Run time Adaptation of UMTS Services to available resources

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Abstract—

The UMTS is setting forth new challenges in terms of integration of end-to-end QoS management. Our approach consists of providing an end-to-end adaptation frame to UMTS commercial services. A commercial service provided to the user should be adapted when selected as well as during its transfer through the different parts of the network. These adaptations are due to the fluctuation of the parameters of the network and the need to adapt the QoS parameters. We will then improve QoS management in respect with the contractual commitments, decrease dropped calls rate and optimize resources use by avoiding call rejections and application flow blocking.

The four steps of adaptation of our model will be guaranteed by an "Adaptation Bearer Service (ABS)" which will provide technologies to adapt the media to available resources according to the adaptation mode and the localization of resource limitation. At connection time, the Service Provider or ASP may ask the ABS to adapt the requested service according to the user contract, profile and preferences. At the border of DiffServ network, the router will ask for ABS to adapt the waiting flow of the commercial service according to network resource availabilities and the same at the border of radio network and finally to the terminal according to available CPU, memory, etc.

Our approach is intended to take into account the requirements of mastering the degradation of multimedia services to avoid bad renderings and process a degradation as early as possible. In this paper, we will develop our model, the intended extension and our preliminary ongoing developments. In another respect, those control points constitue a cornerstone to set up the verification of fundamental properties such as synchronisation.

Keywords—UMTS, DiffServ, Run-time Adaptation, ABS.

I. INTRODUCTION

A. Expectations of UMTS users

In addition to usual expectations, UMTS users will require a QoS management of their multimedia services similar to the QoS management used for the services which they access through Internet [1]. Moreover, 3GPP stipulated that QoS is a major factor to a successful UMTS.

We focus upon multimedia service adaptation according to available resources. These new generation services should be reliable and dependable in order to manage numerous transactions at the same time. UMTS is planned to make the users benefit from added values. In addition to the adaptation according to available resources, the added value will also consist of adapting the service to the user profile preferences. In this way the adaptation will be processed according to his profile and preferences. VHE (Virtual Home Environment) [3] of the UMTS provides a set of recommendations for providing the user his home environment with the same ergonomics and with no impact of his localization or the kind of visited network (VN).

B. Problematic

UMTS system does not consider services' adaptation at edges and terminal levels [2], but is based upon dropping the excess of packets transmitted in purpose to provide the service according to a shaping process with no concern about the requirements and specificities of each applicative flow. Moreover, most of the encountered projects focus on specific adaptation aspects or propose local approaches restricted to mobile network, core network, terminal adaptation or service filtering according to the user profile and preferences. Our model targets an end-to-end solution complied with the frame and recommendations specified by VHE and UMTS. Context aware on-line dynamic adaptation of services is still a current problem and, to our knowledge, there is no a global proposition to an end-to-end QoS management. We will develop our work towards tackling this problem. This model will constitute the fundations to develop a global concerted stratégies and policies to optimally allocate resources in conjunction with users' satisfaction.

C. Our approach

We oriented our state of the art towards projects dealing with similar problematic and we retained three major projects dealing with VHE concept for QoS management.

EURESCOM P920 project [13] considers VHE implementation on an IP platform and tests mobility management, localization, Roaming, as well as protocols and signalization mechanisms. The idea is to develop an architecture and services for a global mobility based upon heterogeneous local access networks and develop preliminary tests upon fixed and mobile networks. VESPER project [12] focus on the adaptation of the service according to the user preferences. It is based on VHE concept and the OSA/Parlay Platform. The idea of CAMELEON project [14] is to customize the management of the calls of a user by routing and filtering them according to specific rules. It uses mobile agents technology in order to provide the final user with services. To test the concept, a service concerning the management of adaptive profiles was developed.

Our model to adapt commercial services in UMTS in compliancy with VHE to reach our purpose of QoS management and resource use optimization. It is based upon the insertion of adaptation modules all along the flow path inside the UMTS architecture as shown in figure 1. These modules are on top of flow management modules to process each ingoing application flow in purpose to adapt it to run-time context and user expectations. This model handles the on-line adaptation of services from call moment and then during the call and at display moment.

