Admission Control for Adaptive Multimedia Services Based on User and Service Related Knowledge

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Abstract—The increasing use of complex multimedia services requires advanced resource management mechanisms, in particular in wireless network environments. Since multimedia services may contain several media flows, whose number and properties may vary during an ongoing session, and because user preferences regarding flow importance may also vary, we use "user" and "service" related knowledge at session initiation to specify alternative service configurations that can be enforced in cases of decreased resource availability. We apply this knowledge in the context of admission control, by proposing an algorithm allowing for sessions to be admitted with lower quality configurations in cases when there are not enough resources to admit optimal (highest quality) configurations. We hence show that such an approach leads to an increase in session admission probability. We evaluate the proposed model using a developed simulator tool named ADAPTISE that simulates arrivals, durations and resource allocation of multimedia services. Furthermore, we have rerun the ADAPTISE simulation traces in an LTE network simulator tool to test session performance metrics.

Index Terms—Admission control, multimedia services, simulation, LTE

I. INTRODUCTION

The deployment of high-speed mobile networks, such as 3GPP Long Term Evolution (LTE) [1], paired with the availability of cutting–edge mobile devices, enable the provision of complex and demanding services on the move. Ensuring a high Quality of Experience (QoE) for mobile Internet users (linked to the end user's subjectively perceived quality when using a service) is a key challenge being addressed by operators aimed at increasing the number of customers and preventing customer churn, while also increasing mobile data usage among existing users. According to Akamai [2], the volume of mobile data traffic has doubled from the third quarter of 2011 to the third quarter of 2012. With such an evident and persistent increase in the demand for mobile data, the limitations and variability of wireless resources need to be addressed, calling for appropriate resource management mechanisms.

Multimedia services in general consist of multiple media flows, the number and properties of which may change during the course of an ongoing session. In our previous work, we have proposed a structure called the *Media Degradation Path*

(MDP) to describe multimedia service properties [3]. For a given session, the MDP is defined as an ordered list of feasible and negotiated service *configurations*, where each configuration describes the operating parameters (e.g., codecs used, frame rate, etc.) and resource requirements of all flows, along with a corresponding *utility* value, i.e., a numerical indicator of achievable user perceived quality given that configuration (takes into account also user preferences regarding different flows of the same service). Multiple configurations are ordered according to descending utility value, and as such form a "recipe" of how to optimally adapt the multiple flows in a session in light of decreased network resource availability, accounting for the impact on QoE (indicated using various utility functions).

The MDP thus forms a degradation path from the configuration with the highest user perceived quality (and usually highest resource requirements) to the configuration with the lowest, yet still considered acceptable, perceived quality. Such a recipe allows for service degradation in a controlled manner, as opposed to decreasing resources without considering user preferences or per-flow priority within a single multimedia session. Furthermore, application-level service information considered when constructing the MDP provides input on the capabilities of a service to adapt to different bandwidth availability (e.g., switch to lower quality codec, or eliminate layers in the case of scalable video coding). The information contained in the MDP, incorporating both user and service related knowledge, may be utilized in the context of intelligent resource management mechanisms. We have already shown how to apply the MDP to resource (re)allocation procedures in cases of network congestion [4], [5]. In this paper, we extend our previous work by applying this knowledge to the admission control (AC) problem.

When a session is initiated, AC mechanisms are invoked to make an admission decision based on operator policy, resource availability, service type, and user priority. We argue that in the case of making the information included in the MDP available to a control entity in the network, the admission decision-making may be further extended to consider the possibility

of admitting any given configuration from the MDP (rather than having to either accept or reject one possible session configuration, as is commonly the case in practice). In the case when there are not enough resources to admit the first (optimal) configuration from the MDP, a session may be admitted with an alternative configuration, hence increasing admission probability within a first session establishment attempt. We demonstrate this AC mechanism in a multimedia session simulator tool that we developed for evaluation. Additionally, we evaluate the proposed approach in an LTE network using a previously developed LTE network simulator [6], with the goal being to evaluate overall session performance parameters when using an AC algorithm utilizing MDP information as opposed to an AC algorithm not utilizing MDP information. Results have shown that given MDP utilization, admission probability and throughput were increased, while there were no delay violations and only limited loss violations for different classes of flows (further described in section IV).

The paper is organized as follows. In section II we give a short overview of related work. The proposed approach is presented in section III, while section IV provides simulations and discussion of the results. Section V concludes the paper.

