Modul
- Internet of Things (IoT) -

00-Einführung

Prof. Dr. Marcel Tilly

Fakultät Informatik, Cloud Computing

Organisatorisches

Modulbeschreibung: https://hsro-inf-iot.github.io/

Vorlesungstermin: Donnerstag, 08:00 - 11:15 (1.5h Vorlesung + 1.5h Übungen); Raum B0.11

- **Leistungsnachweis**
  - **PStA** : Die Projektarbeit wird im Rahmen der Übung durchgeführt. Abschlusspräsentation ist am 04. Juli (letzter Vorlesungstermin!)

- **Empfohlene Literatur**
  - Perry Lea: Internet of Things for Architects: Architecting IoT solutions by implementing sensors, communication infrastructure, edge computing, analytics, and security (Englisch Edition)
  - Andrew Minteer: Analytics for the Internet of Things (IoT): Intelligent analytics for your intelligent devices (Englisch Edition)

Überblick

21. März	Einführung in das Internet der Dinge
28. März	IoT Architekturen
4. April	Things und Sensoren
11. April	From Device to Cloud
18. April	Vorlesungsfrei – Ostern
25. April	IoT Analytics
02. Mai	Big Data in IoT
9. Mai	Data Exploration
16. Mai	IoT Platformen
23. Mai	Entwicklung einer IoT Lösung
30. Mai	Vorlesungsfrei; Christi Himmelfahrt
05. Juni	opt. Gastvortrag – Digitalisierung
13. Juni	Data Science in IoT
20. Juni	Vorlesungsfrei – Fronleichnam
27. Juni	Intelligente Cloud und intelligente Edge
04. Juli	PStA Abschlusspraesentationen

PStA

*The “Internet of Things” or IoT is cool. I know this because everyone tells everyone else how **cool** it is. Ask anyone and they will give you their own definition of what IoT means and why it is cool.*

-- Steven Sinofsky

Das schlaue Örtchen – Die Toilette wird Hightech- und Designerprodukt

Moderne Toiletten sind Hightech-Produkte: Dusch-WCs waschen und föhnen, haben Nutzungsprofile, wärmen den Sitz auf Wunschtemperatur vor und saugen Gerüche ab.

Internet of Things = IoT

Wie misst man ob eine Thema *cool* ist?

Google Suche nach “*Internet of Things*” -> ~ 2.500.000.000 Treffer

zum Vergleich

„*Taylor Swift*“ -> ~ 628.000.000 Treffer

oder

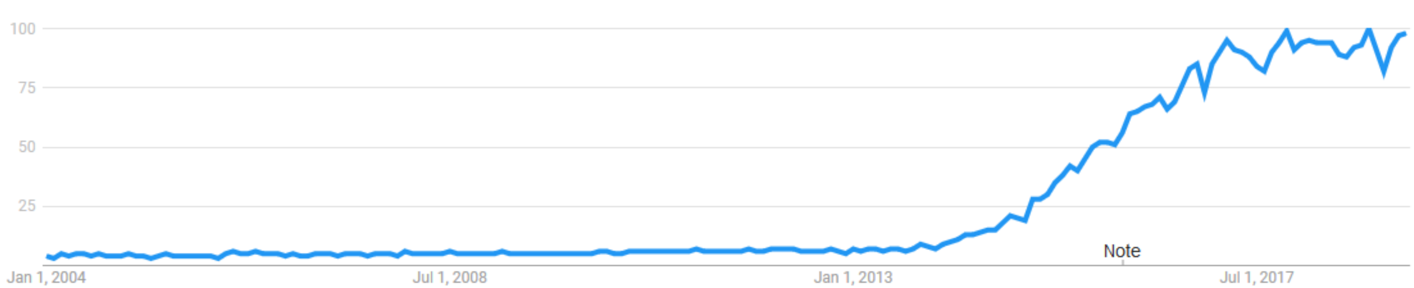
„*Bayern München*“ -> ~ 300.000.000 Treffer

