

## SOCIAL IMPACT OF CYBER PHYSICAL SYSTEM

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**Abstract-** As computation and communication becomes easier, cheaper and widely distributed, they embedded directly in objects and structures which easily interact with physical environment and also expand human skills. CPS is absolutely necessary to sustain the growth in several important technological areas from transportation, to energy, to manufacturing, to health care. Even though many of the applications are there for Cyber Physical System, it is not clear whether the functional properties are due to cyber or physical or both. Many sensing data and driving units which collects, process and exchange information that bridge the cyber world of computing and communication with physical and biological world. The user can interact with physical world to Cyber Physical via Simulation, Automation, and Unique Identifier. It is not new to us, but it integrates physical or embedded system with cyber or internet, which gives digital world. This paper mainly focus on Cyber Physical System and its evolution, functions, goals, challenges, social impacts, comparison with other fields and its applications.

**Keywords -** Cyber Physical System, Cyber World, Embedded System, internet

### 1. INTRODUCTION

Cyber Physical System (CPS) is the integration of computation, networking and physical processes where it ranges from pace makers to large scale [1]. The name ‘Cyber’ which implies the integration of 3 C’s that is Computation, Communication and Control. The name ‘Physical’ which implies natural or man-made system which is governed by law of physics. The system in which the cyber and physical systems are tightly integrated at all scales and levels are called Cyber Physical System [2]. CPS is characterized by large number of tightly integrated heterogeneous components in a network which may expand and contract dynamically. CPS is rapidly growing to enrich human to human, object to object, and human to object interactions in the physical world and virtual world. [3]

### 2. EVOLUTION OF CPS

The evolution of the CPS has been a result of continuous development work by many of the researchers in various disciplines. The evolution stages from the embedded system to Cyber Physical System are shown in the following figure 1.

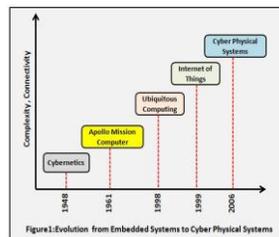


Figure 1. Evolution of CPS

During the journey evolution of Cyber Physical System has following generations [7]

1. Cybernetics was defined as “scientific study of control and communications in the animal and the machine” by Norbert Wiener in 1948.
2. Guidance Computer for Apollo Mission is an early Embedded Computer System using Real Time Operating System and Machine Code for programming developed in 1961.
3. Ubiquitous Computing was defined as “computing made to appear anytime and everywhere” by Mark Weiser in 1998 to describe intelligent devices and appliances.

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4. Internet of Things was conceptualized as “internet of computing devices embedded in everyday objects, enabling communication between them” by Kevin Ashton in 1999 to describe network of smart objects.
5. Cyber Physical Systems is a term introduced by Helen Gill in 2006 to describe the systems which “link physical world through sensors and actuators with the virtual world of information processing”.

### 3. ARCHITECTURE OF CPS

The architecture of CPS consists of Sensor, Actuator and controller for physical world interaction. Data's are collected from physical world through sensors. Different types of sensors are used to sense and collecting the data from the environment. Depending upon the requirements, the sensors are connected to the CPS. Controller controls the sensor and actuators with the physical system. Figure 2 shown the architecture of the Cyber Physical System.

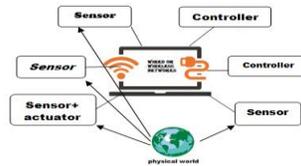


Figure 2. Architecture of CPS

### 4. FUNCTIONS OF CPS

Cyber Physical System undergoes five stages [5], they are

- ✓ Configuration stage
- ✓ Cognitive stage
- ✓ Cyber stage
- ✓ Data to Information stage
- ✓ Smart Connection stage.

#### 4.1 Configuration stage:

The configuration stages is self-configured for resilience, self-adjust for variation, self-optimize for disturbance

#### 4.2 Cognitive stage:

The Cognitive stages focuses on integrated, simulation & synthesis, remote visualization for human interaction, collaborative diagnostics and decision making

#### 4.3 Cyber stage:

A Cyber stage uses three things as follows,

- ✓ A twin model for components and machines,
- ✓ Time Machine for variation identification and memory,
- ✓ Clustering for similarity in data mining.

