Specifying and Modeling Cloud Cyber Physical Systems Based on AADL

Lichen Zhang
Faculty of Computer Science and Technology
Guangdong University of Technology
Guangzhou , China
zhanglichen1962@163.com

***Abstract*—In cyber physical systems(CPS), the physical world and the information world are merged to form a new structure that combines both hardware and software, and become the core technology system that supports and leads the transformation of a new generation of industries. With the rapid development of network technology, the data generated has also increased rapidly, which means that today's information society has entered the era of big data, and the technology of adapting to the cloud platform has gradually matured. The cloud computing platform provides flexible and relatively inexpensive storage space and computing resources for the development of big data technology. This also provides basic support for the development of big data driven CPS based on the cloud platform. In this paper, we specify and model cloud cyber physical systems based on AADL, which can specify, model, and analyze cloud cyber physical systems, finally implement cyber physical systems on cloud platforms, provide availability analysis, reliability analysis. data quality analysis, real-time performance analysis, security analysis and resource consumption analysis.**

Keywords-cloud; CPS; big data; AADL; specification

I. INTRODUCTION

In cyber physical systems(CPS), the physical world and the information world are merged to form a new structure that combines both hardware and software, and become the core technology system that supports and leads the transformation of a new generation of industries. With the rapid development of network technology, the data generated has also increased rapidly, which means that today's information society has entered the era of big data, and the technology of adapting to the cloud platform has gradually matured. Typically, CPSs have limited computation and storage capabilities due to their tiny size and being embedded into larger systems. With the emergence of cloud computing and the Internet-of-Things (IoT), there are several new opportunities for these CPSs to extend their capabilities by taking advantage of the cloud resources in different ways [1]. Cloud computing is a model for enabling convenient, on demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [2]. The cloud computing platform provides flexible and relatively inexpensive storage space and computing resources for the development of big data technology. This also provides basic support for the development of big data driven CPS based on the cloud platform[3].

Cloud based cyber physical systems are. Their design needs appropriate concepts and tools which are not available under systemic or object oriented methods. UML, the most used nowadays, cannot, in its standard form, satisfy the requirements of such design.

In this paper, we specify and model cloud cyber physical systems based on AADL [4], which can specify, model, and analyze cloud cyber physical systems, finally implement cyber physical systems on cloud platforms, provide availability analysis, reliability analysis. data quality analysis, real-time performance analysis, security analysis and resource consumption analysis.

II. CLOUD CYBER PHYSICAL SYSTEM SPECIFICATION AND MODELING

Architecture Analysis & Design Language (AADL) is proposed by Society of Automotive Engineers (SAE) [4]. Compared with other architecture modeling languages, such as UML and SysML, AADL is especially effective for model based analysis and specification of complex real-time embedded systems. “It includes abstractions of software, computational hardware, and system components for a) specifying and analyzing real-time embedded and high dependability systems, complex systems of systems, and specialized performance capability systems and b) mapping of software onto computational hardware elements.” [4][5]

AADL is used to model the software and hardware architecture of an embedded, real-time system. Due to its emphasis on the embedded domain, AADL contains constructs for modeling both software and hardware components (with the hardware components named "execution platform" components within the standard). This architecture model can then be used either as a design documentation, for analyses (such as schedulability and flow control) or for code generation.. AADL (Architecture Analysis and Design Language), which is a modeling language that supports text and graphics, was approved as the industrial standard AS5506 in November 2004. Component is the most important concept in AADL. The main components in AADL are divided into three parts as shown in Fig.1 [6]: software components, hardware components and composite components. Software components include data, thread, thread group, process and

978-1-5386-7445-1/18/$31.00 ©2018 IEEE
DOI 10.1109/DCABES.2018.00017

subprogram. Hardware components include processor, memory, bus and device. Composite components include system..