Wissenschaftliche Artikel zu IoT ca. 3.070.000 Ergebnisse

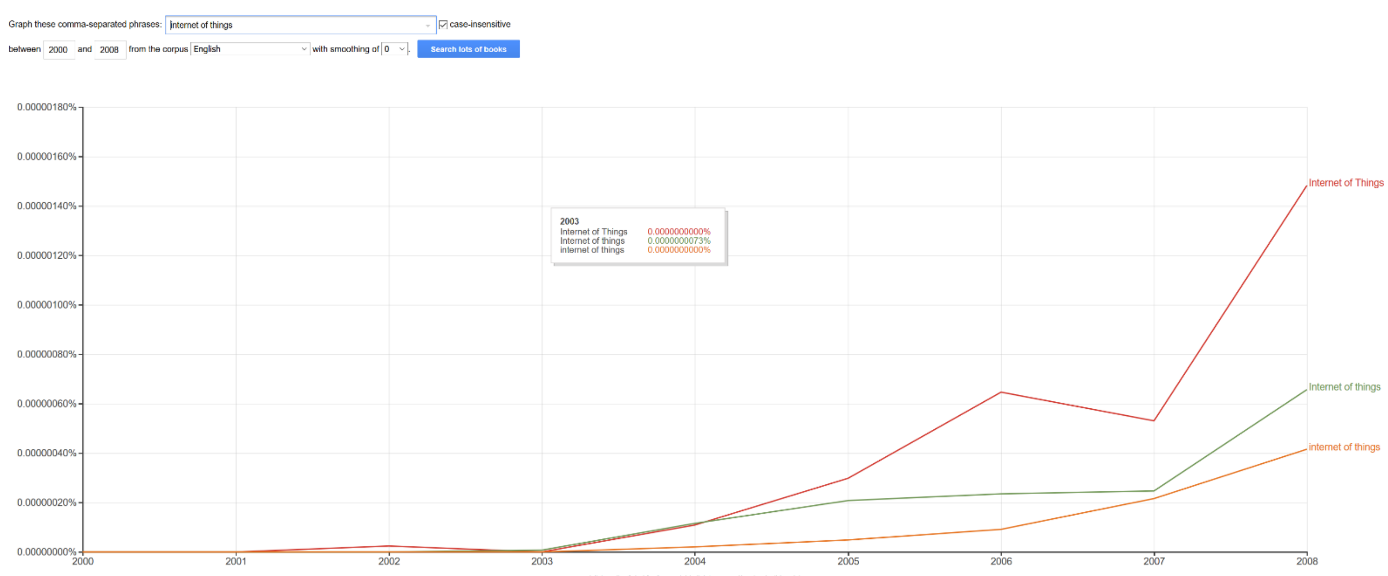
Stand: 20.03.2019

Trends in Internet

Google Trends: „IoT“

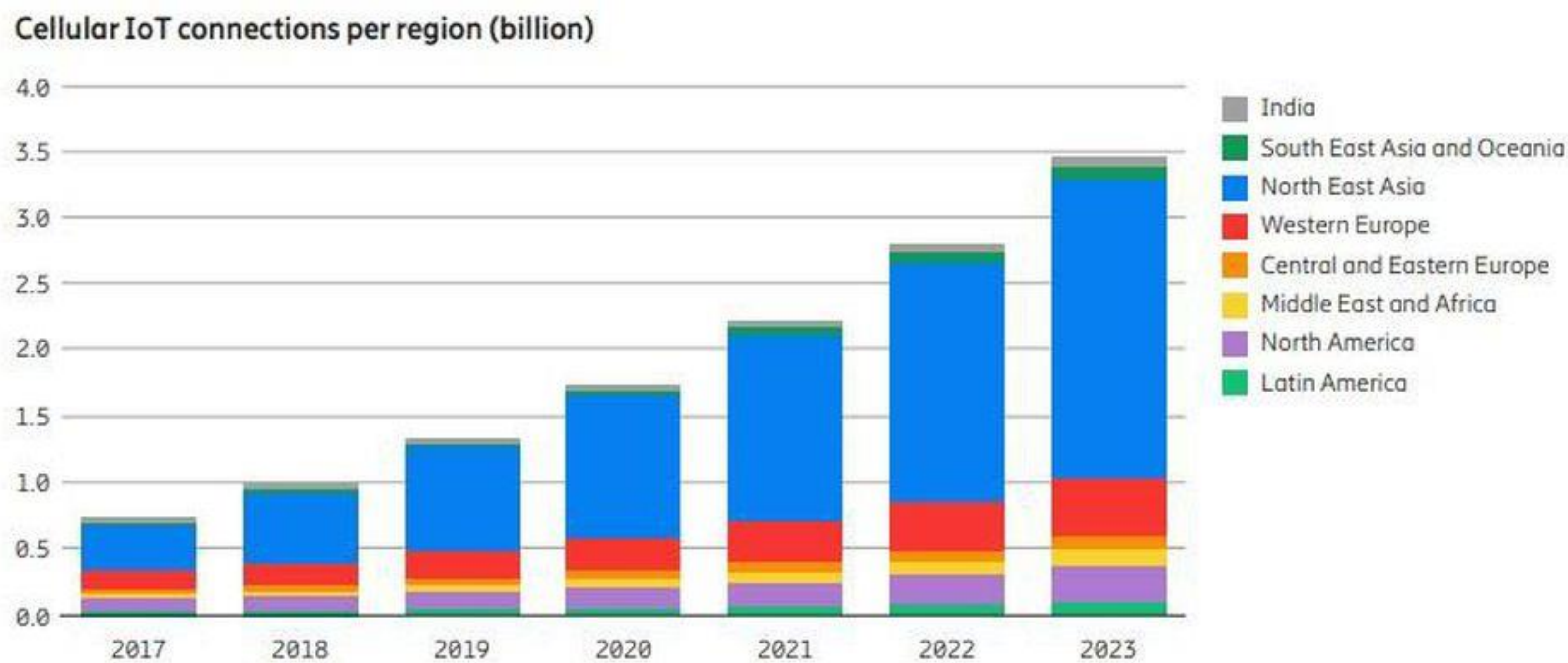


Google Books Ngam Viever: „Internet of Things“



IoT Potential

Ericsson is forecasting the number of cellular IoT connections is expected to reach 3.5B in 2023, increasing at a CAGR of 30% (CAGR = Compound Annual Growth Rate).



https://www.forbes.com/sites/louiscolumbus/2018/12/13/2018-roundup-of-internet-of-things-forecasts-and-market-estimates/#499cf567d838

„When wireless is perfectly applied the whole earth will be converted into a huge brain, which in fact it is, all things being particles of a real and rhythmic whole. We shall be able to communicate with one another instantly, irrespective of distance. Not only this, but through television and telephony we shall see and hear one another as perfectly as though we were face to face, despite intervening distances of thousands of miles; and the instruments through which we shall be able to do his will be amazingly simple compared with our present telephone. A man will be able to carry one in his vest pocket.“

- — **Nikola Tesla**, "*When woman is boss*", Colliers, January 30, 1926

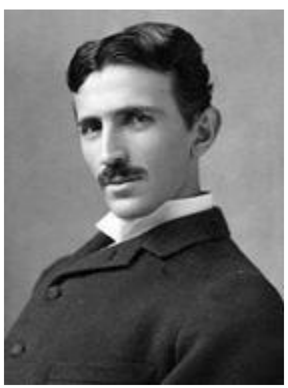


Image taken from:

History of Internet of Things (1/6)

1949

The bar code is conceived when 27 year-old Norman Joseph Woodland draws four lines in the sand on a Miami beach. Woodland, who later became an IBM engineer, received (with Bernard Silver) the first patent for a linear bar code in 1952. More than twenty years later, another IBMer, George Laurer, was one of those primarily responsible for refining the idea for use by supermarkets.