#### 4.4 Data to Information stage:

Data to Information stages governs the multi-dimensional data correlation, and degradation and performance prediction.

#### 4.5 Smart Connection stage:

Smart Connection stage deals with plug and play and Tether-free communication.

### 5. APPLICATIONS OF CPS

Due to its unique features, CPS has various applications in various domains. The CPS plays major role in the following area.

#### 5.1 Vehicular systems and transport:

Modern vehicles are cyber-physical systems, which provide enhanced displays, information, entertainment, manage the motion and energy consumption of the automotive. One of the examples is a system performance optimization model for unmanned vehicle CPS with wireless sensor network (WSN) navigation. The vehicle primarily receives signals from WSN for conducting its movements. For improving positioning accuracy, it is important to have fast communication and response of the vehicle. To address this issue, their model uses the particle swarm optimization (PSO) algorithm [9].

### 5.2 Medical and Health-Care Systems:

CPS functionality is very crucial in development of medical systems. The design of a CPS for providing health-care services to people with disabilities and frail elderly people. The interactive CPS observes the motion and activities of daily living of the users. Based on this, the CPS provides the services to the user at the desired location. These services include reminding the user of crucial and important activities such as taking medicine and assistance in shopping [9].

### 5.3 Smart Homes and Buildings

A smart community architecture, which is modeled as a cyber-physical system with cooperating objects, namely networked homes. In smart homes, the sensors and actuators are configured such that they can be controlled remotely through the internet. Through this, the activities of the users can be monitored. Smart community takes the concept of smart homes further by using networking among a group of smart homes. The individual homes are modeled as multifunctional sensors and whenever necessary, automatic or human-controlled physical feedback is given to improve community safety, health-care quality and home security. The authors also discuss the communication and networking in the smart community [9].

### 5.4 Social Network and Gaming:

CPS video games enhance the video games of cyber world with more physical inputs, such as those from inertial sensors. This can improve users' participation and provide better experience of realism [9].

### 5.5 Power and Thermal Management:

A technique for temperature management for 3D multi-core processor system. Their technique models the heat consumption of the 3D chip using a thermal model, and uses this model to estimate future power consumption of the chip. Further, their technique senses the temperature of the processor-chip and adjusts the fluidic flow-rate to always maintain the system temperature. The cyber-physical nature of operation of their technique provides real-time, prediction-and correction and fine-grained control of the chip temperature [9].

### 5.6 Data Centers:

A data center can be modeled as a Cyber Physical System. The cyber part is the online applications and services which ensure communication and computation. The physical components ensure correct functioning and continuous operation. The interaction of cyber and physical components make power management challenging [9].

### 5.7 Electric Power Grid and Energy Systems:

An increasing demand for reliable energy and numerous technological advancements have motivated the development of a smart electric grid. The smart grid will expand the current capabilities of the grid's generation, transmission, and distribution systems to provide an infrastructure capable of handling future requirements for distributed generation, renewable energy sources, electric vehicles, and the demand-side management of electricity.[8]

### 5.8 Networking Systems:

In several CPSs, camera-equipped portable devices are used to capture, send and receive real-time videos for CPS; however it also requires them to have ubiquitous broadband network access [9].

### 5.9 Surveillance:

The design of a cyber-physical alarm system. This alarm establishes connection using internet through GPRS/CDMA/3G. Using the existing mobile communication network, the alarm achieves mutual communication control among terminal equipment's and users. The alarm uses terminal equipment, which detects the physical world. This information is communicated to the user. In turn, the user can control and manage the physical world using the communication system of the alarm [9].

## 6. COMPARISON WITH OTHER FIELDS:

1) While comparing CPS with IOT, IOT is nothing but connecting things (object and machines) to the internet and eventually to each other, where as CPS are integration of computation, networking and physical process.IOT emphasizes communication protocols whereas CPS empharizes hybrid system and formal verification of dynamical system.IOT is composed of network of sensors,actuators and devices whereas CPS uses sensors to connect all distributed intelligence to the environment. IOT is nothing but connected CPS where as CPS is the disconnected entity.IOT uses special sensors to identify products and materials whereas CPS helps in complete merging of virtual and physical world.CPS used shared knowledge and information from processes to independently control logistic and production system.IOT has roots in communication networks and wireless communication whereas CPS has roots in control, sensors network and Control System. IOT forms second level of vertical digital integration whereas CPS forms first level of vertical digital integration.IOT refer to unique identification and internet connected embedded system where as CPS are uniquely identifiable and can communicate through internet.

