Strengthening Trust in the Future ICT Infrastructure

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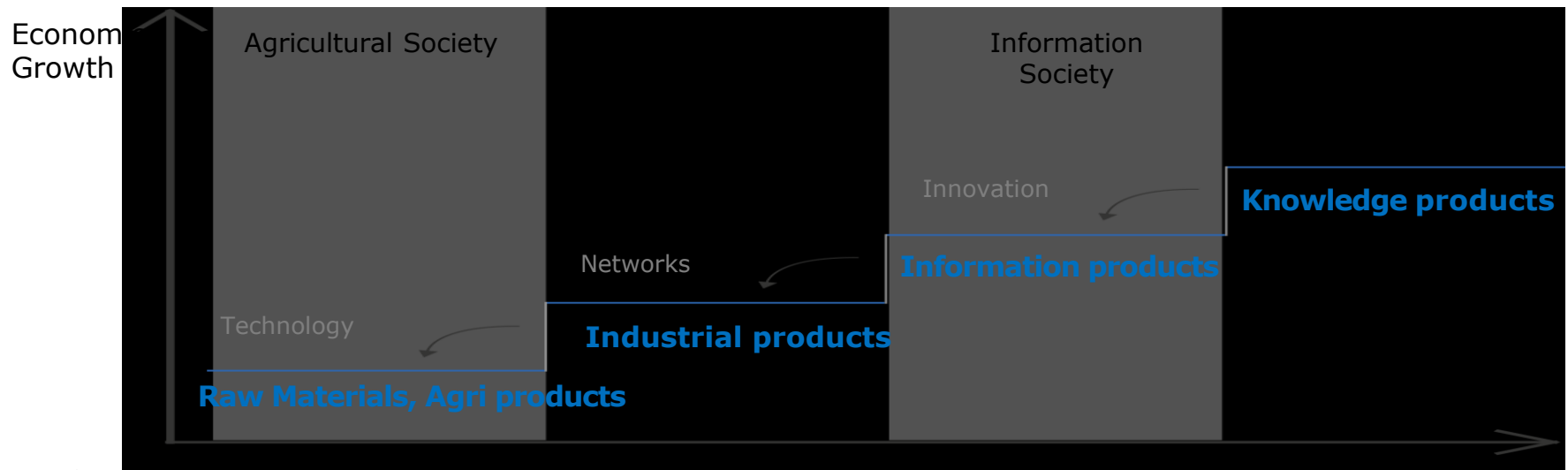
- **Summary**

Towards Knowledge Society and Economy

❑ **Knowledge Society**

- based on the creation, dissemination and utilization of knowledge.
- Knowledge is 'working capital' and the key value of industries.
- Knowledge is applied to enhance economic and social development.

❑ **Information Society**

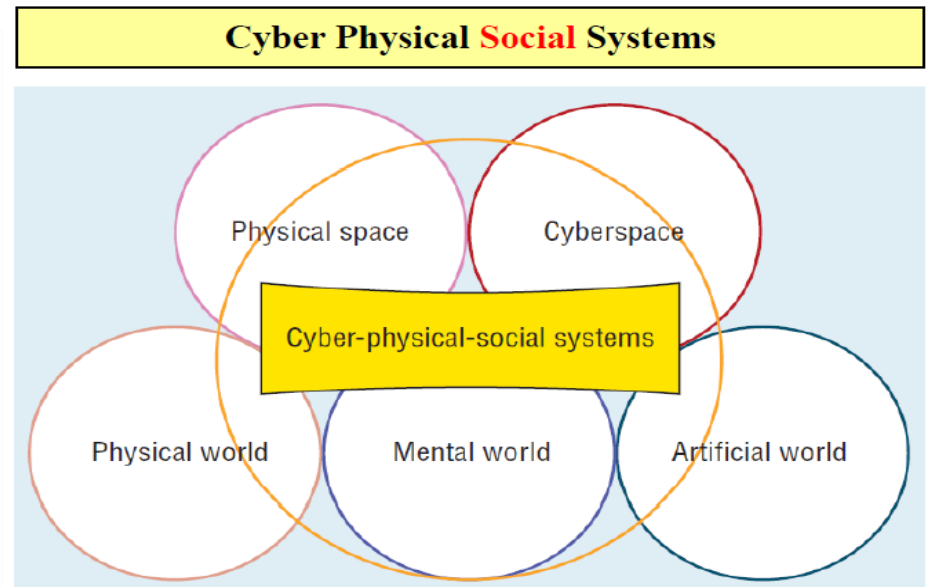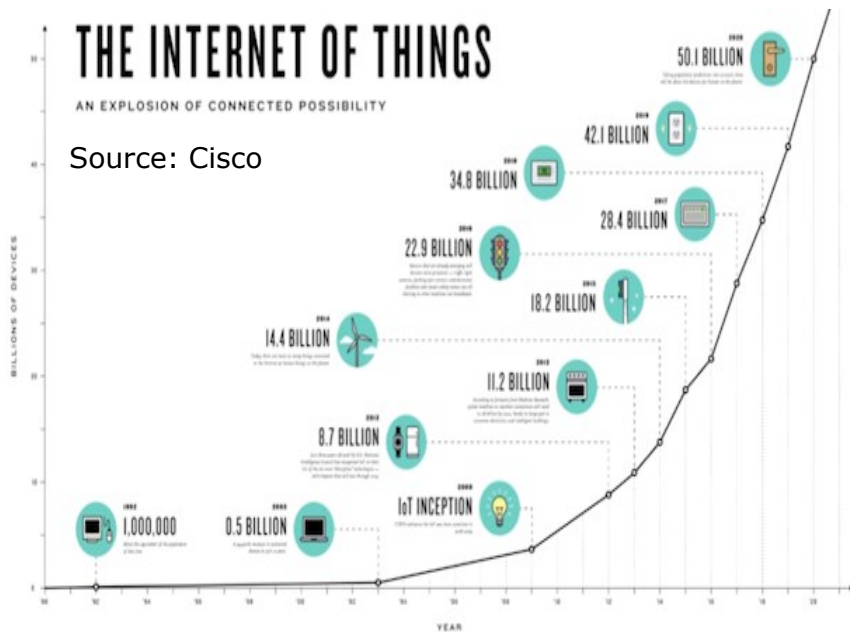- Focus on ICT and the availability and accessibility of information.

