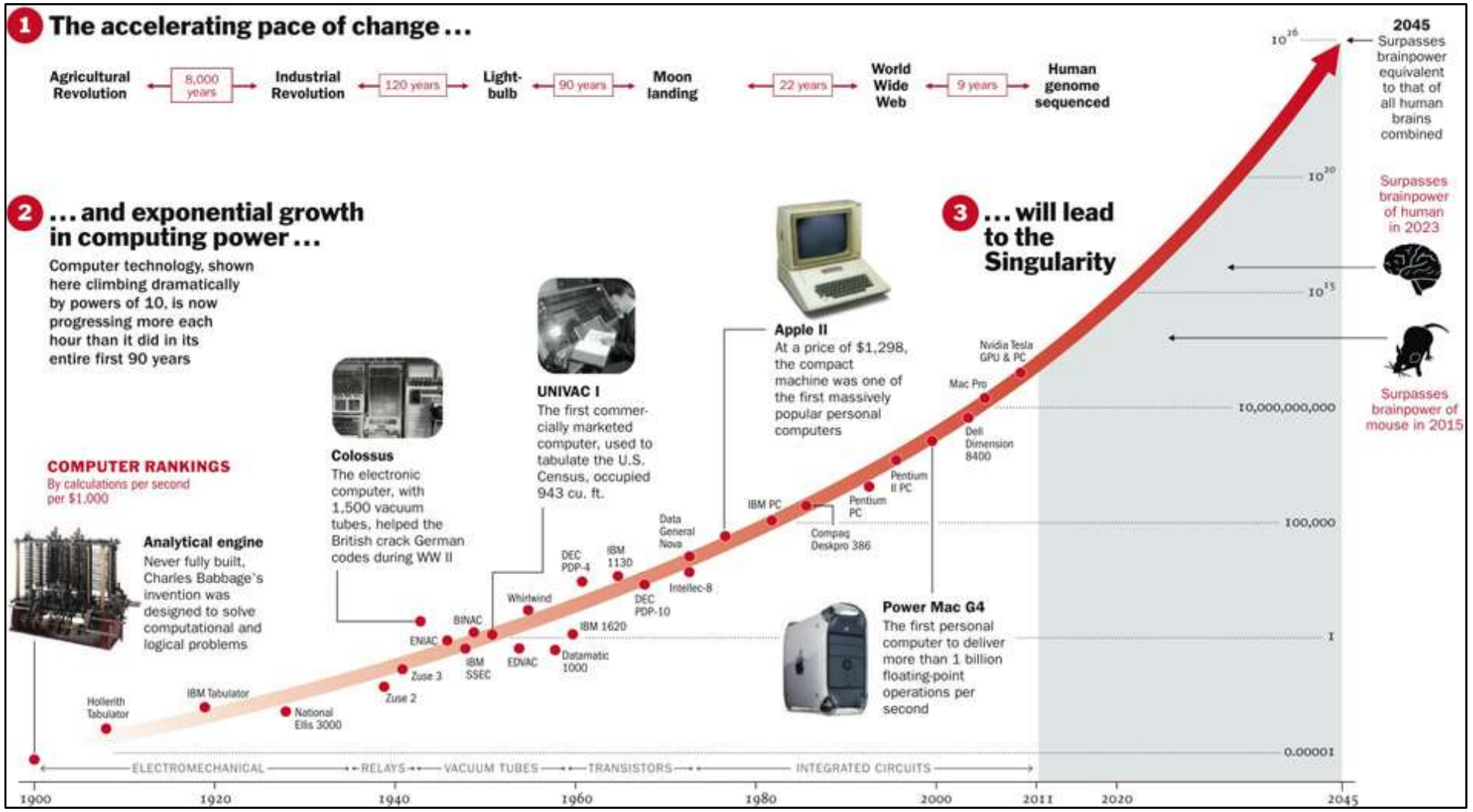
Early Reality (2010)



Intel:
Compute moves to zero



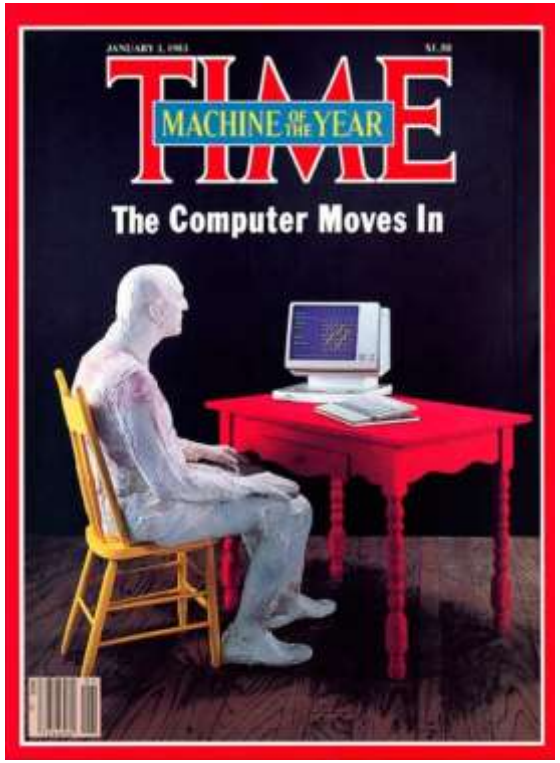
Ref.: Brian David Johnson, Intel, 2012



Ref.: TIME USA 2019 - http://content.time.com/time/interactive/0,31813,2048601,00.html

Exactly 40 Years ago:
A big step for mankind?

The computer is named Time's person of the year.



TIME MAGAZINE

1982
MACHINE OF THE YEAR
THE COMPUTER

Comparison:

1982: 621,000 home computers in the U.S.

40 years later:

2021: 621,000 computers sold in the U.S. every 3 days.

Ref.:
Time Magazine

Ubiquitous Computing: The Roots

The idea of ubiquitous computing as invisible computation was first articulated by **Mark Weiser** in 1988 at the **Computer Science Lab at Xerox PARC.**

Mark Weiser
July 23, 1952 - April 27, 1999

Xerox PARC:
"*Palo Alto Research Center*"
(now "*Palo Alto Research Center Incorporated*")
http://www.parc.xerox.com/

"Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives."

→ **Calm Technology**

"Ubiquitous Computing is fundamentally characterized by the connection of things in the world with computation"

Ref.:
http://www.ubiq.com/hypertext/weiser/weiser.html

Scientific American Ubicomp Paper

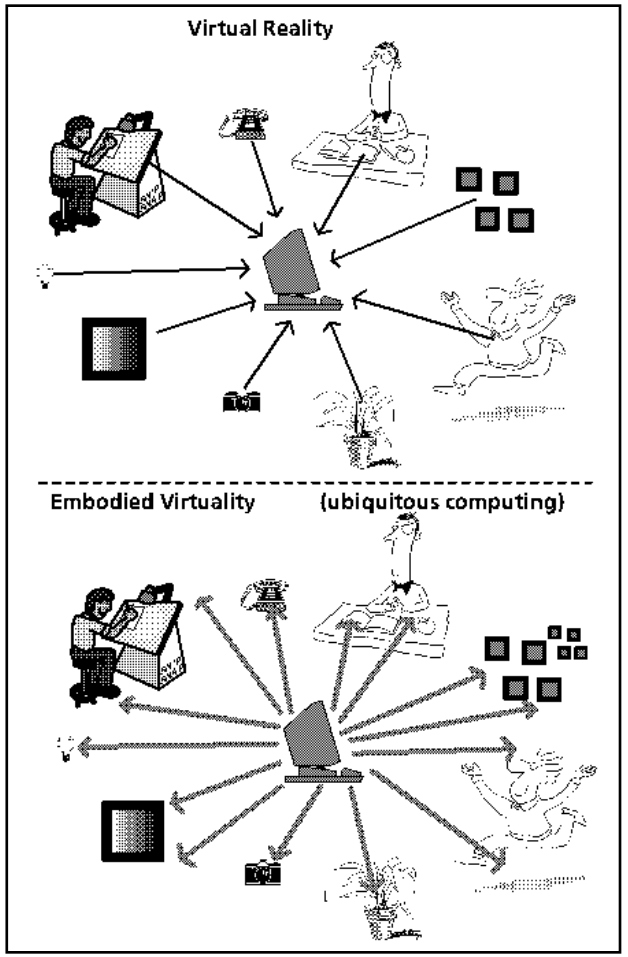
SCIENTIFIC AMERICAN.COM

Mark Weiser:
The Computer for the 21st Century,
Sci. Amer., 265 (3), 94-104, September 1991

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."

Mark Weiser, March 23, 1993

"Ubiquitous computing is the method of enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user."



Ubiquitous Computing:
Virtual Reality vs. Embodied Virtuality

SCIENTIFIC AMERICAN.COM

Mark Weiser:
The Computer for the 21st Century

"*Most important, ubiquitous computers will help overcome the problem of information overload.*

There is more information available at our fingertips during a walk in the woods than in any computer system, yet people find a walk among trees relaxing and computers frustrating. Machines that fit the human environment, instead of forcing humans to enter theirs, will make using a computer as refreshing as taking a walk in the woods."

→ We will come back to this.

Trends in Computing: persons involved and new paradigms

Nicholas Negroponte, 1995 MIT Media Labs	"Things that think want to link" "Things That Think also includes Things That Link" This is the doctrine on which pervasive computing is based!
David Culler, 1999 University of California Berkeley	"New eras of computing start when the previous era is so strong it is hard to imagine that things could be different"
Neil Gershenfeld, 1999 MIT's Media Lab., Things That Think consortium.	"When things start to think" Hardware-architecture definition of "Smart Devices" BILL of Things' rights (Things have right to): Have an identity, Access other objects Detect the nature of their environment.
Adam Greenfield, 2006	"Everyware"

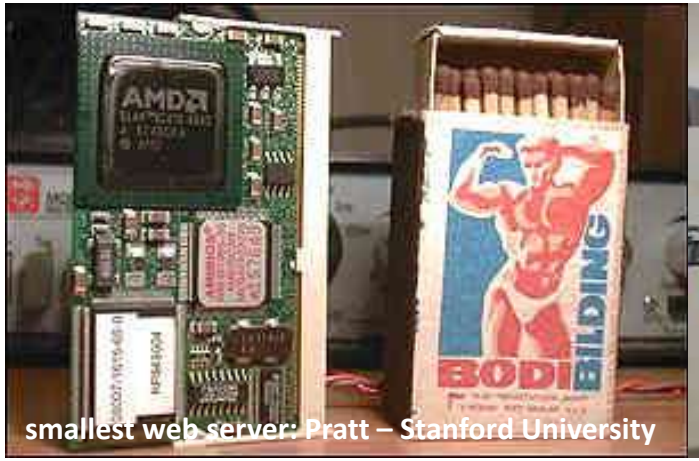
→ **Smart devices** → **The Internet of Things**

(not related to AI)

Smart device:
A physical object with an embedded processor, memory, sensors and/or actuators, and a network connection.

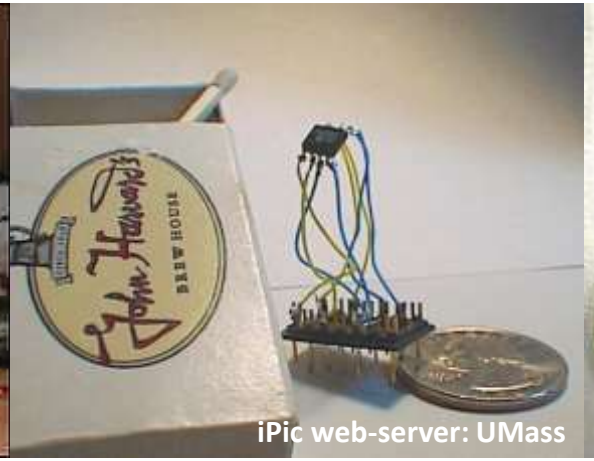
Ref. Photo Negroponte: Spiegel.de; Photo Culler, Gershenfeld, Greenfield: wikimedia.org

Smart Devices and basic technologies: Early entries (1999+)



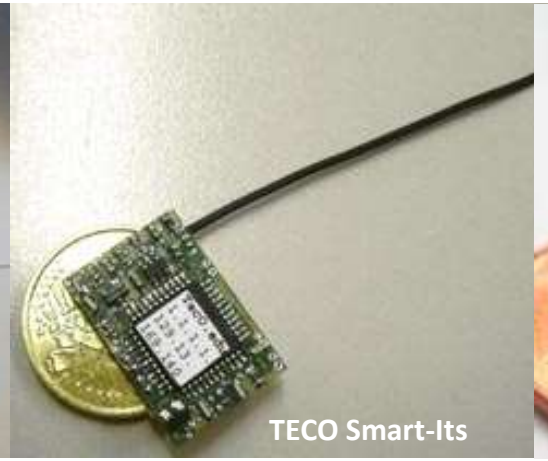
smallest web server: Pratt – Stanford University

Ref. http://news.bbc.co.uk/1/hi/sci/tech/276762.stm



iPic web-server: UMass

Ref.: http://www-ccs.cs.umass.edu/~shri/iPic.html

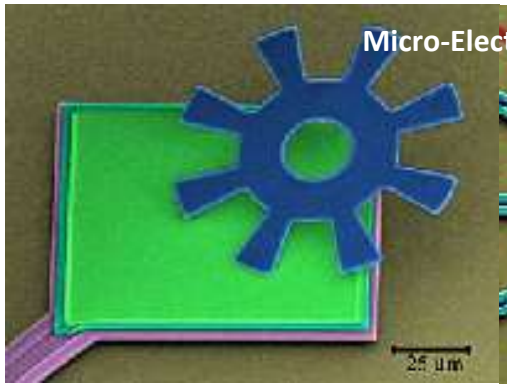


TECO Smart-Its

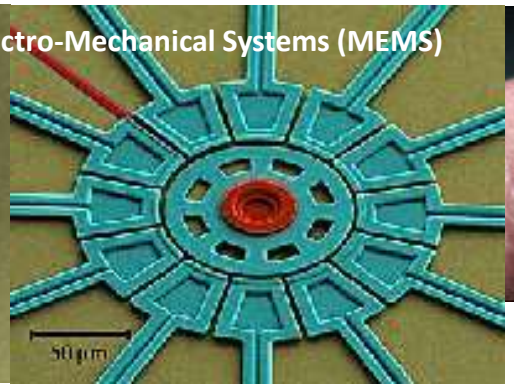
TECO µPart
Particle Computer

Ref.: http://particle.teco.edu/, http://www.smart-its.org/

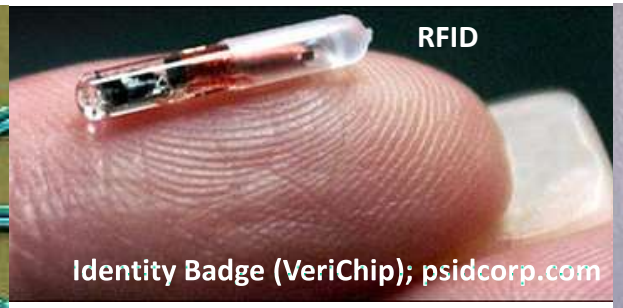
→ European initiative "The Disappearing Computer"



Micro-Electro-Mechanical Systems (MEMS)

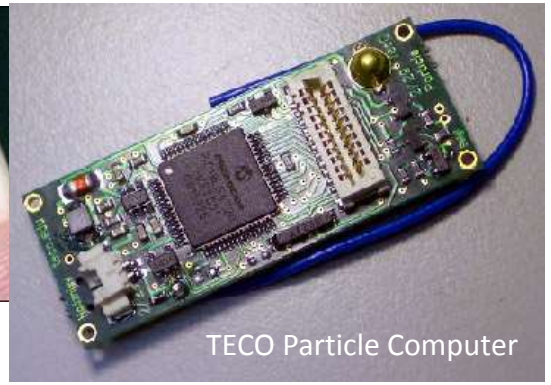


Ref.: http://www.mems-exchange.org/



RFID

Identity Badge (VeriChip); psidcorp.com



TECO Particle Computer

New computing concept: Motes, Smart Dust, Sensor Networks

Main Mica2 Board

Mica2

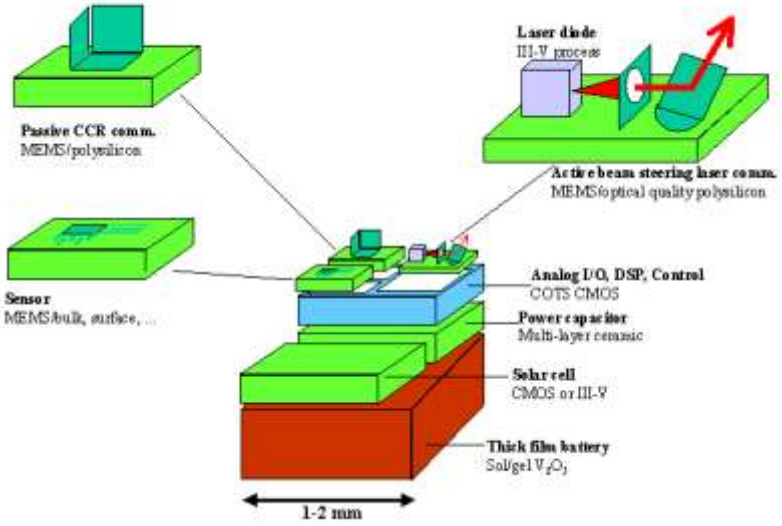
Transceiver Board

Mica2Dot

MicaDot Sensor Board

Spec Mote

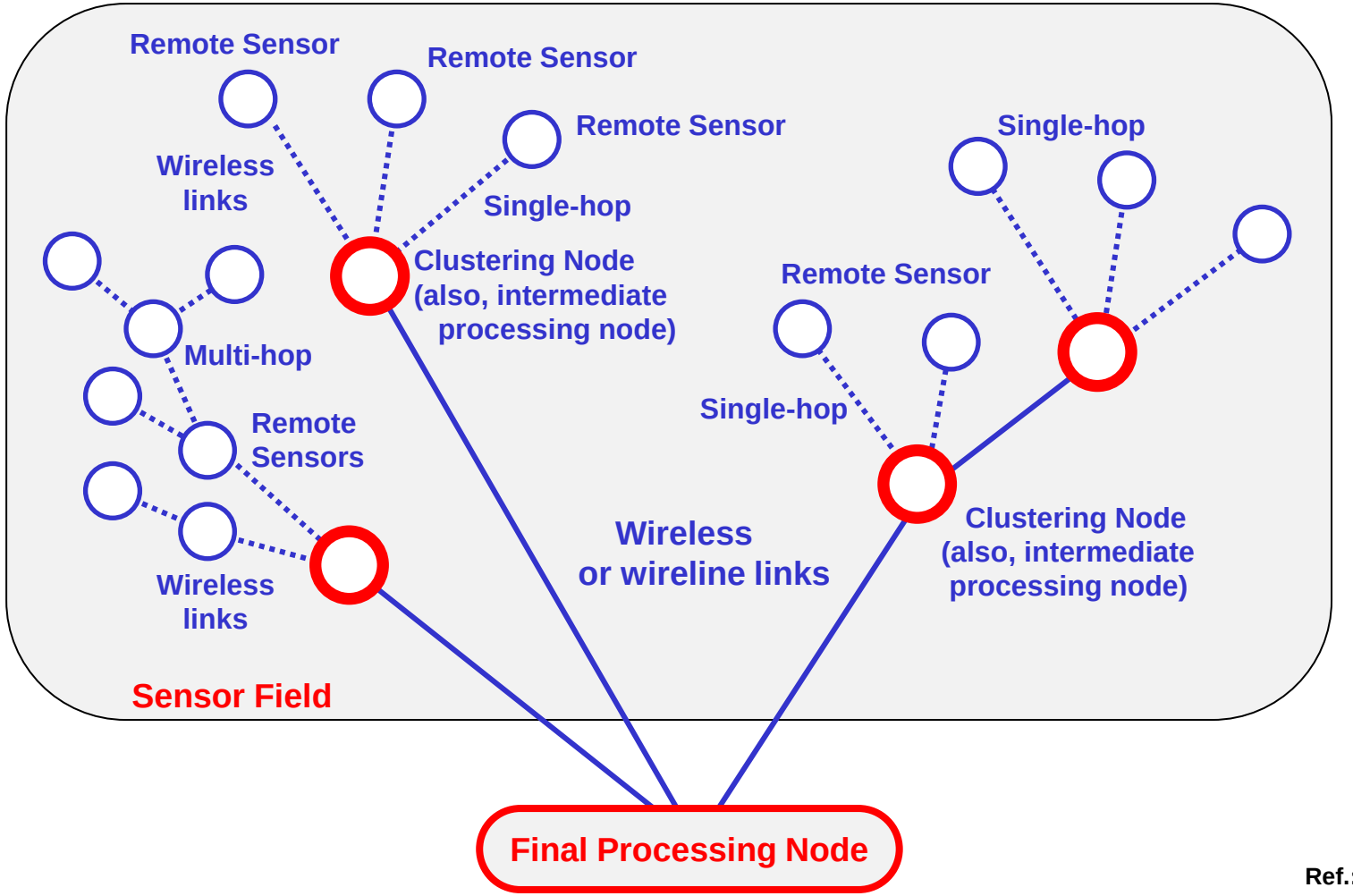
Smart Dust Components



UCLA Medusa

MIT µAMPS

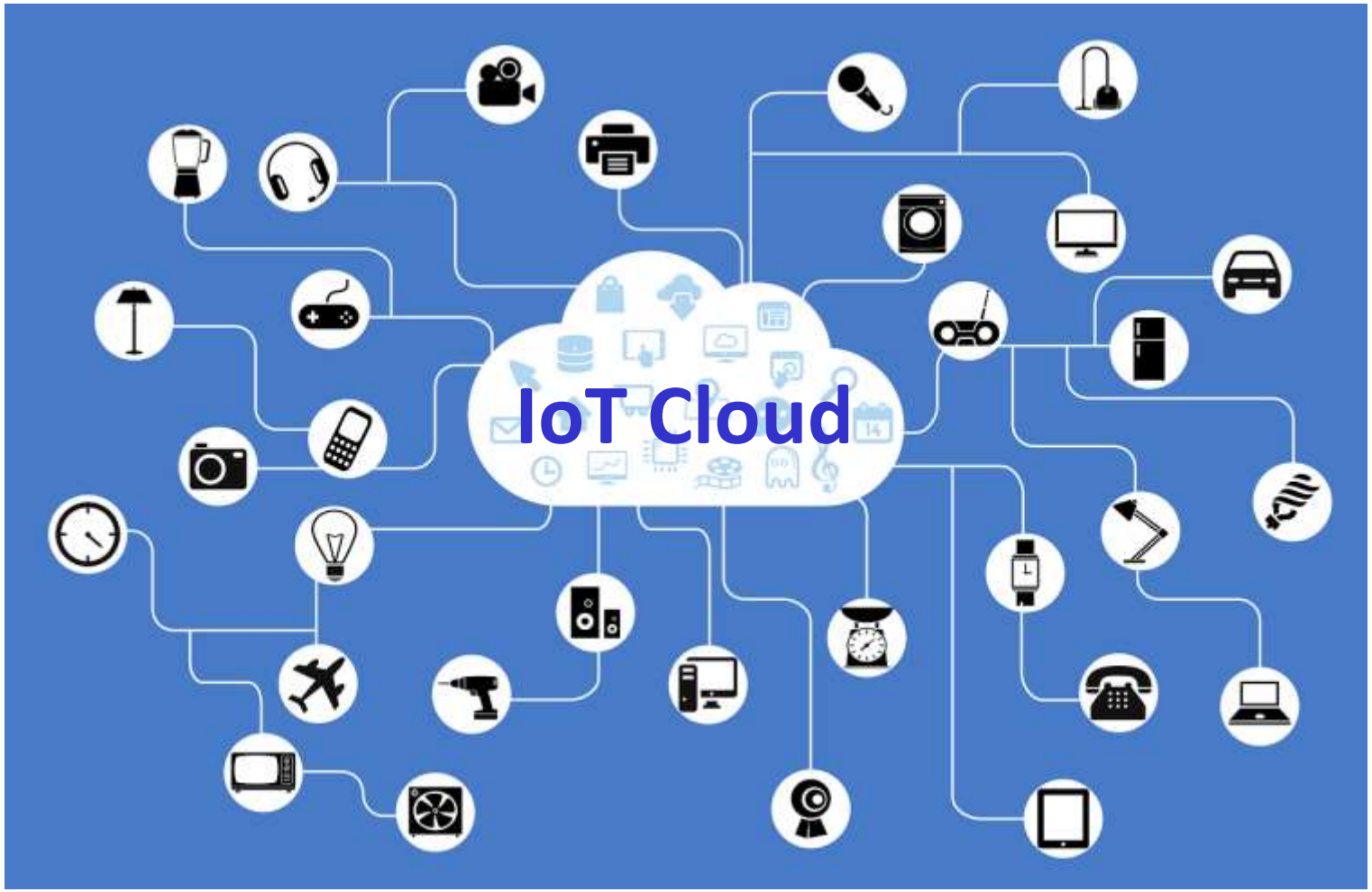
Typical sensor network arrangement



leading to

Ref.: adopted from
Kazem Sohraby, Daniel Minoli, Taieb Znati.
"Wireless sensor networks", 2007

