

>> 4.0 Round Trip << : From AI, Digital Natives and Innovation Cultures towards to Future of Work, Life, and Society

Mercedes-Benz Werk Bremen
„Arbeit und Digitalisierung“
Bremen - Grand Central alter Bahnhof Oberneuland
November 2nd, 2016

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Cybernetics Lab IMA/ZLW & IfU
Faculty of Mechanical Engineering
RWTH Aachen University

I. Introduction

- Breakthroughs in Artificial Intelligence and a networked world

II. Reinventing Cybernetics: The Intelligence of the new systems

- The paradigm change: from centralized to decentralized control algorithms and models
- Trends in mobility and transportation

III. Demographic Change and Digital Natives

- National and international population shifts
- Societal changes in the digitalization age - Trends in a „born digital“ world

IV. Innovation in Times of Revolutions

- Who makes innovations? – The vendor change in 4.0
- What are innovations? – From the basics to innovation in 4.0
- How to innovate? – About innovation cultures in 4.0

V. Work 4.0 – Blue-Collar, White-Collar and the Question of Creativity

- Pattern in the blue-collar/white-collar scheme
- Hi there, AI... 😊 - from GOFAI zu creative systems

VI. Summary and Outlook

... leading to the 4th industrial (r)evolution...

Breakthroughs - A new era of artificial intelligence

Communication technology

bandwidth and computational power

Embedded systems

miniaturization

Watson
2011

Semantic technologies

information integration

Google Car
2012



→ Systems of "human-like" complexity

... leading to the 4th industrial (r)evolution...

Breakthroughs - Everybody and everything is networked

Communication technology

bandwidth and computational power

Embedded systems

miniaturization

Semantic technologies

information integration

Car2Infra-
structure



Smart
Grid

Smart
Factory



Team
Robotics

Swarm
Robotics



Towards eMobility and eMobility components

Everybody and everything is networked – Big Data & Cyber-Physical Systems



In February 2015, Audi installed collaborative robots – “Cobots” in Ingolstadt, working “hand-in-hand” with humans

For the automobile industry, that means:

The production is changing – AND – the product is changing !



Tesla X 2015, other Teslas since 2006; Forbes: “most innovative enterprise”

„local“
to „global“

„local“
to „global“

around 1750

around 1900

around 1970

today

1st industrial revolution

Mechanical production systematically using the power of water and steam

Power revolution

Centralized electric power infrastructure; mass production by division of labor

Digital revolution

Digital computing and communication technology, enhancing systems’ intelligence

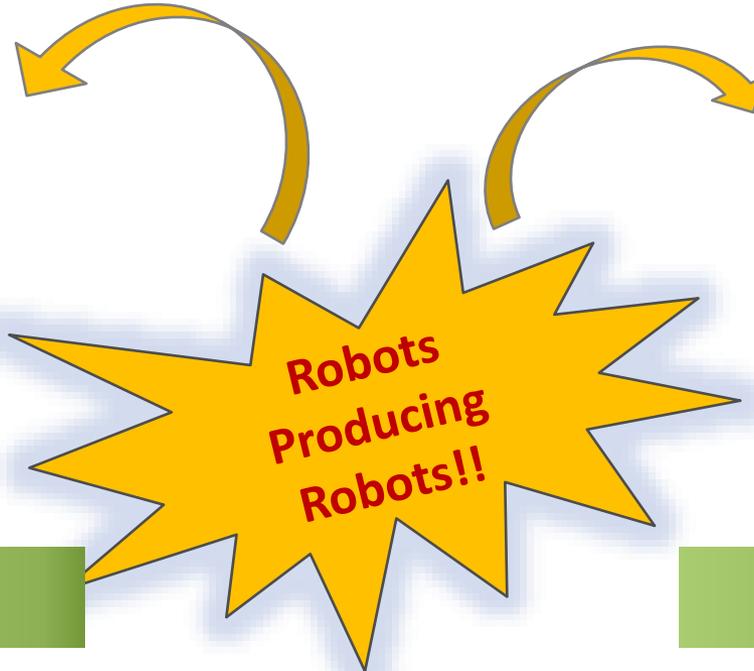
Information revolution

Everybody and everything is networked – networked information as a “huge brain”

Towards eMobility and eMobility components



Vision by pgottschalk



Concept car Mercedes F105
Tesla X 2015, other Teslas since 2006; Forbes:
“most innovative enterprise”

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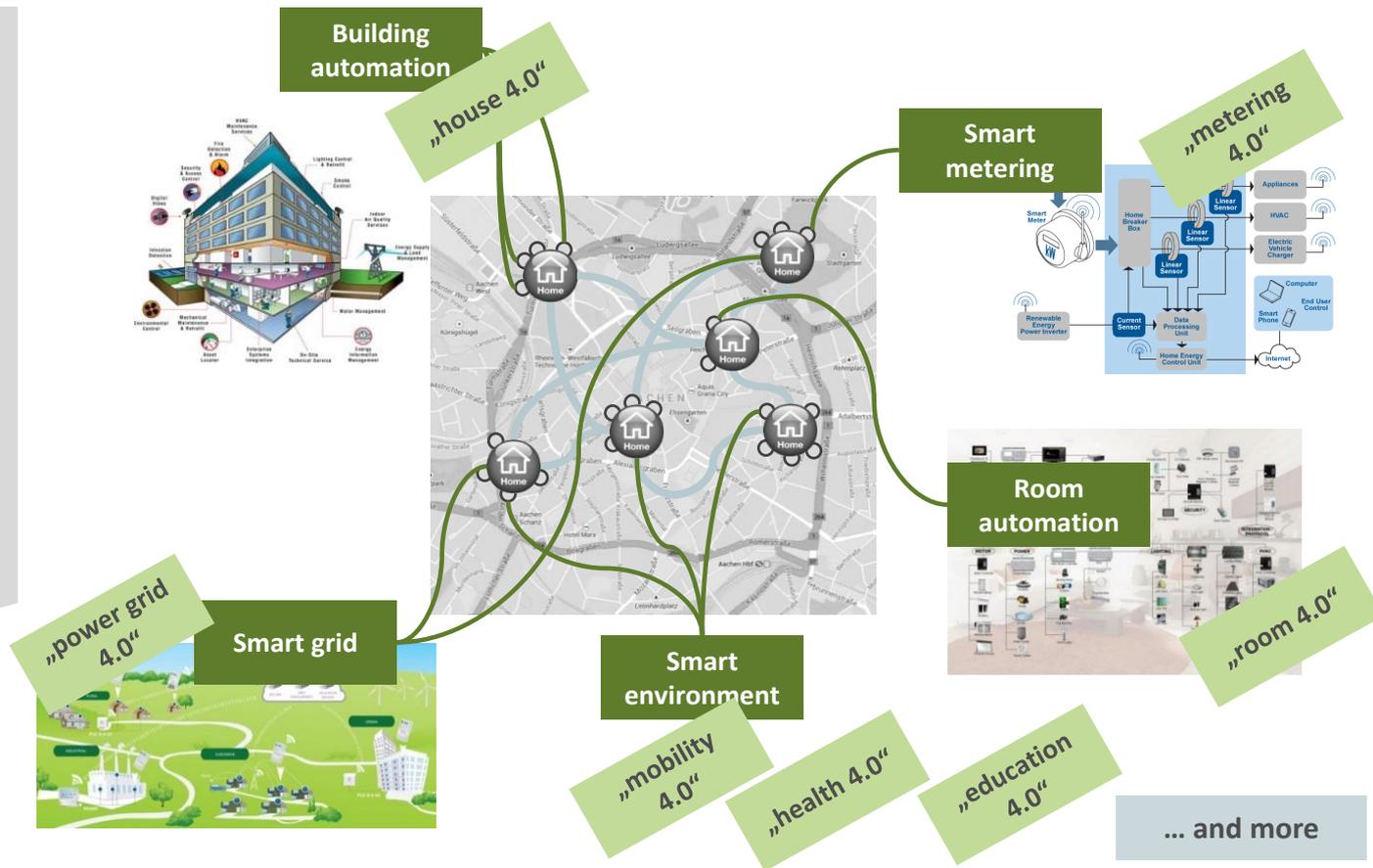
today

Information revolution

Everybody and everything is networked – networked information as a “huge brain”

“Industry 4.0 will address and solve some of the challenges facing the world today such as resource and energy efficiency, urban production and demographic change.”

Henning Kagermann et al.,
acatech, 2013



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Everybody and everything is networked – networked information as a “huge brain”

... leading to the 4th industrial (r)evolution...
And how do these systems work?

