

IoT Internet of Things

Hartmut Seitter

Agenda – Topics which should be covered in this course

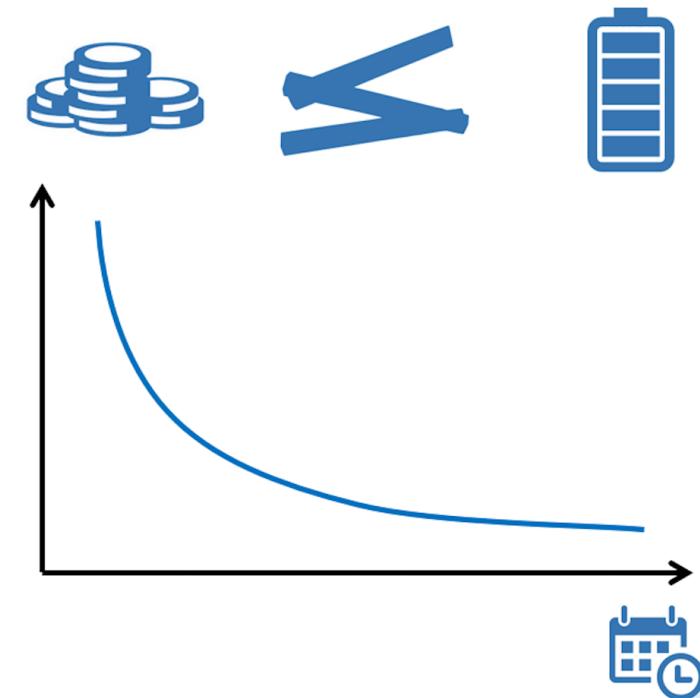
- **Introduction**
 - IoT Definition
 - What are the disciplines of IoT
 - A brief history about IoT
- **Application scenarios for IoT**
 - (Cool?) applications and a lot of opportunities
- **Sensors**
 - Wireless, sensor, networks and IoT
 - From Sensors and Actuators to
 - ... embedded systems and computation
- **Circuits**
 - Energy and Wireless
 - Digital & Analog
- **Embedded Systems**
 - Technology Drivers,
 - Energy,
 - Microcontroller,
 - Software

Agenda – Topics which should be covered in this course

- **Connectivity and Networking**
- **IoT Networks and Communication frameworks**
 - MQTT
 - LoRaWAN
 - CoAp
 - ZigBee
 - Thread Matter
- **Embedded power supplies, energy harvesting and constraints**
- **Architecture of distributed systems**
- **Internet principals, routing for IoT**
- **Consumer Producer and publish-subscriber communication patterns**
- **Information security and privacy concepts**
- **IoT Lab**

What is the Internet of Things

Sensors, Microprocessors, Radio Modules



Vision

*"The basic idea of the IoT is that **virtually every physical thing** in this world can also **become a computer** that is **connected to the Internet** (ITU, 2005)."*

E. Fleisch, 2010

IoT Introduction

- The **Internet of things (IoT)** describes physical objects (or groups of such objects) that are embedded with [sensors](#), processing ability, [software](#), and other technologies that connect and exchange data with other devices and systems over the [Internet](#) or other communications networks.[\[1\]](#)[\[2\]](#)[\[3\]](#)[\[4\]](#)
- Das **Internet der Dinge (IdD)** (auch: „Allesnetz“;[\[1\]](#) [englisch](#) *Internet of Things*, Kurzform: IoT) ist ein [Sammelbegriff](#) für Technologien einer globalen [Infrastruktur](#) der [Informationsgesellschaften](#), die es ermöglicht, physische und virtuelle Objekte miteinander zu vernetzen und sie durch [Informations- und Kommunikationstechniken](#) zusammenarbeiten zu lassen.[\[2\]](#)[\[3\]](#)[\[4\]](#)

Source

https://en.wikipedia.org/wiki/Internet_of_things#History

https://de.wikipedia.org/wiki/Internet_der_Dinge#Zielsetzung

AI hat auch eine Antwort auf die Frage ‘What is IoT’

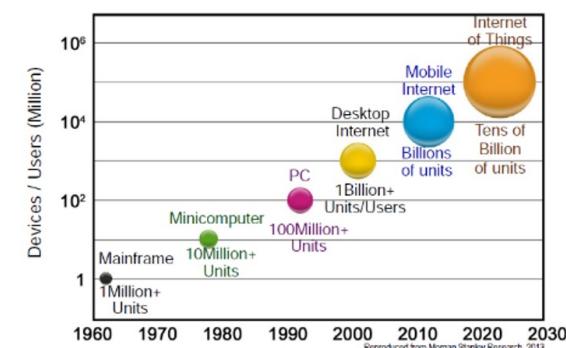
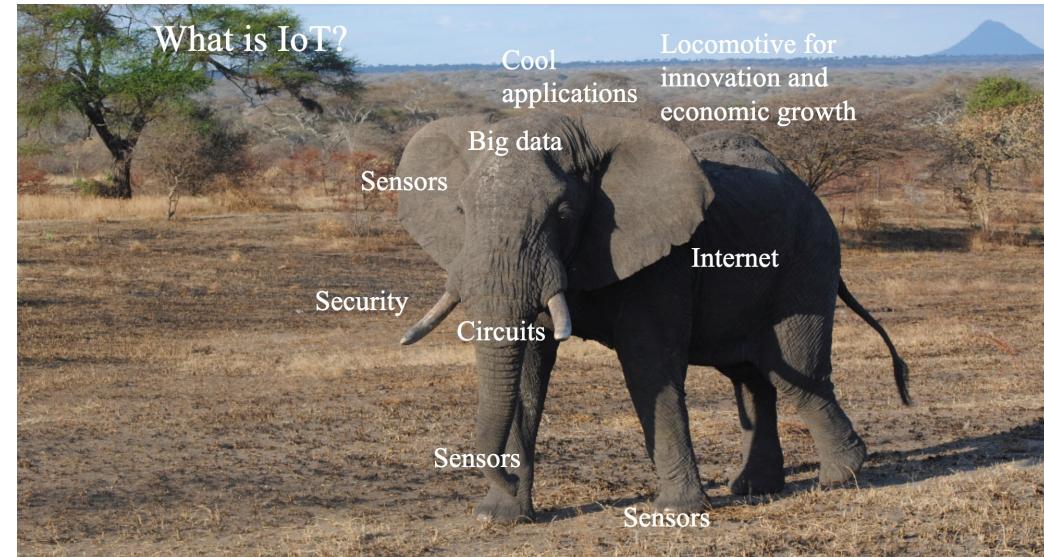
The Internet of Things (IoT) is **the connection of physical objects to the internet, enabling them to collect and exchange data with other devices and systems**. These objects, or "things," are embedded with sensors, software, and other technologies, and range from everyday household items to sophisticated industrial tools. The **goal of IoT is to automate tasks and improve work and living environments** by providing better user experiences, increasing efficiency, and offering new services.

Definitionen of IoT

- The internet of things, or IoT, is a network of interrelated devices that connect and exchange data with other IoT devices and the cloud. (TechTarget)
- Das „Internet of Things“ (IoT) bezeichnet die **Vernetzung von Objekten über das Internet.** (Nexus)
- The IoT architecture starts with an IoT device—a piece of technology that supports internet connectivity and is equipped with a sensor or means of measurement. (Stoftware AG)
- IoT uses a variety of technologies to connect the digital and physical worlds. (McKinsey)

Why is it important?