Transformation to IoT Cloud



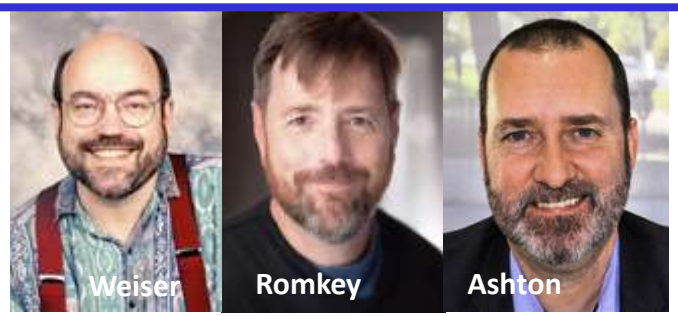
Picture Ref.: PIxabay

The Internet of Things - IoT

Future Computing – Today Innovation Terminology

- Post-PC Era
- Dissappearing Computer
- Ubiquitous Computing (UbiComp)
- Pervasive Computing
- Nomadic Computing
- Proactive Computing
- Mobile Computing
- Wearables
- Ambient Intelligence (AmI)
- Embedded Systems
- Wireless (Sensor/Actuator) Networks
- Physical Computing
- Tangible Media
- Cyber-Physical Systems (CPS)
- Smart Dust, Smart Devices, Smart Appliances
- Cloud Computing
- Big Data
- Industry 4.0

Development of the Internet of Things (IoT)



1988
Mark Weiser
Xerox PARC
"UbiComp"

1999
Kevin Ashton (at P&G)
coins "Internet of Things"

2009
Cisco
IoT officially adopted

IoT

1993
Quentin Stafford Fraser
coffee pot

2005
Arduino
Hardware

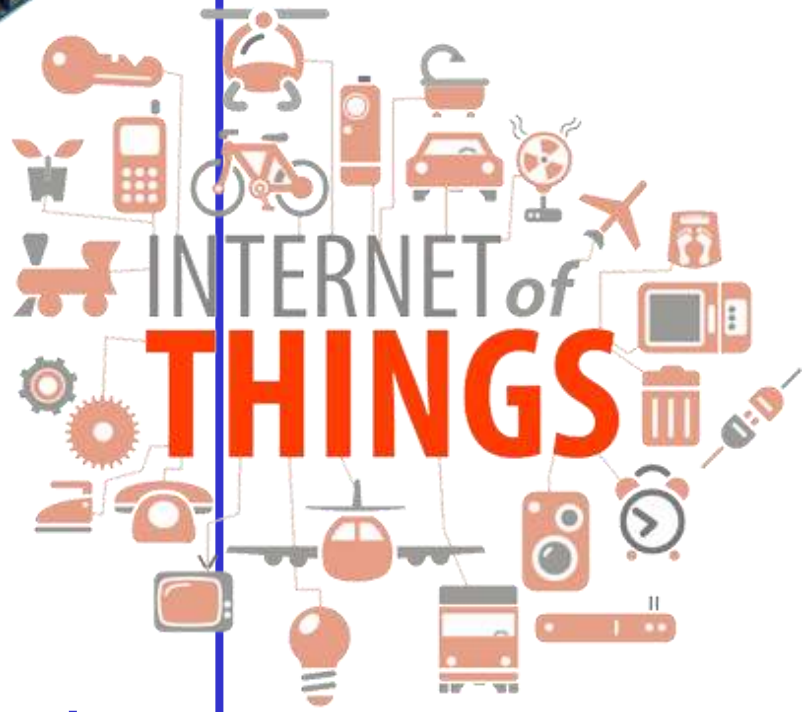
2012
Raspberry PI

1982
Carnegie Mellon
The "Only" Coke
Machine on the
Internet

1990
John Romkey
Internet (Sunbeam)
Toaster
(at Interop)

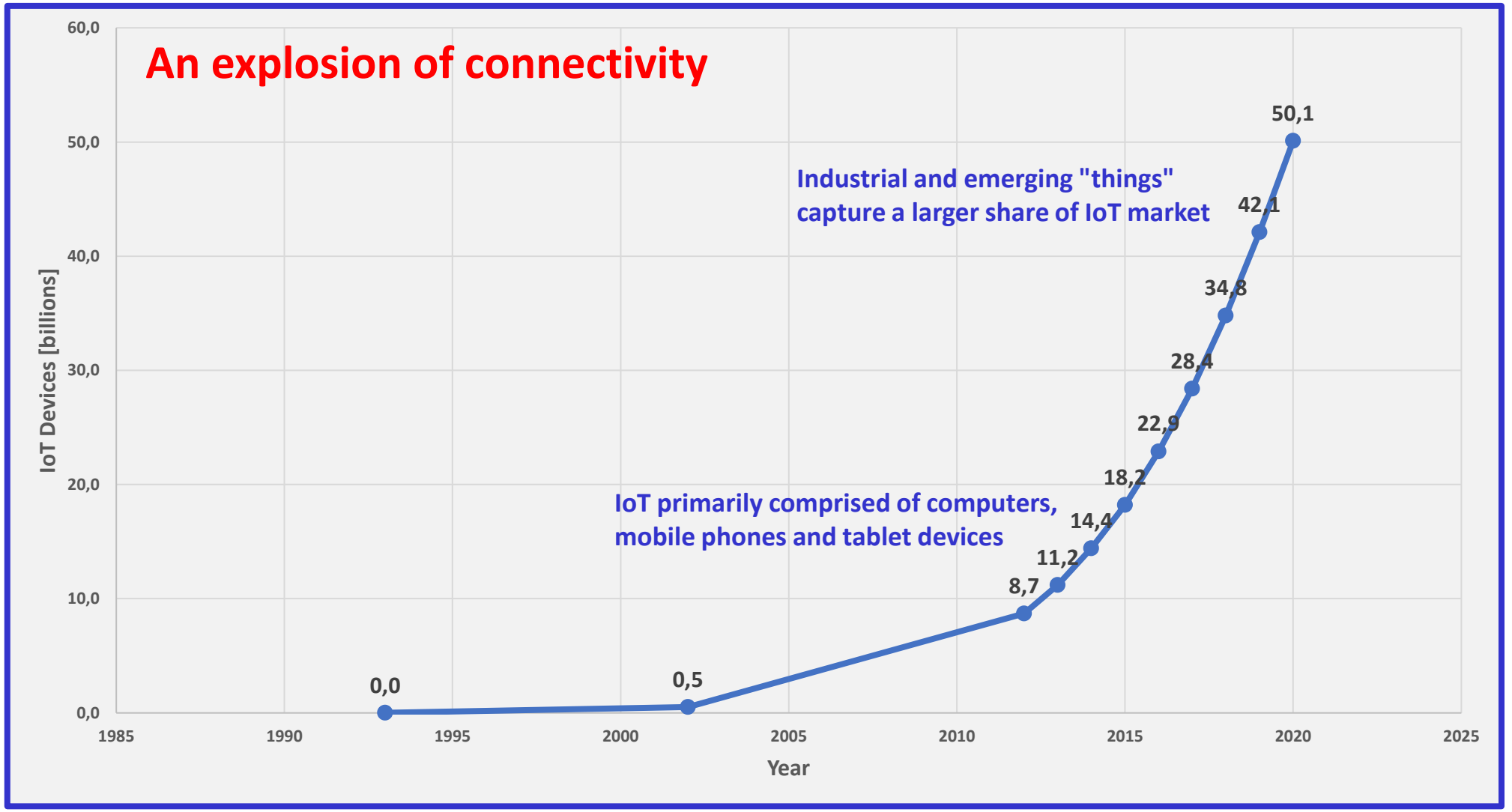
2014
IIoT starts

1980 1990 2000 2010 2020



Ref.: Mark Weiser photo: https://alchetron.com/Mark-Weiser; Kevin Ashton photo: Larry D. Moore, CC BY-SA 4.0, Wikimedia Commons;
John Romkey photo: romkey.com

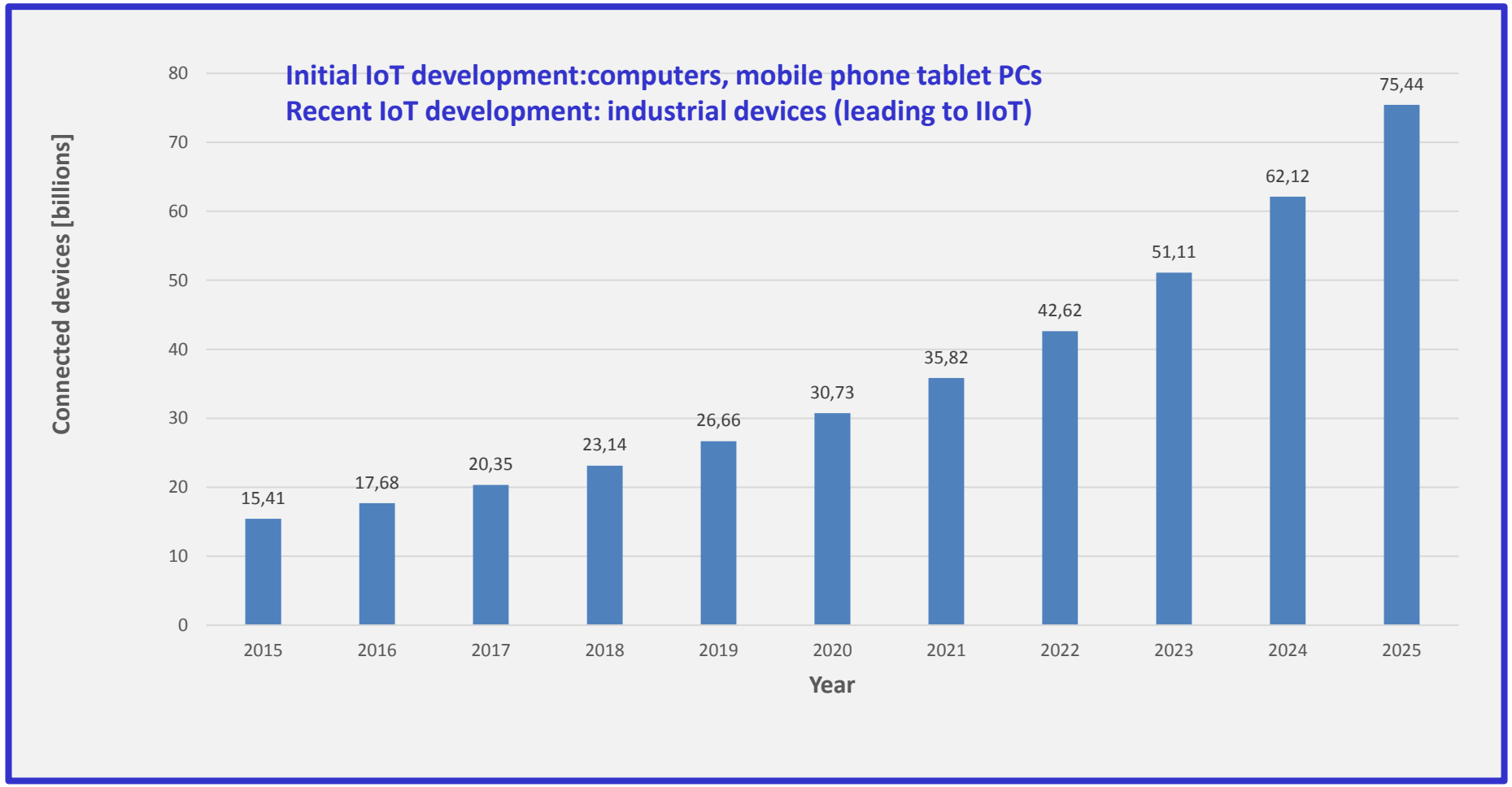
Electronic Devices – global development *



* including projected data

Ref.: IHS, Forbes

Internet of Things (IoT) connected devices installed base worldwide *

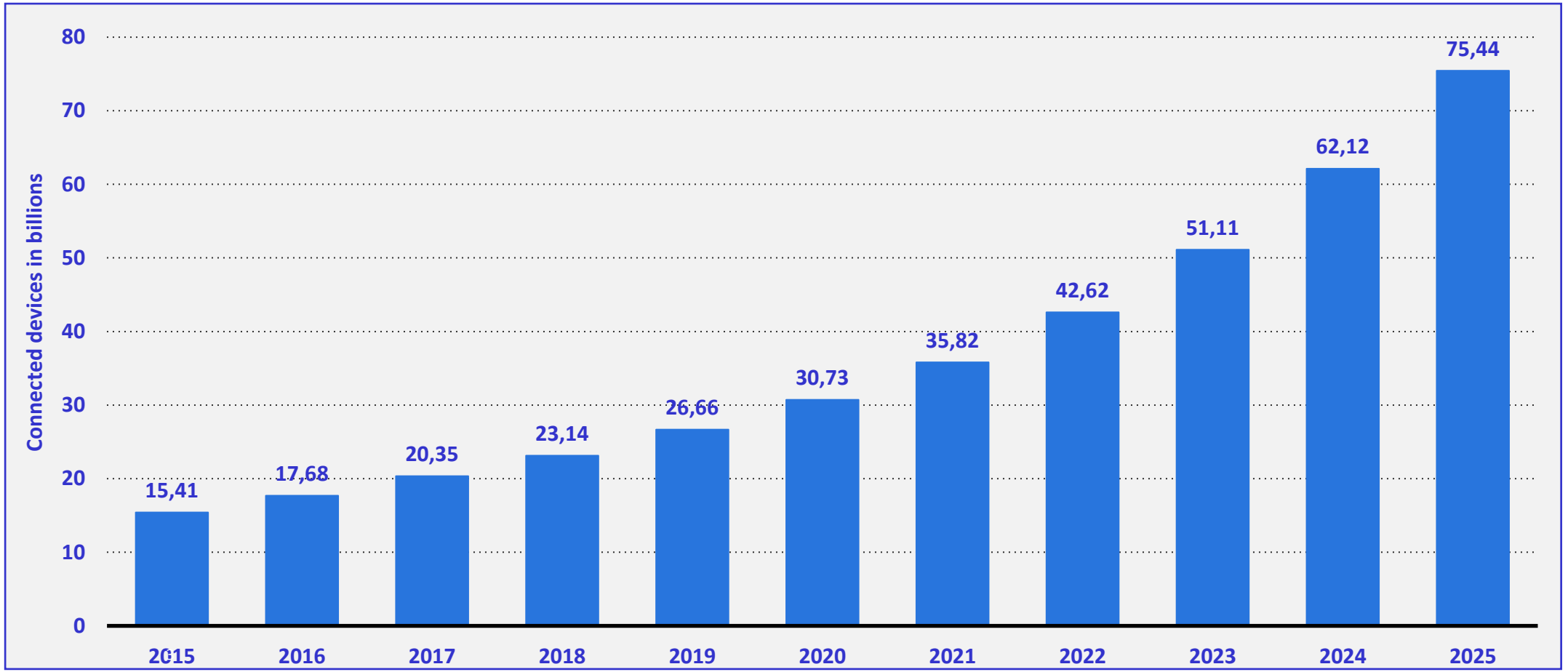


* including projected data

Ref.: IHS, Forbes

statista

Internet of Things (IoT) connected devices installed base worldwide from 2015 to 2025 (in billions) *

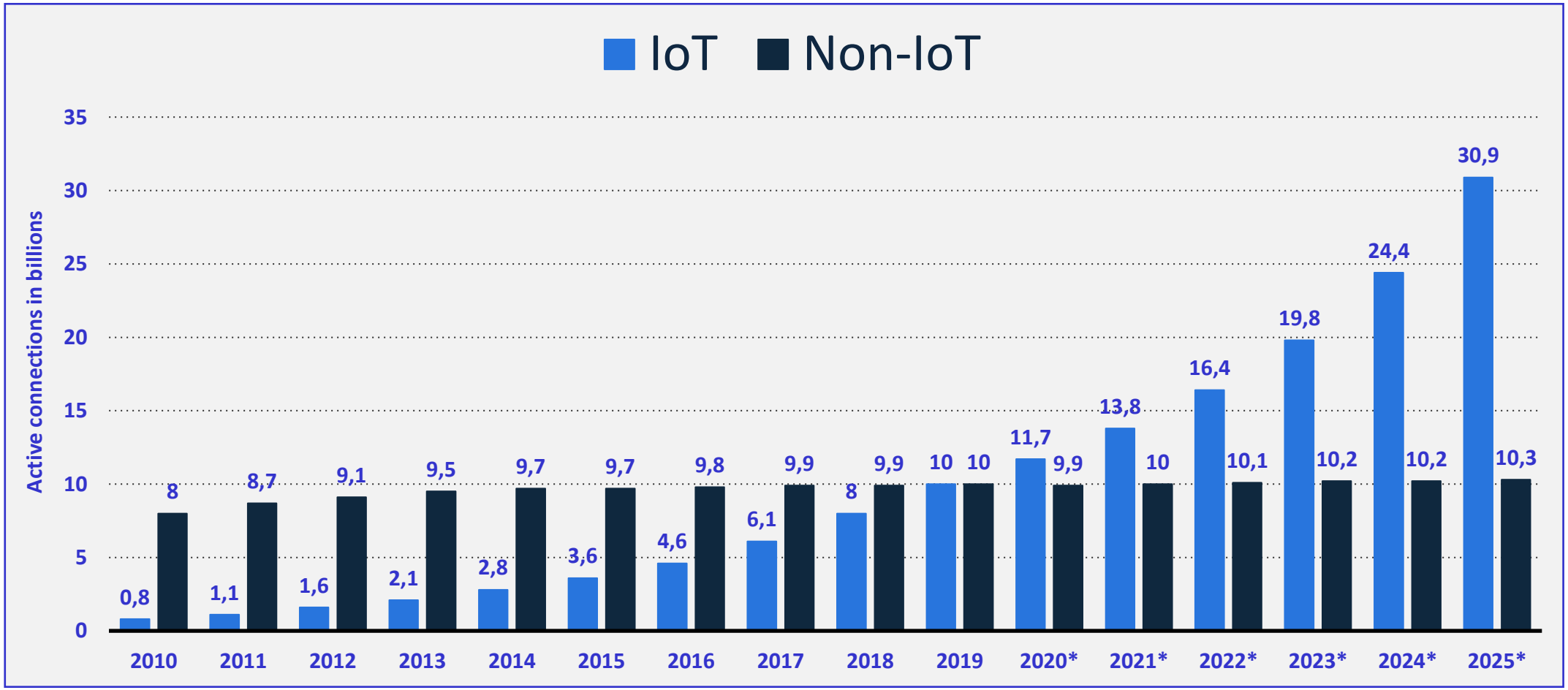


Note(s): Worldwide; 2015 to 2016
Further information regarding this statistic can be found on page 8.
Source(s): IHS; Forbes; ID 471264

