Software-Defined Collaborative RAN Caching and Scheduling: A Preliminary Study for SDN-on-the-Edge

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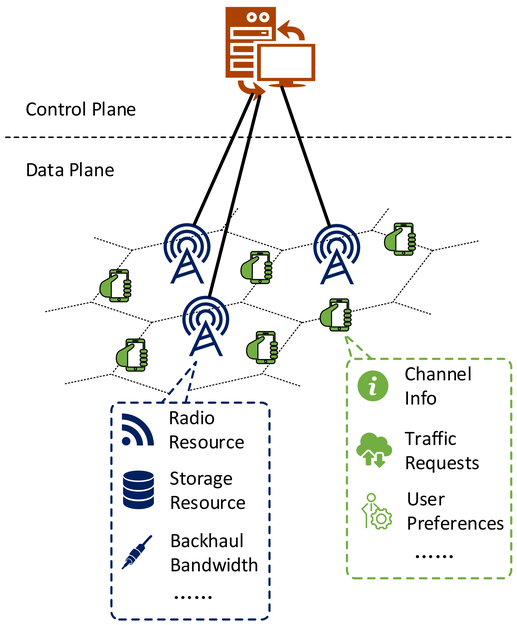
SDN-on-the-Edge

SDN-on-the-Edge employs the Software-Defined Networking (SDN) to the radio access networks (RANs). A central controller controls a set of (nearby) BSs, as follows*.



Benefits:

- **Centralization**: SDN enables global and optimal resource allocation and collaboration among BSs.
- **Adaption**: SDN advances monitoring and adaption to dynamics.
- **Granularity**: SDN enables fine-grained management with low cost.

* Some icons used in this figure are taken from www.flaticon.com.

Collaborative and Fine-Grained RAN Video Caching and Scheduling: A Preliminary Study

As a preliminary study, we try to understand how to reap the merits of SDN-on-the-Edge, by studying video caching and scheduling problem in the RAN. Our studied problem incorporates the following tasks:

- **Resources**: enable *collaborative* resource (cache and backhaul) utilization among BSs ⇨ **Centralization**
- **User dynamics**: consider the *density* and the *preferences* of users in the RAN ⇨ **Adaption**
- **Caching & scheduling**: cache and schedule videos for all users in *fine-grained video layers* ⇨ **Granularity**

Algorithmic Solution

We develop a 2-stage (caching and scheduling) programming-based algorithm for this problem.

Caching:

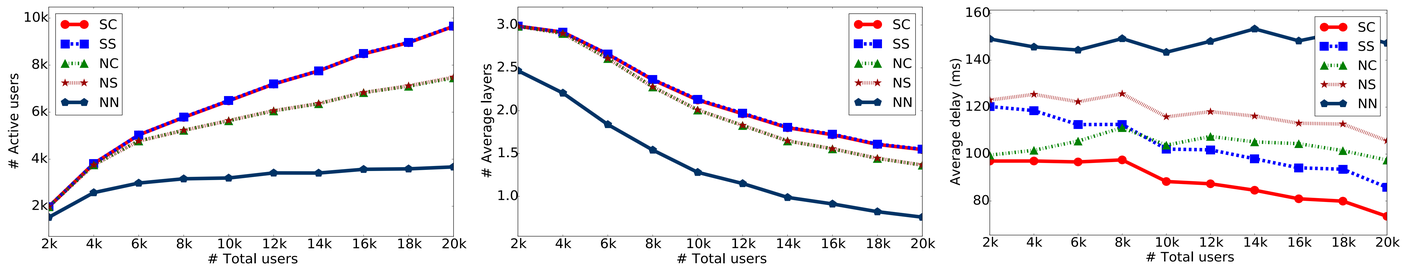
Form ILP formulation and get LP relaxation
↓
Solve LP and obtain fractional solution
↓
Compute *effectiveness value* of each caching decision and sort
↓
Greedily round the caching decisions in sorted order
↓
Output caching decisions

Scheduling:

Form LP with *fixed* caching decisions
↓
Solve LP and obtain fractional solution
↓
Round down scheduling decisions to obtain a basic solution
↓
More can be scheduled? — YES → Schedule some more requests via backhaul → (back to Solve LP)
NO ↓
Output scheduling decisions

Performance Evaluation

Given the algorithm, we compare between *different combinations of techniques* enabled by SDN-on-the-Edge. Both video layering and collaborative caching improve the RAN w.r.t. number of users served and user received delays.



SC: Video layering + Collaborative caching
SS: Video layering + Non-collaborative caching
NC: No video layering + Collaborative caching
NS: No video layering + Non-collaborative caching
NN: No caching

Discussions and Extensions

Southbound communications: only backhaul (BSs to core) but not edge links (UEs to BSs) are considered in the current work.

User modeling and estimation: model and estimate future user behaviors and dynamics based on user density and history.

Dynamics handling: design smart algorithms that respond to user and network changes in real-time.

Hierarchical management: exploit a hierarchical control architecture and locality to scale to large-area RANs.

Conclusions

In this preliminary study, we used RAN video caching and scheduling to study the merits and challenges for using SDN on the edge. Via our algorithm, our evaluation showed that SDN-on-the-Edge improves the performance of the RAN, but challenges do exist including scalability and dynamicity, which we will seek to address in our follow-up research.

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