II. RELATED WORK

The majority of related work dealing with AC has based decisions on service type, with AC algorithms assigning different priorities to sessions based on priority categories [7] or based on the service type regarding real-time transfer requirements [8]. In [9] the resources already allocated to non-real-time flows can be freed in order to admit more real-time flows. In order to accommodate different service types, channel capacity is often partitioned into several zones such that each session is assigned a zone and its admission decision is based on available capacity of the regarding zone. Usually, the zones are organized hierarchically such that the sessions being assigned a higher priority zone have access to lower priority zones as well. In [10] the authors consider two service categories with different priorities, with additional handoff sessions being considered of high priority as well, thus forming three zones. Considering network load variability, zone limits can be variable as well, e.g., in [11] and [12] there are two different service categories, and the zone limits are dynamically adjusted based on the proportion of higher category sessions. The approach proposed in [13] allows for different possible bandwidth configurations to be assigned to sessions by considering maximum and optional bandwidth values for new sessions. If the optimal bandwidth value cannot be assigned, optional values are tried before rejection of the session, thus increasing the admission probability. While this approach is conceptually similar to ours, the difference lies in the fact that we consider the possibility of sessions comprised of multiple simultaneous media flows, and hence address their joint impact on the end user perceived quality when deciding on alternative resource configurations to be assigned. To the best of our knowledge, this presents a novel approach related to AC mechanisms.

In our work, we also assume resources to be partitioned into zones, with different priorities assigned to different services and users. Each session has a corresponding MDP (one MDP per session, negotiated and calculated at session establishment, as discussed in our previous work). In addition to the optimal service configuration and requested resource allocation, all alternative configurations and their resource allocations are assumed to correspond to acceptable end user perceived quality levels.

We consider our approach in the scope of the 3GPP Evolved Packet System (EPS), which utilizes class based traffic management [14]. There are nine classes defined, each of them identified with a QoS Class Identifier (QCI) which specifies standardized packet forwarding treatment for a given traffic flow. The following parameters are defined per QCI:

- priority: 1 to 9, 1 being the highest priority,
- bearer type: guaranteed or non-guaranteed bit rate,
- packet delay budget,
- packet error loss rate.

In case that a resource reallocation is necessary, the Allocation and Retention Priority (ARP) defines the priorities of sessions regarding resource pre-emption. ARP is defined per session and consists of three values:

- priority: 1 to 15, 1 being the highest priority,
- pre-emption capability: defines whether a session can acquire resources already assigned to other sessions with lower priority,
- pre-emption vulnerability: defines whether a session can loose resources in favour of other sessions with higher priority.

III. MDP-DRIVEN ADMISSION CONTROL

A. The MDP construct

In previous work, we have proposed a Quality Matching and Optimization Application Server (QMO AS) [15] [3], included along the session establishment signaling path and responsible for matching parameters signaled in a *user profile* (specifying user preferences and user equipment capabilities, e.g., screen resolution, processing power) with parameters specified in a *service profile* (specifying service requirements, e.g., supported media flows and codecs, utility functions). The QMO AS performs matching of parameters and finds an optimal service configuration for each session, along with a chosen number of suboptimal configurations. The results are stored in a data construct we refer to as the MDP, which is further signaled to the communication endpoints and the underlying network to be used for service adaptation and resource allocation requests. The optimal configuration ensures the highest user QoE (based on a utility-driven optimization process) for the regarding service. User preferences serve to indicate an individual user's preference regarding the relative importance of multiple flows comprising a session, and can thus be different for different users of the same service. For example, in the case of a streaming service that consists of audio and video flows, certain users may prefer audio while

others prefer video. If audio is preferred, the video flow is the first to be degraded in suboptimal configurations, while the audio flow quality is kept high as long as possible. Otherwise, the audio is the first to be degraded. Consequently, user- and service-related knowledge is utilized when constructing the MDP, and can be applied to resource allocation mechanisms.

