

SMART CITY: AN INTRODUCTION

Dr. Zijun Zhang, PhD
Professor
Department of Data Science

What is Smart City?

Wikipedia Description

A smart city is an urban area that has been developed with a high level of technological advancement, utilising a variety of electronic methods and sensors to collect specific data.

IEEE Description

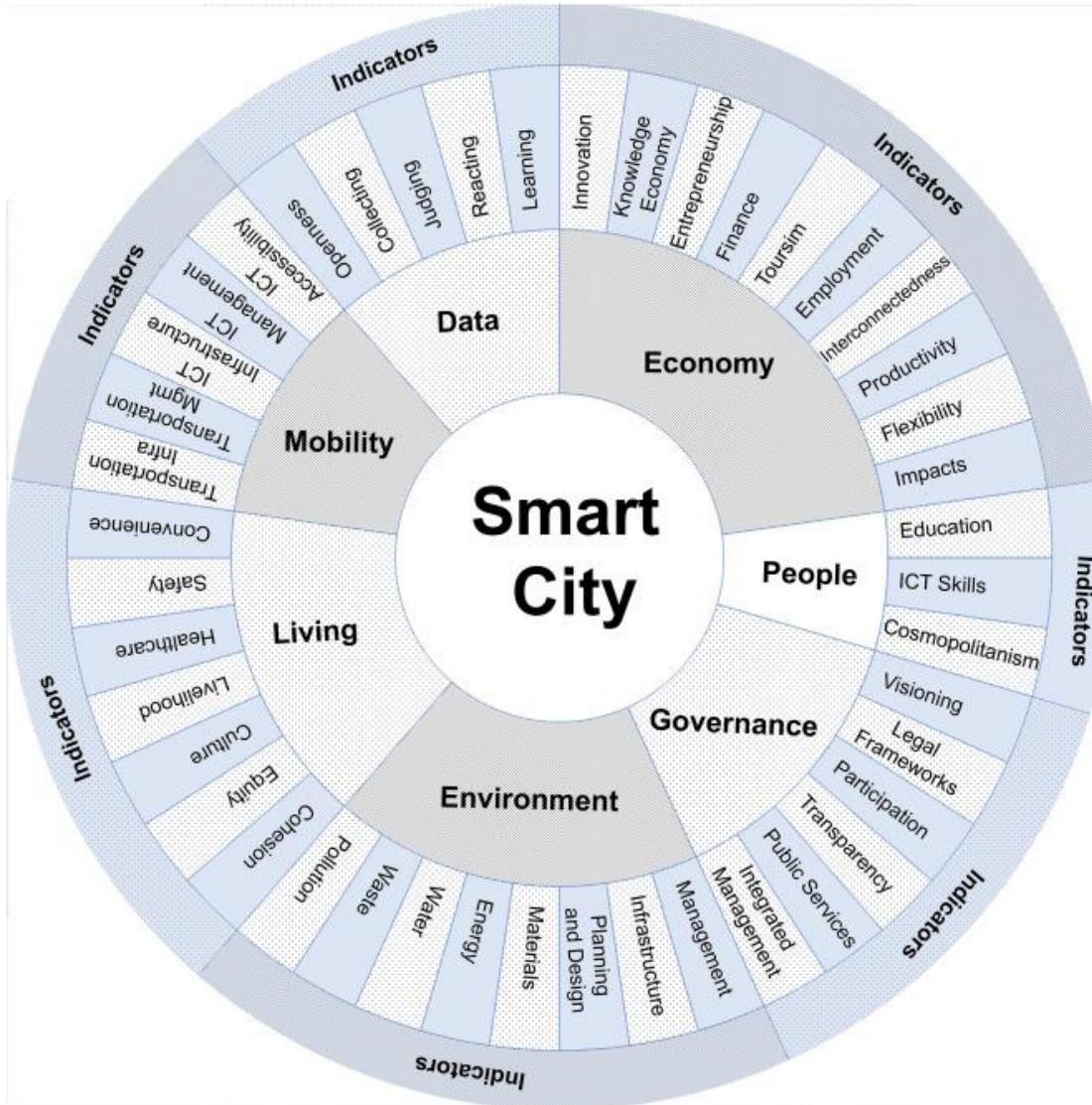
A smart city brings together technology, government, and society as well as includes but not limited to following elements: A smart economy, smart energy, smart mobility, smart environment, smart living, smart governance, etc.

What is Smart City?

IBM Version

A smart city is an urban area where technology and data collection help improve quality of life as well as the sustainability and efficiency of city operations. Smart city technologies used by local governments include information and communication technologies (ICT) and the Internet of Things (IoT)..

Elements in Smart City



Information From

A. Shrif, "A critical review of selected smart city assessment tools and indicator sets," *Journal of Cleaner Production*, Vol. 233, pp. 1269-1283, 2019

Worldwide Smart City Development Status

Amsterdam, Netherland

- Smart city initiative started from 2009, more than 170 projects...
- Platform: IoT + Data + Decision-making
- Focus on traffic management, energy saving, and public security

Worldwide Smart City Development Status

Columbus, Ohio, USA

- Electric vehicles replace vehicles consuming fuels
- Electricity charging station networks
- Ride sharing

Worldwide Smart City Development Status

Dubai

- Wifi Connected City
- E-payment
- More focus on business side

Worldwide Smart City Development Status

Stockholm

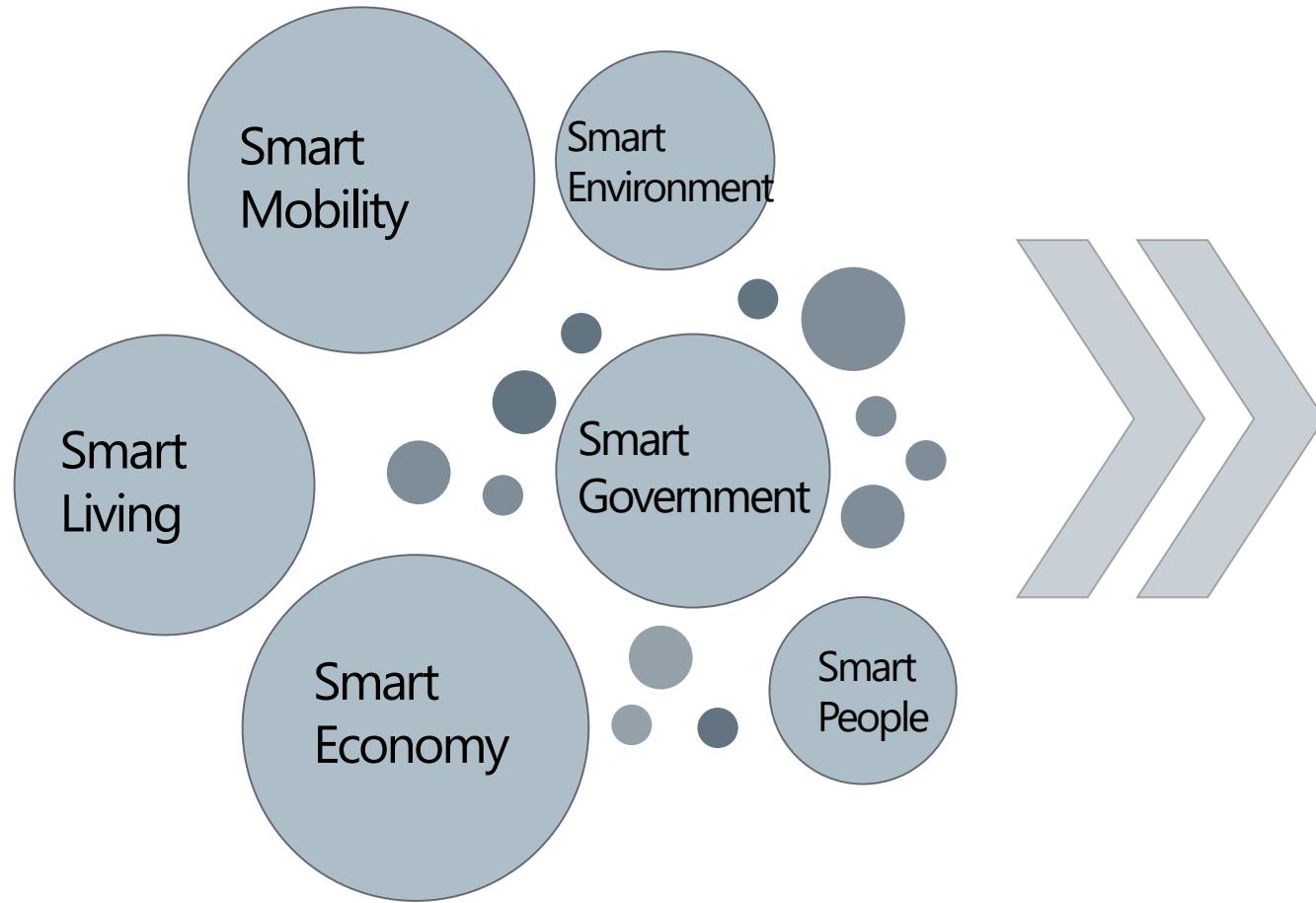
- Green IT: Energy efficient building
- Traffic Management
- E-Services, public resources

Worldwide Smart City Development Status

Smart Nation Singapore (<https://www.smartnation.sg/>)

- Lean and Agile digital government services
- Business: E-payment, E-commerce, etc.
- Digital Identify
- National Sensing Platform
- Urban Mobility

Smart City: Hong Kong Definition



Smart City: Hong Kong Definition



Smart Mobility

- Intelligent Transport Systems and Traffic Management
- Public Transport Resources
- Environmental Friendly Transport
- Smart Airport

Smart Living

- Wifi Connected City
- Digital Payment
- EIDs
- Support for Ederly Care and Healthcare

Smart Environment

- Climate Issue
- Green and Intelligent Building
- Waste Management
- Pollution Monitoring