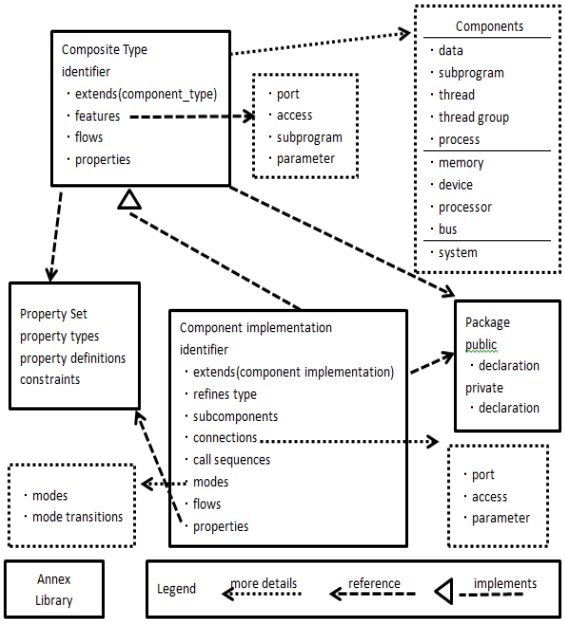

Figure 1. AADL Elements

The graphical notations for specification of the architecture using the SAE AADL standard are summed up in Fig.2 [6]

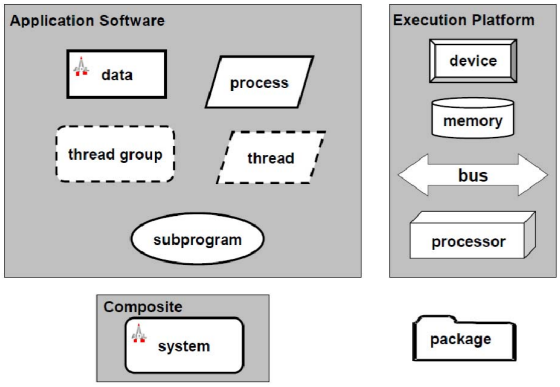

Figure 2. Summary of AADL elements in graphical representation

Cloud computing systems can be characterized as Software-as-a-Service, Platform-as-a-Service, and Infrastructure-as-a-Service providers.

SaaS is the often the top-most layer in an organization's cloud strategy. It refers to software that is hosted on someone's else's infrastructure, but delivered to a client organization's end users as a service, often accessed through a specific web portal. A service framework must be developed for sensor networks to make SaaS platforms are not a viable option for cyber physical applications. Cloud platform SaaS is modeled as Fig.3.

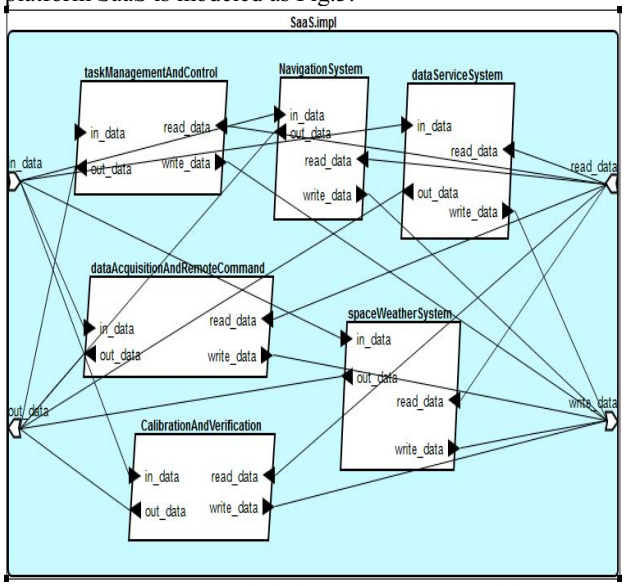

Figure.3. Cloud platform SaaS system model

Cloud platform services, or Platform as a Service (PaaS), provide cloud components to certain software while being used mainly for applications. PaaS provides a framework for developers that they can build upon and use to create customized applications. All servers, storage, and networking can be managed by the enterprise or a third-party provider while the developers can maintain management of the applications. Cloud platform PaaS sytem model is modeled as Fig.4.

