“Research on Disruptive ICT Top Technologies: Expected Impact in Context of Cybersecurity”

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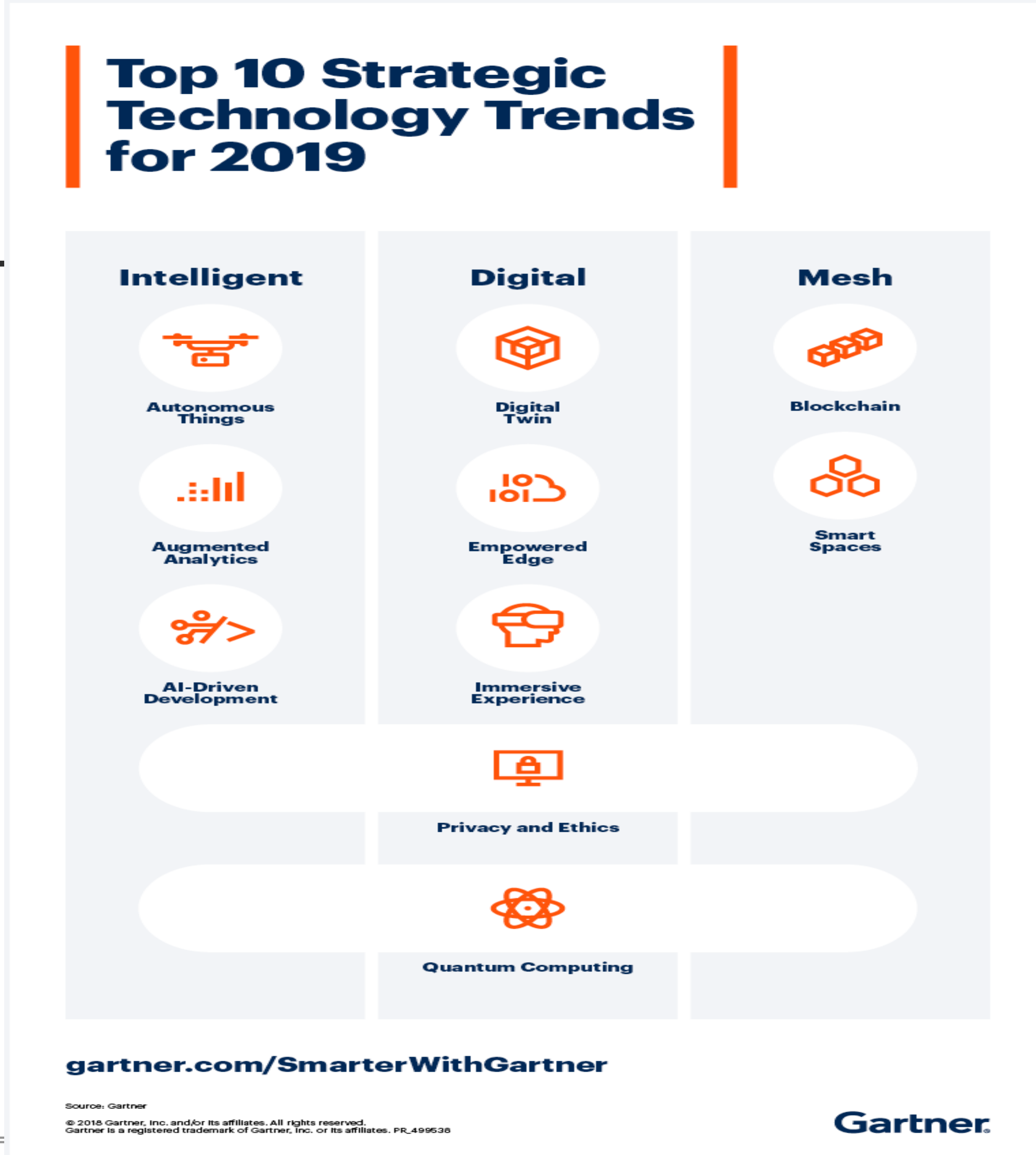
Digital World – Status, Challenges, Approaches

“The World is becoming an intelligent, digitally enabled mesh of people, things, and services.”