Smart City: Hong Kong Definition



Smart People

- Nurturing Young Talent
- Innovation and Entrepreneurial Culture



Smart Government

- Open Data
- Smart City Infrastructure
- Adoption of Technology



Smart Economy

- Strengthen Existing Pillars
- Promoting Sharing Economy
- Develop New Pillars

Smart Cities: Intelligent Transport and Traffic

City Brain Project – Alibaba, Hangzhou

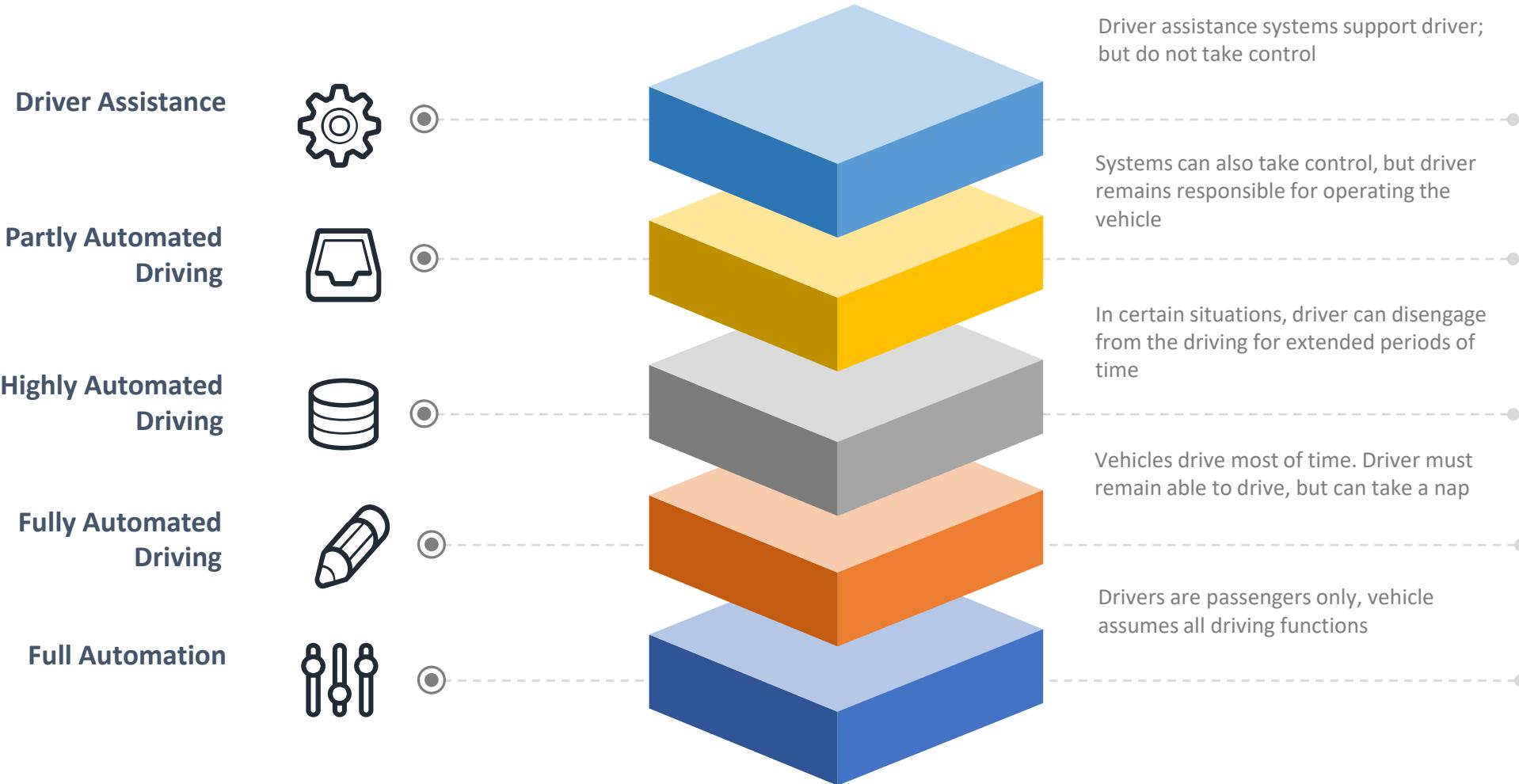


City Brain Project - Hangzhou

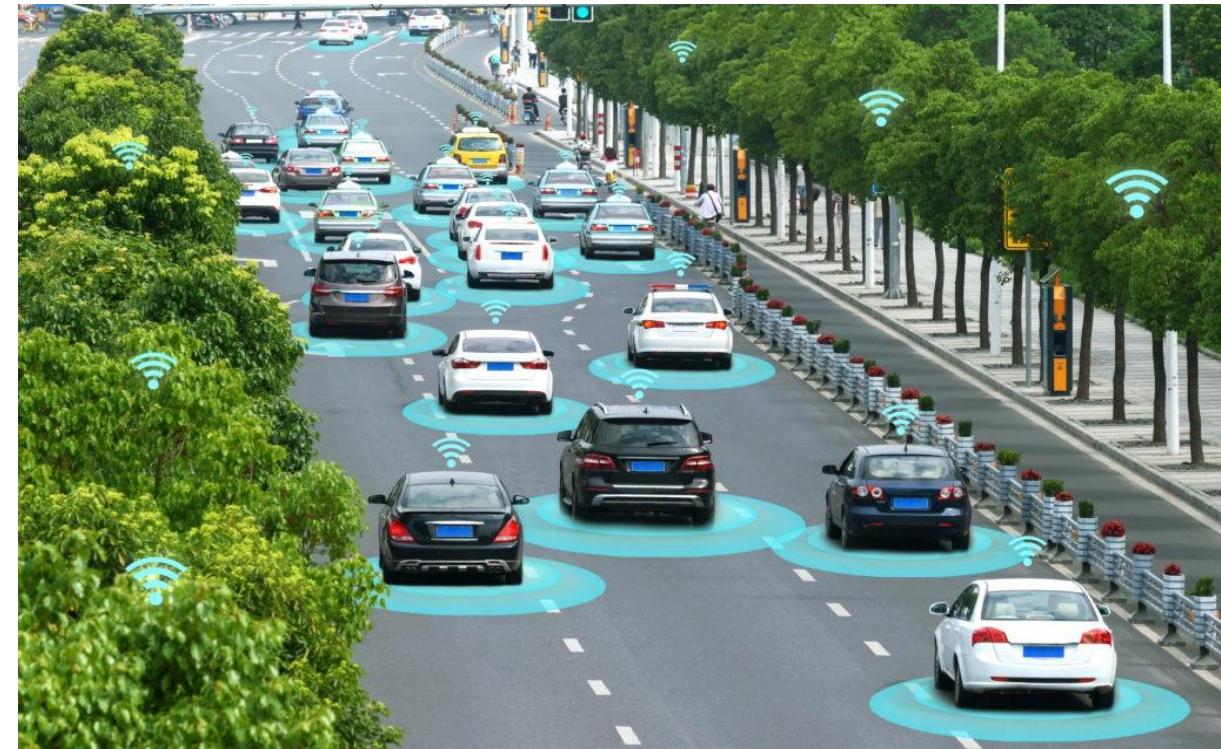
- Start from transportation and data collection
- Expand to traffic monitoring and management
- Expand to energy consumptions and public resources accesses
- Expand to business sectors

Transportation System: Autonomous Vehicle

Five levels of Autonomous Driving

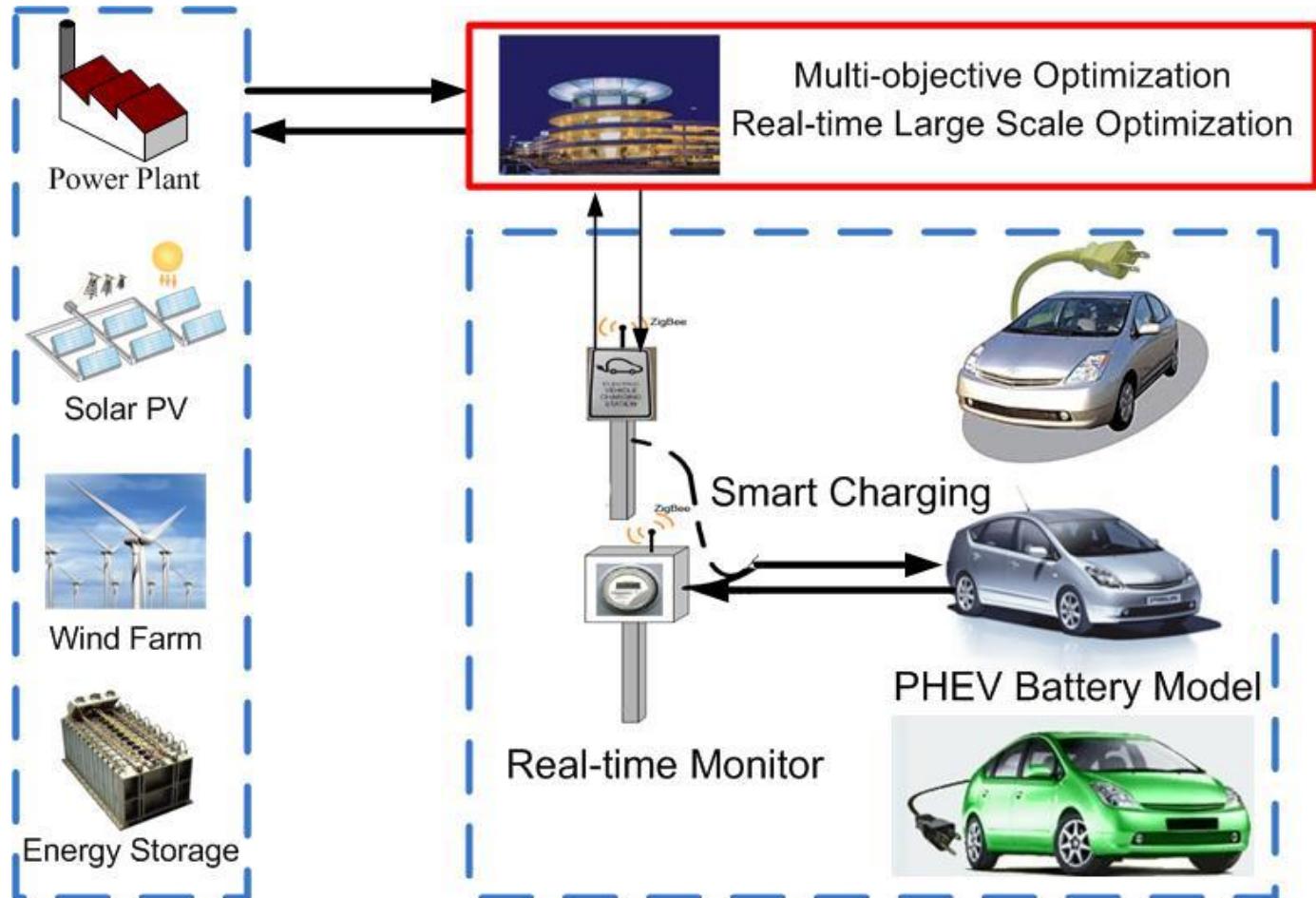


Transportation System: Autonomous Driving



Electric Vehicles and IoT

Dr. M. Chow research group
<https://research.ece.ncsu.edu/adac/performance-optimization-of-a-large-scale-phevpev-enabled-parking-deck/>

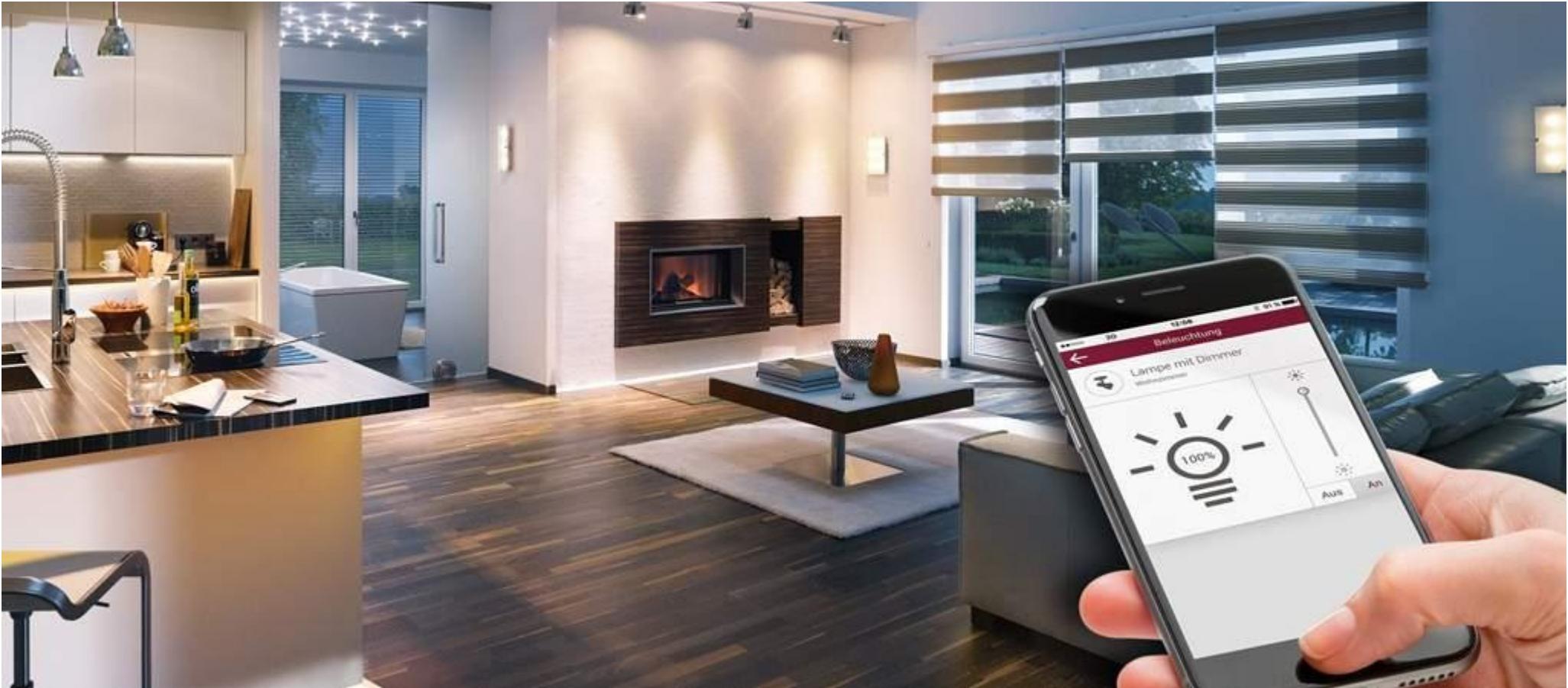


EV in Energy Internet and Integration, EI²

An integration of IoT technology, Cloud computing, Edge computing, Big Data, and AI