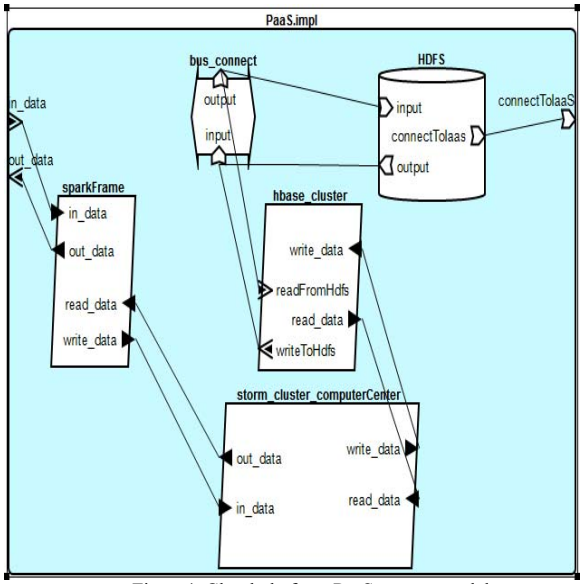

Figure4. Cloud platform PaaS system model

III. Case Study: Flight Cyber-Physical Systems Specification and Modeling

Flight Cyber-Physical Systems (FCPS) is the research and development direction of the new generation of flight systems. Take the example of the NextGen air transport system being developed in the United States. It uses automatic surveillance broadcasting (ADS-B), automated air traffic management system, NAS voice system, performance-based navigation system, system-wide information management, and decision-making. Support systems and safety management systems make flights safer, more efficient, and more predictable. This paper elaborates on the development and typical features of CPS, analyzes the architecture of CPS, introduces the concepts and features of big data and cloud computing platforms, and proposes a big data-driven flight based on cloud platform. Information physics fusion system model. Based on the data characteristics of flying CPS and the storage requirements and characteristics of flight data, a systematic system-level (SoS) flying CPS architecture is built. Fig. 5 [7] represents the architecture of future flight system[8] [9].

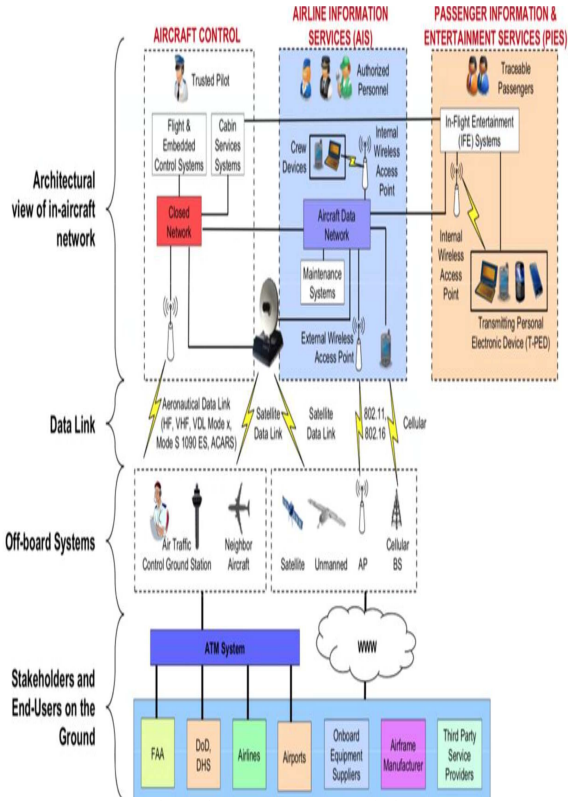

Figure 5. the architecture of Future Flight System

Fig.6 represents the physical model of flight management system based on AADL.