Communication technology
bandwidth and computational power

Embedded systems
miniaturization

Semantic technologies
information integration



Towards intelligent and (partly-) autonomous systems AND systems of systems

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- **Term:** „governance“, to navigate
- **Born around 1940**
- **1948:** “Cybernetics or control and communication in the Animal and in the machine” (Norbert Wiener)
- **until 1953:** Macy-Conferences

Feedbackloop

Circular explanations for systems behavior, self-regulation
(Forrester, Ashby)

Autopoiesis

System capacity to maintain and stabilize itself
(Maturana, Varela)

Decentralization

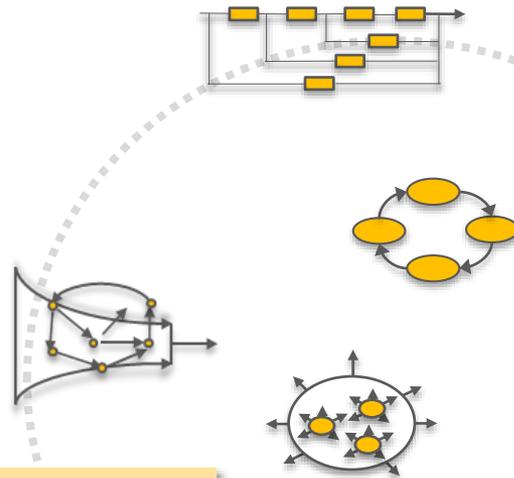
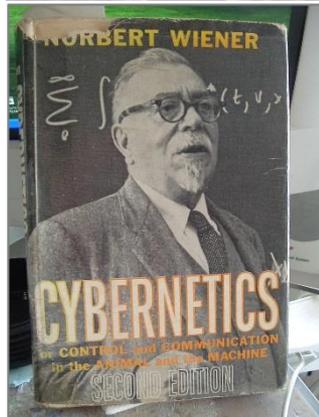
Decentralized navigation, bottom up processes
(Stafford Beer)

Emergence

Spontaneous new properties, swarm behavior
(Wolfram, Gell-Mann)

Complex Systems

Multi-component systems in complex interactions
(Stafford Beer)

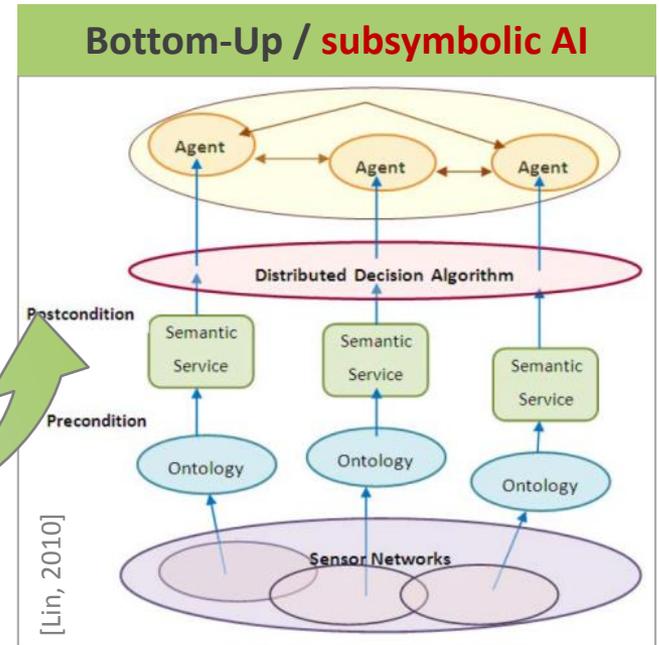
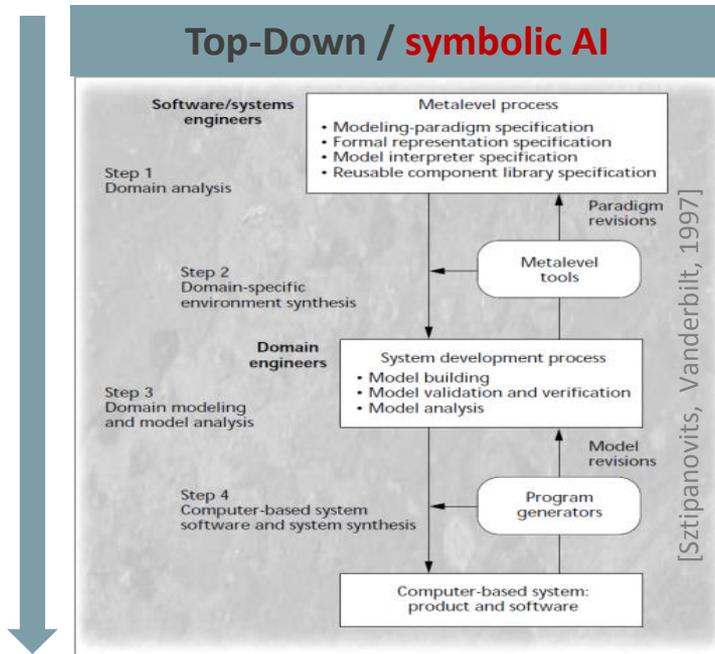


→ Two competing movements? --- From top-down to button-up design

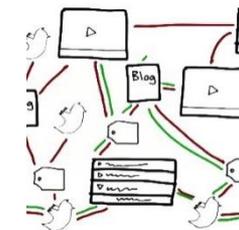
Knowledge storage/
knowledge retrieval



GOFAI
Good old fashioned Artificial Intelligence; based on high-level "symbolic" knowledge representations



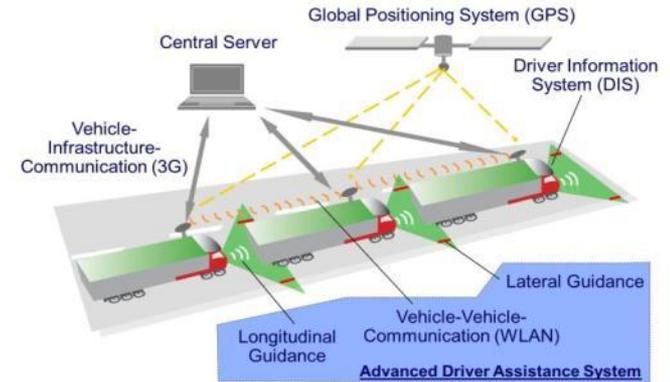
Connectivism
interaction as basis of intelligence



Knowledge on demand /
knowledge acquisition

→ The KONVOI project (several institutes from RWTH & industry partners)

- 2005-2009
- automated / partly autonomous transportation e.g. by electronically coupling trucks to convoys
-
- several successful tests with trucks: Chauffeur, KONVOI, SARTRE (EU), Energy-ITS (Japan), ...



- Adv. driver assistance system for trucks
- short distances between vehicles of approx. 10m at a velocity of 80 km/h
- Energy-ITS: 4m ! (2013)
- KONVOI:
 - Car2infrastructure components!
 - Model of multi agent systems

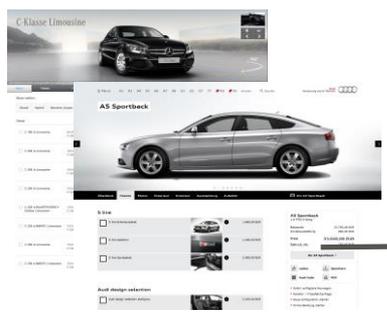
-
- expected improvements:
beyond safety, reduction of fuel consumption and gained road space

Changes already „under construction“ With decentralized models towards lot size 1

→ Organization forms on demand – individualized by client – initialized by product

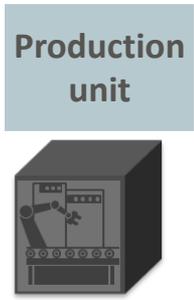
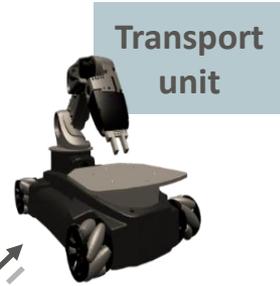
- ↗
 - Heterogeneous player modeled as multi agent concept
 - Models from biology and social sciences
 - Based on autopoiesis & embodiment theory
- !
 - Product agitates as “super-agent”:
 - Plans production and transportation steps
 - Requests services from agents
 - Negotiates with other products for agent-resources

- - Konvoi 2005-2009, RWTH with partners
 - (partly) autonomous driving via convoys



Outside world

Fabrication



Virtual service provider



© Daniel Ewert 2013



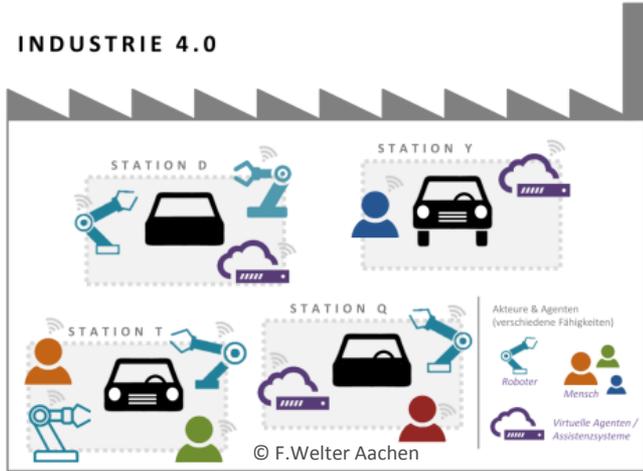
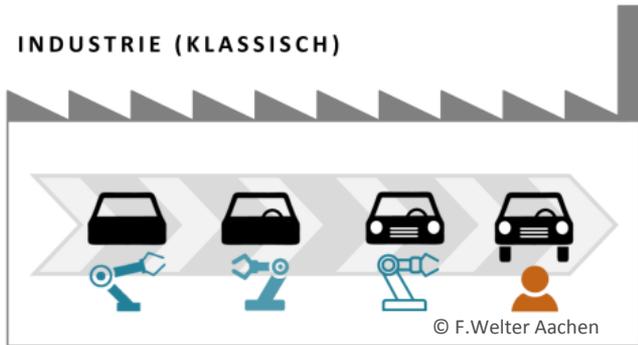
Audis collaborative robots in Ingolstadt, the “Cobots” pick up components and pass them to workers (02/2015)

- New “body concepts” for robots
 - New types of “sensible” robots, mainly “lightweight”
- Real-time capability:
 - New fast sensors allows avoiding accidents in close cooperation
- New intelligence models:
 - New AI for “context understanding”



PhD Ying Wang, RWTH, IMA/ZLW & IfU, 2016

➔ Towards hybrid teams and in-the-box production



„My colleague the robot...“



Again more: In a few years, automated driving might outcompete human drivers. Security issues, the demographic change, and the decreasing attractiveness of the job may add to a fast change.

www.cargocap.de



Google



Daimler



DHL



Rolls Royce



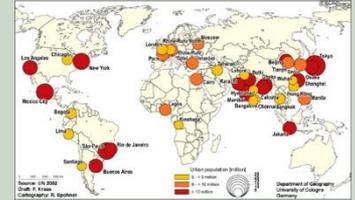
rail-bound caps

Some even more "out of space" concepts

The third dimension



! "In 2030, 70% of all humans will live in cities. Already then, about 10% will live in megacities (i.e., more than 10 Mio people). Escalating..."



