Fog Robotics: An Introduction

Siva Leela Krishna Chand Gudi, Suman Ojha, Benjamin Johnston, Jesse Clark and Mary-Anne Williams

Abstract— **Cloud Robotics (CR) is an emerging and successful approach to robotics. The number of robots or other IoT devices may increase drastically in the future which might need enormous bandwidth and there might be security concerns. If robots in CR are not secured then robots can even become surveillance bot by hackers. Moreover, if an internet connection is lost due to network hitches then in that crucial moment robot may not be available to complete its given task. For example, a robot assisting a person can stop working unexpectedly or work with the instructions from hacker. In order to address such problems, we propose a new approach to robotics - Fog Robotics (FR) in this paper, so a network of robots can be used more securely and efficiently as compared to CR.**

I. INTRODUCTION

Cloud Robotics (CR) was coined by J. Kuffner claiming robots could be independent with no limits towards processing and computation power [1]. CR provides on demand tasks/ services, large data storage related to maps, object, data, images, libraries, trajectories etc. all together in one place. It was also claimed that it could reduce burden on robots as they share information from the cloud. But right now, the situation is changing related to security and speed, and a new method should be available to tackle this issue. Using the well-established concept of Fog Computing [2], we present the concept of Fog Robotics(FR) in this paper. It can be defined as an architecture which consists of storage, networking functions, control with decentralized computing closer to robots. Since this is a short introduction, our discussion will mainly revolve around the advantages of FR.

II. FOG ROBOTICS ARCHITECTURE

The Fog Robotics architecture consists of a Fog Robot Server (FRS), a Robot, and a Cloud system(Fig. 1). If a robot requests data then it will first query the FRS and upon availability, it can be directly used without involving the cloud. If not, then the cloud will be utilized. It can teach robots by sharing dynamic data with neighboring robots, such as to be careful while moving towards a room as recently one robot got crashed. FR improves security by allowing sensitive information to be shared without requiring it to be sent over external networks.

An FRS contains a knowledge base, computing resources, environment models, recent robot outcome results such as maps, user details, deep learning models, etc. It works as a bridge between the robots and the cloud. It reduces bandwidth and processing burden on cloud servers by processing data locally.

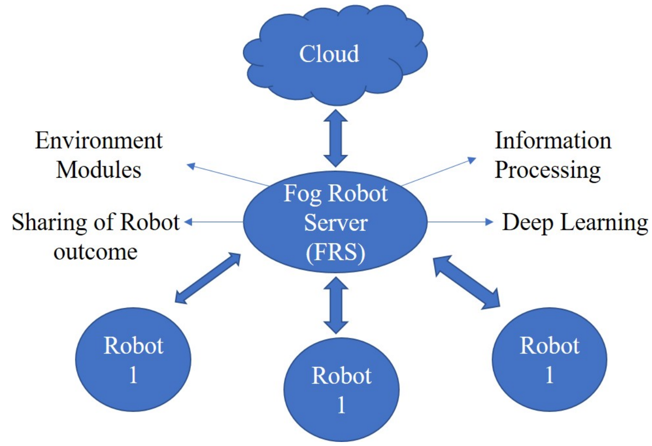

Fig. 1. Architecture of Fog Robotics.

Service is delivered with the help of a local FRS which makes latency and delay in jitter low. The distance between client and server is near (probably one hop) based on the circumstances such as the location of robot. FRS nodes will be high in number, providing mobility and wireless connectivity for all kinds of real time interactions. It is more secure and hard to hack as they are not directly connected to cloud. This whole process involves observing, realizing, sharing, and reacting based on the condition of robot.

III. APPLICATIONS

An important application of FR can be seen in airports. For example, if we consider a person asking a robot about his departure place, then it can guide him until the escalator and hand over its job to another robot waiting on the other side of the escalator. The other robot will guide the person to their destination. This process involves saving the persons name, face, gender, shirt color, and age; and this helps the second robot to recognize the person. In a similar way, FR techniques can be applied in hotels, universities, subways, bus terminals, train stations, homes and the list goes on.

*This research was supported by Innovation and Enterprise Research Laboratory (The Magic Lab), Centre for Artificial Intelligence, University of Technology Sydney, Australia

S.L.K.C. Gudi, S. Ojha, B. Johnston, J. Clark, M.A. Williams are with the Innovation and Enterprise Research Laboratory (The Magic Lab), Centre for Artificial Intelligence, University of Technology Sydney, 81 Broadway, Sydney NSW 2007, Australia. (e-mail: 12733580@student.uts.edu.au,suman.ojha@uts.edu.au,benjamin.johnston@uts.edu.au, jesse.clark@uts.edu.au, mary-anne.williams@uts.edu.au).

REFERENCES

[1] J. Kuffner, "Cloud-enabled humanoid robots," in *Humanoid Robots (Humanoids), 2010 10th IEEE-RAS International Conference on, Nashville TN, United States, Dec.*, 2010.

[2] A. V. Dastjerdi, H. Gupta, R. N. Calheiros, S. K. Ghosh, and R. Buyya, "Fog computing: Principles, architectures, and applications," in *Internet of Things*. Elsevier, 2016, pp. 61–75.