Smart Home: Overall Concepts



Smart Home: Intelligent Appliances



IoT, Data, Automatic Control

Smart Home: Personal Assistants



Amazon Alexa

小米



MI: 小愛

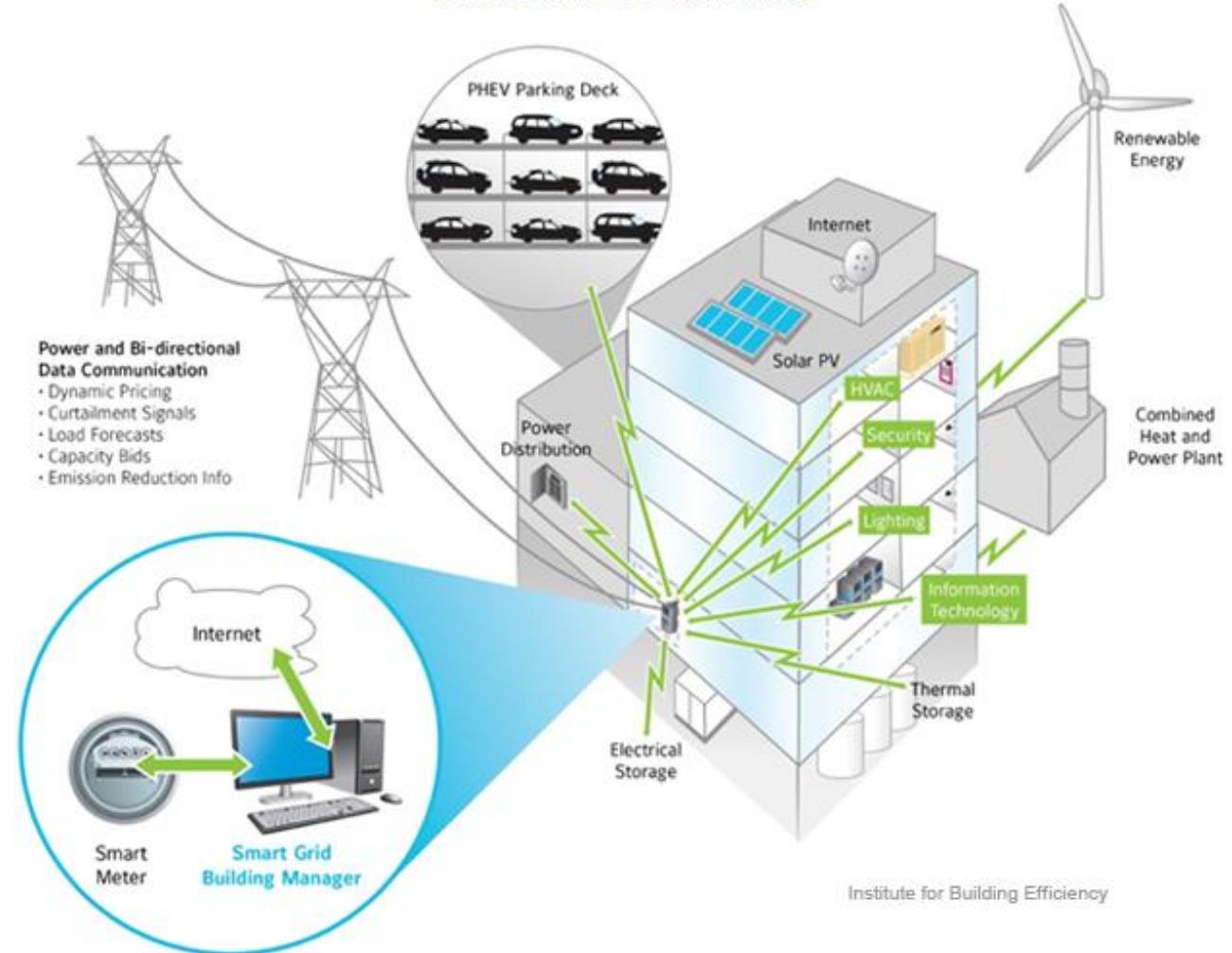


Iphone: Siri

Natural Language Processing, Voice Signal, Machine Learning

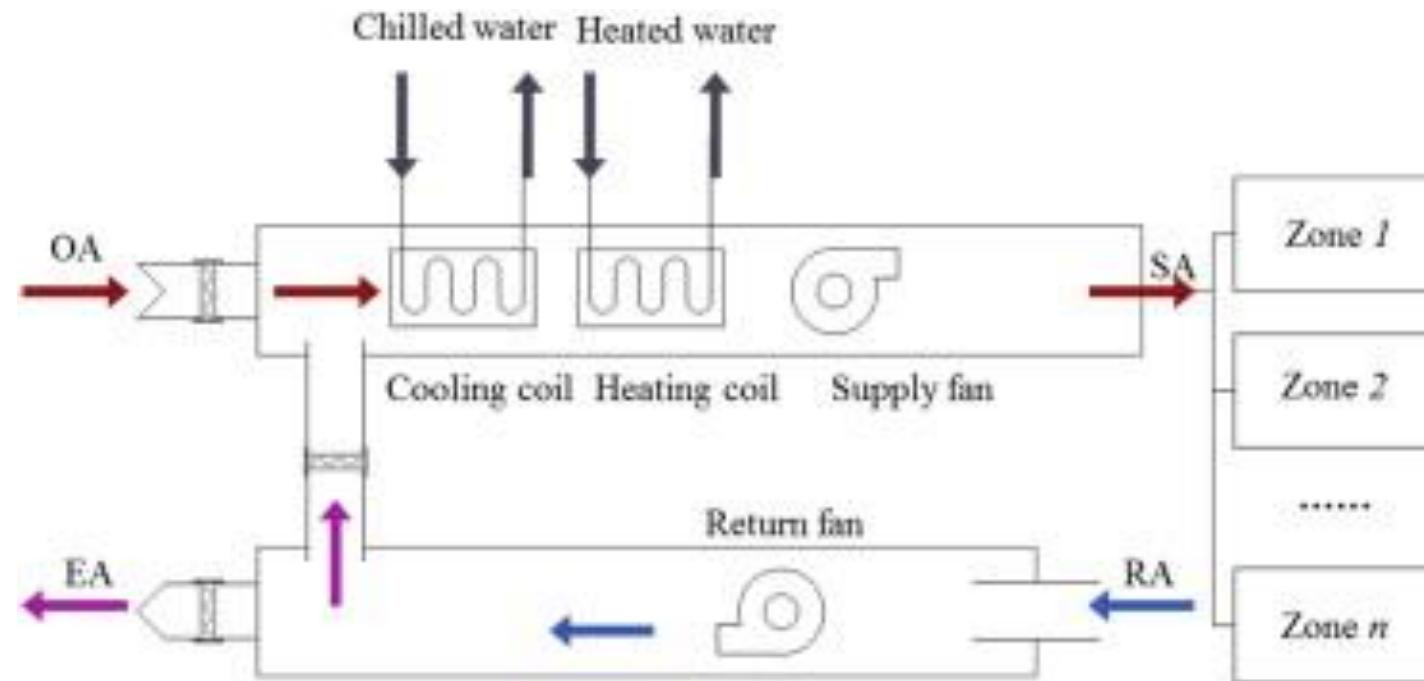
Smart Building: Energy efficient

A Smart Grid Needs Smart Buildings



1. Connecting building systems;
2. Connecting people and technology;
3. Connecting to global environment;
4. Connecting to smart grid;

Smart Building: HVAC Systems



Data-driven HVAC System Operation

Smart Building: Better Services

Alibaba Future Hotel



AI Shopping Mall Management



Less Human, More Efficient Services, Automated Processes

E-Commerce and Logistics

E-commerce means using the Internet and the web for business transactions and/or commercial transactions, which typically involve the exchange of value across organizational or individual boundaries in return for products and services.

E-commerce lives on the development of IT and cyber worlds. It offers a platform for accessing a variety of goods and services without the limitation of regions and time. Definitely, the logistics is one of the fundamental infrastructure supporting e-commerce, which realizes the delivery of values in the real world.

E-Commerce and Logistics

- Alibaba and JD.com
- Amazon
- E-bay
- HKTVMall

Products and Services, Standard and Customization, Digital Money and Finance, FinTech Development

Sharing Economy

New paradigm of economic development: Inspired by the IT development

Peer-to-peer business

Crowd-based capitalization

Optimally utilize idle resources

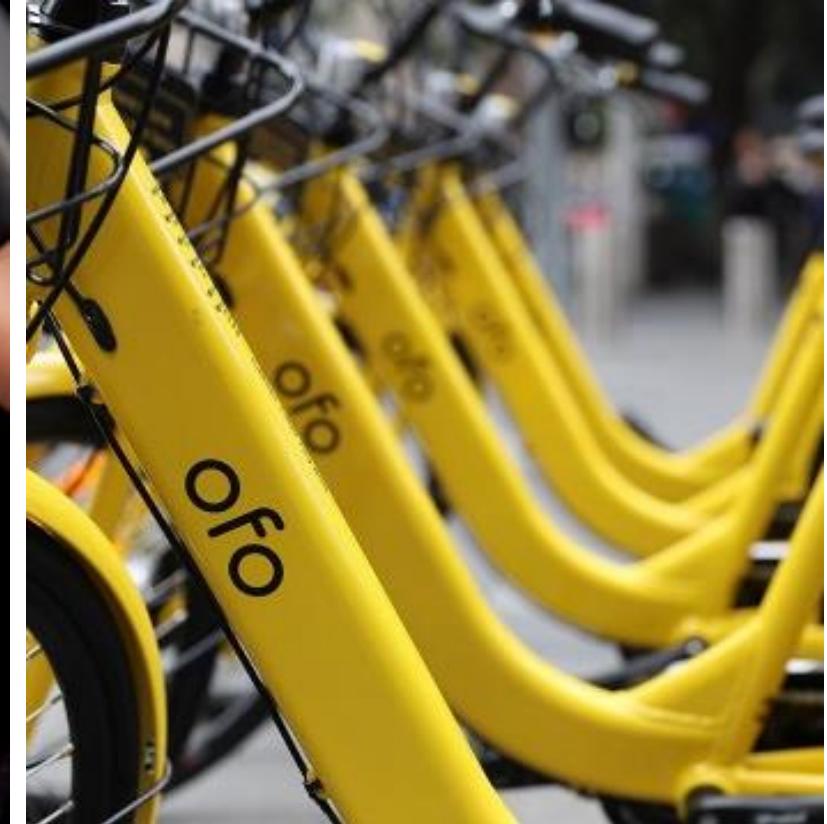
Flexibility in the asset management



Didi



Uber



Ofo

Sharing Economy



Cloud Computing



AirBnB

Sharing Economy

Sharing Economy

How does data science involve in sharing economy:

- 1) IoT infrastructure for accessing demand and supply
- 2) Data-driven optimization for real-time resources allocation and planning
- 3) Business insights gained through data analytics
- 4) Monitoring service and operations quality

Smart City: The Future

- A connected world
- Break boundaries of accessing information and resources
- More efficient and automated process
- Optimization of public resources
- Lower cost and flexible services
- Mass-customization
- Digitalization and intelligence
- Its definition involves with time

Smart City Scope – Technical Side

A smart city solution:

- Sensing (IoT systems): Measurement; Edge data processing; Data transmission and storage
- AI-methodological side: Big data analytics; deep learning; optimization; cloud computing
- AI-application side: computer vision; process engineering; system models; decision-making
- Automation: system control; condition monitoring; robotics; reliability

Cloud Computing and Internet of Things

Two key components in Smart Cities

Cloud Computing

- Many applications nowadays are cloud based.
- Internet serves as channel for application accesses
- Website serves as interface for the interaction
- Better protection of core techniques
- Easy maintenance and more flexible business model (licensing)

What is Cloud Computing?