* including projected data

statista

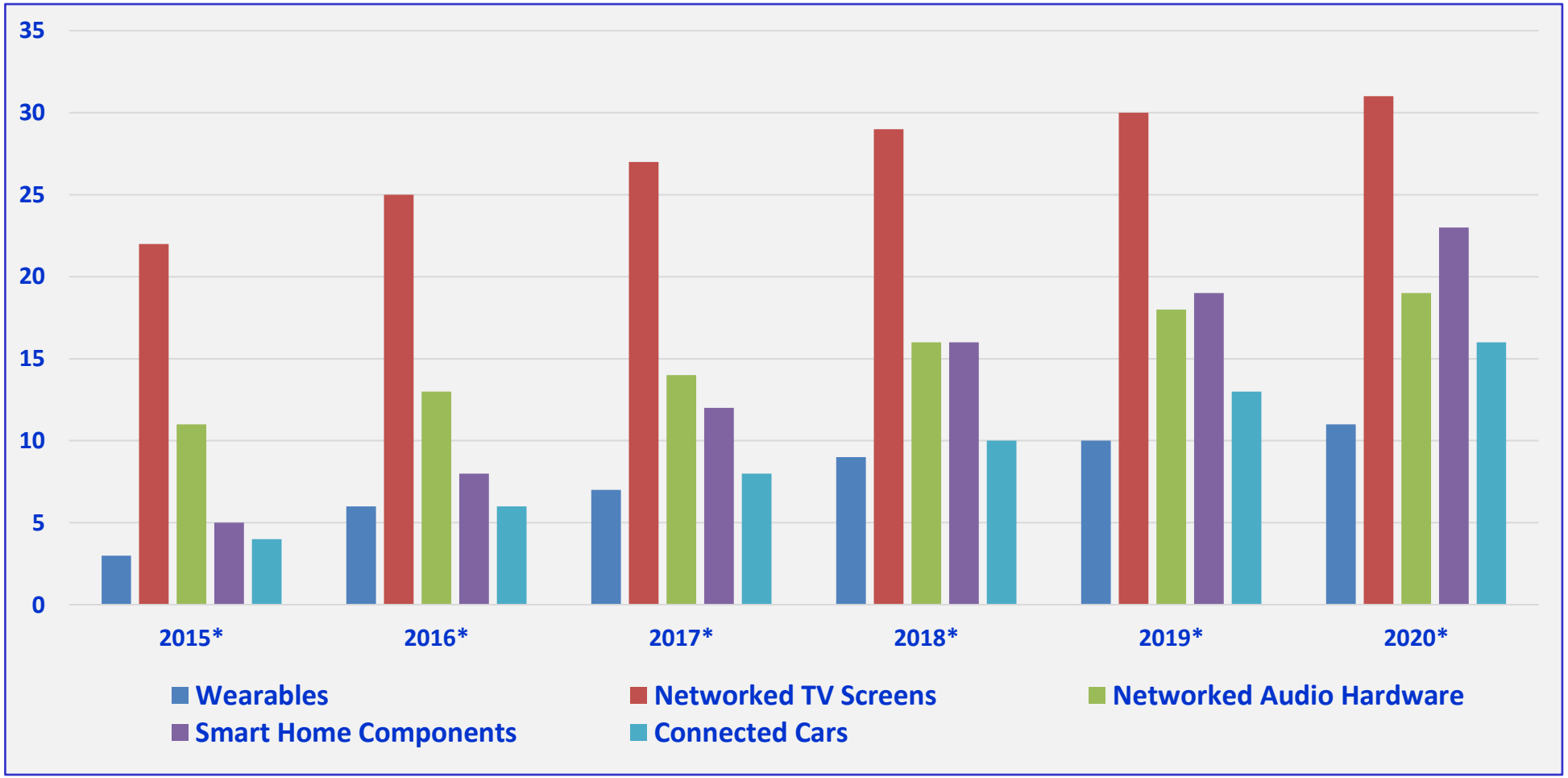
Internet of Things (IoT) and non-IoT smart (consumer) appliances active device connections worldwide from 2010 to 2025 (in billions)



Description: The total installed base of Internet of Things (IoT) connected devices worldwide is projected to amount to 30.9 billion units by 2025, a sharp jump from the 13.8 billion units that are expected in 2021. Read more
Note(s): Worldwide; 2015 to 2019; * Estimate. According to the source, non-IoT includes mobile phones, tablets, PCs, laptops, and fixed line phones. IoT includes all B2B and consumer devices connected. Read more
Source(s): IoT Analytics

statista

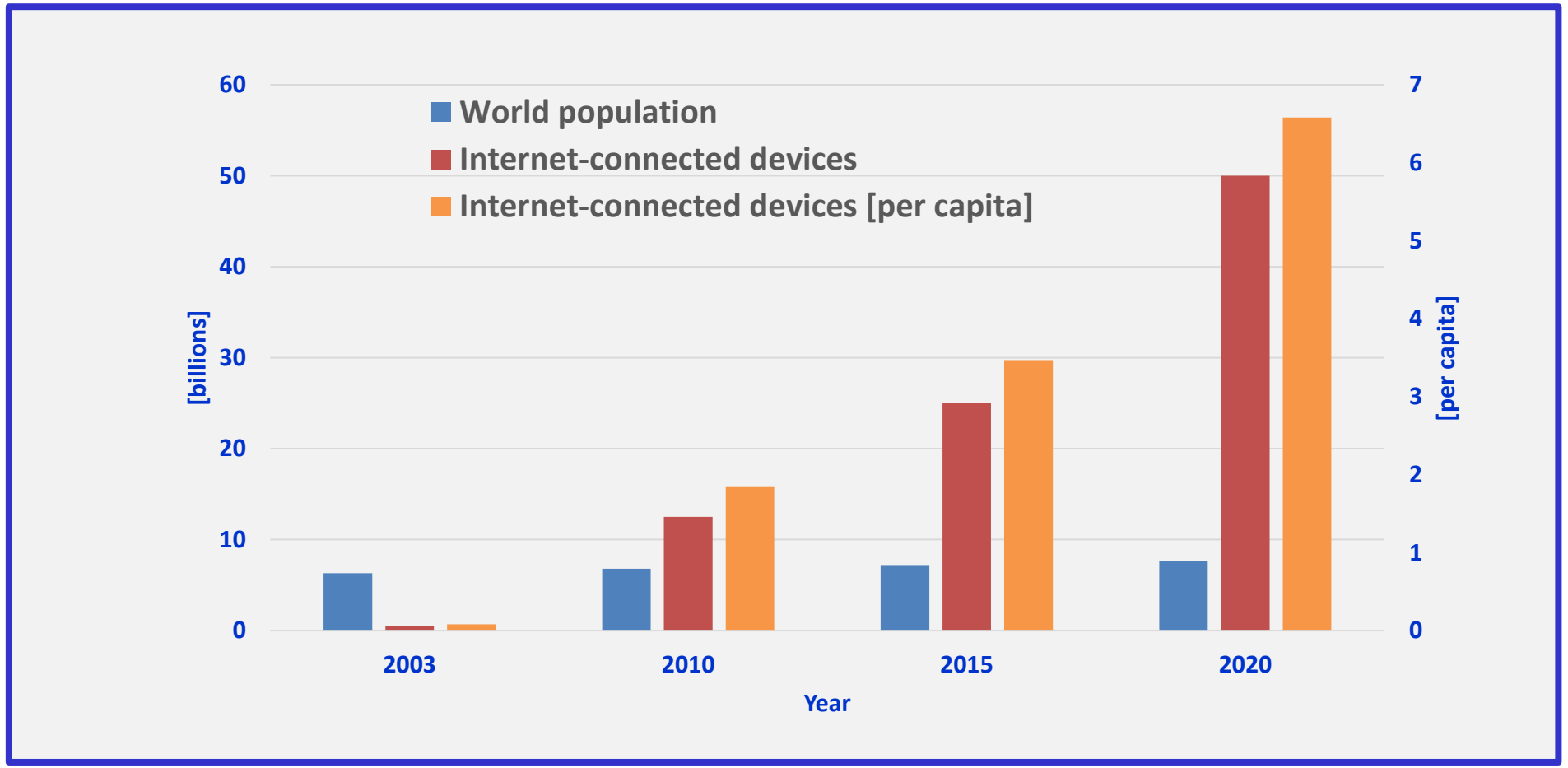
Consumer IoT Devices in Germany 2015 – 2020
[in Million Units]



Quelle(n): Deloitte; ID 537105

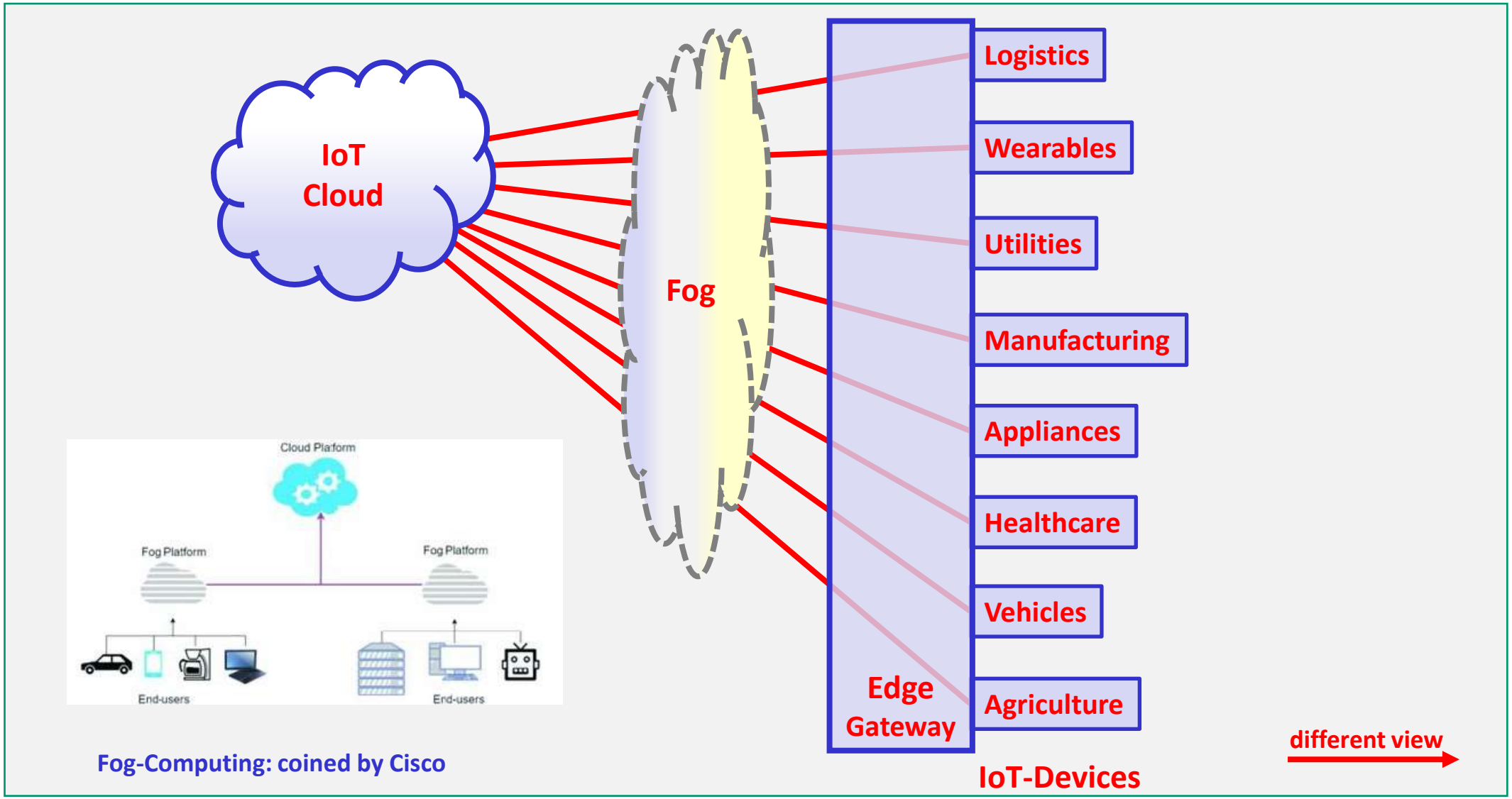
statista

Internet-connected devices compared to world population



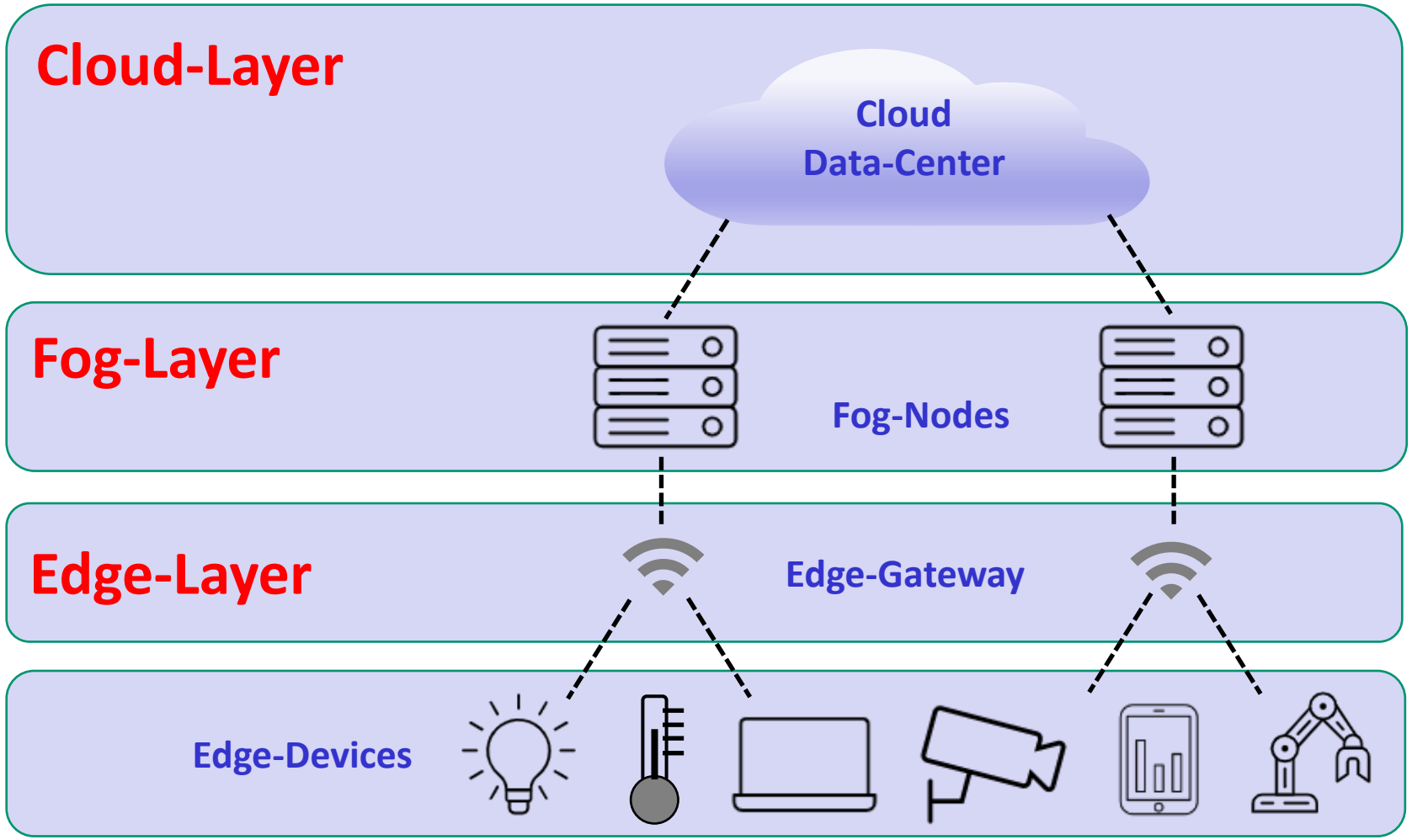
Ref.:
Cisco Internet Business Solutions Group (IBSG)

Typical IoT Architecture (current status)



Fog-Computing: coined by Cisco

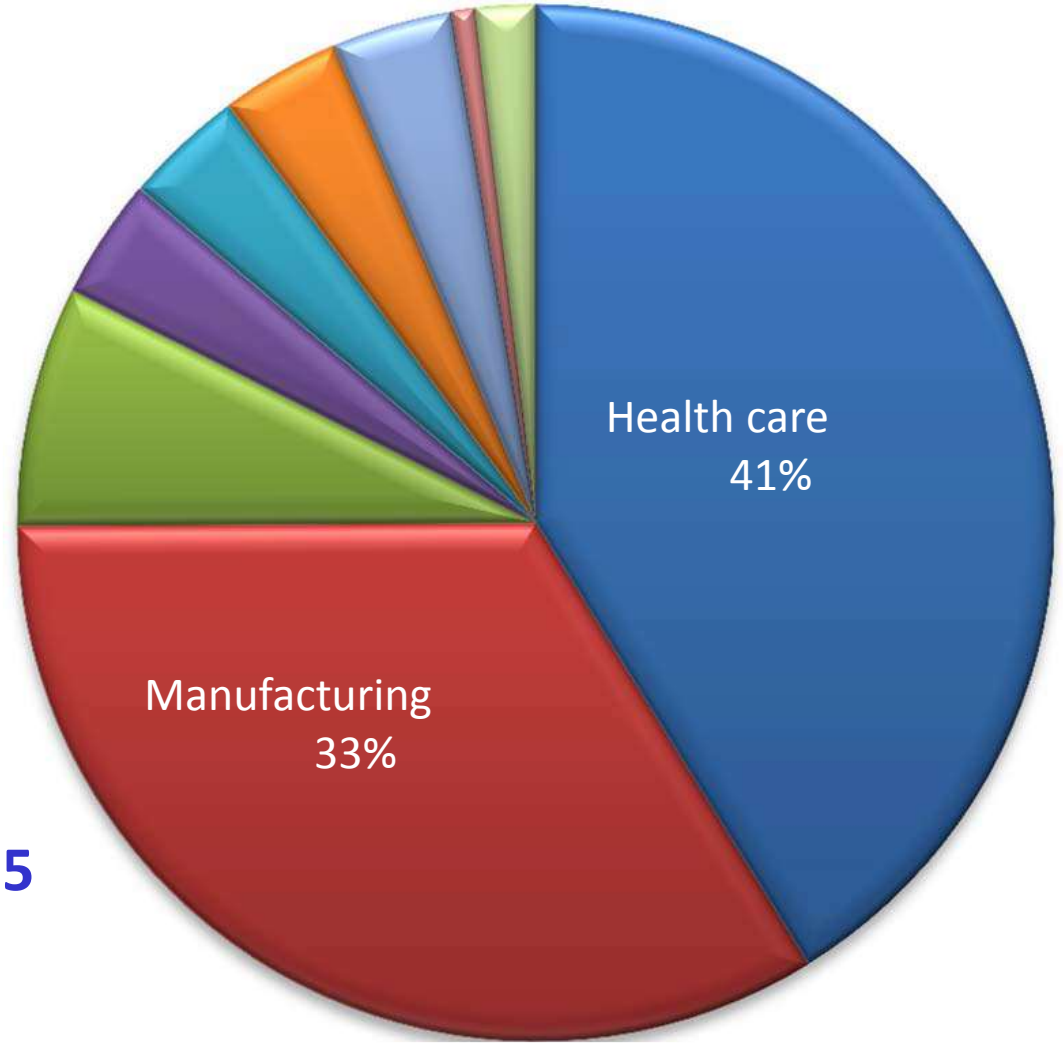
Typical IoT Architecture (current status)



Edge-Devices:

- energy efficient
- supporting AI/ML/DL
- low latency
- green technology
- ...

Potential Economic Impact of Sized IoT Applications

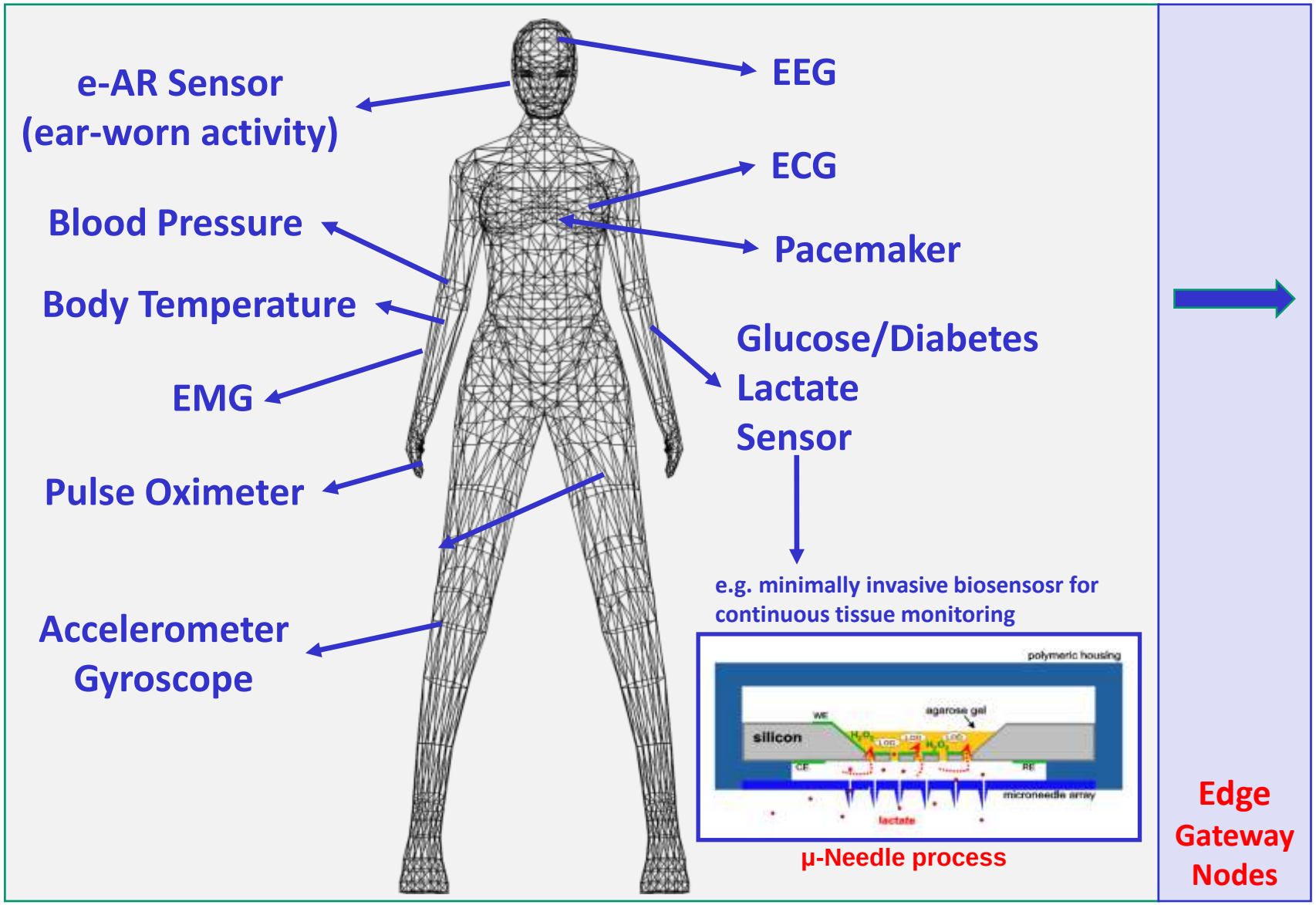


Projected market of IoT by 2025

Case Study

Ref.: Ala Al-Fuqaha et al., Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications

Case Study: IoT – BAN/BSN



Sensor nodes:

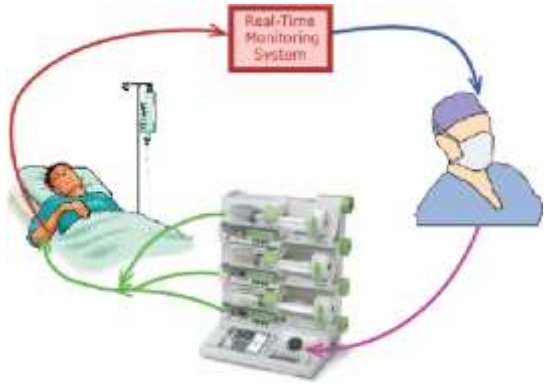
- **e-AR (ear-worn Activity Recognition) sensor** (for capturing the posture, gait and activity of the patient)
- **Wound healing sensor** (for monitoring the progress of healing for burn patients)
- **Blood pressure sensor** (for measuring the blood pressure for patients with hypertension)
- **EMG (electromyography) sensor** (for capturing the muscle activities of orthopaedic patients)
- **Blood glucose sensor** (for measuring the glucose level of diabetic patients)
- **Heart rate sensor** (for detecting abnormal heart conditions of cardiac patients).

