Radio Access Scheme using Super Pilot Channel in Reconfigurable Multi RAT-based Wireless Communication System

Woogoo Park
Wired & Wireless Convergence Research Department
ETRI
Daejeon, KOREA
wgpark@etri.re.kr

Hoyoung Song
Wired & Wireless Convergence Research Department
ETRI
Daejeon, KOREA
hsong@etri.re.kr

***Abstract*—In this paper, we propose a new radio access method using super pilot channel in reconfigurable multi Radio Access Technology (RAT)-based wireless communication system. The goals of the proposed method are directed to a system and a process for radio access having compatibility with existing systems, being capable of increasing frequency efficiency, and being capable of increasing the transmitting rate. The intermediate results of the paper lay the ground for designing a new 5G air interface beyond LTE-A, which suits the diverse needs of future applications, like interference coordination between small cells and macro cells.**

Keywords-reconfigurability; wireless communication; pilot channel; super pilot channel; micro-band; macro-band; dynamic spectrum allocation; flexible spectrum management

I. INTRODUCTION

Various standards for wireless communication technologies have been established. Global wireless network operators have been taking steps to advance throughput of their mobile networks as part of the fourth generation LTE (Long-Term Evolution) communications technology. An important factor in radio access is the interference among cells [1]. By a very dense deployment of low-cost, low-power base stations, both the spatial reuse of radio resource and transmit power efficiency can be potentially improved. It is envisioned that the next generation wireless networks will consist of macro-cells and a high density of small-cells with different capabilities including transmit power and coverage range [2]. Also, to improve spectrum efficiency, the D2D (Device-to-Device) communication is one of the solutions in heterogeneous networks [3]. The interference between macro-cells and small-cells as well as the interference between adjacent small cells is always a serious concern. The widely used inter-cell interference (ICI) mitigation techniques in homogeneous networks are soft frequency reuse [1] and interference self-cancellation scheme [4]. Although small cells can help reduce data traffic density, complexity should be improved in using ICI. Especially ICI mitigation techniques in D2D should be applied to both small and wide area cells; to both low and high frequency bands; to both high and low mobility scenarios; and also it could improve the effective SINR (Signal-to-Interference and Noise Ratio). The core concept of the fourth generation network is as follows: every (Signal-to-Interference and Noise Ratio). The core concept of the fourth generation network is as follows: every device uses an IP address, and the proposed network of a convergence type includes an IP-based core network and access networks based on various existing standards. The fact that these various standards operate in different bands restricts any approach to accommodate all future standards. In most cases, existing sensing frequency bands have a too wide range of 400MHz to 6GHz [5]. Therefore, it takes a long sensing time to use a different system, and a large amount of power is consumed. The advantage of this paper is that it allows tight coordination features such as interference in D2D. It also provides potential for spectrum gains like easier deployment and other site cost. The rest of this paper is organized as follows: Section II describes the related works. In Section III, the system description and the proposed frequency structure of a cell are presented. Then in Section IV, the radio access scheme with access method of macro-band and micro-band SPC (Super Pilot Channel) in RAS is considered. Conclusion is shown in Section V.

II. RELATED WORKS

Small cells in heterogeneous network are typically overlaid on the existing macro cells and installed in the dense area close to small cell users [2]. It is noted that small cell users need sensing time for avoiding interference from macro cell. Compared to the interference management of D2D communication on the different frequencies in the previous work [3], we propose interference management not only D2D but also general mobile users by allocating SPC-based channel over macro cell area including small cells. In an attempt to reduce sensing time among heterogeneous networks, E^2R is currently developing concepts and solutions for a Cognitive Pilot Channel (CPC), encompassing both in-band/out-band and downlink/uplink functionalities [6]. It focuses on the network selection strategy according to the information which could be brought by CPC, whereas our key ideas are reconfigurable and broadcast-based SPC assignment by designing of frequency structure of macro and micro cells. Another works is that a novel homogeneous mesh grouping scheme based broadcast CPC mode is designed to improve the efficiency of broadcast CPC mode in the Cognitive Wireless Networks

[7]. However the CPC is based on broadcasting technology and each access station is provided with multiple RAT information. This requires a supervising CPC control station for managing the RAT overall. J. R. Moorman presented the development and implementation of a software radio designed for a 3G system that expands upon the notion of the physical layer software radio to encompass upper layer processing capabilities [8].

