Fifth SG13 Regional Workshop for Africa on "ITU-T Standardization Work on Future Networks: Towards a Better Future for Africa"
(Cairo, Egypt, 02-03 April 2017)

Technology Convergence – IMT-2020, Cloud Computing and Big Data including Trust

Gyu Myoung Lee

LJMU/KAIST

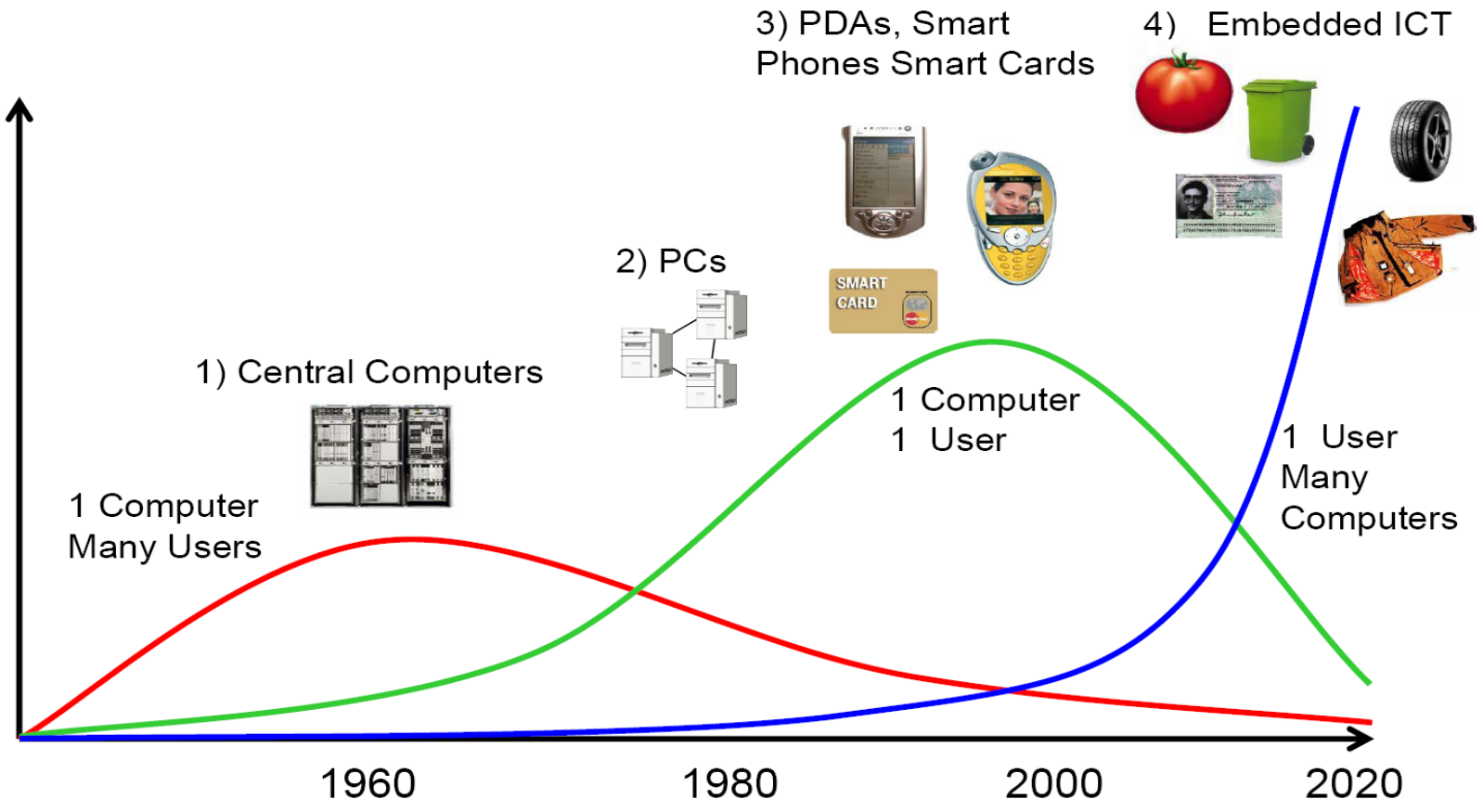
ITU-T WP3/13 Co-chair, Q16/13 and Q4/20 Rapporteur

gmlee@kaist.ac.kr

Contents

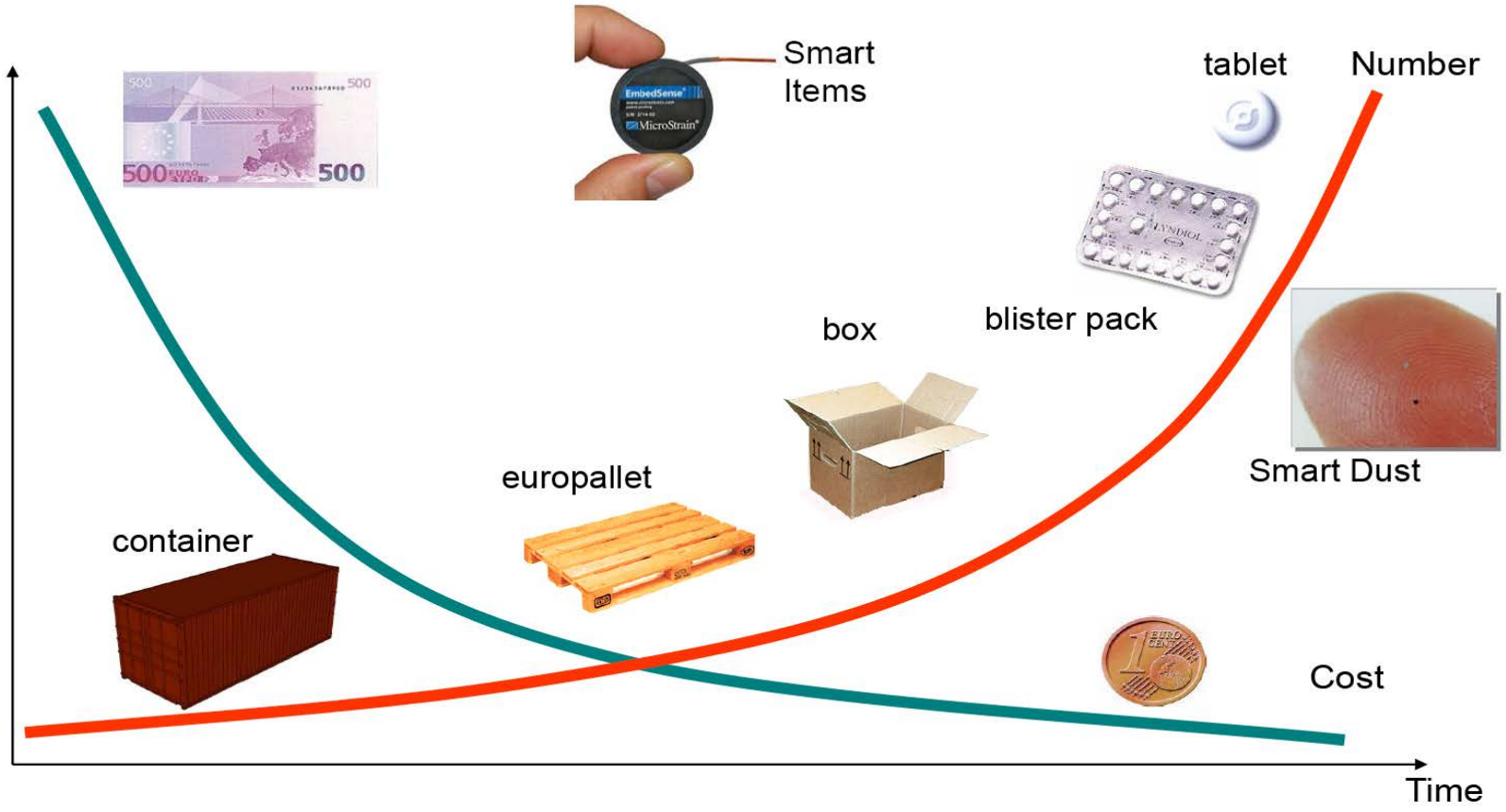
- Introduction – Trends
- Technology convergence – Different views
- Key technical aspects
  - Networking
  - Computing
  - Big data
  - Trust
- Conclusion