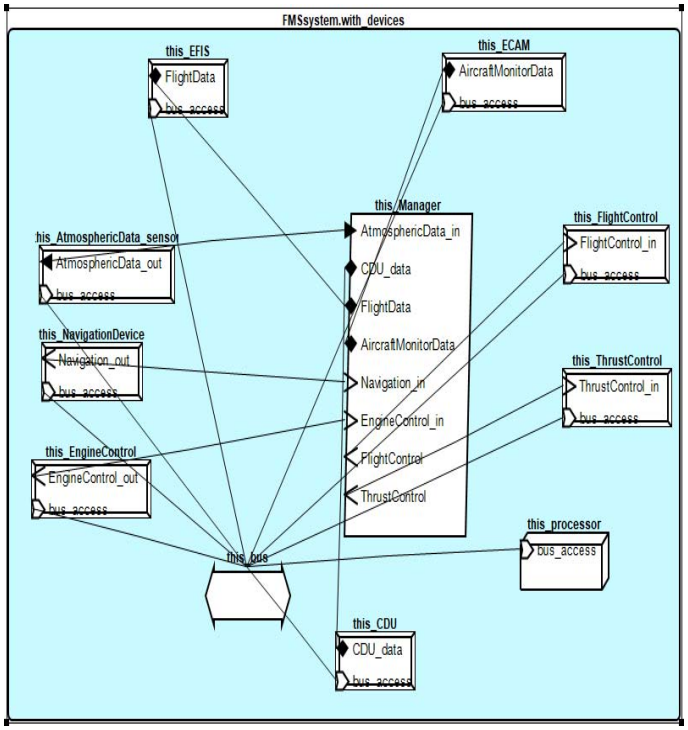

Figure 6. the Physical Model of Flight management System

Fig.7 represents future cloud Flight System model based on AADL.

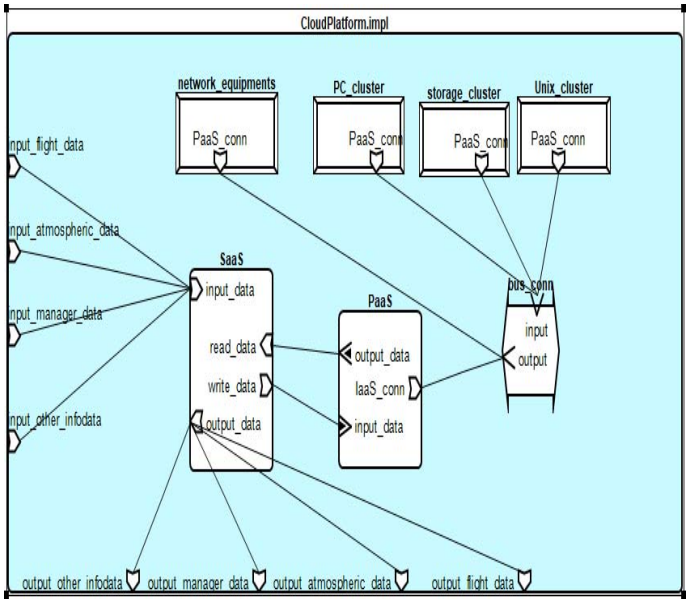

Figure 7. future cloud Flight System model based on AADL

Fig. 8 represents the functional modeling of flight Management System..

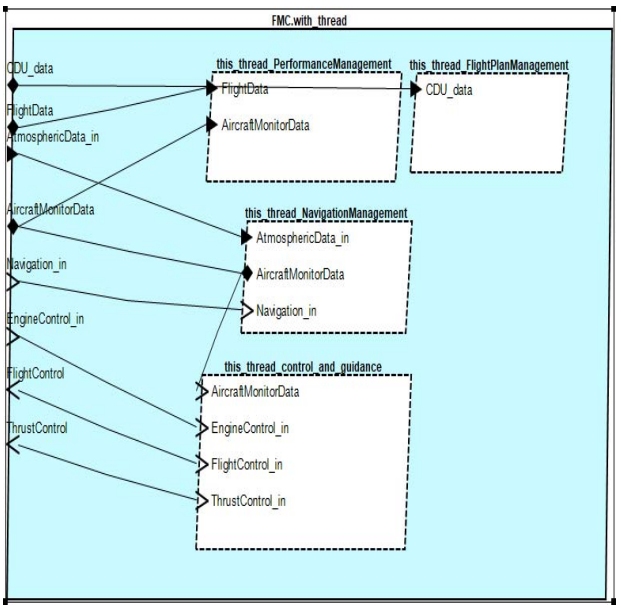

Figure 8. the functional modeling of flight Management System

Fig.9 represent Implementation of the Cloud Platform PaaS System Model.