Source: ITU Technical Report, "Future Social Media and Knowledge Society", Jun Kyun Choi, 2015.11.
UNESCO World Report, "Toward Knowledge Society", 2005, www.gesci.org, "What is the Knowledge Society?"

ICT is a Basis of Knowledge Society

❑ ICT is a Basis of Knowledge Society and Economy

- ICT evolution affects the means of knowledge creation and processing.

- Social media offer many more possibilities for knowledge sharing.

- IoT will be the global infrastructure for the knowledge society.

Source: Cisco

THE INTERNET OF THINGS
AN EXPLOSION OF CONNECTED POSSIBILITY

50.1 BILLION
42.1 BILLION
34.8 BILLION
28.4 BILLION
22.9 BILLION
18.2 BILLION
14.4 BILLION
11.2 BILLION
8.7 BILLION
1,000,000
0.5 BILLION
IoT INCEPTION

Cyber Physical Social Systems

Physical space • Cyberspace

Cyber-physical-social systems
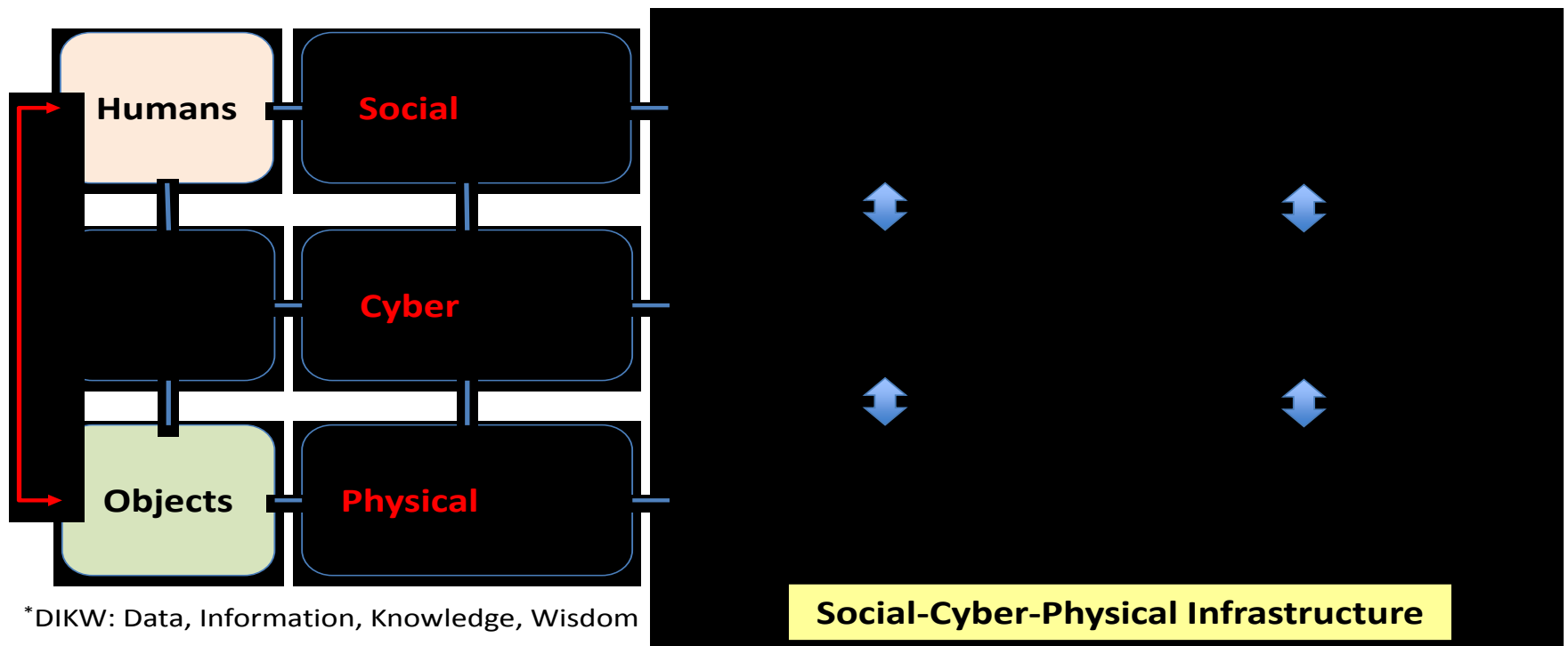
Physical world • Mental world • Artificial world

