

ENABLING CYBER - PHYSICAL - SOCIAL SYSTEMS(CPSS) FOR A BETTER FUTURE

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ENABLING CYBER-PHYSICAL-SOCIAL SYSTEMS (CPSS) FOR A BETTER FUTURE

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JEC-ECC2012 Alexandria, Egypt

A BETTR FUTURE: CAN WE PROTECT OURSELVES?



Technologies required to
sense geo-spatial data
process large data in shorter time
alerts in an efficient way?

Sensing technology

Computational power

Efficient Applications

ANOTHER WORLD: THE UNFORTUNATE FACTS

The Unreached	Category
3 billion people live on less than \$2.50/day	<i>Poverty</i>
1 billion people unable to read	<i>Education</i>
1.5 million children die of diarrhea each year	<i>Health</i>
1.6 billion people live without electricity	<i>Energy</i>
• • •	• • •

Can we change these facts?

YES WE CAN!!
CPSS HAS AN ANSWER!!!

OUR VISION



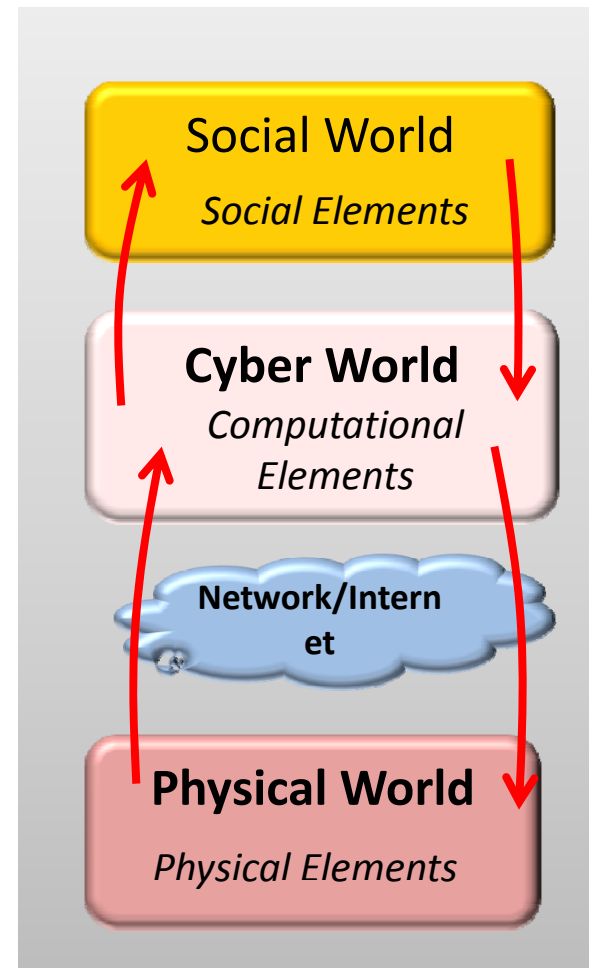
Our life shall be made better by means
of "CPSS"!

CPSS

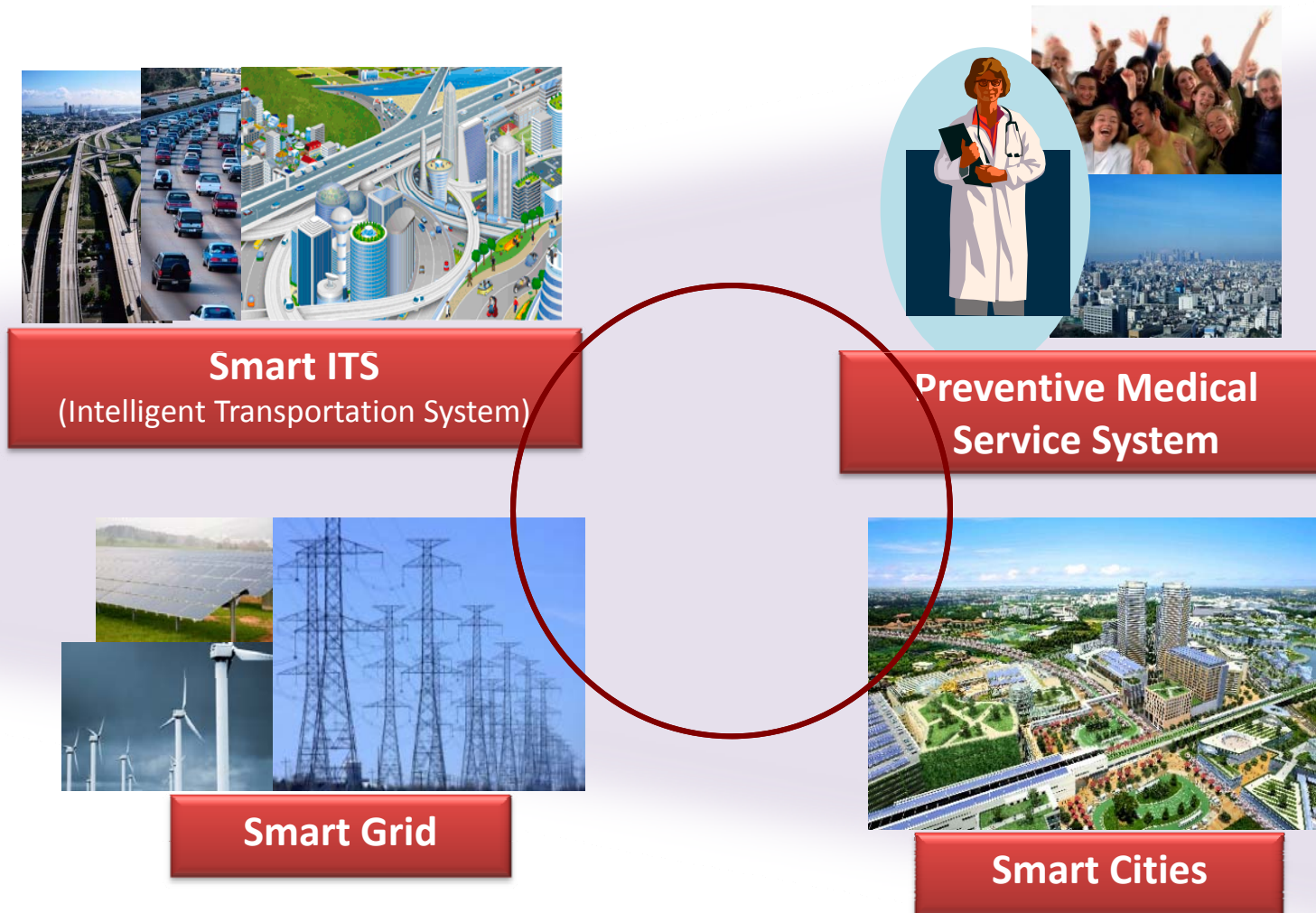
(CYBER-PHYSICAL-SOCIAL SYSTEMS)

Cyber-Physical Social Systems (CPSS)

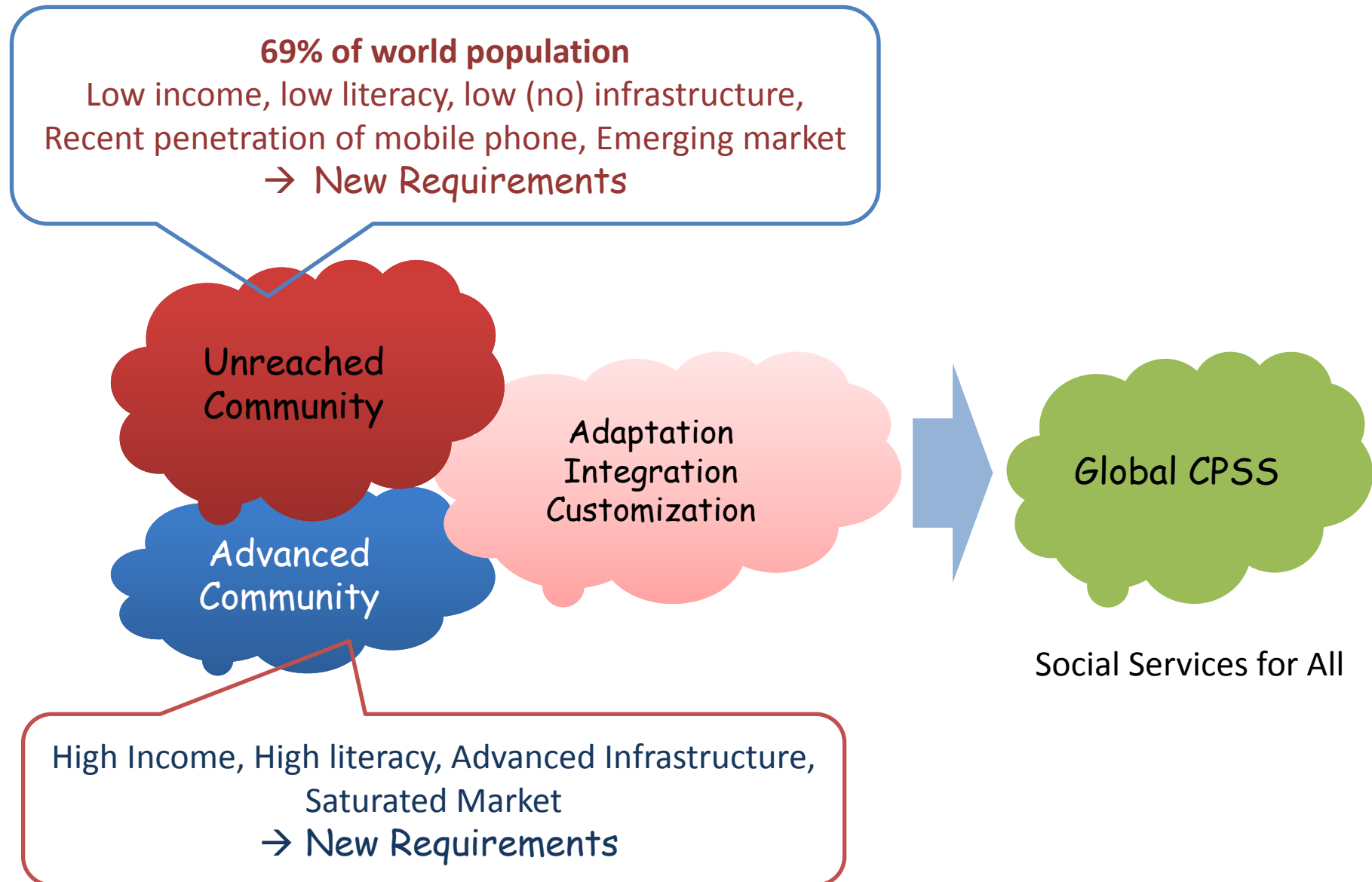
Merging computing, networking and society with physical systems to create new revolutionary science, technical capabilities and **better quality of life**.



