RAN Slicing to meet Data Rate Requirements

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RAN slicing is a form of 5G virtualization that allows network infrastructure owners to dynamically "slice" their network resources (i.e., spectrum, power, antennas, among others) to different mobile virtual network operators (MVNOs), according to their current needs. We consider data rate requirement as a major factor in creation of the slice. Our goal as part of the class project, is to come up with a solution for efficient RB allocation to a MVNO by selecting optimal MCS for each MVNO based on channel conditions at each TTI, such that the required data rate is achieved at each TTI.

System Model:

We consider the RAN consisting of a set B = {1, 2, . . . , B} of B base stations (BSs). The RAN is administered by a NO, who periodically rents to a set M = {1, 2, . . . , M} of M MVNOs virtual RAN slices built on top of the underlying physical network B. For the sake of generality, we assume RAN slices are valid for T time slots. This way, slow-changing networks (e.g., cellular networks in rural areas during nighttime) can be modeled with large values of T, while small values of T can be used to model fast-changing networks (e.g., urban areas during daytime).

Similar to LTE, spectrum resources are represented as RBs, where each RB represents the minimum spatio-temporal scheduling unit. Also, we consider an OFDMA channel access scheme (as in downlink LTE) where RBs are organized as a resource grid, and where N_{RB} and T represent the number of available subcarriers and temporal slots, respectively. Thus, the set of available resources at each BS is R, with $|R| = N_{RB} \cdot T$.

The MCS of each MVNO directly determines the modulation and coding rate – how much information (in unit of bits) is modulated and coded in each RB for this source node. The higher the MCS is, the higher the modulation and coding rate is. On the other hand, the maximum amount of information can be transmitted on one RB also depends on the channel condition. If the channel condition for this RB is poor and the source uses a high MCS, information carried in the RB will not be successfully received and decoded by the BS.

Therefore, the achievable data rate by an RB depends on both the MCS selected by the scheduler as well as the channel condition for this RB.
We consider the below interaction between MVNO and NO :
1) MVNO's RAN slice requests are collected by the NO.
2) The NO generates a slicing profile L = $(L_{m,b})_{m\in M,b\in B}$ where $L_{m,b}$ represents the amount of resources that the NO should allocate to MVNO $m \in M$. on BS b in the time span $0 \leq t \leq T$.
3) At each TTI, the NO allocates the RB's among the MVNOs by choosing an appropriate MCS such that all MVNO's data rate requirement is satisfied.

As part of the of the project, we are trying to address the third step. As a first step for the project, we are trying to mathematically define the problem. This could take 2-3 weeks. Once we have the mathematical definition of the problem, we will find the optimal solution. This could take another 2-3 weeks. Following this, we have plans to evaluate the performance on a Test bed.

References :

The system model was developed based on the below paper: The Slice Is Served: Enforcing Radio Access Network Slicing in Virtualized 5G Systems [https://arxiv.org/pdf/1902.00389.pdf]