1955

Edward O. Thorp conceives of the first wearable computer, a cigarette pack-sized analog device, used for the sole purpose of predicting roulette wheels. Developed further with the help of Claude Shannon, it was tested in Las Vegas in the summer of 1961, but its existence was revealed only in 1966.

1960

Morton Heilig receives a patent for the first-ever head-mounted display.

1967

Hubert Upton invents an analog wearable computer with eyeglass-mounted display to aid in lip reading.

October 29, 1969

The first message is sent over the ARPANET, the predecessor of the Internet.

History of Internet of Things (2/6)

Technische Hochschule Rosenheim

1973

Mario Cardullo receives the first patent for a passive, read-write RFID tag.

1974

A **Universal Product Code** (UPC) label is used to ring up purchases at a supermarket for the first time.

1977

CC Collins develops an aid to the blind, a five-pound wearable with a head-mounted camera that converted images into a tactile grid on a vest.

1981

While still in high school, Steve Mann develops a backpack-mounted "wearable personal computer-imaging system and lighting kit."

1980 protoype with 1.5'' CRT (1)

1982

Members of the Carnegie-Mellon Computer Science department install micro-switches in the Coke vending machine and connect them to the PDP-10 departmental computer so they could see on their computer terminals how many bottles were present in the machine and whether they were cold or not.

1989

"The Internet Toaster", Working together with his friend Simon Hackett, John Romkey rose to the occasion and connected a Sunbeam Deluxe Automatic Radiant Control Toaster to the Internet at Interop'89

Hackett demonstrating the Toaster (2)

Images taken from: (1) http://wearcam.org/ieeecomputer/r2025.htm
(2) https://www.livinginternet.com/i/ia_myths_toast.htm

History of Internet of Things (3/6)

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September 1991

Xerox PARC’s Mark Weiser publishes “The Computer in the 21st Century” in *Scientific American*, using the terms “ubiquitous computing” and “embodied virtuality” to describe his vision of how “specialized elements of hardware and software, connected by wires, radio waves and infrared, will be so ubiquitous that no one will notice their presence.”

1993

Columbia University’s Steven Feiner, Blair MacIntyre, and Dorée Seligmann develop KARMA--Knowledge-based Augmented Reality for Maintenance Assistance. KARMA overlaid wireframe schematics and maintenance instructions on top of whatever was being repaired.

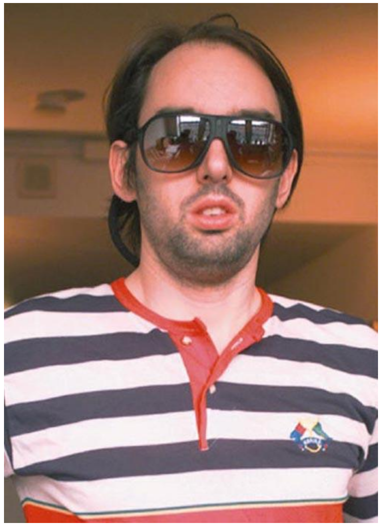
1994

Xerox EuroPARC’s Mik Lamming and Mike Flynn demonstrate the Forget-Me-Not, a wearable device that communicates via wireless transmitters and records interactions with people and devices, storing the information in a database.

1994

Steve Mann develops a wearable wireless webcam, considered the first example of lifelogging.

Early 1990s setup



1994 version

History of Internet of Things (4/6)

1995

Siemens sets up a dedicated department inside its mobile phones business unit to develop and launch a GSM data module called “M1” for machine-to-machine (M2M) industrial applications, enabling machines to communicate over wireless networks. The first M1 module was used for point of sale (POS) terminals, in vehicle telematics, remote monitoring and tracking and tracing applications.

December 1995

MIT’s Nicholas Negroponte and Neil Gershenfeld write in “Wearable Computing” in *Wired*: “For hardware and software to comfortably follow you around, they must merge into **softwear**… The difference in time between loony ideas and shipped products is shrinking so fast that it's now, oh, about a week.”

1999

The **Auto-ID** (for Automatic Identification) Center is established at MIT. Sanjay Sarma, David Brock and Kevin Ashton turned RFID into a networking technology by linking objects to the Internet through the RFID tag.

1999

Kevin Ashton, the Executive Director of Auto-ID Labs at MIT, was the first to describe the **Internet of Things**, while making a presentation for Procter & Gamble: *“…If we had computers that knew everything there was to know about things, using data they gathered without any help from us, we would be able to track and count everything and greatly reduce waste, loss and cost. We would know when things needed replacing, repairing or recalling and whether they were fresh or past their best*.”

https://en.wikipedia.org/wiki/Kevin_Ashton

History of Internet of Things (5/6)

2000

Starting off what is now becoming a meme, LG announces it's first **Internet refrigerator** plans

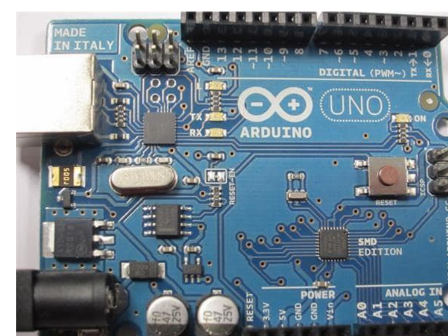
April 2002

Jim Waldo writes in “Virtual Organizations, Pervasive Computing, and an Infrastructure for Networking at the Edge,” in the *Journal of Information Systems Frontiers*: “…the Internet is becoming the communication fabric for devices to talk to services, which in turn talk to other services. Humans are quickly becoming a minority on the Internet, and the majority stakeholders are computational entities that are interacting with other computational entities without human intervention.”

2005

Ahead of its time, the Nabaztag (Now a part of Aldebaran Robotics) was originally manufactured by the company Violet and created by Rafi Haladjian and Olivier Mével. The little WiFi enbabled rabbit was able to alert and speak to you about stock market reports, news headlines, alarm clock, RSS-Feeds, etc as well as connect to each other. The statement was "if you can even connect rabbits, then you can connect anything"

A team of faculty members at the Interaction Design Institute Ivrea (IDII) in Ivrea, Italy, develops Arduino.



