When Inter-RAN meets Cloud: Distributed Intelligence for Mobile Offloading

White paper: NSF Future Wireless Cities Workshop, Feb. 2016

Yufeng Xin, RENCI, UNC Chapel Hill yxin@renci.org

1 Introduction

The concept of Inter-RATs (Radio Access Technologies) has attracted growing research and deployment interests. The representative technology is the micro cell (Femtocell and small cell) where the macrocell connections can be offloaded to the small cell base stations that connects to the wired Internet. On the other direction, WiFi connections can be offloaded to the cellular channels. With advancement in 4/5G LTE and unlicensed spectrum system, the options of offloading among different technologies grow fast, which only makes the interference and mobility management more complicated. While the majority of work has been done in a single cell (micro- or macro-) scenario, most recent studies have expanded the scope to a more distributed scenario and turned to powerful mathematical tools like game theory and distributed machine learning.

In parallel, the mechanism of network function virtualization (NFV) has quickly gained acceptance in cellular networks to free the existing centralized EPC core and RAN system from low efficiency and rigid operation. The later, often referred as Cloud RAN (CRAN), has echoed a very recent networking and big data movement in pushing more system functions and intelligence to the edge of the Internet, represented by the frameworks like "edge computing", "fog networking", of "Cloudlet", etc, sharing many overlapping components and ideas.

Though promising, above researches are still in their infant stage in terms of scale and system optimization. The Inter-RATs and cloud based edge computing and networking framework have not been connected. We think the newly emerging SDN and NFV technologies are the key to make this link, which would be a corner stone in the smart city communication vision. Virtualization has become the desired solution approach in distributed heterogeneous resource environment with the need of on-demand provisioning and per user or per application isolation. Our research will centered around a two dimension system virtualization concept model: (1) *infrastructure virtualization*: user devices (UE), spectrum, access network, cloud (compute and storage); (2) *function virtualization*: interference and mobility management, offloading, end-to-end performance optimization, data replication and processing.

2 Some challenges in Research and Testbed

Information model and system abstraction. It is very advantageous to unify the application layer content, user preference, wireless environment (geographic and traffic), and resource (access network and cloudlet) using an unified information model as the foundation of end-to-end programmability. In this sense, we need to add more semantic description to the current schema or meta data based approach. As semantic web technology has a record of proved success in wireless sensor networks and heterogeneous cloud resource provisioning, we believe the development of a comprehensive ontology based semantic model is one of the most fundament component.

Co-allocation of NFV middle boxes and edge computing. Coupling the NFV with the Cloudlet framework would provide a powerful infrastructure-as-a-service platform to significantly scale up the available system capacity and wireless networking offloading flexibility. In addition, user and data security and privacy guarantees can be dynamically added along with data movement and aggregation. Given the large number of UEs, different wireless cells, and Cloudlets, it is a great challenge in distributed resource allocation that includes various provisioning, control, and management functions, which requires innovations in algorithms, protocols, and programming languages.

New services and applications. Cloudified wireless networks and flexible mobile offloading would enable many new services and applications. For example, an application running in a UE can distribute some of its data inquiry and computing into the distributed cloudlets and utilize the best combination of the available wireless channels.

Testbed. Funding agencies and industries have invested heavily in wireless testbeds including sensor networks, WiFI, WiMax, LTE, etc. However, due to the inherited difficulties in signal locality, spectrum license, and mobility, their scale is rather small, and have not been well cloudified, especially in integrating with the edge/fog computing architecture. Plus, the complexity in the interfaces between the different cells coupled with the high mobility of UEs, deserves continuous study and experimentation.

3 Biography

Yufeng Xin is a senior researcher at RENCI, UNC-Chapel Hill and an Adjunct Professor at NC State University. He is a key developer of the GENI ORCA control framework. His research focuses on high-speed networks, cloud computing, wireless networking and their applications to CPS. He is the PI at RENCI for a NSF CPS Award and a NSF US Ignite award, the co-PIs for other two NSF CNS Award and a DoE ASCR award. He obtained his PhD in Operations Research and Computer Science from North Carolina State University.