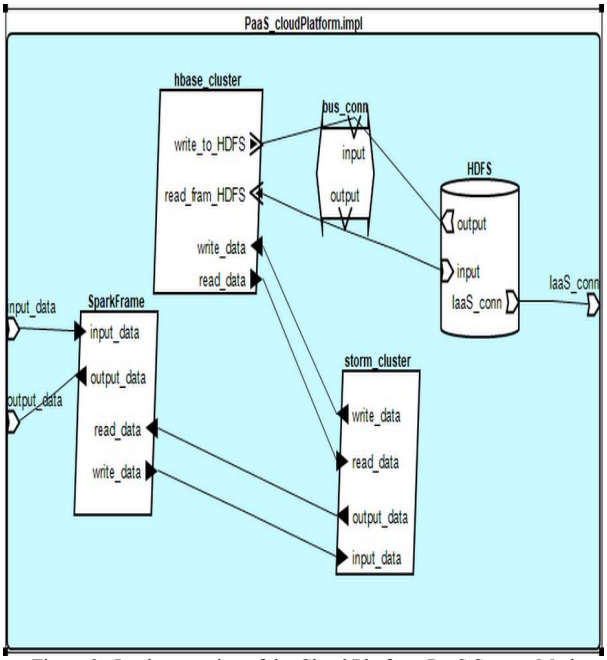

Figure 9. Implementation of the Cloud Platform PaaS System Mode

IV. Conclusion

In this paper, we specified and modeled cloud cyber physical systems based on AADL, which can specify, model, and analyze cloud cyber physical systems, finally implement cyber physical systems on cloud platforms, provide availability analysis, reliability analysis. data quality analysis, real-time performance analysis, security analysis and resource consumption analysis. We used flight cyber-physical systems as an example to show modeling cloud cyber physical sytems based on AADL.

In future work , we extend MapReduce in real time aspects to of enable the scheduling of mixed hard and soft real-time MapReduce applications, we extend AADL to model cloud based cyber physical systems with formal techniques.

Acknowledgment

This work is supported by the national natural science foundation of China under grant(No.61572142), natural science foundation of Guangdong province under grant(No.2015A030313490).

References

[1] Rihab Chaâri et al. Cyber-physical systems clouds: A survey, Computer Networks, Volume 108, 24 October 2016, Pages 260-278

[2] Krainer, C. and Kirsch, C. "Cyber-Physical Cloud Computing Implemented as PaaS", Proceedings of the 4th ACM SIGBED International Workshop on Design, Modeling, and Evaluation of Cyber-Physical Systems (CyPhy'14), Berlin, Germany, 2014

[3] Nizar Idoudi, Nada Louati, Claude Duvallet, Rafik Bouaziz, Bruno Sadeg and Faiez Gargouri. A Framework to model real-time databases, International Journal of Computing & Information Sciences Vol. 7, No. 1, January 2009, On-Line, Pages 1 - 11

[4] SAE AS5506. Architecture Analysis & Design Language (AADL) v1. SAE Aerospace Standard, 2004.

[5] Hudak J J, Feiler P H. Developing aadl models for control systems: A practitioner's guide[J]. 2007

[6] Xiaojie Tu , Jinrui Xu , Qing Wu , Xiaomin Liu. Modeling and reliability evaluation of Avionics Clouds based on AADL and GSPN, 2013 IEEE/AIAA 32nd Digital Avionics Systems Conference (DASC), 5-10 Oct. 2013

[7] Gill H. Cyber-physical systems: Beyond es, sns, and scada[C]//Presentation in the Trusted Computing in Embedded Systems (TCES) Workshop. 2010.

[8] Atkins E M, Bradley J M. Aerospace cyber-physical systems education[C]//AIAA Infotech@ Aerospace (I@ A) Conference. 2013: 4809.

[9] Sampigethaya K, Poovendran R. Cyber-physical system framework for future aircraft and air traffic control[C]//Aerospace Conference, 2012 IEEE. IEEE, 2012: 1-9