

Cyber Physical Systems and Cloud Computing

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Abstract:

Cyber Physical systems(CPS) is combination of Physical Systems and computer network. In CPS, we integrate network technologies with physical systems. This is a complex process and for such processes, data processing takes a longer time. To minimize the time and increase the efficiency, we can use cloud computing. With Cloud computing results can also be achieved using systems with low computing capabilities.

1 Motivation

It can be said that World population is at decline. And the service sector seems to be booming. This situation created shortage of skilled humans in this sector. This gave rise to innovating new technologies to develop machines which can takeover humans or generally create stability in service sector. In recent years, there has been a rapid growth in innovation of new technologies. Specifically with physical systems that is machines, technology has made it easier to build new physical systems. Such Physical Systems has to be operated remotely or make it intelligent. For this, Software integration is required to make it work and increase its efficiency. This is where comes the Cyber Physical Systems(CPS). Cyber Physical Systems (CPS) is the future of technology sector.

Software integration which also provides computing, storing, sensing and controlling is a very complex process. Such complex processes tends to take incredible amount of time, storage and computational abilities. Any of the lack of previous features will affect its efficiency and working. While software integration, lots of data processing is being done in the background and for optimum efficiency this process has to be error free. While processing it gets very complex and chance of errors increases. To solve such complex issues, we would also need a system with exceptionally high computational capabilities. Even such systems doesn't guarantee the optimum result. At the same time a similar concept in computing was evolving and later became mainstream called as Cloud Computing. Cloud computing solved most of the problems of software integration with physical systems.

Along with the mentioned challenges, other challenges including consumption, security, privacy, and reliability were also eliminated by Cloud computing. This resulted in more research of cloud computing in Cyber Physical Systems so as to improve the computational capabilities and dive more into new innovations of technologies. This also paved the way for much more developments in Physical Systems.

2 Foundation

2.1 Cyber Physical Systems

Cyber Physical Systems(CPS) is the combination of digital and physical components to achieve optimum result[1]. Although CPS is extremely similar in terms of basic Architecture and networking, CPS is more deep rooted and complex concept to begin with. Basically, CPS are Feedback Systems possibly with humans, economics and environment in the loop. It can also be said that CPS are feedback systems that are networked and distributed with wireless sensing and actuation , real time, adaptive and predictive and Intelligent[3]. CPS requires Cyber Security, Safety, Improved Design tools and Design methodology[4]. Cyber Security includes Resilience, Privacy, Malicious Attacks and Intrusion Detection. Whereas Safety includes, Losses, Safety constraints and Hazard Analysis which identifies unsafe control actions[5].

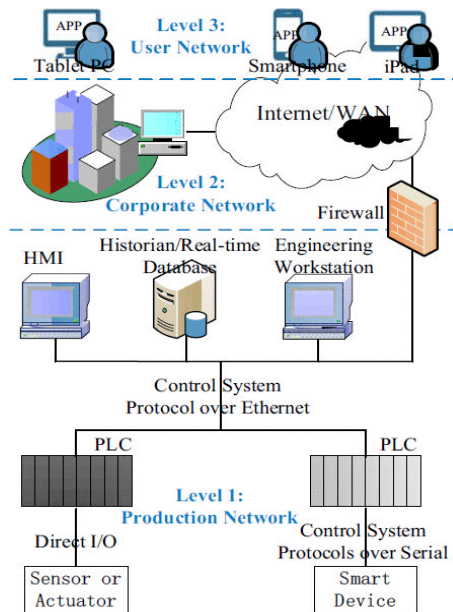


Fig. 1: levels of cps[1]

Cyber security imperils safety[6]. Improved Design tools enables Design methodology that supports Specification, Modelling, and Analysis of Interoperability, Hybrid and Heterogeneous Models including Models of computation and continuous and Discrete,

Networking and Clock Synchronization. Design methodology also supports Scalability and complex management through Modular and Composability, Synthesis and Interfacing with Legacy Systems. Validation and Verification is also an important part where design methodology supports[7]. It includes Assurance, Certification, Simulation, Stochastic Models. Cyber Physical Systems have applications in Communication, Consumer, Energy, Infrastructure, Healthcare, Manufacturing, Military, Physical Security, Robotics, Smart Buildings, Transportation.