- **Cloud Computing** is a general term used to describe a new class of network based computing that takes place over the Internet,
 - basically a step up from Utility Computing
 - a collection/group of integrated and networked hardware, software and Internet infrastructure (called a platform).
 - Using the Internet for communication and transport provides hardware, software and networking services to clients
- These platforms hide the complexity and details of the underlying infrastructure from users and applications by providing very simple graphical interface or API (Applications Programming Interface).

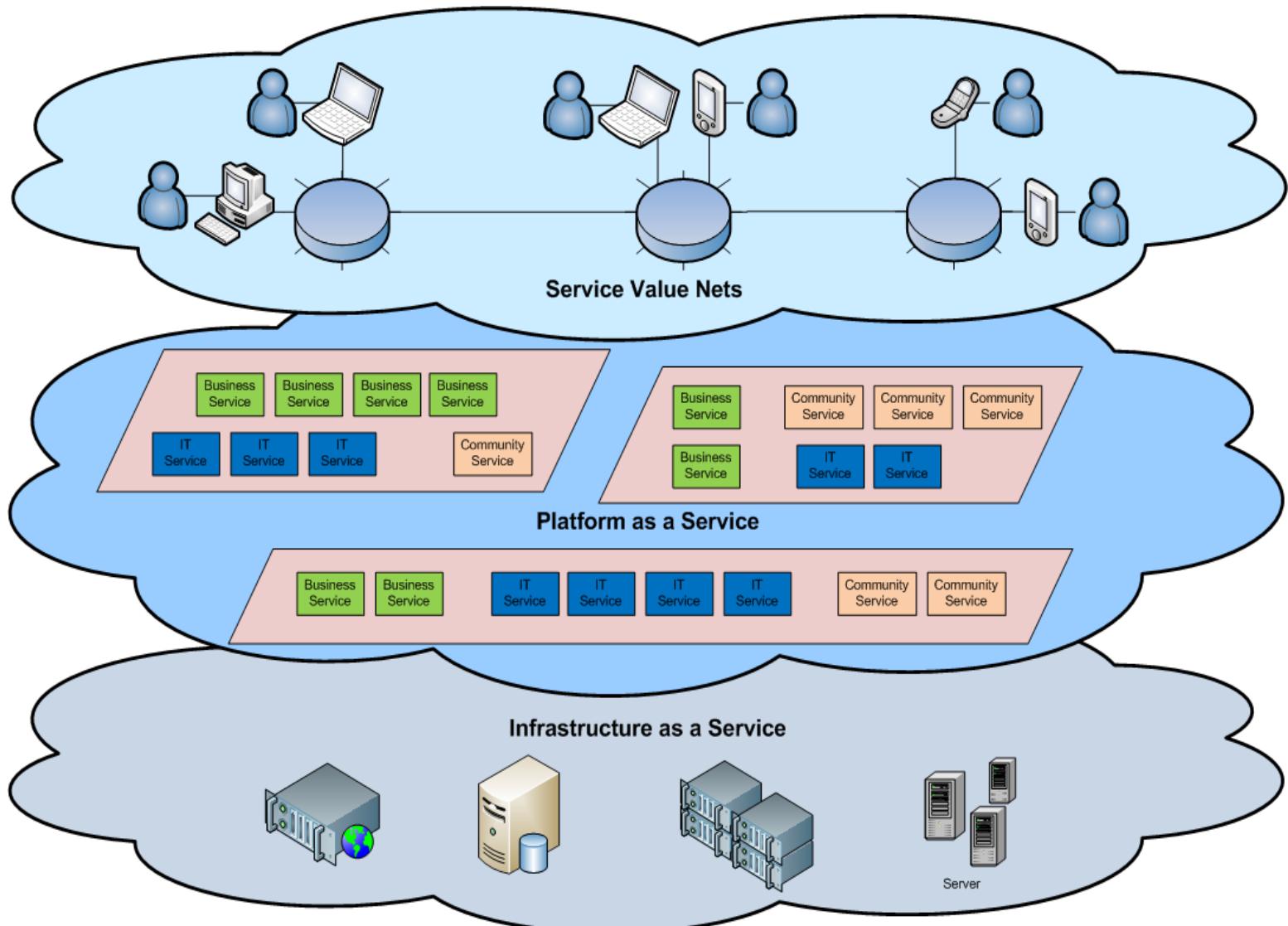
What is Cloud Computing?

- In addition, the platform provides on demand services, that are always on, anywhere, anytime and any place.
- Pay for use and as needed, elastic
 - scale up and down in capacity and functionalities
- The hardware and software services are available to
 - general public, enterprises, corporations and businesses markets

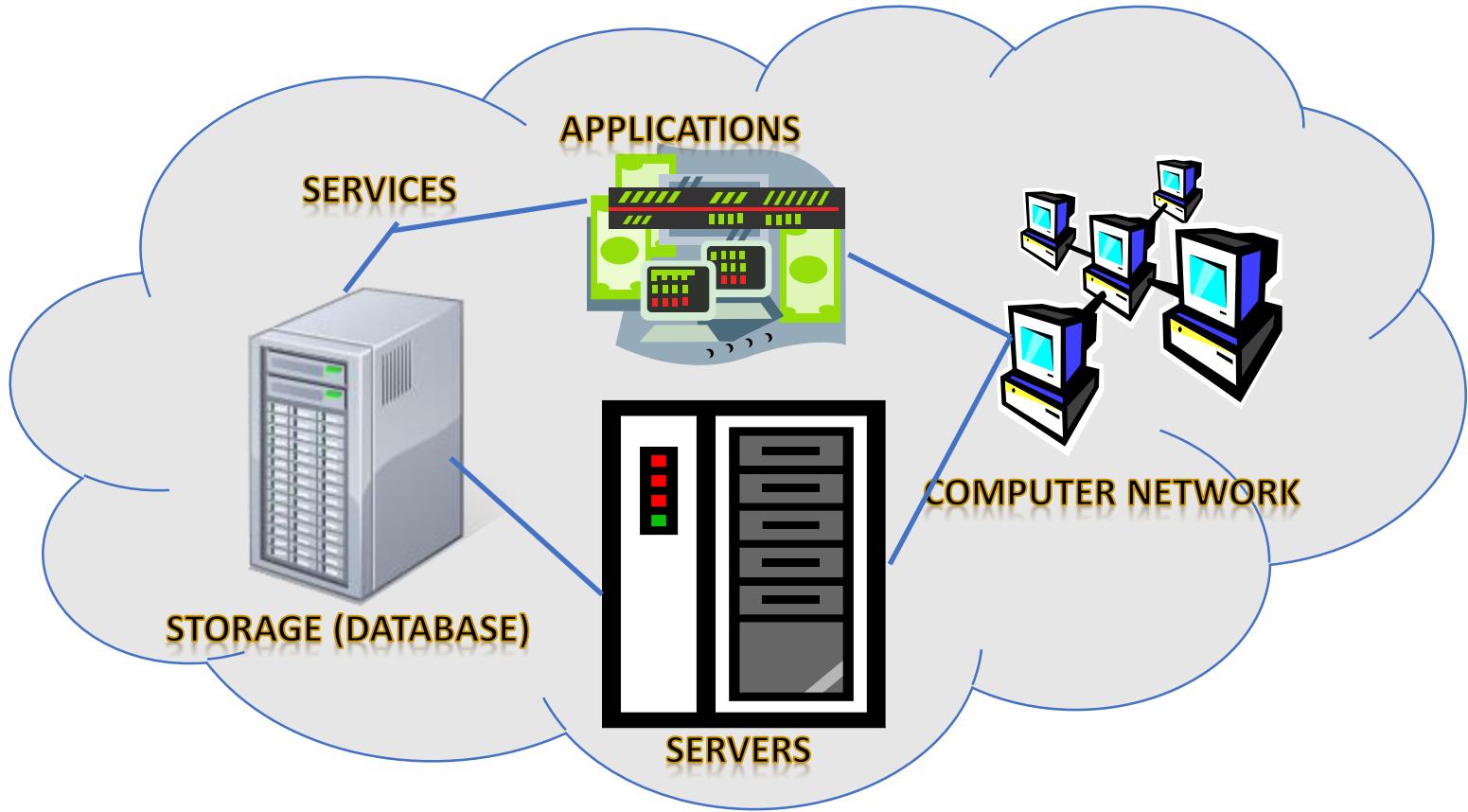
What is Cloud Computing

- Cloud computing is an umbrella term used to refer to Internet based development and services
- A number of characteristics define cloud data, applications services and infrastructure:
 - **Remotely hosted:** Services or data are hosted on remote infrastructure.
 - **Ubiquitous:** Services or data are available from anywhere.
 - **Commodified:** The result is a utility computing model similar to traditional that of traditional utilities, like gas and electricity - you pay for what you would want!

Cloud Architecture



Cloud Architecture



- Shared pool of configurable computing resources
- On-demand network access
- Provisioned by the Service Provider

Cloud Computing Characteristics

Common Characteristics:

Massive Scale

Resilient Computing

Homogeneity

Geographic Distribution

Virtualization

Service Orientation

Low Cost Software

Advanced Security

Essential Characteristics:

On Demand Self-Service

Broad Network Access

Rapid Elasticity

Resource Pooling

Measured Service

Cloud Service Models

Software as a Service (SaaS)

Platform as a Service (PaaS)

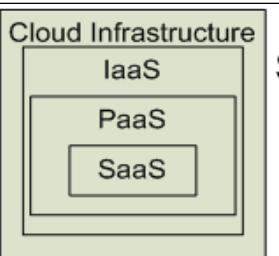
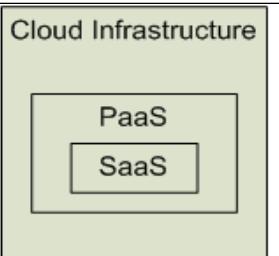
Infrastructure as a Service (IaaS)

SalesForce CRM

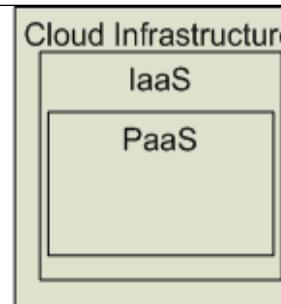
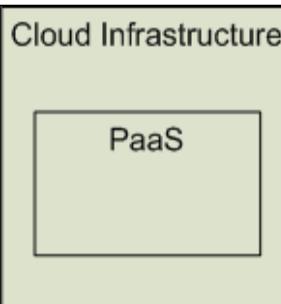
LotusLive



Google App



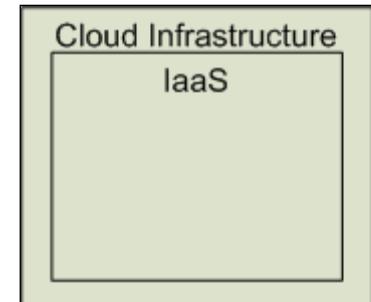
Software as a Service (SaaS)
Providers
Applications