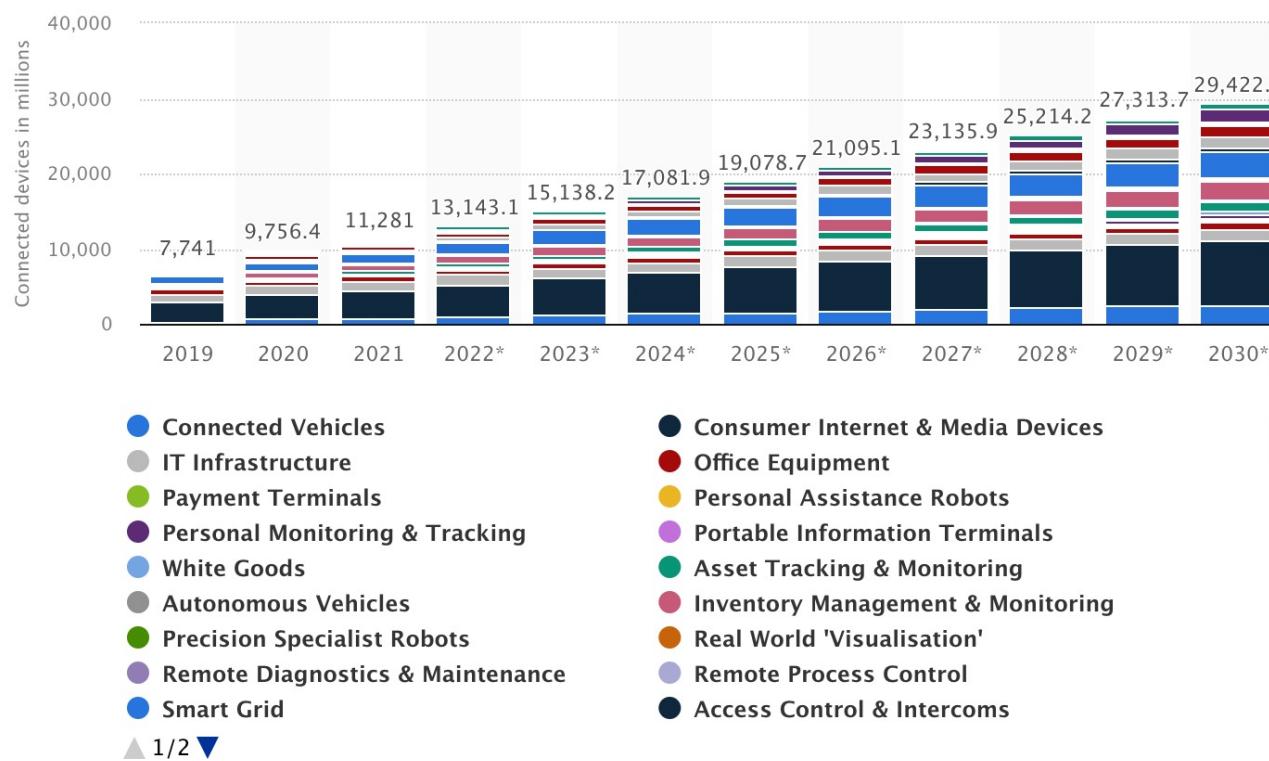
- In my point it very closely related to Industry 4.0
- It takes place nearly everywhere
- An illustration of what is the Internet
- Many experts say ‘the IoT will be the next big thing’



Major Technology Cycles = 10x More Users & Devices
Driven by: 1) Lower Price, 2) Improved Functionality & Services

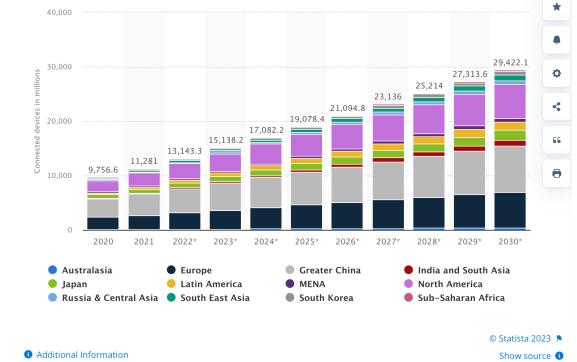
Source:Texas instruments

History of IoT



Number of Internet of Things (IoT) connected devices worldwide from 2019 to 2030, by use case

© Statista 2023



"The Internet of Things (IoT) is the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these things to connect and exchange data, creating opportunities for more direct integration of the physical world into computer-based systems, resulting in efficiency improvements, economic benefits, and reduced human exertions."

Source:

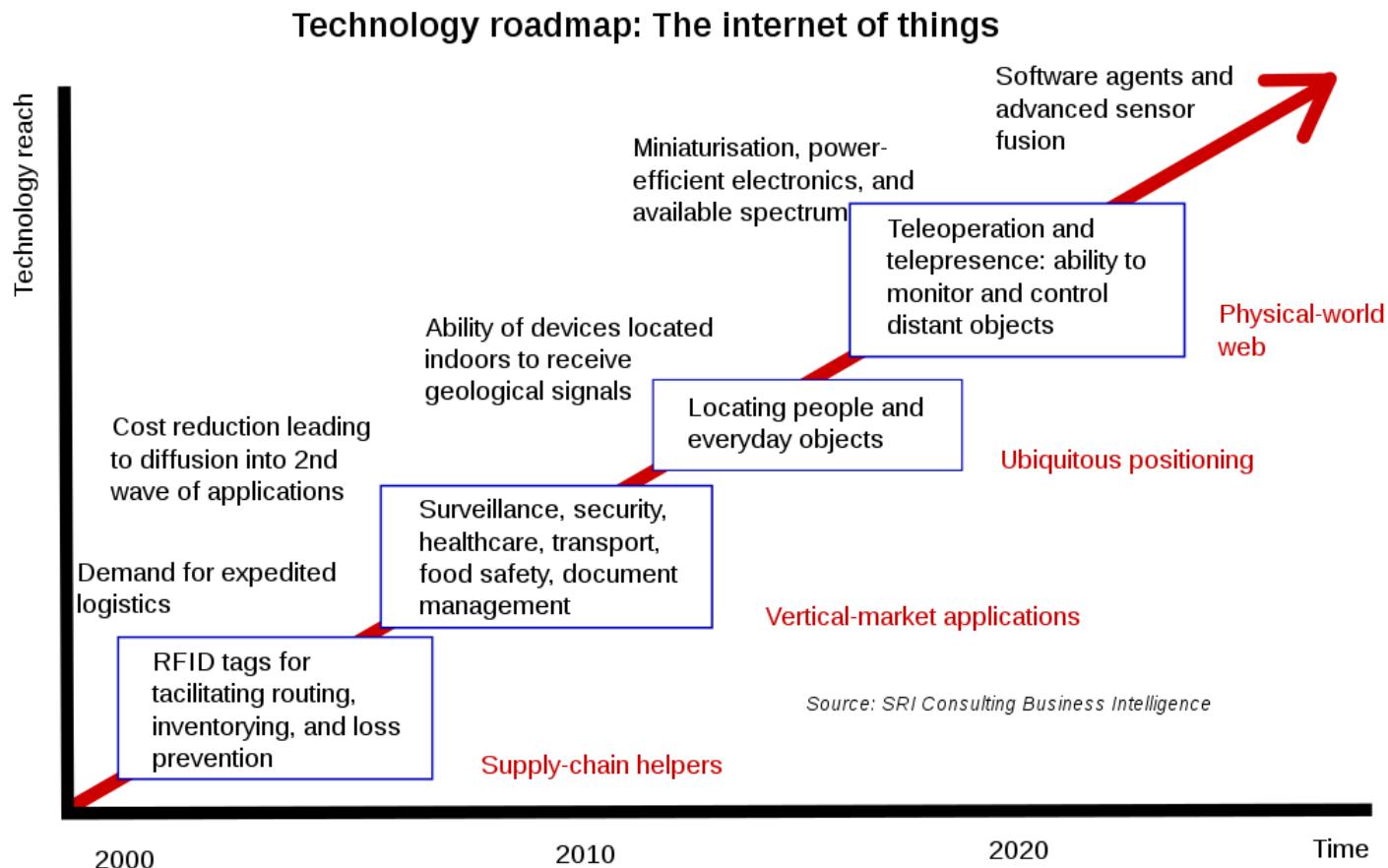
<https://www.statista.com/statistics>

History of IoT

- 1970- The actual idea of connected devices was proposed
- 1990- John Romkey created a toaster which could be turned on/off over the Internet
- 1995- Siemens introduced the first cellular module built for M2M
- 1999- The term “Internet of Things” was used by Kevin Ashton during his work at P&G which became widely accepted
- 2004 – The term was mentioned in famous publications like the Guardian, Boston Globe, and Scientific American
- 2005-UN’s International Telecommunications Union (ITU) published its first report on this topic.
- 2008- The Internet of Things was born
- 2011- Gartner, the market research company, include “The Internet of Things” technology in their research