To realize the structure of device with a high mobility, flexibility and reconfigurability, software Defined Radio (SDR) is one of possibilities. It provides the seamless shifting between existed air-interface standards. Extending the flexibility further, a system capable to sense the spectrum space available for communication and adapt to it is Cognitive Radio (CR). Obviously SDR in CR should be configured not only to independent standards, protocols and services but also to the extensively dynamic nature of bandwidth allocation [9]. In [10], a low-cost reconfigurable antenna array was implemented for SDR-based Communication Systems.

In this paper, we propose a prototype of a reconfigurable radio access for microcells as well as macro cell, based on SPC that will be integrated with multi-RAT networks and shown operation of a micro-band based on a micro-band SPC between a RAS and its RMS. SPC is used through interworking with a Reconfigurable Mobile Station (RMS) to provide an optimum radio access environment satisfying Dynamic Spectrum Allocation (DSA) and Flexible Spectrum Management (FSM). The first RAS, which evolves to enable SPC-based multi-access, shares corresponding SPC information through broadcasting (macro-band) to support radio environment sharing and reconfiguration of the RMS based on the sharing (micro- band). As used herein, “reconfigurable” means that a number of RATs are supported, and RMSs can be configured in conformity with each RAT. Such technology includes CR/SDR technology, etc. In practice, a large number of CPC control stations are expectably necessary on a global scale, and a considerable amount of cost and time will be incurred. In this paper, we focus on inter-cell interference between the macro cell and the small cell as well as frequencies allocation under heterogeneous networks.

III. Proposed Model

A system for radio access in a wireless communication system in which a number of RATs exist includes RAS configured to share radio environment information and the RATs with an adjacent RAS using a macro-band SPC. The RAS being reconfigurable in conformity with RATs and a RMS configured to transmit and receive the radio environment information and the RATs to/from the RAS using a micro-band SPC and access the RAS using the micro-band SPC, the RMS being reconfigurable in conformity with RAT of the accessed RAS.

A. System Description

Fig. 1 briefly depicts a method for radio access based on a SPC in a reconfigurable multi-RAT mobile communication system. It shows RASs in RAT-i to handle RATs supported in respective cells. RMSs in RAT-j access the RASs and receive a service using the RATs. The macro-band SPCs (red arrows) in RAT-1 exchange information regarding the RATs between the RASs. The micro-band SPCs (blue arrows) in RAT-j perform access and control between the RASs and the RMSs. Each RAS supports RAT, which is supported by a cell, managed by the RAS itself. Respective RASs configured to transmit the macro-band SPCs may be configured in a mesh type. Various RATs are used in Fig. 1 and RATs have different cell radius. In the overlapping cell environment using RAT-1, respective RASs belonging to RATs (RAT-2, RAT-3, RAT-4, RAT-i, and RAT-j) use their own RATs. In a cell using RAT-2, the current RAT-1 can be used simultaneously (i.e. overlapping cell). For example, a WiBro cell capable of managing a wide range of networks may include a WLAN cell capable of managing small-scale networks. A RMS in RAT-j transmits an access request to an accessible RAM in RAT-i using micro-band SPC between RAS-j and RAM in RAT-j and, when the access request is acknowledged, communication becomes possible. In order to enable this process, the RAS in the center cell broadcasts RAT and radio environment information to RASs in adjacent cells using a macro-band SPC between center RAS and RAS-j in RAT-j to share the radio environment information. Based on the information broadcasted using the macro-band SPCs between RAS-j and RAM in RAT-j, when the access is acknowledged, communication becomes possible.

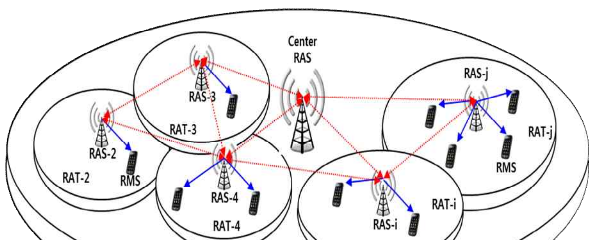

Figure 1. Super pilot channel-based cell configuration

B. Arrangement of Frequencies

In Fig. 2, single center cell is surrounded by six adjacent cells and it communicates with RMSs using same frequency. For example, a cell managed by RAS1 is surrounded by six adjacent cells managed by six RASs{2,3,4,5,6,7}. Furthermore, a cell managed by RAS3 is surrounded by six adjacent cells managed by six RASs{1,2,4,8,9,10}. The RASs of such center cells broadcast radio environment information using the macro-band SPCs to share the radio environment information. For example, RAS3 is an adjacent cell of RAS1 and receives radio environment information through the macro-band SPC.