The Post-PC Era



Source: DFKI, German Research Center for Artificial Intelligence

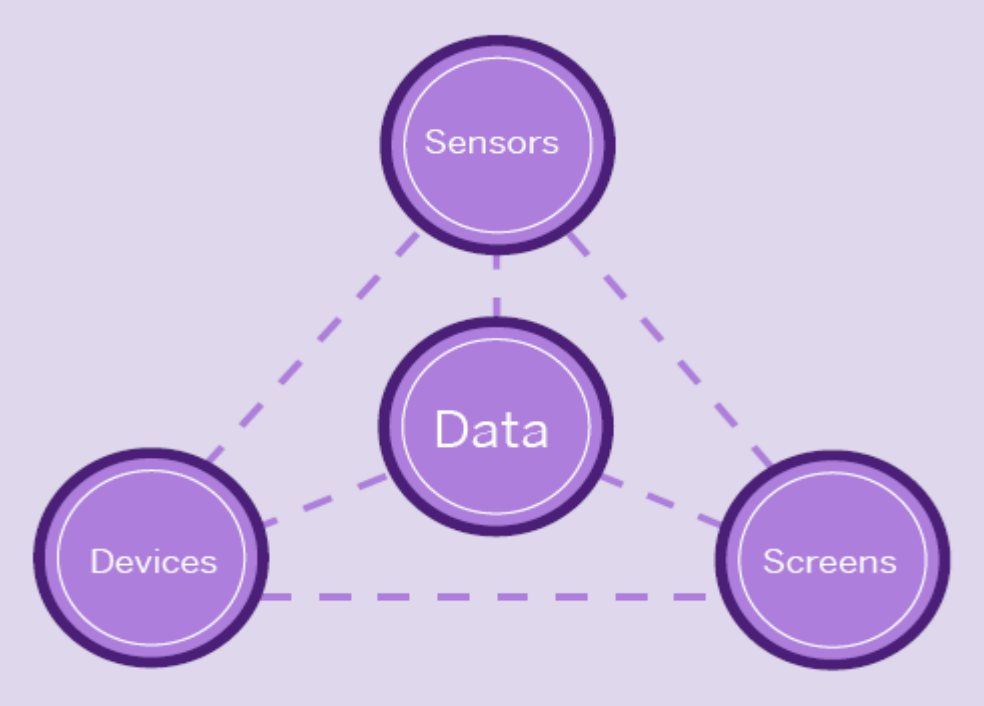
From RFID to Smart Sensor Items



Source: DFKI, German Research Center for Artificial Intelligence

DDSS

- The transformational technological developments of the next decade

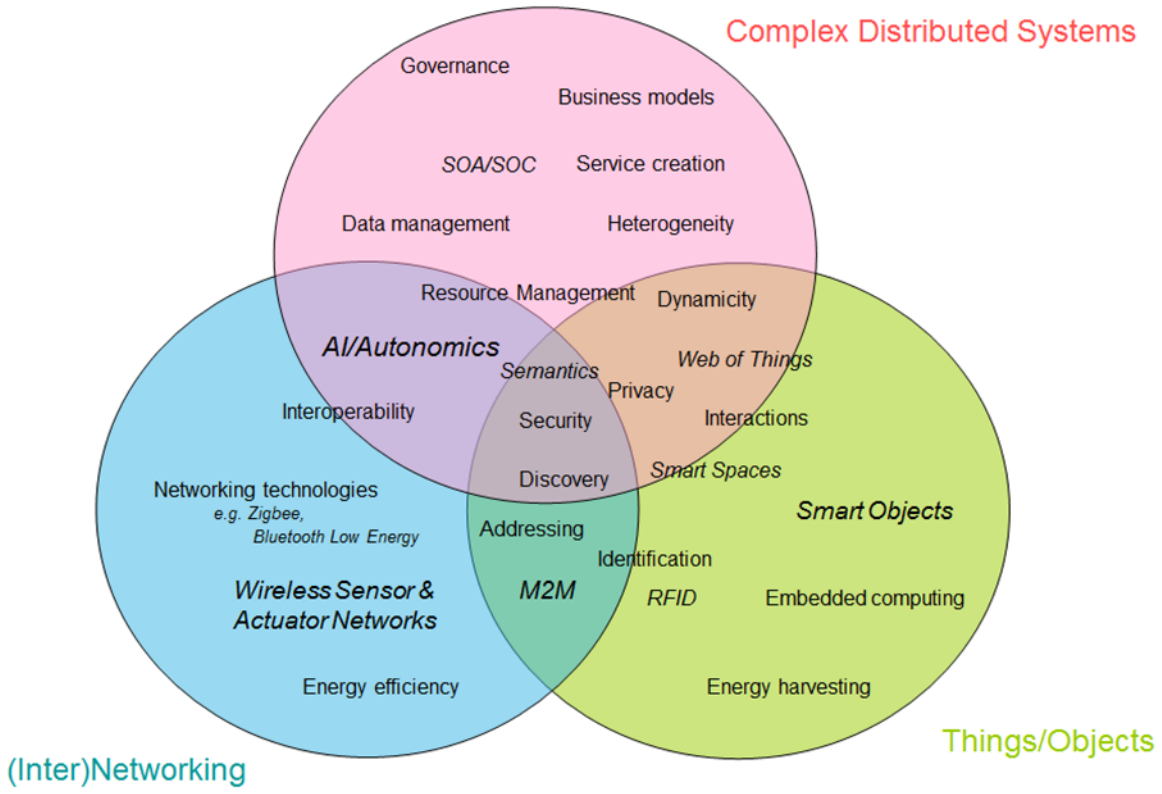


Source: Technology 2020 (The Future Company)

