Innovative Life Enabled by Cyber-Physical "Social" Systems (CPSS)

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Innovative Life Enabled by Cyber-Physical "Social" Systems (CPSS)

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Digital Innovation…

- On October 5, we lost the most “innovative” person in the world, or Steve Jobs.
- Macintosh, iPod, iPhone, iPad, … What he built really changed the world and the way we live and think.
- “Innovation distinguishes between a leader and a follower,” Steve said.
- What is the next “innovation”?

CPS (Cyber-Physical Systems)

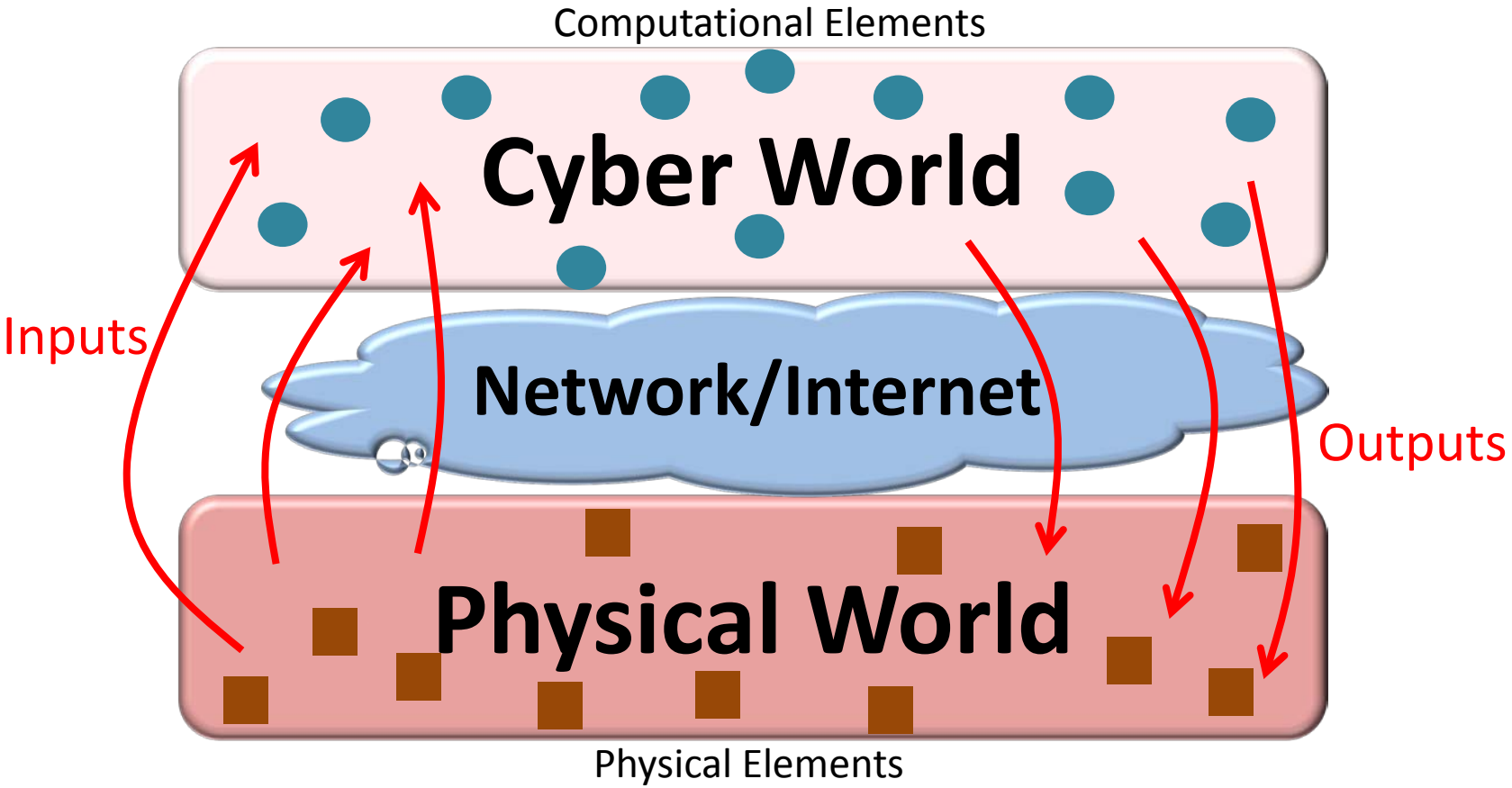
What is CPS ?
- From Wikipedia -

- A cyber-physical system (CPS) is a system featuring a tight combination of, and coordination between, the system's computational and physical elements. Today, a pre-cursor generation of cyber-physical systems can be found in areas as diverse as aerospace, automotive, chemical processes, civil infrastructure, energy, healthcare, manufacturing, transportation, entertainment, and consumer appliances. This generation is often referred to as embedded systems. In embedded systems the emphasis tends to be more on the computational elements, and less on an intense link between the computational and physical elements.
- Unlike more traditional embedded systems, a full-fledged CPS is typically designed as a network of interacting elements with physical input and output instead of as standalone devices. The notion is closely tied to concepts of robotics and sensor networks. The expectation is that in the coming years ongoing advances in science and engineering will improve the link between computational and physical elements, dramatically increasing the adaptability, autonomy, efficiency, functionality, reliability, safety, and usability of cyber-physical systems. The advances will broaden the potential of cyber-physical systems in several dimensions, including: intervention (e.g., collision avoidance); precision (e.g., robotic surgery and nano-level manufacturing); operation in dangerous or inaccessible environments (e.g., search and rescue, firefighting, and deep-sea exploration); coordination (e.g., air traffic control, war fighting); efficiency (e.g., zero-net energy buildings); and augmentation of human capabilities (e.g., healthcare monitoring and delivery).

