On Performance Estimation of Prefetching Algorithms for Streaming Content in Automotive Environments

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Media streaming in automotive environments is becoming more important with the proliferation of 3G/4G technologies and the general demand for consuming internet content in cars. Especially the rising popularity of Music on Demand and Media Cloud Storage services pushes automotive manufactures efforts to provide decent music streaming capabilities in vehicles. This fact has recently brought car manufactures and music streaming services together. Thanks to today's mobile broad band Internet connectivity, music streaming is becoming available in the car. Volvo and Ford have announced to pair up with the popular music streaming service Spotify. Ford does already have a partnership with Rhapsody's music streaming and with the cloud music service Amazon Cloud Player while BMW is going to bring Rara to their vehicles.

With the increasing usage of those services in cars in the future, the service provider will face network problems and so users will experience more and more usability drawbacks when listening to their music. These issues on the one hand arise from the fact, that the mobile network load will be easily exhausted in crowded areas with many users listening music in their cars. On the other hand, cars frequently need to pass spots of bad reception like tunnels, underpasses or street canyons in urban areas. Whereas in rural areas totally disconnected regions and frequent handovers due to higher driving speed need to be taken into account.

In order to tackle such issues, new prefetching algorithms are needed that can bridge connectivity interruptions and prevent network overload. Cars are not as personalized end devices as smartphones, since various persons can be the driver, or the user respectively. This is one reason why simple pre-buffering of personalized song lists does not help here, as it might waste a lot of bandwidth and local storage when downloading lots of songs which will possibly not be heard. Consequently, suitable prefetching algorithms need to consider network coverage along driving route, as well as current network usage information. In this way, cache utilization and bandwidth consumption can be reduced to a minimum. Moreover, the load can be balanced for all users, throughout the available mobile network.

The development and assessment of the named class of smart prefetching algorithms is quite complex as they involve a variety of external information and require greater coordination efforts between vehicles. For this purpose, we present a comprehensive simulation environment, which provides the relevant information input and simulates interaction of a greater number of vehicles with a cellular network. Our existing simulation framework VSimRTI couples discrete event simulators from different fields. VSimRTI is already capable to simulate vehicular traffic, application logic and communication between the vehicles via ad-hoc networks by coupling the relevant simulators. In this work, we need to extend this tool for the feasibility to simulate cellular communication between vehicles and the according multi-media server. Therefore, a new cellular communication simulator has been developed and coupled to VSimRTI. This simulator VSimRTI_Cell especially focusses on simulating the transmission delay through the wireless and wired parts of the network. The major advantage of our approach is the independence of the wireless access technologies (3G, 4G). Moreover, the setup can respect for external cellular users (e.g. in crowded areas) which are not equipped in our simulation, but still consume a certain amount of the shared cell bandwidth. Even though, the implemented communication models abstract from different details, they are adequate for evaluations from application perspective.

The main contribution, presented in this paper, is our simulation environment and evaluation methodology for smart prefetching algorithms, not the algorithms themselves. Therefore, we employ algorithms which are very basic, but involve all necessary aspects of smart prefetching. For future work, we plan on advancing our algorithms by including communication of meta data among the vehicles for load balancing and user side content access prediction like title skipping in playlists.

Finally, we will show the results of an exemplary evaluation study which compares different basic algorithms for prefetching music content. By these results, we will show that our simulation environment is capable of mapping the relation of bandwidth utilization depending on the number of vehicles downloading media and its impact on user experience. We will further present an evaluation methodology for prefetching algorithms, which is able expose the benefits of such algorithms.