[freestyle translation, source pwc studies]

The megacities of the future



At a certain point, due to purely mathematical reasons, extended 3-dimensional building structures can not longer be served by purely 2-dimensional (street) networks.



Third dimension



Above ground



Below ground



Some even more “out of space” concepts

The new construction

„Digital warehouses are replacing physical spare parts storages“

[freestyle translation, source Logistik magazine]



! „3D printing is on its way to leave the somewhat ‘restricted’ areas of spare part business, tool making etc. and is about to become a serious challenger for all traditional manufacturing models“.

[source Prof. Erman Tekkaya, TU Dortmund]



Harbor Rotterdam – 3D printer farm for metal printing (after piloting, now roll-out in 2016)



Water carbonators reaching high sales figures



3D printing of house (source Univ. of Southern California 2013)



3D print of pasta – Barilla (tests since 2015)



“plastics instead of parcels?” - UPS moving from logistics to 3D printing (tests since 2013)

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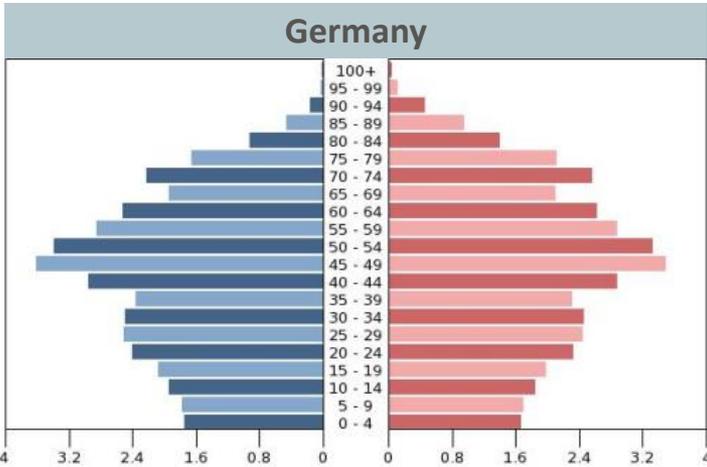
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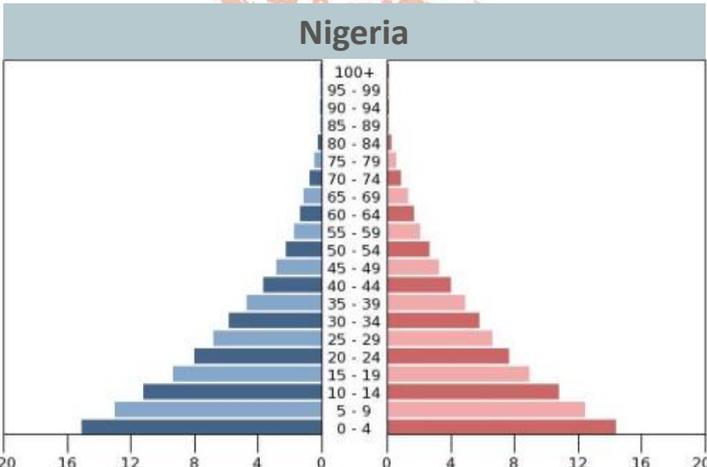
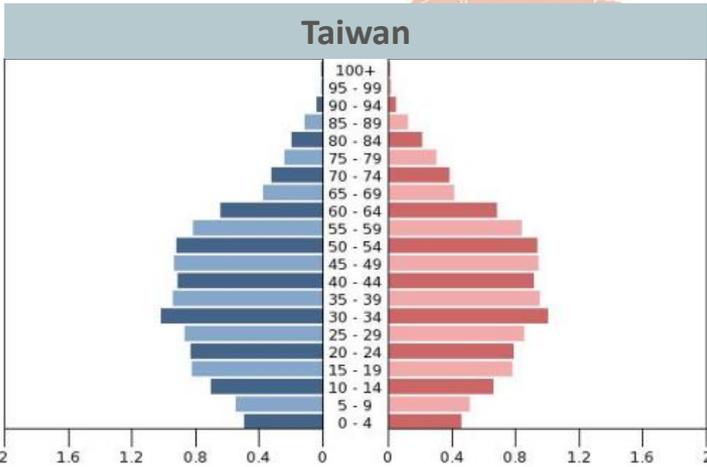
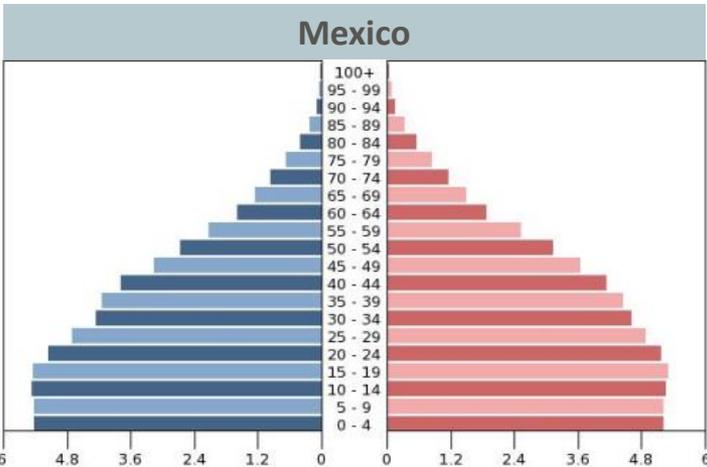


Demographic change... Population shift (international)

→ Aging/shrinking societies

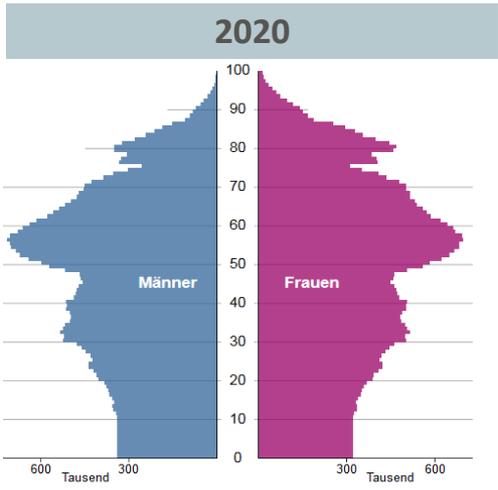
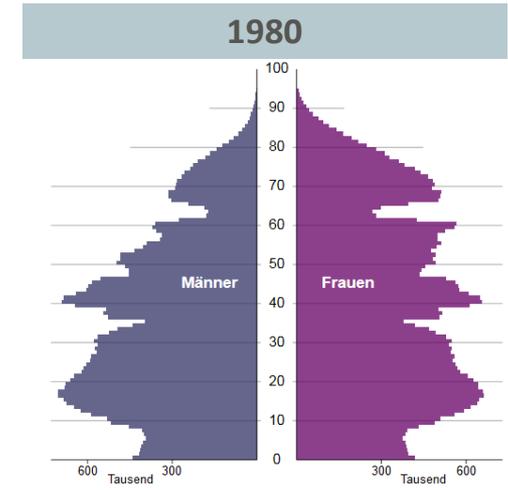
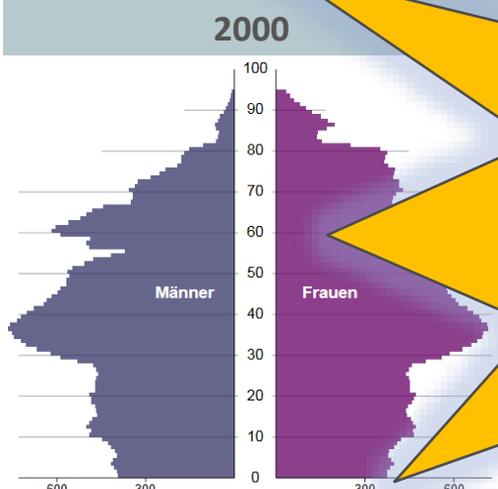
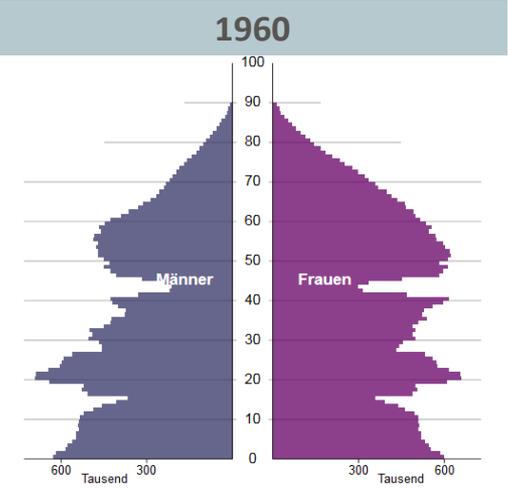