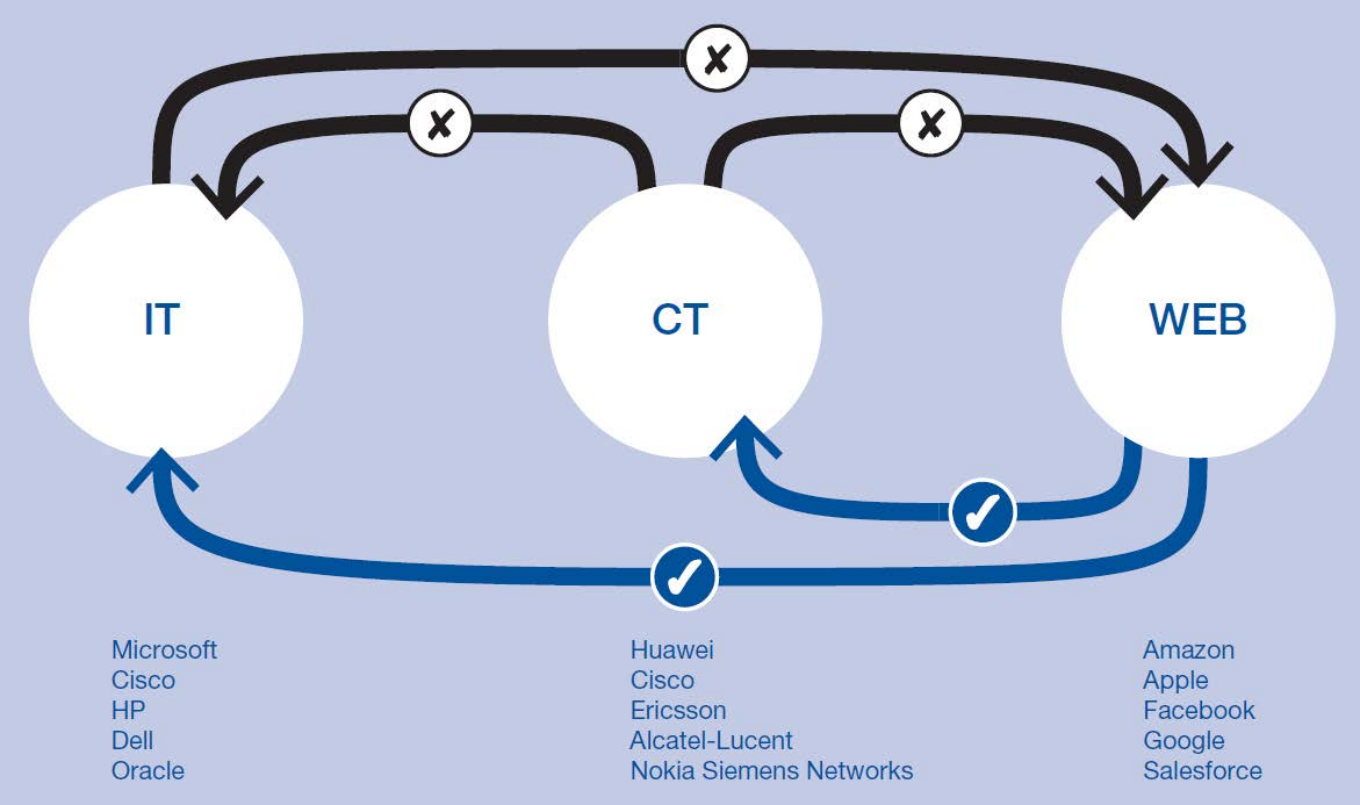
Enabling Technology

"Internet of Things – converging technologies for smart environments and integrated ecosystems" River Publishers

Technology Convergence (1)

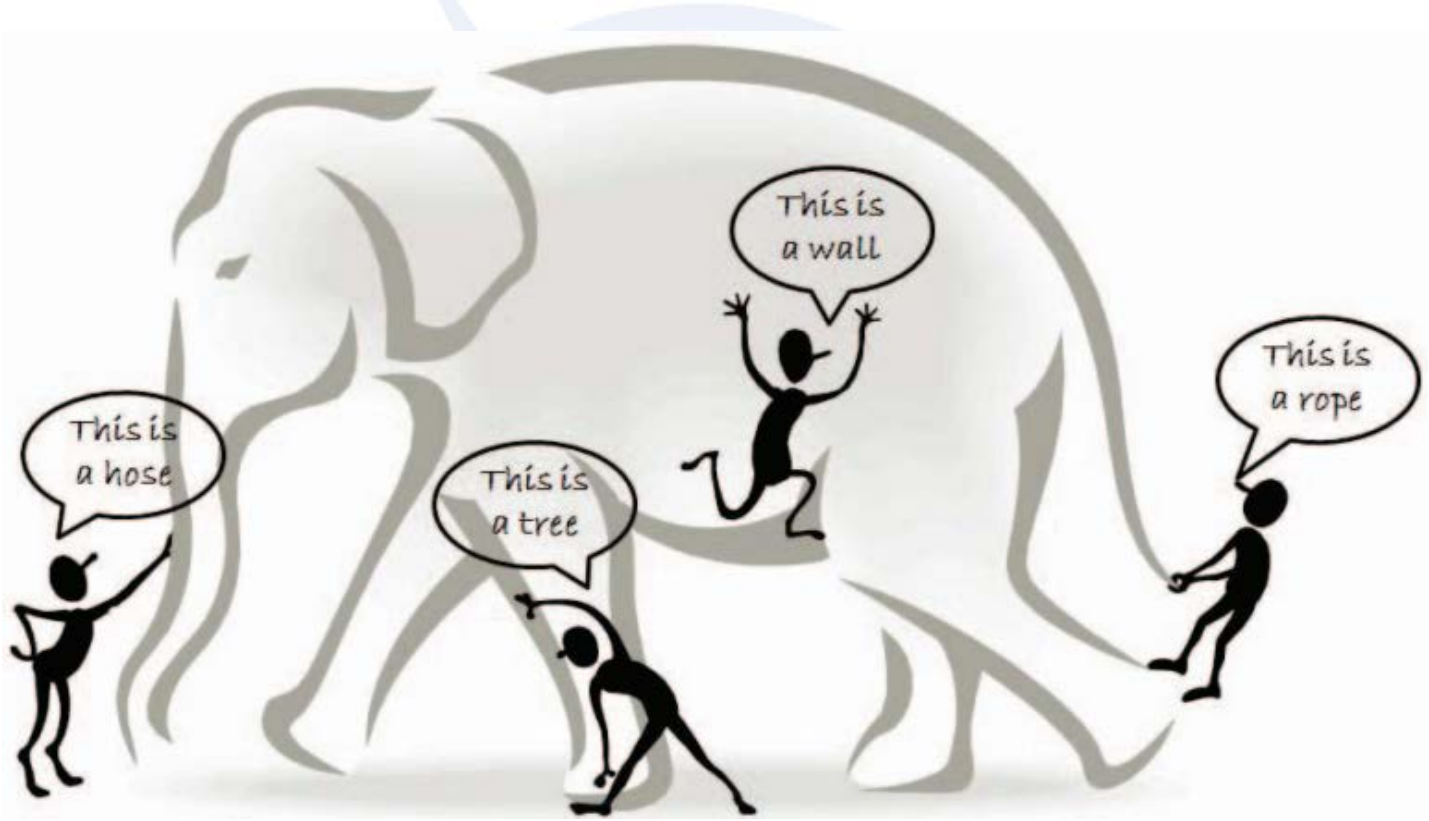


Technology Convergence (2)



Source: Huawei Technologies

The blind men and the giant elephant



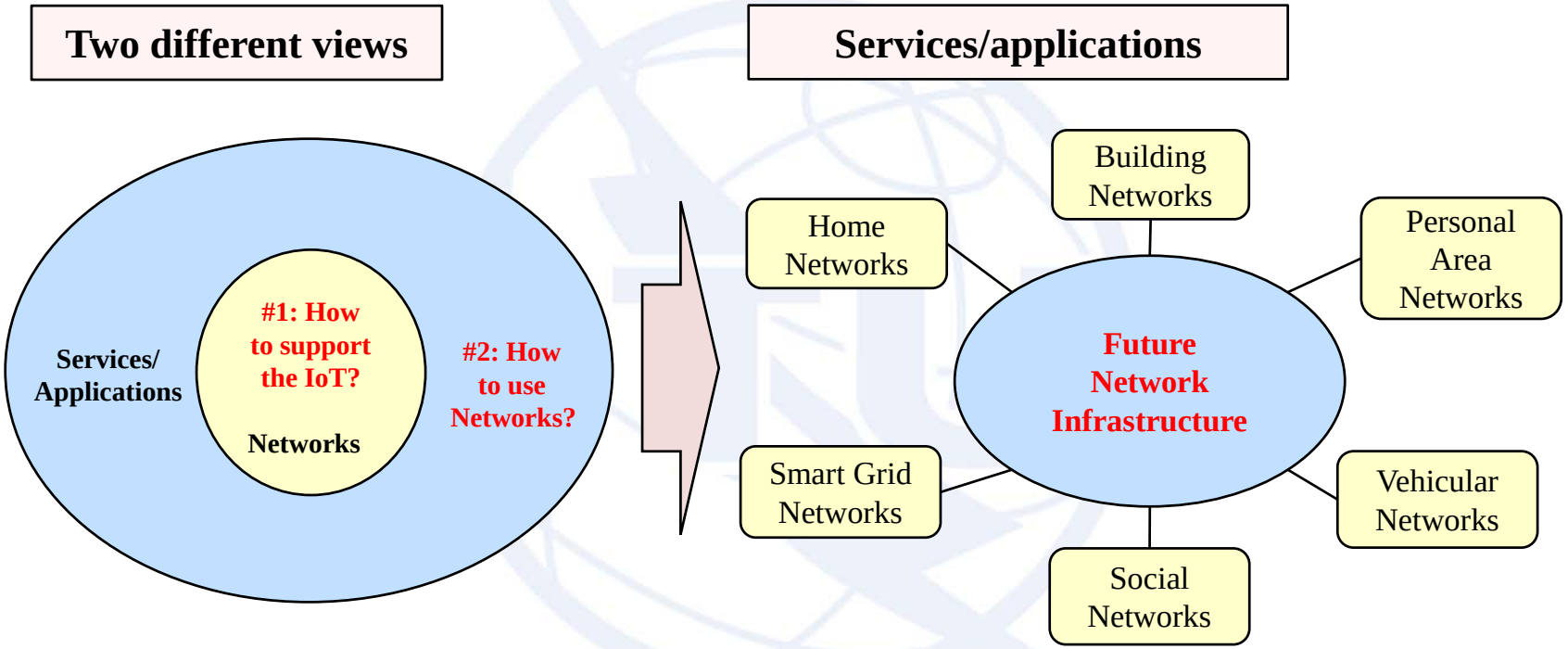
The localized (limited) view of each blind man leads to a biased conclusion

