

# Poster: Cyber-Function Virtualization for Mobile Cyber-Physical Systems

Sunghwan Kim, Yohan Kim, and Hyuk Lim  
Gwangju Institute of Science and Technology (GIST)  
Gwangju 61005, Republic of Korea  
{sunghwankim, yohankim, hlim}@gist.ac.kr

## ABSTRACT

In this paper, we propose virtualization based cyber-functions for mobile cyber-physical systems (CPSs). If a physical object of a CPS has a high level of mobility, and as the network path length from the cyber-function box gets larger, it becomes very difficult to satisfy the data exchange delay requirement. The proposed scheme can perform the migration of the cyber-functions to an appropriate location on the cyber-infrastructure using virtualization techniques.

## Keywords

Mobile controller; cyber-physical system; virtualization

## 1. INTRODUCTION

A cyber-physical system (CPS) is a tightly-coupled interactive system between cyber-functions and physical objects. The cyber-functions provide a variety of data and control services for physical objects. For example, in a smart transportation system, vehicles are the physical objects controlled by management software in cloud based cyber-infrastructure, and these physical objects are connected to cyber-functions through wired or wireless data networks.

Most CPSs have a certain requirement for network quality of service (QoS) because the physical dynamics of CPSs should be controlled for stabilization. If the network delay between the cyber-functions and the physical objects is too large, the physical object can easily become unstable. In mobile CPSs where physical objects have a certain level of mobility, it is much difficult to keep providing sufficient QoS for stabilizing the physical objects.

## 2. CYBER-FUNCTION VIRTUALIZATION

We propose a mobile cyber-function virtualization (CFV) technique, which virtualizes cyber-functions such as feedback control and enables the migration of cyber-functions to an appropriate location on cyber-infrastructure to satisfy the QoS for physical systems. Cyber-functions can be virtual-

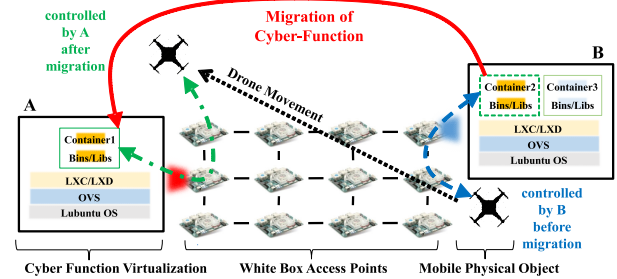


Figure 1: Migration of cyber-function for a flying drone.

ized and migrated using a virtual machine (VM) hypervisor or Linux container technique [1]. Figure 1 illustrates a CPS scenario, wherein a drone flies from the bottom right corner to the top left corner. Before the movement, the drone is controlled by the access point (AP) at the right corner on the top. However, the delay constraint is not satisfied as the drone flies by. The migration is performed to an AP that is close to the new position of the drone.

## 3. SYSTEM IMPLEMENTATION

We implemented the testbed illustrated in Figure 1 using a software-defined-networking (SDN) environment. The testbed comprised HP 2920 switches (OpenFlow 1.3 supported), Odroid XU4 embedded boards, and Netgear wireless routers. The devices were connected to and managed by an OpenDayLight SDN controller [2]. The movement of flying drones was emulated, and the cyber-function for the drone controller was implemented using a Linux container. The delay constraint was set to 5 ms. The end-to-end delay on average was 4 ms. The migration downtime of the cyber-function container was 1.6 s between two virtualized Linux boxes.

## 4. ACKNOWLEDGMENTS

This work was partly supported by IITP grant funded by the Korea government (MSIP) (No. B0101-15-0557, Resilient Cyber-Physical Systems Research, and No. R7117-16-0218, Development of Automated SaaS Compatibility Techniques over Hybrid/Multisite Clouds).

## 5. REFERENCES

- [1] Linux container. <https://linuxcontainers.org>.
- [2] OpenDayLight (ODL). <http://www.opendaylight.org>.

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).

*MobiSys '16 Companion, June 25–30, 2016, Singapore.*

© 2016 Copyright held by the owner/author(s).

ACM ISBN 978-1-4503-4416-6/16/06..

DOI: <http://dx.doi.org/10.1145/2938559.2938591>