Quelle: <https://www.guru99.com/iot-tutorial.html>

A brief history of the IoT technology roadmap



Source: https://de.wikipedia.org/wiki/Internet_der_Dinge

IoT: Number of applications and connected devices have grown exponentially

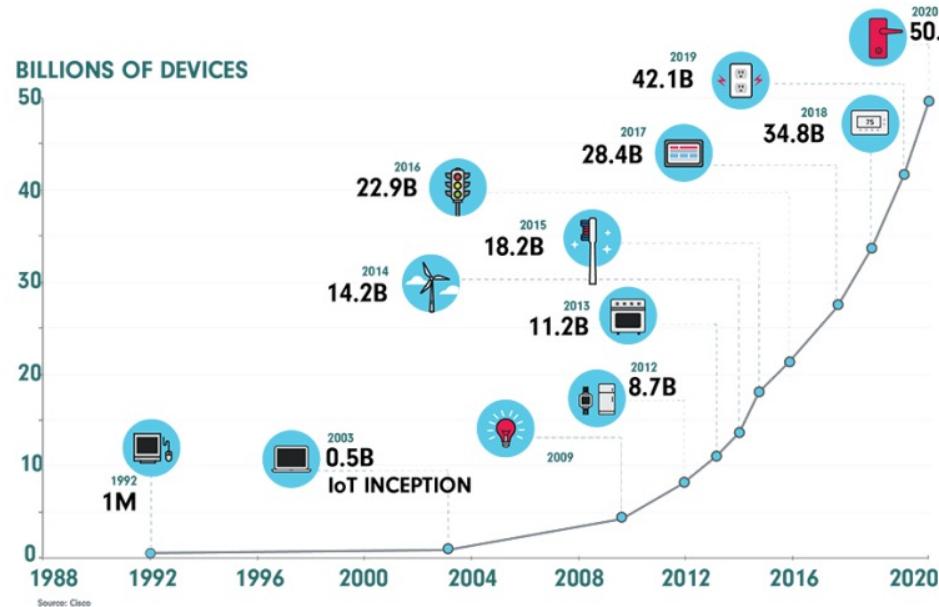
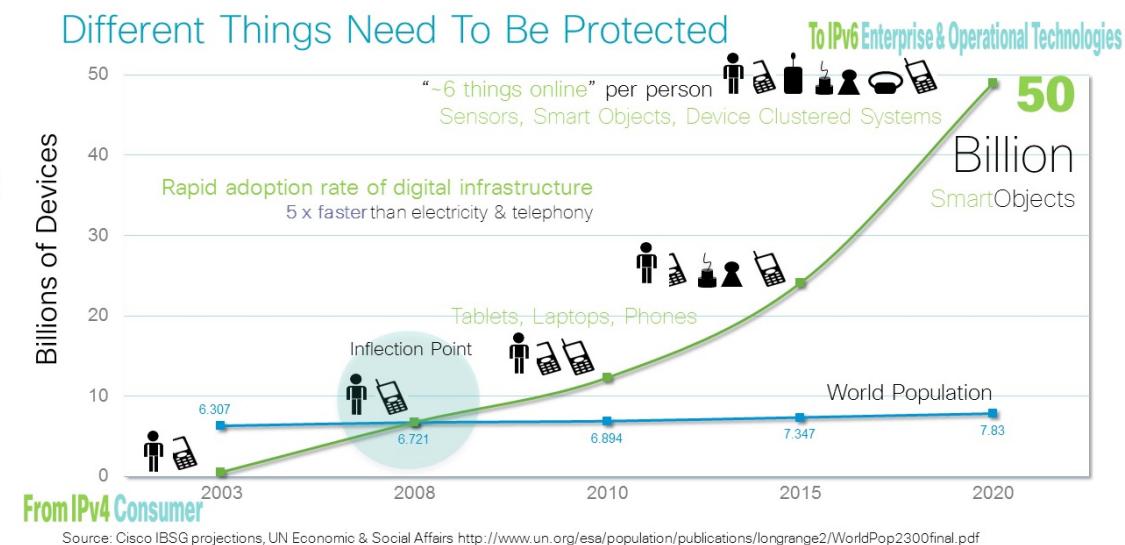


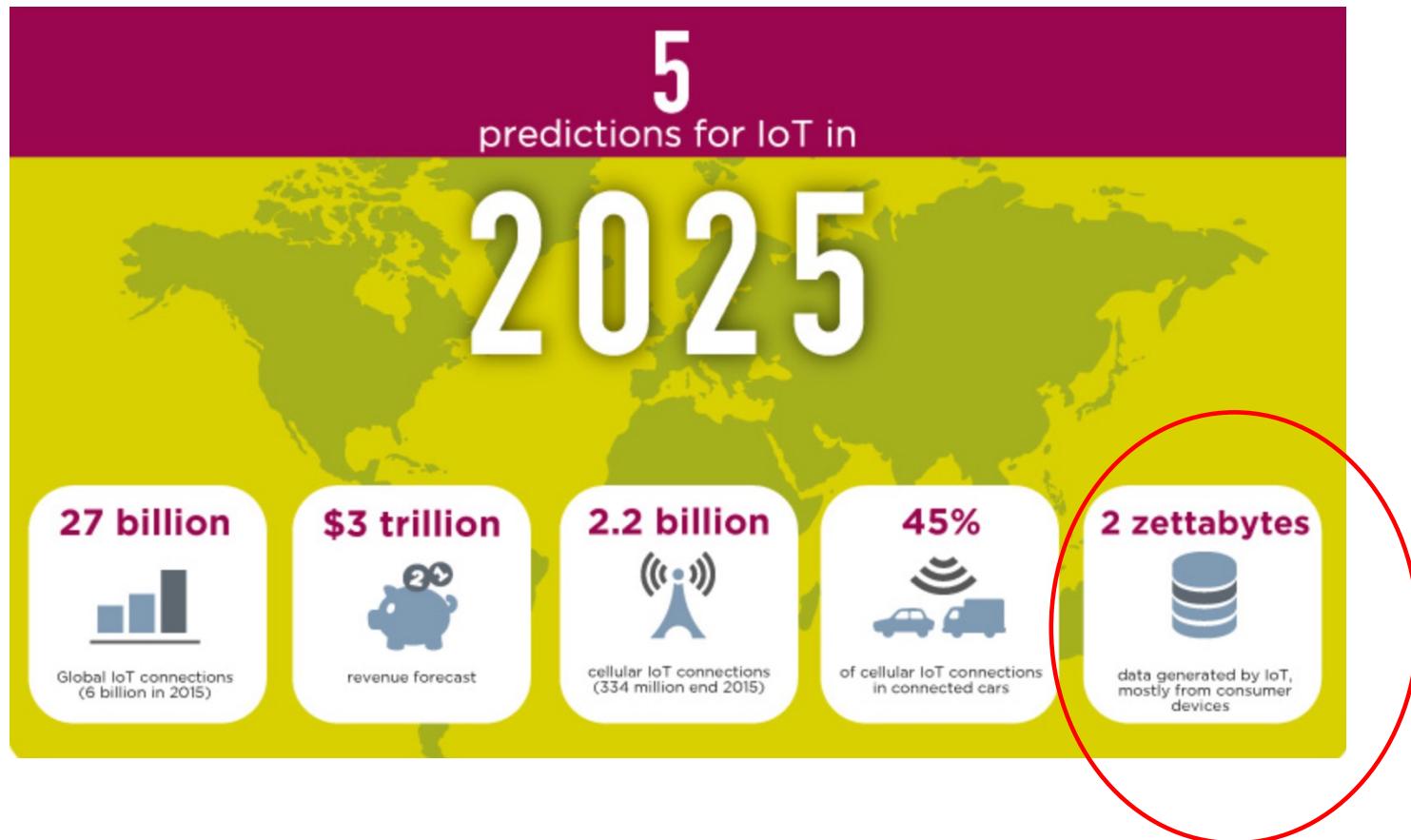
Figure 1: Growth of IoT devices. Source: Cisco.