The MDP further enables the description of multimedia service dynamics. Since media flows can be added or removed during a session, the configurations from the MDP are grouped into *service states* where each service state contains flows that can be active simultaneously at any given time. By adding or removing a flow, session state is changed and a configuration from the new state is selected and enforced. An example MDP of a 3D virtual world service with the possibility of adding an audio chat or video stream is shown in Fig. 1. There are three service states: *State 1* with 3D virtual world and a video stream, *State 2* with 3D virtual world and audio chat and *State 3* with 3D virtual world only. For each state, an individual set of configurations is defined, e.g., in *State 1* the configurations will define video and virtual world operating parameters such as video resolution and codec, virtual world level of details etc., and the corresponding resource requirements and achievable utility value. The addition or removal of a media flow causes the switch to a different active state and the enforcement of a new configuration from the new state. In the context of network resource allocation, certain resources in that case may need to be either released or additionally allocated.

For the purposes of this paper, the initially active state (i.e., at session establishment) is considered at session start time, as it is the one that is considered by the admission decision. If there are state changes during an ongoing session, they can also affect AC decisions if the session changes its resource consumption, thus affecting the amount of the available resources for new incoming sessions.

B. Admission control algorithm

We assume three service categories, namely *bronze*, *silver* and *gold* and divide the available resources into zones pertaining to these categories. Additionally, handoff sessions (i.e., sessions being taken over from another base station) of each service are assigned higher priority, which makes four zones. The first zone is available to all sessions, the second to bronze handoff sessions and all silver and gold sessions, the third to silver handoff sessions and all gold sessions and the fourth to gold handoff sessions only, as shown in Fig. 2a. Besides the zones, we also define the *zone critical border* B_0 as a limit that, when crossed by resource consumption, instructs the admission control algorithm to admit sessions with suboptimal configurations, as depicted in Fig. 2b. For the session i the end of the zone that it belongs to is denoted by T_i and the area between the limits B_0 and T_i is defined as a *critical area*. The resource consumption in the figures spans from left to right (from T_0 to F, where F marks the end of the area with occupied resources and the beginning of the area with free resources), so that free resources are on the right. For each session, the zone critical border is calculated as a predefined percentage of the resources from the regarding zone, and the limits for different suboptimal configurations are created by dividing the critical area into n equal intervals, where n is the number of configurations from the MDP of the incoming session. If free resources overlap with the interval for choosing the optimal configuration (i.e., if the limit F in Fig. 2b is left from B_0), that configuration is selected. Otherwise, if free resources overlap with the critical area, the best suboptimal configuration, whose interval is overlapped with free resources, is selected. For example, in Fig. 2b the free resources span just across the limit B_{n-2} and F is between B_{n-3} (not shown in the figure) and B_{n-2}, thus indicating the selection of the configuration $n-1$, out of n configurations from the regarding session's MDP. If free resources do not even reach the critical area (F is right from T_i), the session is rejected. The algorithm is also presented in pseudocode in Algorithm 1.

As stated previously, we consider our approach in the context of the 3GPP QoS class based specification. We assume that the total available resources are subdivided between nine QCIs, and divide each QCI slot into the four zones as defined. Since different flows of the sessions may pertain to different QCIs, the selection of the configuration for the new sessions is conducted as explained above for the flow pertaining to the QCI with the least free resources, called *critical QCI*. When the appropriate configuration is found for the flow in question, the parameters of other flows from that configuration are selected as well, e.g., for a session with five configurations in the MDP and three flows $f1$, $f2$ and $f3$ pertaining to QCIs 1, 3 and 7, respectively, if QCI 3 is critical, the selection of the configuration is conducted based on the parameters of the flow $f2$ from the MDP configurations. When the appropriate configuration for the flow $f2$ is found, the parameters from that configuration are enforced for flows $f1$ and $f3$ as well.

The ARP parameter is used as an additional check and similarly to the limit B_0 we define another limit A as the beginning of the area for checking the ARP priority value, for the flow pertaining to the critical QCI, as depicted by the Fig. 2c. For flow f pertaining to critical QCI, with a selected bandwidth equal to r, the interval from A to T_i is divided into 15 subintervals (as there are 15 ARP priority values defined) and the session is admitted only if the limit $F - r$ pertains to the interval with index less than or equal to the ARP priority of the regarding session. Thus, in Fig. 2c the session would be admitted if its ARP priority is less than or equal to 7. We have set the limit A as the middle of the interval B_0 and T_i, as experiments we have run have shown this approach to lead to the highest rate of admitted sessions. In this paper, we do not use the pre-emption capability and vulnerability flags. Future work will address this issue, as well as the concept of preemting resources between different QCIs.