(Gartner Group Inc., 2017)



Top 10 Strategic Technology Trends for 2019
Intelligent
Autonomous Things
Augmented Analytics
AI-Driven Development
Digital
Digital Twin
Empowered Edge
Immersive Experience
Mesh
Blockchain
Smart Spaces
Privacy and Ethics
Quantum Computing
gartner.com/SmarterWithGartner
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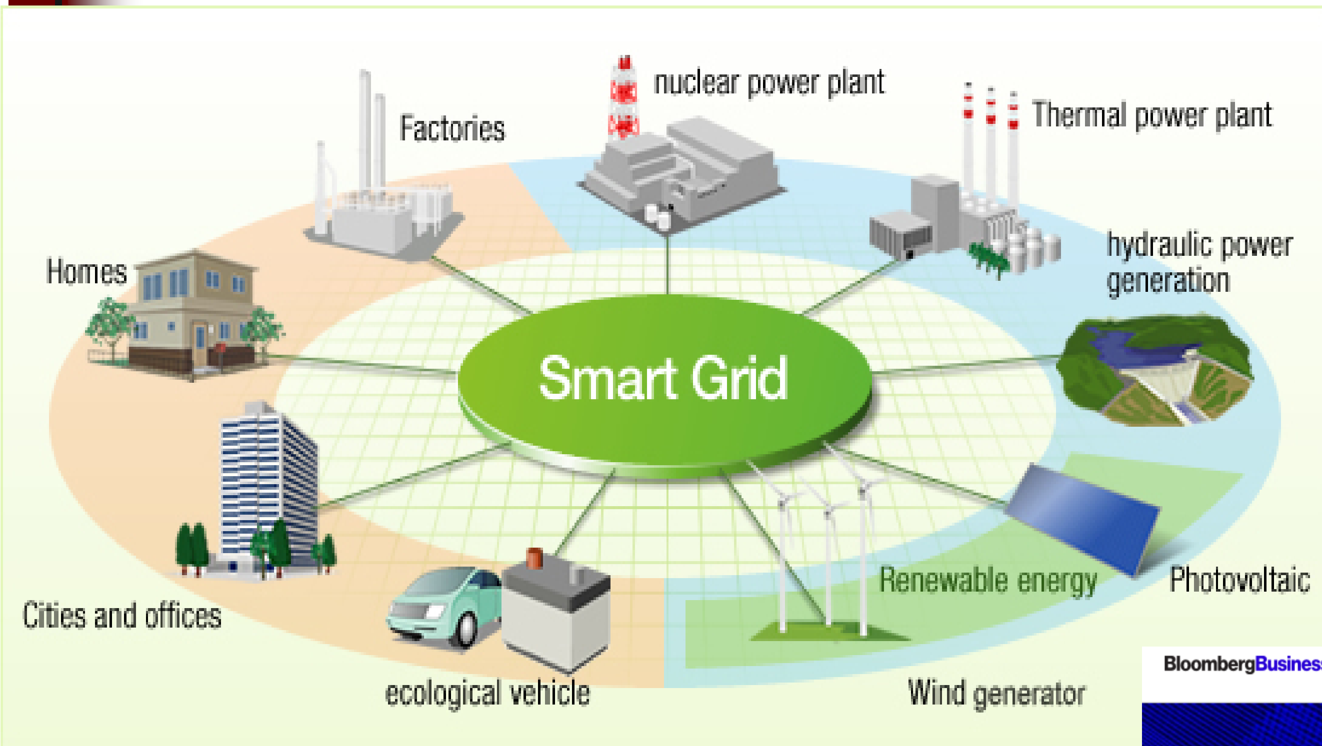
Opportunities vs. Security Risks, e.g. Smart Grids



From: http://cleantechnica.com/2014/02/19/global-smart-grid-investment-grows-china-leads-us-f