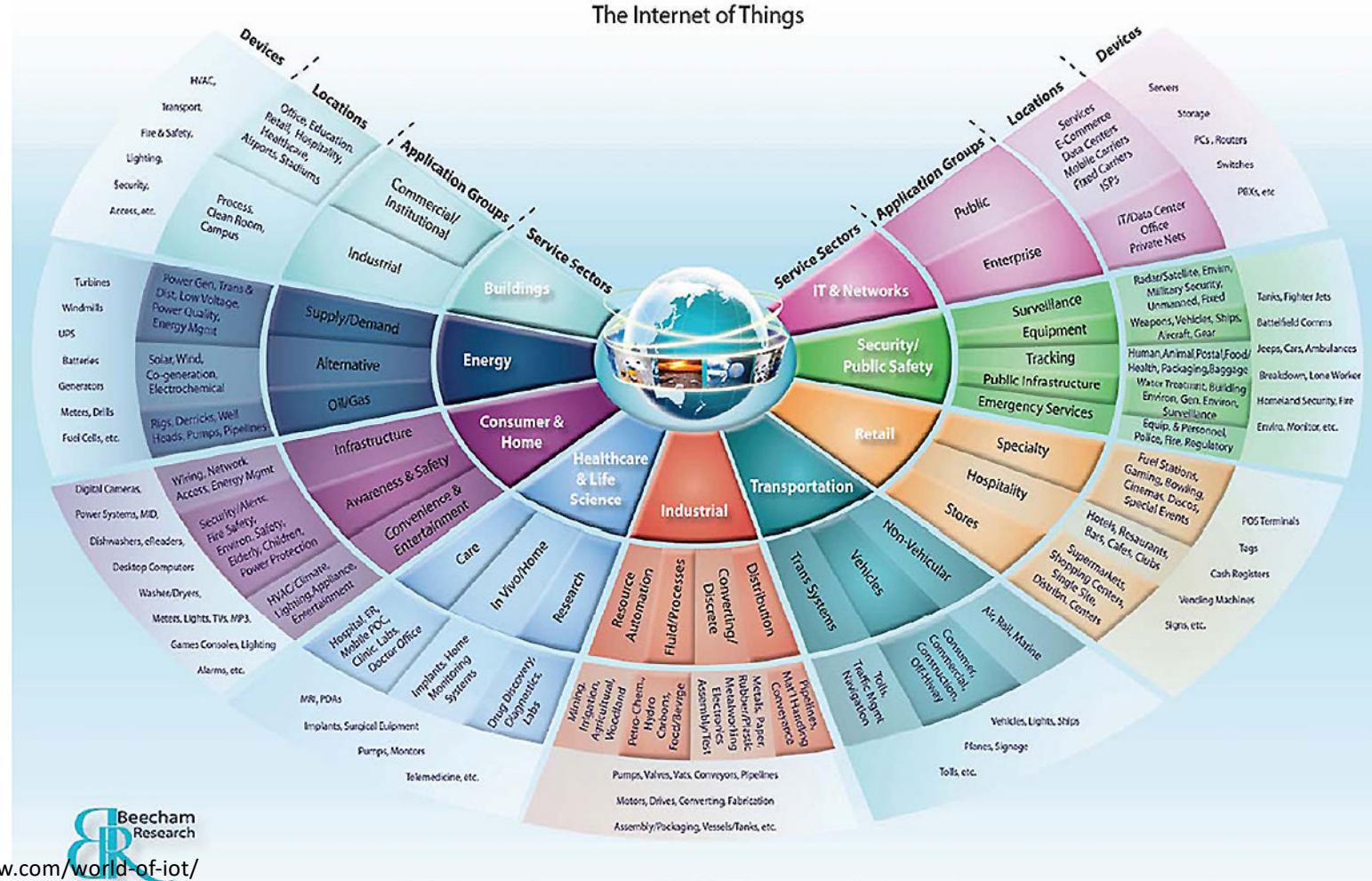
The ‘things’ or ‘objects’

- **What are IoT devices?**
 - IoT devices are the nonstandard computing devices that *connect wirelessly to a network* and have the *ability to transmit data*, such as the many devices on the internet of things.
 - IoT involves extending internet connectivity beyond standard devices, such as desktops, laptops, smartphones and tablets, to any range of traditionally "dumb" or non-internet-enabled physical devices and everyday objects. Embedded with technology, these devices can communicate and interact over the internet. They can also remotely be monitored and controlled.
 - What is an example of an IoT device?
 - Connected devices are part of an ecosystem in which every device talks to other related devices in an environment to automate home and industry tasks. They can communicate usable sensor data to users, businesses and other intended parties. The devices can be categorized into three main groups: consumer, enterprise and industrial.

IoT: Growth, growth and Data growth



The world of Internet of Things



Cool Applications –what do we want to do IoT for us?

- **Sustain (Smart cities)**
- **Move (Self driving cars)**
- **Heal (Healthcare)**
- **Feed (Agriculture)**
- **Make (Manufacturing and packaging)**
- **The purpose of this section is two fold:**
 - Get you excited about IoT potential
 - And more importantly, have you thinking of better ideas than the ones already out there

Cool Applications –what do we want to do IoT for us?

- What 'cool' IoT Applications do you know
 - Share your ideas

Das wäre jetzt der Zeitpunkt für eine interaktive Diskussion und Ihre Sicht auf 'cool IoT Apps'

Some ideas from my side smart, smart, smart....

- **Smart Cities**
 - Smart Water management
 - Smart parking system
 - Smart waste management
 -
- **Mimo Monitors**
 - Real time monitoring baby's health parameter
 -
- **Rolls-Royce Intelligent Engines**
 - help airlines reduce fuel usage and fly routes more efficiently
 -
- **UPS**
 - Using the data of more than 200 data points for each vehicle, UPS takes measures to reduce idling time and fuel consumption.
- **John Deere**
 - monitor the soil health, moisture levels, wind speed, solar radiation, rainfall, air and soil temperature, and leaf wetness and sends this data to farmers.
 -

Cool App e.g.: “Waste management”

Case Study: Dublin Airport

“

After deploying the solution, we have been able to go from collecting 840 containers 4 times a day to collecting just 80 containers a day. This has increased our operational efficiency upwards of 90% and resulted in significant cost savings. The solution has also provided us with data which has allowed us to recognise peak times in areas and from that adjust the allocation of staffing in those areas as well as increase waste container capacity where needed.

Hannah Forbes

Contract Services Specialist, Dublin Airport



Cool App e.g.: “Waste management”

Smart Waste Management

- Ultrasonic fill-level sensor
- Cellular IoT
- Solar powered
- Predictive pattern recognition



<http://ecubelabs.com/integrated-waste-management/>

Es gibt auch regionale Projekte – smart waste management in Herrenberg

Sprechende Mülleimer

Ein historischer Marktplatz. Rings herum Fachwerk-Fassaden mit adretten Blumenkästen. Im Hintergrund die Stiftskirche, „Glucke des Gäus“ genannt. Majestatisch thronend am Schlossberg. Mit dem übrig gebliebenen Gemäuer auf dem Plateau darüber und mit dem Rathaus darunter (wie das Wahrzeichen der Stadt ist auch dieses Gebäude mit einem malerischen Glockentürmchen ausgestattet) stellt die spätgotische Kirche ein ideales Fotomotiv dar.

Nichts soll und darf diese Idylle stören, erst recht nicht ein überquellender Mülleimer.