(Source) Fei-Yue Wang, "The Emergence of Intelligent Enterprises: From CPS to CPSS," IEEE Intelligent Systems, July 2010

Source: ITU Technical Report, "Future Social Media and Knowledge Society", Jun Kyun Choi, 2015.11.
UNESCO World Report, "Toward Knowledge Society", 2005, www.gesci.org, "What is the Knowledge Society?"

Risk of Knowledge Societies (1/2)

- Knowledge become strategic and, if exploited for ill-intentioned ends, could wreak irreparable damage and create unpredictable dangers.
- It is difficult to identify and prevent risks of knowledge in the complicated ICT infrastructure.

Humans

Social

Cyber

Objects

Physical

*DIKW: Data, Information, Knowledge, Wisdom

Social-Cyber-Physical Infrastructure

Risk of Knowledge Societies (2/2)

❑ Risks on Data Integrity
- Knowledge can be created through the data processing.
- Data integrity refers to maintain the accuracy and consistency of data.
- It is critical to design, implementation, and usage of any system which stores, processes, or retrieves data.

❑ Risks of the Operation of Systems
- The advent of S/W and H/W accelerates the deployment of autonomic processing and operation of systems.
- How can we trust the H/W and S/W systems?

❑ Social Networking Risks
- False knowledge propagation gives rise to great confusion in societies.
- It is caused by social networking worms, data leaks, Botnets, etc.

Objectives

❑ **Trust Provisioning for Future ICT Infrastructure**

- Process of preparing and equipping systems to expect and prevent risks to provide trustworthy services to its users.

❑ **Objectives of this work**

- Key challenges for a trustworthy ICT infrastructure

- Generic ICT Trust Conceptual Model

- Generic architectural framework for trust provisioning

- Strategies for future standardization on trust
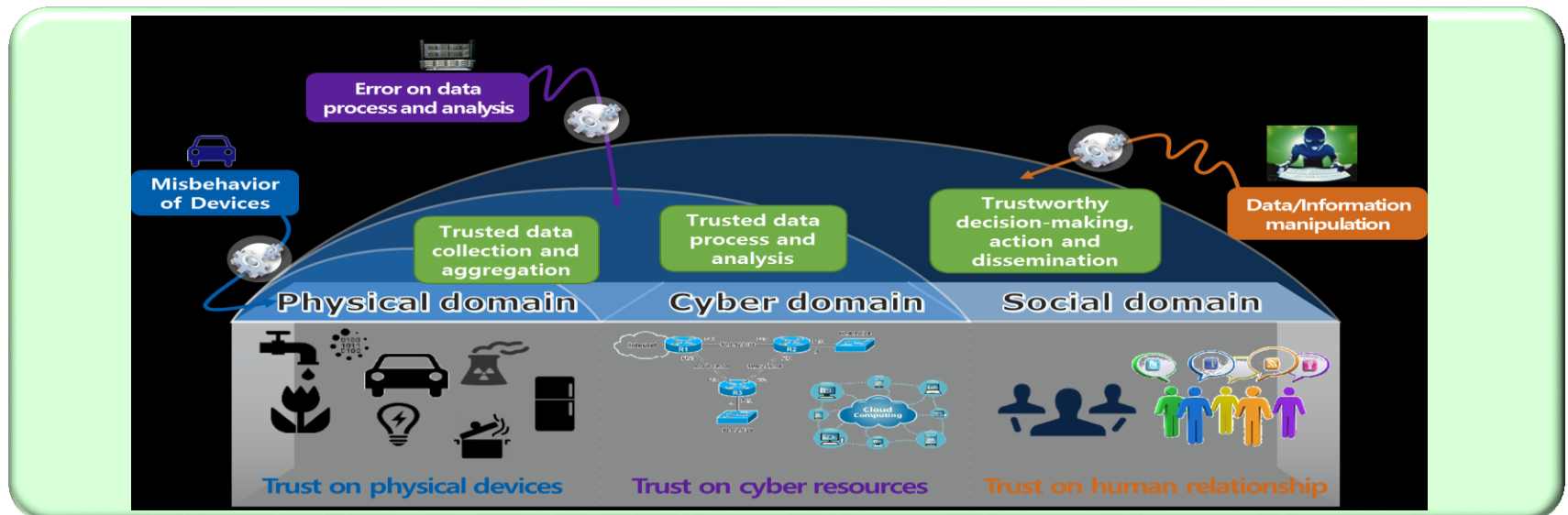
Understanding of Trust

Trust is not just a simple, monolithic concept; it is multi-faceted, operating at many levels of interaction, and playing many roles.