Opportunities vs. Security Risks, e.g Car 2 Car

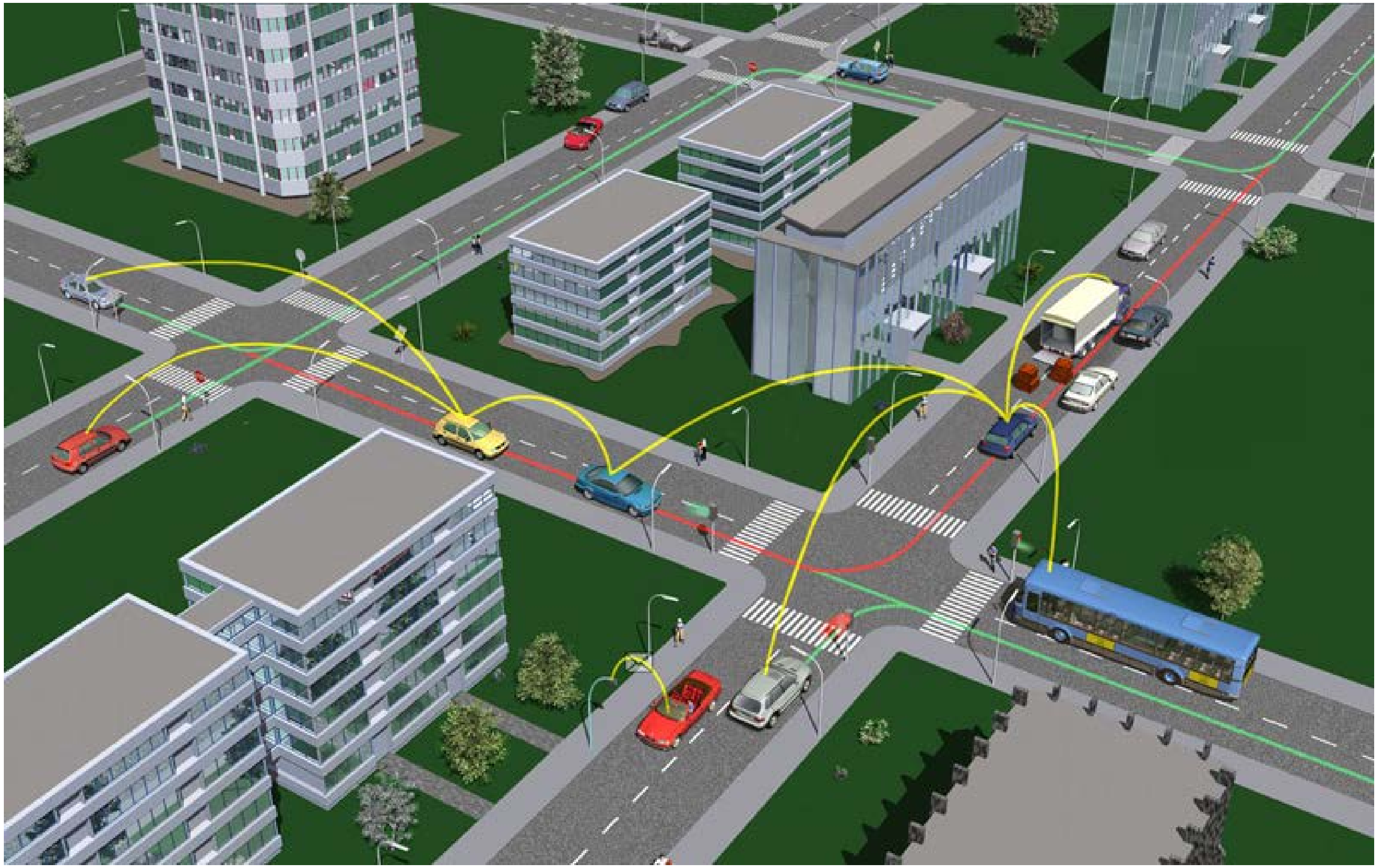


Image: https://www.car-2-car.org/index.php?id=5

Top Technology Trends of ICTs …. (1)