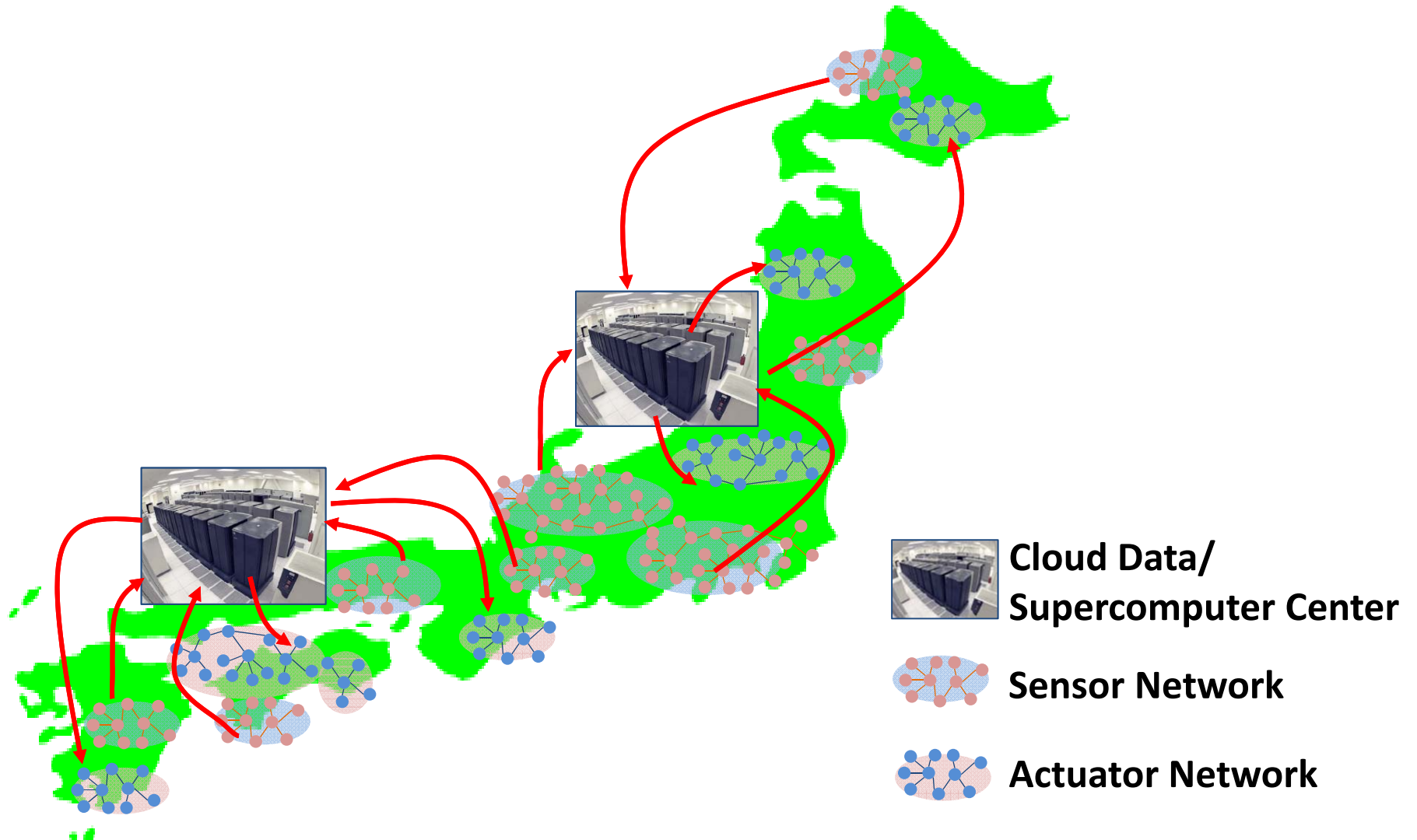
INDIVIDUAL SYSTEMS NEED TO BE CONNECTED



COMMUNITIES NEED TO BE CONNECTED



CITIES NEED TO BE CONNECTED



COUNTRIES NEED TO BE CONNECTED



CONTINENTS NEED TO BE CONNECTED

Current Cyber Physical World



Not all are connected yet!!

Future Cyber Physical World

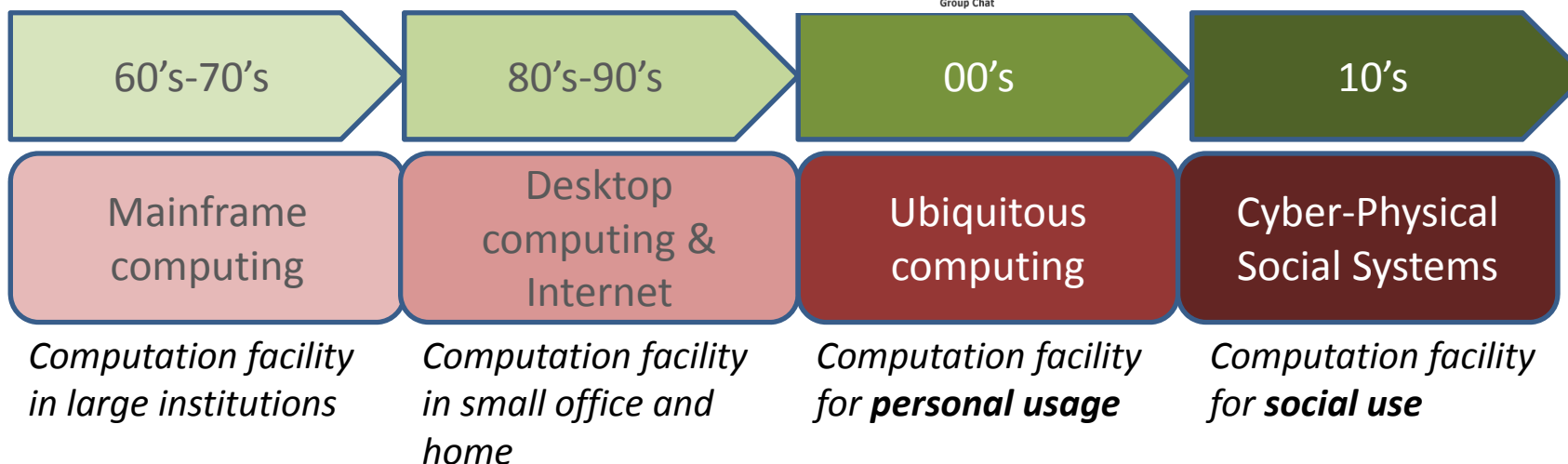
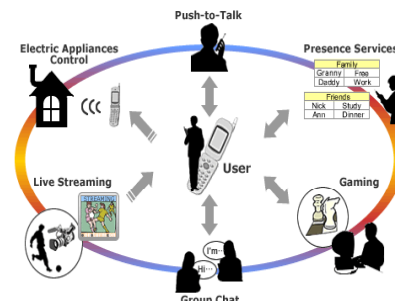
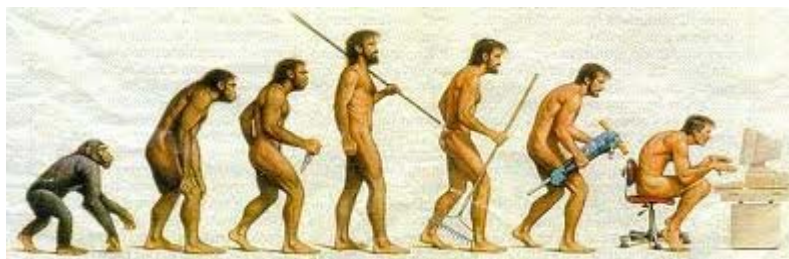
Distributed,
Asynchronous and
Hybrid Dynamic System



**Larger, More Flexible and Robust
Useful for the majority**

TECHNOLOGIES WE HAVE TO SUPPORT CPSS

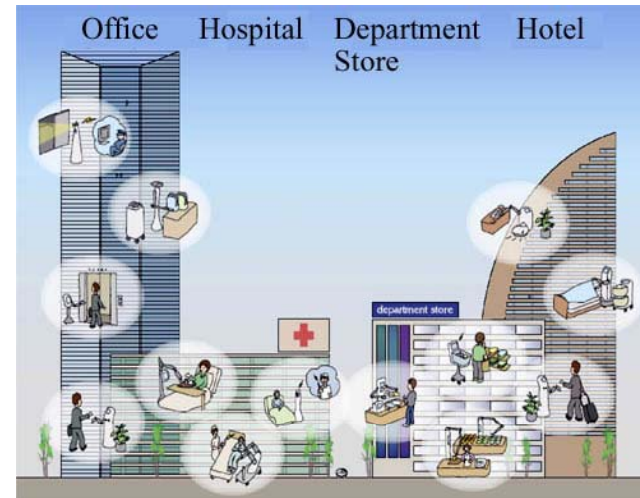
THE NEXT COMPUTING REVOLUTION



SENSORS IN SMART INFRASTRUCTURES



Smart Cities



Smart Zones



Smart Bridges

JEC-ECC2012, Alexandria, Egypt



Smart Buildings

SMART CARS AS NETWORK OF COMPUTERS



Cars drive themselves



"Computers on Wheels"

EMBEDDED MEDICAL DEVICES

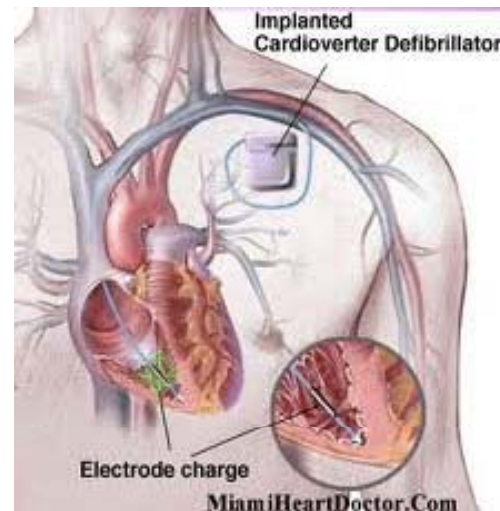
- AUGMENTATION OF HUMAN CAPABILITIES -



Portable



At Hospital



Implantable



Wearable

ROBOTS' ROLE!!