Lexical Semantic

Trust means reliance on the integrity, strength, ability, etc., of a person or object.

In Computer Science

- "User trust" : a subjective expectation an entity has about another's future behavior.
- "System trust" : the expectation that a system will faithfully behave to fulfil its intended purpose.

Technical Perspective

- Technical trust
- Business/trading trust
- Human trust

Confidence	Dependence	Goodness
Belief	Ability	Honesty
Expectation	Faith	Future
Integrity	Surety	Strength

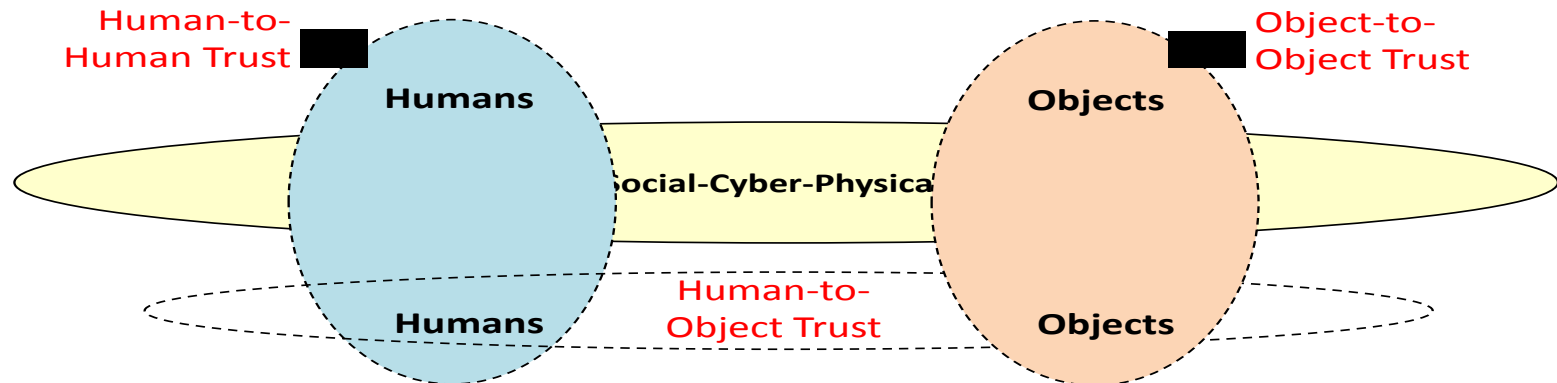# Challenges and Technical Issues (1/3)

❑ Social-Cyber-Physical Trust Relationships

- Social/cyber/physical objects have their associated information.
- Individual trust and community trust are needed.
- Trust as a cross-domain relationship should be considered.

❑ Holistic Trust for Interconnected Systems

- Trust must be addressed in all services and infrastructures, as well as in all system and component levels, in a holistic manner.
- Trust management is required to apply between heterogeneous systems and service domains.
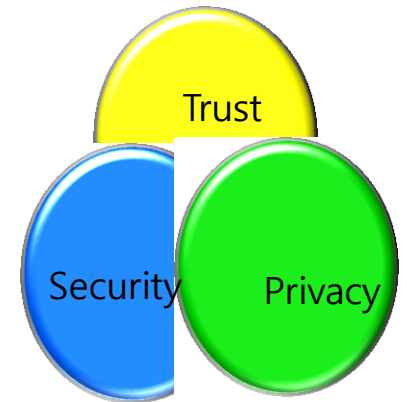
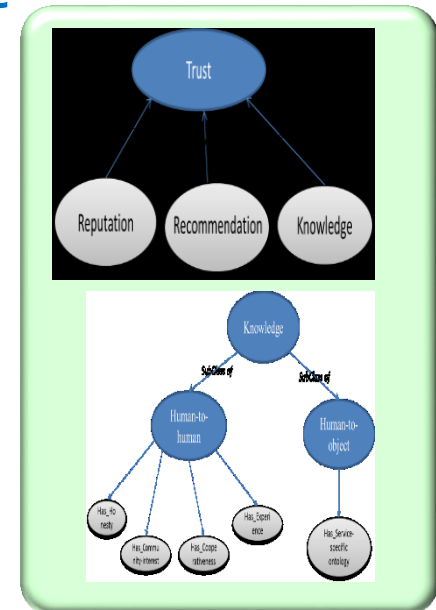<Trust relationships in a trustworthy social-cyber-physical infrastructure>

❑ Trust-Security-Privacy

- Trust, security and privacy become tightly coupled.
- Trust requires cooperation and co-engineering with security and privacy.

❑ Measurement and Formalization of Trust

- Trust modeling and reasoning with a trust metric or trust index.
- Identification and measurement of trust levels objectively or subjectively.

❑ Dynamics of Trust

- Trust is situation-specific and changes over time.
- Due to the dynamics and complexity of trust, it is necessary to combine different trust mechanisms.

Challenges and Technical Issues (3/3)

❑ **Resource Constraints**

- For small-sized objects with limited computing power, trust solutions with lightweight become a necessity.