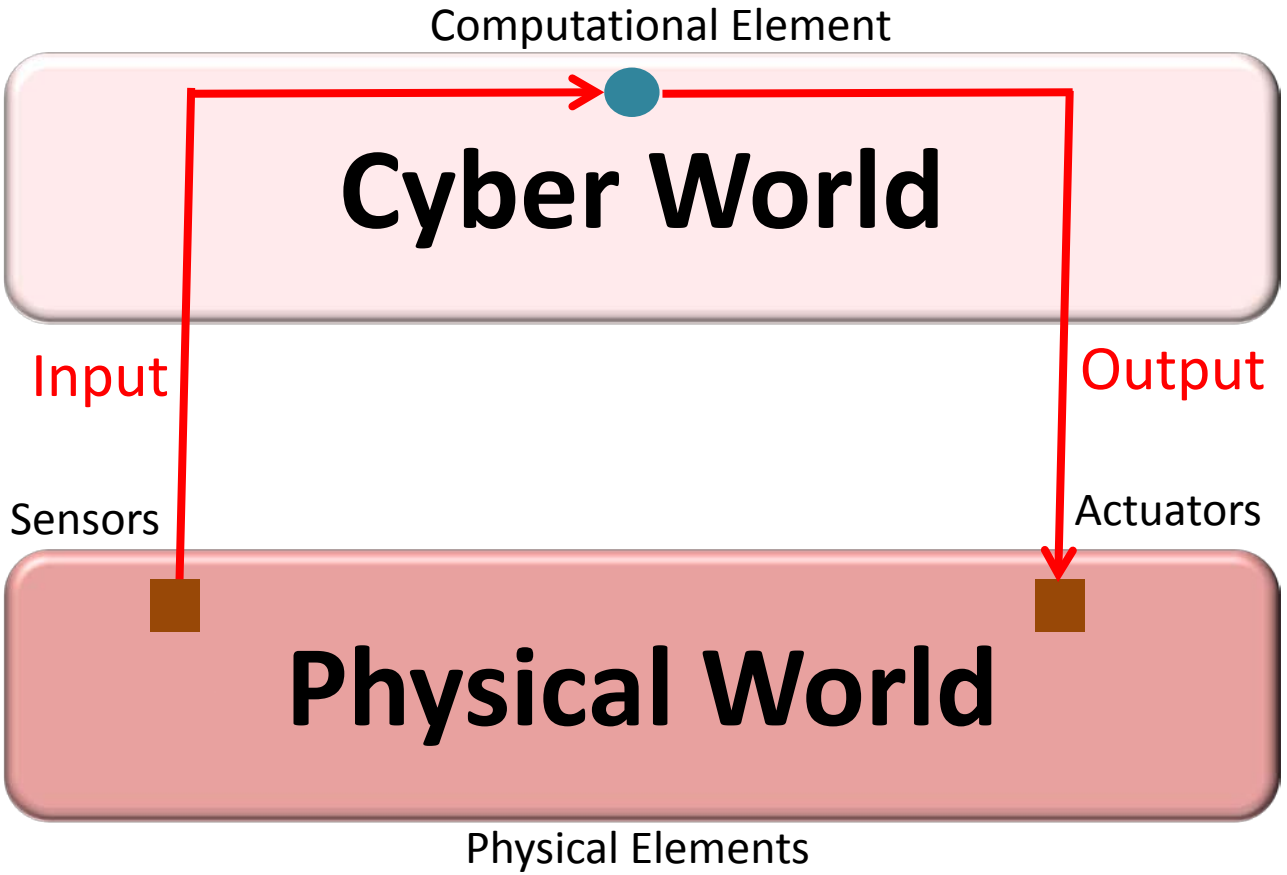
What is CPS ?
- From ICCPS2011 -

- As computers become ever-faster and communication bandwidth ever-cheaper, computing and communication capabilities will be embedded in all types of objects and structures in the physical environment. Applications with enormous societal impact and economic benefit will be created by harnessing these capabilities in time and across space. Such systems that bridge the cyber-world of computing and communications with the physical world are called cyber-physical systems.
- Cyber-physical systems (CPS) are physical and engineered systems whose operations are monitored, coordinated, controlled and integrated by a computing and communication core. This intimate coupling between the cyber and physical will be manifested from the nano-world to large-scale wide-area systems of systems. And at multiple time-scales.
- Cyber-physical systems will transform how we interact with the physical world just like the Internet transformed how we interact with one another.

