Pricing NOMA Wireless Networking Access With Uber Driver-Passenger Ridesharing Concept

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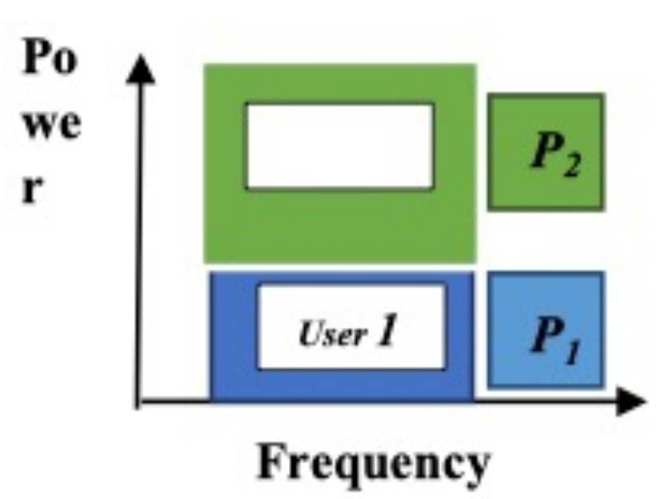
Introduction: Non-Orthogonal Multiple Access Network pricing scheme

Non-orthogonal multiple access (NOMA) has received tremendous attention for the design of radio access techniques for fifth generation (5G) wireless networks and beyond. The basic concept behind NOMA is to serve more than one user in the same resource block such as subcarrier, time slot, frequency, space and power, to serve more than one user in the same wireless resource, a time-slot in TDMA, a frequency band in FDMA, a spreading code in CDMA, or space in SDMA. With benefit of this concept, NOMA network promotes better resource usage efficiency like lower transmission latency, higher user fairness and spectral efficiency compared to orthogonal multiple access (OMA) techniques.



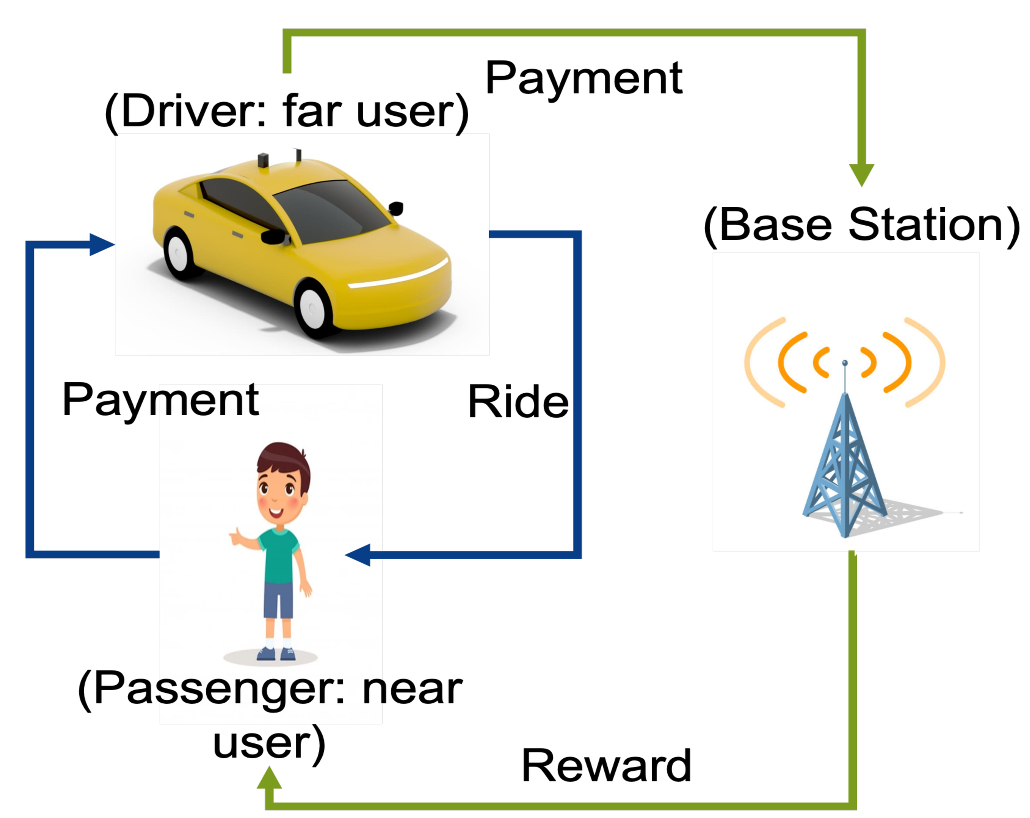
In this research, we put up a new pricing scheme for the NOMA network among users with Uber/Lyft driver-passenger ridesharing concept. The pricing scheme between different users is similar to an Uber/Lyft shared riding system where the taxi driver and passenger utilize the same signal block. The passenger would make a payment for riding and the driver would get utility from the passenger as well as service from the base station. The utility function of users is illustrated based on the measuring quality of service (QoE).

System Design: Uber Driver-Passenger Ridesharing Concept

Compared with a signal block serving for one user in OMA network, more users can shared the power resource in the NOMA block. In this situation, rather than playing games between new coming users with the base station, shall the coming user give payment to another user for resource sharing and how to price the service?

How to allocate the power for the existing user and coming users?

The pricing scheme between different users is similar to an Uber shared riding system where the taxi driver and passenger utilize the same signal block. The passenger would make a payment for riding and the driver would get utility from the passenger as well as service from the base station.



Solution Finding QoE-Utility-Power-Price

What is an optimal pricing strategy for the driver to set the price for passenger? What is an optimal power purchasing strategy for passengers to maximize their utility? We can consider the process between driver and passenger user finding equilibrium point as a two-stage stackelberg game. The utility function of users is illustrated based on the quality of service (QoE).

