# Cyber-Physical Cloud Computing as a Future Cloud

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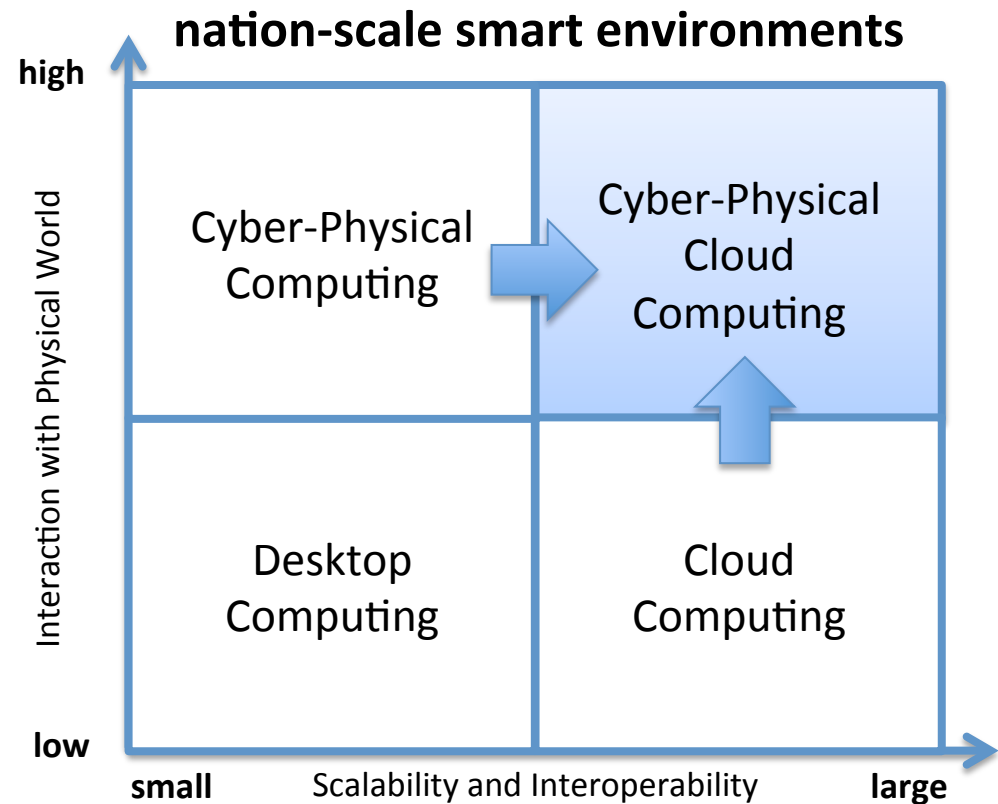U.S. Department of Commerce