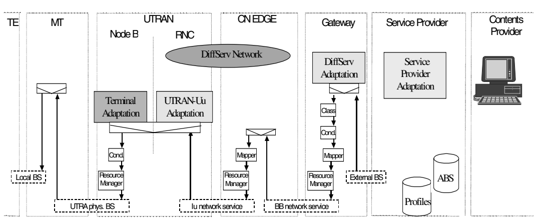


Figure 1. Our Adaptation architecture upon UMTS architecture

We specified for this purpose an Adaptation Bearer Service "ABS" which will set up different adaptations according to the place where the application flow should be adapted. "SP" will stand for the application service provider and "CS" for Commercial Services which is the service requested by the final user. "ABS" are uploaded on line according to the need to adapt commercial services at each place where the adaptation reveal to be necessary. The places are specified by the enttrance to a different UMTS architecture level : ASP, ISP, NSP, radio network and terminal equipement.

Before transmitting the commercial service flow, the context aware adaptation module may have to treat its content to get inside the available traffic envelop and keep compliant with the user contract, pofile and preferences. For example, the context may specify bandwidth limitations or terminal restrictions. During transmission, the availabilities of physical resources will drive the adaptations. At display moment, the commercial service may also be adapted according to physical resources available on the terminal (memory, CPU,…).

II. THE ADAPTATION MODEL

We developed an end-to-end adaptation approach for commercial services which is based upon the capabilities provided by the underlying UMTS infrastructure. The adaptation string is decomposed into four stages : service adaptation at service provider level, the adaptation at the frontier of DiffServ domain, the adaptation according to the available radio resources and the adaptation according to the terminal capabilities. Let us detail the different stages of an end-to-end adaptation of a commercial service and its mechanisms and protocols.

A. At DiffServ network level

In the case where available resources inside the DiffServ network are not enough to transfer the flow of a commercial service arrived at the border of the network, our model will then take in charge the adaptation of the flow of the service using DiffServ specific ABS. The useful ABS will be either uploaded from the service provider or called directly from a hosted ABS warehouse at the visited network (VN).

In the next part of section II we will develop the selection mechanism of ABS and then the mechanism which will allow the adaptation of the commercial service using ABS.

1) Correspondence between DiffServ and UMTS class of service: The edge PEP (GGSN) determinates the DiffServ class of service which corresponds to the running commercial service. A table of correspondence between the classes of DiffServ and UMTS services was already supplied to him by the PDP (cf. figure 2). The supply of this table is made at each update of QoS parameters on the network. In this correspondence table of DiffServ QoS parameters relate to each class of DiffServ and UMTS services.

	Conversational class		Background class		Streaming class		Interactive class
Name of service	Conversational Voice	Video phone	E-mail	FTP	High Quality Streaming Video	Still Images Download	Voice Messaging
Unique Identifier	CS2	CS1	CS3	CS4	CS6	CS7	CS8
Class of DiffServ service	AF12	AF11	BE	BE	AF23	AF32	BE
Delay	500ms				500ms		500ms
Bitrate	25 kb/s	384 kb/s			32 kb/s	32 kb/s	13 kb/s

Figure 2. A correspondence table sent by the PDP to the Edge PEP

Once the PEP fixed the DiffServ class of service to attributed to the commercial service and its parameters of QoS, it seeks an ABS already used by others commercial services of the same category and which QoS envelope is appropriate. In the case the PEP finds the adequate ABS for the commercial service, the ABS is instantiated and activated to be then executed by the "Start process". However, if the PEP does not find locally an adequate ABS, it requests the PDP to look for an ABS either from the ABS warehouse hosted by the visited network, or from the services provider.

2) Finding ABS hosted by the visited network: it consists of looking for expected ABS in the ABS warehouse hosted by the visited network. The PDP takes in charge this localization according to signaletic files information and in case of success gives back a local reference. This localization will be based upon the identity of commercial service which requires an adaptation to the required QoS.