Case Study: IoT and Telemedicine for anesthesia practices *

Medical Internet of Things (mIoT)
From remote monitoring to smart hospital

MIoT cloud-based network for anesthesia on-line monitoring

Application:
Continuous Monitoring in Anesthesia



Cloud

Secure data storage and remote visualization

Raspberry Pi
USB
USB

Arduino UNO

Laptop

Mobile

ECG Sensor
Bispectral index (BIS)

DOA
Depth of Anesthesia

TDM
Therapeutic Drug Monitoring

Simultaneously monitoring different physiological parameters

Blood pressure and heart rate, Drug Concentration Monitoring (control level of sedation)

Block Diagram: based on proposal for distant ECG monitoring IoT architecture by P. Singh and A. Jasuja, IoT Based Low-Cost Distant Patient ECG Monitoring System, 2017 International Conference on Computing, Communication and Automation (ICCCA)

* Ref.: Nadia Tamburrano, IoT and Telemedicine for anesthesia practices enabled by an Android application with cloud integration, Master Thesis, Polytechnic of Turin, 2018

Already before and parallel to the development of Ubiquitous Computing (Ubicomp) and finally the Internet of Things (IoT), another very important innovation has taken place:

The development of

Picture Ref.: PIxabay

Thinking about Mark Weiser's dream

Some remarks of Stephen Hawking:

"The development of full artificial intelligence could spell the end of the human race … It would take off on its own, and re-design itself at an ever-increasing rate. Humans, who are limited by slow biological evolution, couldn't compete and would be superseded."

From an interview with the BBC, December 2014

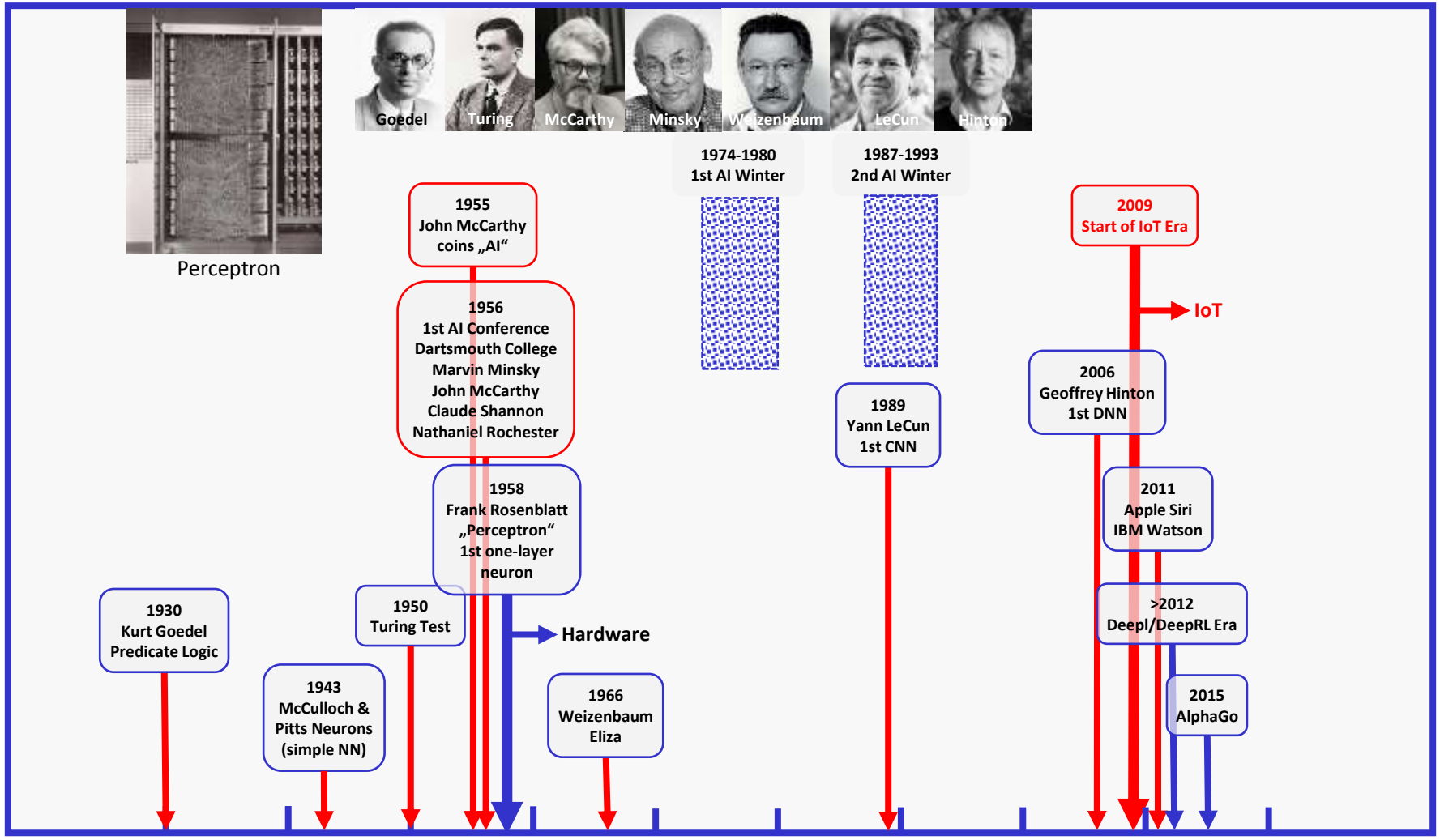
AI will be 'either best or worst thing' for humanity.

The Guardian, October 2016



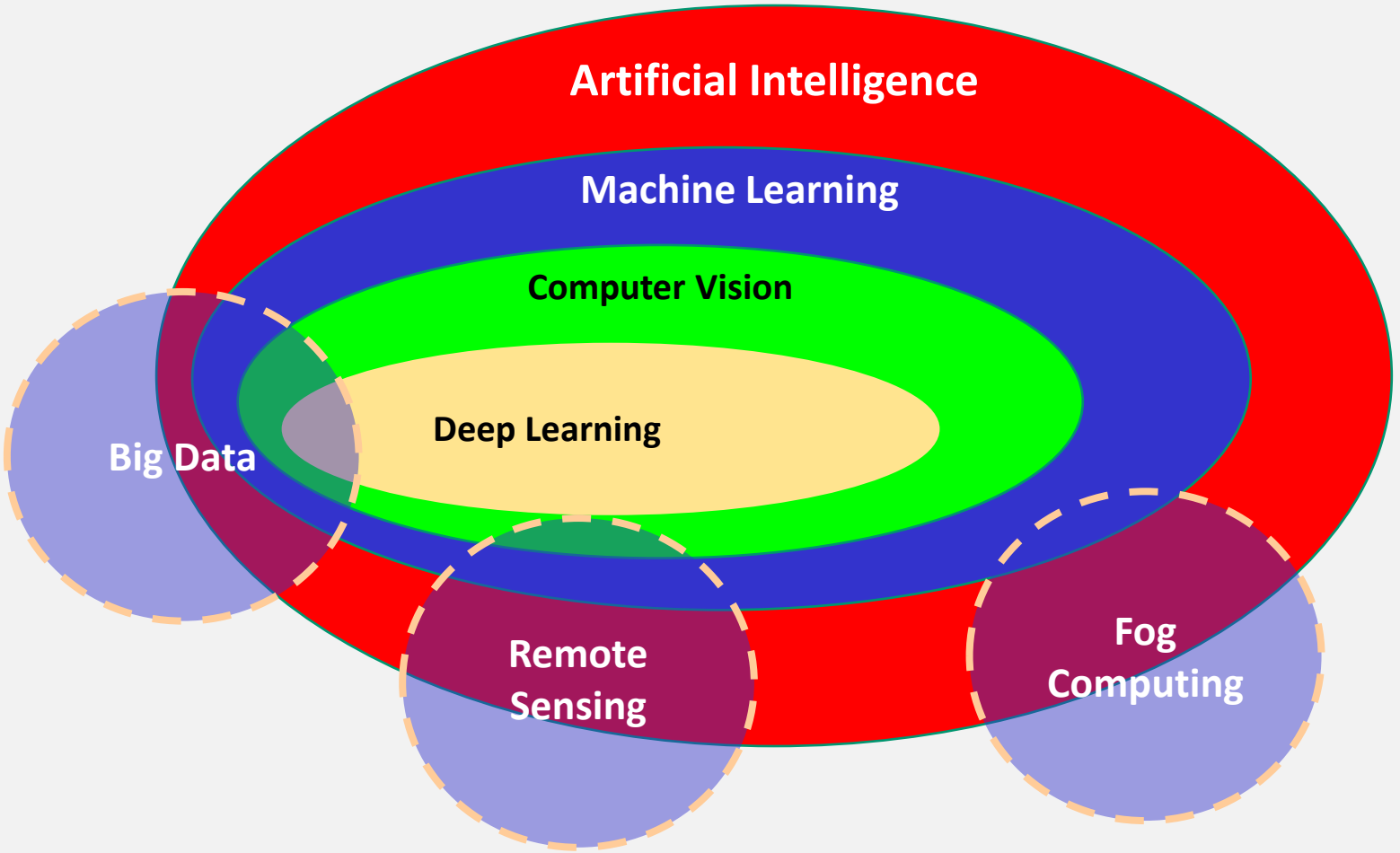
Ref.:
Stern.de

Development of Artificial Intelligence (AI)



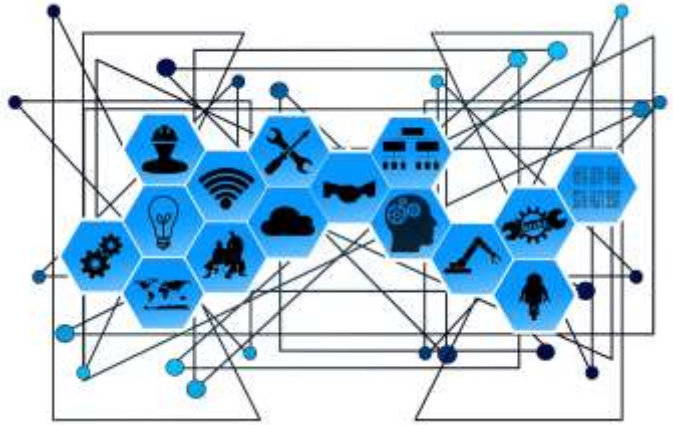
Ref.: Goedel-Wikipedia.org, Turing-National Portrait Gallery, John McCarthy-The Franklin Institute, Minsky-Royal Society of Chemistry, Weizenbaum-MIT, Yann LeCun-TED.com, Geoffrey Hinton-acm.org

Hierarchies of Artificial Intelligence



A co-evolution and perfect symbiosis: the combination of IoT and AI

→ Result: **The Artificial Intelligence of Things: AIoT**



Why symbiosis?

AI needs IoT:

an important prerequisite for AI (and its subsection Machine Learning) is the availability of (big) data. Big data has applications in every business: industry, manufacturing, agriculture, healthcare, government, financial services. Data is the Lifeblood of AI.

but also:

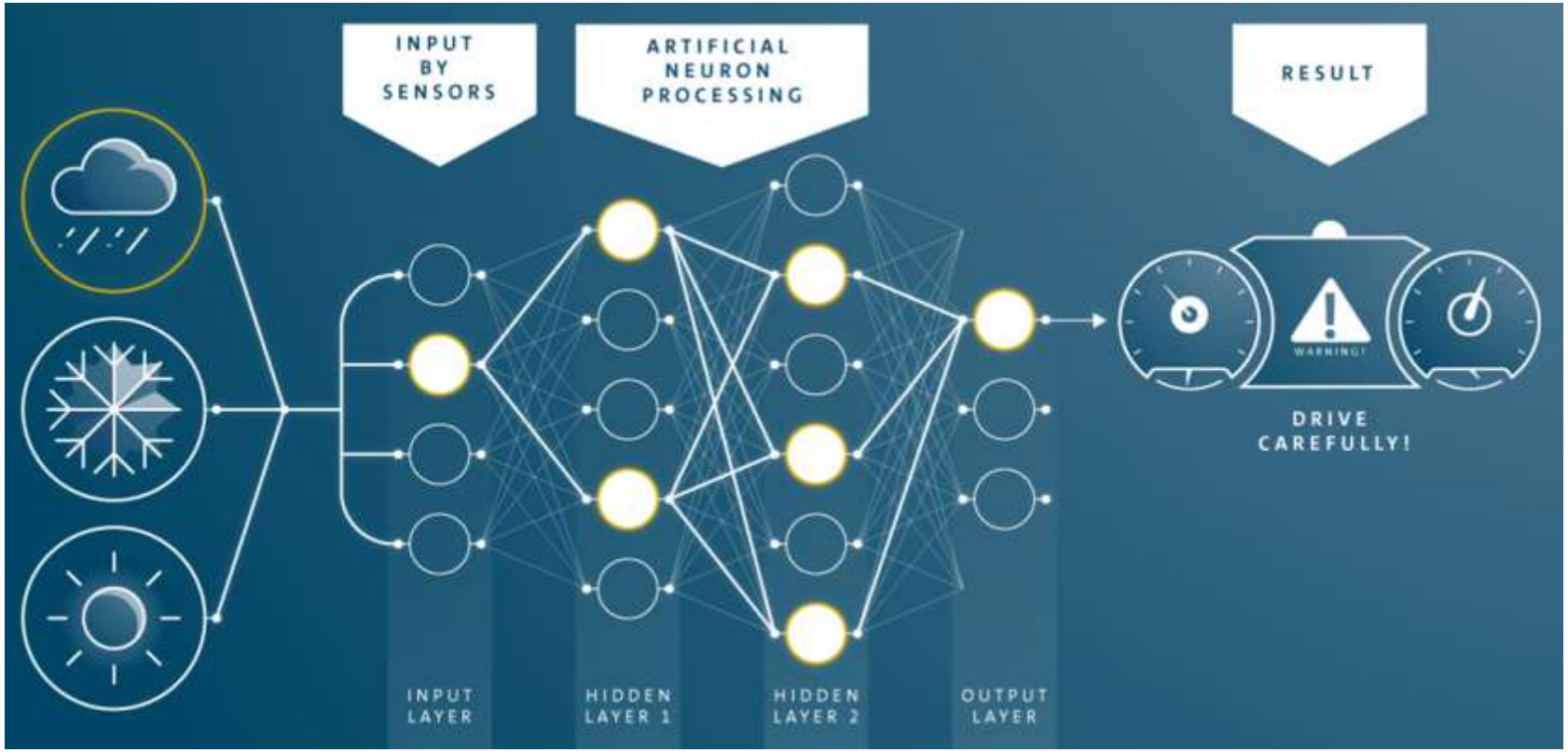
IoT needs AI:

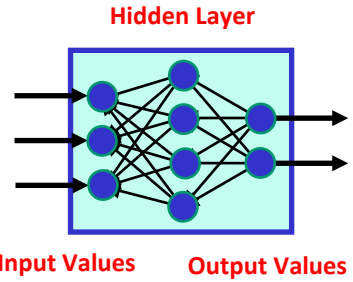
The Internet of Things started with few sensor nodes, but comprises nowadays a very high number of connected and collaborating multimodal (smart) elements. A manual analysis is not possible anymore, IoT needs cloud services to work efficiently. AI is the ideal partner technology for a comprehensive system evaluation. Data-driven decision making.

Picture Ref.: PIxabay

Case Study - Application Example:
Internet of Things and Artificial Neural Network (ANN)

Volkswagen Neural Networks (Cooperation Volkswagen-Stanford University)





IoT Sensor Input (weather data)

Artificial Intelligence (data processing)

AIoT Output (driver information)

Application Area: Development of autonomous and assisted driving, in this case especially the detection of slippery roads.

Ref.: https://www.volkswagenag.com

IoT and AI: Frameworks for AI application

Many (open-source) frameworks and libraries available for AI Machine Learning and Deep Learning are based on Python.

- TensorFlow (Google Brain)
- PyTorch (Facebook AI)
- Keras
- Orange3 (originally C++)
- NumPy - Numerical Python
- SciPy
- Scikit-Learn (based on SciPy)
- Pandas
- Matplotlib
- Theano (MILA, University of Montreal)
- Spark MLlib (Apache)
- MXNet
- NLTK - Natural Language ToolKit
- NeuroLab
- ffnet (feedforward neural network)
- Lasagne
- pyrenn (recurrent neural network)

Fraunhofer IMS

AIfES - Artificial Intelligence for Embedded Systems

Embedded AI – Artificial Intelligence for microcontrollers and embedded systems

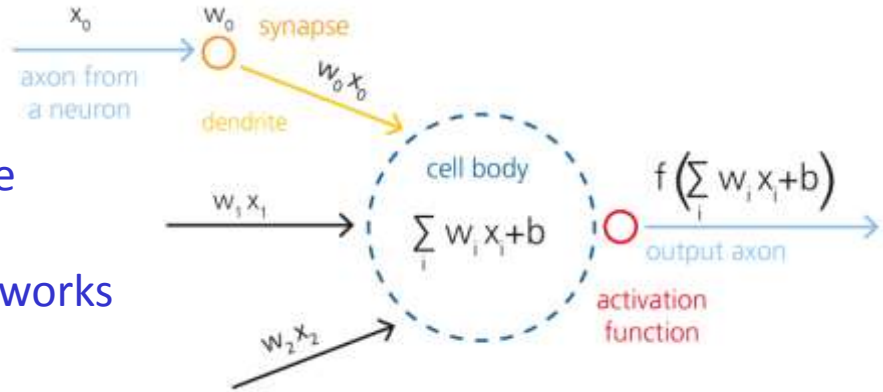
AIfES comprises a platform-independent machine learning library implementing a fully configurable Feedforward Neural Network (FNN).

The artificial neuronal network in AIfES:

AIfES includes a Feedforward Neural Network (FNN), which is configurable in almost all parameters and also allows deep network structures. The network structure can be individually adapted to the actual technical task.

Features:

– Number of inputs and outputs are freely definable
– Number of hidden-layer and neurons per layer are configurable
– Different activation-functions with additional parameters
– Prepared to import already trained FNNs from other ML frameworks



Legal issues for using AIfES :

– Free of charge: Private projects or developers of Free Open Source Software (FOSS) under the GNU Affero General Public License (AGPL) version 3.
– Commercial without distribution under GNU AGPL V3: license agreement required with Fraunhofer IMS

Ref.: https://www.ims.fraunhofer.de/en.html

Fraunhofer IMS

AIfES - Artificial Intelligence for Embedded Systems

Selected platforms and microcontrollers supported by AIfES :

- Windows (DLL)
- Raspberry Pi with Raspbian
- Arduino UNO
- Arduino Nano 33 BLE Sense
- Arduino Portenta H7
- ATMega32U4
- STM32 F4 Series (ARM Cortex-M4)

Ref.: https://www.ims.fraunhofer.de/en.html

Intermediate Thoughts (or Questions):
What happened to Mark Weiser‘s "walk in the woods"?

Calm technology should recede into the background of our lives. Using computers should be as refreshing as taking a walk in the woods.

Today we are not just walking in a calm IoT world. IoT and AIoT/BIoT have entered our environment, our nature, our forests.

Two example projects show how well this symbiosis is working today:

1. **The "Beewise/Beehome“ project (and others)**
2. **The "Tree Projects 4.0 (Baum 4.0)“ (and others)**

"Walk in the woods"

On the way to Mark Weiser‘s forest dream: Taking care of our bees

The Forests:

- Habitats for our bees and wild bees
- More than 20.000 bee species mapped worldwide
- Problem:
  every year 30 to 40% of the bees are dissapearing *

Solution:

AIoT/BIoT entering our environment, our nature, our forests.

❖ Abnormally high die-offs (30–70% of hives) of honey bee colonies in North America ("colony collapse disorder" - CCD)

... in order to prevent

A WORLD WITHOUT BEES

TIME Magazine
2013

Ref.: TIME Magazine A World Without Bees, Aug. 19, 2013

Example Organization:

Department for Environment Food & Rural Affairs

GOV.UK

The World Bee Project is a member of the UK Government Department for Environment Food & Rural Affairs (Defra) Pollinator Advisory Steering Group (PASG).

Case Study IoT: IoBee
Beehive health IoT application to fight Honey Bee Colony Mortality

EU Project 2017 to 2020
Funded under Horizon 2020 Framework Programme
https://cordis.europa.eu/project/id/760342

Purpose:
Development of in-hive and in-field monitoring and implementation of satellite imagery and Spatial Decision Support Systems (SDSS).