2.2 Cloud Computing

Cloud Computing is basically delivery of computing services remotely via internet for economical, efficient and flexible resources[8]. Complex processes can also be done using cloud computing. Cloud Computing is divided into three categories, Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS)[9]. Cloud network is also bifurcated into three parts, Private cloud, Public cloud and Hybrid cloud. SaaS uses third party software and tools to host applications and websites via the internet. Examples of SaaS are Salesforce, Netsuite. PaaS uses third party software and tools and hosts it on its own platform. Examples of PaaS are google, Heroku. IaaS uses third party software and tools to host and store data and compute on its own servers. Examples of IaaS are Oracle, AWS, Azure.

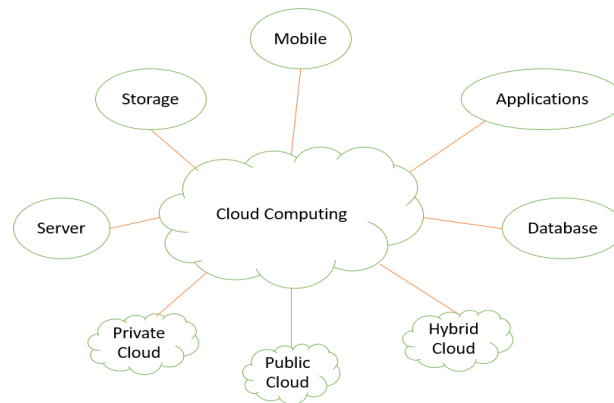


Fig. 2: Structure of Cloud Computing [10]

Private cloud stores data and computes on private server. In Public cloud, public servers are made available to the customers over internet. Different customers can share the same server and its economical. Hybrid cloud comprises of public cloud and private cloud. In Hybrid cloud, customers have the option to use private cloud for highly confidential data and public cloud for not so important data.

3 Concept and Working of CPS with Cloud Computing

3.1 CPS and Cloud Computing

CPS are characterized by seamlessly interweaving the physical world of infrastructure objects and the virtual world of information processing[2]. In CPS, ambient information about infrastructure objects in physical space is gathered by sensors and then forwarded to cyber space for processing[3]. Afterwards, operational commands are released from cyber space and executed by actuators to control infrastructure objects[4]. From the mentioned process CPS is intertwined with cloud computing to achieve high optimum output. Although CPS combines the advantages of distributed systems and embedded real-time systems, it is insufficient when dealing with big data parallel processing and critically real-time requirements[5]. Thus, the need for cloud technology is required. Cyber Physical Systems combined with Cloud Computing has paved the way for the Industry 4.0 where reputed companies around the world have already demonstrated the technology with future prospects. To understand attacks on CPS better, we can divide CPS and cloud computing into two parts. First part of CPS being cyber systems, which involves computing, communication and storage. Storage can be further classified as storage modification or data remanence. Communication involves, eavesdropping, packet modification, man in the middle attack and resource blocking. Computing includes information leakage, enforced computing error and timing error. Second part of CPS being physical systems, which involves sensors and actuators. attacks on sensors is sensor spoof or DoS (Denial of Service). Whereas Actuators have authentication failure and deadline miss.

3.2 Applications of CPS and Cloud Computing

Common Applications of CPS comes under sensor based autonomous system. There are many applications of CPS apart from common applications. Some of them are, power grid, autonomous cars, government, navigation, medical spaces and many more. Advancement of technology has only increased the applications in real life world using CPS. Recently, cloud computing has also proven to be a boon for complex processes. Cloud Computing is helping to develop new Cyber physical systems and has made it possible to grow. Another great application of CPS in our daily life would be waste sorting. Most of the people might not know about this but we are using CPS for sorting waste for years and will be using it for many years until a new Cyber physical system is developed which is more efficient than the current one.