History of Internet of Things (6/6)

2009

Google starts self-driving cars

2011

Gartner adds IoT to the Hype Cycle

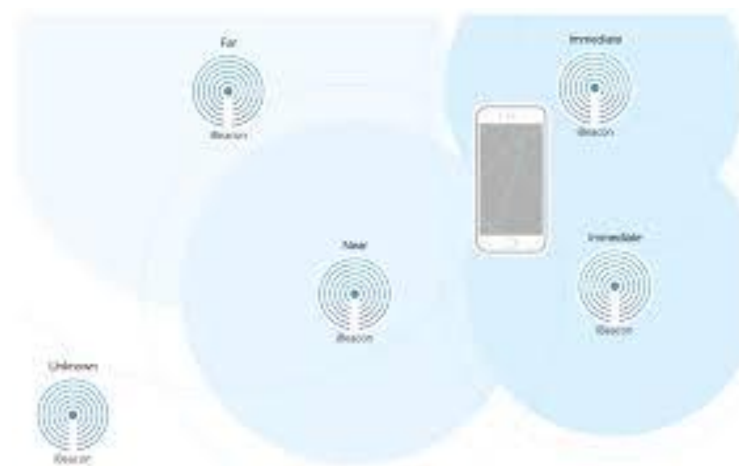
2013

Google creates advanced smart glasses

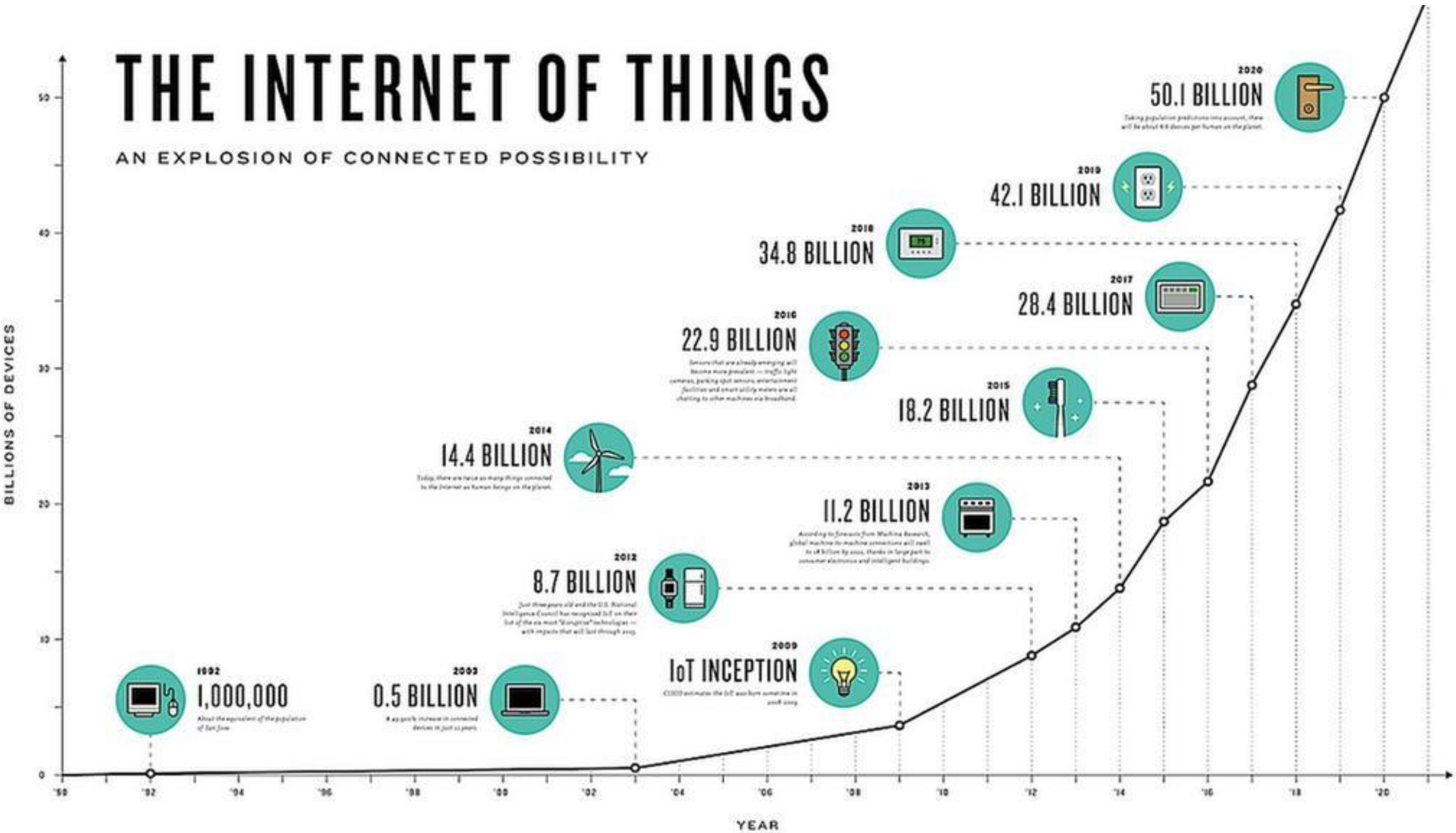
2014

Apple creates iBeacon protocol for Beacons

The number of devices exceed the number of people



Device Growth