IoBee

The consortium

The consortium has the complementary business capabilities, commercial networks and research expertise to guarantee a quick route to market for the technology, driven by: IRIDEON expert in IoT Sensor Applications, Avia-GIS expert in Insect Spatial Decision Support Systems and Arnia expert in smart beehive systems. These will be supported by TEIC, expert in Insect Bioacoustics, Pattern Recognition and Acoustic Surveillance, and Bee Life European Beekeeping Coordination.

irideon innovation partners

IRIDEON SL (Coordinator) – Spain
Spanish-German company

BeeLife European Beekeeping Coordination

Bee Life European Beekeeping Coordination – Belgium

AVIAGIS

Avia-GIS BVBA – Belgium

HELLENIC MEDITERRANEAN UNIVERSITY

Hellenic Mediterranean University
Greece

Canetis

Canetis – Italy

Ref.: https://io-bee.eu/

IoBee

Purpose: explain why bee populations are crashing.
Two novel superior environmental sensors help fill in the knowledge gaps, monitoring environmental threats to bees.

1. **Sensor placed in beehives: Bee Counter**
   Beehive sensor installed at the hive entrance counts bees entering and leaving the hive in real time. Determines mortality rates in the field, and identifies deviations in flight duration and nectar availability. The sensor can also identify types of bees and hive pests.
   One way the sensor does so is via a technique called light extinction, which measures the size of an insect's shadow. The sensor also measures light scattering in various colour bands, identifying species by colouration.
2. **Sensor placed in nearby fields:**
   Optoelectronic sensor counts and identifies insects flying outside the hive (density and diversity of pollinators in the field). As insects fly through the sensor field, the sensor automatically identifies their flight pattern and matches it with species in the database. So insects can be efficiently identified without need for trapping and manual counting.

Together, the sensors monitor environmental changes and provide early warnings of threats.

Ref.: https://io-bee.eu/

IoBee

Automatically count bees entering / exiting the hive, with higher accuracy.

Profile bees' bioacoustic fingerprint as normal (healthy) or abnormal (unhealthy) and assess the potential risk of abnormal mortality.

Automatically detect the potential presence of invasive species (wasps, moths, flies, beetles, Africanized bees, etc.) that may harm the colony or bring diseases.

Collect, share data and analyze information of importance, and simulate the spread of infectious bee diseases / pests.

Provide a space-time information system that integrates data in one information environment for planning and decision.

Ref.: https://io-bee.eu/

Case Study AIoT: BEEWISE (Beehome)
Earth's first robotic beehive

Automated beekeeping platform based on precision robotics, AI/ML, and IoT

BEEWISE

TEL AVIV UNIVERSITY
Pursuing the Unknown

Ref.:
Ms. Netaly (Zelcer) Harari, Beewise: Automated Beekeeping, Tel Aviv University, Israel

partially funded by European Commission

TO BEE OR NOT TO BE.

Earth's first robotic beehive

Automated beekeeping platform based on IoT & AI

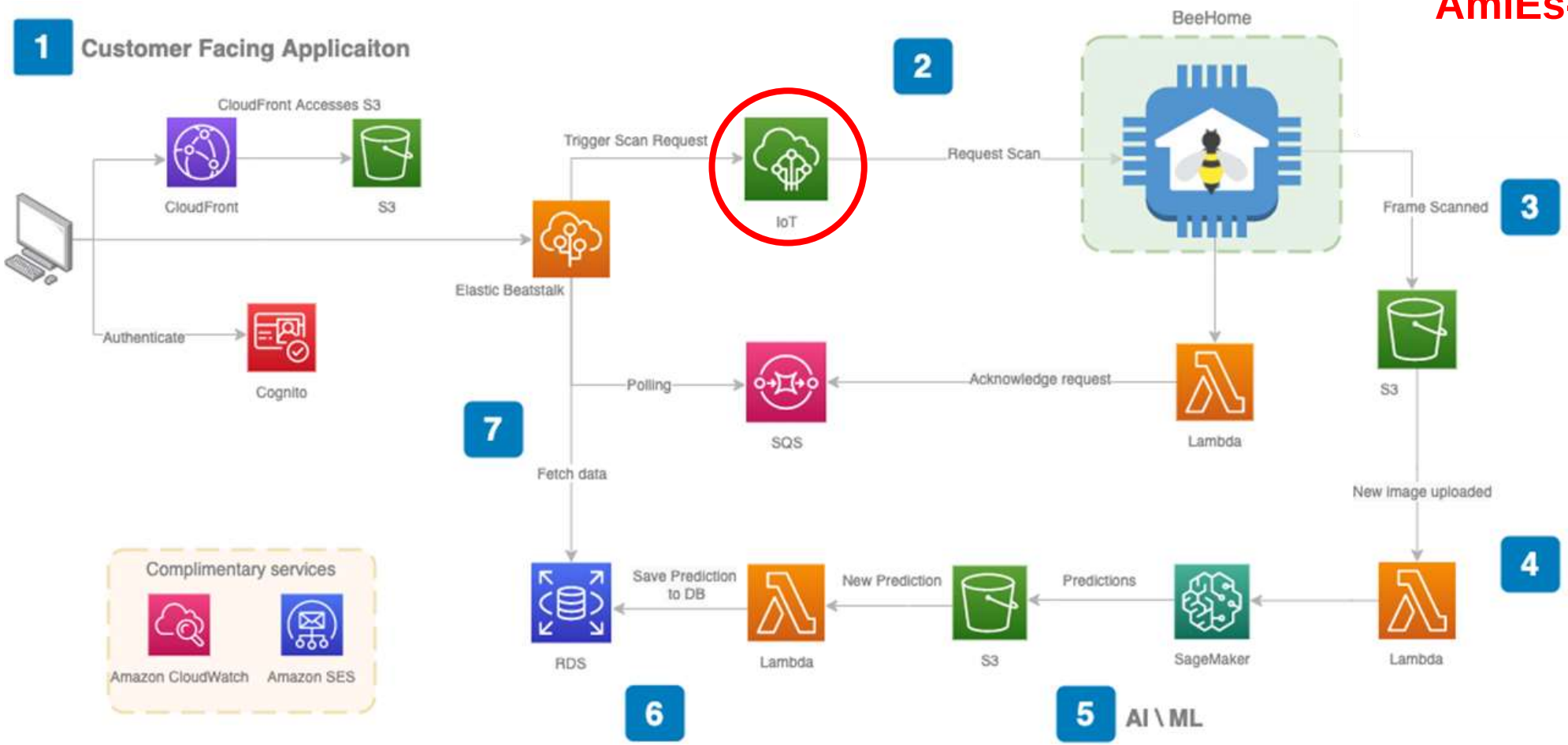
BEEWISE

TEL AVIV UNIVERSITY
Pursuing the Unknown

partially funded by European Commission

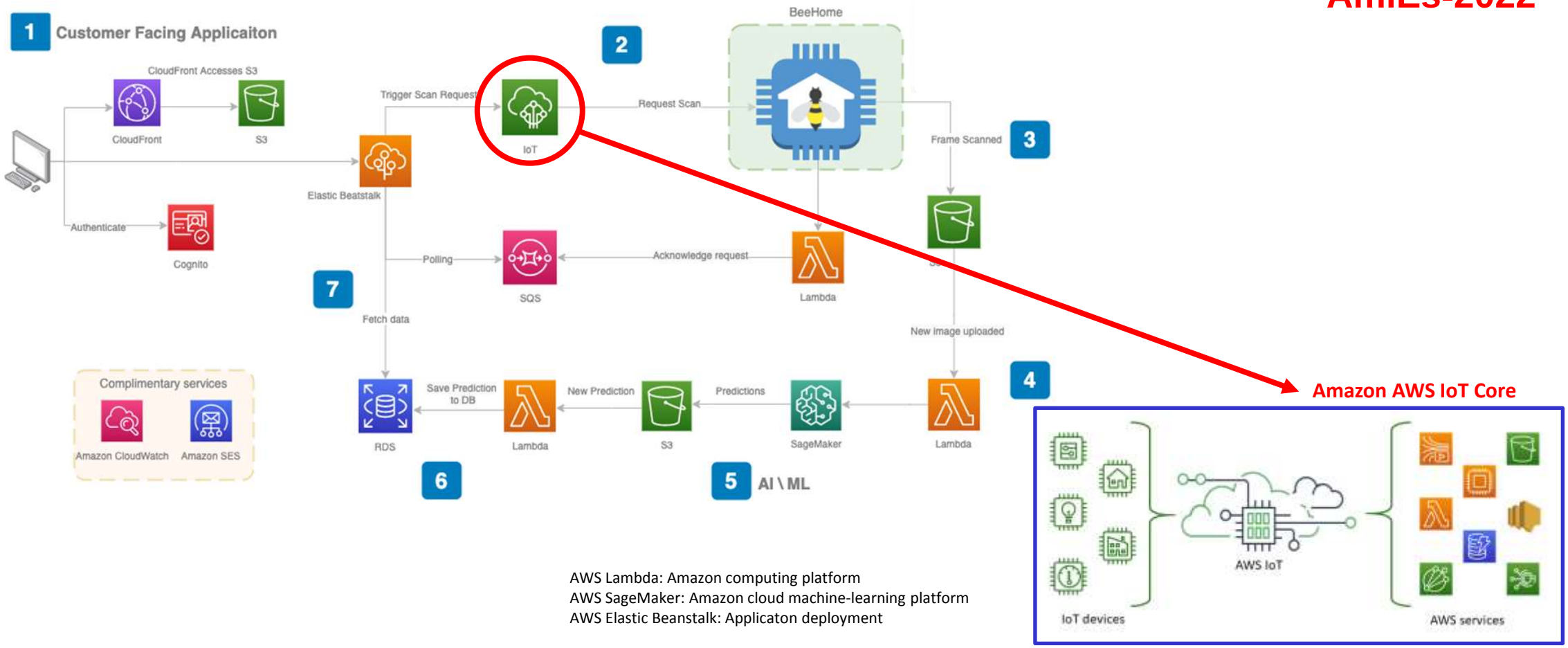
AWS Lambda
Amazon SageMaker
Amazon AWS IoT Core

Ref.:
Ms. Netaly (Zelcer) Harari, Beewise: Automated Beekeeping, Tel Aviv University, Israel



1. Beekeeper request to scan hives within the BeeHome, using the web application.
2. Request reaches the BeeHome. Robot begins the scanning process.
3. BeeHome uploads each frame image to an S3 bucket.
4. A Lambda is triggered, enrichting the image with metadata and triggering the ML process.

5. Predictions and annotated versions of the frame image are being uploaded to an S3 bucket.
6. A Lambda is triggered to process the ML data and save it into a persistent data storage.
7. Data about the frame is available for the application to present.



AWS Lambda: Amazon computing platform
AWS SageMaker: Amazon cloud machine-learning platform
AWS Elastic Beanstalk: Applicaton deployment

1. Beekeeper request to scan hives within the BeeHome, using the web application.
2. Request reaches the BeeHome. Robot begins the scanning process.
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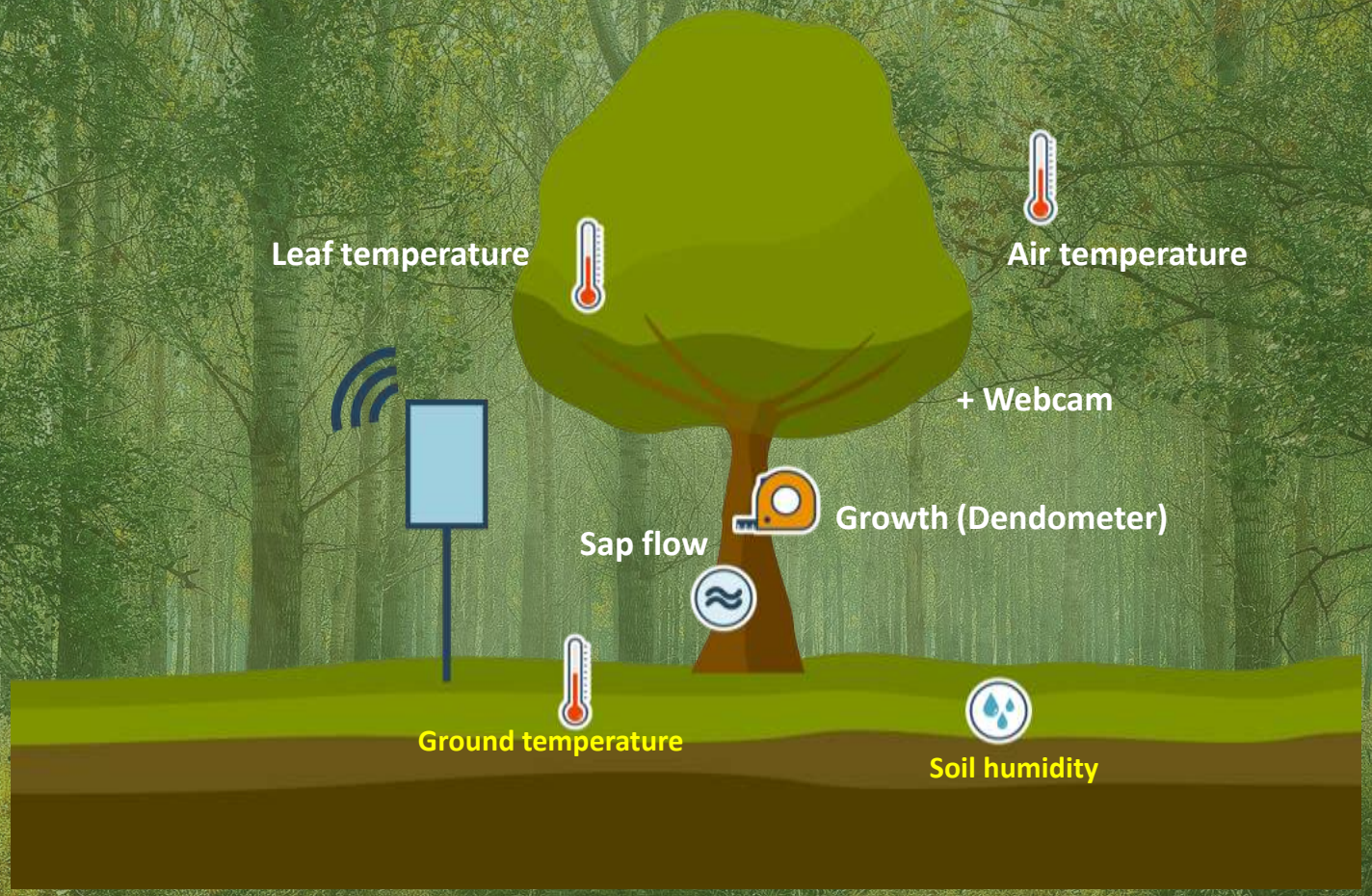
Mark Weiser

Walking in the Woods

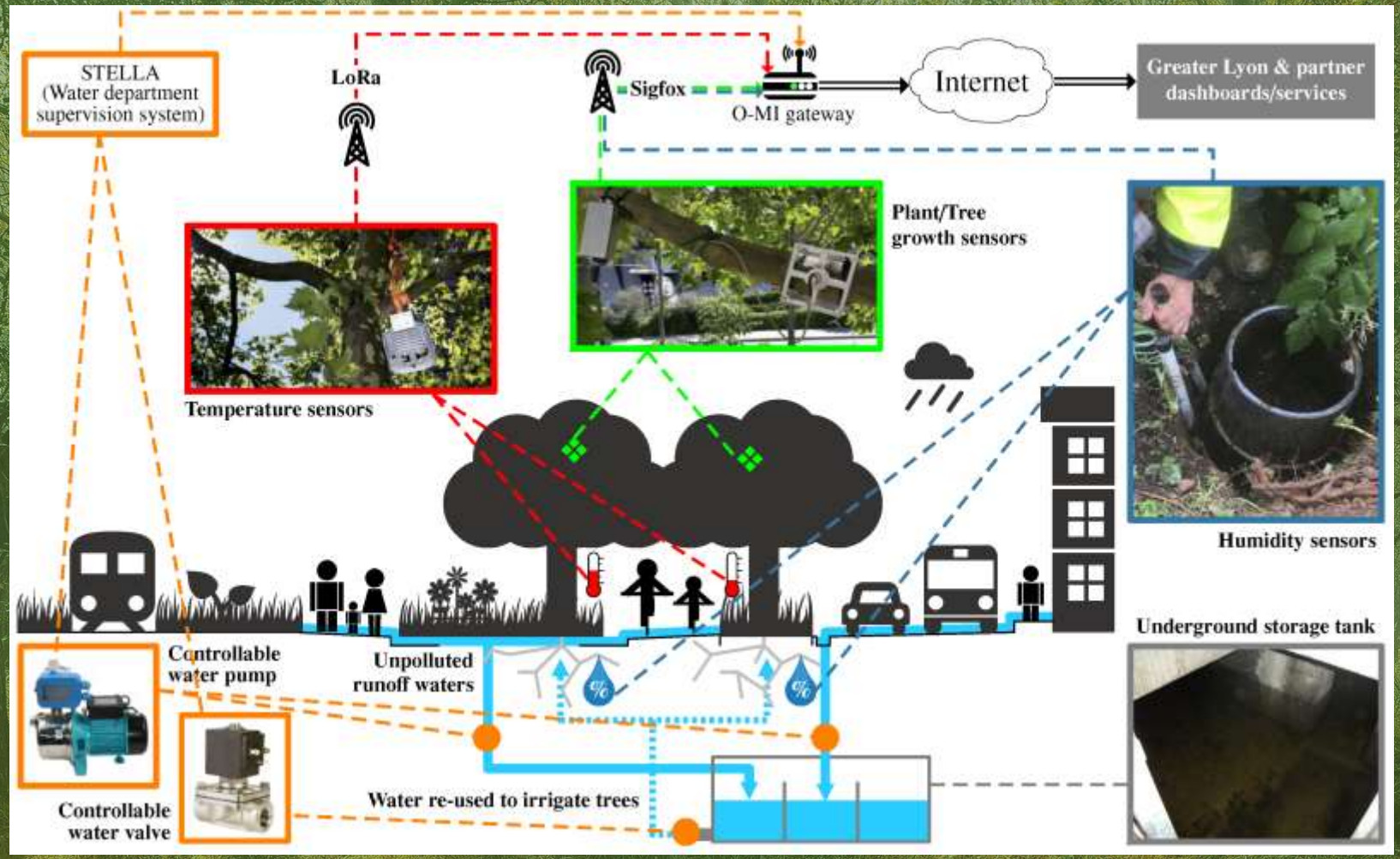
Case Study: IoT Tree Example Application 1: Tree Projects 4.0 (Baum 4.0) – The Talking Tree



Ref.:Technical University Munich (TUM), Eichstätt-Ingolstadt (KU)
Project coordinated by Prof. Dr. Annette Menzel (TUM),
Dr. Marvin Lüpke, M.Sc. (TUM), and Prof. Dr. Susanne Jochner-Oette (KU)

https://www.portal.baysics.de/wiki/baum40story/
Live data: https://www.baysics.de/Baum4/trees.html

Case Study: IoT Tree Example Application 1: Smart Métropole de Lyon Reducing urban heat-island (UHI) effects: by increased the planting of new



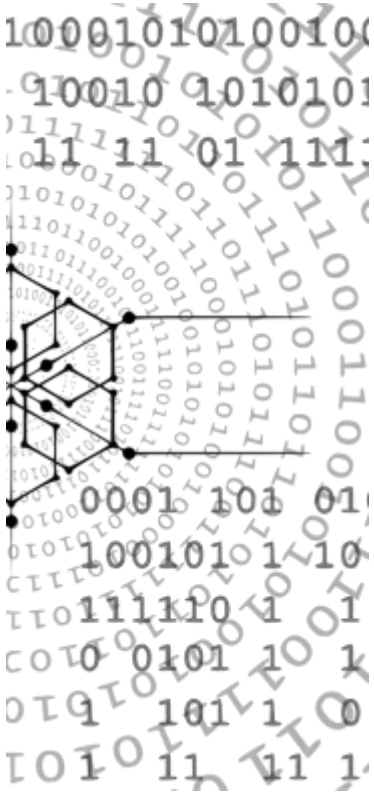
Ref.:Jérémy Robert et al., Open IoT Ecosystem for Enhanced Interoperability in Smart Cities—Example of Métropole De Lyon, Sensors 2017

Further development after IoT and AI

The introduction and integration of the Blockchain Technology *

Blockchain IoT (BIoT):
Foundation of high-trust computing (distributed trusted information technology)

A New Direction for Solving Internet of Things Security and Trust Issues.



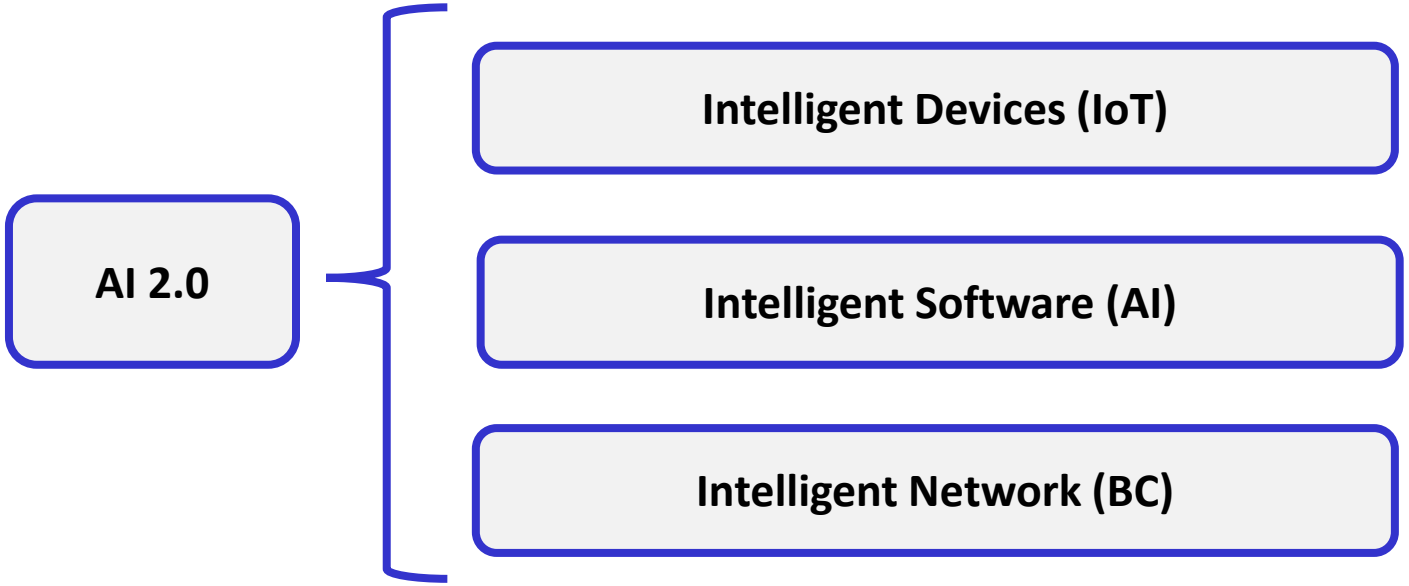
Benefits of BIoT:

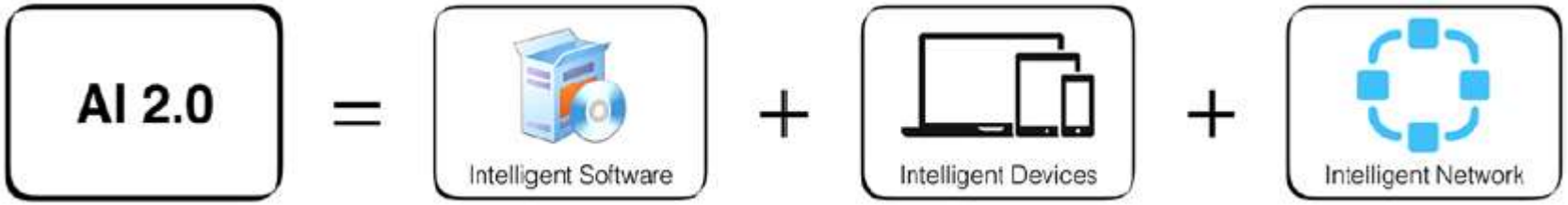
1. Publication/duplication of sensors data in public and distributed ledgers
2. Time stamping by the blockchain infrastructure
3. Data authentication
4. Non repudiation.