→ Growing societies

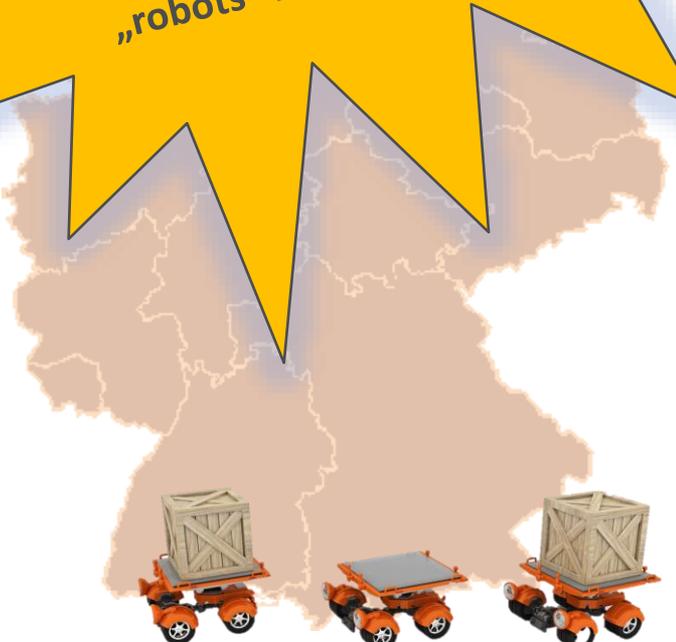


Demographic change... Population shift (national)

→ Aging/shrinking Germany



With this shrinking population,
the current productivity of
Germany cannot be sustained
without the broad use of
„robots“ in all areas!!



© Statistisches Bundesamt 2015

The customer gets powerful.

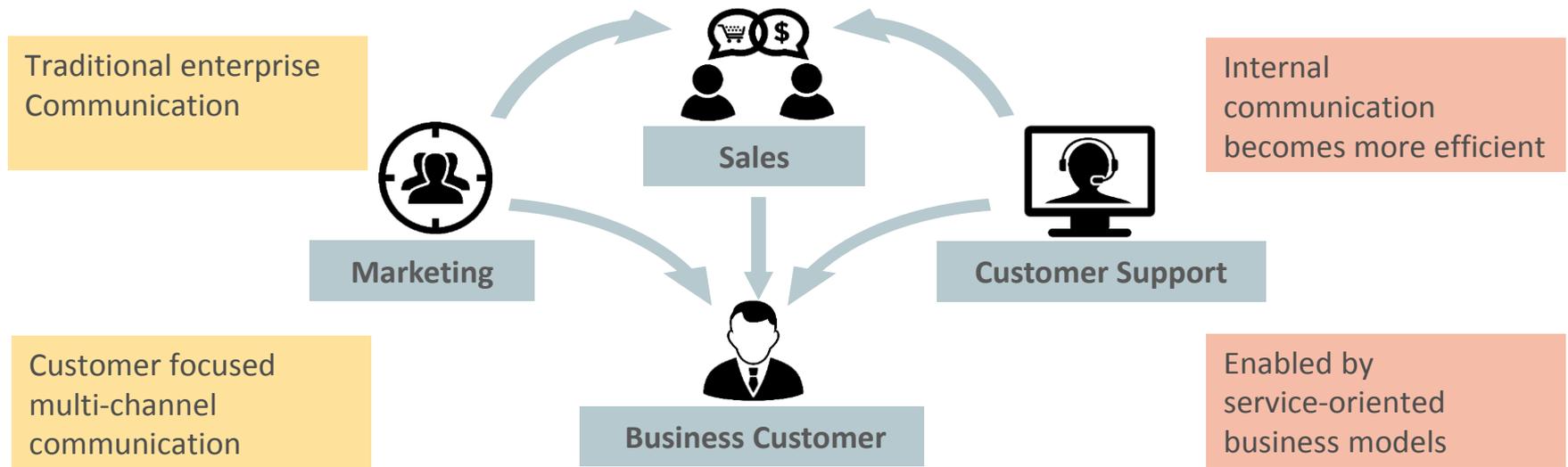


And: he/she expects services in business (B2B) to work in the same comfortable way as at home (B2C).

And – more again: the **digital native** is entering the scene. This guy does not even know what a fax machine is used for. Everything outside the internet does not exist!

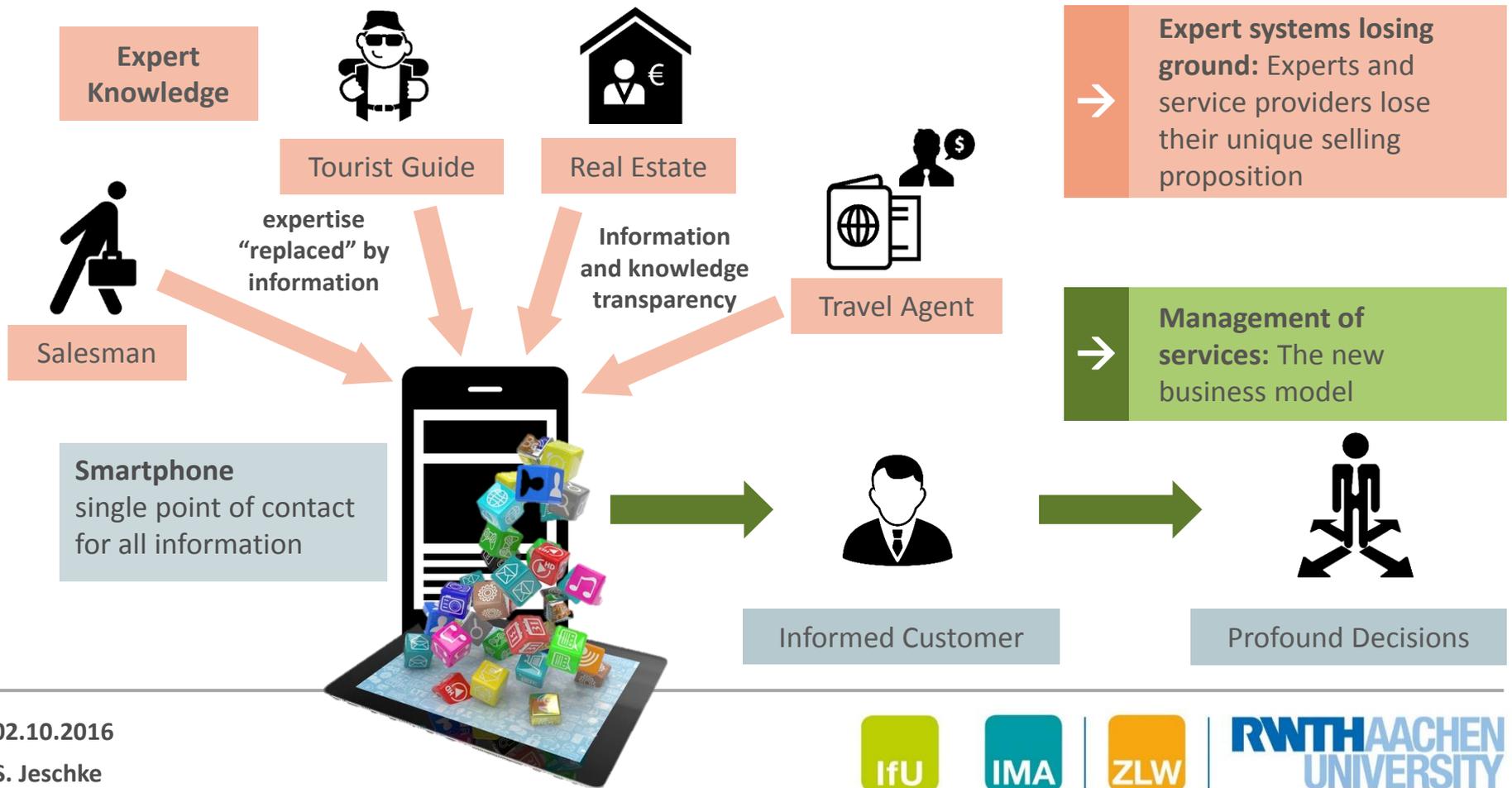


Business units – such as marketing, sales, customer support – communicate with each other, but also directly and autonomously with the customer.



Services become available and experts become obsolete!

