Poster: Design and Evaluation of a Time Efficient Vertical Handoff Algorithm between LTE-A and IEEE 802.11ad Wireless Networks

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***Abstract*—LTE-A and IEEE 802.11ad are two of the networks that can have complementary roles in 5G networking. Thus, this paper proposes a time efficient, predictive, and dynamic Handoff (HO) algorithm between these two protocols. The algorithm presented measures the Signal to Interference Plus Noise Ratio (SINR), the Reference Signal Received Quality (RSRQ), velocity, and the Time of Stay (ToS) for pedestrian mobile users and calculates the best Time to Trigger (TTT) value accordingly. One of the main advances of this algorithm is that the TTT value is calculated dynamically regarding user's velocity and Handoff Failure Ratio (HoFR). Comparisons with other algorithms in this area determine that the algorithm proposed gains the least HoFR for these two protocols by avoiding unnecessary handoffs.**

I. Introduction

One of the major research areas in 5G is the offloading process. With offloading, user traffic traverses the local wireless AP instead of utilizing a continuous connection to cellular networks even in indoor areas. In case of using LTE-A in 5G, a proper network for offloading LTE-A communications with up and downlink data rates of higher than 1 Gbps needs to support the same data rates, otherwise, users will not be willing to switch to the local networks. One of the wireless technologies to support high data rates and being deployed in indoor areas as a replacement of traditional WiFi networks is the IEEE 802.11ad standard. This protocol is known as WiGig because of the Gigabit scale data rates it supports. WiGig provides almost 7 Gbps for downlink and almost 3 Gbps for uplink [2].

Switching the user's network from a home (already connected) network, to a new target network (one of the possible networks to be switched to) and vice versa is known as Handoff (HO) or Handover. In this work, a new time-efficient HO algorithm is designed to provide specifically a seamless connection and offloading between LTE-A and WiGig networks as two of the networks might be used broadly in 5G for high data rates . Results of a comparison with other HO algorithms reveal (cf. Section IV) that the algorithm proposed is capable of reducing Handoff Failure Rates (HoFR) in a predictive fashion. Also, the Time to Trigger (TTT) is updated frequently based on measures defined, and the HO process follows a cross-layer algorithm to increase the time efficiency.

II. Simulation Scenarios, Parameters and Evaluation

Simulation of the scenarios done in Matlab. The focus of this work laid on two scenarios: (1) HO process of a user connected to the LTE-A cell and moves toward the WiGig network as presented in Figure 1. (2) HO process of a user connected to the WiGig network and moves toward the LTE-A cell as presented in Figure 2. Parameter used in simulations are listed in Table 1.

TABLE I
Simulation Parameters

Simulation Parameters	Symbol	Value
eNB Number	N_{LTE}	1
WG-AP Number	N_{WG}	1
Simulation Duration	T_{sim}	1000 s
RSRQ Threshold	$RSRQ_{th}$	19.5 dBm
SINR Threshold	$SINR_{th}$	25 dB
LTE-A eNB Transmission Power	P_{LTE}	30 dBm
WG Transmission Power	P_{WG}	10 dBm
LTE-A Bandwidth	B_{LTE}	100 MHz
WG Bandwidth	B_{WG}	2160 MHz
LTE-A Antenna Height	h_{eNB}	40 m
WG Antenna Height	h_{WG}	1.5 m
Mobility Model	———	Gauss-Markov and LPP
Initial TTT	TTT_i	0.1 s
LTE Frequency	f_{c-LTE}	2100 MHz
WG Frequency	f_{c-WG}	60 GHz
LTE Radius	LTE_r	Whole Simulation Area
User Velocity	V_u	$[0-5]m/s$
Data Transfer Direction	———	Downlink
Number of LTE users	N_{U-LTE}	(1-50)
Number of WG users	N_{U-WG}	(1-50)

The HO algorithm proposed is memory-and-time efficient, and managed in a cross-layer fashion. Number of unnecessary HO and HoFR are managed by TTT value. Being a proactive algorithm, users' mobility, including their next location, speed, and angle of movement, are estimated using the Gauss-Markov mobility model, which is updated and readjusted by the accurate data received from Location Positioning Protocol (LPP). This update increases the precision of the Gauss-Markov model for upcoming estimations.