A blockchain uses a distributed peer-to-peer (P2P) network to keep an unalterable record of every exchange.
Consequence: no need for trusted, third-party intermediaries in digital transactions.

*** well known from Bitcoins, but much more**

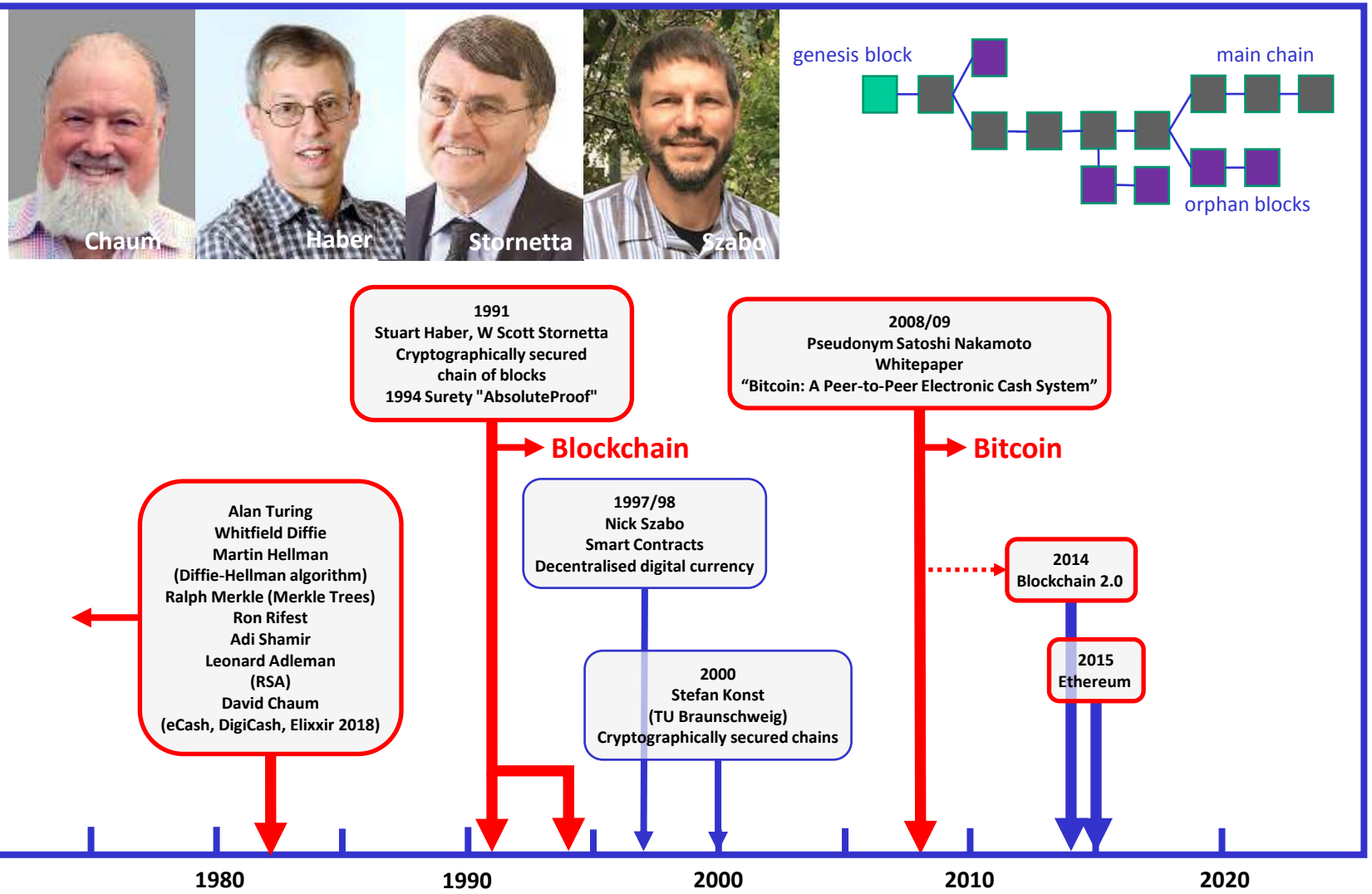
AI 2.0
Combination of AI, IoT, and Blockchain





Ref.: Apress.IoT.AI.and.Blockchain.for.NET.www.EBooksWorld.ir

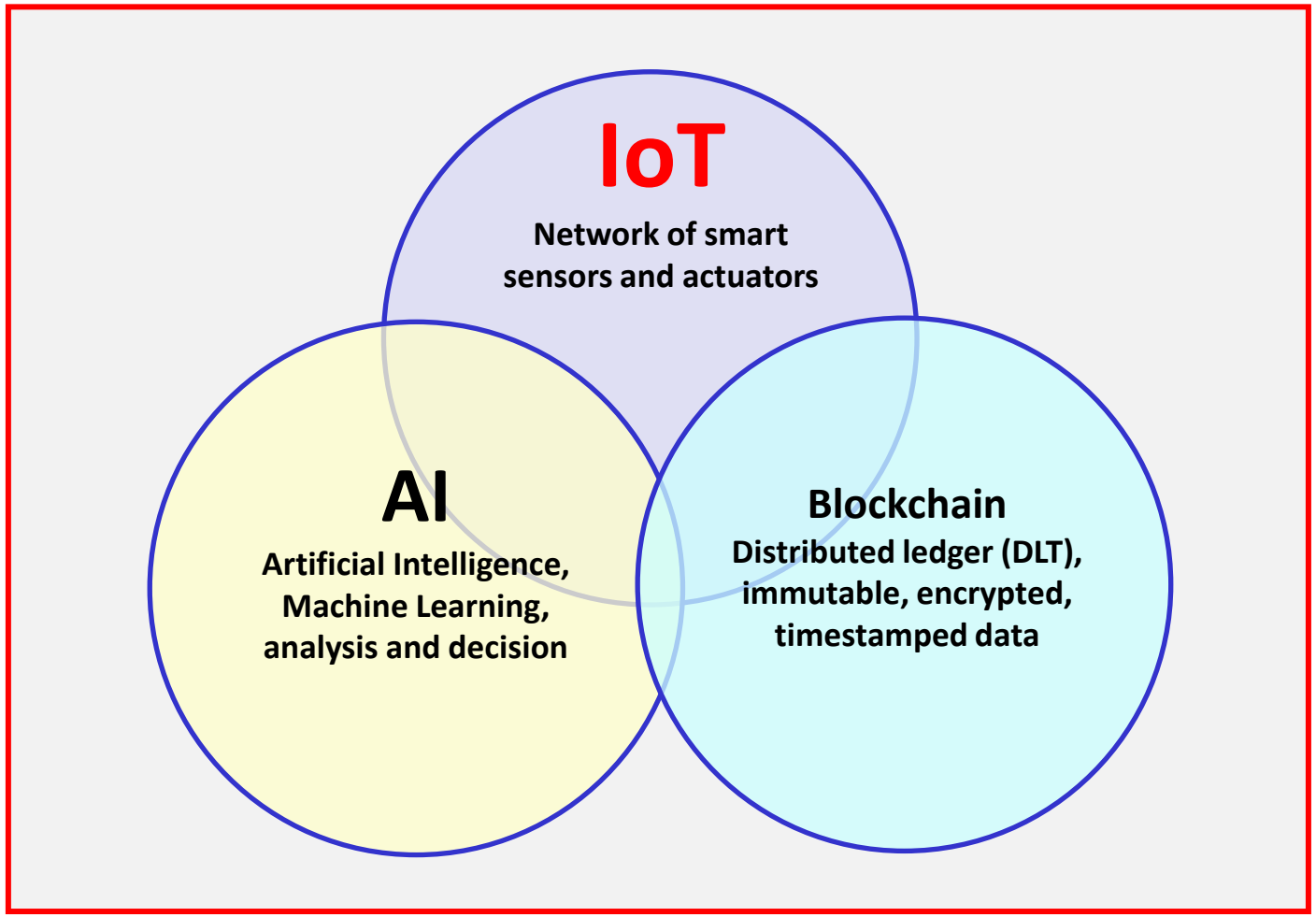
Development of the Blockchain Technology



1982 Cryptographer David Chaum: proposed a blockchain-like protocol in his dissertation "Computer Systems Established, Maintained, and Trusted by Mutually Suspicious Groups."

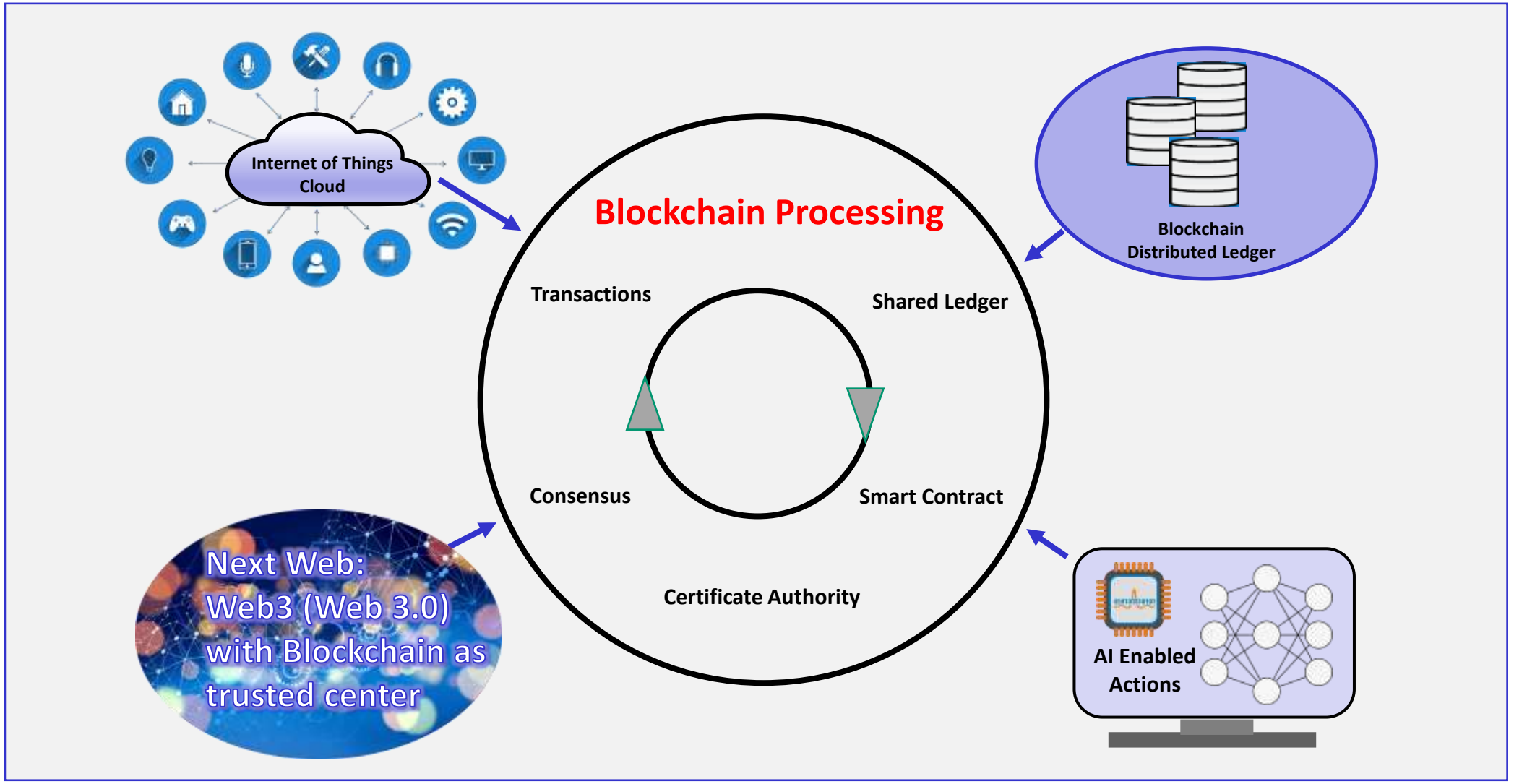
Ref.: Stuart Haber photo: https://mobile.twitter.com/StuartHaber/photo; Nick Szabo photo: https://blockchain.uark.edu/nick-szabo/;
Scott Stornetta photo https://timesofmalta.com/articles/view/meet-blockchains-co-inventor.683308; David Chaum photo: KuppingerCole Analysts

Merging IoT, AI and BC



IoT feels, and AI thinks. Blockchain remembers and protects.

IoT, AI and Blockchain integrated



The Internet of Things: Data Flow

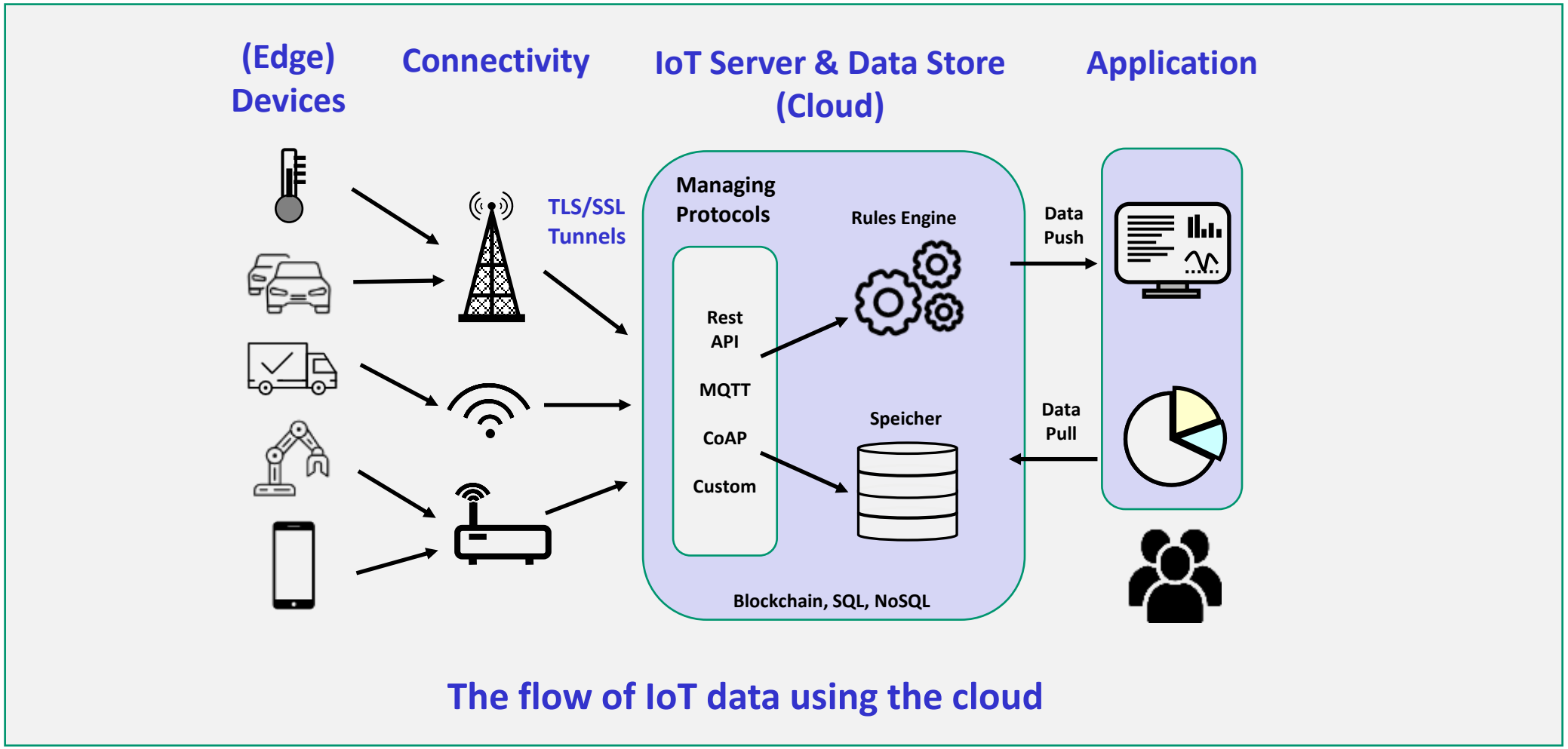
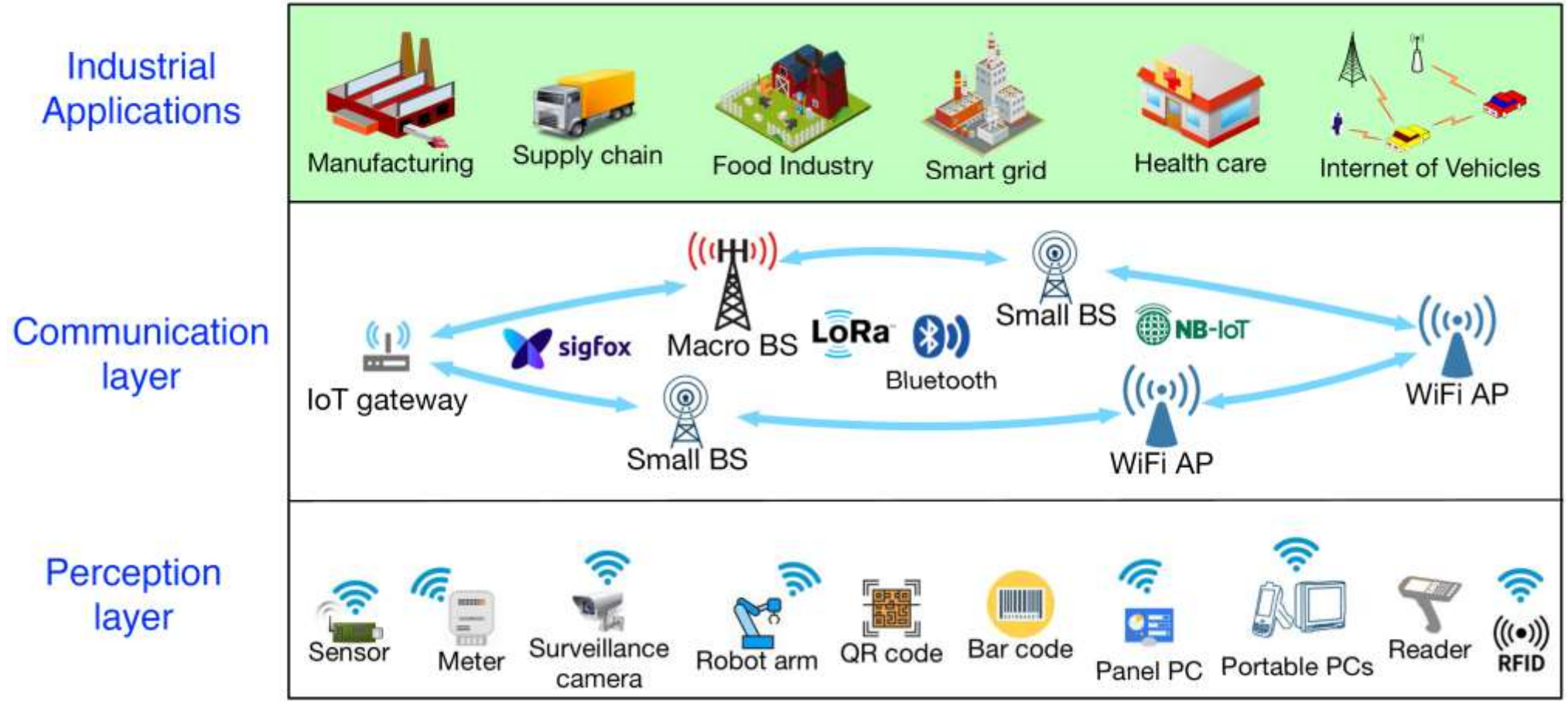