Xindong Wu, et. al., “Data mining with big data,” IEEE TR on Knowledge and data engineering, Jan. 2014.

Key technical aspects

- Networking
- Computing
- Big data
- Trust

Services/applications from two different views



- **Ubiquitous connectivity** allowing for whenever, whoever, wherever, whatever types of communications
- **Pervasive reality** for effective interface to provide connectable real world environments
- **Ambient intelligence** allowing for innovative communications and providing increased value creation

Convergence vs. Divergence

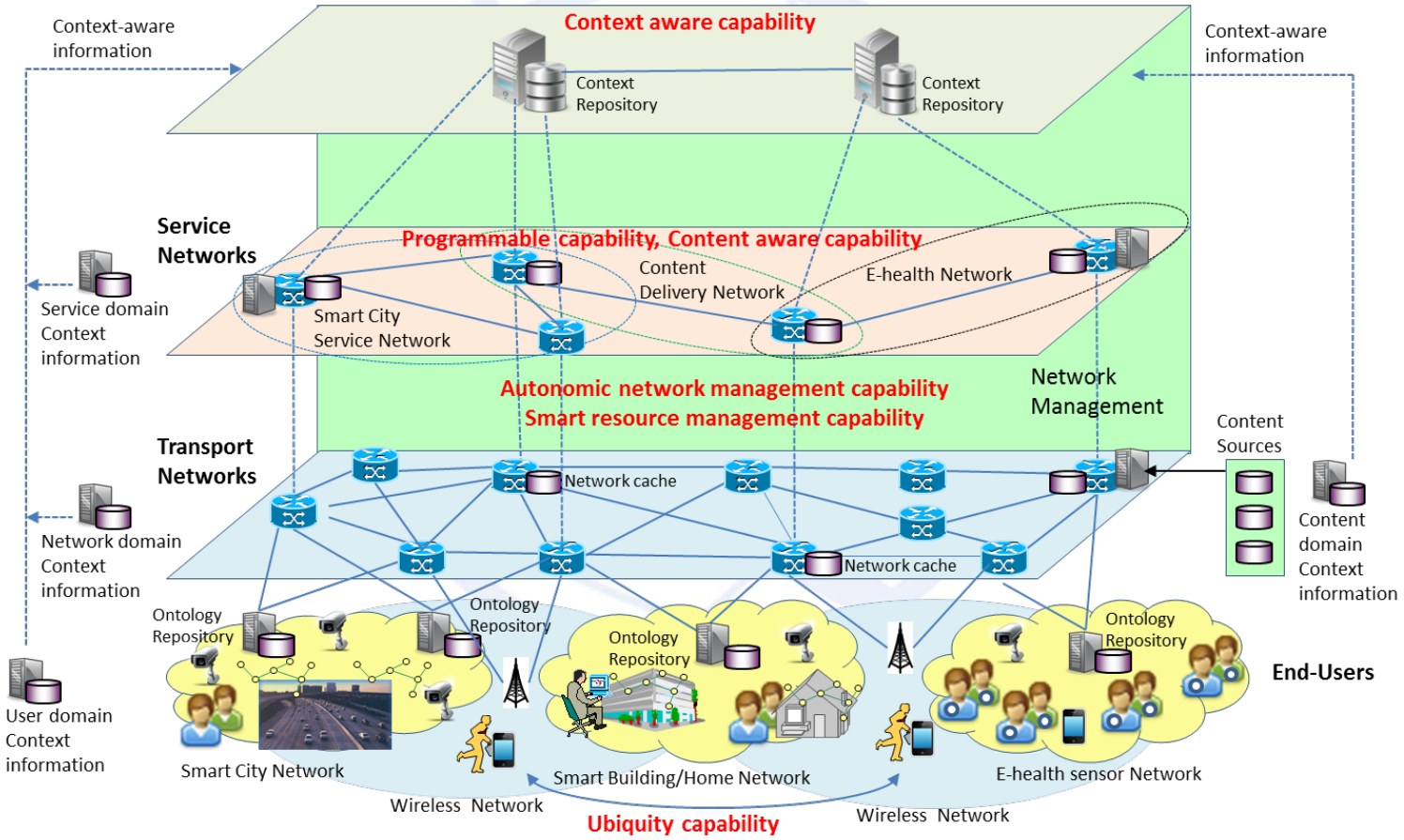
- Philosophy of NGN – "Convergence"
  - Converged packet-based transport network
  - Fixed and mobile convergence
  - More focus on *common infrastructure*
- Mega multi-play – "Divergence"
  - A wide range of objects and services (Heterogeneity)
  - Massively increased network usage/dependence

"Convergence" + "Divergence"
Multiple service networks on common infrastructure

Multiple service networks on common infrastructure

- Common infrastructure
  - Provide a single communications technology that can span all device based applications
- Network sharing decouples networks from infrastructure
  - Partitioning the infrastructure in customized service-specific virtual networks
  - Flexible smart control and reconfiguration of network resources
- Overlay smart networking
  - The creation and maintenance of an overlay topology that logically interconnects all the participating nodes/objects in the physical network (common infrastructure)

An Example – SUN

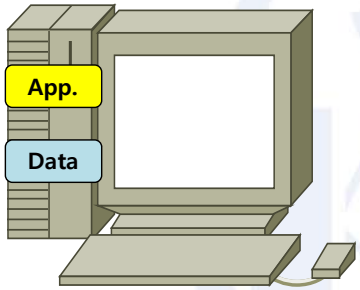


Future communication challenges – 5G scenario

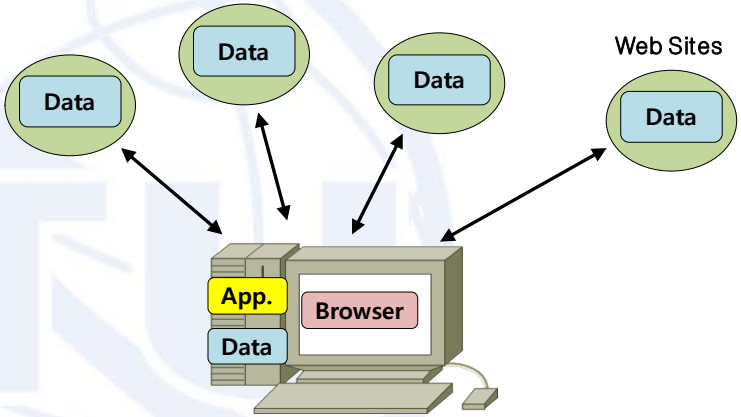
METIS, Mobile and wireless communications Enablers for the Twentytwenty (2020) Information Society

