Integrated Access and Backhaul Network Model in the Form of Jackson Network for Age of Information Analysis *

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Abstract. In this paper, we propose a model of an IAB network consisting of an arbitrary number of base stations (BS) and user equipment (UE) entities connected in a form of a tree graph with a base station called IAB-donor at the root of it. The IAB-donor receives packets from a server to which it is directly connected, then passes the packets though other BSs to the destined UEs. In this paper the IAB network is modeled as a Jackson network, where the nodes correspond to base stations, the source - to the server, and the sinks - to the subscriber devices. The Laplace-Stiltjes transform and the distribution function of the peak age of information on UEs are obtained for the model.

Keywords: Jackson Network · Age of Information · Integrated Access and Backhaul Networks

1 Introduction

The concept of the Age of Information (AoI) began developing in the scientific literature in the early 2010s [1]. The first significant works on this topic appeared in 2012, when scientists began to study the delay of information update and its impact on communication systems and network protocols. Since its introduction, the AoI concept has gained significant attention and has become an important area of study in the field of telecommunications and networking. In this work we study age of information in an Integrated Access and Backhaul (IAB) network [3].

Consider an IAB network consisting of a server generating updates and base stations (BS) transmitting them to user equipment (UE) entities [2]. Such a network can be conveniently modeled as a Jackson network with a single source (server) and multiple sinks (UEs). The packet transmission time between two

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BSs corresponds to a node's service in a Jackson network. Since BSs form a tree graph, there is only one route from a server to an UE. Therefore, the delay on the route will be equal to the sum of delays on each node in the route.

The peak age of information is calculated as the sum of the packet intergeneration time and packet delivery time. The intergeneration time for one of the routes can be obtained through a given packet arrival rate on that route, and the delivery time is the sum of delays at the nodes on the route. Since all these random variables are exponentially distributed with given parameters, the peak information age has a generalized Erlang distribution. This allows us to find the necessary data on the variable such as the Laplace-Stiltjes transform and the distribution function.

2 Conclusion

In this paper, a mathematical model of the IAB network as a Jackson network with one source and multiple sinks is constructed. Only downward direction of packet transmission was considered. Laplace-Stiltjes transform and distribution function expressions are derived for the model. Further studies are planned to verify the analytical results with simulation modeling.

References

1. Kosta, A., Pappas, N., Angelakis, V.: Age of Information: A New Concept, Metric, and Tool. Foundations and Trends in Networking. 12. 162–259. https://doi.org/10.1561/1300000060.
2. Gupta, M., Roberts, I. P., Andrews, J. G.: System-Level Analysis of Full-Duplex Self-Backhauled Millimeter Wave Networks. IEEE Transactions on Wireless Communications, vol. 22, no. 2, 1130–1144. https://doi.org/10.1109/TWC.2022.3201963.
3. 3GPP TR 38.801 v14.0.0 Study on new radio access technology: Radio access architecture and interfaces. 2017.