The novelty of our approach is in the added option of selecting a suboptimal service configuration in the case of unavailable resources for the optimal configuration, hence increasing admission probability and consequently operator
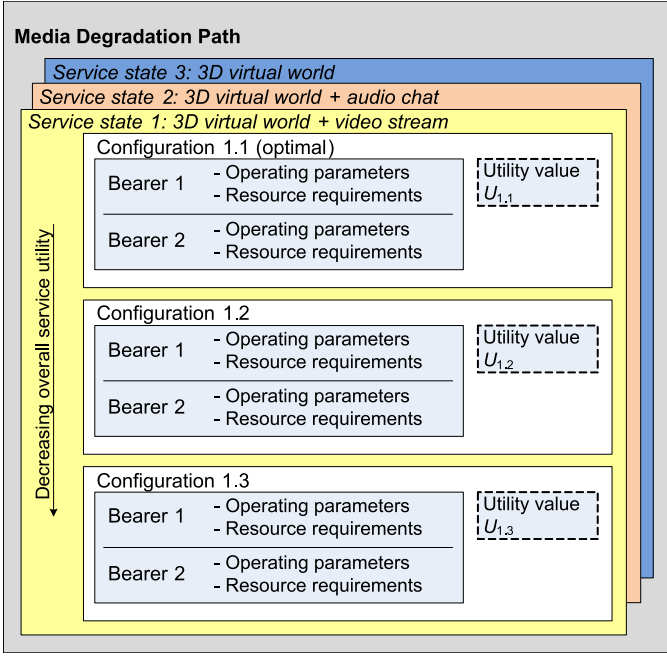
Fig. 1: Media degradation path

(a) Bandwidth zones

(b) Zone critical border

(c) ARP limit

Fig. 2: Bandwidth zones and borders

revenue (resulting from a larger number of established sessions). Furthermore, considering cases of network congestion, the overall end user's satisfaction is increased as a consequence of the increased probability of successful session establishment. Since the suboptimal configurations have been created with the user preferences taken into account, the admission of the session with such a configuration is expected to be more acceptable to the user than random degradation of all the flows, performed by the network in order to "shrink" the required resources of the optimal configuration to fit the available resources. In the case of our example MDP from Fig. 1, supposing that a new session arrives and that the initially active state will be state 1: if there are not enough resources for the optimal configuration containing 3D virtual world graphics data and video streaming, a suboptimal and less resource demanding configuration can be enforced.

IV. SIMULATIONS AND DISCUSSION

In order to evaluate the proposed approach for the AC of complex and variable multimedia sessions, we developed a simulator tool called ADAPTISE (ADmission control and resource Allocation for adaPtive mulTImedia SErvices) implemented in Java. The tool simulates the arrivals and durations of sessions by setting the regarding interarrival and duration distributions and their parameters (exponential, normal, lognormal and Erlang distribution are supported) and also simulates resource consumption as the sum of bit rates of currently active sessions for 9 QCIs. An earlier version of the simulator was presented in previous work [5][4], but has now been extended to support the proposed AC algorithm.

We identified five different example service types, namely 3D virtual environment (VE), massive multiplayer online
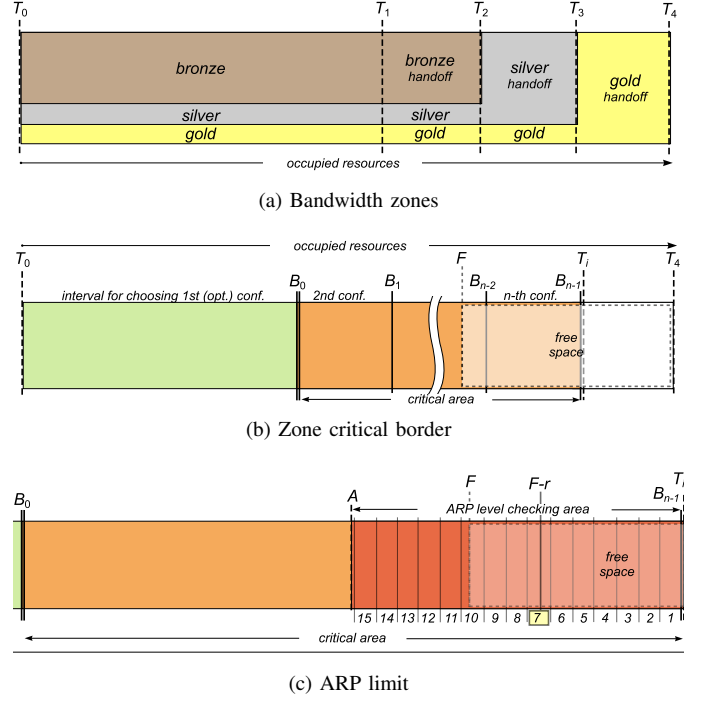