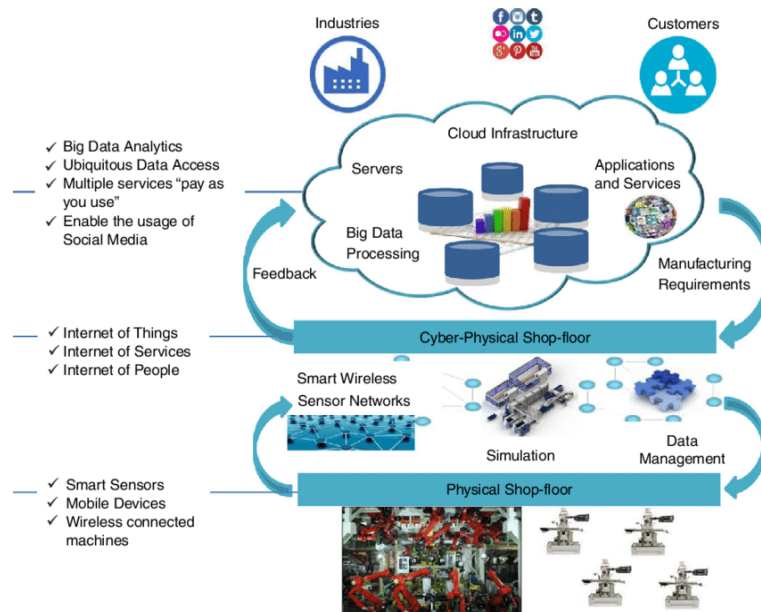


Fig. 3: Conceptual Framework[6]

3.3 Use Case of CPS and Cloud Computing

One of the most important part where CPS is used is in waste separation. When the segregated waste is sent to the waste sorting site, it is further sorted for recycling purposes. For better understanding, we will focus on packagings being sorted according to its material and its ability to recycle. This is where the CPS is used. Manually it is very difficult to sort packaging material according to their core material as well as difficult to know with human eye if its recyclable or not. Recyclability depends on the type of material and the level of microns. Its a very complex issue to solve. Once, the waste packaged waste reaches he site, It will go through a sorting belt. A machine with a lot of sensors is attached to the belt which detects the type of material and the level of microns. If its not a recyclable packaging, it gets discarded.

This mechanical machine is equipped with sensors constitutes the physical system. All this is managed using a detecting software which constitutes the cyber system. The data is the collected continuously and with the help of the cloud computing it can store data as well as train itself using machine learning to increase its accuracy. Everything can be managed from anywhere in the world as long as we feed the correct data to the machine to learn and identify the packaging material. Once the system is in motion, it will create its own eco system and give optimum results. This system will require great amount of energy, perfect

PACKAGING DETECTION SYSTEM

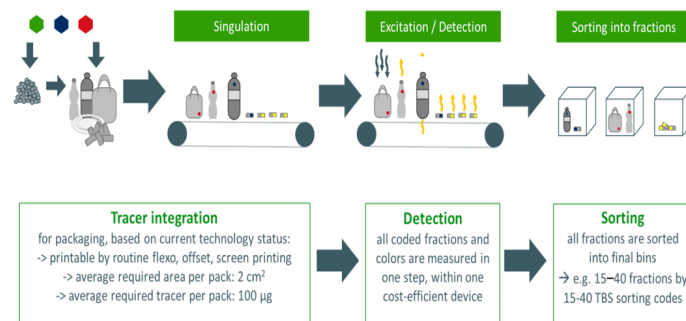


Fig. 4: Packaging Detection System [16]

synchronisation between physical system and cyber system, scalable and resourceful. All of which requires high computing and thus can be achieved using Cloud Computing.

This is a very simple and basic application of CPS. More the complex process, more will be the Cyber physical system. Similarly, we can use CPS for other kind of waste and make the waste segregation and recycling more efficiently.

4 Conclusion

Cyber Physical System(CPS) has made a new path to industry 4.0. Effects of CPS on industries as well as academia is phenomenal. And, In order to process complex processes, cloud computing becomes an optimal choice. In this paper, we understood what is CPS and Cloud computing. We also got to know how the Cyber Physical System along with Cloud computing works efficiently. And just to provide an idea, an example of application of CPS with cloud computing is further explained.

5 Future Work

CPS is one of the most important concepts that can fuel the next technology revolution. A lot of research is still needed to reach its full potential. Different models can be implemented to see how the systems work for different models. One of the most important work that needs to be done in the future is its working on energy. Sometimes for CPS, energy to efficiency ratio doesn't make sense. It is very important to work on energy consumption. There is a lot of scope on further research being done not only on physical system but also on Cyber Systems.

6 Declaration of Originality

I, ..., herewith declare that I have composed the present paper and work by myself and without the use of any other than the cited sources and aids. Sentences or parts of sentences quoted literally are marked as such; other references with regard to the statement and scope are indicated by full details of the publications concerned. The paper and work in the same or similar form have not been submitted to any examination body and have not been published. This paper was not yet, even in part, used in another examination or as a course performance. I agree that my work may be checked by a plagiarism checker.

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