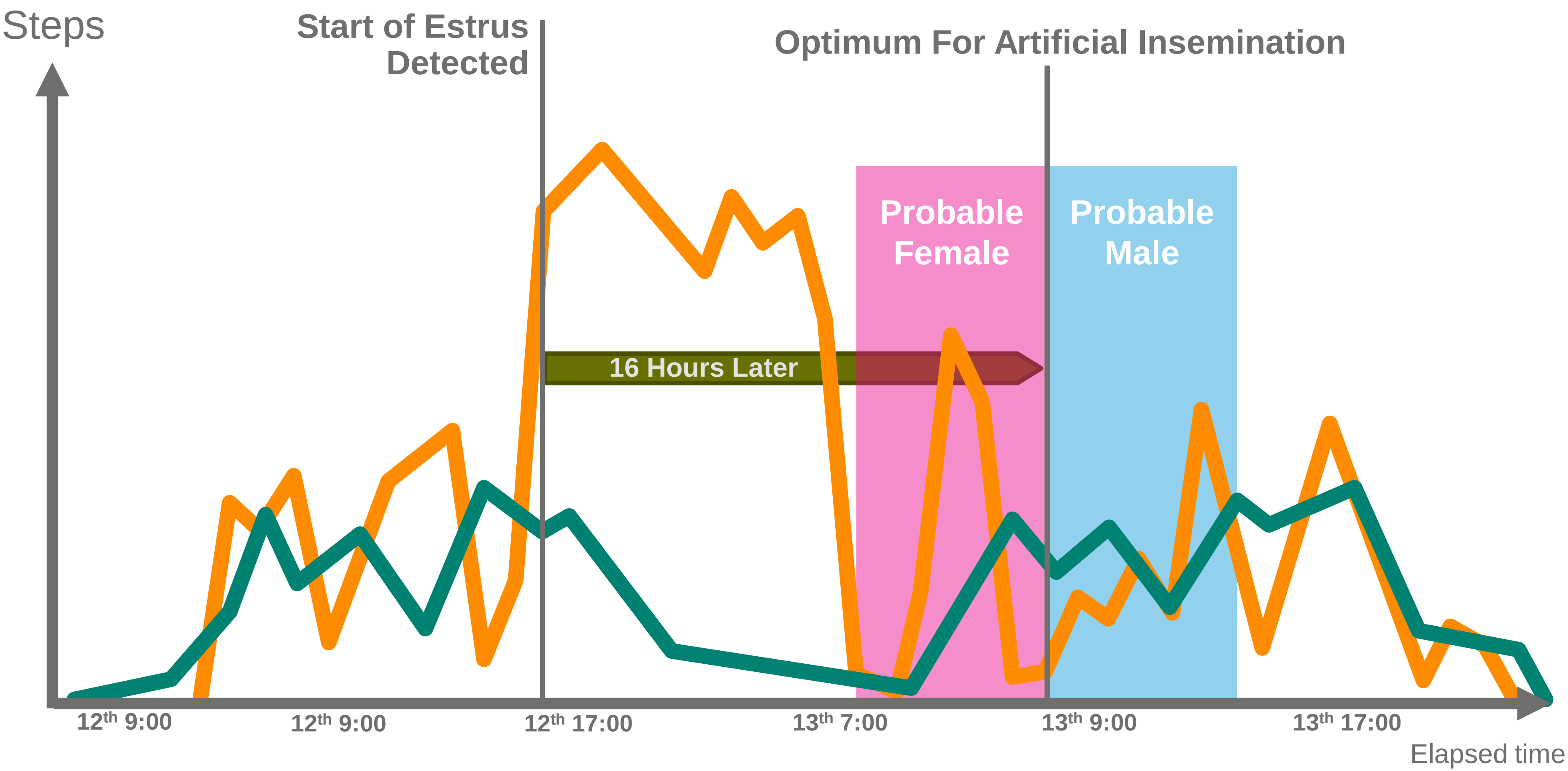


The “Internet Of Things” …
… is neither really about “Things” …
… nor really about “The Internet” …
… its about creating systems …
… that make our daily lives better …
… safer, more reliable, more efficient …
… and more fun!

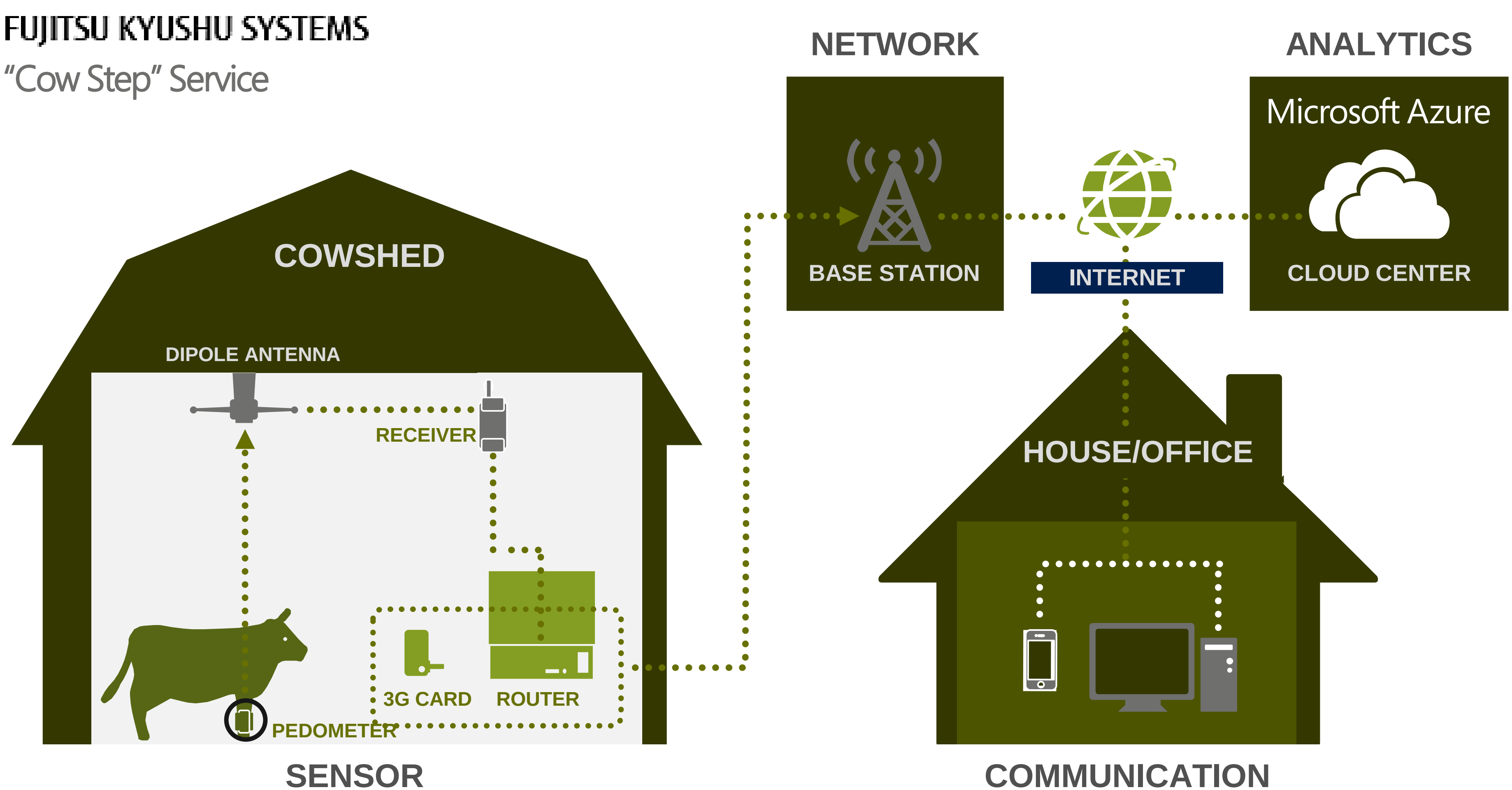
Clemens Vasters; Architect; Microsoft Azure