Houses



Industry



Inaccessible environments



Transportation

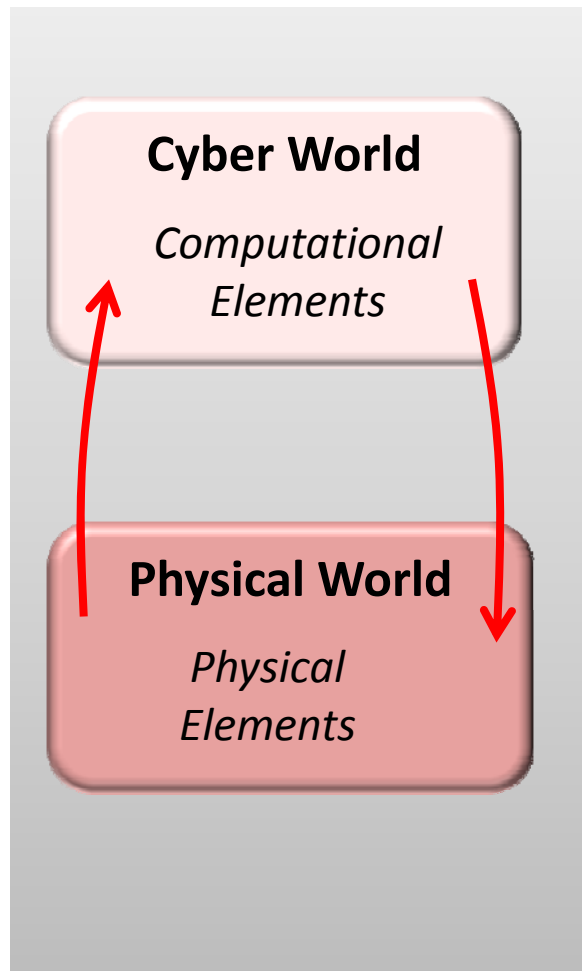


Operating rooms

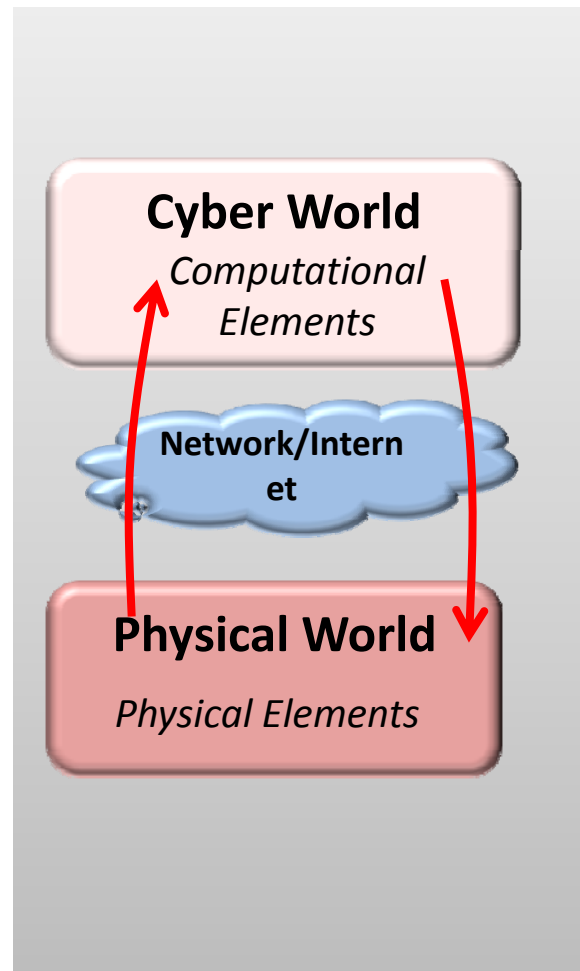


Nursery

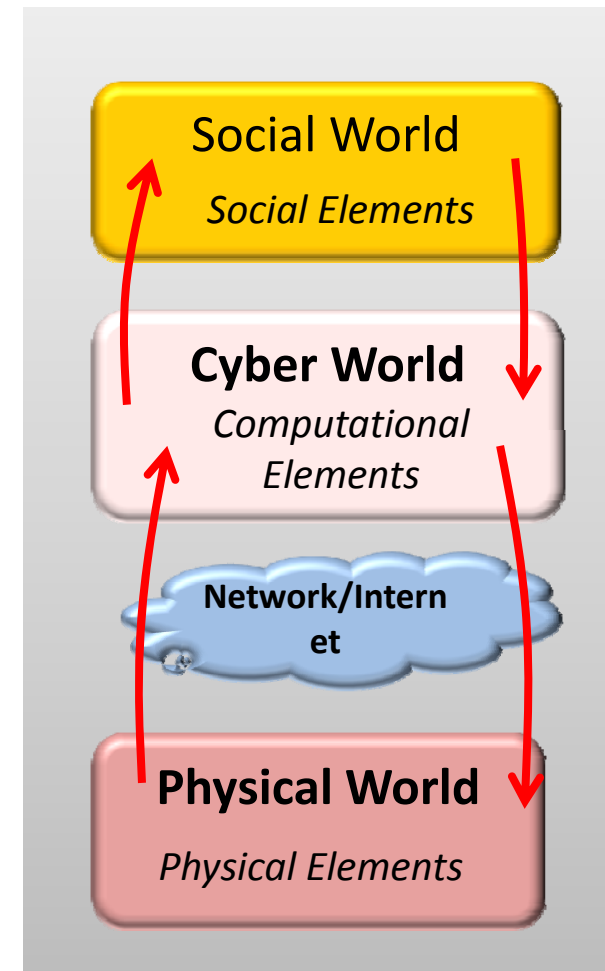
ORIGINS OF CPSS



ES(Embedded System)

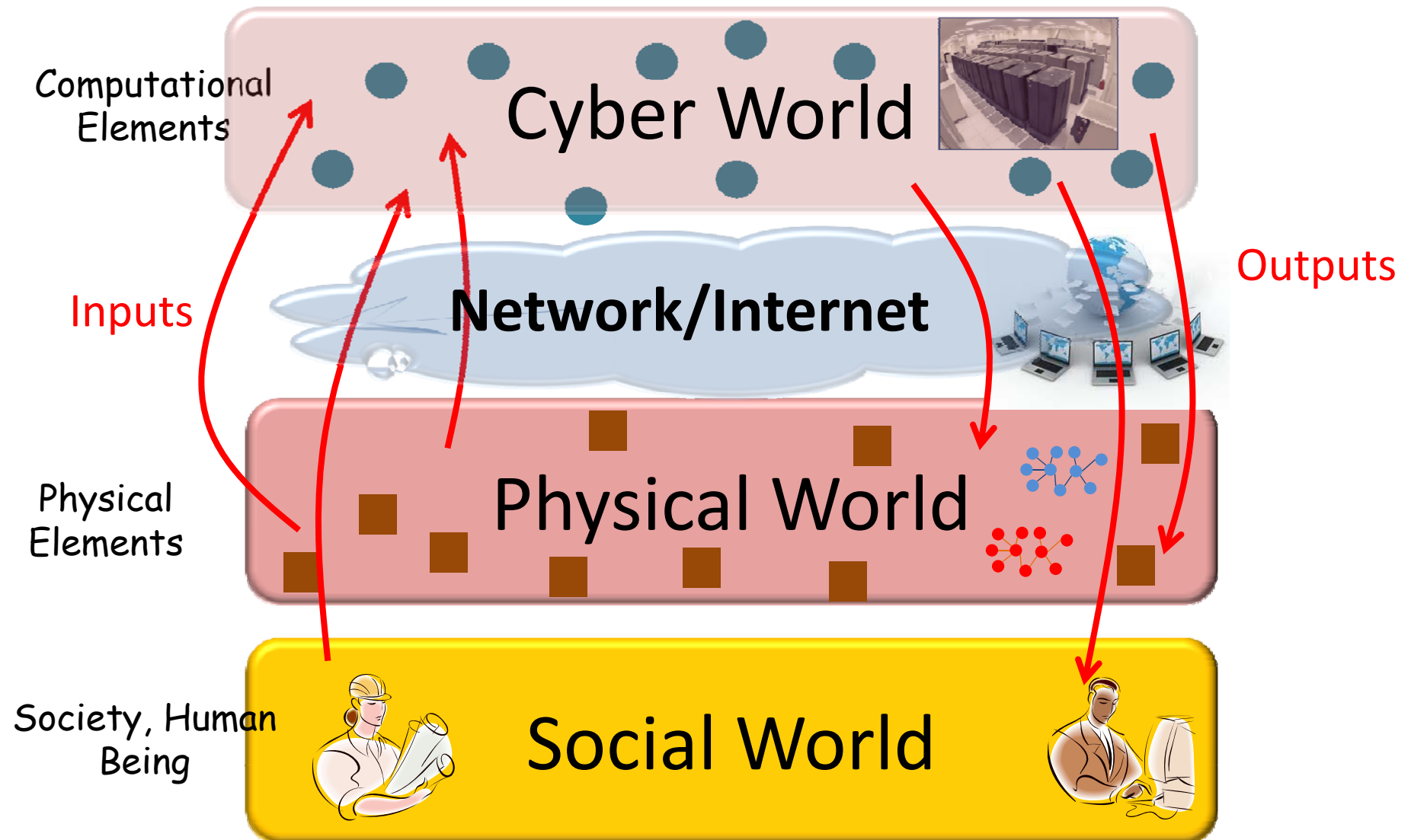


CPS (Cyber Physical System)



CPSS (Cyber Physical Social System)

CPSS (CYBER-PHYSICAL-SOCIAL SYSTEM)

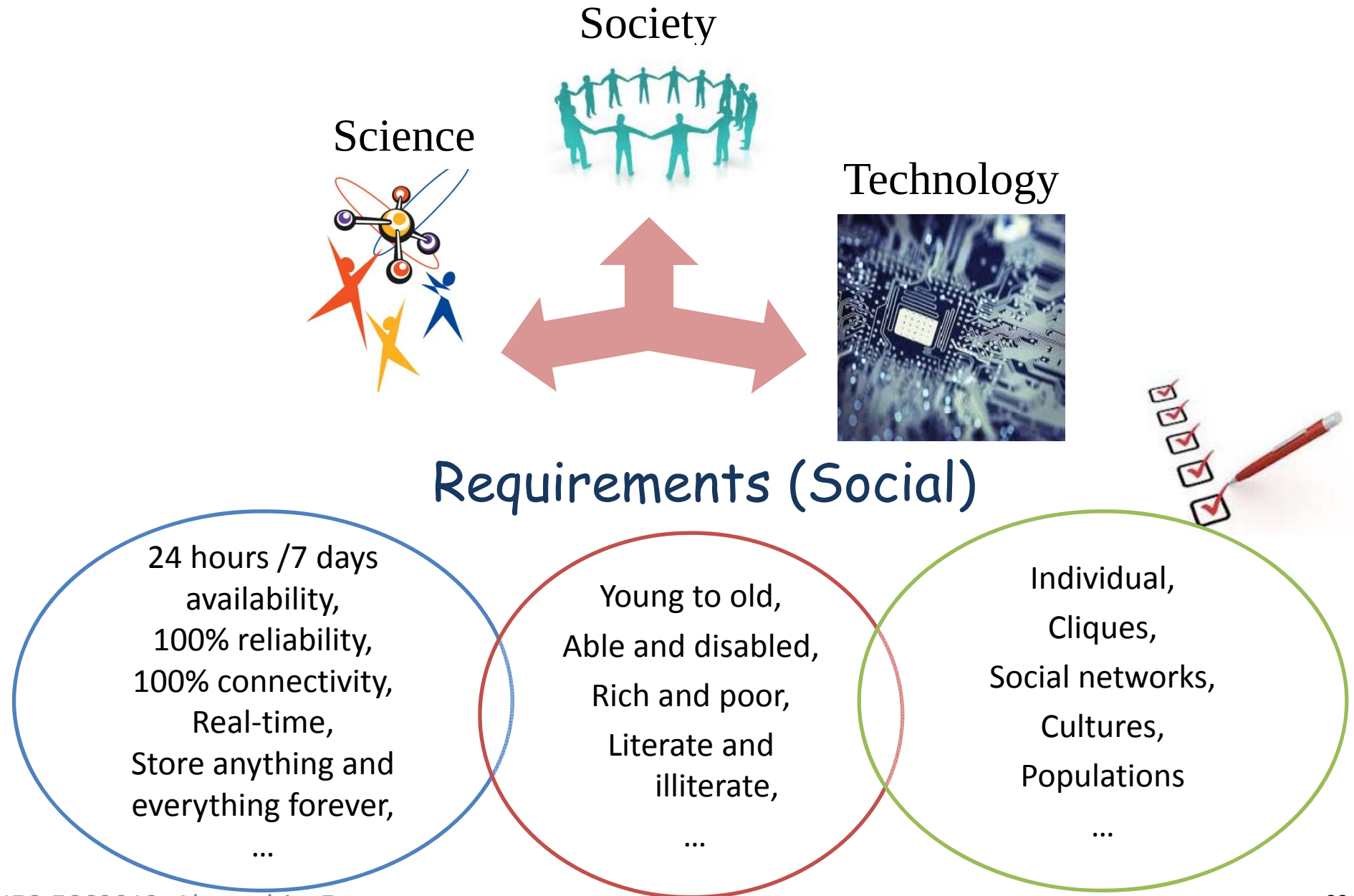


CPSS (CYBER-PHYSICAL-SOCIAL SYSTEM)