Platform as a Service (PaaS)
Deploy customer created Applications

amazon web services™

rackspace®
HOSTING



Infrastructure as a Service (IaaS)
Rent Processing, storage, N/W capacity & computing resources

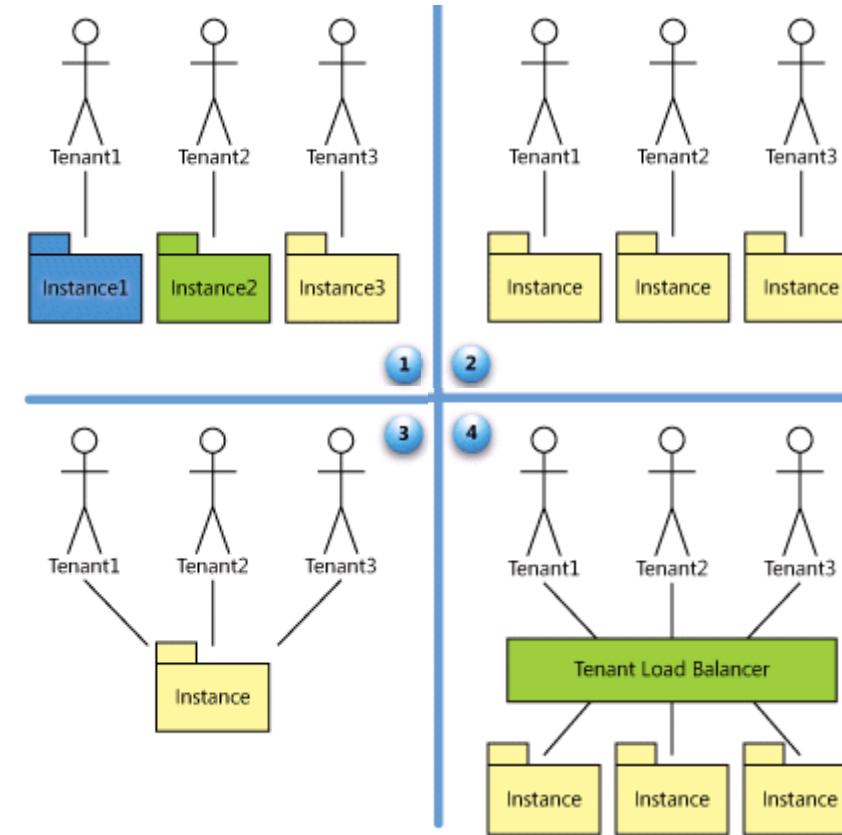
SaaS Maturity Model

Level 1: Ad-Hoc/Custom –
One Instance per customer

Level 2: Configurable per
customer

Level 3: configurable &
Multi-Tenant-Efficient

Level 4: Scalable, Configurable
& Multi-Tenant-Efficient



Cloud Computing Service Layers

Services	Description
Services	Services - Complete business services such as PayPal, OpenID, OAuth, Google Maps, Alexa
Application	Application - Cloud based software that eliminates the need for local installation such as Google Apps, Microsoft Online
Development	Development - Software development platforms used to build custom cloud based applications (PAAS & SAAS) such as SalesForce
Platform	Platform - Cloud based platforms, typically provided using virtualization, such as Amazon ECC, Sun Grid
Storage	Storage - Data storage or cloud based NAS such as CTERA, iDisk, CloudNAS
Hosting	Hosting - Physical data centers such as those run by IBM, HP, NaviSite, etc.

Application
Focused

Infrastructure
Focused

Basic Cloud Characteristics

- The “**no-need-to-know**” in terms of the underlying details of infrastructure, applications interface with the infrastructure via the APIs.
- The “**flexibility and elasticity**” allows these systems to scale up and down at will
 - utilising the resources of all kinds
 - CPU, storage, server capacity, load balancing, and databases
- The “**pay as much as used and needed**” type of utility computing and the “**always on!, anywhere and any place**” type of network-based computing.

Basic Cloud Characteristics

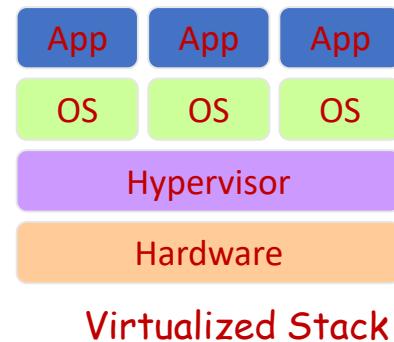
- Cloud are transparent to users and applications, they can be built in multiple ways
 - branded products, proprietary open source, hardware or software, or just off-the-shelf PCs.
- In general, they are built on clusters of PC servers and off-the-shelf components plus Open Source software combined with in-house applications and/or system software.

Software as a Service (SaaS)

- SaaS is a model of software deployment where an application is hosted as a service provided to customers across the Internet.
- SaaS alleviates the burden of software maintenance/support
 - but users relinquish control over software versions and requirements.
- Terms that are used in this sphere include
 - **Platform as a Service** (PaaS) and
 - **Infrastructure as a Service** (IaaS)

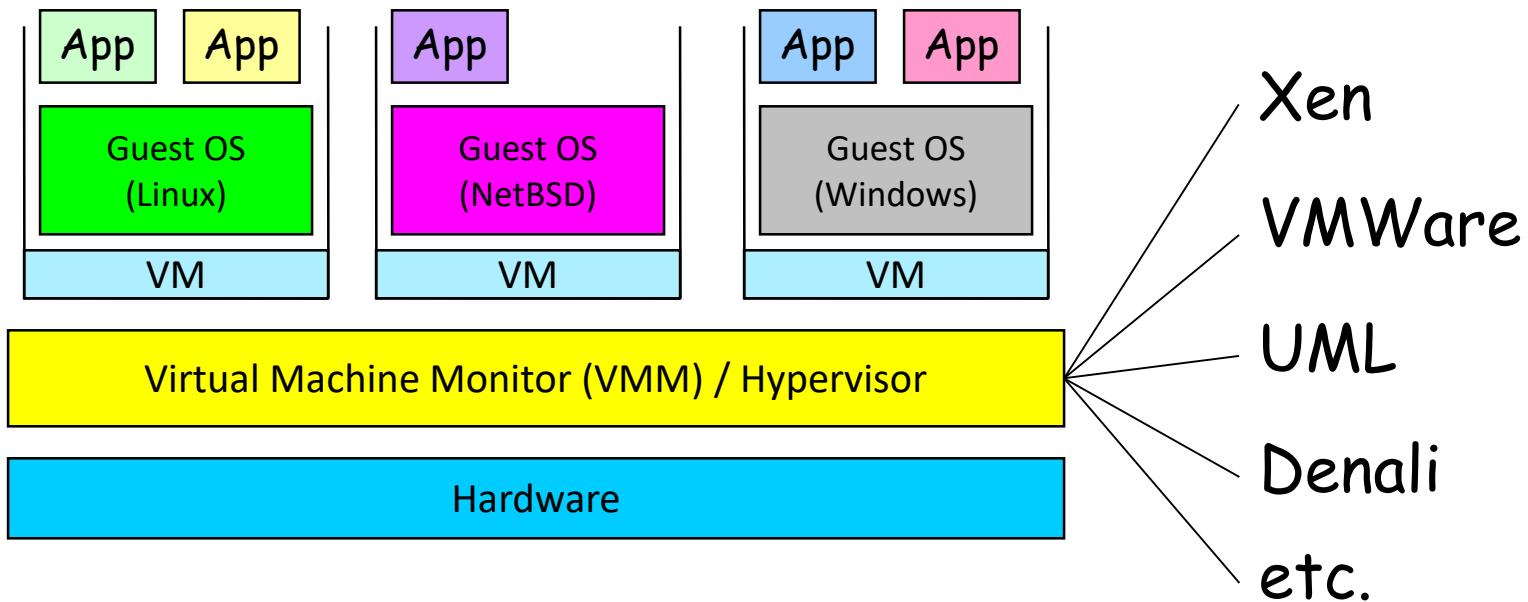
Virtualization

- Virtual workspaces:
 - An abstraction of an execution environment that can be made dynamically available to authorized clients by using well-defined protocols,
 - Resource quota (e.g. CPU, memory share),
 - Software configuration (e.g. O/S, provided services).
- Implement on Virtual Machines (VMs):
 - Abstraction of a physical host machine,
 - Hypervisor intercepts and emulates instructions from VMs, and allows management of VMs,
 - VMWare, Xen, etc.
- Provide infrastructure API:
 - Plug-ins to hardware/support structures



Virtual Machines

- VM technology allows multiple virtual machines to run on a single physical machine.



Performance: Para-virtualization (e.g. Xen) is very close to raw physical performance!

What is the purpose and benefits?

- Cloud computing enables companies and applications, which are system infrastructure dependent, to be infrastructure-less.
- By using the Cloud infrastructure on “pay as used and on demand”, all of us can save in capital and operational investment!
- Clients can:
 - Put their data on the platform instead of on their own desktop PCs and/or on their own servers.
 - They can put their applications on the cloud and use the servers within the cloud to do processing and data manipulations etc.

Cloud-Sourcing

- Why is it becoming a Big Deal:
 - Using high-scale/low-cost providers,
 - Any time/place access via web browser,
 - Rapid scalability; incremental cost and load sharing,
 - Can forget need to focus on local IT.
- Concerns:
 - Performance, reliability, and SLAs,
 - Control of data, and service parameters,
 - Application features and choices,
 - Interaction between Cloud providers,
 - No standard API – mix of SOAP and REST!
 - Privacy, security, compliance, trust...

Cloud Storage

- Several large Web companies are now exploiting the fact that they have data storage capacity that can be hired out to others.
 - allows data stored remotely to be temporarily cached on desktop computers, mobile phones or other Internet-linked devices.
- Amazon's Elastic Compute Cloud (EC2) and Simple Storage Solution (S3) are well known examples
 - Mechanical Turk

Amazon Simple Storage Service (S3)

- Unlimited Storage.
- Pay for what you use:
 - \$0.20 per GByte of data transferred,
 - \$0.15 per GByte-Month for storage used,
 - Second Life Update:
 - 1TBytes, 40,000 downloads in 24 hours - \$200,

Opportunities and Challenges

- The use of the cloud provides a number of opportunities:
 - It enables services to be used without any understanding of their infrastructure.
 - Cloud computing works using economies of scale:
 - It potentially lowers the outlay expense for start up companies, as they would no longer need to buy their own software or servers.
 - Cost would be by on-demand pricing.
 - Vendors and Service providers claim costs by establishing an ongoing revenue stream.
 - Data and services are stored remotely but accessible from “anywhere”.

Opportunities and Challenges

- In parallel there has been backlash against cloud computing:
 - Use of cloud computing means dependence on others and that could possibly limit flexibility and innovation:
 - The others are likely become the bigger Internet companies like Google and IBM, who may monopolise the market.
 - Some argue that this use of supercomputers is a return to the time of mainframe computing that the PC was a reaction against.
 - Security could prove to be a big issue:
 - It is still unclear how safe out-sourced data is and when using these services ownership of data is not always clear.
 - There are also issues relating to policy and access:
 - If your data is stored abroad whose policy do you adhere to?
 - What happens if the remote server goes down?
 - How will you then access files?
 - There have been cases of users being locked out of accounts and losing access to data.

Advantages of Cloud Computing

- Lower computer costs:
 - You do not need a high-powered and high-priced computer to run cloud computing's web-based applications.
 - Since applications run in the cloud, not on the desktop PC, your desktop PC does not need the processing power or hard disk space demanded by traditional desktop software.
 - When you are using web-based applications, your PC can be less expensive, with a smaller hard disk, less memory, more efficient processor...
 - In fact, your PC in this scenario does not even need a CD or DVD drive, as no software programs have to be loaded and no document files need to be saved.