Algorithm 1: MDP-based admission control

forall the *flows* **do**
  determine the zone
  determine the resource consumption of the regarding QCI
$cQCI \leftarrow$ critical QCI; $f \leftarrow$ flow in $cQCI$
if *occupied resources of $cQCI < B_0$* **then**
  select optimal configuration
else if *occupied resources of $cQCI < T_i$* **then**
  //select best feasible subopt. conf.
  $i \leftarrow 0$
  while $B_i < F$ **do**
    $i \leftarrow i + 1$
  select configuration $i + 1$
else
  reject session
  return;
$r \leftarrow$ bandwidth of f in selected configuration
if *ARP priority $\leq$ interval pointed by $(F - r)$* **then**
  admit session
  return;
else
  reject session

Algorithm 2: Admission control without MDP
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   forall the *flows* **do**
     | determine the zone
     | determine occupied resources in the regarding QCI
     | **if** *occupied resources of QCI* $>= B_0$ **then**
        | reject session
        | **return**;
   select optimal configuration
   admit session
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role playing game (MMORPG) with voice chat, video call, voice call, and video streaming. For each of the first three service types mentioned, we defined up to four states, while the last two service types have only one state each. Each state comprises one, two or three media flows. ADAPTISE smulates resource management mechanisms driven by user and service related knowledge, whereby the assigned resources are regarded as the portion of the available and predefined bandwidth value. In order to verify the applicability of such mechanisms in a wireless network scenario, the traces of ADAPTISE simulations were saved and rerun in LTE-Sim v4.0, an open source LTE network simulator developed at Politecnicno di Bari, Italy [6].

Fig. 3 displays ADAPTISE. As shown in the block diagram in Fig. 3a, the whole simulation is controlled by the GUI that is used to set the simulation parameters and generate sessions and their events (arrivals, state changes and ends). The events are processed one by one in the event based simulation. In the case of session arrival, events are processed by the admission control module. In the case of resource shortage, an optimization process may be invoked together with admission control in order to free some resources, as discussed in our previous work [5]. Fig. 3b displays the GUI of the simulator. The table on the left is a list of all the sessions with their starting times. Upon clicking on a session, its states and their respective configurations are displayed in the middle. Other session information includes service and user priorities, ARP parameter, and handoff flag. Below the selected session panel there are two sliders for setting optimization parameters and nine gauges displaying resource consumption across QCIs. A matrix of squares in the middle represents the configurations of currently active session states where each column pertains to a single session. The black squares represent enforced configurations, the white ones represent other configurations from the currently active state and the grey columns represent terminated sessions. The row pertaining to the selected session is coloured blue, while the red rows represent sessions that have been rejected by the admission control. At the bottom of the window there is a console with messages regarding simulation.

A. Simulation setup

The testing methodology was as follows. We ran five different simulation instances in ADAPTISE, each with the same service parameters, given in Table I. The expected number of sessions was calculated by modelling the system as an $M/G/\infty$ queue which assumes exponential interarrival time distribution with parameter λ and arbitrary duration distribution with the mean μ [16]. In that case, the expected number of sessions (if every session is admitted) is Poisson distributed with the mean $\lambda\mu$.

Each of these five simulation instances was run with MDP-based AC (as specified in Algorithm 1 and referred to as AC_{MDP}) and than repeated without it, i.e., by using a simple admission control that rejects the session if there are not enough resources for the optimal configuration (as specified in Algorithm 2 and referred to as AC_{noMDP}). A total of ten simulation instances were created. The zone limits were set to 85%, 90%, and 95% of available resources and the zone critical border B_0 was set to 65% of the available resources because these values proved to ensure the highest rate of session admittance. The simulation trace was created after 150 sessions had already entered the system because at that time the influence of admission control algorithm became significant. The traces were 5 s long and they contained the information regarding sessions that were active in the considered trace interval (although 5 s may seem as a rather short interval, it was long enough to demonstrate the differences between the two algorithms). For each of these sessions, the start times, durations and flow parameters (type and bandwidth) were saved. If there were state changes in the interval, they were also saved in the trace file. The goal was therefore to capture the state in the network during a short time interval at a point when a significant number of sessions had already arrived.