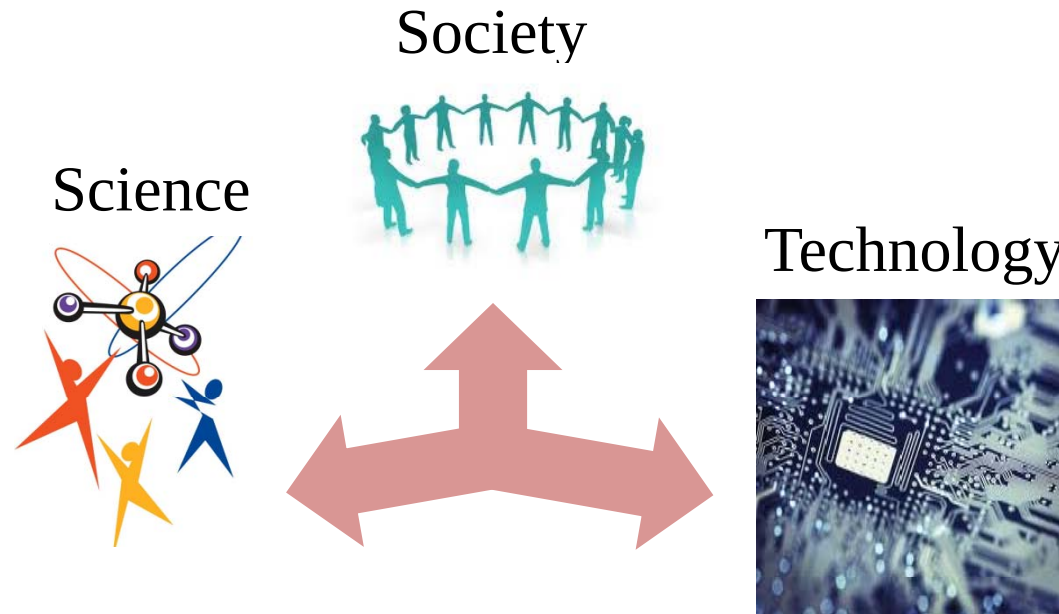


CPSS CHARACTERISTICS

CPSS DRIVERS AND REQUIREMENTS



CPSS DRIVERS AND REQUIREMENTS



Requirements (Social)

CPSS should be everywhere,
used by everyone,
for everything



CPSS INCLUDES THE UNREACHED COMMUNITY

Natural Disaster
Emergency Service

Healthcare

Micro Finance
Practical Education

Agriculture

Multi-Culture
Multi-Language
New Applications

ICT

Mobility
Affordability

Sustainability

REACHING THE UNREACHED

New device, New Service, New Information Architecture



ePassbook

One Family One Card



GramWeb

One Village One Portal



Portable Clinic

One Community One Clinic



Healthcare
Booth

One Community One Booth

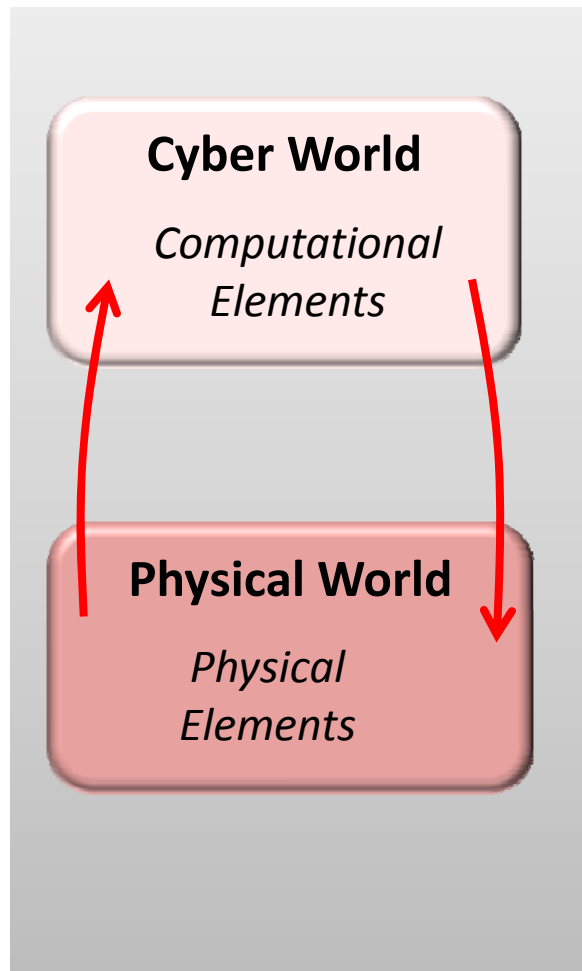


Social Services on Wheels(SSW)

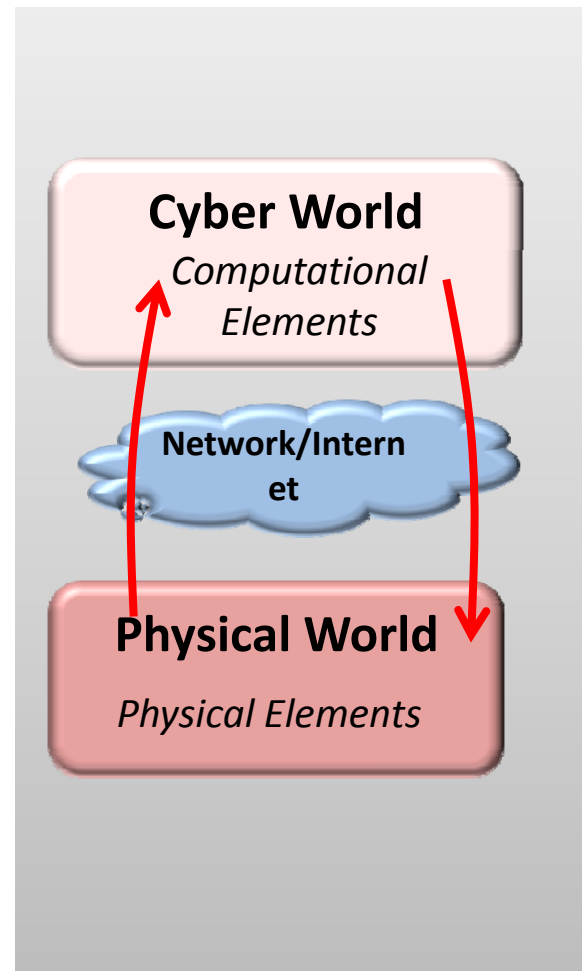
One District One Nomadic Kiosk

TECHNOLOGICAL ASPECTS

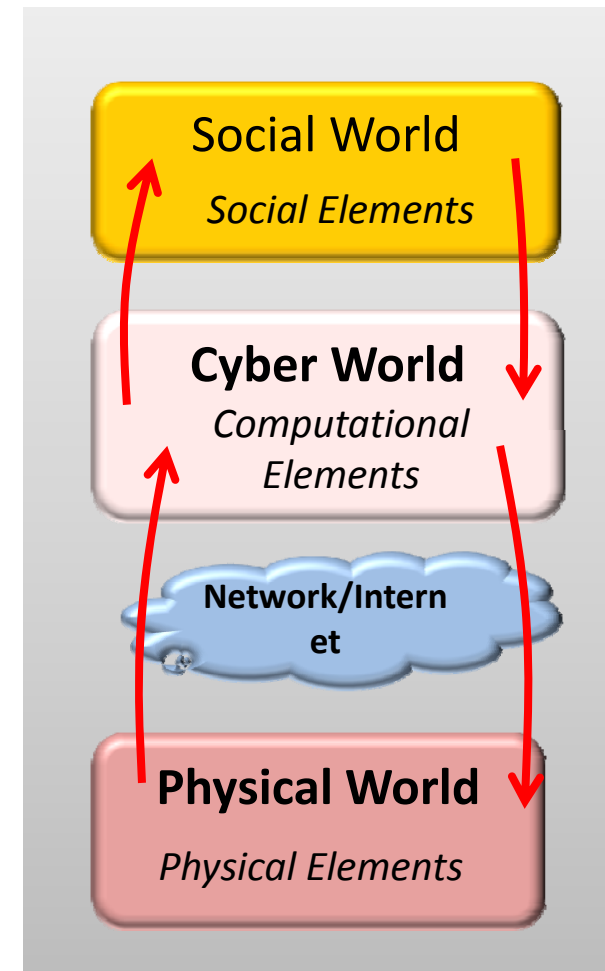
CLASSIFYING ES, CPS, AND CPSS



ES(Embedded System)



CPS (Cyber Physical System)

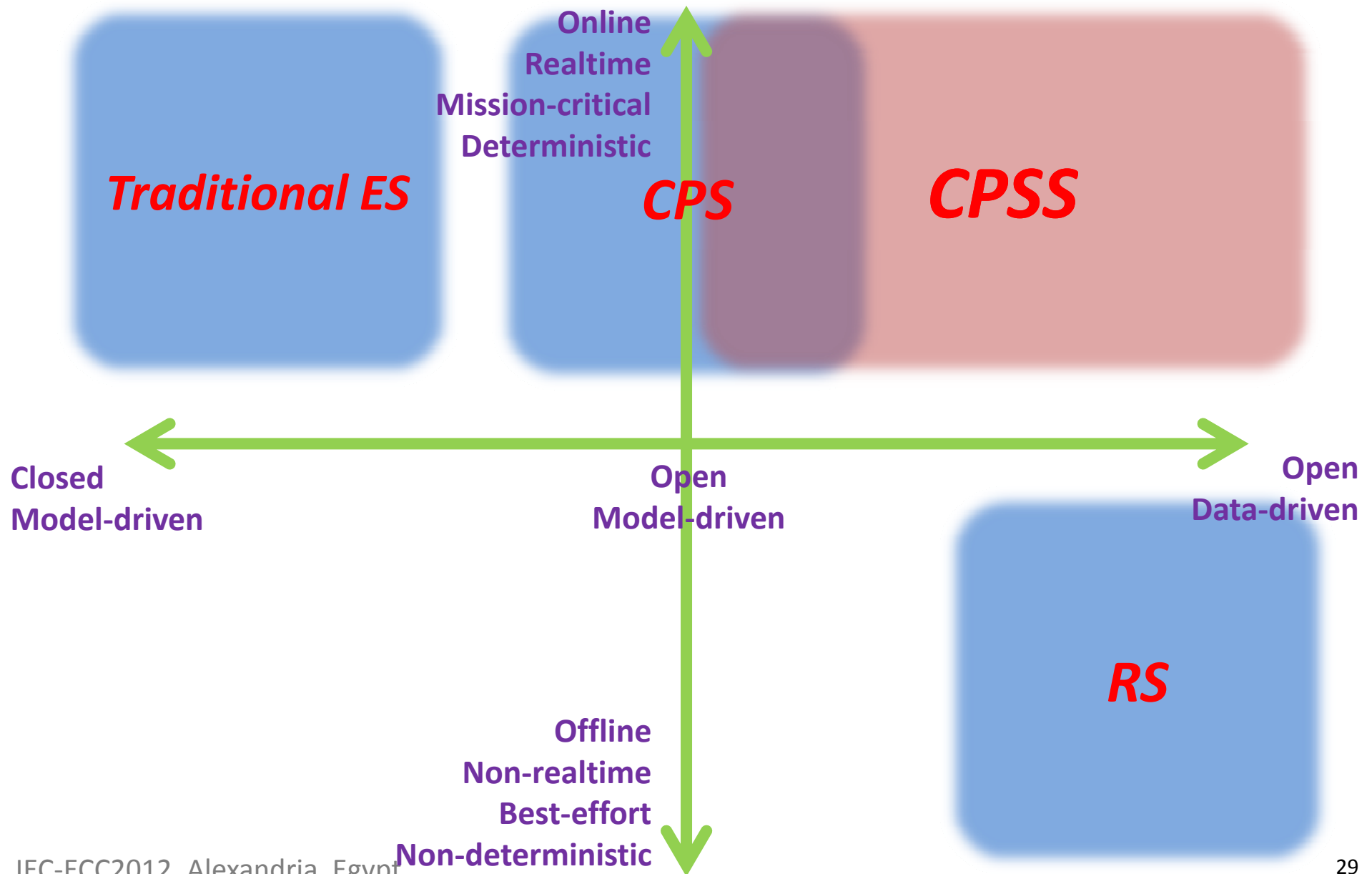


CPSS (Cyber Physical Social System)