Advantages of Cloud Computing

- Improved performance:
 - With few large programs hogging your computer's memory, you will see better performance from your PC.
 - Computers in a cloud computing system boot and run faster because they have fewer programs and processes loaded into memory...
- Reduced software costs:
 - Instead of purchasing expensive software applications, you can get most of what you need for free-ish!
 - most cloud computing applications today, such as the Google Docs suite.
 - better than paying for similar commercial software
 - which alone may be justification for switching to cloud applications.

Advantages of Cloud Computing

- Instant software updates:
 - Another advantage to cloud computing is that you are no longer faced with choosing between obsolete software and high upgrade costs.
 - When the application is web-based, updates happen automatically
 - available the next time you log into the cloud.
 - When you access a web-based application, you get the latest version
 - without needing to pay for or download an upgrade.
- Improved document format compatibility.
 - You do not have to worry about the documents you create on your machine being compatible with other users' applications or OSes
 - There are potentially no format incompatibilities when everyone is sharing documents and applications in the cloud.

Advantages of Cloud Computing

- Unlimited storage capacity:
 - Cloud computing offers virtually limitless storage.
 - Your computer's current 1 Tbyte hard drive is small compared to the hundreds of Pbytes available in the cloud.
- Increased data reliability:
 - Unlike desktop computing, in which if a hard disk crashes and destroy all your valuable data, a computer crashing in the cloud should not affect the storage of your data.
 - if your personal computer crashes, all your data is still out there in the cloud, still accessible
 - In a world where few individual desktop PC users back up their data on a regular basis, cloud computing is a data-safe computing platform!

Advantages of Cloud Computing

- Universal document access:
 - That is not a problem with cloud computing, because you do not take your documents with you.
 - Instead, they stay in the cloud, and you can access them whenever you have a computer and an Internet connection
 - Documents are instantly available from wherever you are
- Latest version availability:
 - When you edit a document at home, that edited version is what you see when you access the document at work.
 - The cloud always hosts the latest version of your documents
 - as long as you are connected, you are not in danger of having an outdated version

Advantages of Cloud Computing

- Easier group collaboration:
 - Sharing documents leads directly to better collaboration.
 - Many users do this as it is an important advantages of cloud computing
 - multiple users can collaborate easily on documents and projects
- Device independence.
 - You are no longer tethered to a single computer or network.
 - Changes to computers, applications and documents follow you through the cloud.
 - Move to a portable device, and your applications and documents are still available.

Disadvantages of Cloud Computing

- Requires a constant Internet connection:
 - Cloud computing is impossible if you cannot connect to the Internet.
 - Since you use the Internet to connect to both your applications and documents, if you do not have an Internet connection you cannot access anything, even your own documents.
 - A dead Internet connection means no work and in areas where Internet connections are few or inherently unreliable, this could be a deal-breaker.

Disadvantages of Cloud Computing

- Does not work well with low-speed connections:
 - Similarly, a low-speed Internet connection, such as that found with dial-up services, makes cloud computing painful at best and often impossible.
 - Web-based applications require a lot of bandwidth to download, as do large documents.
- Features might be limited:
 - This situation is bound to change, but today many web-based applications simply are not as full-featured as their desktop-based applications.
 - For example, you can do a lot more with Microsoft PowerPoint than with Google Presentation's web-based offering

Disadvantages of Cloud Computing

- Can be slow:
 - Even with a fast connection, web-based applications can sometimes be slower than accessing a similar software program on your desktop PC.
 - Everything about the program, from the interface to the current document, has to be sent back and forth from your computer to the computers in the cloud.
 - If the cloud servers happen to be backed up at that moment, or if the Internet is having a slow day, you would not get the instantaneous access you might expect from desktop applications.

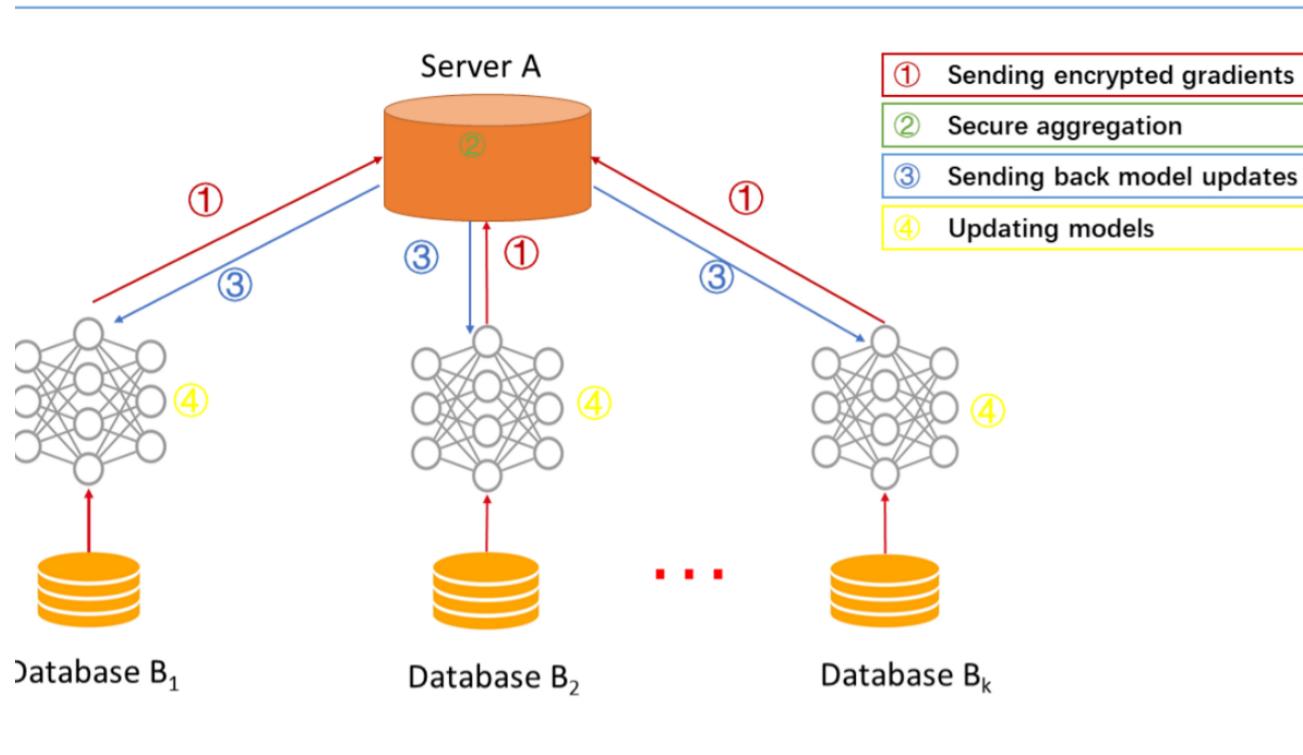
Disadvantages of Cloud Computing

- Stored data might not be secure:
 - With cloud computing, all your data is stored on the cloud.
 - The question is How secure is the cloud?
 - Can unauthorised users gain access to your confidential data?
- Stored data can be lost:
 - Theoretically, data stored in the cloud is safe, replicated across multiple machines.
 - But on the off chance that your data goes missing, you have no physical or local backup.
 - Put simply, relying on the cloud puts you at risk if the cloud lets you down.

Disadvantages of Cloud Computing

- HPC Systems:
 - Not clear that you can run compute-intensive HPC applications that use MPI/OpenMP!
 - Scheduling is important with this type of application
 - as you want all the VM to be co-located to minimize communication latency!
- General Concerns:
 - Each cloud systems uses different protocols and different APIs
 - may not be possible to run applications between cloud based systems
 - Amazon has created its own DB system (not SQL 92), and workflow system (many popular workflow systems out there)
 - so your normal applications will have to be adapted to execute on these platforms.

Recent Cloud + Big Data Analytics



- Data security concern becomes a hurdle of further development of big data analytics in cloud computing
- A new concept – Federated Learning
- New theories and applications are still developing

What is the Internet of Things?



- Internet connects all people, so it is called “the Internet of People”
- IoT connects all things, so it is called “the Internet of Things”

What's the Internet of Things

- Definition

(1) The Internet of Things, also called The Internet of Objects, refers to a wireless network between objects, usually the network will be wireless and self-configuring, such as household appliances.

-----Wikipedia

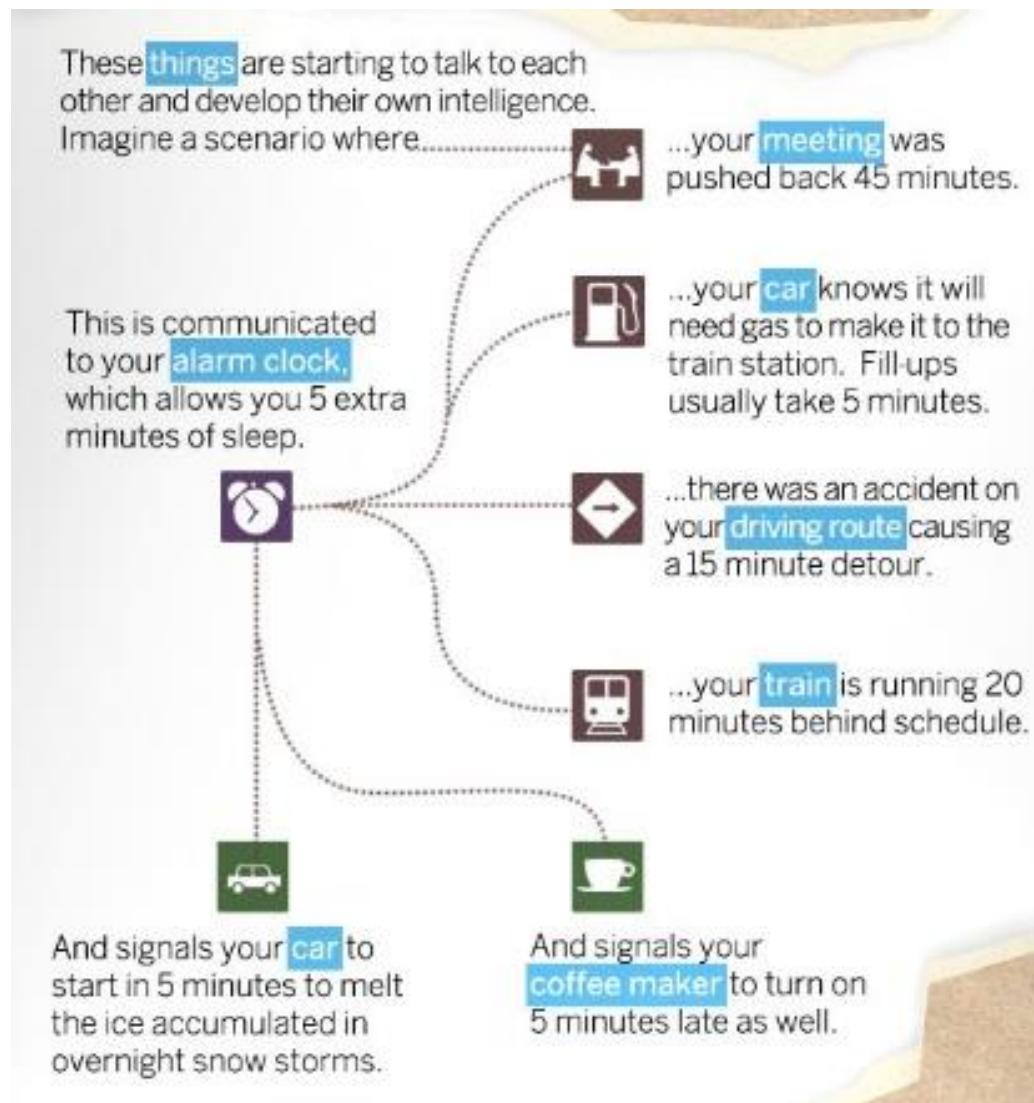
(2) By embedding short-range mobile transceivers into a wide array of additional gadgets and everyday items, enabling new forms of communication between people and things, and between things themselves.