Momentaufnahmen –



die niemand sehen möchte

Deshalb war der Behälter neben dem Marktbrunnen – ebenfalls historisch und äußerst fotogen – einer der ersten, die ausgetauscht wurden. Statt des gängigen Modells, ein feuerverzinkter Stahlbehälter mit orange-farbenem Deckel, wurde ein so genannter Unterflur-Mülleimer aufgestellt. Oder vielmehr eingegraben. Denn was augenscheinlich schwarz, schlank und schmal



START SERVICE LEISTUNGEN BLOG STARTUP-BAUHOF ÜBER UNS KO

Erste Schritte auf dem Weg zu „Smart Herrenberg“

26. März 2019

INHALTSVERZEICHNIS



Schon seit einigen Jahren treibt die Verantwortlichen des TUGs das Thema „Sensoren“ um. Im Wissen um die Erleichterungen, die die Sensorknipsis beispielsweise für die Leitung der Unterflurmülleimer bedeuten würde, ging man beim Amt für Technik, Umwelt, Grün der Stadt

<https://tug-herrenberg.de/blog/erste-schritte-auf-dem-weg-zu-smart-herrenberg/>

Cool App e.g.: “Smart Street Lights”

- <http://www.tvilight.com/>



Up to 80%
energy savings



Reduce light
pollution
and CO2 emissions



Up to 70%
maintenance
cost reduction



True Light-on-
demand
with neighbor trigger

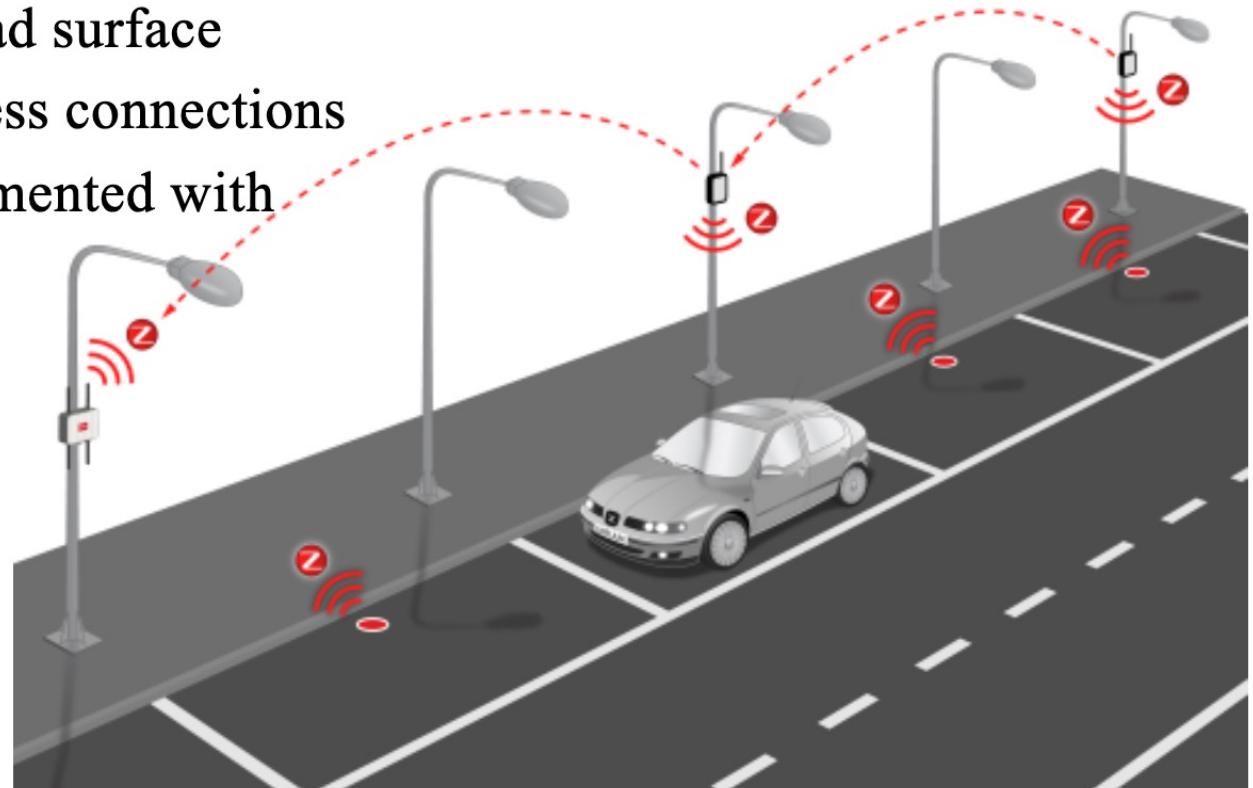


Advanced heatmaps

Cool App e.g.: “Smart Street Parking”

Smart Street Parking

- Infrared- and magnetic-based vehicle detection sensor mounted on the road surface
- Zigbee, LoRaWAN wireless connections
- Mesh networks are implemented with in street lights.
- Apps to direct drivers to empty spaces
- Dynamic parking pricess



Auch in Deutschland ist das ein Thema

Dreifacher Nutzen durch die Modernisierung der öffentlichen Beleuchtung

CO₂ reduzieren

60 Prozent der deutschen Städte sind noch nicht auf LED-Beleuchtung umgestiegen. Hier können Kommunen ansetzen, um ihren Energieverbrauch erheblich zu reduzieren und ihren CO₂-Footprint zu verbessern.

Energiekosten senken

Die öffentliche Beleuchtung macht im Durchschnitt ein Drittel der Stromkosten von Kommunen aus. Hier gibt es viel Einsparpotenzial.

Baustein für die Smart City

Auf jeden Fall lohnt es sich, bei der Erneuerung der Beleuchtung auch das Thema Digitalisierung einzubeziehen. Denn die Beleuchtungsinfrastruktur wird ein wichtiger Bestandteil der vernetzten Stadt werden.



<https://www.engage-deutschland.de/sites/default/files/2021-10/ENGIE-Brosch%C3%BCre-Smarke-Beleuchtung.pdf>



26. Juli 2021

Smart und vernetzt: Mit neuen Funktionen bringt Interact City die Beleuchtung von Herzogenaurach auf das nächste Level

- Signify sorgt für die intelligente Vernetzung der 3.200 Lichtpunkte von Herzogenaurach
- Mit dem neuen Dashboard Interact City von Signify erhält die Stadt ein intuitives Übersichts- und Steuerungsinterface
- Funktionen wie bedarfshängige, mitlaufende Beleuchtung oder unmittelbare Störungsreaktion erhöhen das Sicherheitsempfinden

<https://www.youtube.com/watch?v=a-WvawLns6c>

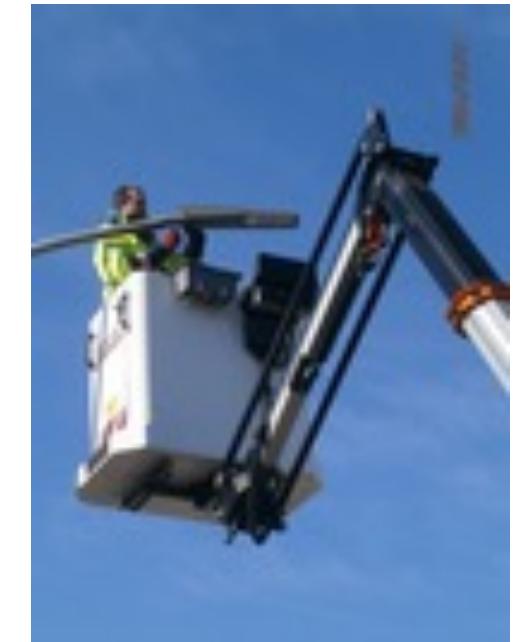
Meine Heimatgemeinde -nicht unbedingt die Inovativste Gemeindeverwaltung, aber

....

Der erste Bauabschnitt der Umrüstung der Straßenbeleuchtung auf hocheffiziente LED-Beleuchtung ist nun abgeschlossen. Im Zuge der Umrüstung wurden 202 Straßenlampen mit LED-Technik installiert. Die eingesparte Energie beträgt zwischen 73% und 86%. So wurden z.B. Leuchten mit einer Gesamtleistung von 166 Watt, durch LED-Leuchten mit 39 Watt ersetzt, wobei die Beleuchtungshelligkeit gleich geblieben ist. Die jährliche Stromeinsparung wird über 55.000 kWh betragen und über 20 Jahre ist mit einer Einsparung von 652 Tonnen CO₂ zu rechnen.

Die Umrüstung der Straßenbeleuchtung wird durch Mittel der Nationalen Klimaschutzinitiative des Bundesministeriums für Wirtschaft und Klimaschutz mit 30% der Baukosten unterstützt.