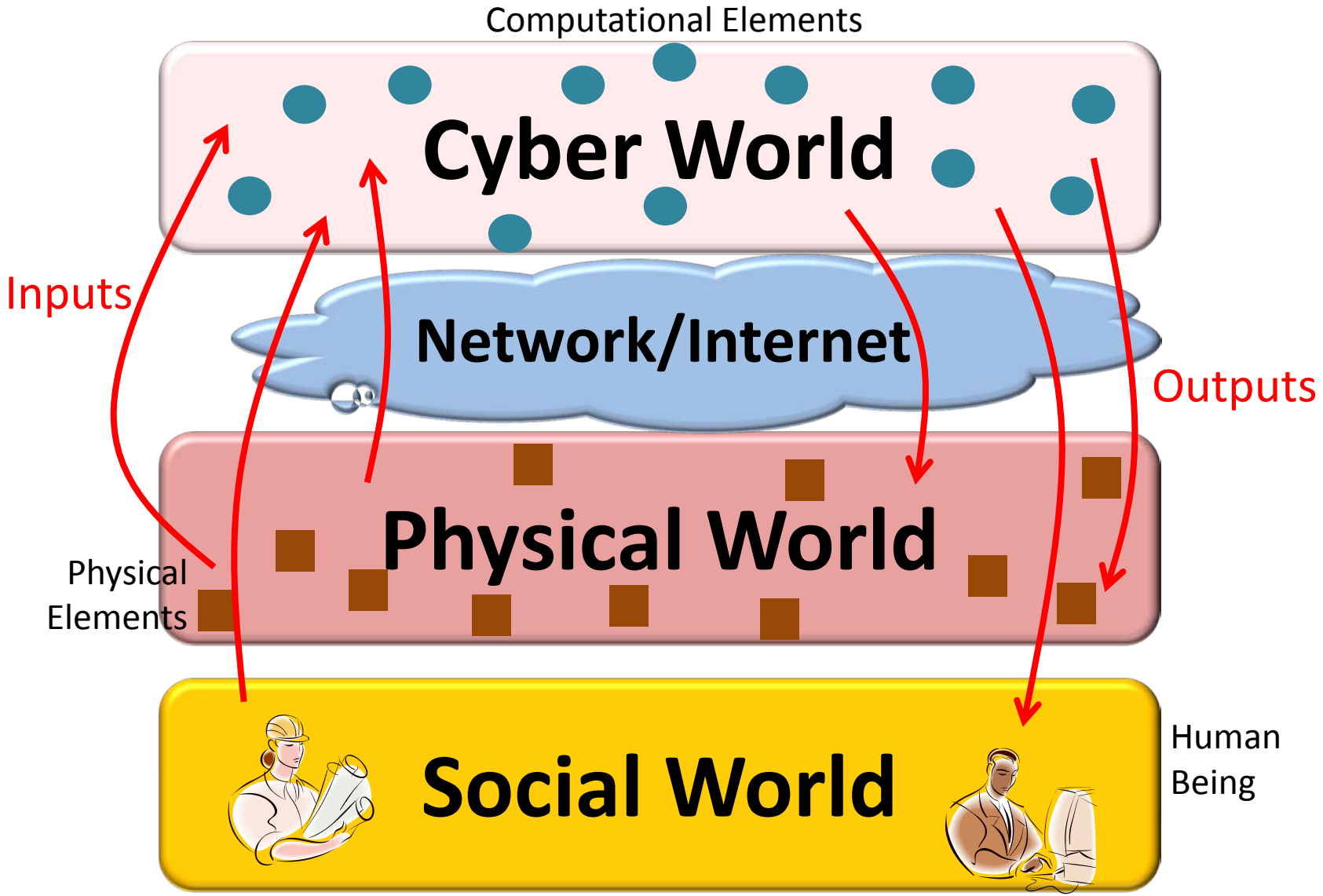
What is CPS?
- A Big Picture -



What is CPS?
- ES (Embedded System) -