Every company is a data company…

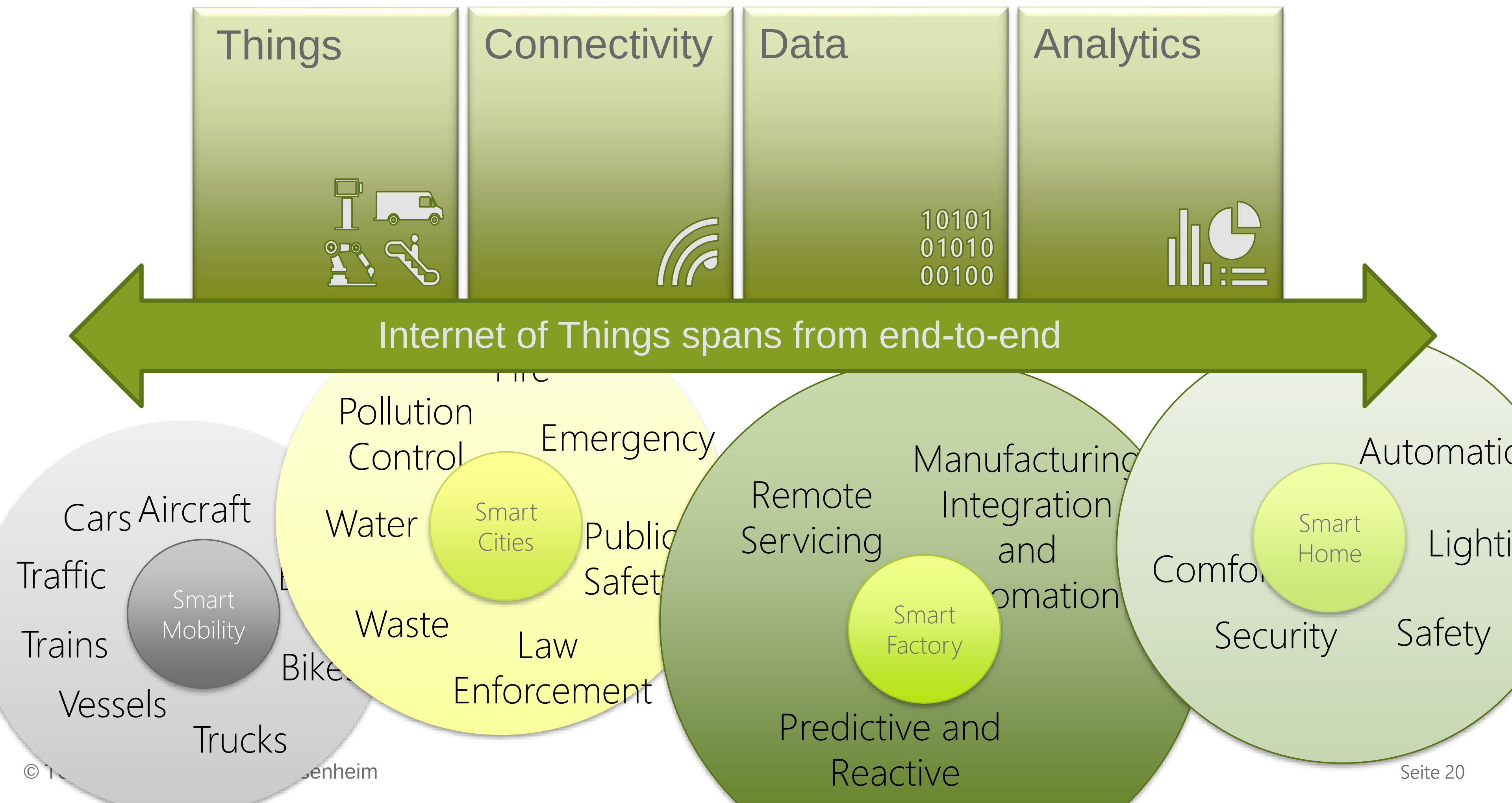
Activity Pattern



Architecture of an Internet of Things Solution



Defining Internet of Things (10.000 ft)



Things

Challenges

Memory
Processor
Energy (Battery) , lifetime
Security
Various generations (old vs new)
Heterogeneous platforms
Provisioning
Variety of device categories (sensor, gateways)
Variety of device types
Programming languages

Technology

Microcontroller vs OS powered
C, Java, Python, JavaScript, C++, C#, ….