From stand alone PC to the Cloud-based IoT

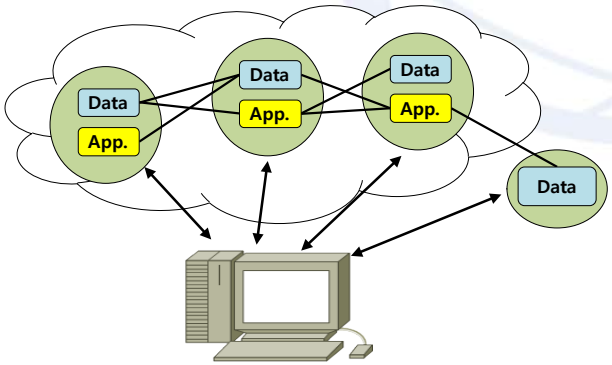
1st Phase – Stand Alone Computer



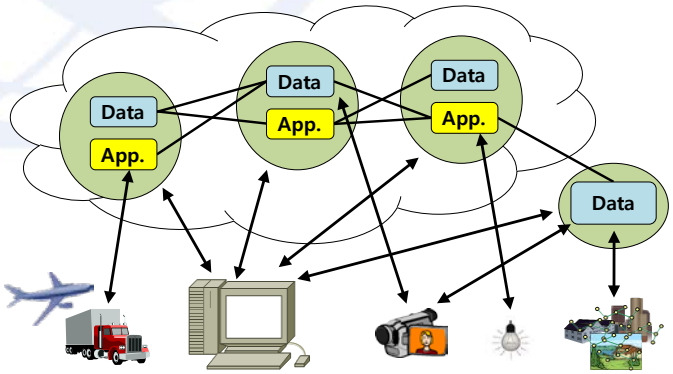
2nd Phase – The Web



3rd Phase – The Cloud



4th Phase – Cloud + IoT

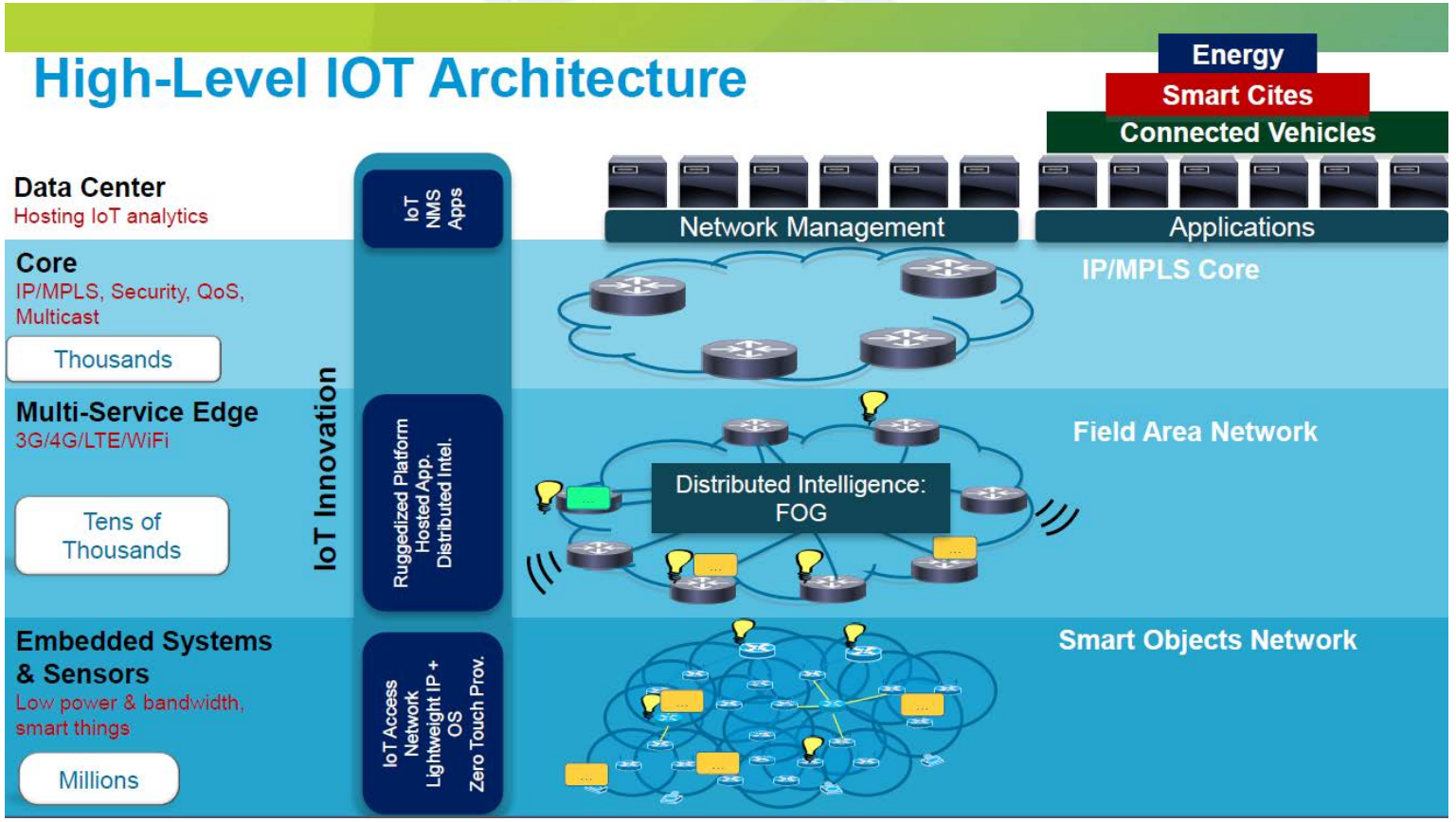


Fog Computing (1)

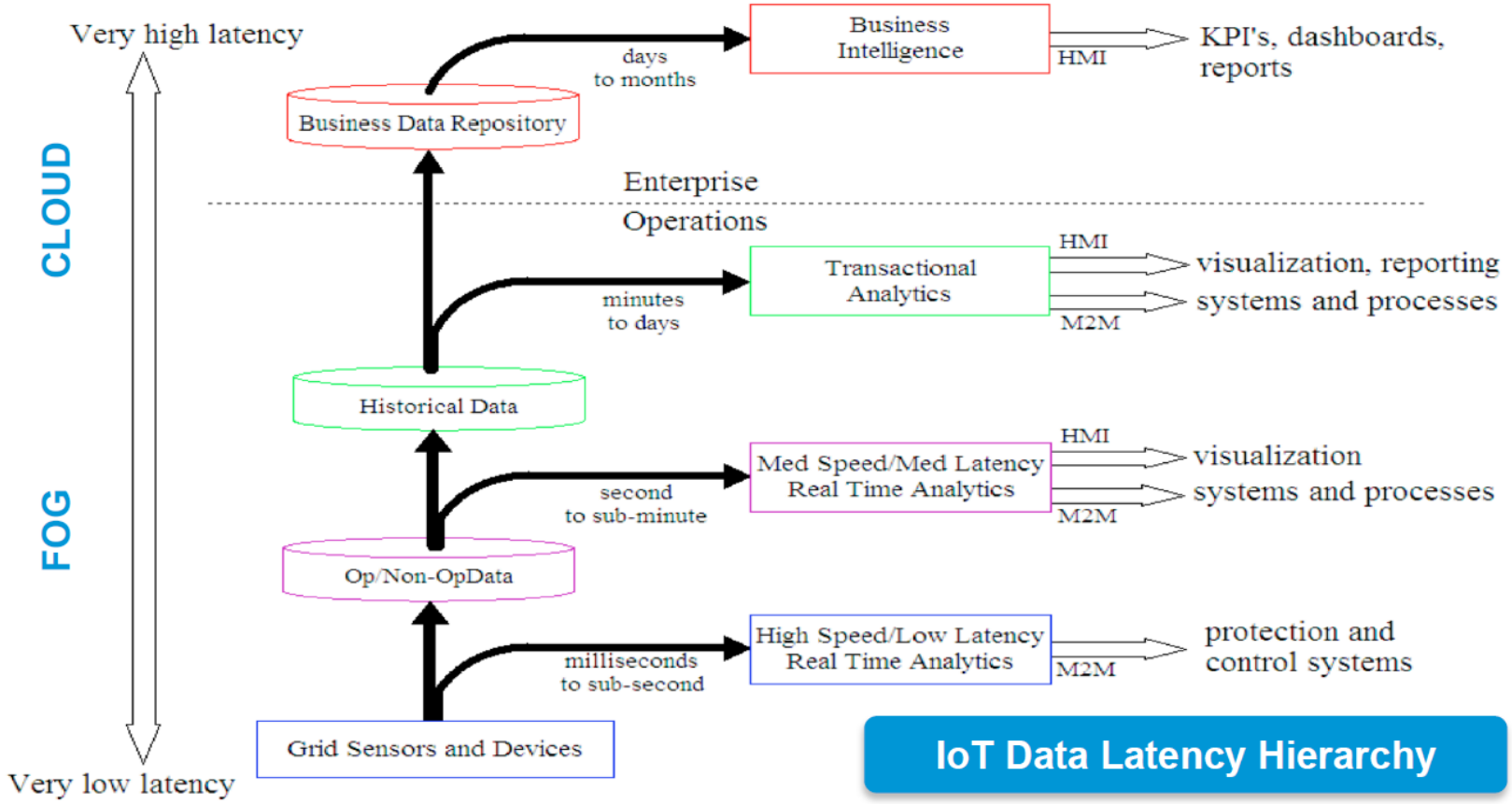
- Fog is the platform where the Internet meets the physical world