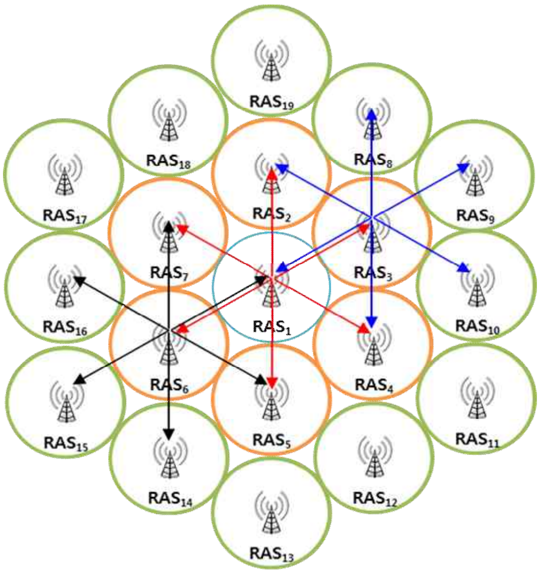

Figure 2. Arrangement of frequencies among RASs

However when RAS3 acts as a center cell, it broadcasts radio environment information to RASs of its six adjacent cells through the macro-band SPC to share the radio environment information. Each unit cell has a first layer of cells, where influence is limited to an adjacent cell by adjusting power intensity without using different frequencies, and a second layer of cells, where a single frequency band is used to communicate with adjacent cells to avoid interference with cells beyond the adjacent cells. For example, the first layer of RAS_1 includes $RASs_{\{12,3,4,5,6,7\}}$ and second layer thereof includes $RASs_{\{8,9,10\}}$.

C. Frequency Structure of a Cell

Fig. 3 shows a RAS with an antenna belonging to the RAS and capable of transmitting a micro-band SPC and a macro-band SPC. The i^{th} RAS has two antennas and two frequency bands corresponding to the two antennas. One frequency band is used to broadcast radio environment information to the $j^{th}(j>i)$ RAS in an adjacent cell using the antenna which belongs to the RAS and which can transmit a macro-band SPC.

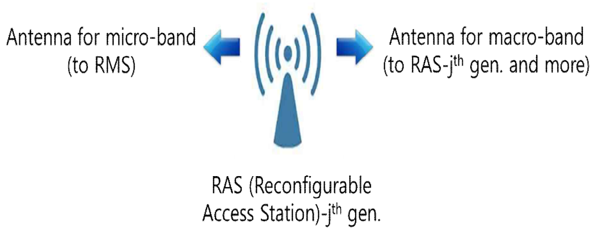

Figure 3. Frequency structure of RAS

In addition, RMSs inside the i^{th} RAS are provided with radio environment information regarding the center cell and adjacent cells using the antenna, which can transmit a micro-band SPC. The two antennas are configured to transmit/receive two different frequency bands respectively, i.e. a macro-band as a frequency band for broadcasting each radio environment information to the $j^{th}(j>i)$ RAS in an adjacent cell and a micro-band as a frequency band for providing RMSs inside the i^{th} RAS with radio environment information regarding the center cell and adjacent cells.

IV. Radio Access Scheme

To cope with the huge demand for capacity in ultra-dense network, next-generation networks rely on densely deployed RAS between macro and small cells. To expand capacity and minimize interference, we used macro-band SPC on between RASs and micro-band between RAS and its RMSs.

A. Access Method of Macro-band & Micro-band SPC in RAS

Figs. 4 and 5 show access method of macro-band and micro-band SPC, which transmits and receives radio environment information between RASs. The RAS in Fig. 4 transmits radio environment information, which has been measured and stored in its storage space, to adjacent RASs including the RAS-2 using the macro-band SPC. The RAS-2 stores the radio environment from the RAS-1 in its storage space, acting as center RAS, and transmits the information from the RAS-1 to RASs including the RAS-3 using the macro-band SPC. In a similar manner, the RAS-3 receives the radio environment information from the RAS-1 and stores the information in its storage space. The RAS-2 similarly transmits its radio environment information to RASs in adjacent cells, i.e. RAS-1 and RAS-3, which then stores the radio environment information from the RAS-2, acting as center RAS, and transmits radio environment information regarding the RAS-1 to RASs in adjacent cells.

