A Bacteria-Inspired Network Platform for 5G Mobile Communication System

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Abstract

A surge of innovation in technologies for 5G mobile communication is on the horizon, but its specification is still just being discussed. This paper presents a novel network platform for 5G mobile communication system, viz Software Defined Wireless Bacterially-Inspired Network (SDWBIN). The SDWBIN platform integrates the concepts of molecular and bacterial communication into traditional mobile communications so that the features of molecule and bacteria (i.e., awareness, infection and diffusion) could be applied to end devices, such as vehicle-to-vehicle, machine-to-machine and device-to-device. In order to realize the design of SDWBIN platform, we exploit the framework of Software Defined Wireless Network to implement the core network in SDWBIN. We expect that the proposed SDWBIN platform can tackle with the communication from an enormous number of devices in 5G systems.

Keywords: 5G Mobile Communication, Molecular Communication, Bacterial Communication, Software Defined Wireless Network

1. Introduction

Mobile communication systems have been developed for many years but still challenging due to unmet user data rate [1]. The 4G mobile communication system expects to achieve 1 Gbps and 100 Mbps for fixed and mobile users respectively. Both of Long Term Evolution (LTE) and LTE-Advanced (LTE-A) are candidate technologies for 4G standard. Recently, researchers [2] start to discuss and investigate the fifth generation (5G) mobile communication system with regard to its specification, requirements and technologies. Various organizations begin to study performance goal and key technology for 5G, such as European Telecommunications Standards Institute (ETSI), Third Generation Partnership Project (3GPP) and International Telecommunication Union (ITU).

The 3GPP proposed LTE-Unlicensed (LTE-U) to tackle with the spectrum utilization in unlicensed bands [3] and also submitted LTE-B to pursue the 5G standard. ITU

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established the 5G promotion group to setup a program towards International Mobile Telecommunications (IMT) for 2020 and beyond. It can be observed that mobile communication is heading into 5G era. However, the opinions of 5G performance goals are widely divided. The overall development from various organizations is that 5G expects to achieve 10 to 100 times better than 4G in network capacity, 10 to 1000 times less in energy consumption, 1000 times more than currently in number of devices, and the network latency is less than 1 ms.

The rest of this paper is organized as follows. Section II introduces the background of this work, i.e., 5G mobile communication system, molecular communication and Software Defined Wireless Network. In Section III, the proposed framework for 5G mobile communication system is given and discussed, such as the service chain and ecosystem of proposed platform. Finally, conclusion of this work is drawn in Section IV.

2. Background

2.1 5G Mobile Communication

ITU announced that IMT-Advanced is the 4G standard in 2008. There are various key technologies, such as LTE and IEEE 802.16e. In addition, ITU expects to propose the future IMT in 2020, which includes many potential techniques, e.g., Heterogeneous Network (HetNet) [4], Massive Multiple-Input and Multiple-Output (MIMO), Cloud Radio Access Network. On the other hand, organizations such as Mobile and Wireless Communications Enablers for the Twenty-Twenty Information Society (METIS) [5] and METIS-II [6] consider that the HetNet of 5G includes Device-to-Device (D2D), Moving Networks (MNs), Ultra-Dense Networks (UDNs) and Ultra-Reliable Communication (URC). Beside, METIS also deems that the core network of 5G is based on the Software Defined Networking (SDN) and Network Function Virtualization (NFV).

2.2 Molecular Communication

In recent years, molecular and bacterial communications have been proposed to realize nano-communication networks [7]. A bio-inspired network utilizes the change of medium and carrier to accomplish information transmissions. For example, researchers [8] developed an engineered gene network for synchronously generating fluorescence oscillations in the population of cells. A deoxyribonucleic acid of cell colony is capable of carrying plentiful information by encoding operation. Then, cell colonies randomly infects a directional cells through the infection operation. However, nano-communication is restricted to transmission range due to the nature of medium [9]. Water is a boon in the desert, but the drowning man curses it. The short-range feature of molecular and bacterial communication is suitable for applying to D2D, Machine-to-Machine (M2M), and Vehicle-to-Vehicle (V2V).

2.3 Software Defined Wireless Network

SDN was proposed to manage and mitigate the enormous network traffic [10]. It decouples the current network architecture into control plane and data plane so that it can provides the better flexibility in dealing with network traffic. Besides, the controller in control plane centrally manages flows in a software manner. In order to cope with wireless networking for mobile networks, the software defined wireless network (SDWN) is proposed. A controller of SDWN is able to recognize wireless access points and works as a normal SDN controller. The Anyfi networks company announces that its Anyfi.net software can be installed on OpenWrt. Accordingly, network administrators are able to build their own SDWN controller for managing wireless networks.

3. Proposed Framework

In this paper, we propose a bacteria-inspired network platform for 5G mobile communication system. The component mapping between traditional bacterial network and our Software Defined Wireless Bacteria-Inspired Network (SDWBIN) is shown in Table I.

3.1 The Framework of SDWBIN

The network platform of proposed SDWBIN is shown as Fig. 1. The bottom layer is a heterogeneous network, which is composed of a large number of access technologies. The middle layer is the SDWN core that executes an open
standard OpenFlow protocol [11]. The upper layer is the network virtualization layer, which is based on the NFV and virtualization technique. Note that the Flowvisor [12] in SDWN Core slices a physical network into several logical networks by inserting a layer between data and control planes.

3.2 The Service Chain of SDWBIN

In order to realize a bacteria-inspired ecological chain for mobile networks, we apply the concept of Service Function Chaining (SFC) to our SDWBIN platform, which is shown as Fig. 2. First of all, the classification operation packs data based on initialized policies and sends to the designed SFC. Then, service functions cope with the received data for dealing specific logic components. The service function forwarder is responsible for controlling the traffic forwarding of SFC. After that, SFC defines a set of service functions and traverses all of them serially. According to above operations, the proposed SDWBIN can realize the features of bacterial communication in mobile communication systems, such as the cross-layer infection and short-range diffusion.

3.3 The Ecosystem of SDWBIN

The ultimate goal of proposed SDWBIN is to construct a bacteria-inspired self-organized ecosystem, which is shown as Fig. 3. In the expected ecosystem, each biological chain has its own infection and diffusion approach. The exclusive approach is similar to the communication between devices, e.g., M2M, D2D and V2V. A bacterium searches an optimal path to execute infection and diffusion as well as a user seeks the best path to transmit data in wireless networks. We realize the interactions between different biological chains in mobile communication system based on cross layer design. Therefore, the proposed SDWBIN platform is capable of integrating different access networks and achieving self-organization for the potential goal of 5G mobile communication system.
4. Conclusion and Future Work

In this paper, we proposed a novel framework called SDWBIN to integrate molecular and bacterial communication into mobile networks. In addition, SFC is applied to the proposed platform for constructing the ecosystem of SDWBIN. The SDWBIN expects to facilitate the communication between users in 5G system through molecular features. In the future, we intend to implement the SDWBIN platform and investigate research issues with regard to security and privacy, quality of service, mobility and interference avoidance.

References