CLASSIFYING ES, CPS, RS (RECOMMENDATION SYSTEM), AND CPSS

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

CLASSIFYING ES, CPS, RS, AND CPSS



HYBRID MODEL & DATA-DRIVEN CONTROL THEORY

Hybrid Model & Data-Driven

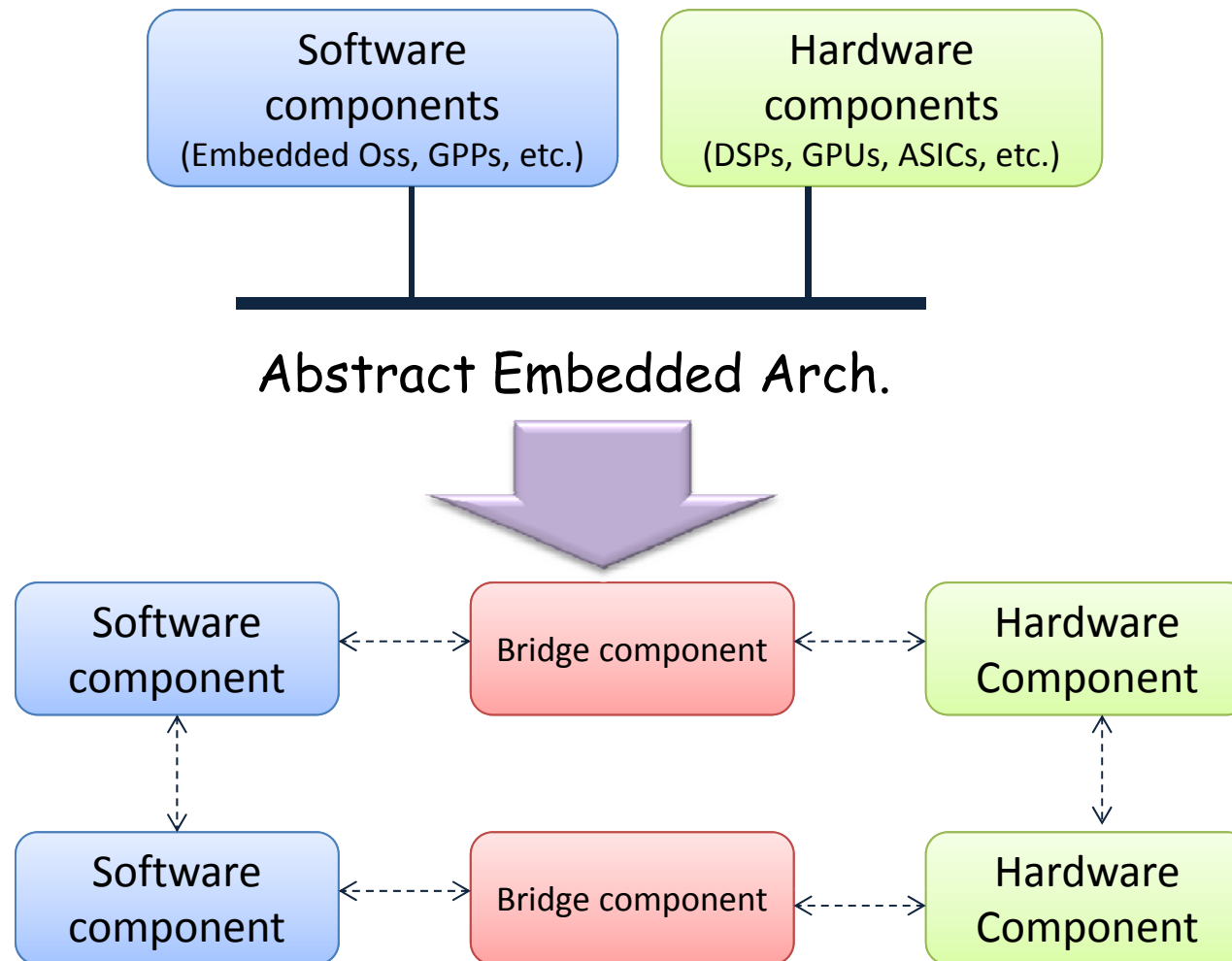
Model-Driven

- Traditional Control Theory
 - Feedback
 - Feedforward
- Simulation

Data-Driven

- BigData
- Data Mining
- Knowledge Mining
- Data Assimilation

A MODEL FOR CYBER SYSTEMS ARCHITECTURE



A bridge component is filling the semantic gaps of components for execution and interface

A Unified Component Model for CPSS

NEXT-GENERATION CPSS GRAND CHALLENGES IN SOFTWARE SYSTEM DESIGN

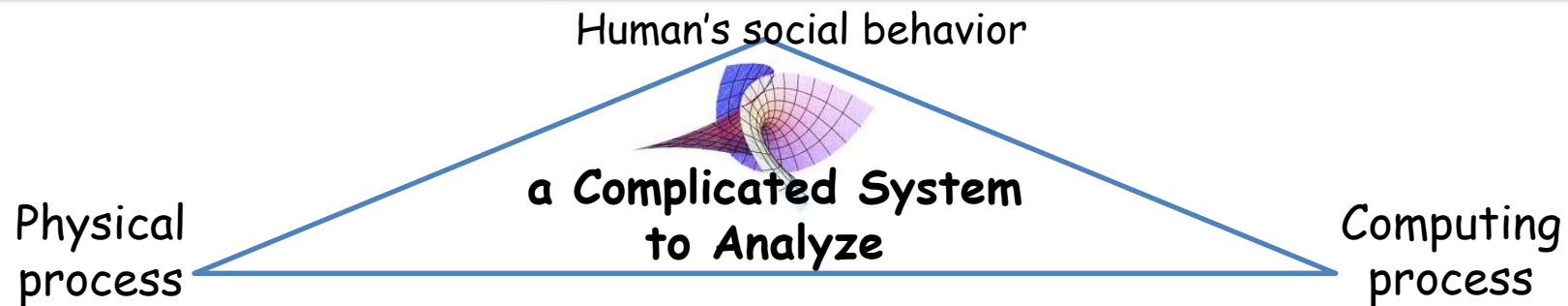
Limitations

- Complex physical environments
- The immense diversity of hardware platforms
- The diversity of applications themselves and their requirements

Challenges

- The design of an underlying software architecture
- The automatic composition of services
- Careful design of APIs and consideration of hardware heterogeneity

CPSS CHARACTERISTICS



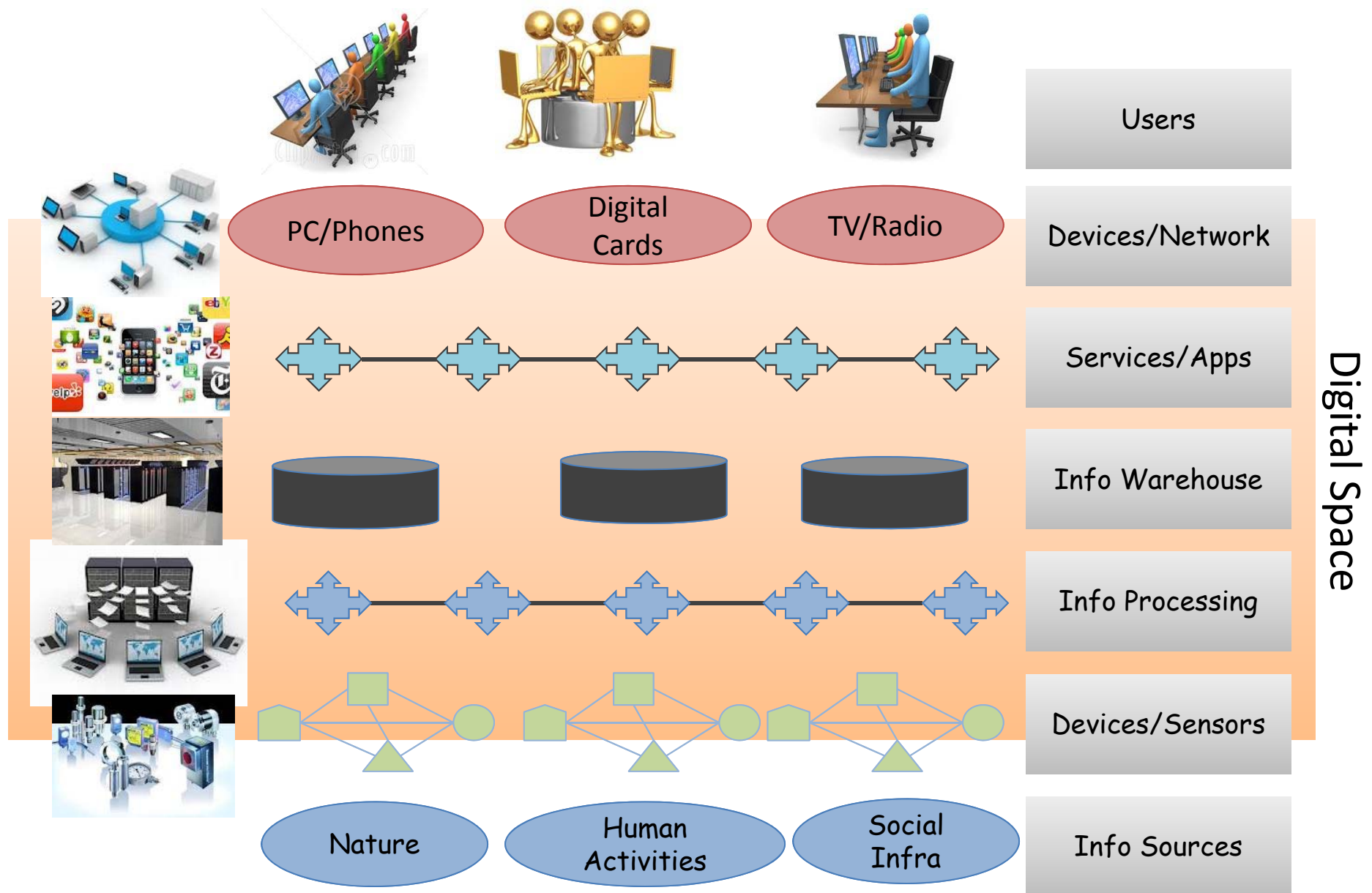
Technical Limitations of Today's CPSS

- Lack of a unified view of physical, hardware, and software entities
- Lack of sufficient modularity and flexibility → difficult to get integrated to CPSS
- Development in isolation, Combining in ad-hoc fashion
- Difficulty of establishing correctness, realtimeness, and performance properties
- Incompetent management of massive data, info. processing, analysis, and retrieval