❑ **Trustworthy System Lifecycle**
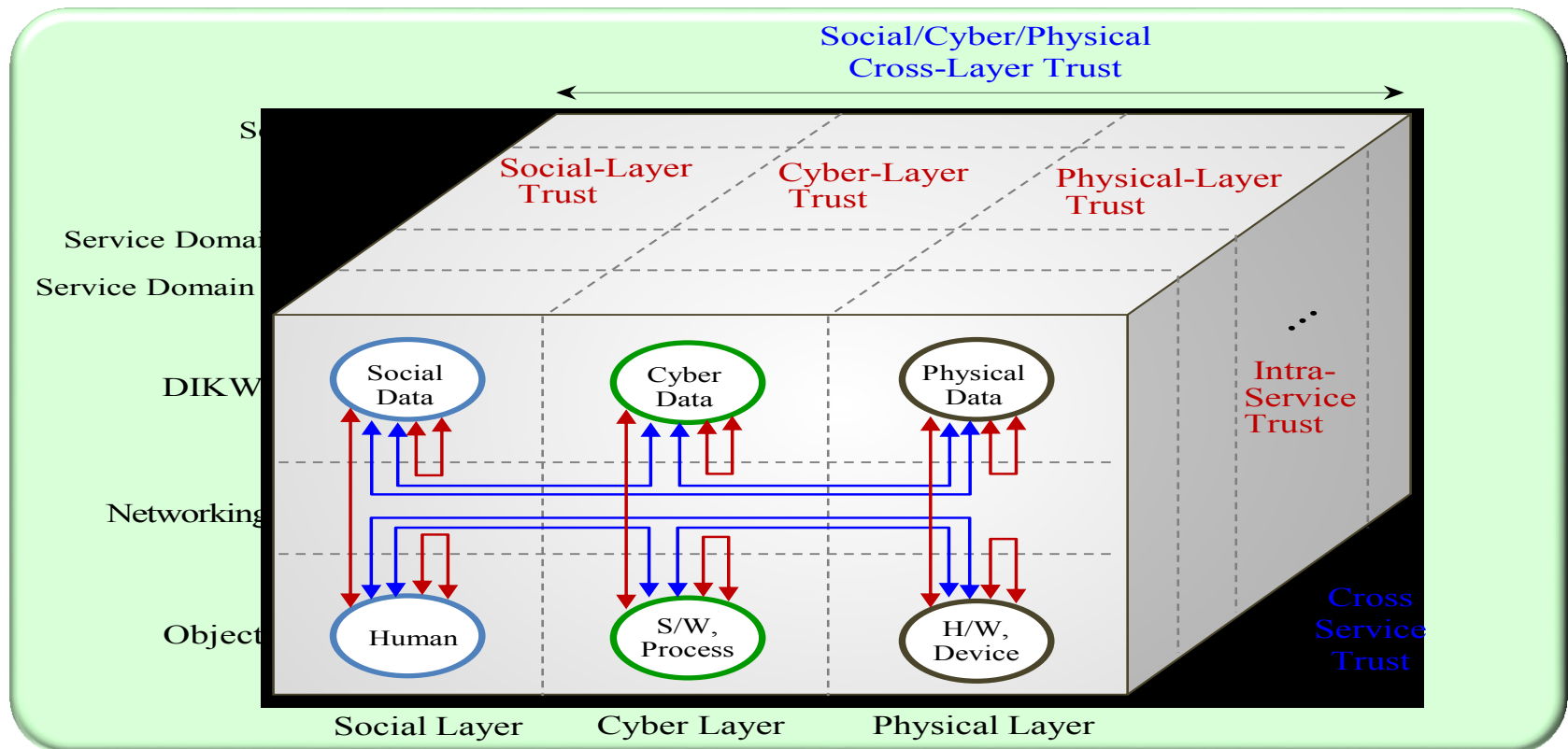
- A systematic methodology to cover all relevant trust aspects of a design, development and operation life cycle.

<Various kinds of Internet of Things >

Generic ICT Trust Conceptual Model (1/2)

❑ Physical/Cyber/Social Layer Trust

- Physical layer trust on devices and their data.
- Cyber layer trust on S/W and their data and information.
- Social layer trust on human and their knowledge.

Generic ICT Trust Conceptual Model (2/2)

❑ **Cross Layer Trust**

- There are interactions between social, virtual and physical objects.
- Human interactions with cyber/physical objects should be performed in a trustworthy way.
- Appropriate trust models for the interactions between social, information and communication networks are required.

❑ **Cross Service Trust**

- Trust management is service and domain specific.
- Trust management to cover trust relationships between different service domains.
- A trust service brokering mechanism for efficient, effective and suitable trust dissemination.