Figure based on: AI, IoT and the Blockchain

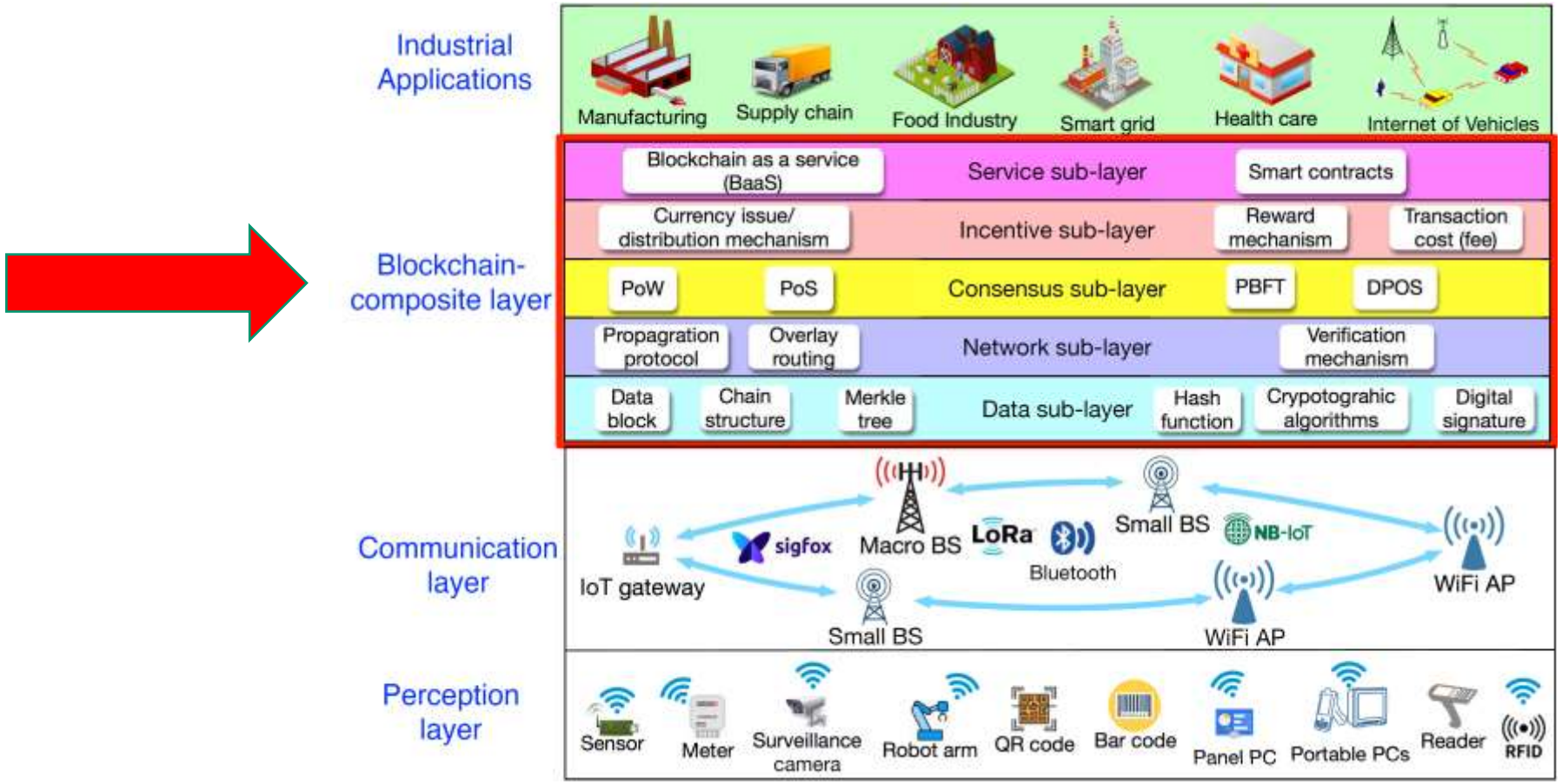
Architecture of Internet of Things - IoT



Ref.:
Hong-Ning Dai, Zibin Zheng, Yan Zhang, "Blockchain for Internet of Things: A Survey,„
in IEEE Internet of Things Journal, vol. 6, no. 5, pp. 8076-8094, Oct. 2019, doi: 10.1109/JIOT.2019.2920987

Architecture of Blockchain of Things - BCoT

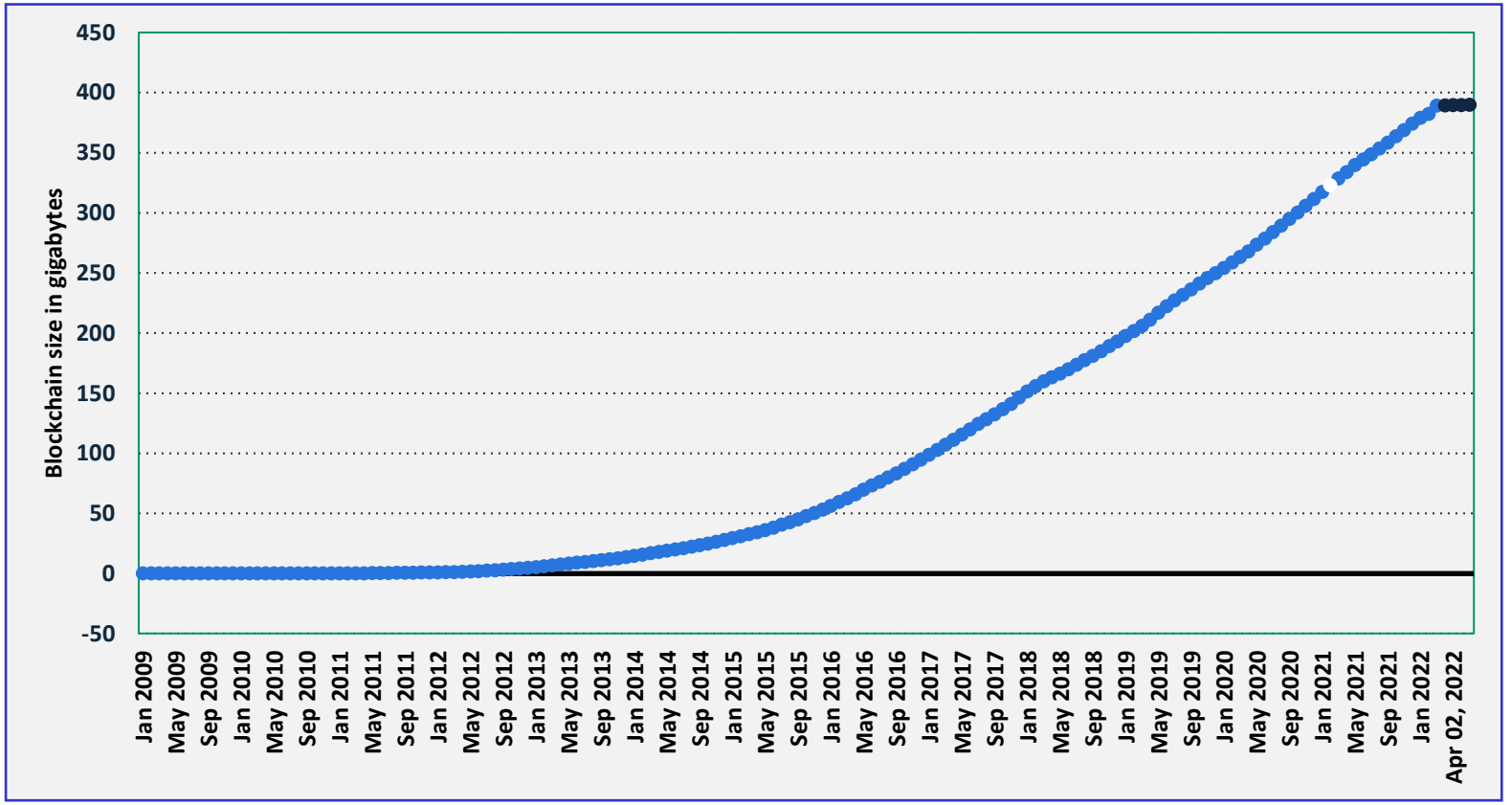
as proposed by Hong-Ning Dai, Zibin Zheng, Yan Zhang, with blockchain-composite layer as a middleware between IoT and industrial applications.



Ref.:
Hong-Ning Dai, Zibin Zheng, Yan Zhang, "Blockchain for Internet of Things: A Survey,„
in IEEE Internet of Things Journal, vol. 6, no. 5, pp. 8076-8094, Oct. 2019, doi: 10.1109/JIOT.2019.2920987

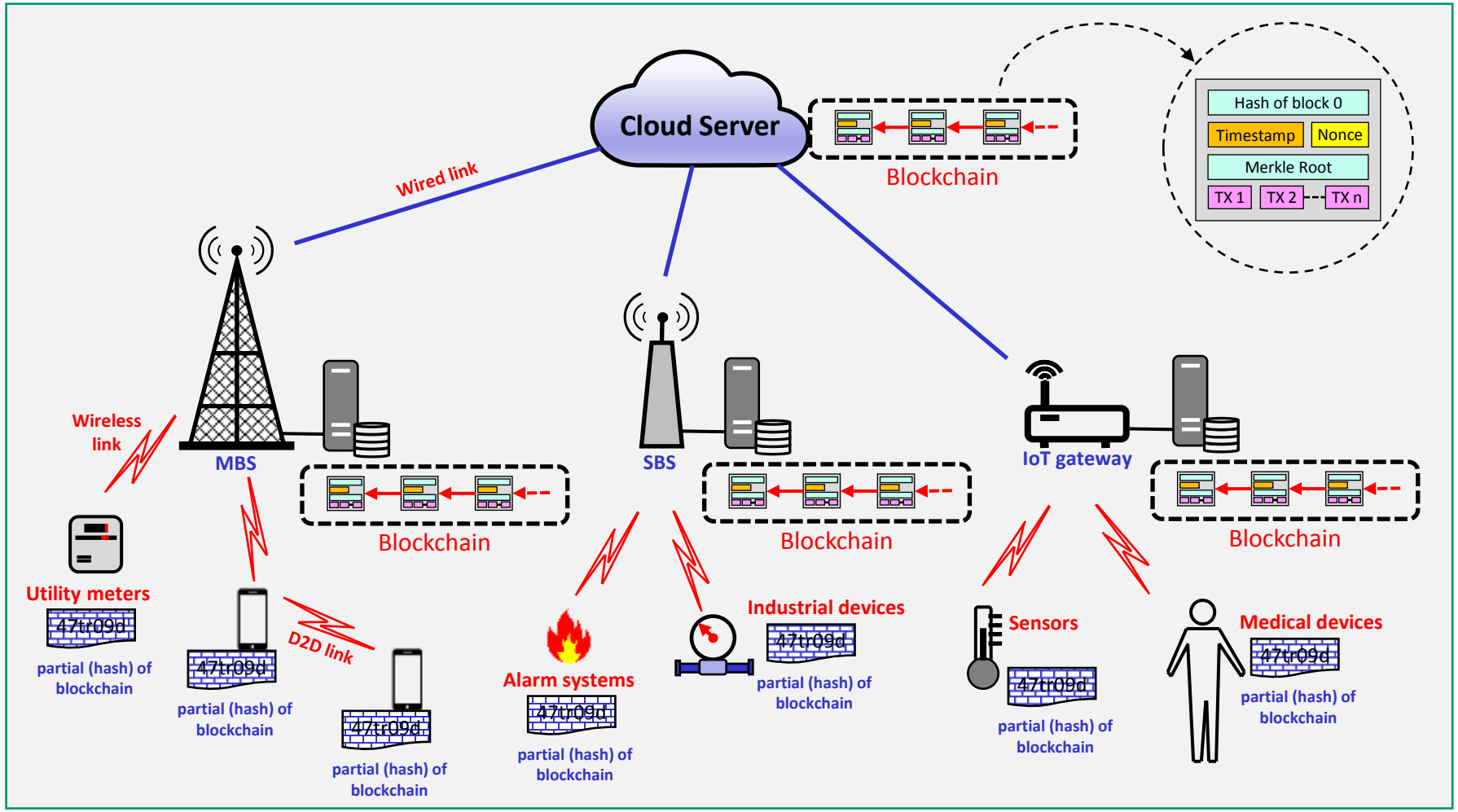
Blockchain Example

Size of the Bitcoin blockchain from January 2009 to April 4, 2022 (in gigabytes).



statista

Blockchain Example



MEC-Server (Multi-access edge computing)

Figure based on:
Hong-Ning Dai, Zibin Zheng, Yan Zhang, "Blockchain for Internet of Things: A Survey,,,
in IEEE Internet of Things Journal, vol. 6, no. 5, pp. 8076-8094, Oct. 2019, doi: 10.1109/JIOT.2019.2920987

The IoT World of Definitions and Akronyms (a selection)

IoT Main groups

IoT	Internet of Things (2G-3G-4G)
IIoT	Intelligent / Industrial Internet of Things (5G)
IoIT	Intelligent Internet of Intelligent Things (6G)
IoT 2.0	Intelligence of Things (or simply IoT)
XIoT	Extended Internet of Things
AIot	Artificial Intelligence of Things
BIot	Blockchain IoT (other meanings exist)
BCoT	Blockchain of Things
CIoT	Cloudification of the Internet of Things

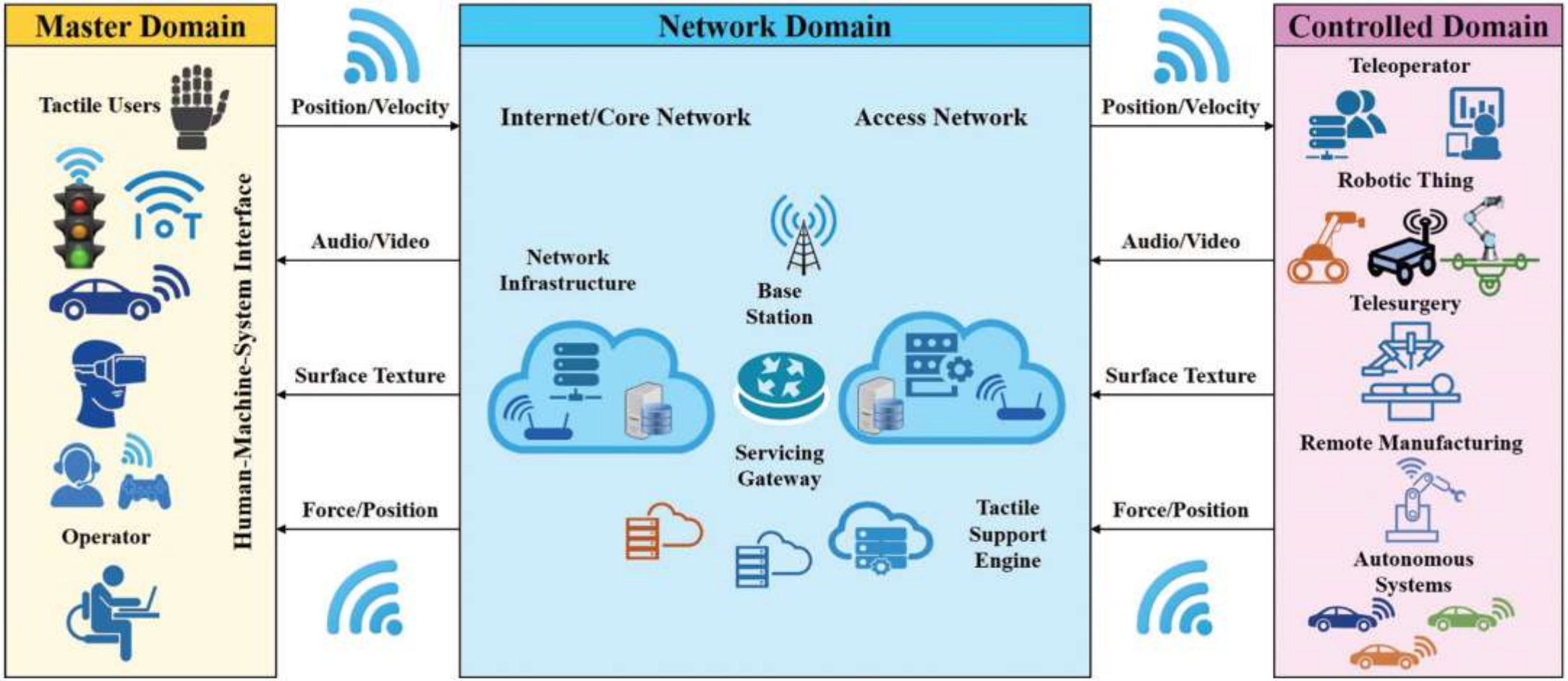
IoT subgroups (examples)

IoTS	Internet of Things Senses
TIoT/TIIoT	Tactile IoT/IIoT

Internet of Things Senses (IoTS) overview

Ref.: Editors: Ovidiu Vermesan, Joël Bacquet, 2020
Internet of Things – The Call of the Edge, Everything Intelligent Everywhere
based on:
Ovidiu Vermesan et al. (incl. George Kornaros), New Waves of IoT Technologies Research – Transcending Intelligence and Senses at the Edge to Create Multi Experience Environments

Tactile Internet of Things



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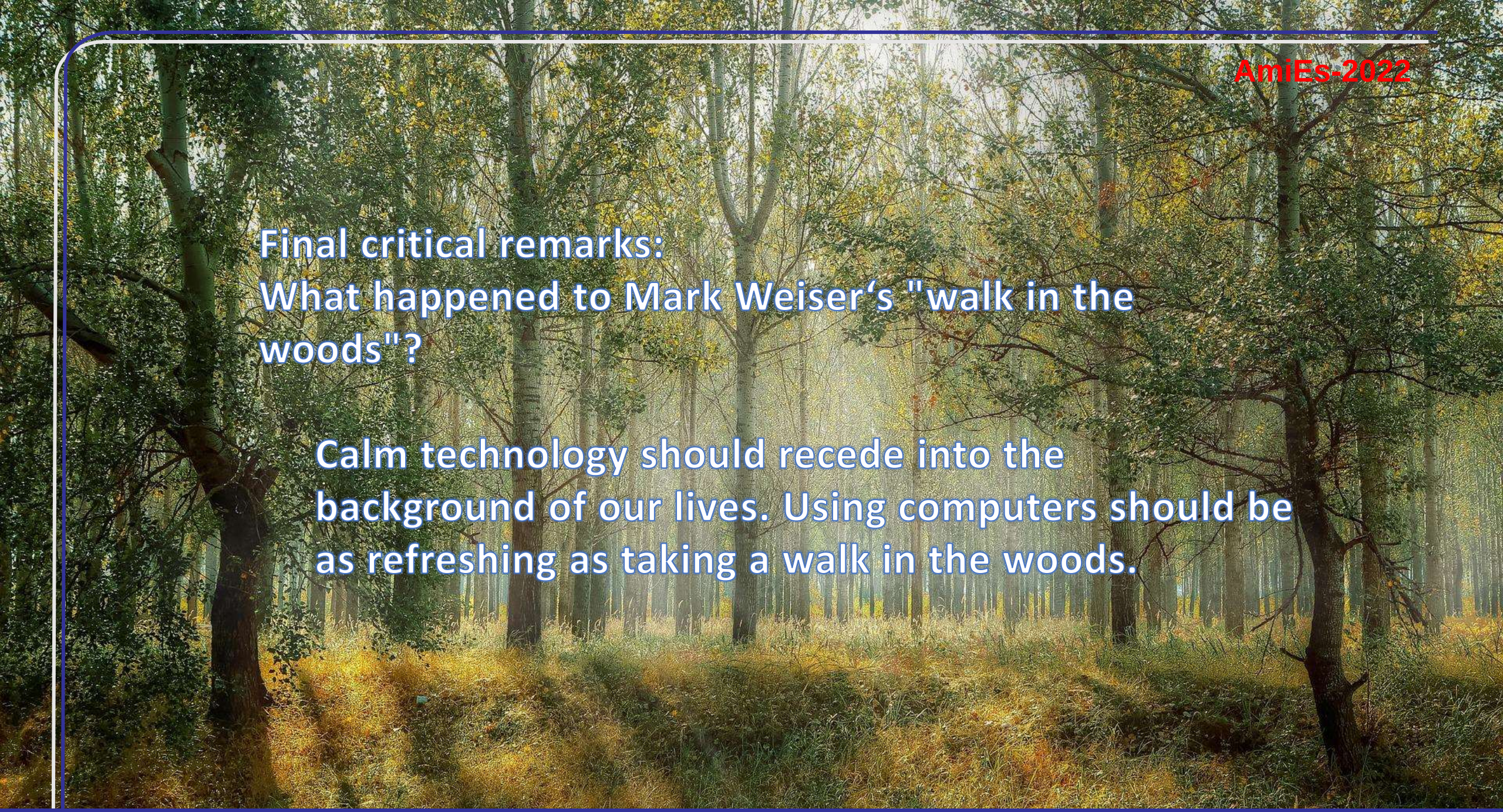
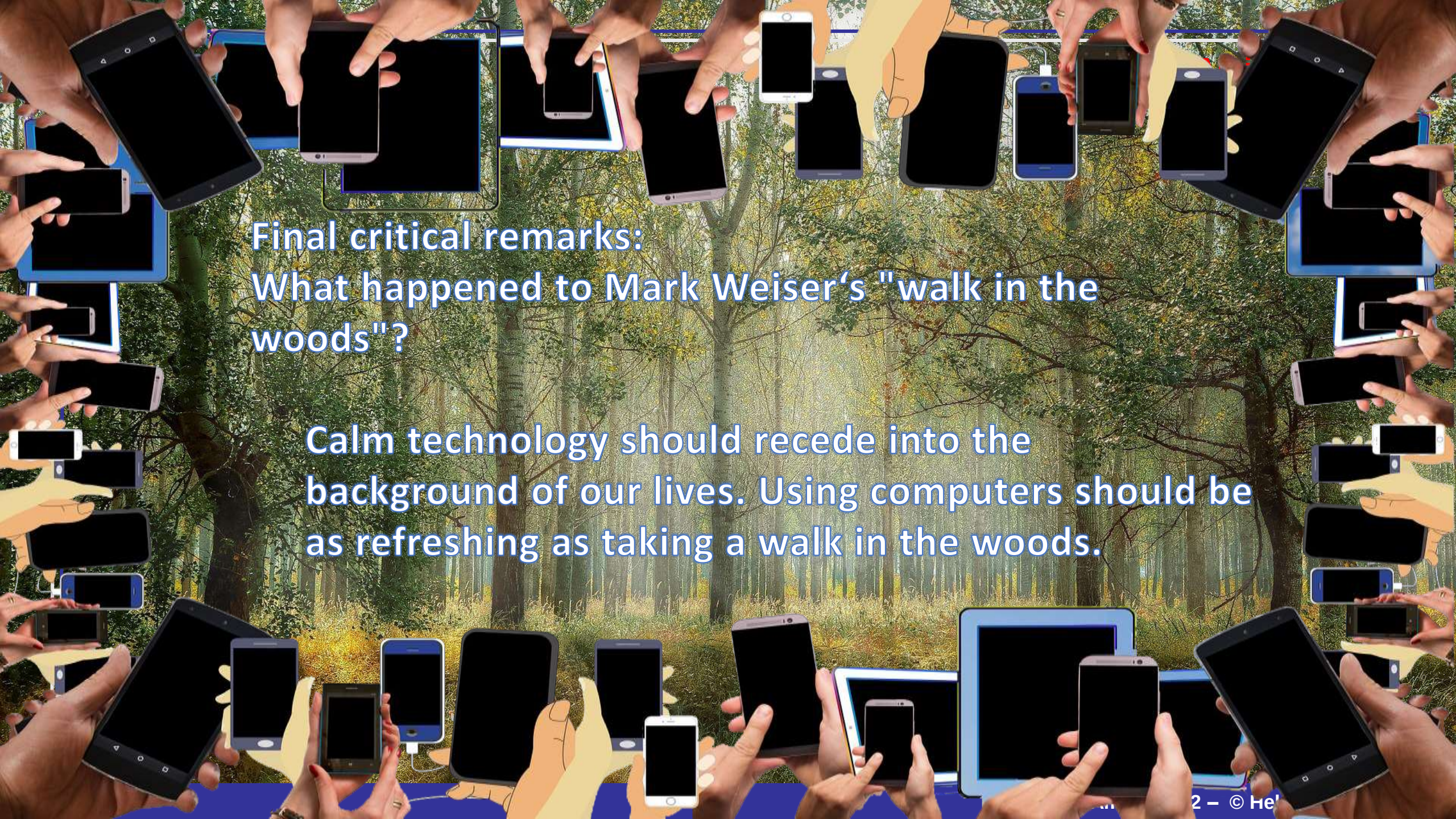