# Requirement 8: Collaborative parallel strategic "future cloud" development initiatives

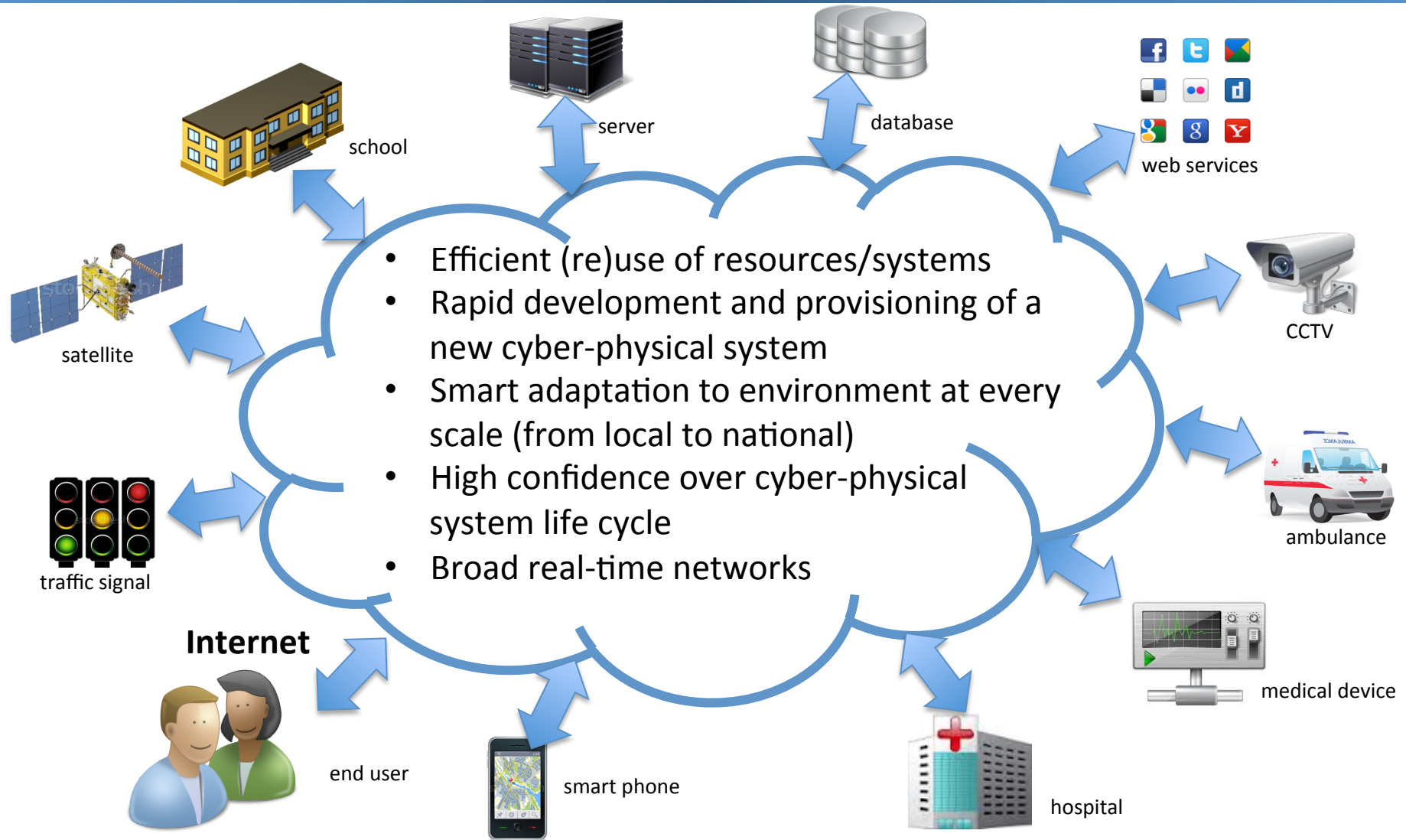Cloud computing : security, interoperability and portability requirements

Lessons learned from the *Great East Japan Earthquake*



Photo by Roberto Devido

**nation-scale smart environments**

high

Interaction with Physical World

| | |
|---|---|
| Cyber-Physical Computing | Cyber-Physical Cloud Computing |
| Desktop Computing | Cloud Computing |

low

small    Scalability and Interoperability    large

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# Connecting Cyber- and Physical Systems to the Cloud

- Efficient (re)use of resources/systems
- Rapid development and provisioning of a new cyber-physical system
- Smart adaptation to environment at every scale (from local to national)
- High confidence over cyber-physical system life cycle
- Broad real-time networks

school

server

database

web services

CCTV

satellite

ambulance

traffic signal

**Internet**

medical device

end user

smart phone

hospital

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# Cyber-Physical Cloud Computing

- NIST & NICT on-going Collaboration

- An environment that can rapidly build, modify and provision auto-scale cyber-physical system composed of a set of **cloud services**



Cyber-Physical Cloud Computing Implementation

Cyber-Physical Cloud Services

Cyber-Physical Systems

(Enhanced Usability)