- Suites of Use Cases
  - (Mobile) Content Delivery
    - *Low latency Apps (gaming, streaming, augmented reality ...)* - Geo-distributed apps
  - *Sensor/actuator networks, Smart Cities*
    - Large-scale distributed control systems
  - *Connected Vehicle, Int.Transportation, Smart Grid*

Fog Computing (2)



Fog & Cloud

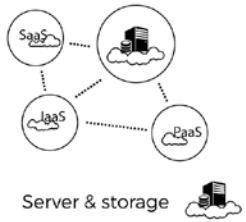


IoT Data Latency Hierarchy

Scalable Distributed Computing Hierarchy

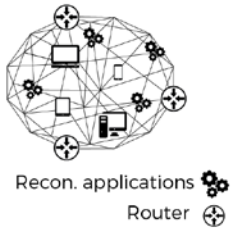
CLOUD Computing

- Advanced Applications
- HPC
- Storage
- Networking
- Management



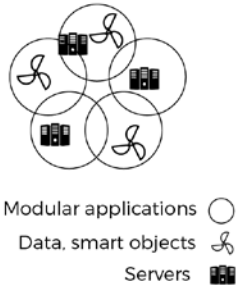
FOG Computing

- Reconfigurable Applications
- Data Centres
- Multi Service Edge
- Service Delivery Support
- Mobility and Routing



DEW Computing

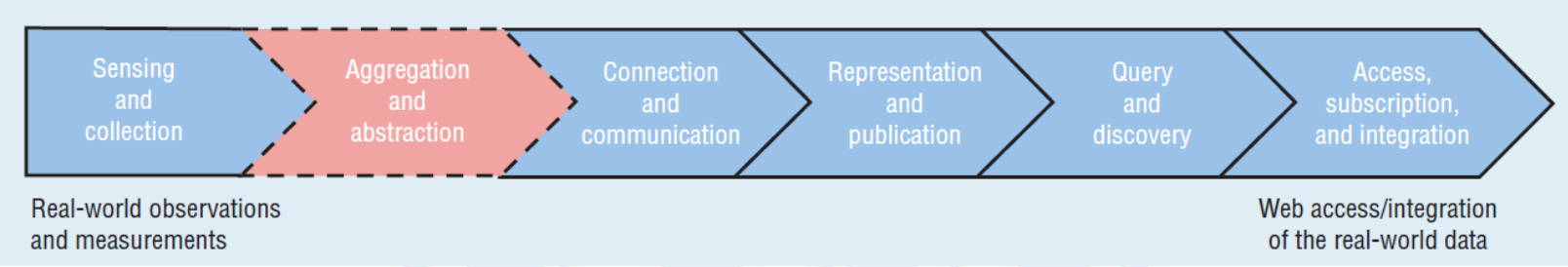
- Modular Applications
- Application modules
- Big Data Access
- Smart Objects
- Embedded Systems
- Sensors and Detectors
- Adaptable Devices and WLAN
- Rich (mobile) Clients

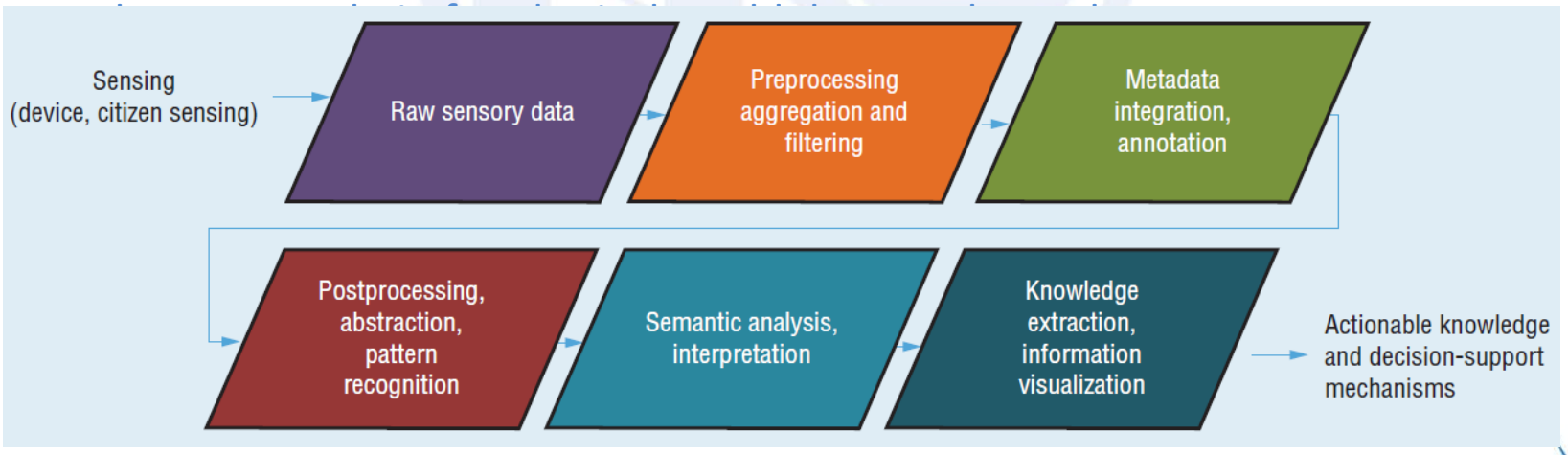


"Scalable Distributed Computing Hierarchy: Cloud, Fog and Dew Computing" OJCC, 2015