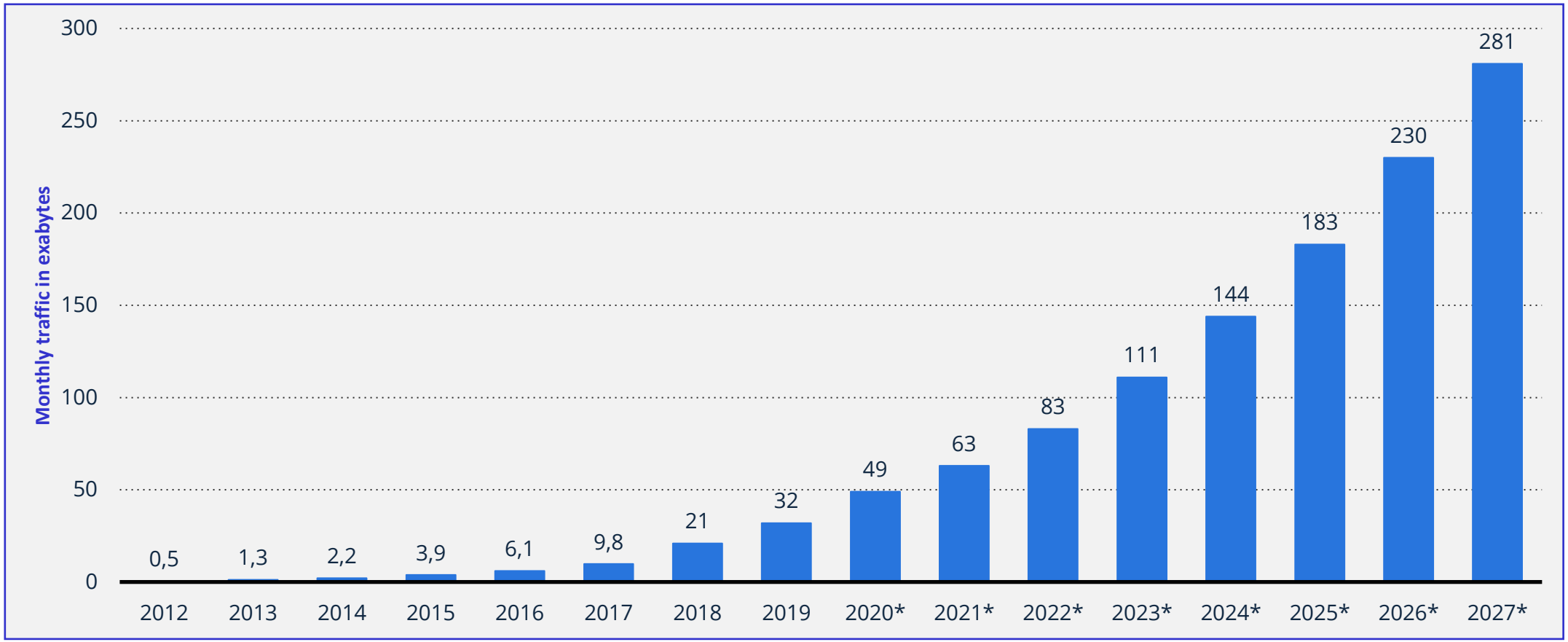
Final critical remarks:
What happened to Mark Weiser‘s "walk in the woods"?

Calm technology should recede into the background of our lives. Using computers should be as refreshing as taking a walk in the woods.


Final critical remarks:
What happened to Mark Weiser‘s "walk in the woods"?
Calm technology should recede into the background of our lives. Using computers should be as refreshing as taking a walk in the woods.

Example of Calm Technology

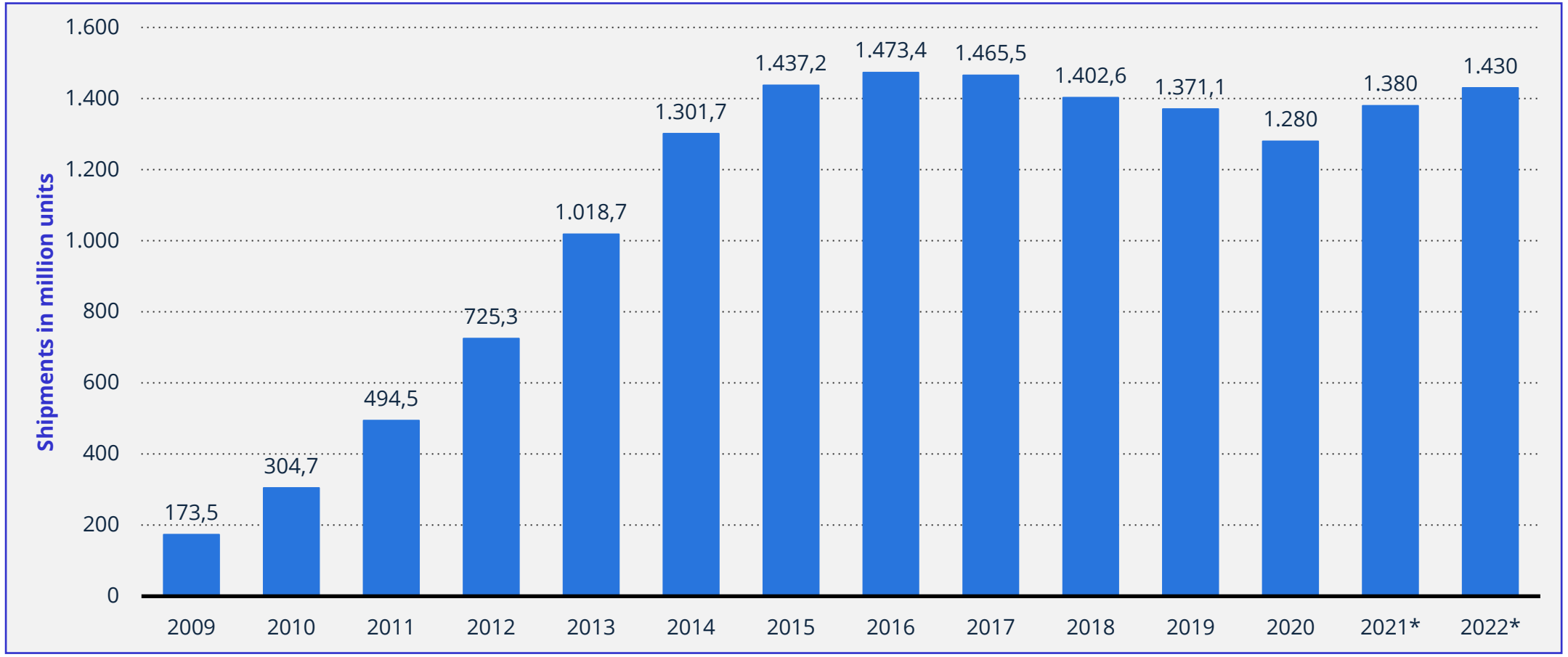
Average monthly smartphone traffic worldwide from 2015 to 2027 (in exabytes - 10^{18})



Description: The forecast illustrates the average monthly smartphone traffic worldwide from 2012 to 2027. By 2027, the average monthly data traffic from smartphone devices worldwide is projected to amount to 281 exabytes. Read more
Note(s): Worldwide; 2015 to 2021; * Forecast. Read more
Source(s): Ericsson

statista

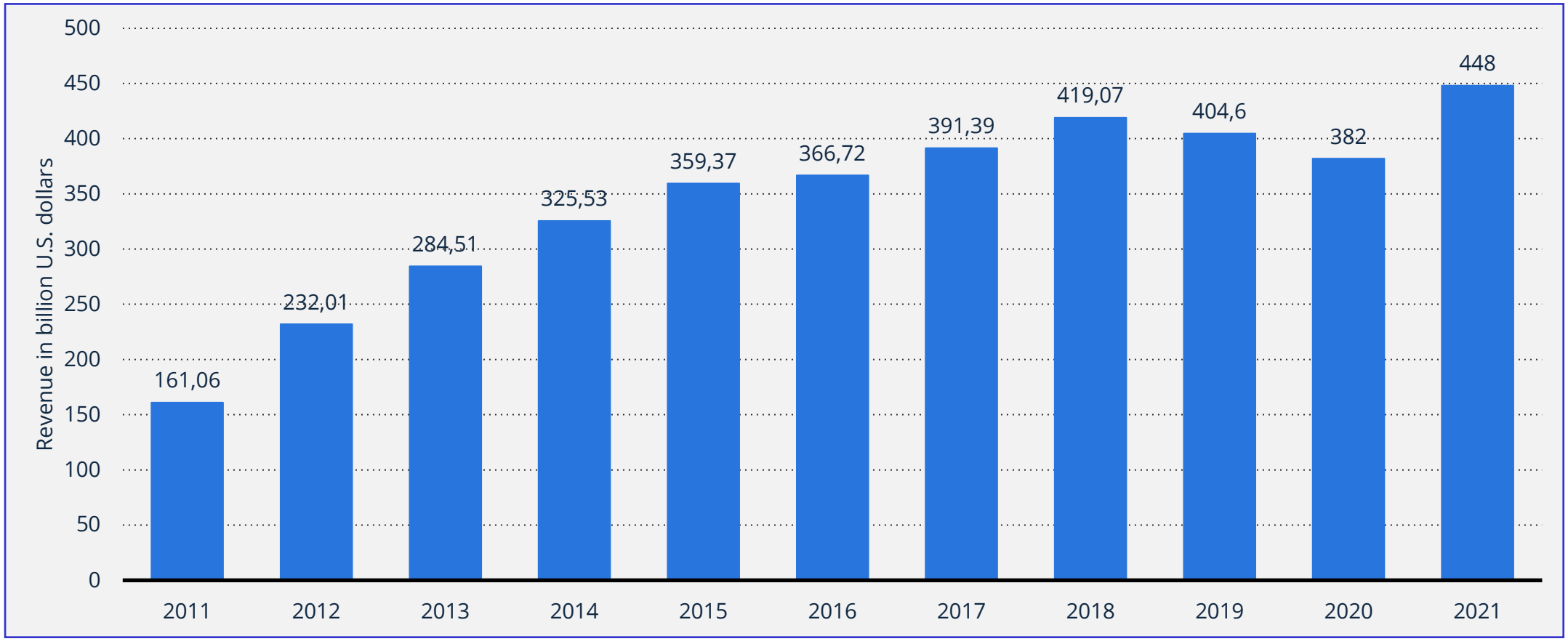
Global smartphone shipments forecast from 2010 to 2022 (in million units)



Description: The total unit shipments of smartphones worldwide increased from 2009 to 2016, when shipments peaked at 1.47 billion units. Since then the shipments have decreased to 1.28 billion units shipped in 2020. However, the source forecasts that smartphone shipments will increase in the coming years. Read more
Note(s): Worldwide; 2010 to 2020; *Forecast Figures have been taken from several publications by the source. Read more
Source(s): IDC

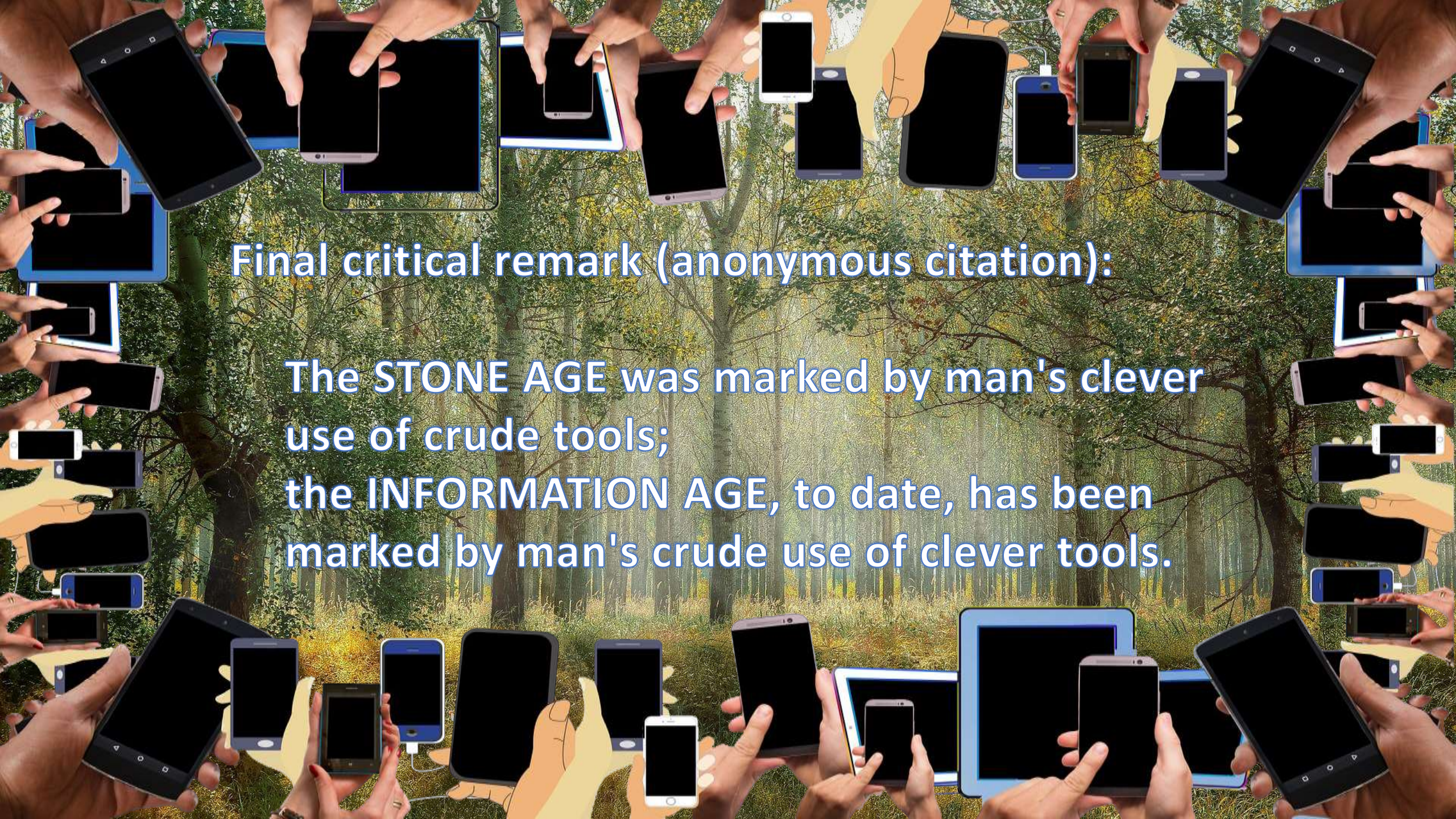
statista

Smartphone revenues worldwide from 2011 to 2021 (in billion U.S. dollars)



Description: The statistic shows the smartphone revenues worldwide from 2011 to 2021. In 2021, global smartphone revenues amounted to approximately 448 billion U.S. dollars. Read more
Note(s): Worldwide; 2011 to 2021
Source(s): Counterpoint Research

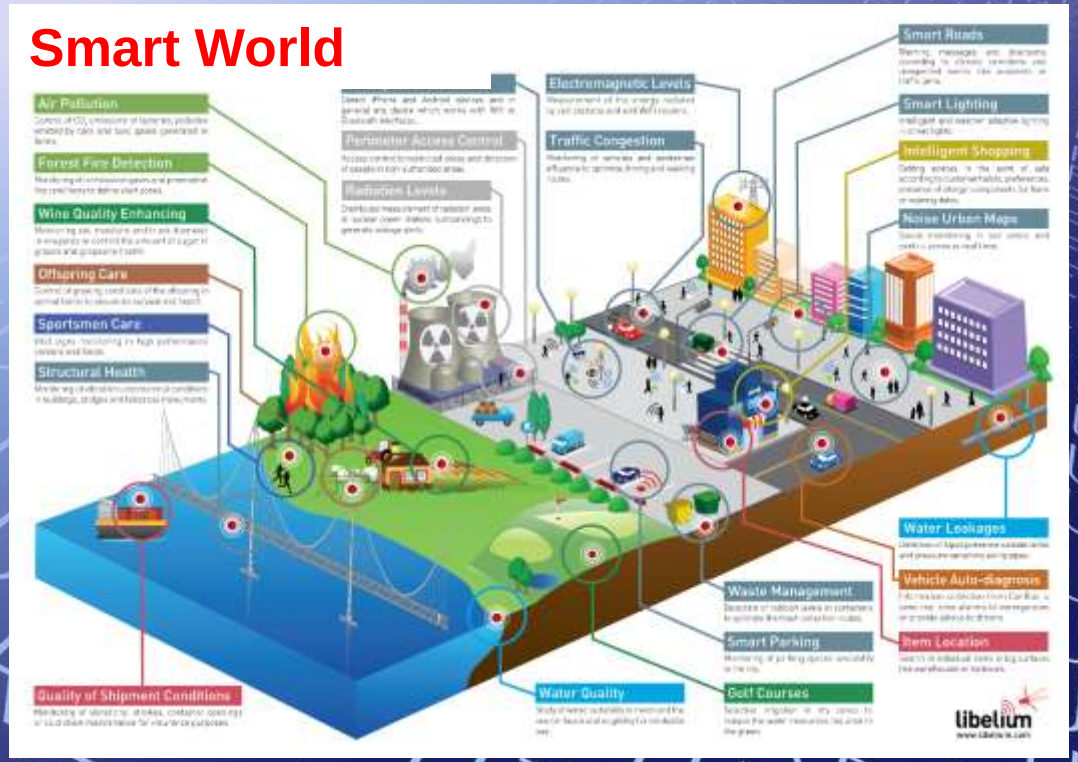
statista


Final critical remark (anonymous citation):
The STONE AGE was marked by man's clever use of crude tools;
the INFORMATION AGE, to date, has been marked by man's crude use of clever tools.

What comes next?

Convergence into Smart City (with 5G and/or 6G)?

Not enough!



Maybe Smart World.

But that needs more than just intelligent technologies!

And how would Mark Weiser judge the current development and see the future?

Obviously, the computer is not being used the way he envisioned and hoped for.

Will he accept the state-of-the-art or will he use the words that Ted Nelson used when he compared the Internet with his ambitious Xanadu Project: "I do not buy in! "?

Very likely:

Mark Weiser would approve and be surprised how far his idea of Ubiquitous Computing has advanced us.

→ Technology Assessment

Let us go back to the beginning:

Back to Kiel

Back to Kiel and Schleswig-Holstein

Kiel Sailing City (Kiel Week, Olympic Games)

Outlook and Collaboration

Universities and Reseach Institutes (selected, limited to the city of Kiel):

- University of Kiel
- Kiel University of Applied Sciences
- GEOMAR Helmholtz-Centre for Ocean Research Kiel
- Leibniz Institute for Science and Mathematics Education – IPN
- Faculty of Engineering of the Kiel University (CAU)
- University Medical Center Schleswig-Holstein (UKSH)
- ZBW – Leibniz Information Centre for Economics
- Kiel Institute for the World Economy (IfW)
- Max Rubner Institute (Consumer health protection in the nutrition sector)
- Science Center - Wissenschaftszentrum Kiel

Strong background Research, education and knowledge transfer

- Internet and Internet of Things, Data Science Research and Development, Embedded Systems, Renewable Energies, Wind Engineering, Naval/Maritime Engineering
- Technology Transfer Universities-Industry
- International Cooperations and Exchange Programs

Outlook and Collaboration (State of Schleswig-Holstein)

Important Business Sectors:

- **Digital economy**

  Comprises the areas of information technology (IT), telecommunications (TC), ICT hardware, ICT trade, e-commerce, media-related areas and media, with a clear focus on the areas of information technology with software development, media-related areas and e-commerce.

- **Renewable energies**

  Export country for clean green electricity. Around 2,981 wind turbines rotate here on land with a total output of 6,916 megawatts (MW).

- **Life sciences**

  Approximately 110,000 people in about 260 companies in the fields of medicine and medical technology

- **Maritime economy**

  The maritime economy includes research, development and production activities related to the sea. In terms of turnover and employment, shipbuilding and its suppliers form the core of the industry. With an annual turnover of around 8.5 billion Euros, this sector of the economy has a 12 percent share of Schleswig-Holstein's gross domestic product. 15 educational and research institutions are active in the maritime sector in the state and more than 2,100 companies employ around 40,000 people.

- **Mechanical Engineering**

  Companies in the mechanical have an above-average export share of around 64 percent. World market leaders:Sauer-Danfoss and Vossloh, Caterpillar and Jungheinrich benefit, among others.

- **Tourism/Hospitality industry**

  With 1,190 kilometres of coastline and countless beaches on two seas, around 300 lakes, 32,000 kilometres of rivers, Schleswig-Holstein is a true holiday paradise. Sports: sailing, surfing or rowing, riding or golfing, cycling or hiking. International cultural offers: Kiel Week, Wacken Open Air, Schleswig-Holstein Music Festival

Ref: https://wtsh.de/en/schleswig-holstein-strong-industries

Obviously there are plenty of opportunities in Germany, Schleswig-Holstein, and Kiel.

You are always welcome to visit us!

Thank you very much for your attention!

Prof. Dr. Helmut Dispert
Kiel University of Applied Sciences
Faculty of Computer Science and Electrical Engineering
Kiel, Germany

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Institutional: http://www.fh-kiel.de/index.php?id=dispert
Private: http://dispert.international-university.eu/