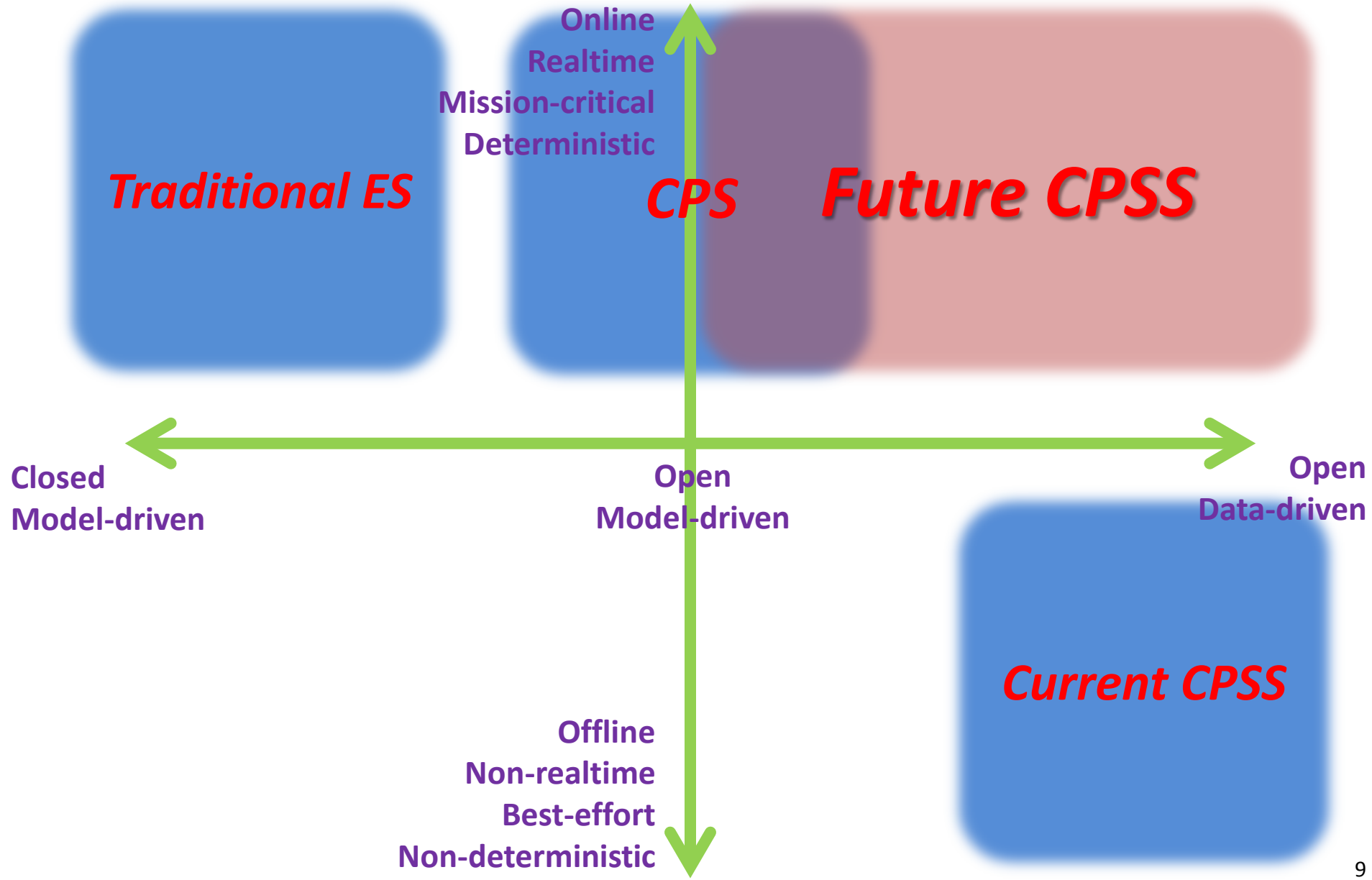
What is CPSS (Cyber-Physical-Social System)?
- Another Big Picture -



