DAS for Smart Communities: Challenges and Approaches

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***Abstract*—Distributed antenna system (DAS), one of the key technologies to realize smart decisions in wireless communication systems, can settle network smart coverage problem and improve system energy/spectrum efficiency significantly. This paper summarizes and analyzes the existing DAS research for smart wireless communities. Furthermore, some future research challenges and directions are highlighted.**

***Index Terms*—Smart communities, DAS, spectrum efficiency.**

I. Introduction

The fast-growing demand for data transmission rate and multimedia services have posed strong challenges for the next generation mobile communication system. Distributed antenna system (DAS) is one of the most promising technologies to serve a large number of users because of its wide coverage, low power consumption, and large diversity gains.

In the traditional DAS network structure, antennas are co-located in the center of cell to provide severs for users and the dead spots within the cell caused by shadow fading and path loss may degrade the quality of wireless communication significantly. The cell-edge users may suffer from both weaker signal strength due to relatively longer propagation distance and stronger inter-cell interference. Nowadays, the remote antenna units are uniformly distributed in cell, which can reduce the shadow fading and path loss, so that it can get better performance and user experience.

When it comes to smart communities, all community owners are expected that the residential smart community system will bring the following experiences: 1) a high degree of security; 2) a comfortable human environment; 3) broadband digital communication; 4) convenient integrated community information services; 5) home smart; 6) property management smart information. Most of the existing research and technological advancements have vitalized the ubiquitous information access and communication by device connection in practice. All the devices generated and shared information accessing to smart communities will improve people's quality of life by making smart decisions. Therefore, DAS technology may play an important role to realize a smarter life for future community circumstances.

In this work, we summarizes the existing DAS research for smart communities from the aspects of antenna distribution, system capacity, spectrum efficiency/energy efficiency, and green access technology. Furthermore, we introduce some research opportunities and challenges in the future.

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II. The State-of-art of DAS for Smart Communities

A. Antenna Distribution

Both the antenna number and position distribution of DAS can impact on its system performance. In [1], the antenna position is optimized to maximize the average cell capacity. When users are evenly distributed, the problem is transformed into equivalent vector quantization code design and the theoretical optimal value of antenna distribution radius can be deduced. In [2]-[4], the influence of antenna gain and deployment location control on system capacity are analyzed, respectively. In [5], the optimization of position location in composite fading channel is investigated under single and double cell antenna deployments.

B. System Capacity

Compared with the traditional centralized antenna system, DAS can get higher system capacity due to the following reasons: 1) it can shorten transmission distance between mobile user and base station and reduce signal attenuation; 2) the antenna unit is simple, low cost, and less mutual interference/transmission power; 3) spatial diversity gain is high; 4) resource management is flexible and efficiently.

In [6], the downlink capacity of DAS is studied and a multi-cell downlink power allocation algorithm based on symbol programming is proposed in single-user multi-cell scenario. In [7]-[8], the capacity of single and multi-user system under centralized and distributed antenna distributions are deduced, respectively. The stochastic matrix theory is used to analyze the multi-user multi-antenna uplink capacity problem. In addition, the multi-carrier aggregation DAS resource allocation problem has been widely concerned. Analysis and simulation

results show that distributed deployment of antenna units can effectively improve system capacity.

C. Spectrum/Energy Efficiency

Due to lack of wireless spectrum and energy, it is pointed out in [9] that DAS is a new network architecture that has inherent advantages in increasing spectrum/energy utilization and covering blind spots. Experimental results shows that cooperation among antenna units in DAS can enhance system throughput and improve quality of transmitted signal. Furthermore, due to the network architecture of DAS, the distance between users and remote antenna units is shortened, which makes it possible for remote antenna unit and mobile user to transmit signals at a lower power.

D. Green Access Technology

The existing works in DAS green access technology are mainly analyzed in time domain, frequency domain, and space domain. It is suggested to turn off power amplifier when there has no data or only a little flow in downlink transmission. In addition, a multi-frequency broadcast single frequency network (MBSFN) transmits same signal simultaneously from different downlink cells so that the different MBSFN will be distinguished and terminal user will not be interfered by adjacent cells. The signal anti-jamming capability becomes stronger due to the superposition of MBSFN cells.