Trust Architectural Framework
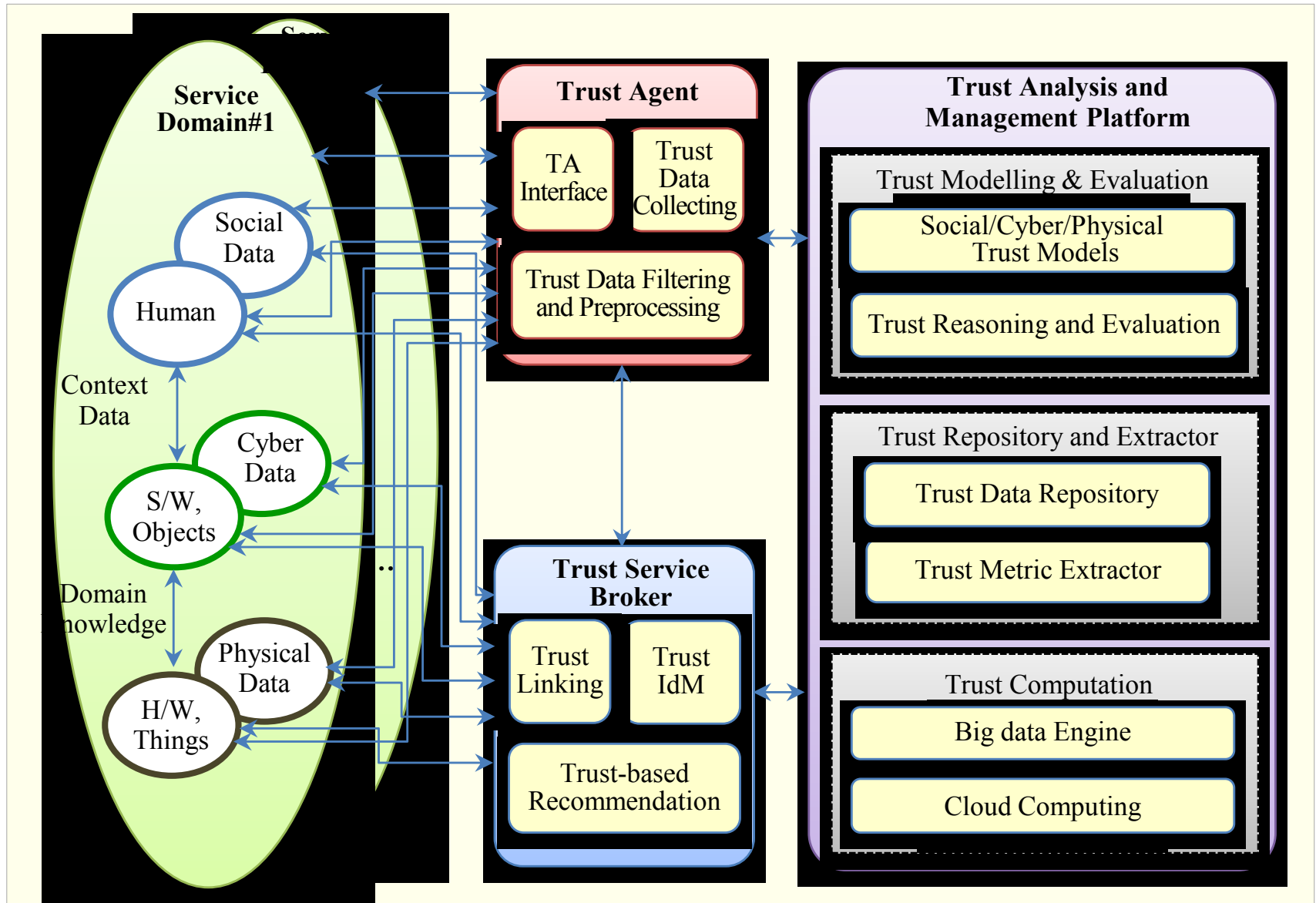
Trust Architectural Framework

❑ Trust Agent
- gathers trust-related data from social, virtual or physical objects.
- consists of TA Interface, trust data collection, trust data filtering and preprocessing modules.