Cyber-Physical Cloud Systems

Cyber-Physical Cloud Services

(Enhanced Flexibility)
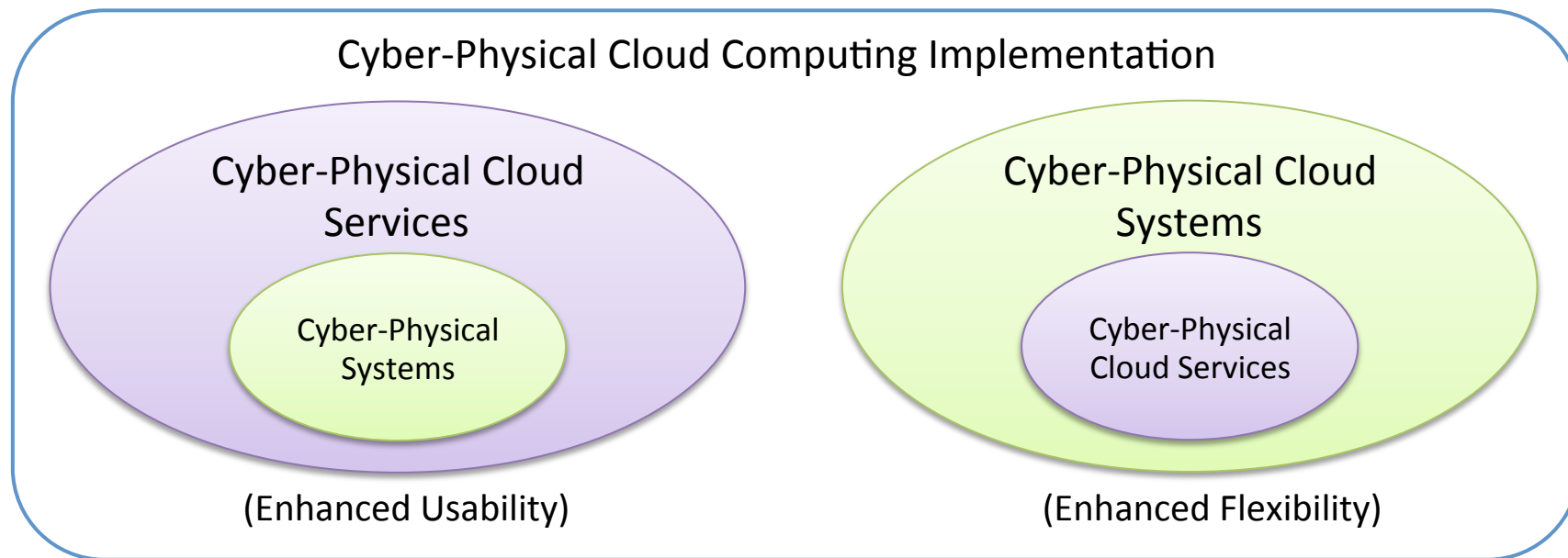
To support cloud five characteristics (On-demand self-service, Broad network access, Resource pooling, Rapid elasticity, Measured service)