-----WSIS 2005

Internet of Things Technically

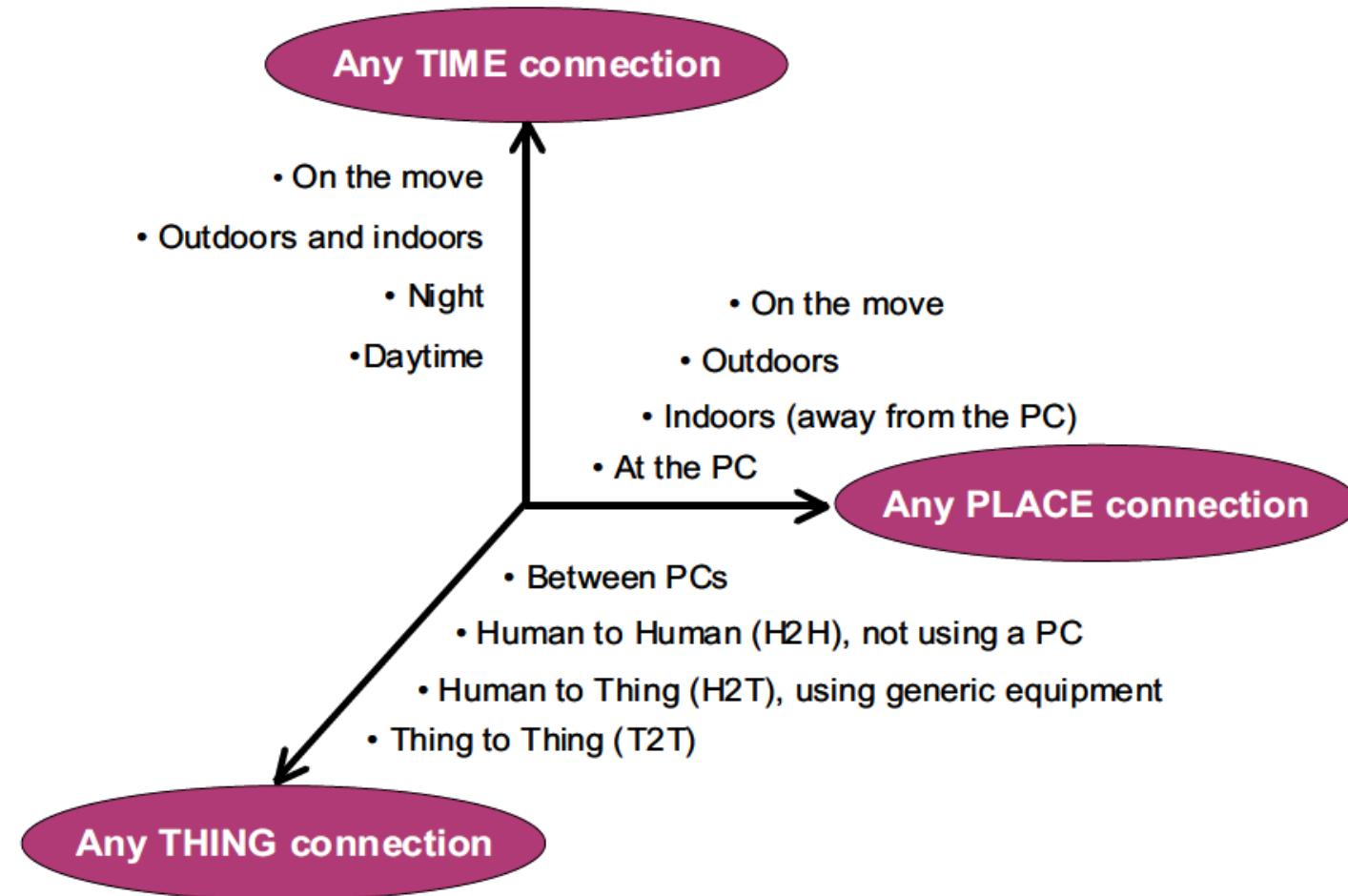
- What to measure? Or measure everything measurable?
- What kinds of sensors?
- Sensor location optimization and sensor network design
- Data transmission protocols
- Edge computing, edge devices
- Central system for information integration – Cloud may participate here

Will it affect your life?



Welcome to our NEW DIMENSION

Figure 1 – A new dimension



Source: ITU adapted from Nomura Research Institute

Why Internet of Things?