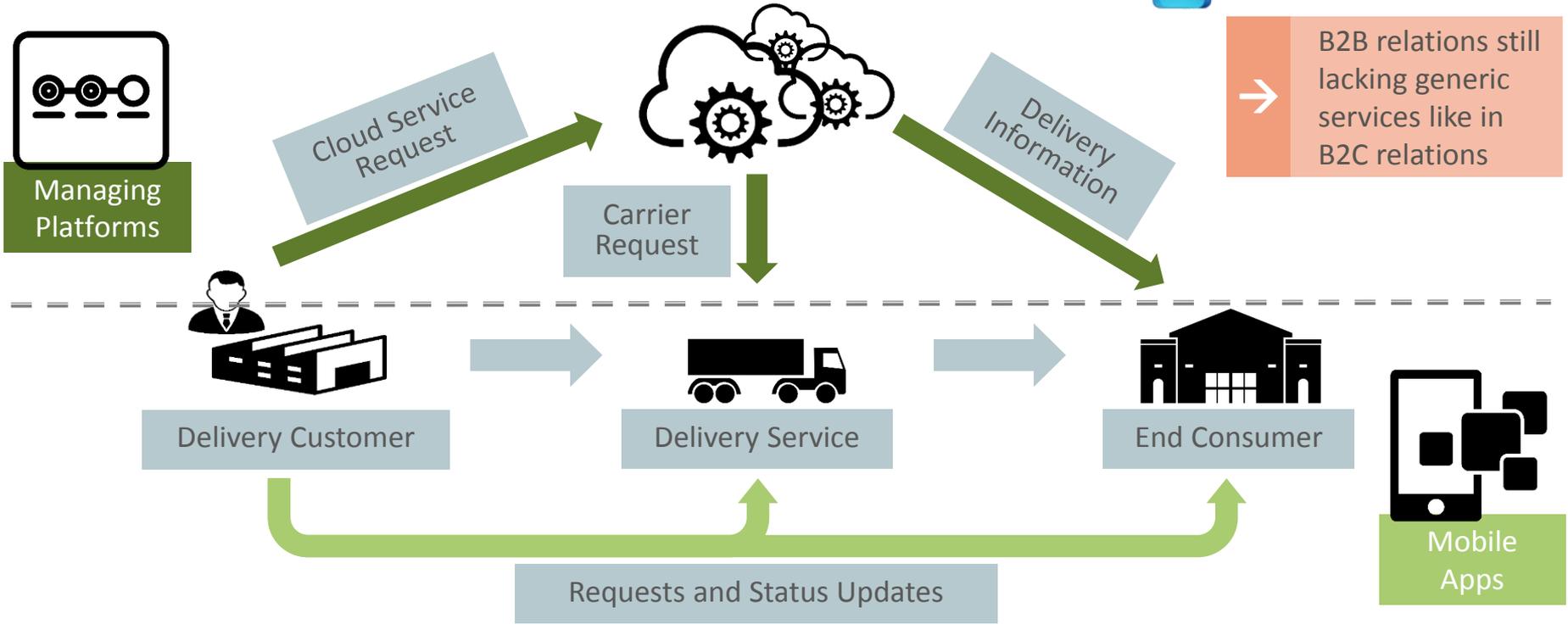
As information becomes more and accessible, experts lose information power. This observation is inline with all earlier changes along the information chain, starting with the book printing ...



Logistics 4.0 or „Logistics as a Service“ (LaaS)

The terminology is based on concepts as Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) up to Anything-as-a-Service (XaaS). It is sometimes referred to as "on-demand XY", without hosting or owning the necessary infrastructures and tools.

The philosophy behind it is: "Just do it – I don't care how!"



Sharing economy:

“A common premise is that when information about goods is shared (typically via an online marketplace), **the value of those goods may increase** for the business, for individuals, for the community and for society in general.”

[Wikipedia, 2015]

„The sharing economy endangers traditional business models. E.g. carsharing could choke off the demand of new cars...”

[<http://www.haufe.de/> 2015]



Toyota verschenkt Brennstoffzellen-Patente: Frei für die Zukunft

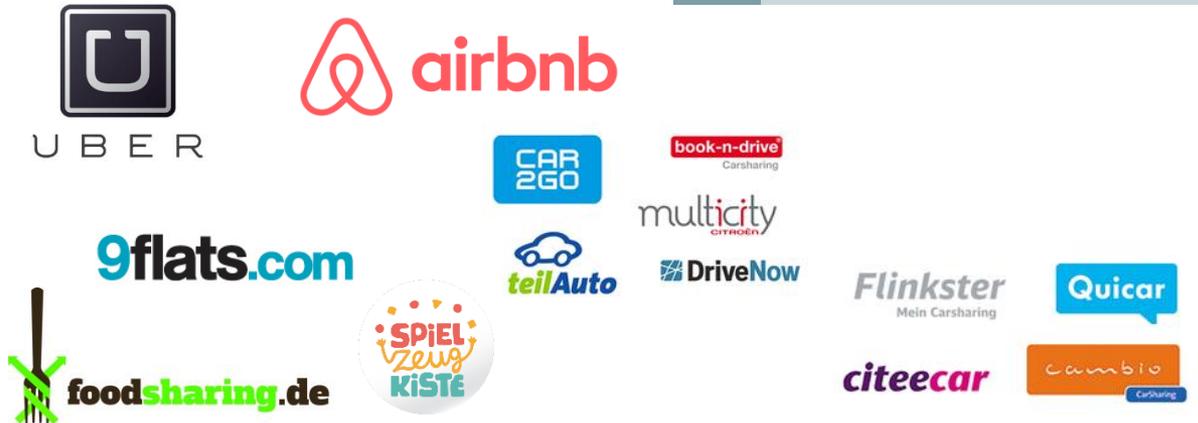


Toyota Mirai: Der Hersteller verschenkt seine Brennstoffzell...

! Uncertain future of patents... IPR?

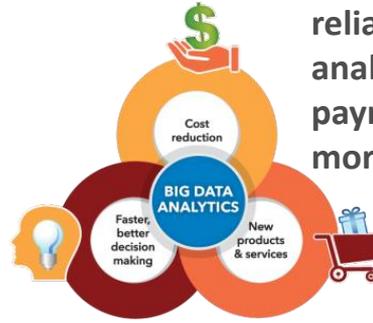
! “...already today, about 25% of the Germans can be counted as ‘social-innovative co-consumer’”

[Heinrichs, Leuphana, 2015: Auf dem Weg in eine neue Konsumkultur?]



Service Innovations

Lateral thinking - what's next?



SAS: all types of reliability analysis, e.g. payment moral etc.

Which new business models are about to break through?

Will the product be delivered to customer before it has been ordered, „Anticipatory Shipping“?

Send medicine before a disease spreads...

Who is ordering?

Which kind of foresight do Big Data Technology will come up with in the future?

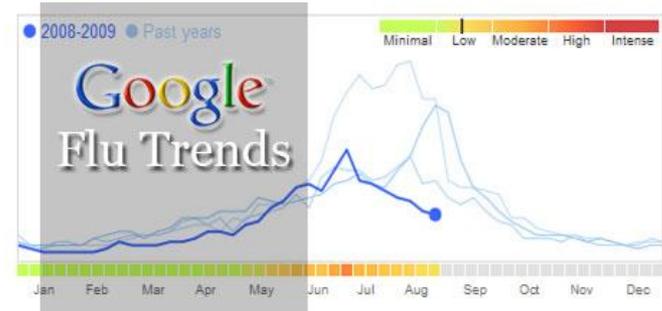


?



gild

GILD: “Roboter Recruiting”; selecting employees on a purely algorithmic basis



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Characteristics of Industrial Revolutions: The vendor change



Latest version of Google's self driving car (Huffington Post, 28.5.2014)



Sony announced autonomous car in 2015, based on their experience in visual sensors



Ford 021C concept car 2012, designed by Newson now at Apple (1999)



Apple Inc.



Tesla X 2015, other Teslas since 2006; Forbes: "most innovative enterprise"



Car specialists? – No.

- Connectivity & data specialists.
- Energy & sensor specialists.

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SONY



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Apple Inc.



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An autonomous car is more like a computer on wheels than a car which includes one or many computers.

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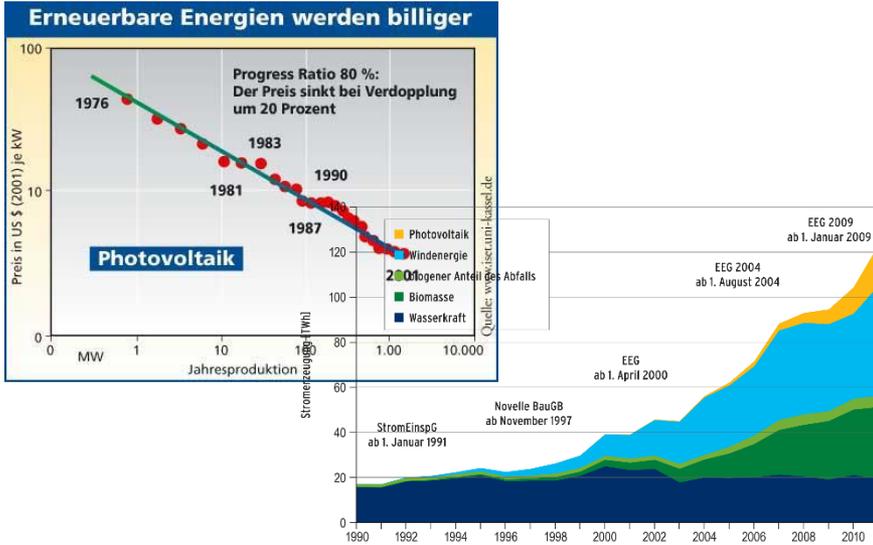
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The energy sector...