Important Development Challenges

- A unified component model
- Bridging significant semantic gaps
- Scalable design, Analysis and Validation Capabilities
- Safety, Security and Reliability

CPSS LAYERS



CPSS EXAMPLES

OPTIMIZE THE PLANET BY MEANS OF CPSS SYSTEMATICALLY



Smart ITS
(Intelligent Transportation System)



**Preventive Medical
Service System**

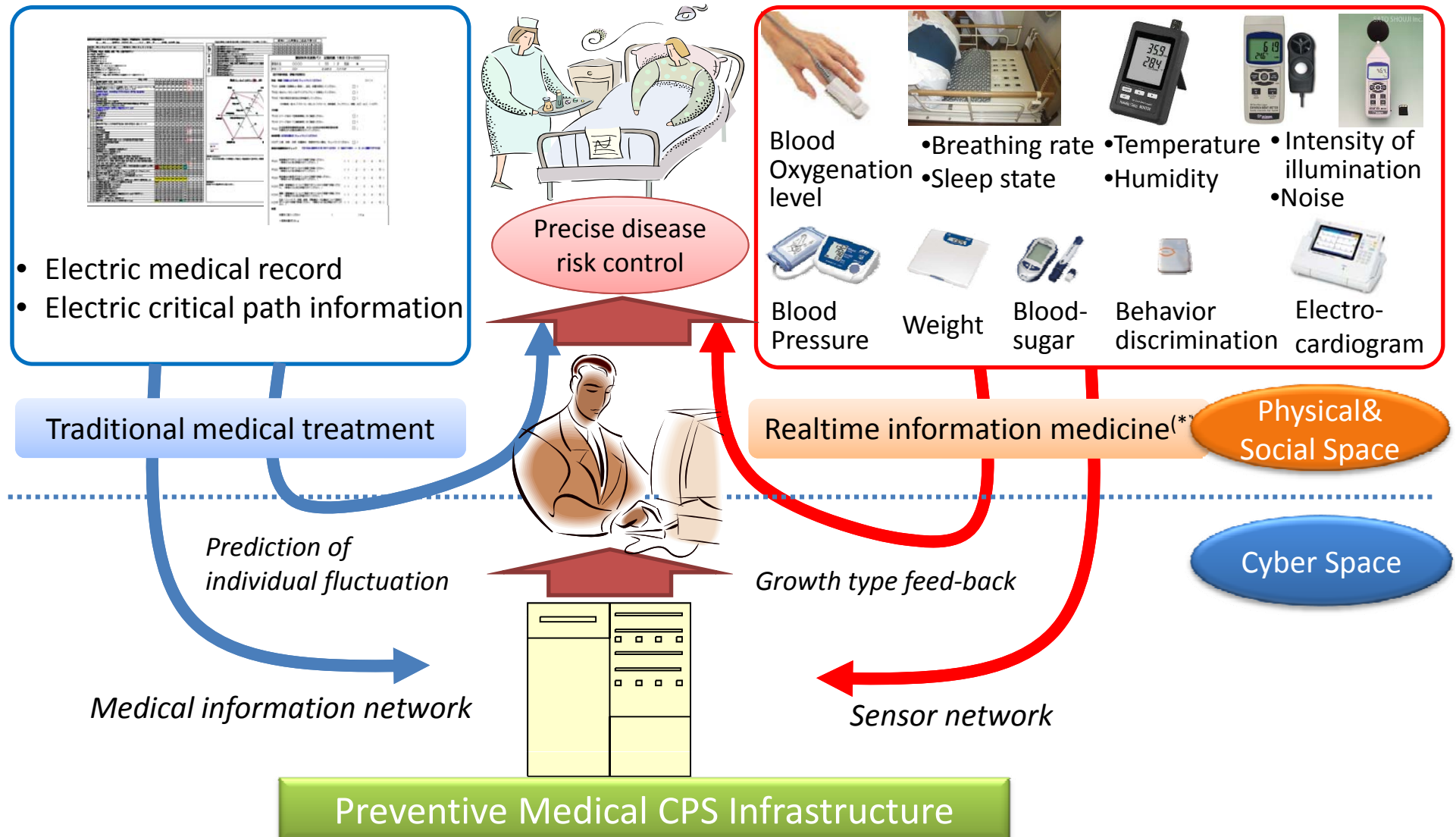


Smart Grid



Smart Cities

PREVENTIVE MEDICAL SERVICE SYSTEM



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

CPSS FOR AUTOMOTIVE

- **Safety** : most serious challenge in automotive transportation
→ Thousands of deaths, Millions of injuries, hundreds of billions economical cost!

The World Health Organization Prediction

Road traffic accidents will be the 3rd leading cause of death
by the year 2020

CPSS FOR AUTOMOTIVE

- **Safety** : most serious challenge in automotive transportation
→ Thousands of deaths, Millions of injuries, hundreds of billions economical cost!

The World H

Road

Grand Challenges:

Minimizing Traffic Deaths

Minimizing Traffic Congestion

leath

CPSS FOR AUTOMOTIVE

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The World Health Organization Prediction

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Solutions

Constructing new roads or improving existing facilities?

CPSS FOR AUTOMOTIVE

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The World Health Organization Prediction

Road traffic accidents will be the 3rd leading cause of death
by the year 2020

Solutions

~~Constructing new roads or improving existing facilities?~~
Expensive and leads to several environmental, political and social issues.

CPSS FOR AUTOMOTIVE

- **Safety** : most serious challenge in automotive transportation
→ Thousands of deaths, Millions of injuries, hundreds of billions economical cost!

The World Health Organization Prediction

Road traffic accidents will be the 3rd leading cause of death
by the year 2020

Solutions

Improving single vehicle safety technology AND
Telecommunicating, computing, processing and sharing on-line
traffic information under a **CPSS**

SENSOR-NETWORKED ITS (INTELLIGENT TRANSPORTATION SYSTEM)

Collecting data from
the sensors on vehicles

Sending data to data
centers via WAN

Analyzing
data in data
center

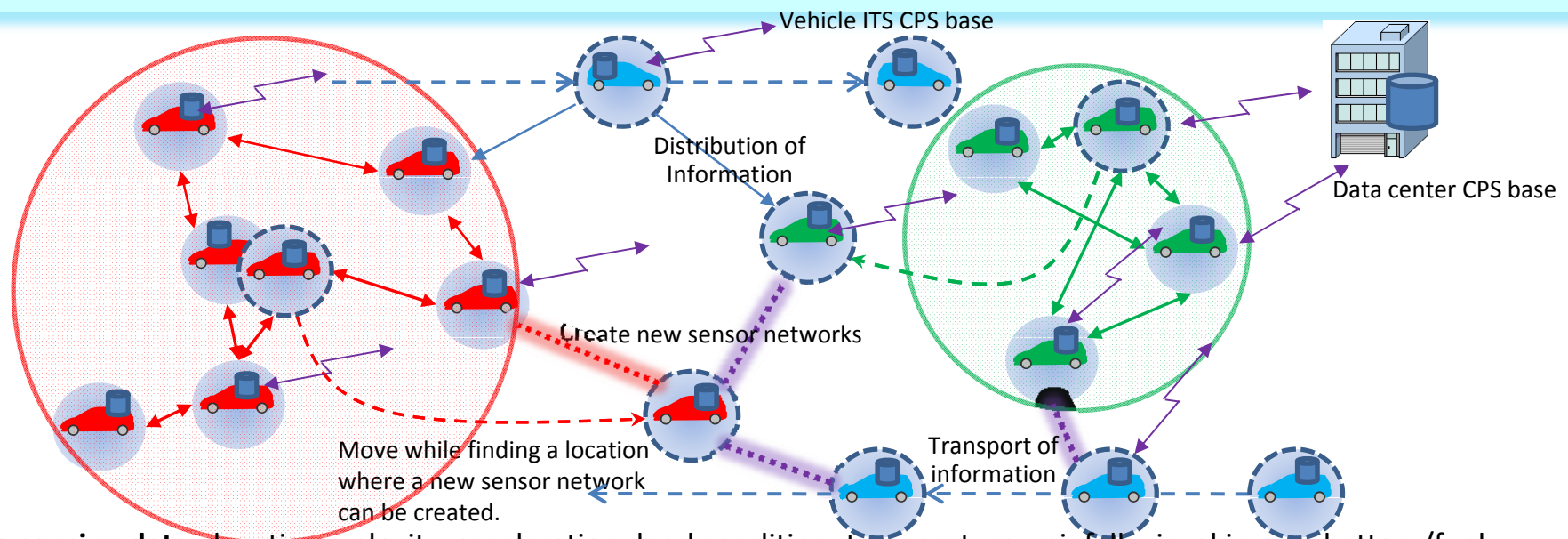
Guiding vehicles for
efficiency and safety

The analyzed data in the data center is shared using vehicle to vehicle communication

→ to improve own traffic information, and traffic efficiency and safety!

The vehicle-to-vehicle communication

→ for creating sensor network to provide min. communication capability in an emergency condition!