Connectivity

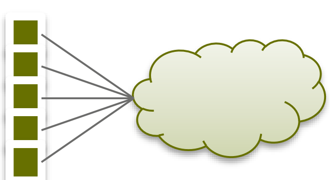
Challenges

Amount of connected things
Variety of protocols
Variety of **communication pattern**
Security
Variety of **topologies**
Discovery
Coverage
Partial connectivity

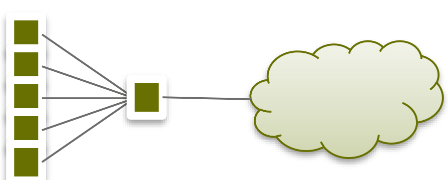
Technology

Device-/Configuration Management
HTTPs, MQTT, AMQP, CoAP
CAN, Modbus,
Bluetooth Low Energy (BLE), Zigbee
6LowPan
OPC-UA
LORA, MIOTY, …

Topology

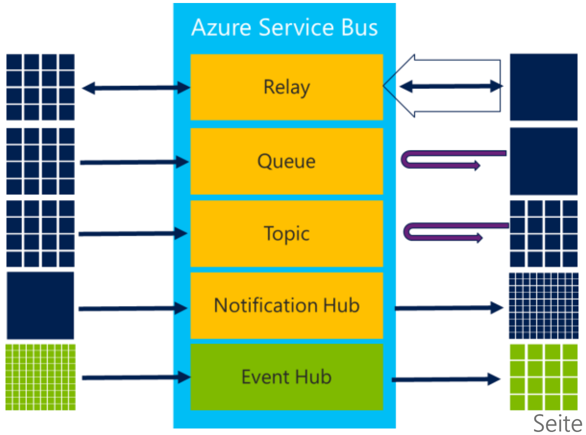


directly connected



gateway connected

Communication Pattern



Data Storage

Challenges

Amount of Data (Big Data) - Volume
Speed of Data (Data Rate) - Velocity
Data format (semantics) - Variety
Data trust
Data quality

Technology

SQL
Map-and-Reduce (Hadoop)
Stream Processing (Spark)

Analytics Insights

Challenges

Amount of Data
Quality of Data (Bias)
Insights
Data understanding (Exploration)
Scale
Execution of Analytics/ Distribution

Technology

Machine Learning

Why global?
•Data born in the cloud: There is data which is created in the cloud
•“Wisdom of the crowd“: Correlate and aggregate data from various sources to extract knowledge
•Global view
•Scale and history

Why local analytics?
•Data born locally and action is required local
•Data Reduction: Not all data needs to be sent to the cloud
•Connectivity: Devices are not always connected
•Privacy: User is concerned about privacy

MSR ASIA (Jingbo Shang, Yu Zheng, Wenzhu Tong, Eric Chang, and Yong Yu)
http://research.microsoft.com/pubs/217455/frp0542-zheng-final.pdf

Inferring Gas Consumption and Pollution Emission of Vehicles throughout a City

Congestion and traffic jams cause drivers to waste gas, which on a mass scale causes greater air pollution that impacts on the environment and people's health. This study inferred the gas consumption and pollution emission of vehicles traveling on a city’s road network, using GPS trajectories generated by a sample of 32,000 taxicabs in Beijing over a period of two months.

http://urbanair.msra.cn/

Fighting wildfires with data

Every second counts when combating a wildfire. Time lost can result in devastating loss of life or property. The University of the Aegean in Greece developed the VENUS-C Fire app—featuring Bing Maps, Microsoft Silverlight, and Windows Azure—to calculate and visualize the risk of wildfire ignition and to simulate fire propagation in the Greek island of Lesvos during its dry season. The university team generates a visualization of environmental factors each morning for the island's fire management team, who then use the app to determine optimal resource allocation across the island for the day.

Windflow: AI Takes to the Skies

- **Research question**: “Could we take the information that was already available and use it to predict wind conditions without needing any additional infrastructure?”

- Could airplanes in flight be employed as a vast sensor network to determine atmospheric conditions?

- Could data available today be used to infer winds on a large scale without special plane-based wind sensors and new infrastructure to access and combine signals from planes?

- http://windflow.azurewebsites.net/

http://research.microsoft.com/en-us/um/people/horvitz/planesenors.pdf

Domain: Manufacturing

- **Monitor manufacturing equipment**
  Improve your processes using industrial IoT solutions. Use sensors and advanced analytics to predict needed maintenance, and reduce unplanned downtime cutting into production time.

- **Provide predicitve maintenance to customers**
  Create new business models that offer predictive maintenance and performance monitoring for the equipment you produce, delivering a richer customer experience

- **Improve field services**
  Access sensor data to improve field service scheduling, ensuring the right technicians and tools are dispatched before potential issues become a major problem.

Domain: Transportation

- **Maintain vehicle performance**
  Keep vehicles on the road by predicting and monitoring maintenance needs—fixing potential issues during downtime to keep your business moving

- **Optimize fleet operations**
  Streamline logistics using real-time data and alerts to optimize delivery routes, monitor performance, and quickly respond to delays or issues as they happen.

- **Keep traffic moving**
  Monitor and process real-time traffic data to help manage transportation infrastructures, assess road conditions, and ease congestion.

Domain: Smart spaces

- **Create safer cities**
  Connect infrastructures to better regulate traffic, make emergency systems more efficient, and reduce police and emergency medical technician response time

- **Create smart buildings**
  Connect building devices and systems to bring more efficient operation and control to building owners, operators, and occupants.