! “2011, in Germany ... the big traditional power companies— E.ON, RWE, EnBW, Vattenfall — owned only 7% of the renewable-energy capacity installed by the end of 2011. Individuals, however, owned 40% of the renewable energy capacity, energy niche players 14%, farmers 11%, ...”

[Rifkin, 2014: The Zero Marginal Cost Society]

The communication sector...



! „The reason for Germany's fall-back ... is mainly the result from avoiding optical fiber and instead, to count on VDSL.“

[transl. from Schmidt/Netzökonom, 2015]

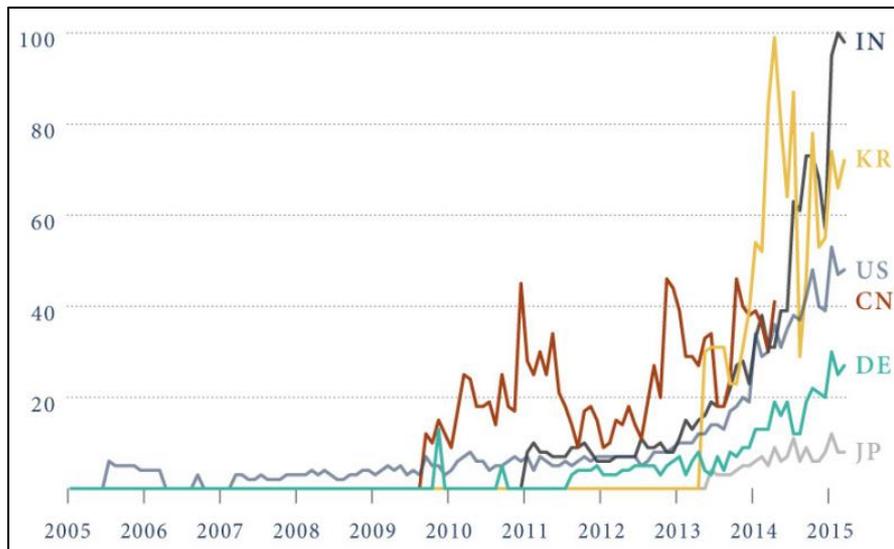
“...a lot of the rural areas start “broadband clubs” where they build themselves parts of the necessary infrastructure...”

[transl. From Nyteknik Interjournal, 2014]

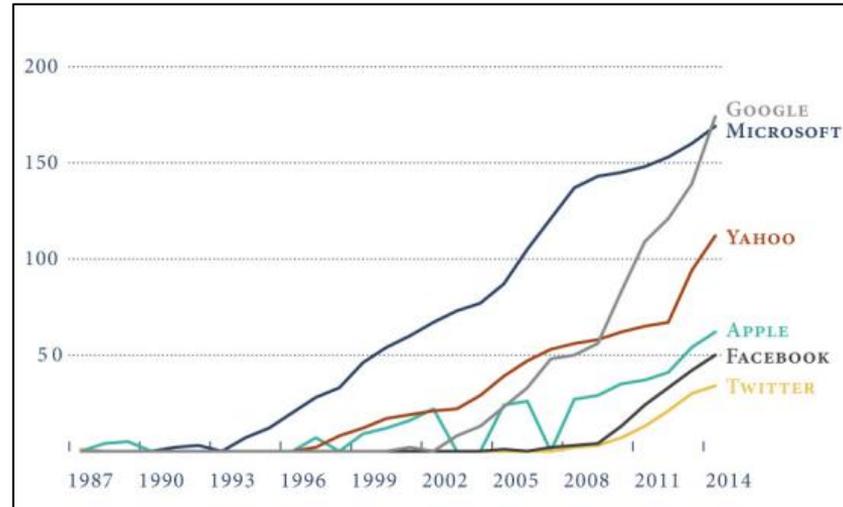
Worldwide rising significance of Big Data and Internet of Things/Cyber Physical Systems

American LEs take over!

- 1st place: US
- China, South Korea are catching up fast
- Germany: falling back?!



Interest in Internet of Things (Nets ,n' Clouds Analytics Aachen based on Google Trend Analysis)



Company takeovers (Nets ,n' Clouds Analytics Aachen)



@ Andersch Consulting

The vendor change The strenght of innovation shifts

China gains in innovation capability in DATA NETWORKS and other data related technologies as Big Data etc.

(slowly displaces US and Germany from top positions?!)

409 Players



Process Control Network Wireless Communication Sens
Electronic Device Plant Assembly Radio Frequency RFID Tag Integri
Circuit Semiconductor Device User Interface Light Electrically Conductiv
Fluid Body Field Device Heat Plate Communication Channel Storage Element Resi
Layer Resonant Frequency Industrial Vehicle Phase Change Memory Access Point

346 Players



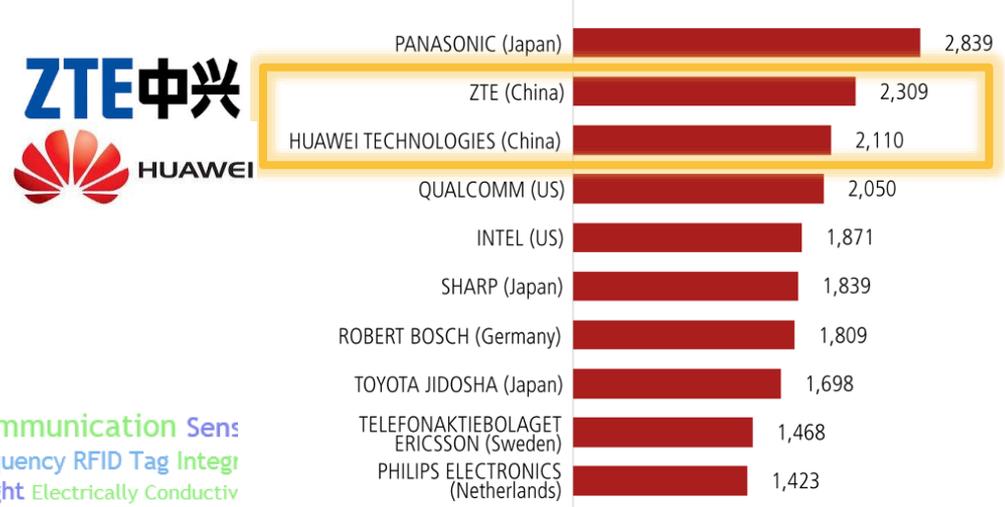
Data Transmission Method Thereof Wireless Sensor Network Remote
Control Power Supply Radio Frequency Identification Industrial Personal Computer
Circuit Board Temperature Measuring Electric Energy Wind Power Mobile Phone
Transformer Substation Frequency Hopping Artificial Intelligence Real Time Video
Case Body Flash Memory Air Conditioner Air Conditioning Plant Anti Fake Super Frame
Screen Printing LED Light Emitting Video Frequency Thin Film Transistor Failure
Diagnosis WiFi Terminal

272 Players



Signal Control Device Industrial Standards Control Unit
Communication Device Radio Frequency Identification Mobile Terminal Mindestens
Zumindest Sending and Receiving Data Carrier Electrically Conductive Chip Card RFID
Tag Network Element Circuit Board Electrode Motor Vehicle Rotor Treatment Device
Fahrzeug 1 Ground Conveyor Transport and Storage Container Short Message 5 Real
Time Critical Data Data Link Layer Alternating Voltage Board Computer