III. Research Opportunities and Challenges of DAS for Smart Communities

As a kind of new network architecture, DAS has its inherent advantages in promoting smart communications. There are still several issues that should be resolved for smart communities in the future.

Firstly, the interference of DAS mainly refers to inter-cell mutual interference. Some recent works on DAS for smart communities are interference management. Additionally, unlicensed spectrum operation causes uncertainty as to whether the spectrum and services are truly available, which results in a trial-and-error process users that do not appreciate. However, community cooperation is an effective method to suppress this kind of interference. So, in the future smart community networks, how to achieve multi-cell collaboration to suppress interference is a major challenge for DAS development.

Secondly, wireless channels of DAS accompanied by emergence of many unpredictable random phenomena from reflectors and scatterers are extremely complex. In general, it is modeled as a composite fading, including path loss, shadow fading, or multi-path fading, where the path fading is caused by radiation spread and propagation of transmitted power. This model can reflect the change of the received signal power in a macroscopic range. However, it is found that received power at different receiving points is greatly different and even it fluctuates at different time points of same receiving point. As antennas are distributed in different locations, wireless channel modeling of DAS In addition, multi-path makes amplitude, phase, and arrival angle of received signals to fluctuate which changes faster than shadow fading.

Thirdly, the existing channel information of DAS based on distributed MIMO systems is no longer a vector but a matrix, which makes the accurate channel estimation very difficult. DAS operation can be fairly transparent to users, who simply enters a request for a uniform channel estimation provider. DAS can detect that the request is sent to the local antenna server and then hands the communication over to a DAS connection. At present, there is no effective algorithms on channel estimation yet. Consequently, channel estimation has become one of the important challenges for the development of DAS in smart community research.

Moreover, in the current practical market, the cellular operators and vendors are exploring the possibilities of smart communities, such as D2D with DAS in cellular networks. User device can communicate directly with each other over DAS links. All of these user devices generate and share information, which will improve the quality of service by smart decisions. However, the existing internet architecture is host centric and intended for end-to-end communication. Without utilizing the previous context of cities, it is quite difficult to design and build a foreseen future smart community. Therefore, the data generated by various devices needs to be efficiently processed through various techniques and tools.

IV. Conclusion

This paper mainly introduces the research status of DAS and discusses its practical applications in smart communities. Some challenges about large-scale deployment of DAS in smart communities have been summarized. The emergence of DAS provides a favorable condition for the development of future smart communities.

References

[1] X. Wang, P. Zhu, and M. Chen, “Antenna location design for generalized distributed antenna systems,” IEEE Commun Lett., vol.13, no.5, pp.315-317, 2009.

[2] L. Dai, S. Zhou, and Y. Yao, “Capacity analysis in CDMA distributed antenna systems,” IEEE Trans. Wireless Commun., vol.4, no.6, pp.2613-2620, Nov. 2005.

[3] J. Y. Wang, J. B. Wang, and M. Chen, “System capacity analysis and antenna placement optimization for downlink transmission in distributed antenna systems,” Wireless Pers. Commun., vol.71, no.1, pp.531-554, 2013.

[4] D. Castanheire and A. Gameiro, “Distributed antenna system capacity scaling,” IEEE Wireless Commun., vol.17, no.3, pp.68-75, 2010.

[5] DE. Park and I. Lee, “Antenna placement for downlink distributed antenna systems with selection transmission,” IEEE Vehicular Technology Conf., Budapest, pp.15-18, May. 2011.

[6] C. Wan and J. G. Andrews, “Downlink performance and capacity of distributed antenna systems in a multicell environment,” IEEE Trans. Wireless Commun., vol.6, no.1, pp.69-73, 2007.

[7] L. Dai, “A comparative study on uplink sum capacity with co-Located and distributed antennas,” IEEE J. Sel. Areas Commun., vol.29, no.6, pp.1200-1213, 2011.

[8] Z. Xu, C. Yang, G. Y. Li, et al, “Energy-efficient configuration of spatial and frequency resources in MIMO-OFDMA systems,” IEEE Trans. on Commun., vol.61, no.2, pp.564-575, 2013.

[9] A. Attar, H. Li, V. C. M. Leung, “Green last mile: how fiber-connected massively distributed antenna systems can save energy,” IEEE Wireless Commun., vol.18, no.5, pp.66-74, 2011.