From Data to Actionable Knowledge

- The data production and access chain

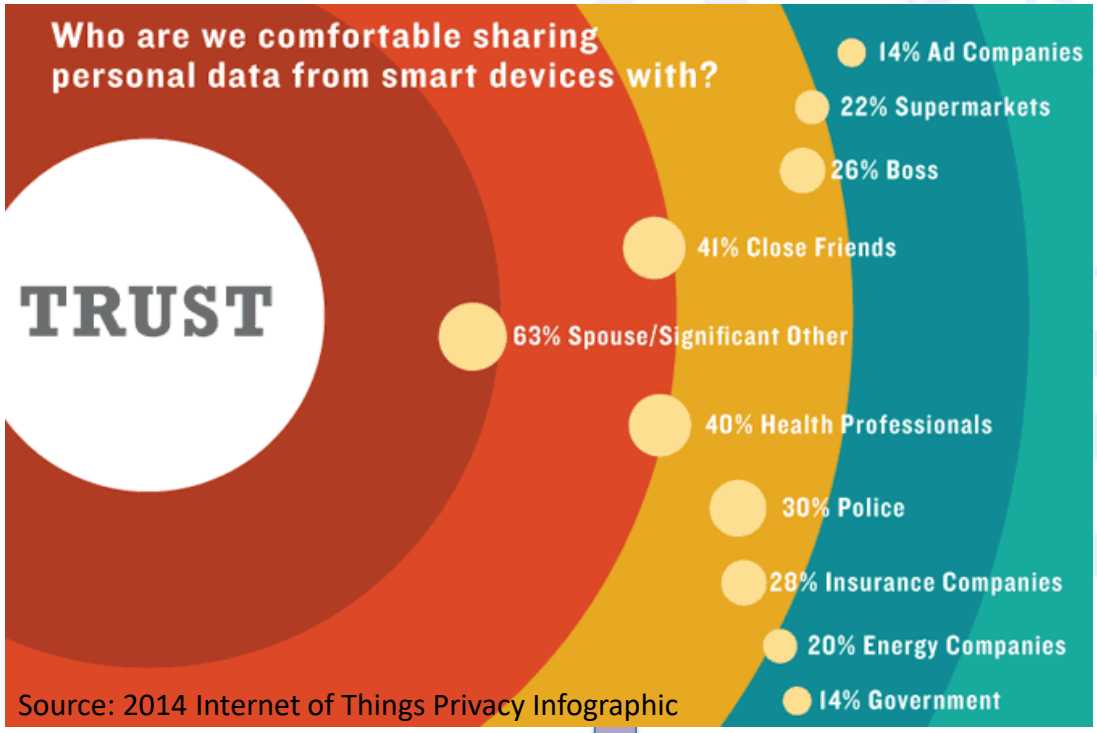




"From Data to Actionable Knowledge: Big data challenges in the WoT," IEEE Intelligent System, 2014