Data rate $R_i = B\log_2\left(1+\frac{P_i|h_i|^2}{\sum_{k=i+1}^{N} P_k|h_k|^2+\sigma^2}\right)$

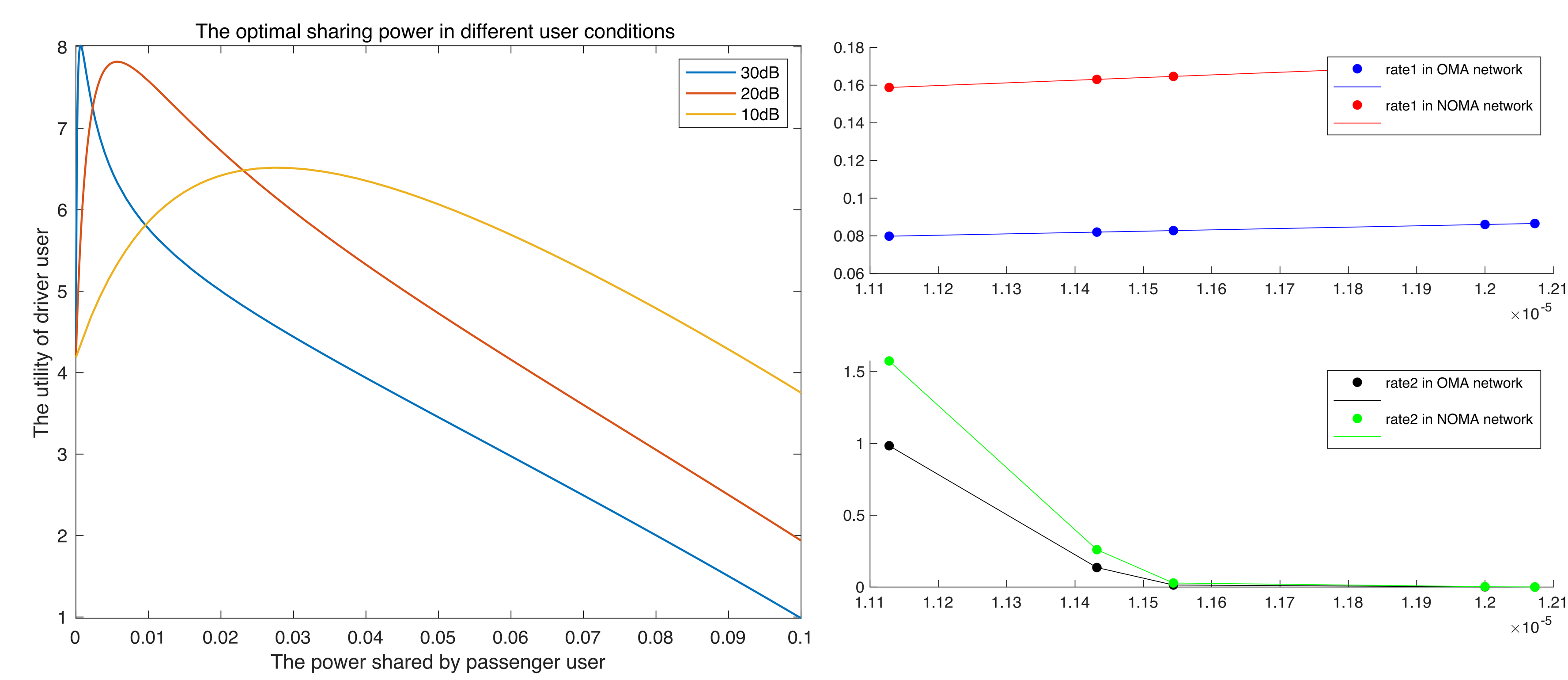
Utility of passenger: $U_1 = \log2(1+\mathrm{B}\times\log_2\left(1+\log_2\left(1+\frac{P_1|h_1|^2}{\sigma^2}\right)\right))+y_2\times p - y_1\times p_1$

Utility of driver: $U_2 = \log2(1+\mathrm{B}\times\log_2\left(1+\log_2\left(1+\frac{(p-P_1)|h_2|^2}{P_1|h_2|^2+\sigma^2}\right)\right))+y_1 * p_1 - y_2\times p$

1. For passenger user: the utility function U1 is concave with respect to P_1 since The two-level logarithmic QoE model when subtracted by a linear cost function introduces concavity to the utility equation. The second order derivative: $\frac{\partial^2 U}{\partial^2 P_1} < 0$. The first order derivative is a monotonically decreasing function and the original function Utility1(P_1) must have a maximum value.

2. For driver user: based on the best response of passenger user, the optimal price can be described by sharing power amount. Therefore, the problem to find optimal power shared by the driver can be solved by global searching algorithm in a given power range.

Results and Discussion



The utility of driver user with different situation is shown in the figure 3. As the distance from the passenger and driver users increases, the SNR difference of their channels increase from 10dB to 30dB. In different SNR conditions, the driver user could find out the optimal sharing power amount with passenger user. Transmission data rate is used to measure the performance of this pricing strategy in NOMA network. Compared with OMA network, this price-power allocation scheme shows better in NOMA network with higher data rate.

Conclusion

1. In this research, we put up a new pricing scheme for the NOMA network among users with Uber/Lyft driver-passenger ridesharing concept.

2. The pricing scheme between different users is similar to an Uber/Lyft shared riding system where the taxi driver and passenger utilize the same signal block. The passenger would make a payment for riding and the driver would get utility from the passenger as well as service from the base station.

3. The utility function of users is illustrated based on the quality of service (QoE) and all users in a signal block can achieve their maximum utilities by deriving game equilibrium.