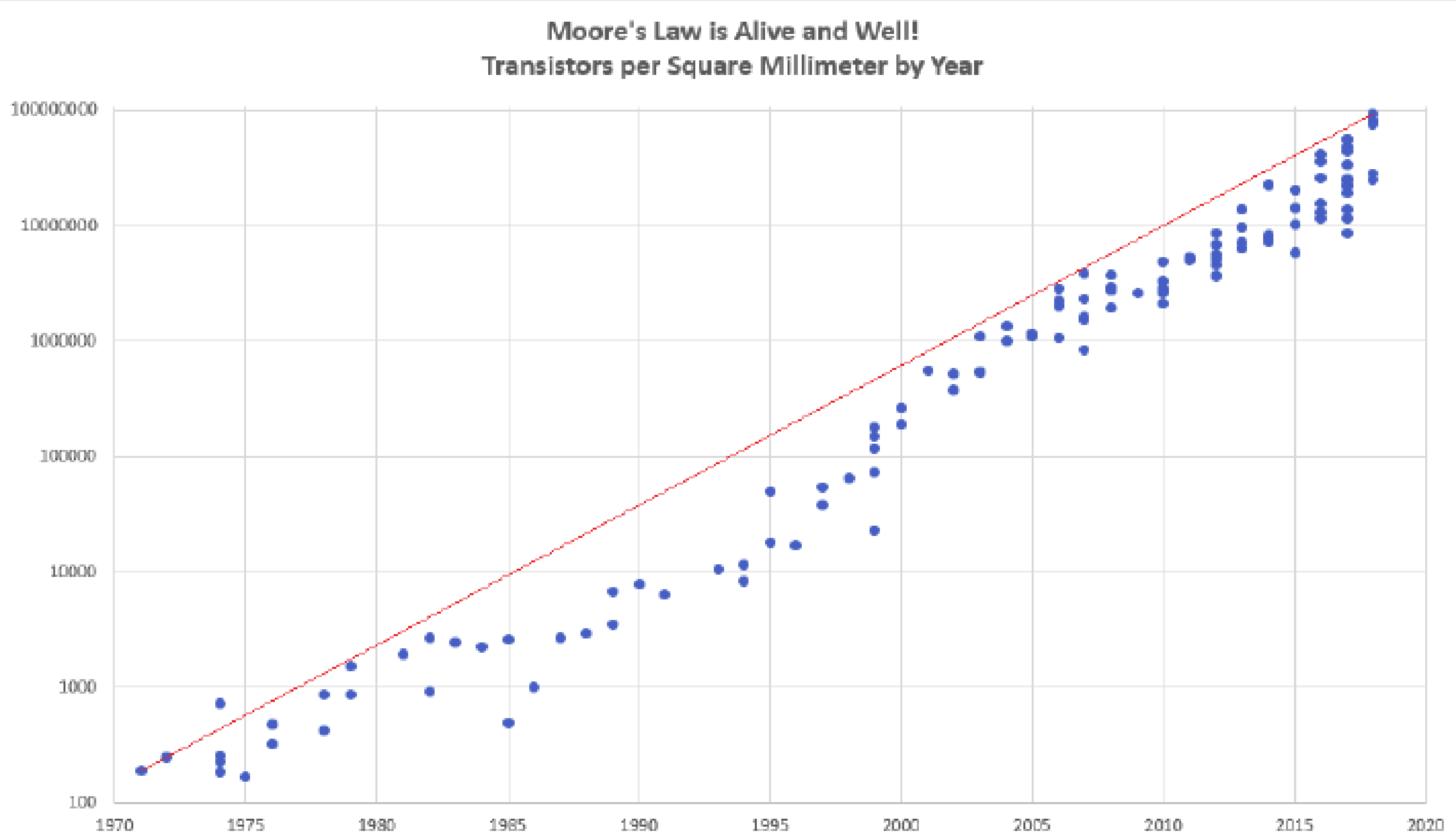
- ….but what can be considered as being a **DISRUPTIVE technology** ??

Major Technology Trends of ICTs …. (1)

- Driving Forces for advancements in ICTs:

→ **Major Hardware advancements**
→ **based on“classical“ semiconductor technologies:**

→ „Moore´s law“ is still valid !