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

SUMMARY

OUR VISION AND MISSION

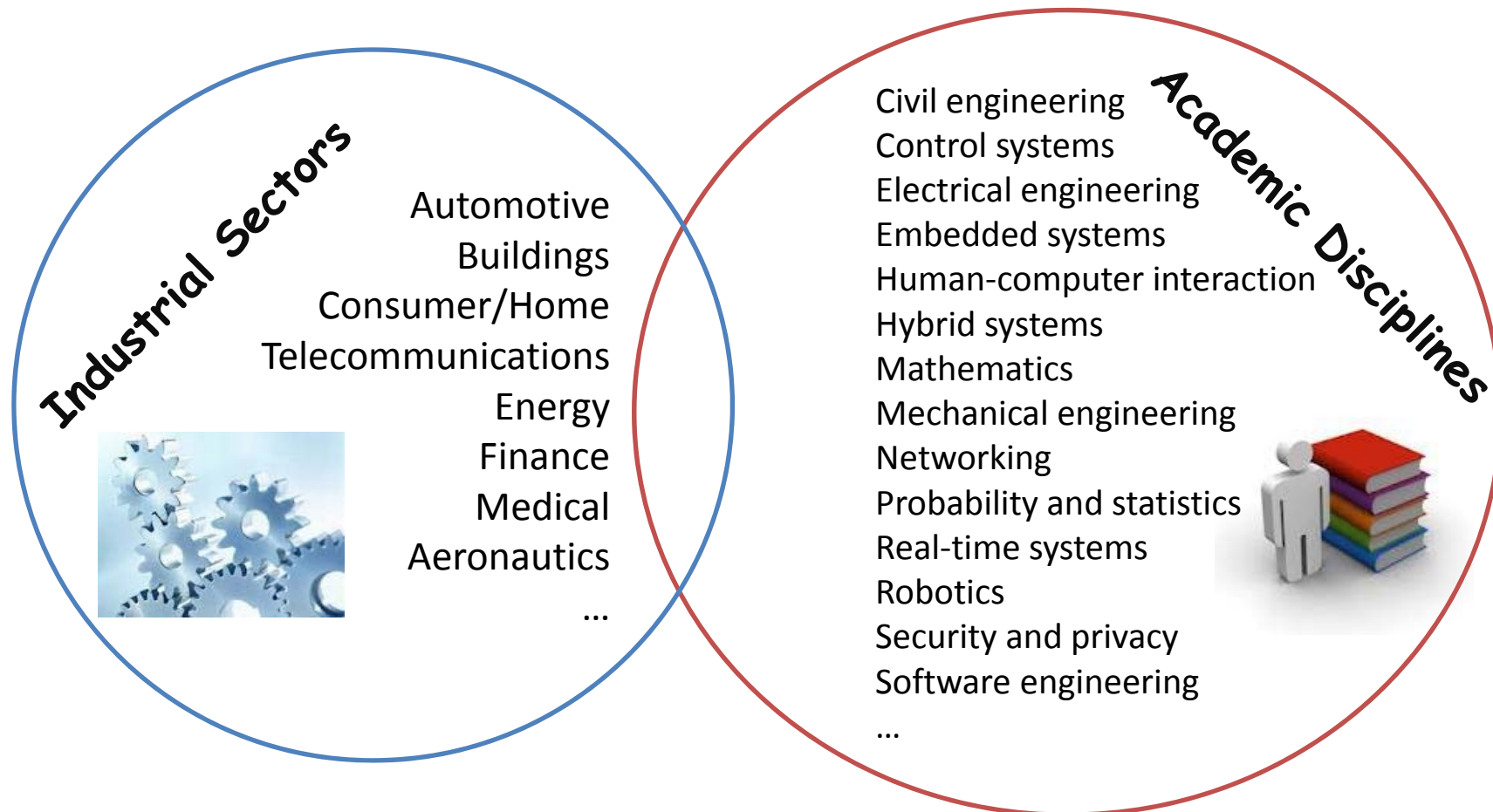


Vision: Our life shall be made better by means of "CPSS"!

Mission: Developing technologies enabling future "CPSS"!

A Key Challenge: Very **Interdisciplinary** Nature of CPSS

Theoreticians, Domain experts, Society
Computer scientists, Engineers (of all types)
Industry, Academia, Government



SUMMARY

Cyber-Physical-Social Systems (CPSS)

Merging computing, networking and society with physical systems to create new revolutionary science, technical capabilities and **better life quality**.

Extraordinary significance for the **future of the societies**.

Falling behind in the foundations of CPSS may render our scientific and technological infrastructure obsolete.

Whether we recognize it or not:

We are in the midst of a pervasive, profound shift in the way humans engineer physical systems and manage their physical environment.

[CPS Computing Community Consortium]

Enabling **Cyber-Physical Social Systems (CPSS)** for a Better Future Merging computing, networking and society with physical systems to create new revolutionary science, technical capabilities and better life quality.



Extraordinary significance for the future of

infrastructure obsolete. Whether we recognize it or not: We are in the midst of a pervasive, profound shift in the way humans engineer physical systems and manage their physical environment. Future **Cyber Physical World Distributed, Asynchronous and Hybrid Dynamic System Larger, More Flexible and Robust Useful for the majority Vision: Making a better life by means of “CPSS” systematically! Mission: Developing technologies enabling future “Cyber-Physical Social System”!** Merging computing, networking and society with physical systems to create new revolutionary science, technical capabilities and better life quality. **CPSS** will transform the way people interact with engineered systems, just as the Internet transformed the way people interact with information. Extraordinary significance for the future of the **societies**.

Whether we recognize it or not: We are in the midst of a pervasive, profound shift in the way **humans** engineer physical systems and manage their physical environment. Future **Cyber Physical World Distributed, Asynchronous and Hybrid Dynamic System Larger, More Flexible and Robust Useful for the majority Vision: Making a better life by means of “CPSS” systematically! Mission: Developing technologies enabling future “CPSS”!** Merging computing, networking and society with physical systems to create new revolutionary science, technical capabilities and better life quality. Extraordinary significance for the future of the **societies**. Falling behind in the foundations of **CPSS** may render our scientific and technological infrastructure obsolete.

Whether we recognize it or not: We are in the midst of a pervasive, **profound shift** in the way **humans** engineer physical systems and manage their physical environment.

Thank You!

شكراً

Any Questions!

BACKUP SLIDES

Response time
(real-timeness)



Security & Privacy



Availability



Warning Systems
(hazards and emergencies)



Seamless Service



What Society
is Concerned
About?



Transparency
(Ease of use)