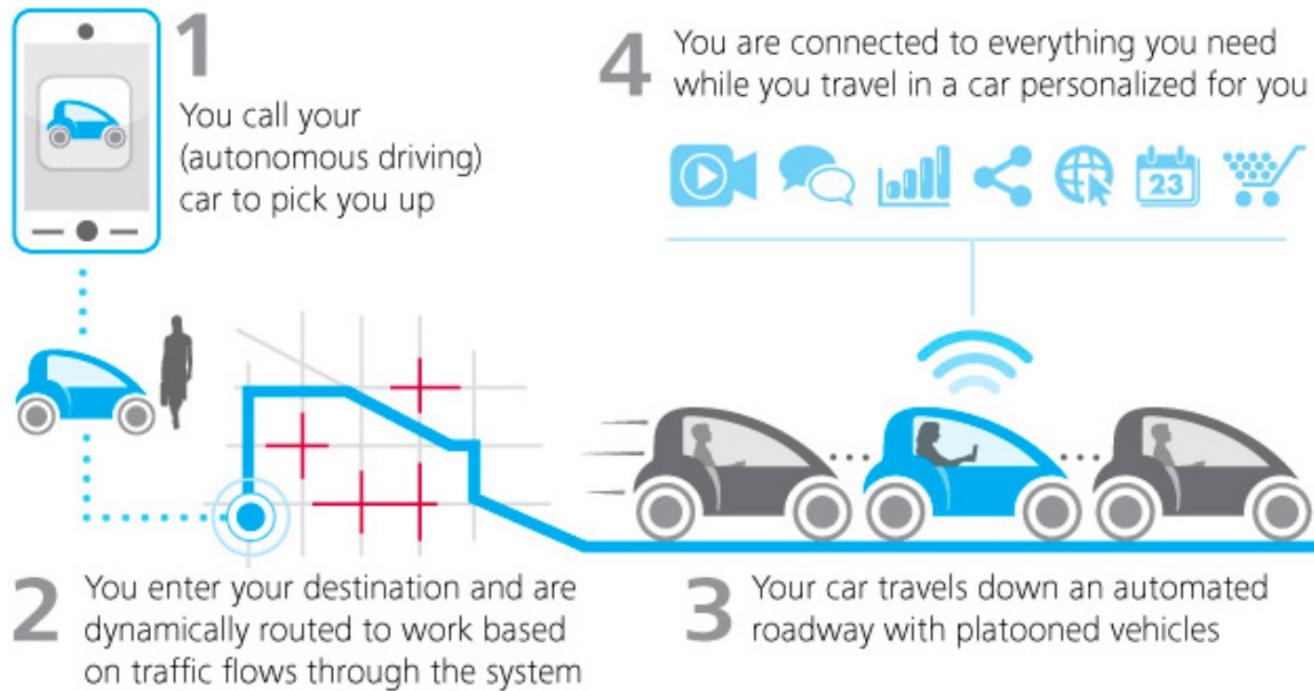
Im Laufe des Jahres 2022 sollen noch weitere 512 Leuchte, durch hocheffiziente LED-Beleuchtung ersetzt werden. Bei dieser Umrüstung werden ca. 124.500 kWh/a an Strom und über 20 Jahre 1094 Tonnen CO₂ eingespart. Der gestellte Förderantrag wurde genehmigt und auch durch eine Zuwendung von 30% von der Nationalen Klimaschutzinitiative des Bundesministeriums für Wirtschaft und Klimaschutz unterstützt.



Aus meiner Sicht: ‘Nur’ ein erster Schritt

Cool App e.g: “Connected Vehicles“

Connected Vehicles – Combine private and collective transportation: The best of both



Source: <http://government-2020.dupress.com/trend/connected-vehicles>

Cool App e.g: “Connected Vehicles“

Connected Vehicles – Stages of Safety Innovation



- Passive vehicle safety uses sensors to take the vehicle's immediate surroundings into consideration.
- Recent efforts enable the sharing of information gathered by the sensors between vehicles, and between vehicles and their surroundings to increase safety further.
 - V2X (vehicle-to-X, where X represents other vehicles, infrastructure, roads, and so on)
 - A step towards autonomous driving

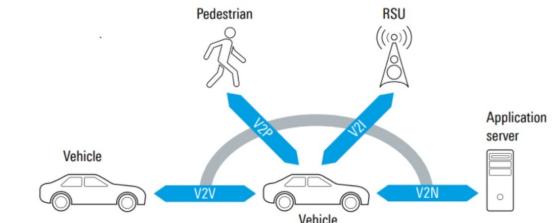
<https://dupspress.deloitte.com/dup-us-en/deloitte-review/issue-12/the-rise-of-safety-innovations-in-intelligent-mobility.html>

V2X – Vehicle to everything communication

- V2X is a communication from vehicle to everything**

DSRC (defined by IEEE 802.11p: WAVE)

DSRC was first introduced as a V2X technology in the Institute of Electrical and Electronics Engineers (IEEE)'s 802.11p standard, a vehicular communication protocol intended for adding wireless access in vehicular environments (WAVE). As the first communication standard for V2X, WAVE uses WLAN technology to establish dedicated short-range communication (DSRC) channels so that the vehicles can communicate directly to other entities within short to medium ranges (typically 300 meters).



C-V2X (defined by 3GPP Releases 14, 15, 16)

Introduced soon after DSRC, C-V2X is another vehicular communication protocol developed for V2X. Defined by the 3rd Generation Partnership Projects (3GPP), C-V2X utilizes cellular radio instead of WLAN, meaning that it utilizes the same set of cellular radio technology as cellphones do. The major difference that sets C-V2X apart from DSRC is that it allows both direct and indirect communication. In **direct C-V2X**, vehicles communicate directly with other vehicles (V2V) and roadside units (V2I) the same way as how DSRC works. Under indirect C-V2X, vehicles communicate with other entities indirectly via the cellular network (V2N), which is something DSRC cannot do.

	DSRC	C-V2X	
Protocol Name:	IEEE 802.11p: WAVE	3GPP Releases 14 and above	
Communication Technology:	WLAN	Cellular (LTE, 5G, 5G NR)	
		Direct C-V2X	Indirect C-V2X
Time of Deployment:	2015	2021	2024
Cellular Network Connectivity:	No	No	Yes

<https://autocrypt.io/dsrc-vs-c-v2x-a-detailed-comparison-of-the-2-types-of-v2x-technologies/>

Connected cars communication types

- **V2V – Vehicle-to-Vehicle**

- Direct communication between vehicles. Information on position, speed, or braking behavior is exchanged in real time to avoid collisions and optimize traffic flow.

- **V2C – Vehicle-to-Cloud**

- Connection to cloud services via the internet. Driving data is uploaded, software updates are distributed, and connected services – such as navigation or maintenance functions – are provided via mobile networks (e.g., LTE or 5G).

- **V2I – Vehicle-to-Infrastructure**

- Connection with the transport infrastructure. This communication helps adapt driving behavior to the current traffic situation and reduce waiting times.

- **V2C – Vehicle-to-Pedestrian**

- Exchange of information with other road users. The goal is to identify and prevent potentially dangerous situations early on.

How does Car Connect work? – Technological foundations

The key components of a connected vehicle at a glance:

- **On-board diagnostics (OBD)** continuously collect technical data such as engine temperature, error codes, or driving behaviour.
- **M2M SIM cards** enable communication with the outside world – nationally and internationally, often in real time.
- **GPS modules** provide precise location data for navigation, tracking, or geofencing.
- Through **cloud connectivity via mobile networks** (e.g., LTE, [5G](#)), data is exchanged, software versions are updated, and services are provided.
- **Apps and OTA (Over-the-Air)** updates allow vehicle settings to be changed via smartphone, remote diagnostics to be performed, or new functions to be installed.

Source: iot.telecom

Aktuell – smart meter Konzept der Bundesregierung

- ... Die intelligenten Systeme sollen helfen, Energie effizient und kostengünstig zu nutzen sowie das Stromnetz zu entlasten. Sie seien somit ein wichtiger Baustein der Energiewende,



☰ Menü | Nachhaltigkeitspolitik 🔎 Suche

Nachhaltigkeitsstrategie Agenda 2030 - die 17 Ziele Beispiele guter Praxis Gemeinschaftswerk Akteure +

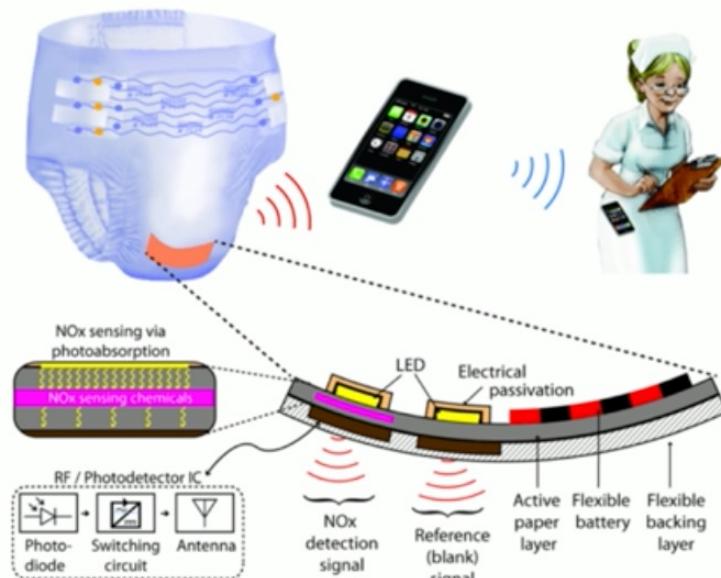
The illustration shows a central grey rectangular device with a screen and a green power button, connected by a line to a blue refrigerator, an orange oven, and a white washing machine. Above the washing machine is a grey lamp. To the right of the central device is a window showing a wind farm with three turbines and a single tree. A play button icon is positioned between the central device and the window. At the bottom left, there is a timestamp '01:01' with a play button icon.