❑ Trust Analysis and Management Platform
- models and analyses trust-related data and the trust relationship.
- consists of trust modelling, trust evaluation, trust data repository, trust metric extractor, trust computation modules.
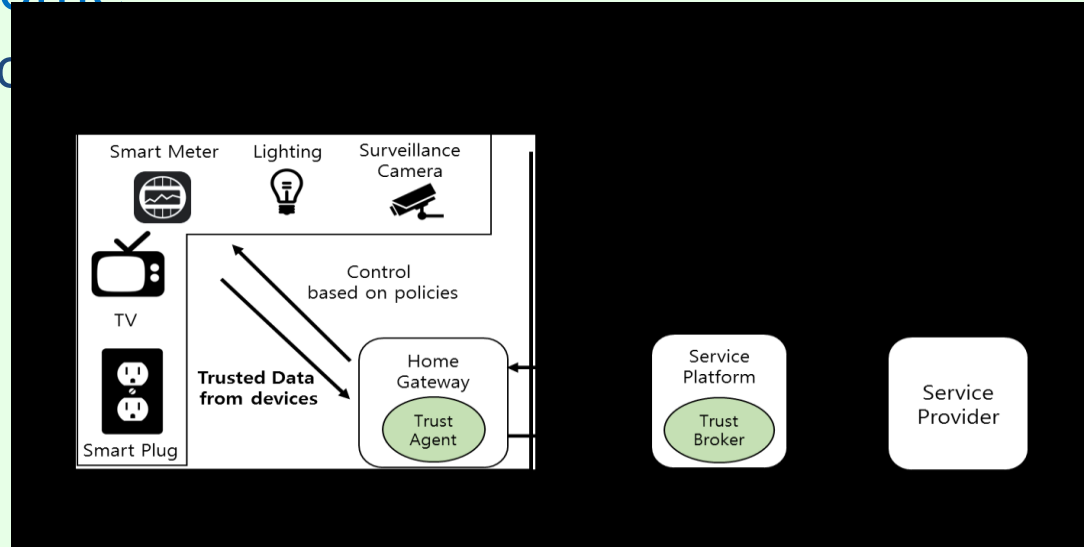
❑ Trust Service Broker
- applies and disseminates trust-based knowledge to various services.
- consists of trust linking, trust IdM, trust-based recommendation.
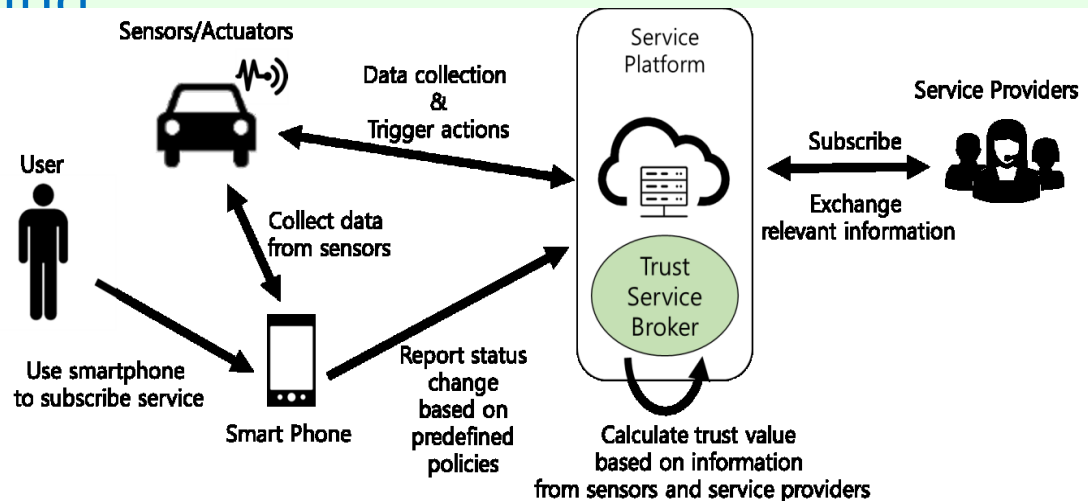
Use Cases

□ **Trustworthy Smart Home**

- enables users to monitor and manage the home appliances remotely and safely.

□ **Trustworthy Car Sharing**

- Provides reliable transaction in consideration of trustworthiness of users and cars.

Strategies for future standardization on trust

❑ Future work for standardization on trust

- Overview of trust in ICT

- Service scenarios and capabilities

- Requirements for trust provisioning

- Architectural framework

- Technical solutions for trust provisioning

- Trust provisioning in IoT

- Trust provisioning in data analytics

ving List Item

| ITU Workshop on "Future Trust and Knowledge Infrastructure" | Technical report on Trust | Trust Overview Service Scenarios | Requirement Framework | Trust in IoT Trust in data analysis |