- **Improve service, experience, and support**
  Increase service efficiency, from repairing broken street lamps to maintaining traffic lights to optimizing garbage truck routes

Domain: Healthcare

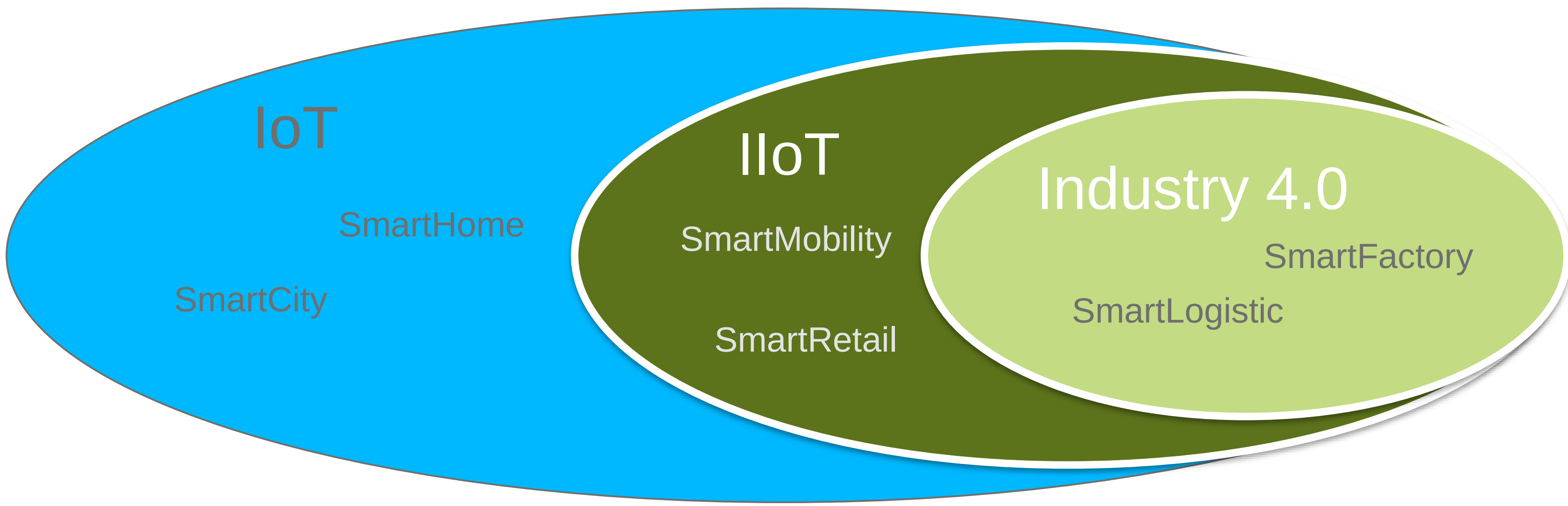
- **Evolve patient care**
  Allow patients to receive care away from their hospital at home, elsewhere around the world. With wearable sensors and service solutions, doctors can reduce readmissions and enable proactive care.

- **Monitor medical assets**
  Help your staff spend less time searching and more time with patients by better tracking and managing supplies and medicine—all on a cloud platform that's HIPAA compliant.

- **Track equipment usage**
  Enhance the overall well-being of patients by tracking how equipment is used, from employing hospital bed sensors to monitoring room temperature and hand washing stations

- **Maintain vital equipment**
  Ensure critical medical devices are ready to use when your patients need them most by fixing potential problems before they occur with predictive maintenance.

IoT vs IIoT vs Industry 4.0



Internet of Things:

Connection of all (smart) things (=physical objects) to a network (internet?) for all kind of domains and scenarios

Industrial Internet of Things:

Connection of all things in **industry** to enable new scenarios with business relevance (worldwide)

Industry 4.0:

Connection of all things in industry to enable new scenarios with business relevance (**in Germany**!)

Use Case: Respond and recover quickly

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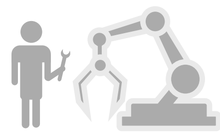
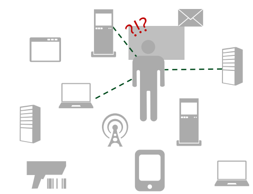
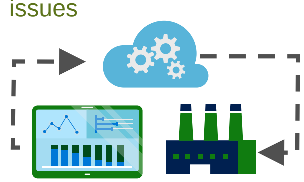
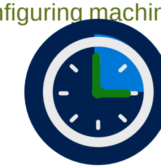
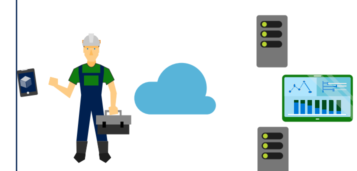
	1	2	3
With fragmented solutions	**Maintain technicians onsite** to determine and resolve issues 	**Take days or weeks** to reroute and reconfigure devices 	**Search for data** needed for root-cause analysis 
With IoT	**Access devices remotely** to diagnose and resolve issues 	**Complete corrections within hours,** including rerouting processes and reconfiguring machines 	**Access comprehensive data immediately** to perform root-cause analysis 

Use Case: Expand, change and scale easily

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	1	2	3
With fragmented solutions	**Solve storage on your own** using capacity planning, capital purchases and on-going maintenance	**Connect new devices later** after customizations and integration efforts are complete	**Take weeks or months** to modify and extend systems with custom connections
With IoT	**Exploit cloud solutions** to scale instantly and pay for only what you need	**Connect new devices now** with little or no configuration required	**Add to and extend systems faster** by building on the extensible architecture

Iot Plattforms

- Amazon Web Services
- Google Cloud IoT
- Azure IoT Suite
- SAP
- Salesforce IoT
- IBM Watson Internet of Things (Bluemix)
- Oracle Internet of Things
- Cisco IoT Cloud Connect
- Bosch IoT Suite
- GE Predix
- Siemens Mindsphere

> *The Internet of Things is not about the things or even the platform the same way we thought about motors or microprocessors. The big winners in IoT will be thinking about an entirely different future, not just connecting to things we already use today in ways we already use them.*

Steven Sinofsky