Let's recap

- **What sensors are used by this ‘cool applications’**
 - Fill level sensors
 - Light and motion sensors
 - Infrared and magnetic sensor-based vehicle detection sensors
 - Camera
 - Temperature, Humidity
 - Pressure
 - Air Quality
 -
- **What communication protocols might be used**
 - BLE and Bluetooth
 - Cellular IoT (LTE,, 5G)
 - Zigbee, LoRaWAN
 - Thread, Matter
 - V2X
 -
- **Network type**
 - WPAN
 - WLAN
 - Low Power Wide Area Network (LoRaWAN, ...)
 - Mesh network

Cool App e.g.: Baby Monitoring

Baby Monitoring – Urinary Tract Infection Monitoring

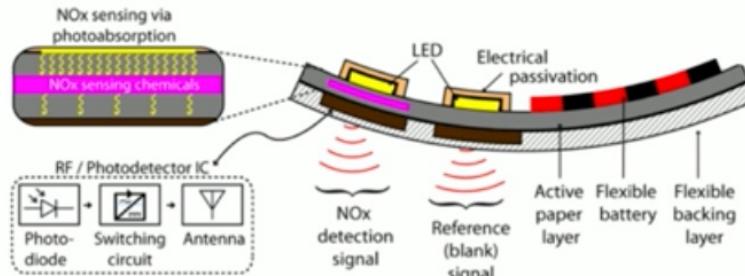


- Urinary tract infection (UTI) is the second most common infection in the US accounting for 7M hospital visits and 100,000 hospitalization per year.
- It is easy to cure if detected and treated in early stage.
- Urine culture test is accurate but time consuming. Dip stick test is fast but high false alarm rate.

<https://sites.google.com/site/jagpurdue/projects/catalyst>

Cool App e.g.: Baby Monitoring

Baby Monitoring – Urinary Tract Infection Monitoring

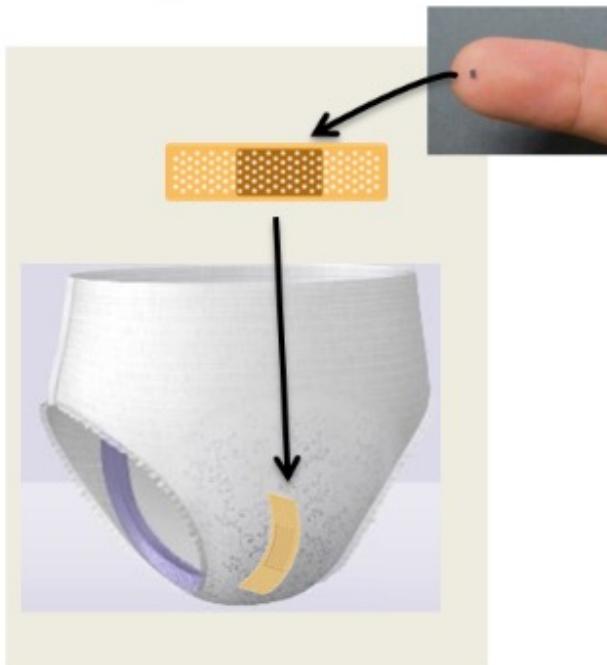


- Urine-activated paper battery (self-powered)
- Paper-based colorimetric nitrite sensor consisting of an LED, a urine-absorbing strip, a reagent strip, an active photodiode, and a reference photodiode.
- Sensor signal is converted into a PWM waveform.
- BLE module transmits the PWM signal to the caregiver.

<https://sites.google.com/site/jagpurdue/projects/catalyst>

Cool app e.g.: Elderly care monitoring

Elderly Monitoring – Incontinence Management



- In most nursing homes, between 40% and 60% of residents suffer from urinary incontinence.
- Smart diaper allows caregivers to remotely detect if an incontinence event has occurred.
- Improved quality and dignity of care by not having to disturb the elderly.

<http://rfmicron.com/health-care/>

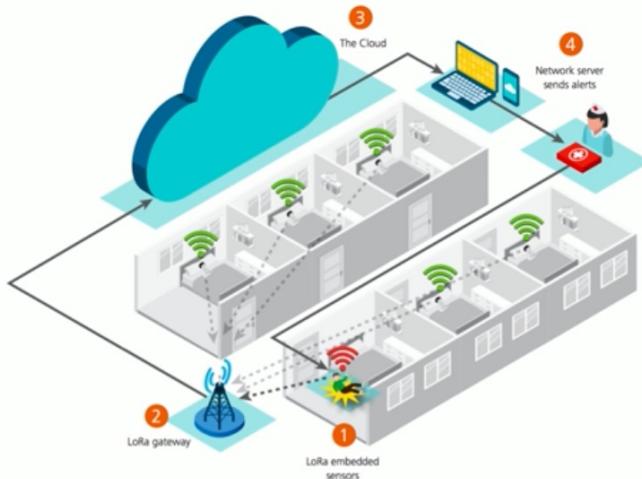
<http://www.medisens.com/news/press-release-1>

Cool app e.g.: Elderly care monitoring

- **25% of Americans aged 65+ falls each year**
- **Every 11 sec an older adult is treated in the emergency room for a fall**
 - **Every 19 minutes an older adult dies from a fall.**
- **Falls are the leading cause of fatal inquiry and the most common cause of nonfatal trauma related hospital admissions among older adults.**
- **Falls result in more than 2.8 million inquiries treated in emergency departments annually, including over 800000 hospitalizations and more than 27000 deaths.**

Cool app e.g.: Elderly care monitoring

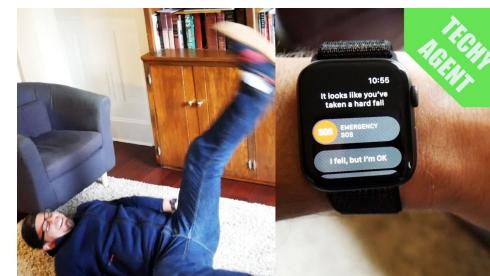
Elderly Monitoring – Fall Detection



- ① Fall/movement data collected by sensors embedded with LoRa Technology
- ② Data from all sensors is sent to a LoRa gateway as person moves
- ③ Gateway sends information to the Cloud where the data is analyzed by an application to determine what is normal and what is a fall
- ④ Application server sends reports and alerts on the fall and location of the person to a computer or mobile device

http://www.semtech.com/wireless-rf/internet-of-things/downloads/Semtech_Health_FallDetection_AppBrief-FINAL.pdf

See also Apple fall detection feature for the apple watch



More cool apps in the healthcare space

Mood Enhancing – Sleep Monitoring

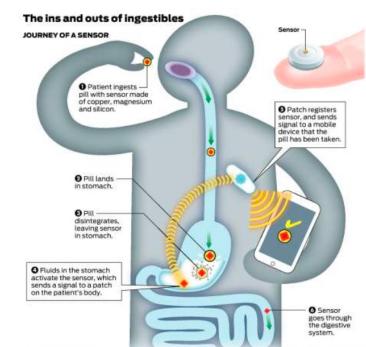


<https://www.beddit.com/>



“Ingestible sensors”!!!