# Requirements of CPC Services/Systems
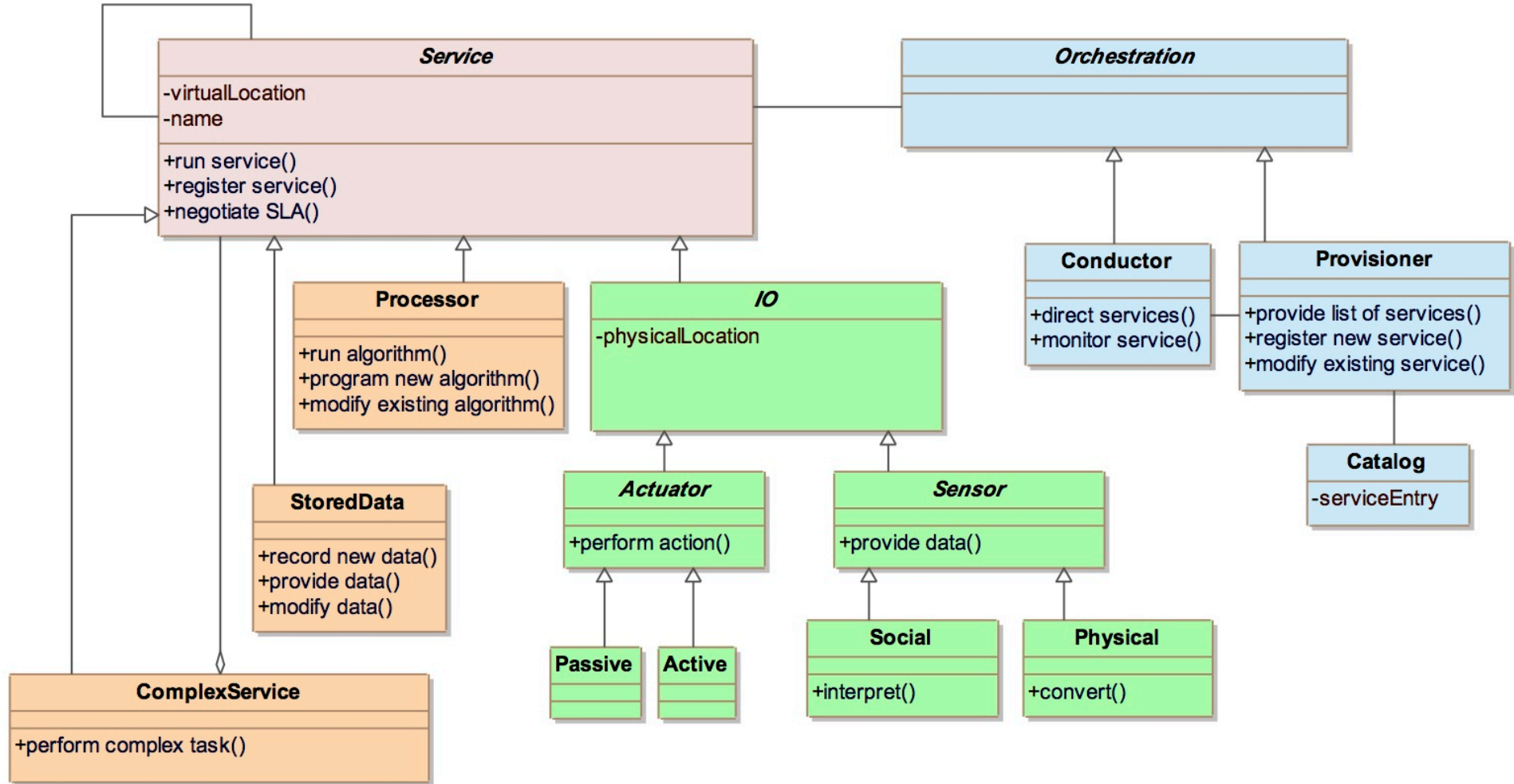
## Computing as a physical act

An eco-social system based on the interaction of billions of networked devices (mobile phones, sensors, actuators, etc.) and human beings, and handling very large amounts of information flow
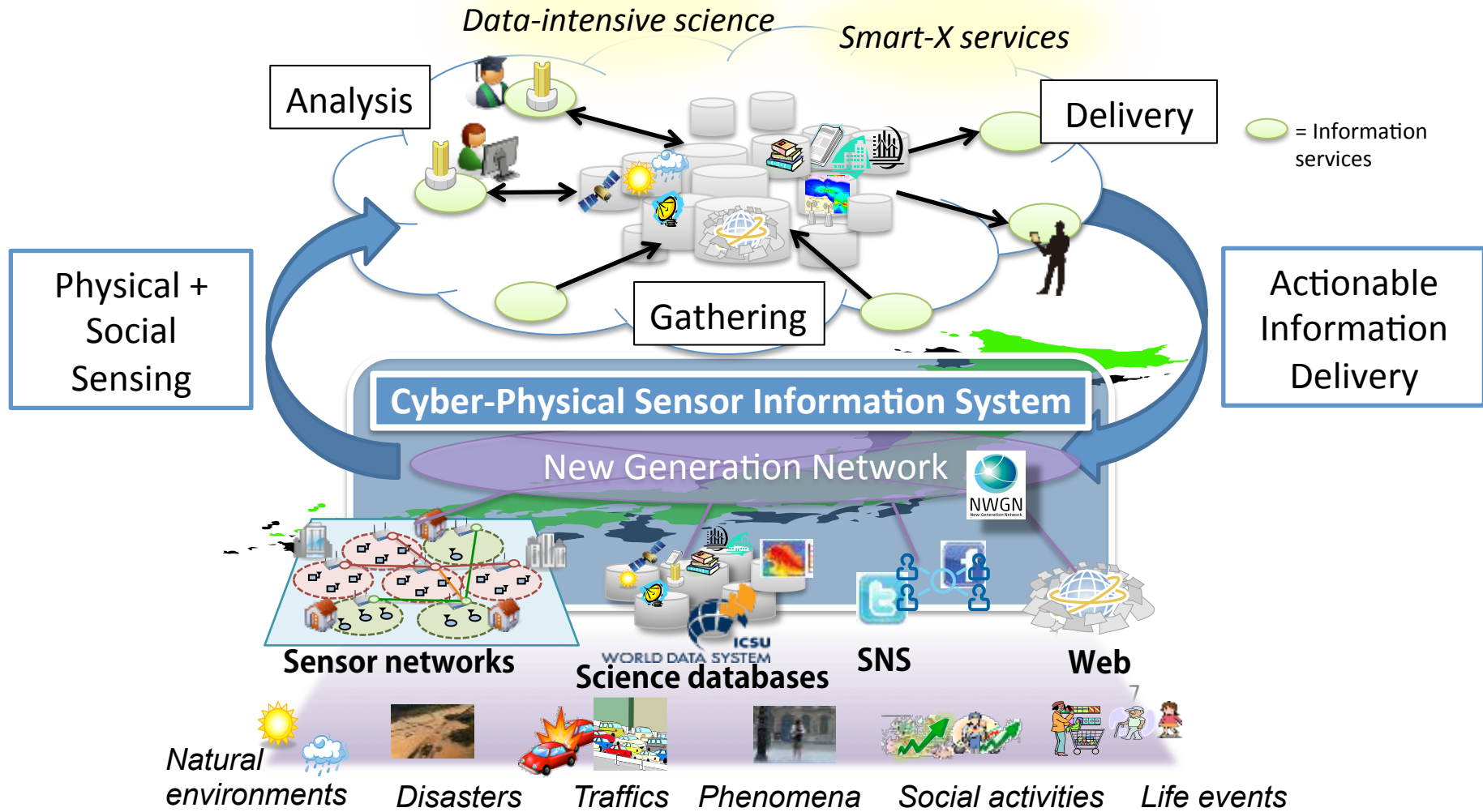