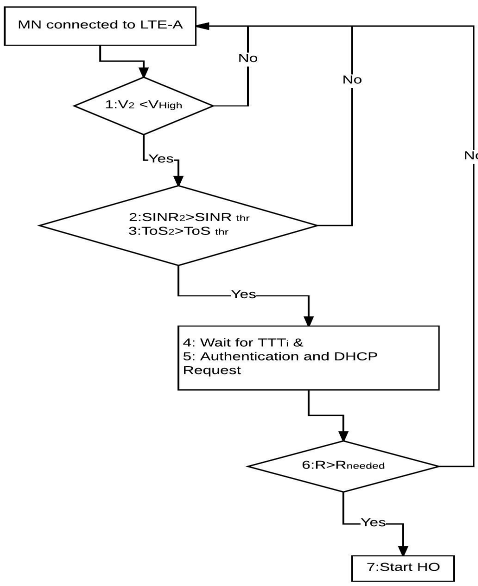

Fig. 1. HO Process: Moving From LTE-A To WiGig

To be computationally efficient, this algorithm does not continuously gather information from target and host networks, instead time intervals are set dynamically according to the amount of TTT to gather information from networks. The algorithm reacts to HoFR increase by adjusting the TTT value. Besides lowering the computational complexity, a binary search is used in TTT calculations to provide faster converges than with a linear method by the order of O(log(n)), which leads a very practical application.

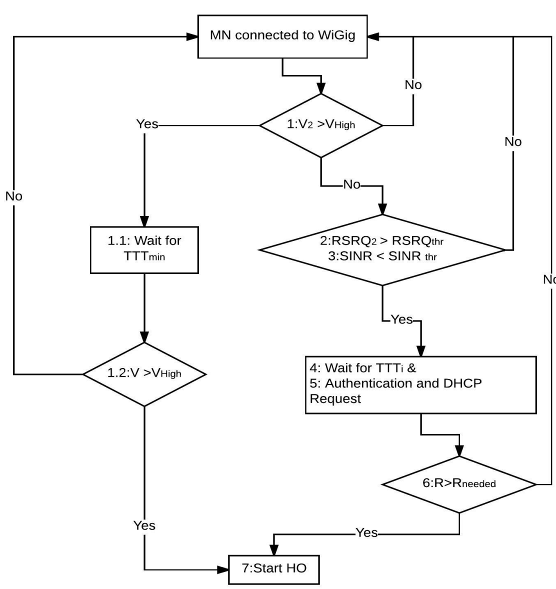

Fig. 2. HO Process: Moving From WiGig to LTE-A

To avoid continuous monitoring of various parameters, this algorithm specifies a high priority to users' velocity. For that reason, checking other variables such as SINR, RSRQ, and TTT is done only, if the user's velocity is in a specific range. Being sensitive to the user's velocity, this new algorithm performs better in comparison to other HO algorithms, especially within the decision making phase for high user velocities.

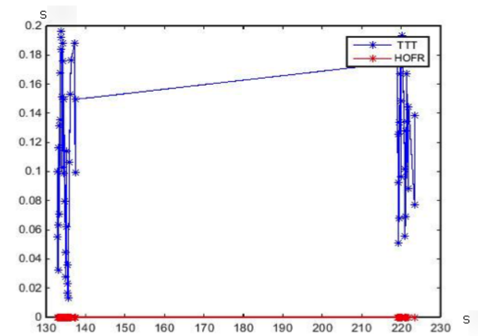

Fig. 3. TTT Variation Using Method of [3] With User Velocity Larger than 3 m/s.

In this algorithm, base (home) and target networks and User Equipment (UE), work together to reduce the process load on each side and calculate the parameters used in decision-making phase. finally, UE decides to start or deny the HO process based on her velocity, current TTT, Reference Signal Received Quality (RSRQ), and Signal to Interference Plus Noise Ratio (SINR). Also, this model is not memory bounded and with only few bytes of memory the user's exact location can be estimated.

Finally, as presented in Figure 3, the proposed algorithm manages to handle the HO process while keeping the HoFR rate close to 0. This is done with keeping the TTT amount in less than 0.2s which will end in a seamless connection. Comparisons with similar HO algorithms [1] revealed that other algorithms cannot be used in scenarios between LTE-A and WiGig networks with the goals of time-efficiency and low data loss during a HO process. High (or constantly increasing) TTT values of other algorithms make them inappropriate to be used for managing the HO processes for these scenarios and in most cases HoFR could not be controlled or reduced by employing the methods used by them.

References

[1] S. R. Niya, B. Stiller, "Design and Evaluation of a Time Efficient Vertical Handoff Algorithm between LTE-A and IEEE 802.11ad Wireless Networks," IFI Tecnical Report No.2018.03, Zürich, Switzerland, Tech. Rep., April 2018. [Online]. Available: https://files.ifi.uzh.ch/CSG/staff/Rafati/Handoff-IFI-2018.03.pdf

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[3] J. Xu, Y. Zhao, X. Zhu, "Mobility Model Based Handover Algorithm in LTE-Advanced," in *10th International Conference on Natural Computation (ICNC)*, Aug 2014, pp. 230–234.