Enhance Adherence – Ingestible Sensors



<http://www.proteus.com/>
<http://www.sfgate.com/business/article/Did-you-take-your-pill-Ingestible-sensors-can-11206980.php>

A few more cool apps

Smart Home – Smart Fridge



Im Januar 2023 führte Samsung Electronics auf der Consumer Electronics Show (CES) 2023 eine verbesserte Iteration seines Family Hub Kühlschranks ein. Dieses aktualisierte Modell integriert fortgeschrittene **künstliche Intelligenz Fähigkeiten, einschließlich verbesserter Spracherkennung Technologie und personalisierte Mahlzeiten Planung Funktionalität.**

<https://www.youtube.com/watch?v=ZAosrqDB0Zw>

Integrating Your Smart Refrigerator into Your Smart Kitchen and into your Home

- Refrigerator holds an inventory list of ingredients together with other smart storage places
- AI will make recommendation what you can cook with these ingredients
- Oven, baking oven, ... will get the cooking info from AI
- You will be guided through the recipe with the help of voice control
-

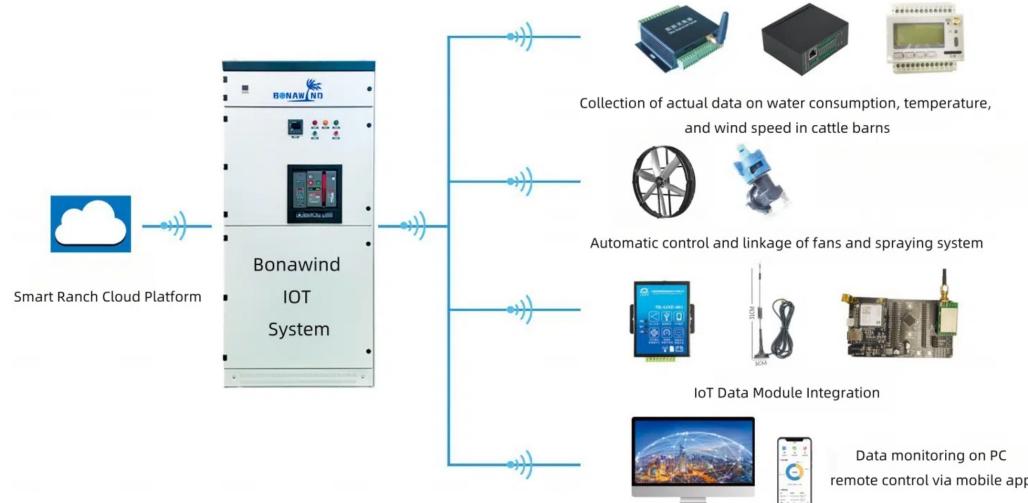
A few more cool apps



Smart Cow – IoT in agriculture



<https://www.youtube.com/watch?v=ewnR1w16Y0g>



<https://www.youtube.com/watch?v=gwpiGv0Fpj5>

A few more cool apps

Smart Home – Smart Fridge



<https://www.youtube.com/watch?v=ZAo srqDB0Zw>

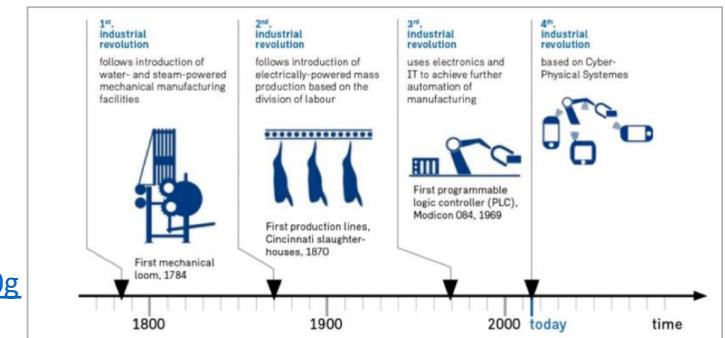
Im Januar 2023 führte Samsung Electronics auf der Consumer Electronics Show (CES) 2023 eine verbesserte Iteration seines Family Hub Kühlschranks ein. Dieses aktualisierte Modell integriert fortgeschrittenen **künstliche Intelligenz Fähigkeiten, einschließlich verbesserter Spracherkennung Technologie und personalisierte Mahlzeiten Planung Funktionalität.**

Smart Cow – IoT in agriculture



<https://www.youtube.com/watch?v=ewnR1w16Y0g>

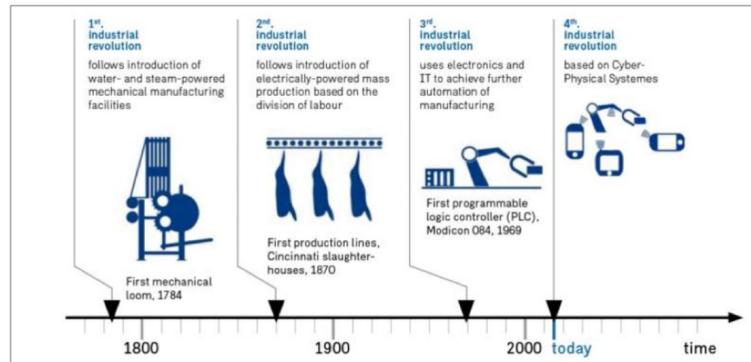
Industry 4.0



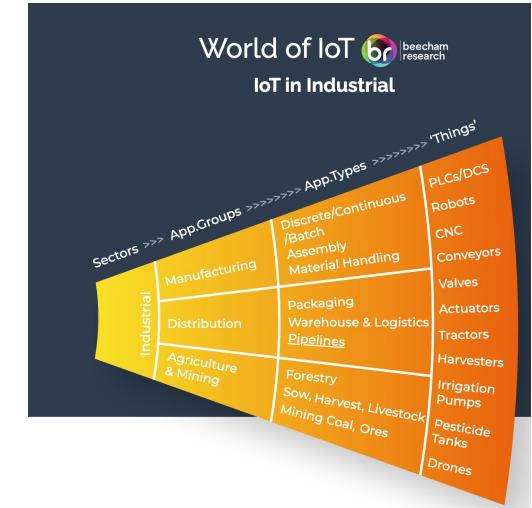
<https://www.youtube.com/watch?v=Y990kaGbJD0>

A few more cool apps

Industry 4.0



<https://www.youtube.com/watch?v=Y990kaGbJD0>



Bundesministerium
für Wirtschaft
und Energie

Bundesministerium
für Forschung, Technologie
und Raumfahrt

Industrie 4.0 bezeichnet die intelligente Vernetzung von Maschinen und Abläufen in der Industrie mit Hilfe von Informations- und Kommunikationstechnologie. Für Unternehmen gibt es viele Möglichkeiten, intelligente Vernetzung zu nutzen.

Bundesministerium für Wirtschaft und Energie zum Thema IoT

- **Zwei Bereich sind aufgeführt:**

- **Smart Home - das intelligente Zuhause der Zukunft**

- Im intelligenten Haus ("Smart Home") tragen die Möglichkeiten dieser Technik zu mehr Komfort und Sicherheit, zur Energieeinsparung oder zur Unterstützung altersgerechten Lebens und Wohnens bei.
-

- **Industrie 4.0 - die Digitalisierung der Wirtschaft**

- Bei Industrie 4.0 entstehen aus physischen Komponenten - zum Beispiel Werkzeugmaschinen - durch die Integration von Rechenleistung und Internet sogenannte Cyber Physikalische Systeme (CPS). Sie bilden die Grundlage der intelligenten Fabrik der Zukunft ("Smart Factory"): Intelligente Maschinen koordinieren selbstständig Fertigungsprozesse, Service-Roboter kooperieren in der Montage auf intelligente Weise mit Menschen, intelligente (fahrerlose) Transportfahrzeuge erledigen eigenständig Logistikaufträge.
-

IoT – Service Sections

- **Buildings**
- **Energy**
- **Consumer & Home**
- **Healthcare and Life Science**
- **Industrial**
- **Transportation**
- **Retail**
- **Security & Public Safety**
- **IT & Networks**

We can also say – IoT is present in all sectors of our live

IoT core components

- **Sensor and Devices that collect data**
- **Connectivity to transmit data**
- **Data processing which analyses data**
- **User interface that represent insights and allow control**
 - (actuators execute tasks that are essential for automation etc.)