Following the capture of these traces, our goal was to evaluate performance parameters in the case that these sessions were admitted in an LTE network. For this reason, we reran each of the ten ADAPTISE simulation instances in LTE-Sim, with set parameters as given in Table II. Each run was repeated 15 times in order to obtain more significant statistical results (i.e., 15 runs for each of the 10 ADAPTISE simulations). The simulation duration in LTE-Sim was set to last 0.2 s longer than the ADAPTISE simulation to ensure that all the packets sent in the considered 5 s interval can be received or lost only due to network effects, and not due to simulation duration (if the simulation had been stopped right after the transmission had stopped, the packets that had been sent at the end of simulation, but not yet received, would be considered lost, although they may not have been lost if given a chance to be delivered).

Since LTE-Sim currently supports only one single traffic class (i.e., there is no support for assigning different traffic handling priorities according to QCI), we set ADAPTISE to use only once QCI for all flows as well. We note that while our AC algorithm supports the notion of multiple QCIs, the use of only a single traffic class presents a limitation of the current study due to lack of multiple supported traffic classes in the LTE simulator. The chosen LTE-Sim scheduler was EXP rule [17].

ADAPTISE flows were mapped to the following flow types
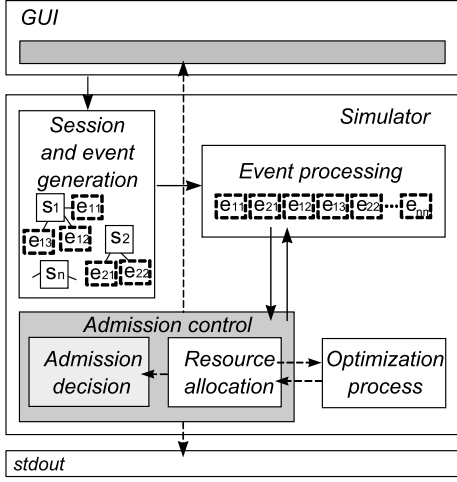
(a) Block diagram

(b) Graphical user interface

Fig. 3: ADAPTISE simulator

TABLE I: ADAPTISE Session Interarrival Time and Duration Parameters

Service	Interarrival time			Duration			Expected sessions [#]
	Distribution	Parameters	Mean [s]	Distribution	Parameters	Mean [s]	
VE	Exponential	$\lambda = 0.00015$	6.67	Exponential	$\lambda = 0.00001$	100	15
MMO	Exponential	$\lambda = 0.00007$	14.29	Normal	$\mu = 100000, \sigma = 30000$	100	7
Video call	Exponential	$\lambda = 0.0001$	10	Lognormal	$\mu_L = 9.5, \sigma_L = 2$	99	10
Voice call	Exponential	$\lambda = 0.0001$	10	Erlang	$r = 30, \mu = 0.00001$	100	10
Video streaming	Exponential	$\lambda = 0.00005$	20	Exponential	$\lambda = 0.00001$	100	5
Total:							47

TABLE II: LTE-Sim Simulation Parameters

Parameter	Value
Simulation duration	5.2 s
Number of cells	1
Cell radius	1 km
Bandwidth	10 MHz
Scheduler	EXP rule
Frame structure	Frequency-division duplex
User speed	3 km/h

TABLE III: Mapping of ADAPTISE Sessions to LTE-Sim Flows

Service	States	LTE-Sim flows
3D VE	Virtual world	CBR
	Virtual world + voice chat	CBR, VoIP
	Virtual world + video stream	CBR, Video, CBR
MMORPG	Gaming	CBR
	Gaming + audio chat	CBR, VoIP
	Gaming + download	CBR, CBR
	Gaming + video stream	CBR, Video, CBR
Video call	Video and audio	Video, CBR
	Audio only	CBR
Voice call	Voice	VoIP
Streaming	Video stream	Video, CBR

that are supported by the LTE-Sim: video, voice over IP (VoIP) and constant bit rate (CBR), as shown in Table III. Each session from ADAPTISE was mapped to one user in LTE-Sim, and each session flow was mapped to one bearer with the regarding flow type.