Moore's Law is Alive and Well!
Transistors per Square Millimeter by Year
100000000
10000000
1000000
100000
10000
1000
100
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

Major / Disruptive Trends of ICTs …. (2)

- High-Performance-Computers:
  -> Sunway TaihuLight: 93 Peta-FLOPS = 93x10^{15}
  -> Design of Exascale Computing: 1 trillion = 10^{18} FLOPS (e.g. Tianhe-3)

- (Zettabyte)-Storage Capabilities:
  - -> 1 Zettabyte (ZT) = 10^{21}bytes; since 2016: 16 ZT;
    Estimates: in 2025: 165 ZT

1 Gigabyte	**GB = 1’000’000’000 Bytes**	**(1’000 MB’s)**
1 Terabyte	**TB = 1’000’000’000’000 Bytes**	**(1’000 GB’s)**
1 Petabyte	**PB = 1’000’000’000’000’000 Bytes**	**(1’000 TB`s)**
1 Exabyte	**EB = 1’000’000’000’000’000’000**	**(1’000 PB’s)**
1 Zetabyte	**ZB = 1´000`000`000`000`000`000`000**	**(1’000 EB’s)**

Major / Disruptive Trends of ICTs …. (2)

→ **„Classical“ physics →** Semiconductor technologies, driving forces for:

- Sensor & actuator developments
- Cyber-physical systems
- Communication networks, e.g. 5G
- increasing computing & storage capacities

→ based on <u>quantum physics:</u>

- Quantum computing
- Quantum communication (→ crypthography)

Major / Disruptive Trends of ICTs ….(4)

…… new (Non-von Neumann) computing principles, e.g.:

- Bio-analogue / Organic Computing → self-x-properties,
  (x = adapting, organizing, repair, ….)
- Neural Computing (artificial neural nets) → reasoning by induction (e.g. pattern recognition)
- Artificial Intelligence applications -> machine learning, data analytics etc. (e.g. "Smart" Systems)

Digital World of Tomorrow ??

- **Important past developments in the digital age:**

  → **Internet:**
  1969: ARPANET (1st message sent by L. Kleinrock)
  1989: World Wide Web (at CERN, Tim Berners-Lee)

  → **1st Smartphone**:
  1995: „Personal Communicator“
  (developed by BellSouth und IBM)

- **Way ahead: ????**

- **Consequences for Cyber Security ????**

The Future Digital World

Predictions are difficult,

especially when it's about the future !

(Winston Churchill; Mark Twain; ....)

Digital World – Current Status

In the Digital World social, public and business life depends on:

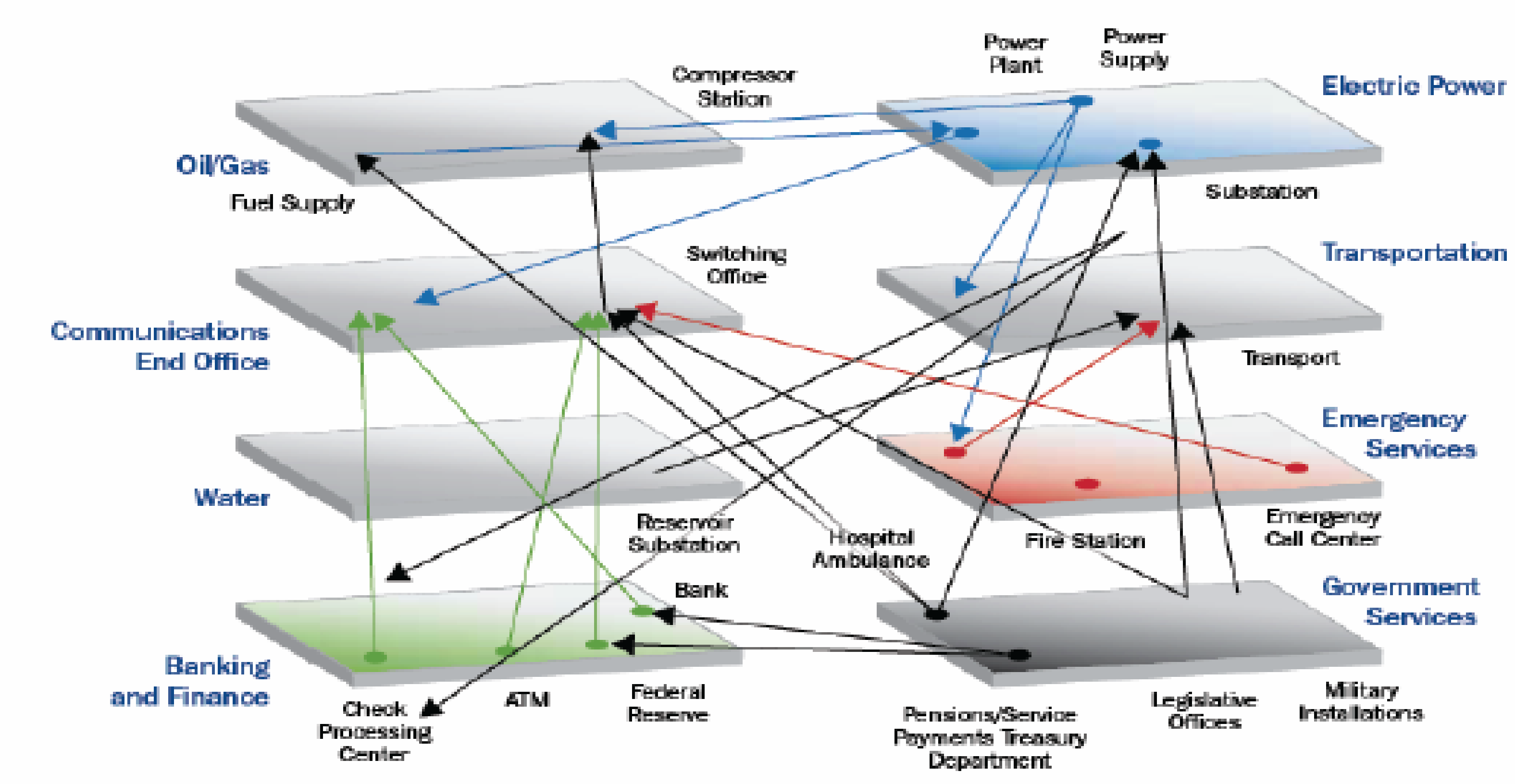
*** Ubiquitous, mostly invisible computing & communication**

*** Global interconnectivity through internet**
-> "Hyperconnectivity" *(World Economic Forum)*

*** Increasing interconnectivity between "everything" (components / systems / humans, ….)**

-> "System-of-Systems" *(Jamshidi, M., "System-of-Systems Engineering - A Definition," IEEE SMC 2005)*

System of Systems Approach Needed for Understanding Interdependencies



(Graphic: Argonne National Laboratory Infrastructure Assurance Center)

Digital World – „Quo vadis“ ?

* Key Questions:

-> How can we master the <u>complexity</u> of these “Systems-of-Systems”? → Impossible !!

-> How to implement <u>resilient systems functionalities</u> despite of errors, failures, misuse, manipulation, …. , or of natural desasters or of hacker attacks ?

-> Tremendeous Changes of values, behaviours, … in our societies !!