2) While comparing with embedded system, embedded system meant only the main brain of system where we execute our codes whereas CPS means the complete system (i.e. physical component and software). Embedded system is confined to single device. Whereas CPS encompasses many constituent systems and devices. With limited resources; embedded system have limited number of task to complete, with software and hardware elements designed to achieve it whereas CPS has unlimited resource and various task can be completed.

## 7. GOALS AND CHALLENGES

Our ultimate goal of the Cyber Physical System is to transform the way we interact with physical world like the internet transformed. In upcoming generations the example of CPS should be found in smart medical devices, smart transportation system, smart building, smart energy systems and the smart grid. The advance in Cyber Physical System makes possible to build the systems that will far exceed the capabilities of simple embedded systems today[6]. It makes our world as digital world. As the above goals are to be made is not an easy task it has to overcome many hurdles. Making our world as smart is not so easy; the control of the system presents enormous challenges. Although CPS is very much attractive and easier it still faces many challenges some of the challenges are listed below:

- ❖ Building the interface between the cyber world and physical world
- ❖ Hard to fix the boundaries in developing world
- ❖ Networking issues in predictable complex systems
- ❖ Problems in interference of the other cross domain
- ❖ Qos issues
- ❖ Monitoring service

Not only are this there many challenging issues to be faced by the Cyber Physical System. in order to overcome these issues many of the researcher working hard for this challenges.

## 8. SOCIAL IMPACT OF CPS

The impact of CPS on two of the greatest challenges of our time: (a) global warming coupled with energy shortage; and (b) the rapid aging of the population and related healthcare demands [11]. “More than 90 percent of the energy coming out of the ground is wasted and does not end as useful. This is the measure of what's in front of us and why we should be excited.” [10]. Buildings and transportations are the major energy users. Green buildings hold great promise [12]. Energy used in lighting and cooling buildings is estimated at 3.3 trillion KW hr. technologically, it is possible to reach the state of “Net Zero Energy” Buildings, where 60- 70% efficiency gains reduce demand and the balance is supplied by renewable sources. However, to reach the goal of Net Zero Energy Buildings, the cyber and the physical worlds must be tightly integrated. The science of computation has systematically abstracted away the physical world and vice versa. It is time to construct a “Hybrid Systems Science” that is simultaneously computational and physical, yielding a unified framework that captures a robust design flow with multi-scale dynamics with integrated networking for the flows of mass, energy and information. Next, rapidly aging populations with age-related chronic diseases is another formidable societal challenge across the globe. It is alarming that the growth of per capital health cost has the shape of exponential curve as the population ages. Future CPS infrastructure can help foster advances in the understanding and cure of chronic diseases and also help the elderly to stay in the comfort of their homes for many more years [11].

## 9. ADVANTAGES OF CPS

The Cyber Physical System is the integration of cyber world and physical world .they are more in various parts of the region in everyday life. The advantages of the Cyber Physical System are as follows: [5]

- A quick way to ensure security in various real-world processes
- Ensures performance in various real-world processes
- The possibility of bringing a positive revolution to the world
- Improve living standards for a number of people
- Countless calculations can be done immediate.

## 10. CONCLUSION

The world travels in the roads of advance technologies .CPS connects physical world to digital world. The high digitalized world; we need CPS based application. In this paper, we have discussed about how the Cyber Physical Systems integrates the real world through cyber and physical system. This paper significantly gives the overview of Cyber Physical System and its functions, applications and goals and challenges facing in today's day to day life, and social impacts of CPS. The CPS application has tremendous potential to improve safety, convenience, and comfort in our daily life. Hence this paper concludes the Cyber Physical System interact with the physical world, they must operate dependably, safety, security, efficiency and in real-time. By 2025, 70 % homes may have CPS smart devises with their digital-cyber based comfortable life.

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