B. Results

The simulation results are obtained by analysing the simulation results of LTE-Sim. For each group of 15 simulations (pertaining to a single ADAPTISE trace) average and 95% confidence interval (where applicable) are calculated for the MDP-based AC_{MDP} scenario and its rerun with AC_{noMDP} algorithm. Fig. 4 portrays the number of active sessions in the considered simulation interval. In the case of all simulation instances, there was an increase in the number of active sessions when the AC_{MDP} algorithm was applied, as compared to the

AC_{noMDP} algorithm, with an average increase of $+24.5\%$ across all five simulation instances. The increase in the number of sessions lead to an increase in the number of bearers, as depicted by Fig. 5. In the case of applying AC_{MDP}, the number of bearers increased by an average of 14.8 across all simulation instances. Fig 6 displays resulting increases in overall throughput values.

In order to assess the effects of the increased number of sessions on performance parameters, we checked for violations of real-time bearer loss and delay requirements, and packet loss for CBR bearers. Assuming the performance requirements for

different types of services as specified in [18], we considered a VoIP flow to be violated if its average packet loss was $\geq 3\%$ or if its average delay was ≥ 150 ms, and a video flow to be violated if its average packet loss rate was $\geq 1\%$ or if its average delay was ≥ 150 ms. Since none of the flows was violated with respect to delay, both in scenarios using AC_{MDP} and AC_{noMDP}, we only provide a comparison for packet loss in Fig. 7. In simulation instances 1 and 2, the ratio of violated real-time bearers is very little affected by MDP and in simulation instance 4 it is even significantly decreased with MDP. In simulation instances 3 and 5 there is the increase of ratio, however a noticeable one in instance 3 only, expected to be caused by significant increase in number of active sessions due to MDP. The size of the confidence intervals might seem big, but considering that Fig. 7 represents the ratio of violated real-time bearers, it should be noted that the number of real-time bearers was in average 28.2 for AC_{MDP} and 34.2 for AC_{noMDP}, and a ± 1 change in number of violated bearers between two different runs of a simulation instance in LTE-Sim makes 3% to 3.5% difference in ratio of violated bearers.

The effect of MDP admission control on CBR bearers packet loss is depicted by Fig. 8. In simulation instances 1, 2 and 4 the change is practically negligible (even in favour of MDP-based approach in instance 1). Similar to the real-time bearers, in simulation instances 3 and 5 there is an increase in loss and a significant increase in instance 5 is expected to be caused by high resource consumption because the regarding throughput value is also the highest.

From the results provided, it is evident that the AC algorithm which took into account the session MDP resulted in an increase in admission probability, hence improving resource utilization by increasing total throughput, with very little cost regarding QoE degradation. The increase in the number of violated real-time flows is almost negligible in most cases and even when it is significant, the ratio of violated real-time bearers is less than 7%. The packet loss ratio of CBR bearers did not change significantly, except for one scenario, but it still remained under 3%.

V. CONCLUSION

In this work we presented a model that utilises user and service related knowledge in the form of an MDP construct to improve admission control mechanisms for complex multimedia services. By creating alternative feasible service configurations, admission probability is increased in comparison to the case when there is just one possible service configuration.
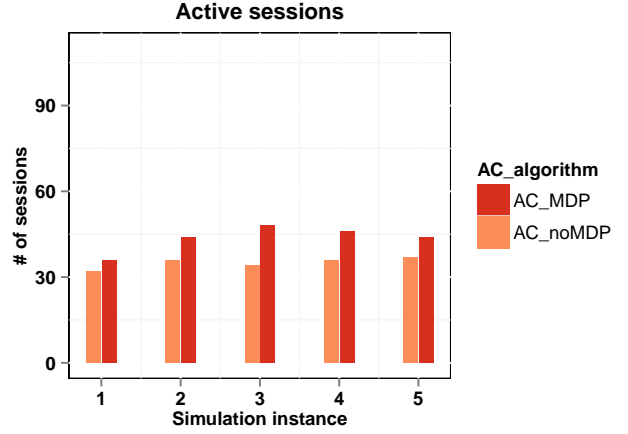