Opportunities vs. Security Risks for Car 2 Car

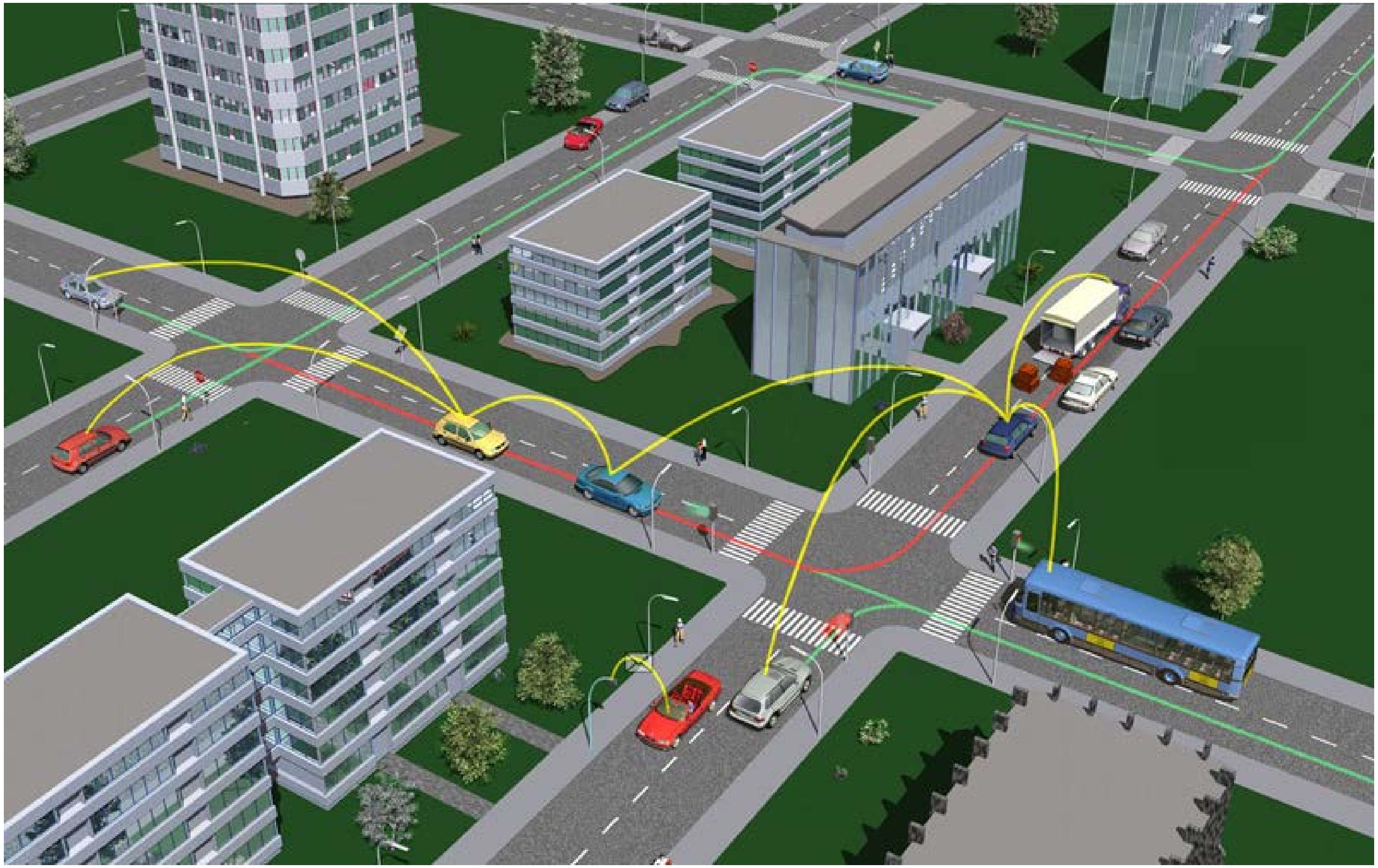


Image: https://www.car-2-car.org/index.php?id=5

Software Complexity (LOC)

