Cloud-RAN and D2D in Next Generation Wireless Communication Systems

Résumé du projet de recherche (Langue 1)

How to do advanced cooperation and coordination among geographically separated base stations and user equipments is the key to enable next generation communication system. • Cloud RAN (C-RAN) : is one of the most promising technologies that will impact future 5G architecture and possibly re-shape existing mobile network environments. Unlike traditional RAN, C-RAN detaches the Baseband units (BBU) from the edge radio equipments (the eNodeB). The baseband processing for many eNB, now called Remote Radio Heads (RRH), is centralized into a single pool of shared, and dynamically allocated BBUs, offering energy and multiplexing gains. These BBU functions could be implemented on commodity hardware and performed on virtual machines, further benefiting from softwarization and Network Function Virtualization (NFV). Finally, the centralization of BBU functions facilitates advanced coordinated multicell signal processing, which are often impractical in regular, distributed BS setups due to stringent synchronization constraints. • Device-to-Device(D2D) : which enables devices to discover the presence of other devices in their vicinity and also allow the communication with them directly with minimum network infrastructure involvement. The D2D link leads to less power consumption, smaller interference and shorter delays and also expand the network coverage via relaying signalling between remote devices to cellular network coverage. Moreover, D2D is a key essential role in public safety communication in which devices provide local connectivity even in case radio infrastructure or backhaul link damage. Several reports and specifications on D2D proximity services, D2D communications has been provided by 3GPP and D2D is also recognized as one of the technology components of the evolving 5G architecture. Our vision is to provide a unified framework in two directions: 1. Model cloud-RAN and D2D link in the network through appropriate abstraction following the software-define network principles 2. Develope more advanced cooperation and coordination methods and algorithms to improve the performance of cloud-RAN and D2D discovery and communication in different cases. Main Objectives Cloud-RAN In recent years of the study of Cloud-RAN, two important obstacles are essential to be solved: 1. Limited Fronthaul (FH) link between RRH and BBU 2. Limited RRH/BBU computation capability The first problem in the adoption is the excessive capacity and latency requirements on the FH link connecting an RRH with the BBU cloud. Several studies have worked on the compression on the fronthaul link; however, the requirement of fronthaul now is still beyond imagination even considering massive MIMO antennas, larger frequency bandwidth transmission and higher modulation and coding scheme which are target for higher spectral efficiency in next generation communication system. Rather than offloading all the BBU processing on the cloud, dividing the Physical RX and TX chain in different blocks, it is possible to keep a subset of these blocks in the RRH. This concept is also known as Flexible Centralization. By gradually placing more and more BBU processing at the edge of the network, the FH capacity requirement becomes smaller but with less opportunity of advanced interference avoidance schemes and higher RRH cost. The second key obstacle is how to well-allocated jobs in the RRH and the cloud (BBU-pool) in the circumstance that the cloud may be composed of several CPU cores with different capability and virtualization environment whereas the RRH may be composed of light-weight CPU can only process simple work. Based on the Flexible Centralization concept, the dynamic job allocation is required for the overall Cloud-RAN network and also required in the BBU pool of C-RAN. Besides, separated allocation of the data plan and control plane job are needed to be considered in order to satisfy the hard HARQ timing constraint for both downlink and uplink in different cell-loading scenarios. Last but not least, the most realistic problem we should considered in the cloud-RAN concept is to consider both the limited FH link and the limited RRH/BBU computation capability and take their interaction impact into account. Since these two roles will impact each other, for example the limited FH link will impact the available supported RRH number and also the job allocation method in the cloud-RAN and vice versa, our objective of cloud-RAN is jointly consider the limited-FH and limited RRH/BBU computation capability and provide an unified method or algorithm to make the cloud-RAN concept in applicable in this circumstance. Device to device communication Several studies and specifications have been started by 3GPP LTE standard with particular focus on public safety network use cases. From the view of the specification, the network infrastructure assistance is still required to well-organized a D2D link, to support user cooperation and also the relaying in the network. The network will take responsibility to allocate resource for D2D discovery and communication and also to guarantee non-overlapping with convential uplink and downlink communication with minimum interference among D2D links. In order to realize such network-assisted D2D communication, several tasks need to be considered: • D2D link abstraction and modeling for the network abstraction graph for resource allocation and interference avoidance • Define common interface and parameters to integrate the control of D2D communications with common DL/UL control plane • Develop new methods and algorithms to improve the D2D communication performance utilizing the cooperation and interference avoidance schemes and also coexistence with common DL/UL behaviours in the network • D2D network realization based on state-of-the-art B4G/5G standard Based on these tasks, our objective of D2D herein is modeling, abstraction and control of user cooperation/coordination in the D2D network. Finally, we would like to implement D2D link over latest standard including discovery/communication/measurement over D2D network.

Résumé du projet de recherche (Langue 2)
Final thesis formulation Focusing on the previously presented objectives we therefore plan to explore the state-of-the-art C-RAN use cases and network topology. The C-RAN network is composed of the RRH/BBU processing, packetization before transmission over FH, FH transmission over C-RAN network, job-allocation among BBU for both uplink and downlink separately. We would like to deal with uplink problem at first and finally solve the joint uplink/downlink problem for each limited case stated in previous 'objective' section, and finally merge these two problems together. The reason for such problem separation is that the uplink side is more time-critical in most of the case due to most of the downlink signals can be prepared even before uplink reception. We are also planning to provide a platform to represent the C-RAN network processing among several RRHs and a centralized BBU pool then apply this platform to evaluate the performance of each algorithms. To sumup, we plan to provide a systematic top-down C-RAN problem solution methodology for the future next generation network. For the D2D, we would like to explore the abstraction and modeling of D2D network state-of-the-art and also research on the D2D standardization status in 4G/5G. As for the network-assisted D2D communication abstraction, the network needs to provide some key measurement indexes to all the devices for D2D link quality measurement for efficient network modeling. As a result, we will identify the key measurement points for D2D and then provide different abstraction and modeling methodologies. Based on the modeling result, we could apply different D2D network formulation methods to form the D2D network of each algorithms and finally check the D2D link successful rate in the overall network without considering coexistence with common uplink/downlink link. From the aspect of real network, we further need to consider the existing uplink/downlink transmission then a unified control plane shall be provided and a joint consideration on overall system performance is required. Finally, we plan to implement the D2D network jointly with common DL/UL communication which is useful for performance proving and provide a basis for next generation communication system.

Organization We will study, design, and develop C-RAN and D2D network and foresee the following organization with the time frame of 36 months: • Analyze C-RAN network topology and state-of-the-art (Y1) • Build and investigate the C-RAN network platform used to provide systematic problem-solver for each limited scenario(Y1-Y2) • Well-defined all the problems needed to be considered in the C-RAN then provide a unified solution approach(Y1-Y2) • Check D2D state-of-the-art and specification status then provide the network modeling strategies (Y1-Y2) • Provide a common control-plane for D2D and common UL/DL network for a realistic system view (Y1-Y2) • Implement D2D network in legacy UL/DL platform and prove algorithm performance(Y2-Y3)