Reliability



Popularity of Services



Flexibility

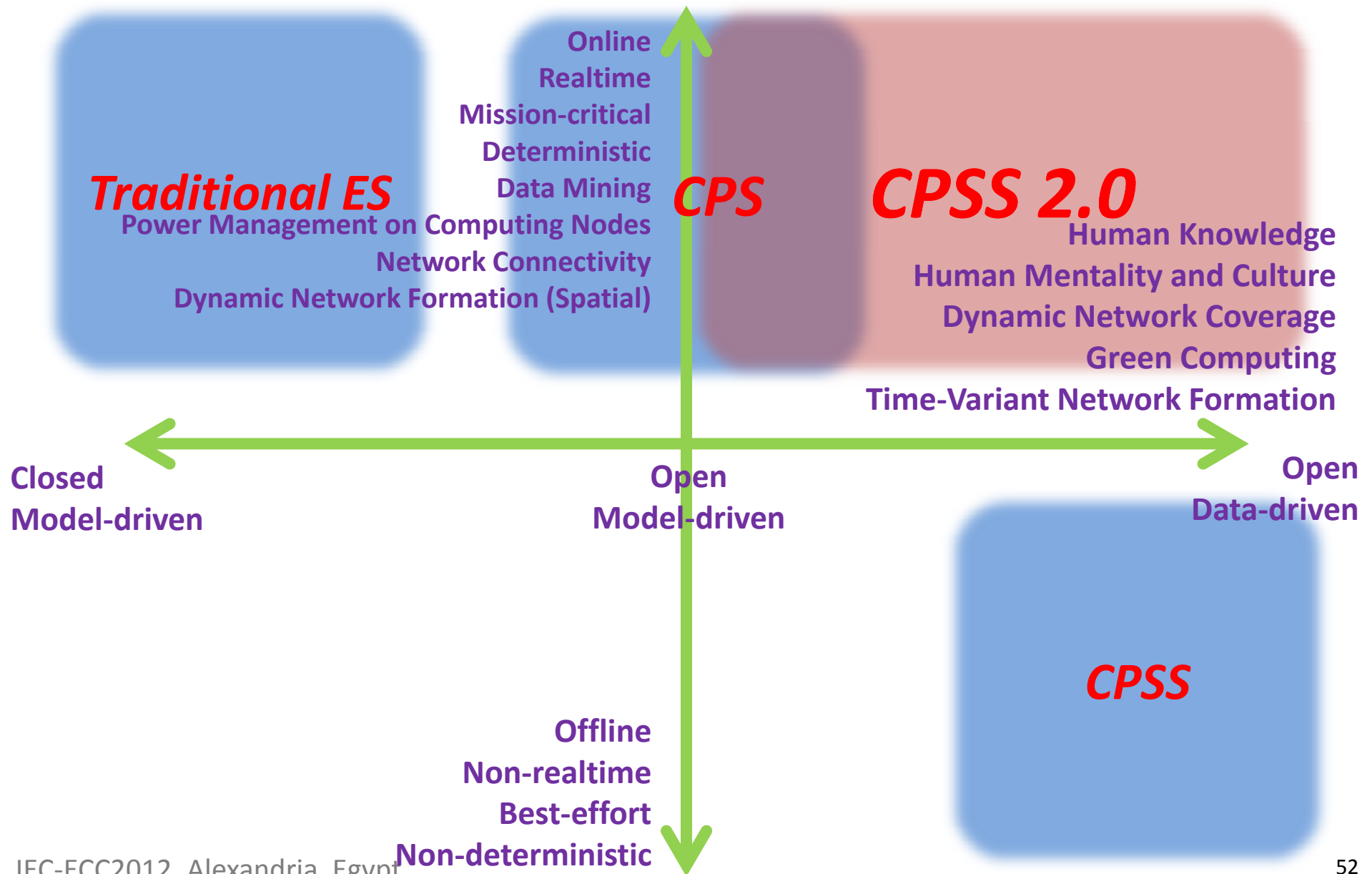


Costs

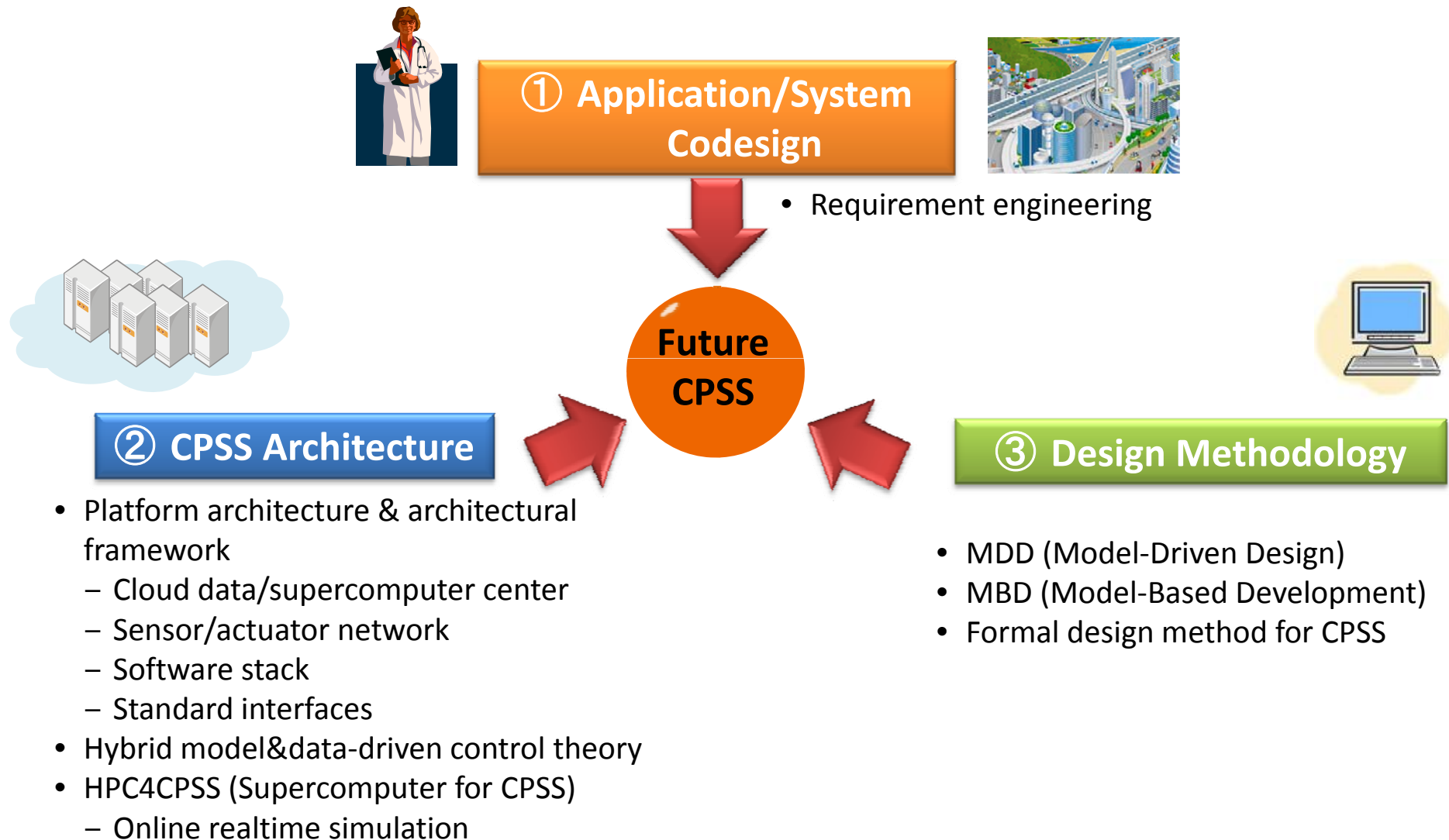
CLASSIFYING ES, CPS, AND CPSS

Taxonomy		ES	CPS	CPSS	CPSS 2.0
Feedback	Offline			✓	
	Online	✓	✓		✓
Realtimeness	Non-realtime			✓	
	Realtime	✓	✓		✓
System	Closed	✓			
	Open		✓	✓	✓
Criticality	Best-effort			✓	
	Mission-critical	✓	✓		✓
Control	Model-driven	✓	✓		✓
	Data-driven			✓	✓
Effects of Feedback	Nondeterministic			✓	
	Deterministic	✓	✓		✓
Knowledge Mining	Data Mining		✓	✓	✓
	Human Knowledge				✓
	Human Mentality & Culture				✓
Power Management	Computing nodes	✓	✓	✓	✓
	All elements (Green Computing)				✓
Network Connection	Connectivity		✓	✓	✓
	Dynamic Coverage				✓
Network Formation	Dynamic topology (spatial)		✓		✓
	Time-varying deployment				✓

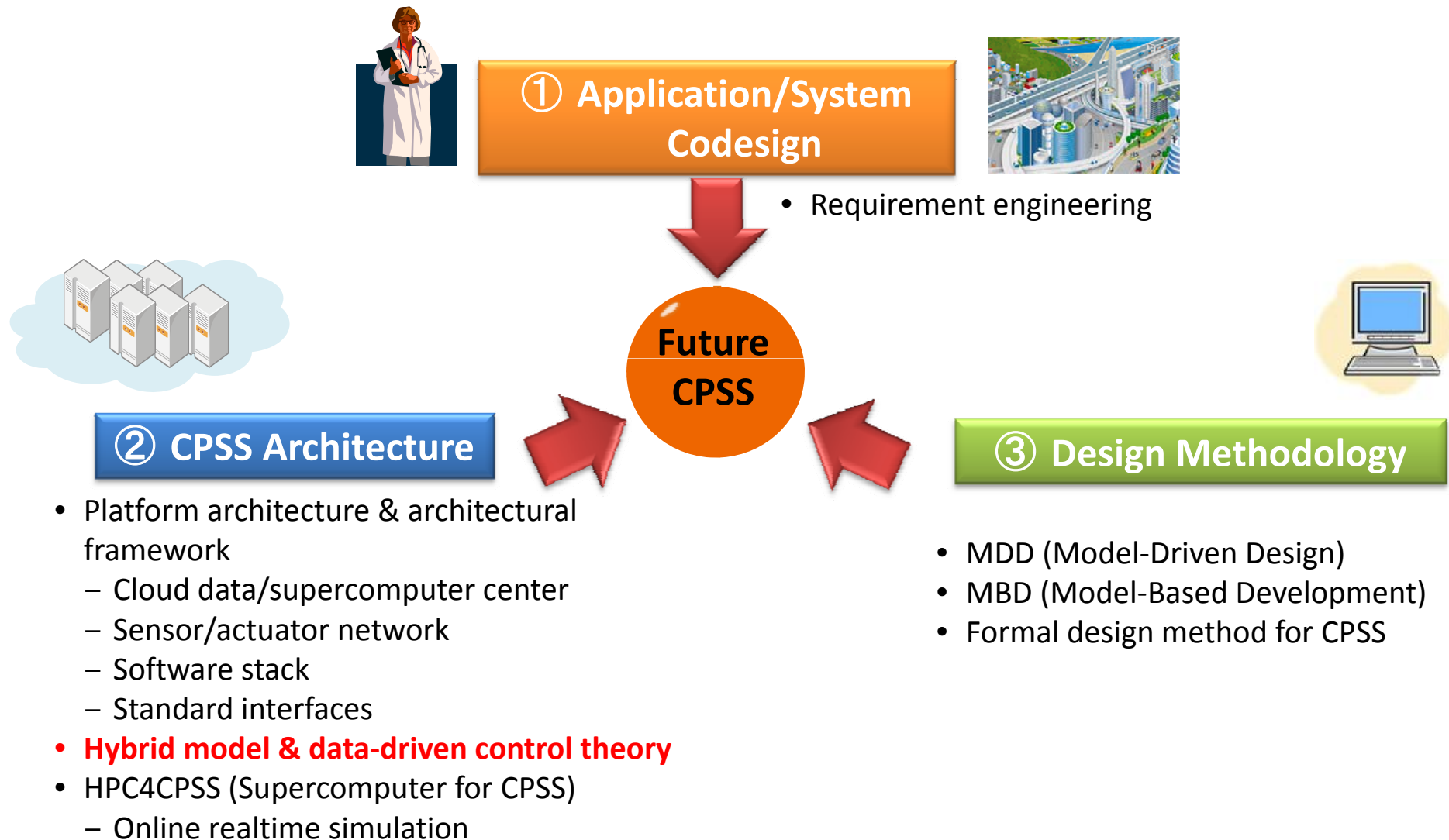
CLASSIFYING ES, CPS, AND CPSS



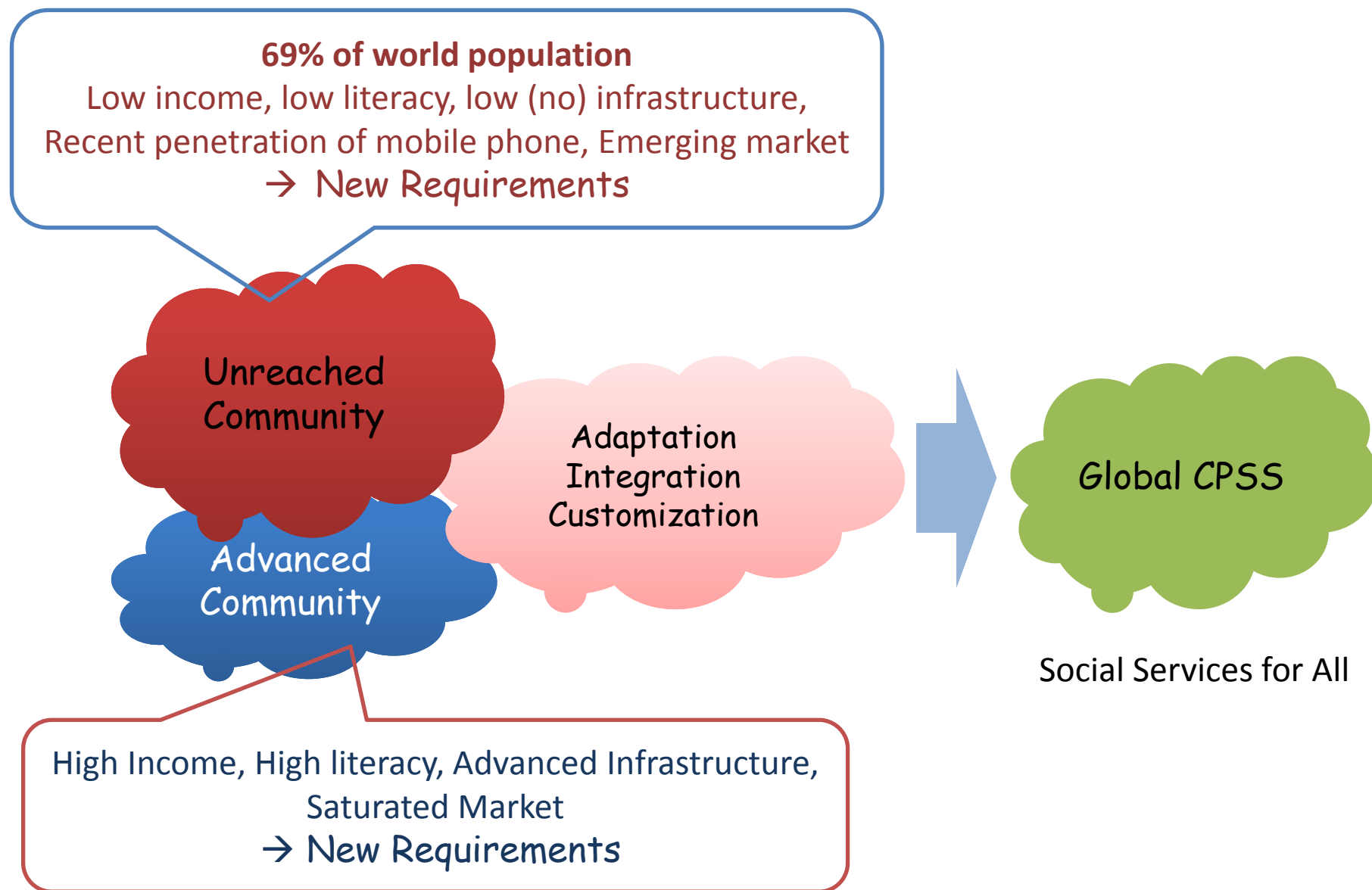
TECHNOLOGIES ENABLING FUTURE CPSS



TECHNOLOGIES ENABLING FUTURE CPSS



REALIZING GLOBAL CPSS



CPSS FOR ASSISTED LIVING

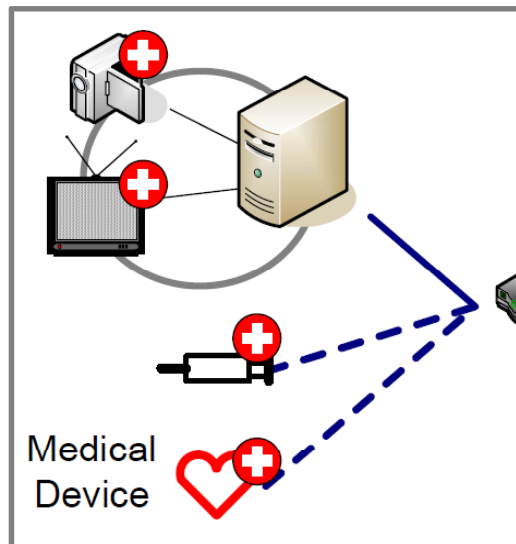
Deteriorating capabilities to sense and interact with the environment for *elderly people*



Live with significantly degraded life quality

Assisted Living Model

Home Environment



Gateway

Monitoring Service



Clinician Service



• Technical Objectives

- Ease of use and ease of deployment
- Security and privacy
- Quality-of-service provisioning
- Evolvability and interoperability
- Safety, robustness and availability

[Courtesy of J. C. Hou and L. Sha, Univ. of Illinois]