Information flow
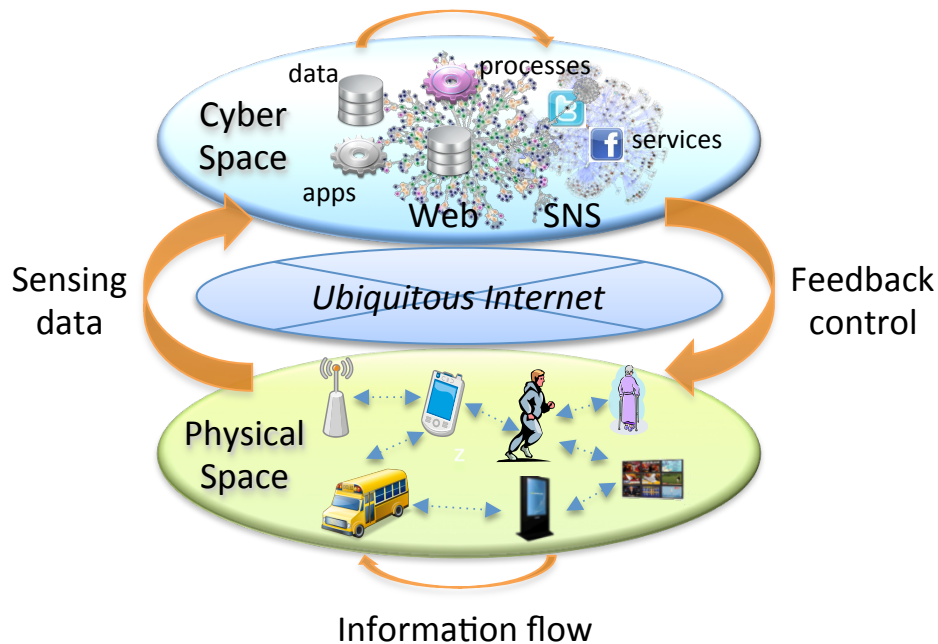
- **Non-Functional Requirements**
  - Adaptable
    rapid (de-)provisioning
    autonomous
  - **Big Data Handling**
    sensor data
    archived knowledge
  - **Real Time Operation**
    continuous data steam
  - **Reliability**
    social data integration
  - Modularity
    component decoupling
  - Standard Interfaces
  - Controllable  Network
  - Secure & Private
  - Clock Synchronization