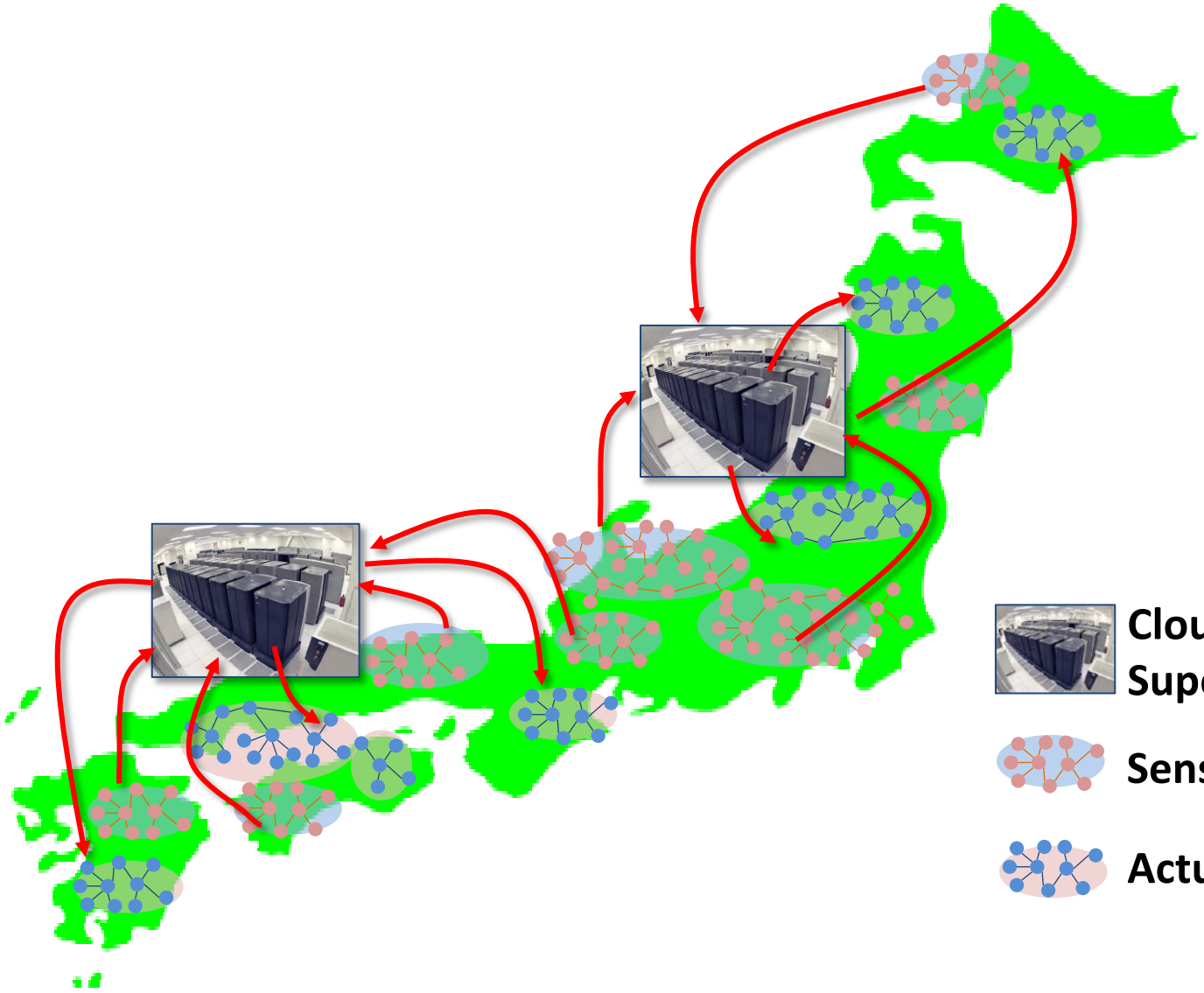
Classifying ES, CPS, and CPSS

Taxonomy		ES	CPS	Current CPSS	Future CPSS
Feedback	Offline			✔	
	Online	✔	✔		✔
Raeltimeness	Non-realtime			✔	
	Realtime	✔	✔		✔
System	Closed	✔			
	Open		✔	✔	✔
Criticality	Best-effort			✔	
	Mission-critical	✔	✔		✔
Control	Model-driven	✔	✔		✔
	Data-driven			✔	✔
Effects of feedback	Nondeterministic			✔	
	Deterministic	✔	✔		✔