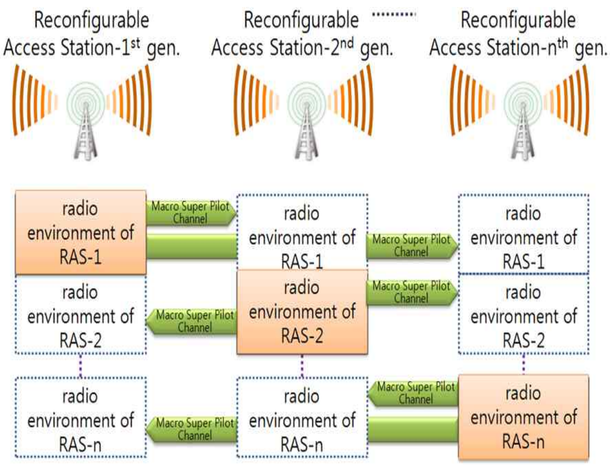

Figure 4. Access method of macro-band SPC between RASs

Fig. 5 shows operation of a micro-band based on a micro-band SPC between a RAS and its RMS and also represents a process of accessing RAS-*i* by RMS using micro-band SPCs (REQ & ACK). It is assumed that RAS-1 supports RAT-1.

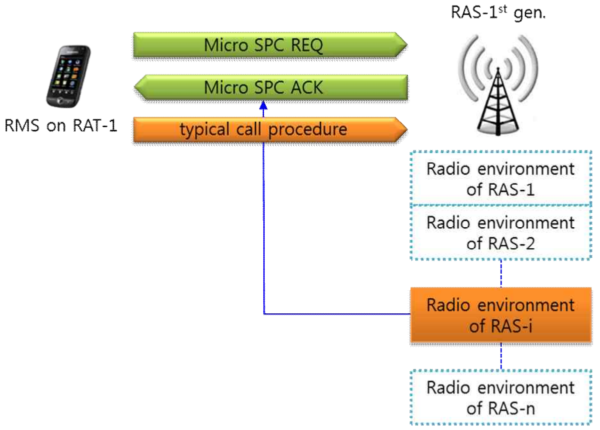

Figure 5. Operation of micro-band SPC between RAS and its RMS

B. Handover Mchanism in SPC Operation

It is assumed that in Fig. 6, RAT-1 is supported by RAS-i, and RAT-2 is supported by RAS-*j*. The RMS existing inside a cell of RAT-1 transmits a micro-band SPC REQ message, which is an in-band signal, to the RAS-*i*.

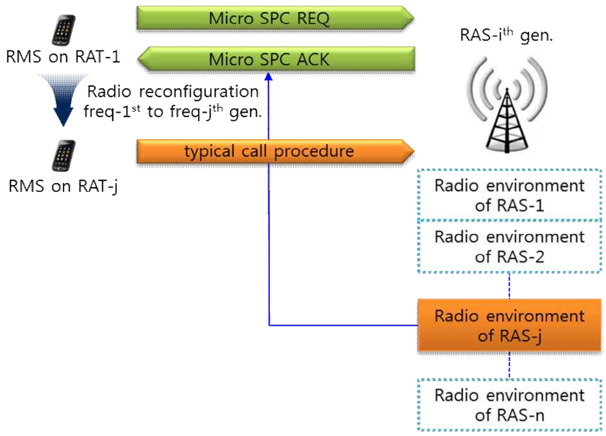

Figure 6. Operation of handover by exchanging adjacent channel information

The RAS-i transmits its radio environment information as shown in Fig. 5, when the radio environment is available. However, when the radio environment is not available, the RAS-i checks the radio environment information of an adjacent cell to see which is more available. Then the RAS-i loads frequency of an adjacent cell, which is the most available, onto a micro-band SPC ACK message and transmits it to the RMS that has made the request. The RMS receives the frequency regarding the RAS-j and changes it into RAT. The RMS moves to the RAS-j and performs a typical call procedure. In Table I, we provide an overview of the structure of radio environment information believed to be closely related to the radio environment information frame of a RAS considered in this paper. Each cell has its radio environment information map data including a self-RAS id field containing its own RAS id and an adjacent RAS id field containing information regarding operators to which RASs belong. In addition, the frequency, radio access specification, channel status, and traffic status are stored for respective operators to which RASs belong. Fig. 7 illustrates the structure of a macro-band SPC.