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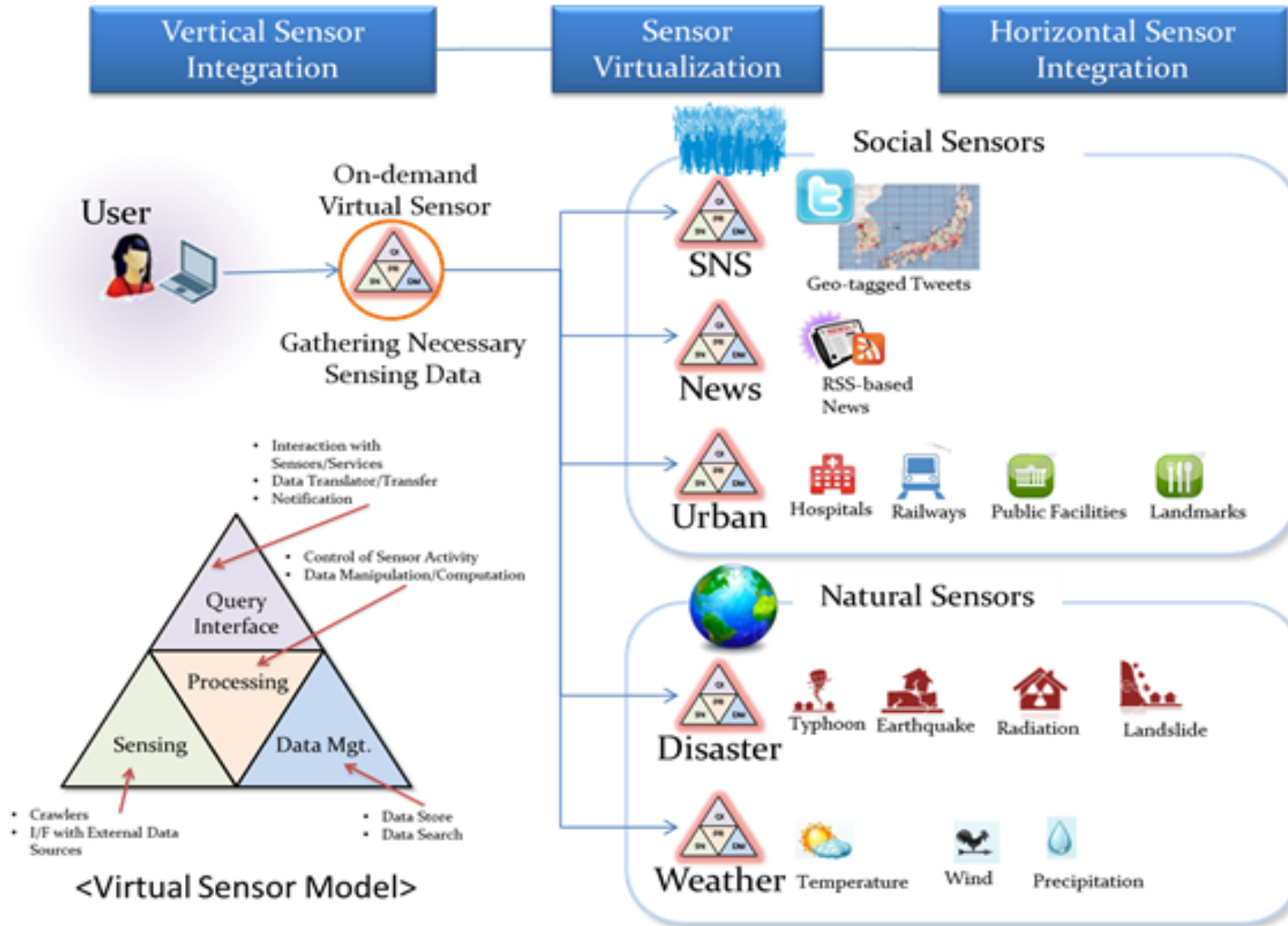U.S. Department of Commerce

# CPC System Conceptual Architecture

# Cyber-Physical Sensor Information System

# Creation of Sensor Information Services

# Research Issues

**ARCHITECTURE**  describing the system

**SEMANTICS**  understanding the concepts

**KNOWLEDGE**  generation from physical and social data

**PERFORMANCE** to meet requirements

**METROLOGY** for physical and cyber

**SECURITY**  of systems and information

**STANDARDS** supporting the system

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# Thank you for your attention!

Standardization

= Cloud node

*join*

Application

Cyber-Physical Cloud Infrastructure

Architecture
Security & Privacy
Data Management
Networking

Testbed

10

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