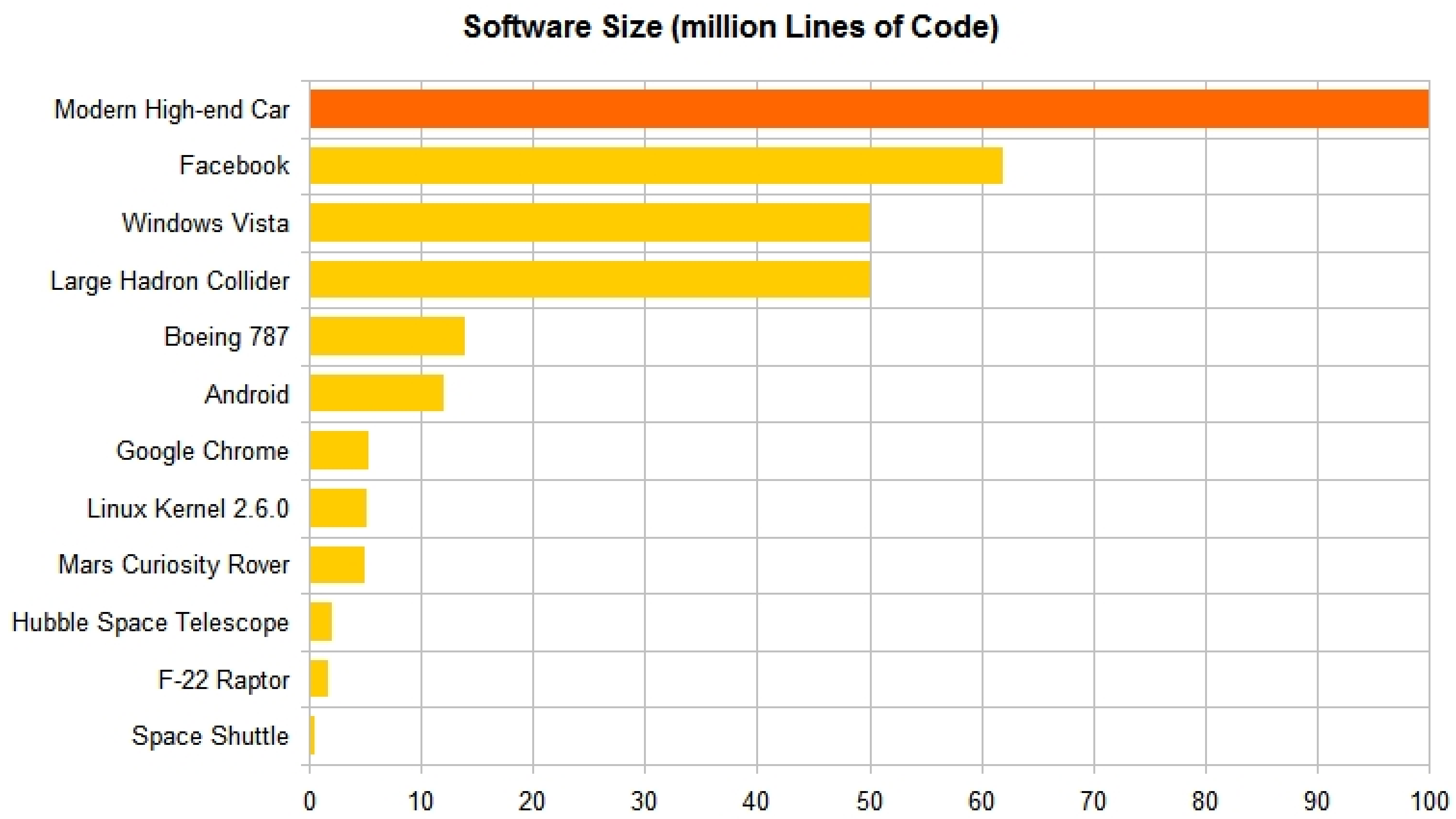


Image: https://www.linkedin.com/pulse/20140626152045-3625632-car-software-100m-lines-of-code-and-counting

Problem: „System State Space Explosion“:

* Simple functional analysis :
  - reachability analysis for each state →
    feasible for a state space size $\leq 10^{100}$!!

- Numerical Analyses (of non-functional parameters, e.g. system´s performance / reliability in a specific state)
  - for state space size $\leq 10^{8}$ (minutes on a PC)
    $\leq 10^{9}$ (computable on a PC)
    $\leq 10^{10}$ (on a PC Cluster)

⇒ Full state space exploration is practically impossible:

⇒ result in emergent system behaviour !!

Digital World – Challenges

* **Key Question for Scientists:**
  -> Mastering the <u>complexity</u> of these
  "Systems-of-Systems"? (→ almost impossible !)

* **Required Basic Approaches:**
  → Standards for systems integration
  → Design of Resilient Systems (at all system levels !)
  and
  → Global Standards & Rules & Ethical behaviour

Digital World – The Challenge

Besides its Tremendeous Benefits,

the Digital World

has the potential to become

a <u>Top Planetary Emergency</u> !

Thank you very much

for your interest

and attention!

Design of Resilient Digital Systems

* Basic Technical Approaches:

- → Strengthen redundancy of functions / components / subsystems;
- → Intensify explorative simulations -> “data farming” experiments