TABLE I. RADIO ENVIRONMENT INFORMATION FRAME

Self RAS id	Adjacent RAS is	Operator	Frequency	RAT	Channel Status	Traffic
RAS_1	RAS_1	O_1	f_1	RAT_1	ch_sts	traffic_sts
			f_2	RAT_2	ch_sts	traffic_sts
		O_2	f_3	RAT_3	ch_sts	traffic_sts
			f_2	RAT_2	ch_sts	traffic_sts
	RAS_2	O_1	f_1	RAT_1	ch_sts	traffic_sts
			f_2	RAT_2	ch_sts	traffic_sts
		O_2	f_3	RAT_3	ch_sts	traffic_sts
			f_2	RAT_2	ch_sts	traffic_sts

A macro-band is similar to an out-of-band signal of a CPC. And radio environment information between RASs includes a REQ message and an ACK message. The REQ message includes a RAS id field and a null field. The ACK message of the receiving RAS corresponds to an ACK signal in response to the REQ signal of the transmitting RAS, and includes self-RAS id and its radio environment information. Fig. 7 illustrates an overview of a macro-band SPC, which is similar to an out-of-band signal of a CPC. It refers to a signal for sharing RAS radio environment information between RASs, and includes an RAS and its radio environment information transmitted between RASs. Fig. 7 illustrates an overview of a macro-band SPC, which is similar to an out-of-band signal of a CPC. It refers to a signal for sharing RAS radio environment information between RASs, and includes an RAS and its radio environment information transmitted between RASs.

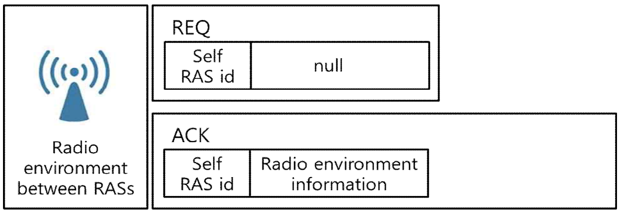

Figure 7. Message of macro-band SPC

The radio environment information includes a REQ message and an ACK message. The REQ message consists of a RAS id and a null. The ACK message consists of RAS id and radio environment information. The RAS REQ message of a transmitting RAS corresponds to a REQ signal requesting radio environment information regarding the receiving RAS, and includes its self-RAS id and null data for compatibility with an ACK signal.

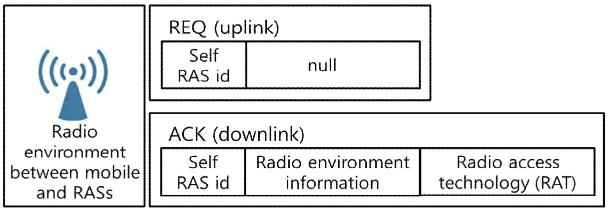

Figure 8. Message of micro-band SPC

Fig. 8 is shown as an overview of a micro-band SPC, which is similar to an in-band signal of a CPC. It refers to a signal for transmitting/receiving optimum radio environment information between a RAS and a RMS when RASs share radio environment information, which includes a REQ message and an ACK message. The REQ message refers to a message transmitted from a RMS to a RAS through an uplink, and includes a RMS id field and a null field. The ACK message refers to a message transmitted from the RAS to the RMS.

V. CONCLUSION

To expand capacity and minimize interference among macro and small cells, we proposed radio access scheme using super pilot channel in reconfigurable multi RAT-based wireless communication system, in which includes a RAS configured to share radio environment information and the multi RATs with an adjacent RAS using a macro- band SPC, the RAS being reconfigurable in conformity with the RATs. The RMS is configured to transmit and receive the radio environment information and the RATs to/from the RAS using a micro-band SPC and access the RAS using the micro-band SPC, the RMS being reconfigurable in conformity with RAT of the accessed RAS. For further study, we will set up the simulation model using our proposed radio access scheme with super pilot channel and then evaluate its result.

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