Dynamic control of
industry and daily life

Accessibility &
Usability

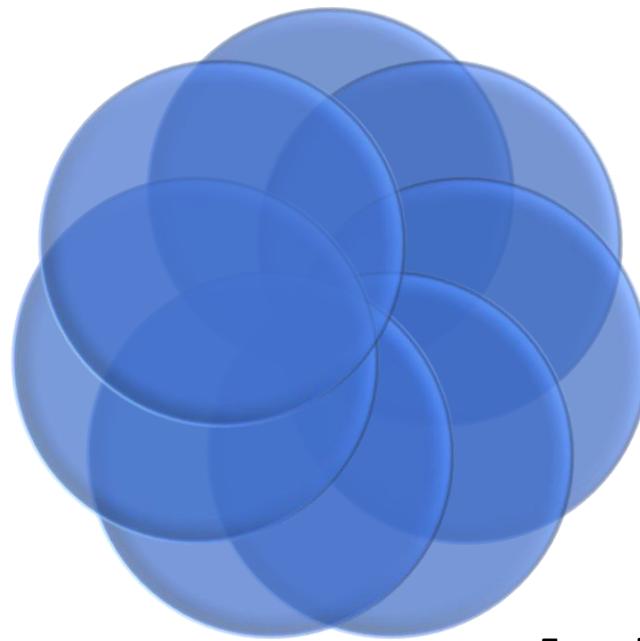
Universal transport
& internetworking

Flexible configuration

Improve the resource
utilization ratio

Better relationship
between human and
nature

Forming an intellectual
entity by integrating
human society and
physical systems

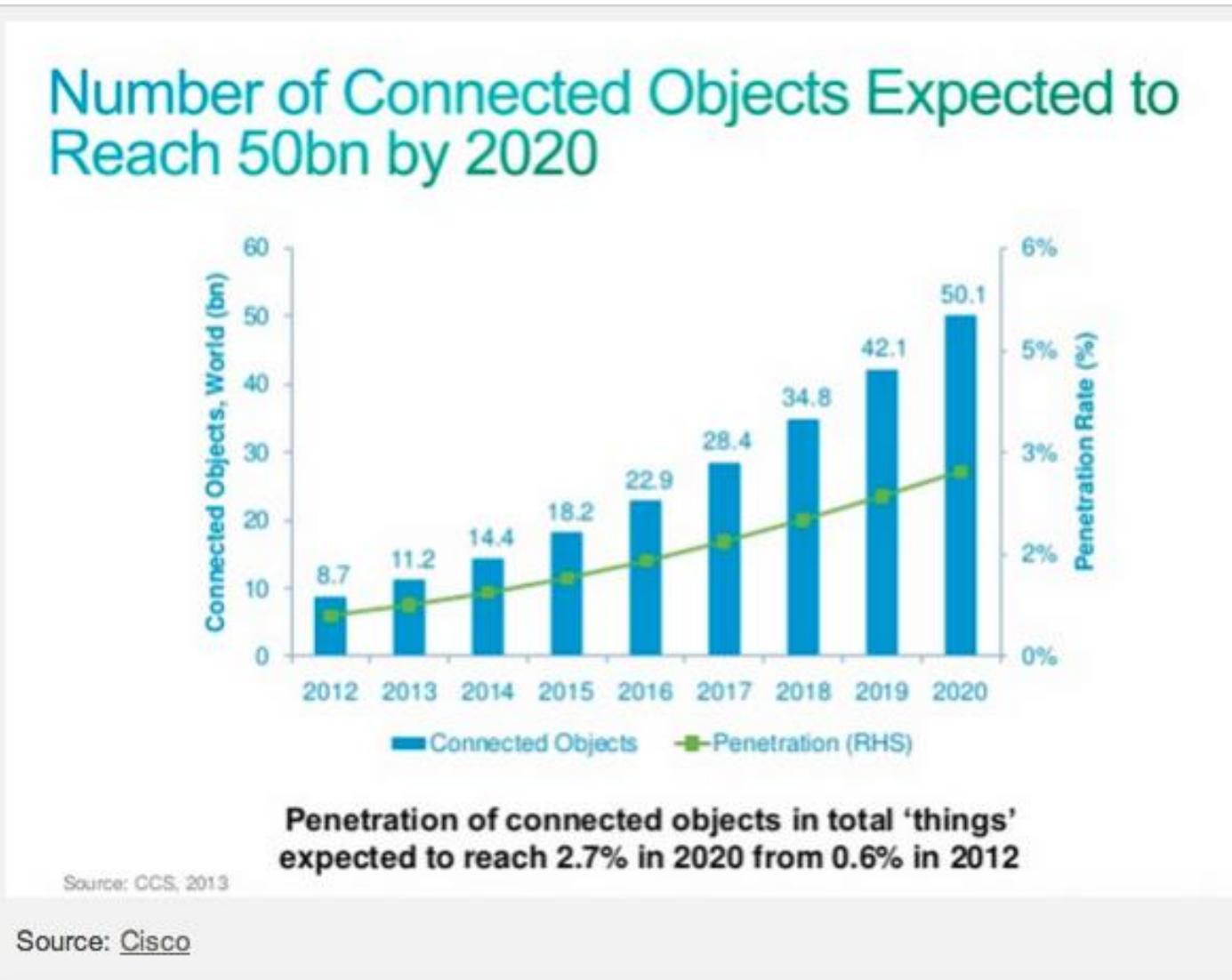


History of the Internet of Things

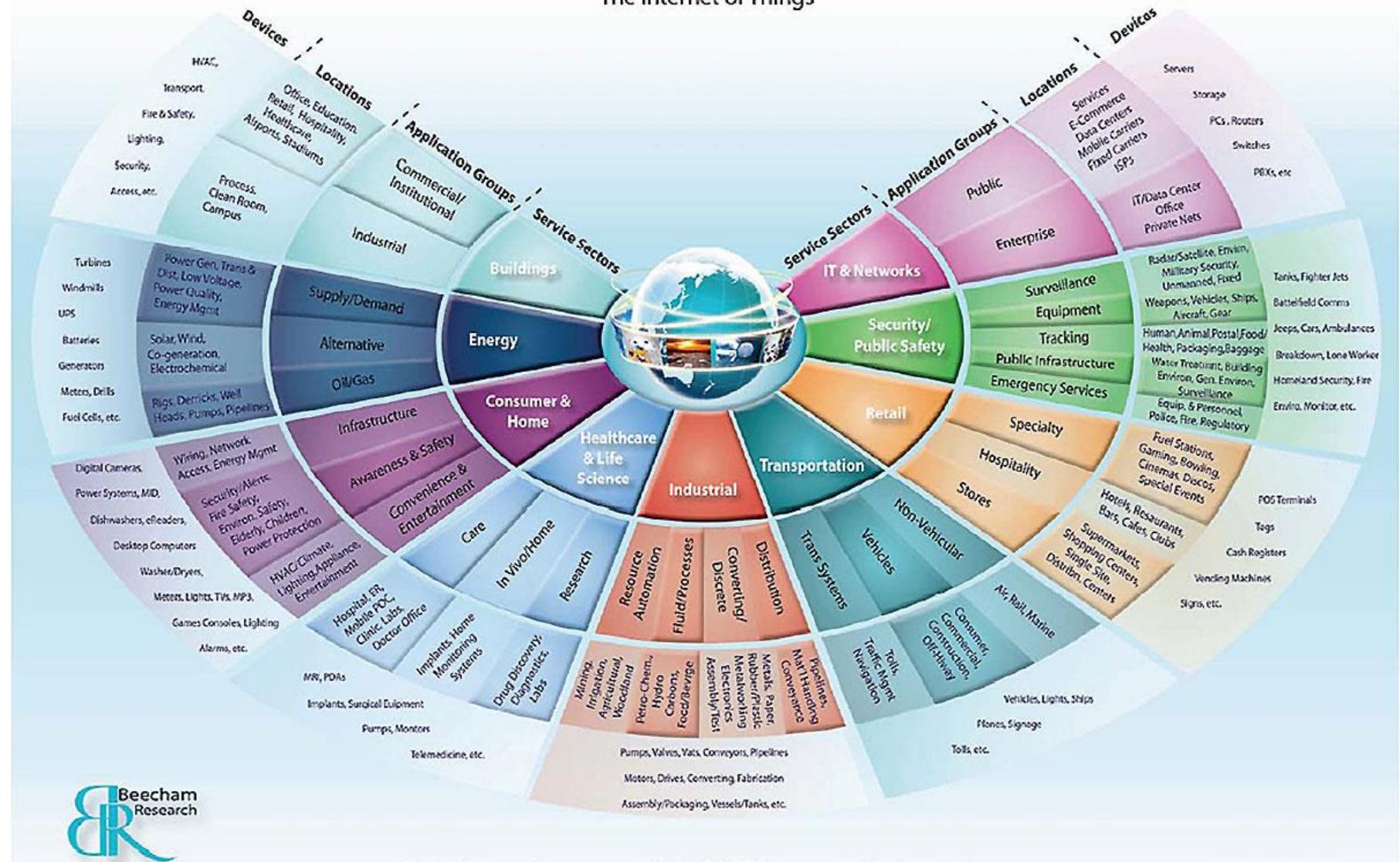
- History

- 1997, “The Internet of Things” is the seventh in the series of ITU Internet Reports originally launched in 1997 under the title “Challenges to the Network”.
- **1999, Auto-ID Center founded in MIT**
- **2003, EPC Global founded in MIT**
- 2005, Four important technologies of the internet of things was proposed in WSIS conference. (RFID, Nano, Wireless sensors, smart tech)
- 2008, First international conference of internet of things: The IOT 2008 was held at Zurich.

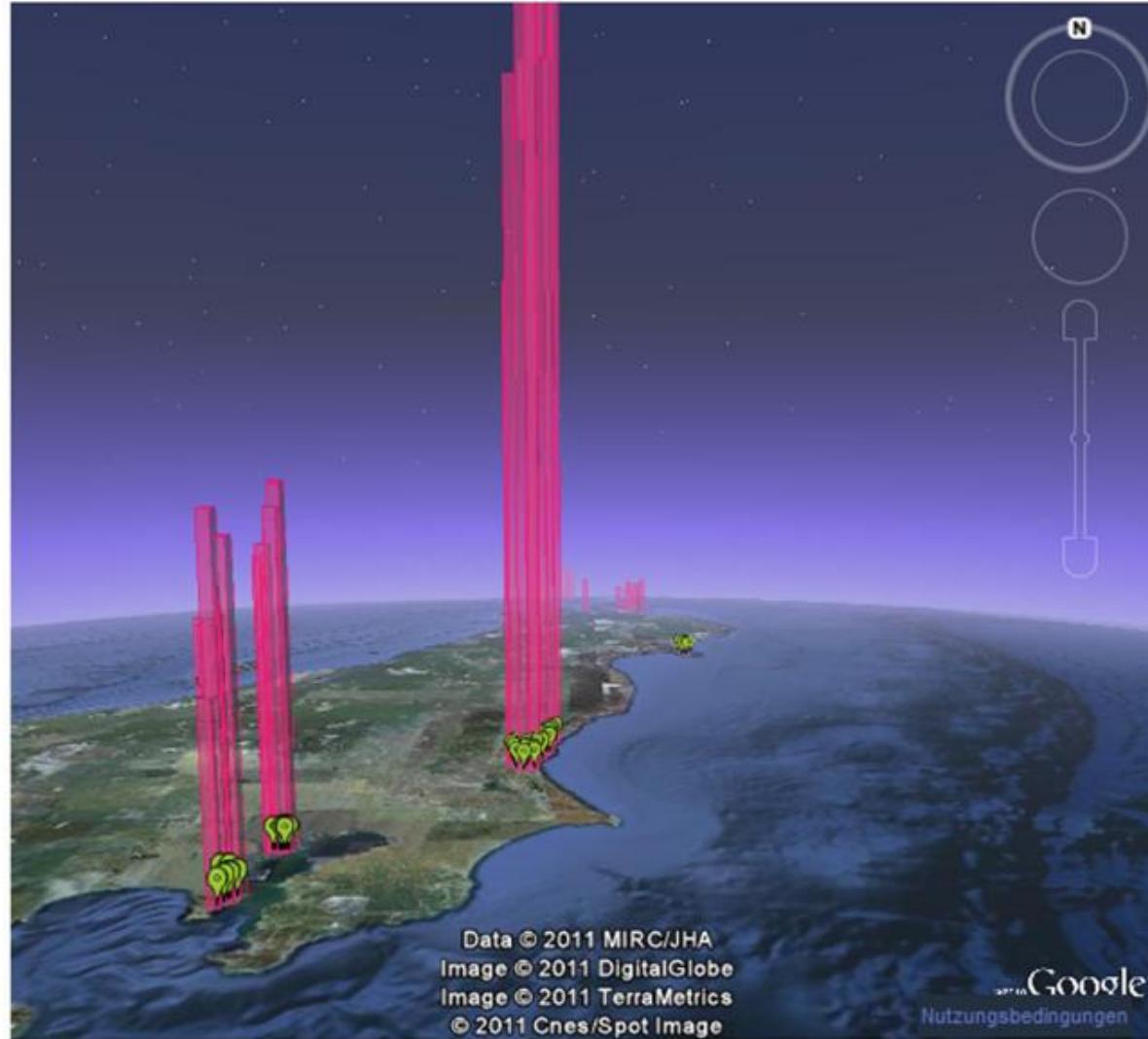
NOW is the time



The Internet of Things

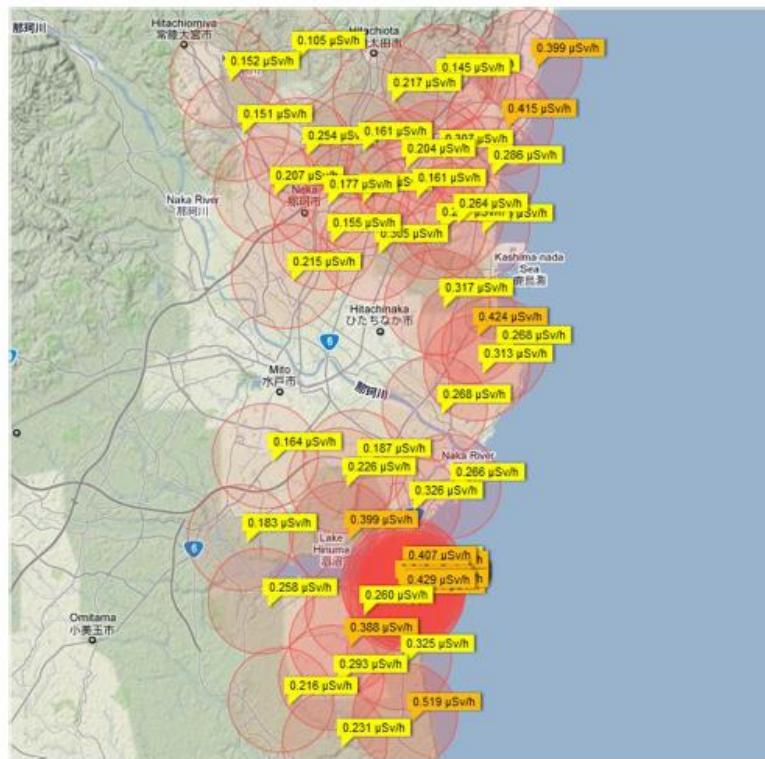
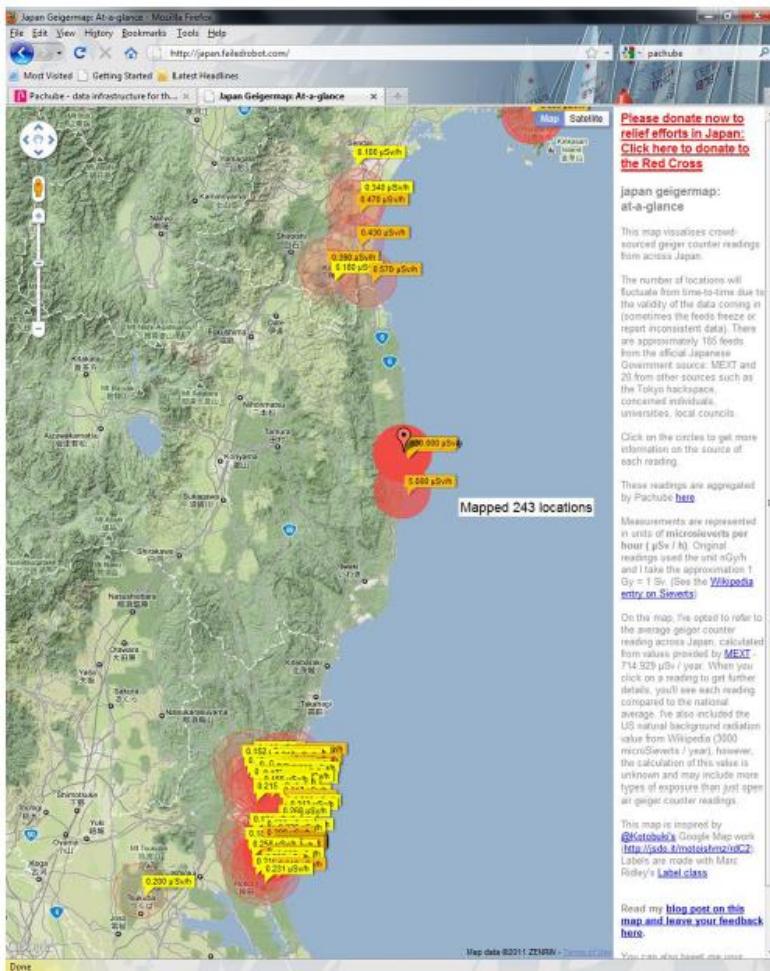


After the Fukushima Disaster on Pachube



<http://community.pachube.com/node/611#3d>, 31.3.2011

Many People Connected Radiation Sensors...



<http://japan.failedrobot.com/>, 31.3.2011

M2M Scenario – Ice Cream Cabinets

- The application provides consumer products companies with detailed information about the location and status of its ice cream cabinets.
- This information can be used to find these cabinets, supply them with new ice cream in time, and monitor their temperature in order to avoid ice cream becoming bad due to a defective ice cream cabinet.
- The ice cream cabinets become smart items that monitor their energy consumption, send alarms, and become an active part in the companies operation processes as well as sustainability efforts.



IoT Configuration

- 2.5 million ice cream cabinets
 - Worldwide distributed
 - Biggest growth markets: China and India
- Sensoring
 - **Need to refill**
 - Avoid stock-outs
 - **Location**
 - Reliably find and refill
 - **Temperature / power outage**
 - Detect failures and avoid product loss
 - **Behavioral statistics**
 - Conclude conversion rate



Internet of Things

- A very general term and framework
- It targets on sensing systems, networking systems, and information systems
- IoT technologies can be application-driven, but simplest, deploying a set of sensors, collecting data, and centralizing the information
- IoTs are more hard-ware side; however, it forms the foundations for building cyber-worlds on top of physical systems and developing communication channels
- Edge computing and Cloud computing

Internet of Things vs. Cloud Properties

