

## Master thesis 30/60 cr.: Beamforming in wireless coded caching systems

The figure shows the telecommunication traffic daily profile in Western Europe (2020) [1, Fig. A3.3]. Two main highlights of the figure are:

- 1) high traffic profile variation, and
- 2) video streaming taking the biggest slice of the cake.

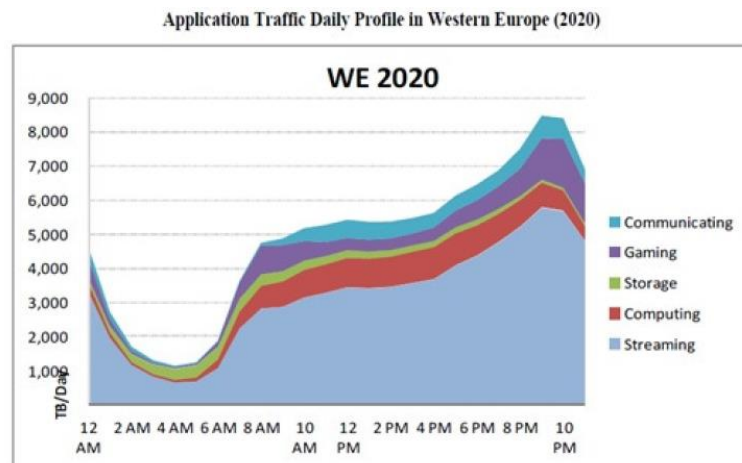


Figure 1. Application traffic daily profile in western Europe, 2020 [1, Fig. A3.3].

Particularly, video has high variation of the daily traffic profile, and increases the backhaul peak rate during the night significantly. For instance, YouTube and Netflix alone account for almost half of the peak downstream traffic in USA [2]. This is important because wireless network is designed based on the peak traffic. Then, with a variant daily traffic profile, the network will be underutilized most of the time, which is not economically viable. Thus, predicting the videos of interest in high-traffic periods, and *caching* them in the access points close to the devices during the low-traffic periods will result in significant cost reduction. For these reasons, caching is currently used by different content providers where, for instance, caches serve up to 90% (resp. approximately 60%-80%) of the Facebook [3] (resp. Netflix [4]) content requests.

In wireless networks, caching is defined as storing popular reusable information at intermediate nodes reducing the backhauling load [5]. This is of interest in delay- and/or backhaul-limited applications such as V2X, D2D [6]-[7] and wireless backhaul, e.g., [8]-[9]. Caching is a fairly old topic. Initial (un-coded) caching schemes were based on distributing the same information between the caches and minimizing the cache miss probability which is defined as the probability of the event that the device's requested files are not previously buffered in the caches. Minimizing the cache miss probability improves the *average* system performance. On the other hand, the outstanding work of [10], [11] exploited the network coding concept and the multicasting opportunity of cache networks to introduce *coded-caching*, minimizing the *worst-case* backhaul *peak rate* in the high traffic period.

As opposed to un-coded caching, with coded-caching the cache nodes are filled in with different sub-packets during the low traffic period. This gives the chance to *broadcast* specific superpositions of different sub-packets during the high-traffic periods, which reduces the peak load correspondingly. Different reports have studied the performance of coded-caching networks from an information theoretic perspective, and have shown orders of magnitude performance improvement, compared to state-of-the-art uncoded-caching methods. However, in such works, normally the effect of the wireless channels is neglected, i.e., the wireless channel is assumed to work perfectly. In this thesis,

we are going to relax this assumption and verify the efficiency of coded-caching in the presence of wireless networks (see [12]).

### Scope of the thesis

- Perform a deep review of the state-of-the-art uncoded- and coded-caching schemes.
- Developing a realistic channel model considering the wireless aspects of the link between the server and the cache nodes using multiple antennas.
- Performing analytical evaluations to demonstrate the efficiency of coded-caching methods, compared to uncoded-caching. Here, the effect of beamforming will be included into the analysis.
- Performing simulations to validate the analytical results and study the effect of different parameters as well as various message decoding/buffering schemes on the network performance.

The candidate is supposed to be interested in mathematical and simulation-based analysis, and skillful in MATLAB. Some knowledge on beamforming will be a plus. The study can be defined as a 30- or 60-credit thesis, per candidate interest/capabilities. However, a 60-credit thesis is preferred. Finally, the results of the thesis will be published as a conference/journal publication.

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