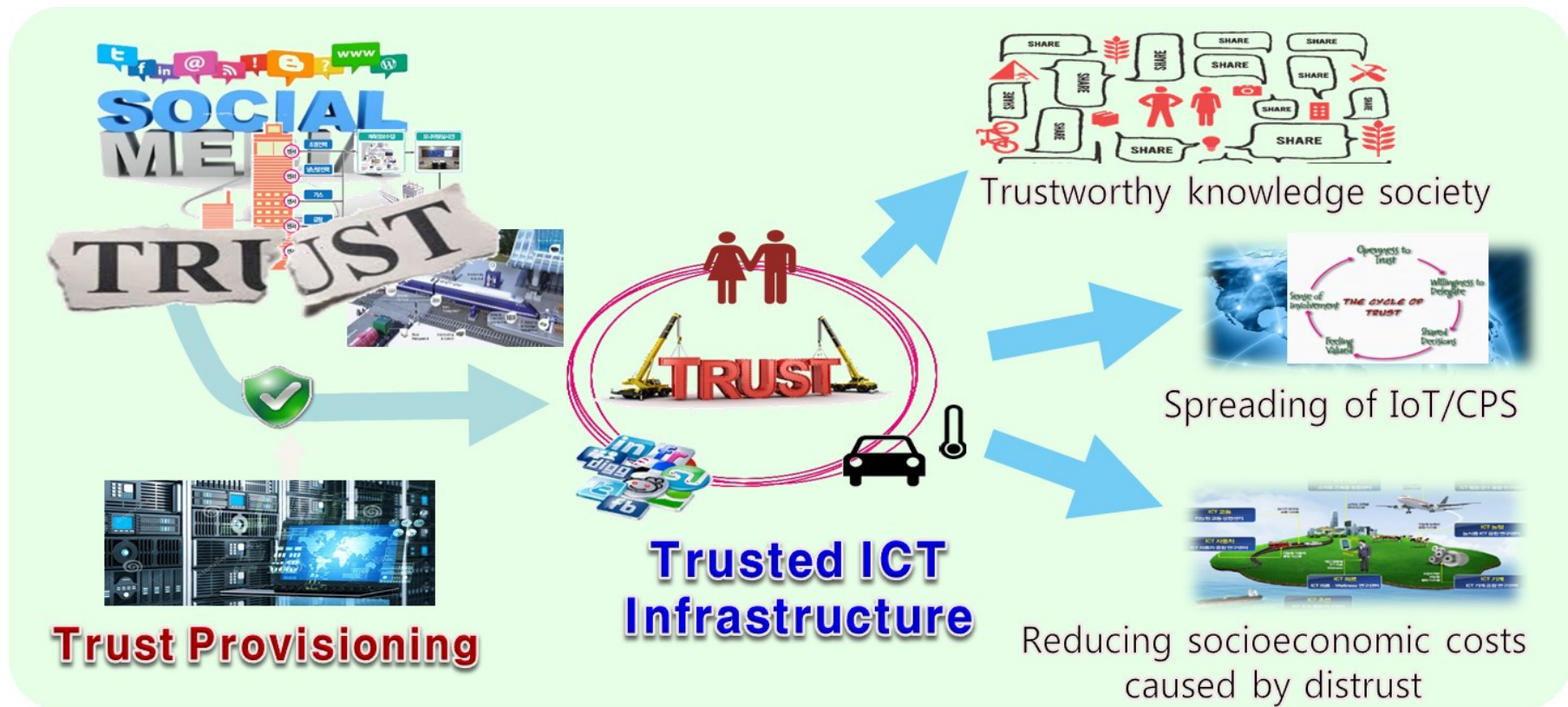2014   2015   2016   2017   2018

Summary

- Trust Provisioning in Future ICT Infrastructure
- Standardization on Trust
- Participation in ITU-T CG-Trust
- Governance of trustworthy ICT infrastructure

Trust Provisioning → **Trusted ICT Infrastructure** → Trustworthy knowledge society / Spreading of IoT/CPS / Reducing socioeconomic costs caused by distrust

References

[1] Gyu Myoung Lee, et al., "Internet of Things," in a book "Evolution of Telecommunication services," LNCS, volume 7768, Springer, ISBN 978-3-642-41568-5, pp.257~282, 2013.

[2] Overview of Internet of Things, ITU-T Y.2060, June 2012.

[3] Edith Ramirez, Privacy and the IoT: Navigating Policy issues, Opening remarks of CES, Jan. 2015, https://www.ftc.gov/public-statements/2015/01/privacy-iot-navigating-policy-issues-opening-remarks-ftc-chairwoman-edith (visited on 2015-11-17).

[4] Data-driven Innovation for Growth and Well-being – Interim synthesis report, OECD, Oct. 2014, http://www.oecd.org/sti/inno/data-driven-innovation-interim-synthesis.pdf (visited on 2015-11-17).

[5] Ovidiu Vermesan, Peter Friess, "Building the hyperconnected society – IoT research and innovation value chains, ecosystems and markets," River Publishers, 2015.

[6] "The Zettabyte Era: Trends and Analysis," Cisco white paper, May 2015.

[7] KCN (Knowledge Centric Networking), https://www.ee.ucl.ac.uk/kcn-project/ (visited on 2015-11-17).

[8] L. Atzori, A. Iera, G. Morabito, and M. Nitti, "The Social Internet of Things (SIoT) – When social networks meet the Internet of Things: Concept, architecture and network characterization," Computer networks, vol. 56, no. 16, pp. 3594-3608, Nov. 2012.

[9] Fei-Yue Wang, "The Emergence of Intelligent Enterprises: From CPS to CPSS," IEEE Intelligent Systems, July 2010.

[10] Jay Lee, et al., "A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems," Elsevier Journal, Jan. 2015.

[11] George Vanecek, "The Internet of Things, ambient intelligent and the moving towards intelligent systems," IEEE Smart Tech 2012, Sep. 2012.

[12] Wanita Sherchan, Surya Nepal, Cecile Paris "A survey of trust in social networks", ACM Computing Survey, vol.45, issue 4, no. 47, August 2013.

[13] Zheng Yan, et al., "A survey on trust management for Internet of Things," Journal of Network and Computer Applications, Mar. 2014.

[14] Trust pyramid, http://www.johnhaydon.com/how-make-people-trust-your-nonprofit/ (visited on 2015-11-17).

[15] Trust Definition White Paper - "Defining, Understanding, Explaining TRUST within the uTRUSTit Project", August 2012.

[16] "Trustworthy Systems of Systems," ERCIM News, no.102, Jul. 2015.

[17] The Online Trust Alliance, https://otalliance.org/ (visited on 2015-11-17).

[18] The Trusted Computing Group, http://www.trustedcomputinggroup.org/ (visited on 2015-11-17).