PCT top applicants, 2013



PCT applications published in 2013

However: Up to now, Chinese patents are weak in the implementation

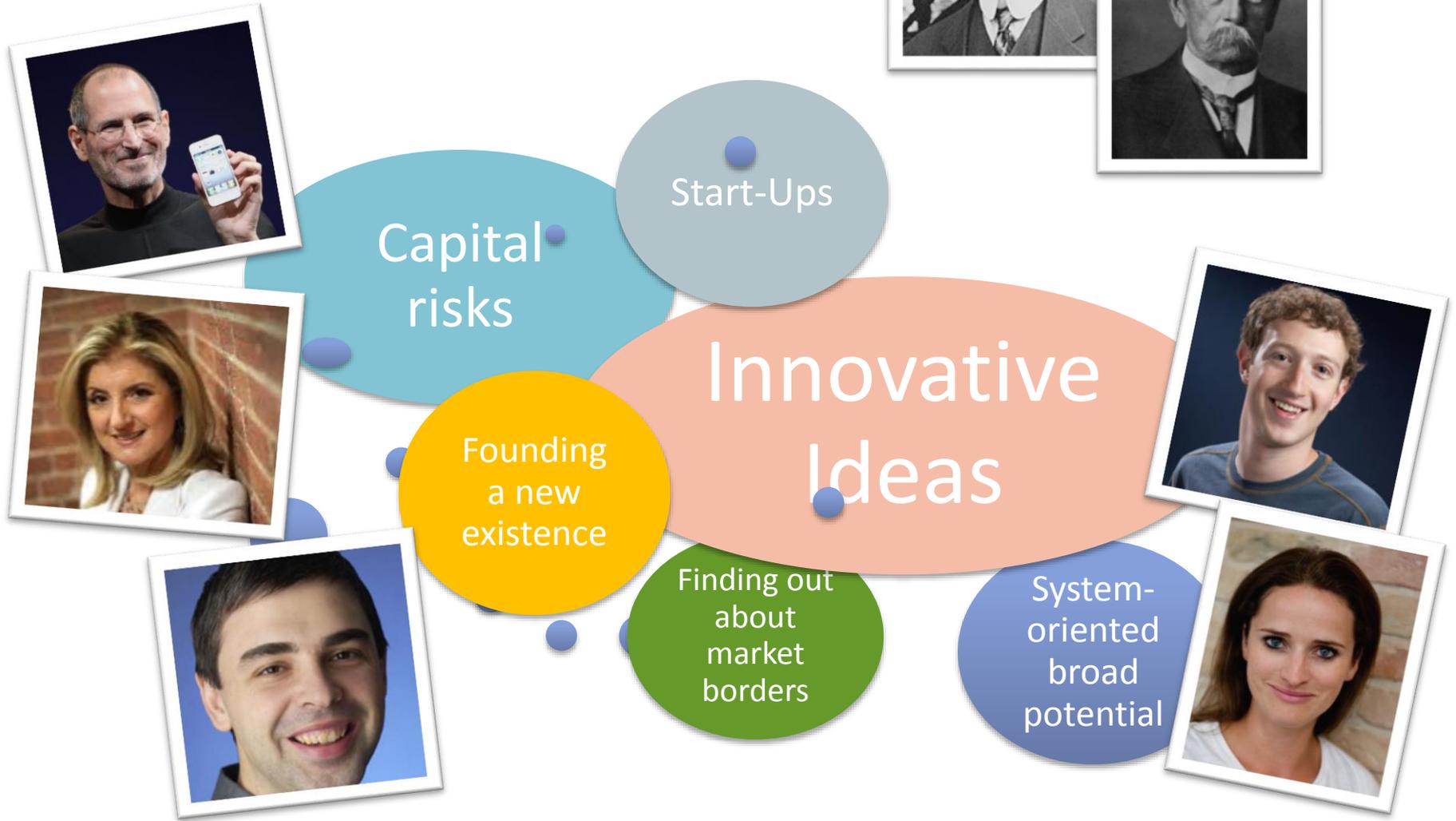


- Still relatively low level of the patent applications when it comes to the application (of 4.0 technologies)
 - Low level of newness
 - Imprecise description
- Evolutionary innovations

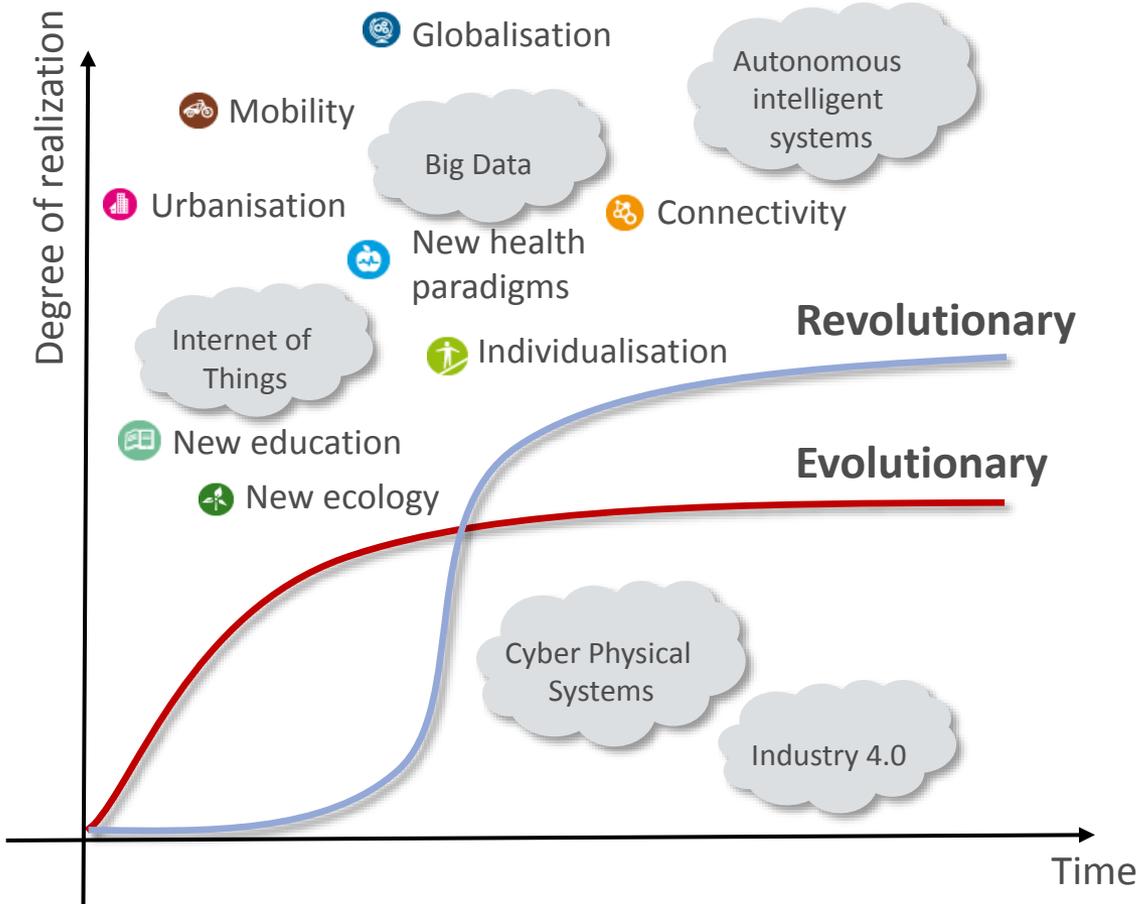
Fraunhofer IAO 2015: www.iao.fraunhofer.de/images/iao-news/chinesische-patentaktivitaeten.pdf

The vendor change

Innovation comes from fresh minds!



The two ways of innovation



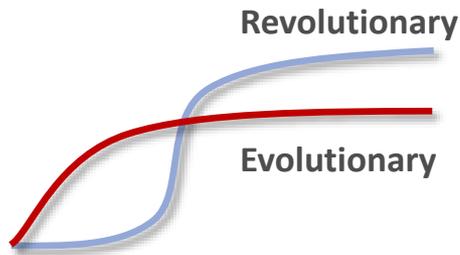
“Innovations are divided into **two categories**:

- **Evolutionary innovations** (continuous or dynamic evolutionary innovation) that are brought about by many incremental advances in technology or processes and
- **Revolutionary innovations** (also called discontinuous innovations) which are often disruptive and new.”

IMPORTANT:

- In times of Industrial Revolutions, the revolutionary innovations dominate.
- In the times between, the evolutionary innovations dominate.

The innovators' dilemma



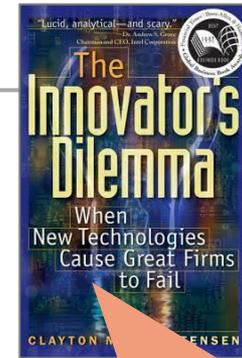
Evolutionary innovations:

- Improvement and optimization of an already existing product or process
- Changes ,locally‘
- **Mainly carried out by established players**



Revolutionary innovations:

- Something „really new“
- Characterized by categorial changes and with strong consequences for the society, ,globally‘
- **Mainly carried out by market newcomers**



By C. M. Christensen, 1997
new edition 2015

- The more professional organization are, the stronger they tend to remain in their traditions since...
 - ... management structure is organized in such a way that it „reproduces“ itself
 - ... clients‘ sugestions always address traditional ways
 - ... self-affirmation feedback...
- Standard management methods as TQM, CIP(KVP), Kaizen, standards, lean management, etc. address evolutionary processes
- ... **hampering categorial changes, system changes and disruptive changes**

Joseph A. Schumpeter (1883-1950)

- Austrian-American economist
- Harvard professor
- One of the most influential economists of the 20th century



Schumpeter:

In this turbulent environment, innovation is the new old magic formula to survive, act and compete efficiently in the long run.

Theory of business cycles and development (The theory of economic development, 1911)



- Importance of “Unternehmergeist”
- Innovation and imitation as driving forces of competition
- Political business cycle
- Theory of capitalism and socialism

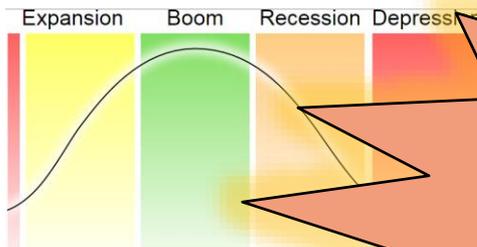
Creative destruction:

“Process of industrial mutation that

- ... incessantly revolutionizes the economic structure from within,
- ... incessantly destroying the old one,
- ... incessantly creating a new one”

[<http://www.haufe.de/> 2015]

**→ Destruction is necessary.
It is not a „system failure“
but a necessity for reforms.**



„Creative destruction“
First definition of disruptive, revolutionary innovations

Since the 1960s:



- research on organizational cultures in respect to innovation, “innovation culture”

Breakthrough of the “culture concept” in the 1980s

Hofstede’s “cultural dimensions theory” (1980)

- 5 cultural dimensions
- Still most cited European social scientist
- Critics addresses mainly the particular dimensions and the measurement process, but not the general approach.