Classifying ES, CPS, and CPSS



Japan National-wide CPSS

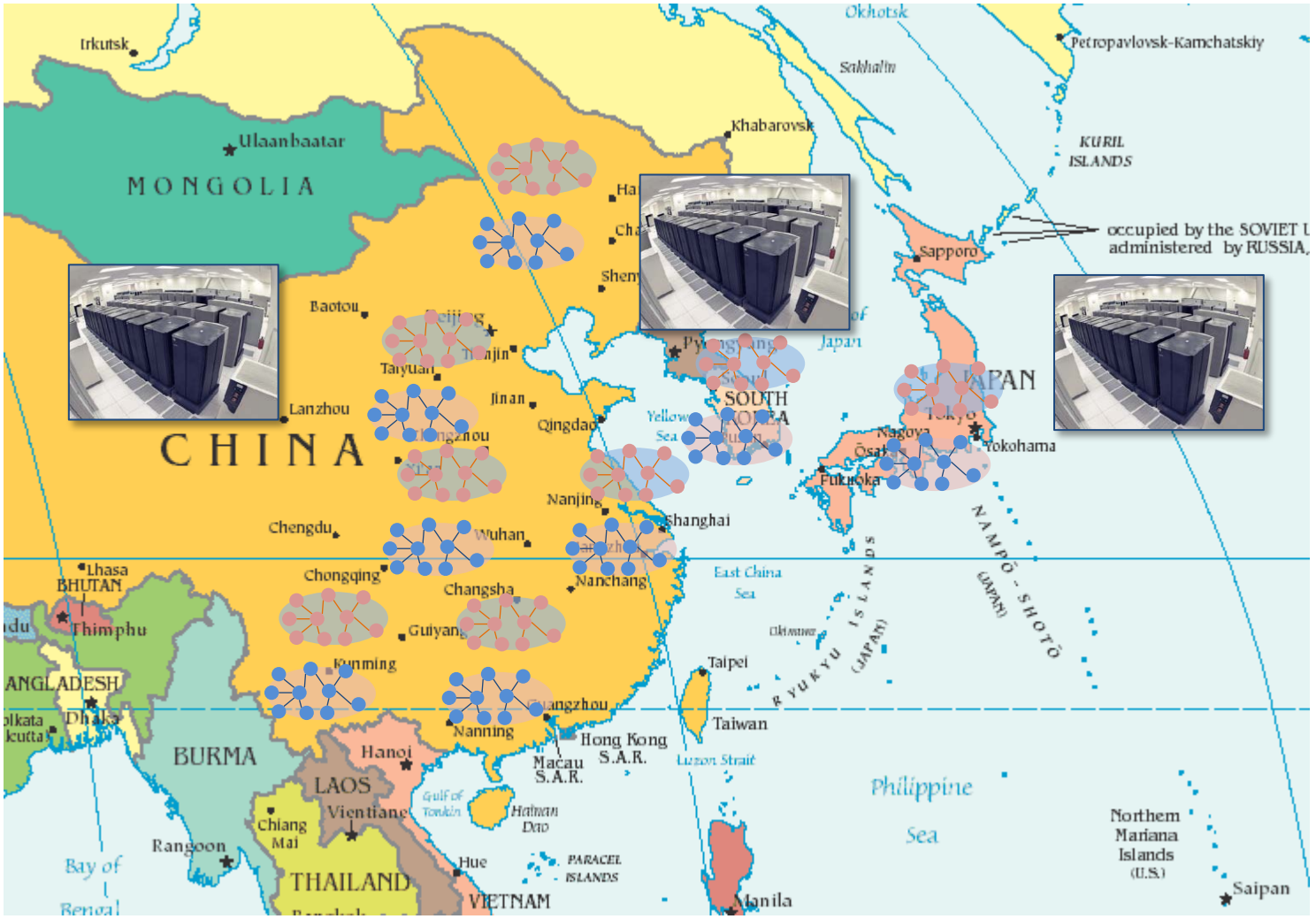


Cloud Data/
Supercomputer Center

Sensor Network

Actuator Network

East-Asia Regional-Wide CPSS



Future CPSS Enabling Innovative Life

Smart ITS

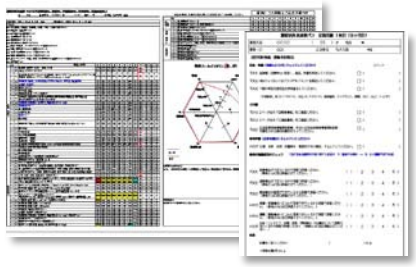
Preventive Medical Service System

Automotives

Smart Grid

Smart Cities

Preventive Medical Service System



- Electric medical record
- Electric critical path information

Precise disease risk control





Blood Oxygenation level
•Breathing rate
•Sleep state
•Temperature
•Humidity
• Intensity of illumination
•Noise





Blood Pressure
Weight
Blood-sugar
Behavior discrimination
Electro-cardiogram

Traditional medical treatment

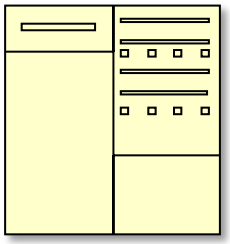
Real time information medicine(*)

Physical& Social Space

Cyber Space

Prediction of individual fluctuation

Growth type feed-back



Medical information network

Sensor network

Preventive Medical CPS Infrastructure

(*): Information Medicine : A concept provide right information at right timing to improve health