Fig. 4: Number of active sessions per simulation instance
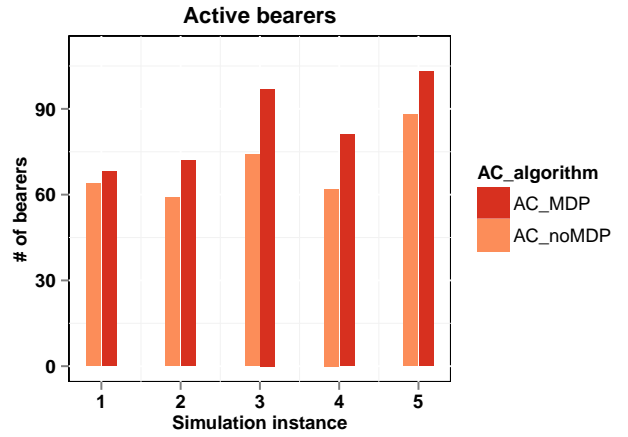

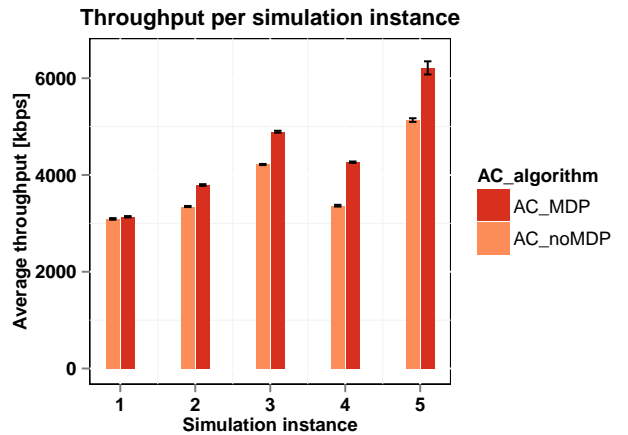Fig. 5: Number of bearers per simulation instance

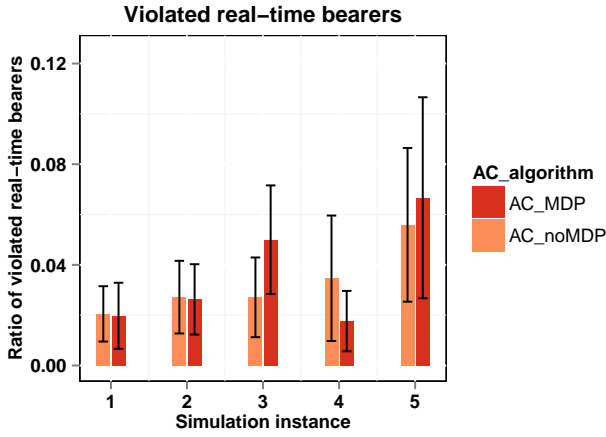Fig. 6: Total throughput with 95% CI shown

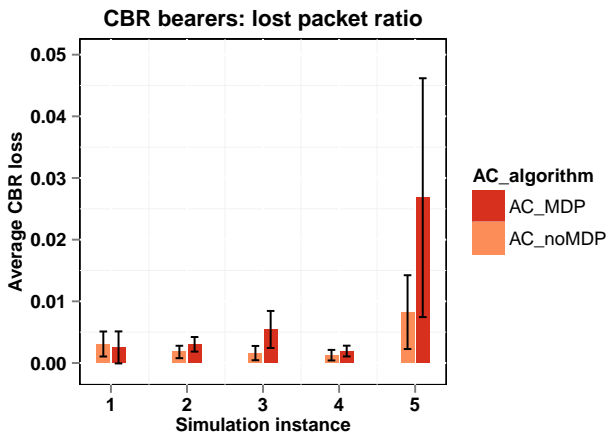Fig. 7: Real-time flows with violated loss, 95% CI shown

Fig. 8: Average loss of constant bit rate bearers with 95% CI shown

The notion of user satisfaction is considered by taking user preferences into account in creation of alternative service configurations. With an increase in the number of admitted sessions, an operator's revenue is also expected to increase. We implemented the proposed approach in the ADAPTISE simulator in order to demonstrate its functionality. Evaluation of the simulations in an LTE network was conducted by using the LTE network simulator (LTE-Sim). Results have shown that our approach to admission control increases the rate of admitted session with very little or no cost regarding performance.

In our future work we plan to combine mechanisms for admission control and resource reallocation in cases of network congestion, both by using MDP. The combination of the two mechanisms is expected to further increase QoE, network utilisation and operator revenue. The mechanisms will be implemented in the ADAPTISE simulator and verified in an LTE network scenario. We will also run longer simulations in LTE-Sim and test the algorithms in different network conditions. Additionally we will examine our algorithms with different scheduling algorithms implemented in LTE-Sim.

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