Barrier to growth of IoT market

Data and Trust



Source: 2014 Internet of Things Privacy Infographic

Volume – Data at Rest

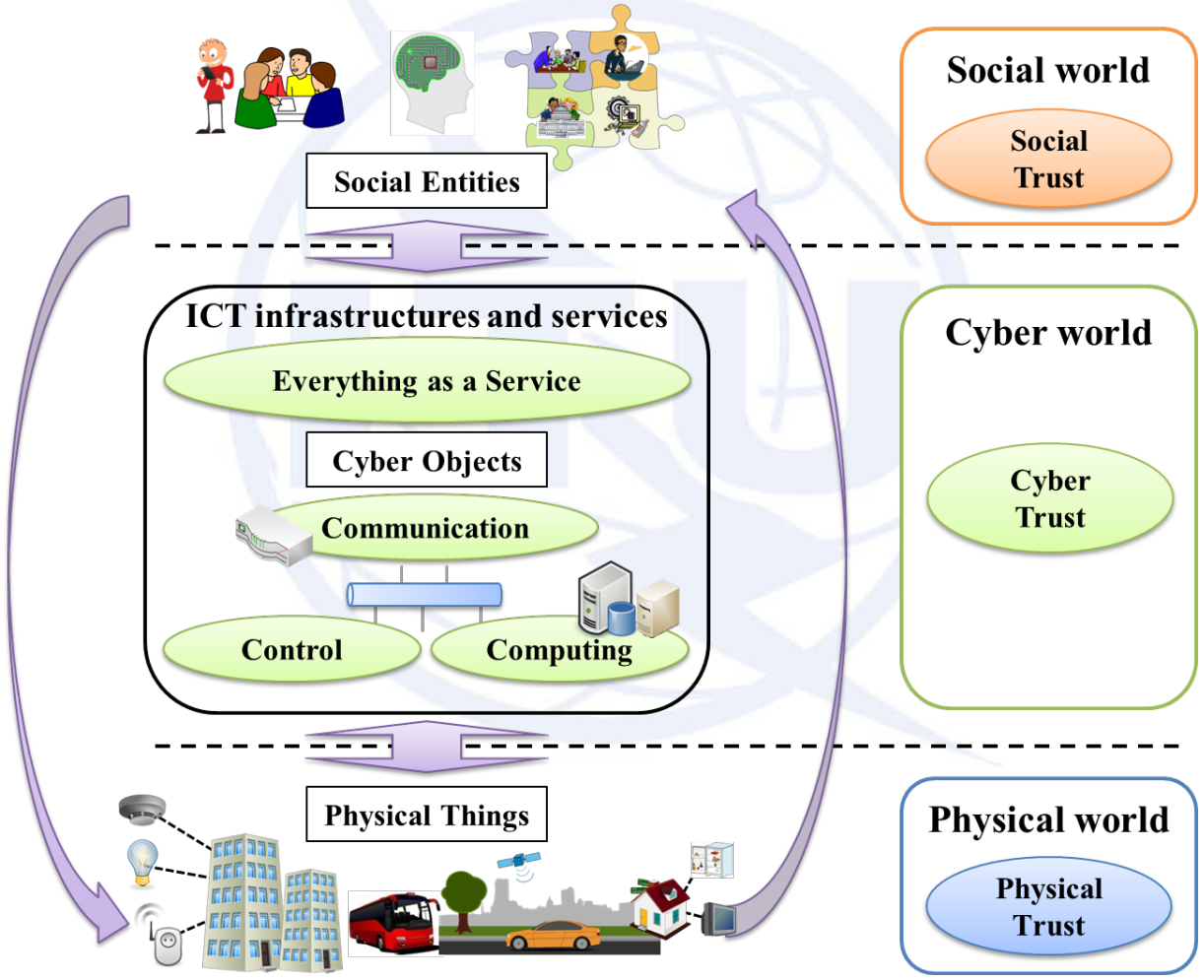
Variety – Data in Many Forms

Velocity – Data in Motion

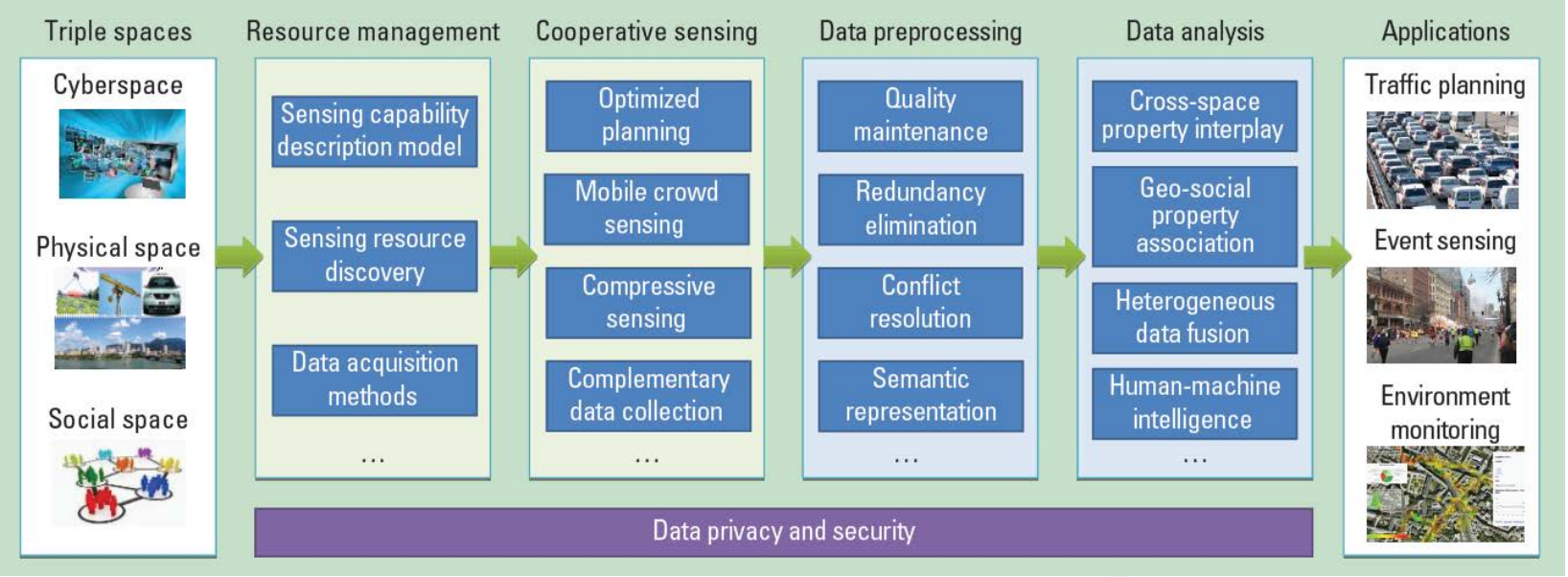
Variability – Data in Change

Veracity – Data in Doubt

Cyber Physical Social System



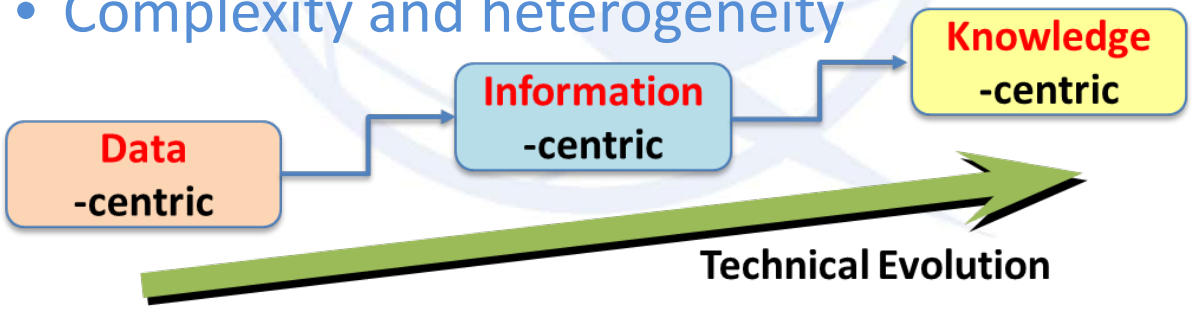
Data-driven cyber-physical-social systems



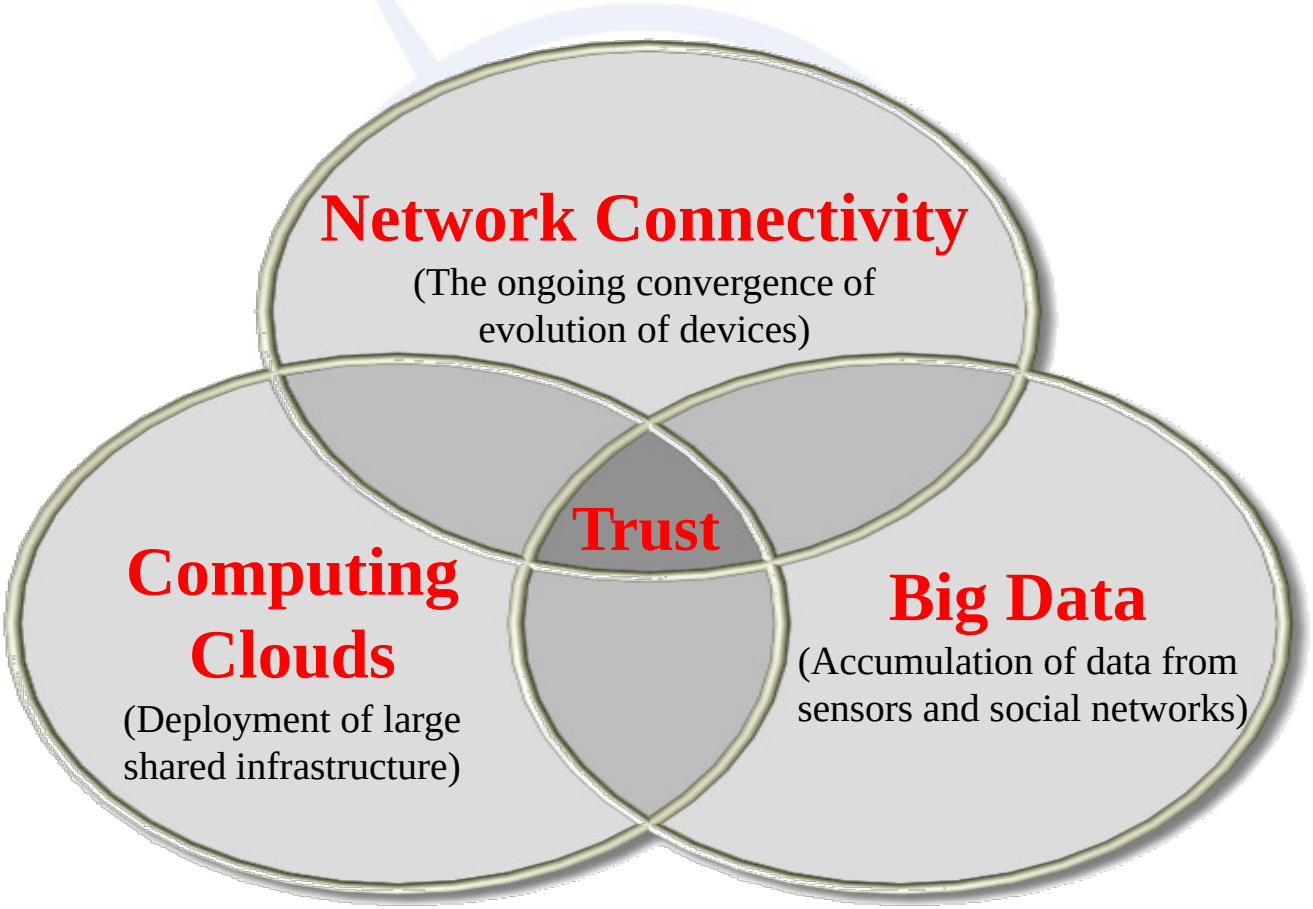
"A Data-Centric Framework for Cyber-Physical-Social Systems", IEEE IT Professional, Nov.-Dec. 2015.

Towards T-SCPI

- Build up Trustworthy Social-Cyber-Physical Infrastructure (T-SCPI)
  - Trust-enabled infrastructure
  - Knowledge centric networking and services
    - Complexity and heterogeneity

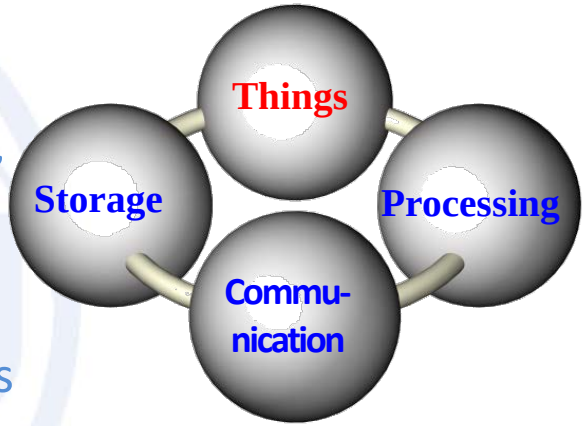


Putting all together



Future Convergence Infrastructure

- Enhancements of networking scope/capabilities
  - Extension of service: fusion services combined with other technologies (e.g., BT, NT, CT, etc.) beyond IT services.
  - Extension of network: additional functionalities/capabilities
  - Extension of end-user: new types of objects connected to the network for enabling the use of various communication services.



Interdisciplinary fusion technologies

Solution for "connectivity + reality + intelligence" to support "5Any" using smart objects (NOTE: 5Any – Any time, Any where, Any service, Any network, Any object)

IoT + Cloud Computing + Smart Grid + …

Conclusion

Future ICT Infrastructure

↓

Trustworthy Social-Cyber-Physical Infrastructure

↓

Trust-enabled knowledge-centric networking and services


ITU