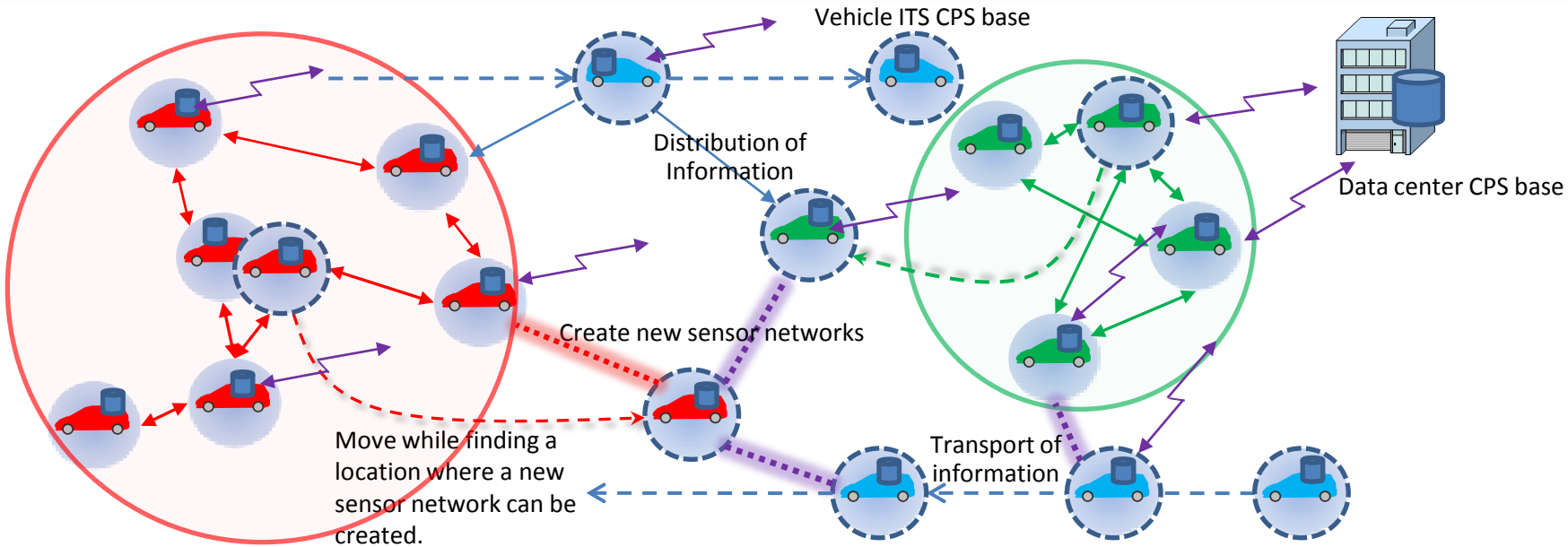
Smart ITS: Sensor-Networked ITS

Concept:

① Collect data using various sensors on the vehicle, and send via WAN to data center. The data is analyzed traffic condition or other status. Then the analyzed data is used to guide vehicles for efficiency and safety.

② At the same time, the analyzed data in the data center is shared using vehicle to vehicle communication. It's used to improve own traffic information, it also improves traffic efficiency and safety.

③ The vehicle-to-vehicle communication can be used to create sensor network which provide minimum communication capability in an emergency condition.



Vehicle sensing data: location, velocity, acceleration, load condition, temperature, rainfall, visual image, battery/fuel condition

Future CPSS Enabling Innovative Life

Smart ITS

Preventive Medical Service System

Automotives

Smart Grid

Smart Cities

Our Mission: Enabling "Future CPSS Enabling Innovative Life"

① Application/System Codesign

- Requirement engineering

Future CPSS

② CPSS Architecture

- Platform architecture & architectural framework
  - Cloud data/supercomputer center
  - Sensor/actuator network
  - Software stack
  - Standard interfaces
- Hybrid model&data-driven control theory
- HPC4CPSS (Supercomputer for CPSS)
  - Online realtime simulation

③ Design Methodology

- MDD (Model-Driven Design)
- MBD (Model-Based Development)
- Formal design method for CPSS