Hofstede (1991):
Culture is the collective programming of the mind which distinguishes the members of one group from another.

Organizational culture...

- ... transfers the concept of culture from cultural anthropology (national cultures) to organisations.
- ... represents the collective values, beliefs and principles of organizational members.
- ... is a product of such factors as history, product, market, technology, and strategy, type of employees, management style, and national culture.

[Wikipedia, 2015]

Innovation culture:

Innovation culture describes a specific type of organisational culture addressing the generation of innovation in the organisation.

[Wikipedia, 2015]

Experimental oriented cultures

! Cultures of free trial, trial and error ...



“This was supposed to be a cube. My height was set wrong and there was a severe exaggeration in extrusion.” (Nancy Fumero, doing experiments with 3D print, 2013)

Error management

! “No blame organization”: dealing positive with failures

Curiosity
Creativity
Trust

Uncertainty avoidance

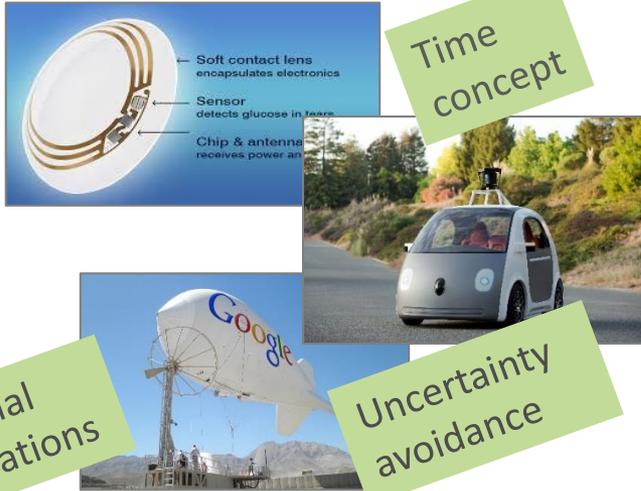
Dealing with both:

- Everybody makes mistakes (incl. the boss)
- Reduce fear of failures
- Failures become public
- Failures are understood as the result of an engagement
- Failures are understood as a contribution to a solution
-

Standards KPIs
ROI Optimization
Lean...

**Majority of established companies today:
Zero defect strategy**

Google



- ! The Google X Labs:
 - Project Google Car
 - Project LOON: internet through balloons
 - Project "smart contact lenses"
 - ...

- !
 - **Still „project driven structure“** for the innovation part – with internal competition
 - 20% freedom for creative thinking



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VI. Summary and Outlook

The typical assumption...

→ ... that job changes in 4.0 are mainly addressing blue collar jobs and/or routine jobs does not hold true.

→ From „blue collar – low qualified“ to „white collar – middle class“...

but probably, this is just a transition phenomenon

High qualified jobs

... as e.g. health professionals face already the taking over through AI in certain fields by Watson, Google Flu, etc.



IBM Watson

Social robots

... will become capable of taking over even complex tasks with personal presence as in **health or home care**



Decentralized platforms

... with automated consensus models (e.g. blockchain) take over complex administrative tasks e.g. in **judiciaries**



Virtual and augmented environments

... allowing for **new international players**, even in tasks requiring humans and presence



Autonomous systems

... as autonomous cars and more advanced production technology will **change the blue collar** – low qualified as well



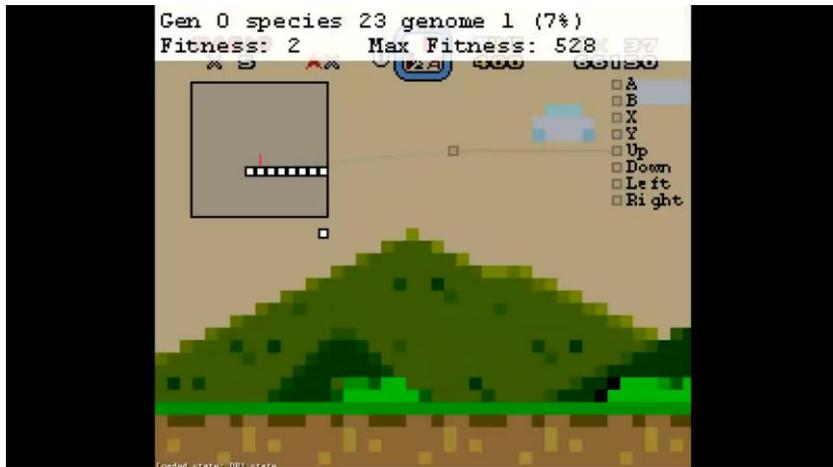
White collar jobs

... are under massive change due to the enhancement in AI, here the impact often hits “**middle class jobs**”





Remember Mario: What if the machine could learn, how to solve a level?
Why not use some kind of intelligent trial-and-error?



[SethBling, 2015]

Neuroevolution of augmenting topologies (NEAT) [Stanley, 2002]

- **Genetic algorithms on top of neural networks**
- At each **state** the system decides what **action** to perform
- Actions are **rewarded** if Mario does not die in return
- Level progress by **evolving** neural networks



Human factor is "very small"

- reduced to very general, mainly formal specifications of the neural network...
However, humans still influences the underlying representation model



However again, I have no clue
WHAT exactly this system is
learning, and WHEN, and...

Reinforcement learning (R-learning)

is inspired by behaviorist psychology – maximizing the expected return by applying a sequence of actions at a current state.

→ can be applied to broad variety of problems



Deep learning

Where the Story Goes: AlphaGo



Go originated in China more than 2,500 years ago. Confucius wrote about it. As simple as the rules are, Go is a game of profound complexity. This complexity is what makes Go hard for computers to play, and an irresistible challenge to artificial intelligence (AI) researchers. [adapted from Hassabis, 2016]



The problem: 2.57×10^{210} possible positions - that is more than the number of atoms in the universe, and more than a googol times (10^{100}) larger than chess.

→ Bringing it all together!

Data-driven learning

Training set

30 million moves recorded from games played by humans experts



Creating deep neural networks

12 network layers with millions of neuron-like connections



Predicting the human move
(57% of time)



Reinforcement learning

Learning non-human strategies

AlphaGo designed by Google DeepMind, played against itself in thousands of games and evolved its neural networks; Monte Carlo tree search



March 2016:

Beating Lee Se-dol (World Champion)

AlphaGo won 4 games to 1.
(5 years before time)



! Achieving one of the grand challenges of AI

[Hassabis, 2016]



“**Creativity** is a phenomenon whereby **something new** ... is formed. The created item may be intangible (such as an idea, a scientific theory, a musical composition or a joke) or a physical object (such as an invention, a literary work or a painting).”

[adapted from Wikipedia, last visited 5/3/2016]

- **DII (descriptions for images in isolation):** Traditional storytelling software
- **SIS (stories for images in sequence):** new approach towards storytelling, including
 - Based on SIND - Sequential Image Narrative Dataset: 81,743 unique photos in 20,211 sequences, aligned to both descriptive (caption) and story language.
 - [Margaret Mitchell / Microsoft, 04/2016, together with colleagues from Facebook]

			
DII	A group of people that are sitting next to each other.	Adult male wearing sunglasses lying down on black pavement.	The sun is setting over the ocean and mountains.
SIS	Having a good time bonding and talking.	[M] got exhausted by the heat.	Sky illuminated with a brilliance of gold and orange hues.

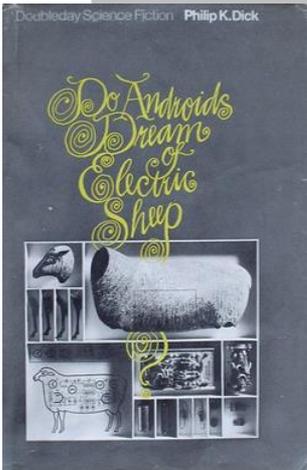
Visual-Storytelling by **Microsoft**
based on deep neural networks (convolutional neural networks)



“**Creativity** is a phenomenon whereby **something new** ... is formed. The created item may be intangible (such as an idea, a scientific theory, a musical composition or a joke) or a physical object (such as an invention, a literary work or a painting).” [adapted from Wikipedia, last visited 5/3/2016]

“Do Androids Dream of Electric Sheep?”

(science fiction novel by American writer Philip K. Dick, published in 1968)



Computational creativity (artificial creativity) ... is a multidisciplinary endeavour that is located at the intersection of the fields of artificial intelligence, cognitive psychology, philosophy, and the arts. [adapted from Wikipedia, last visited 5/3/2016]

Live from **Universidad de Málaga**
 Monday, **July 2nd 2012**
 London 19:30
 Madrid 20:30

Concert: **CAN MACHINES BE CREATIVE ?**

Colossus	piano:	Gustavo Díaz-Jerez
Ugadi	violin:	Cecilia Bercovich
Alphard	clarinet:	Cristo Barrios
Kinoth	violin:	Cecilia Bercovich
	piano:	Gustavo Díaz-Jerez

UMA5

„Can machines be creative?“ by **lamus**, a computer cluster composing classical music by genetic algorithms, concert for Turing's 100th birthday [youtube]



Van Gogh's *Starry Night* interpreted by **Google DeepDream** based on deep neural networks

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Summary ... in five steps!





Thank you!

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