The Signaletic File of an ABS at DiffServ level contains information on the adaptation envelop, mode and required resources, CPU and RAM resources requested to adapt the commercial service as well as the memory requested to store the ABS (cf. figure 3).


```
<?xml version="1.0" encoding="ISO-8859-1" ?>
- <AdaptationBearerService>
    <Name>ABS_for_a_Video_at_64kbit/s</Name>
    <Identifier>ABS_PEP1</Identifier>
  - <TargetServComm>
      <Service name="ServComm_Video_phone" Identity="CS1" />
      <Service name="ServComm_Video_mail" Identity="CS2" />
    </TargetServComm>
    <ProfileofAdaptation>Adaptation_at_DiffServ_network</ProfileofAdaptation>
    <Adaptation_Place>PEP</Adaptation_Place>
    <priority value="1" />
  - <Adaptation_Envelope>
      <Parameter1 type="Bitrate" value="64kbit/s" />
      <Parameter2 type="Delay" value="500ms" />
    </Adaptation_Envelope>
    <AdaptationMode>Compression_at_64kbit/s_of_a_video</AdaptationMode>
    <Physiqual_Resources>
      <Resources name="ABS_Size" value="2ko" />
      <Resources name="Requested_RAM_during_adaptation" value="10ko" />
      <Resources name="Requested_CPU_during_adaptation" value="2%" />
    </Physiqual_Resources>
</AdaptationBearerService>
```

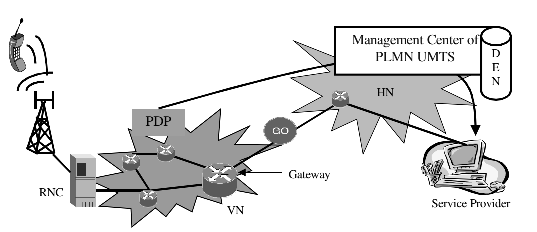

Figure 3. ABS Signaletic file useful at PEP

In case the PDP finds an adequate ABS, this ABS will be downloaded towards the adaptation node. Once at PEP node, listening and notification process detects the arrival of a new ABS. The ABS is then instantiated and activated to be then executed by the "Start process".

However, if the PDP does not find an adequate ABS from an ABS warehouse hosted by the visited network, it invokes the service provider.

3) ABS download from the service provider: The PDP requests the service provider for an ABS to be transmitted to the PEP. The request will contain parameters (cf. figure 4) to help the service provider render the adequate ABS :

- The PEP where the adaptation will take place.
- The identity of the commercial service to adapt.
- The QoS parameters to which the commercial service should comply.



DEN : Directory Enabled Networks - The contents of the directory should allow to correlate the management of the network and the equipments.

Figure 4. PDP requests ABS from services provider

4) ABS selection at service provider: The service provider will consult the information communicated by the PDP and then go through the signaletic files of stored ABS to find a correspondence between :

- The identity of the commercial service communicated by the PDP and the identities inside the signaletic file of each requested ABS.
- The QoS parameters required by the commercial service communicated by PDP and the QoS parameters inside the signaletic file of each stored ABS.

The only ABS considered should belong to the category to be used at PEP level. This categorization is set by a reference on the adaptation place («PEP» in the case of figure 3).

5) ABS provision by the service provider: At this stage, the service provider should take into account the impact of downloading the ABS on the network in the case where the information is available.

6) Commercial service adaptation: One reminds that, the registration of ABS as well as their instantiation and activation are processed by three process :

- Listening and notification process.
- Registration process.
- Start process.

Once at PEP node the listening and notification process detects the arrival of a new ABS, it notifies the registration process which will process the registration of the ABS. The ABS is then instantiated and activated to be then executed by "Start process".

The sequence integrates the «Network Initiated Service Request Procedure», specified in the UMTS recommendations of 3GPP. We extend this procedure to integrate the adaptation of services using ABS. The messages from 6 to 9 represent the extension which we propose for this example to adapt the stream of the commercial service at DiffServ domain.

B. At Radio network level

An adaptation of a commercial service according to the available radio resources may be required. This adaptation also uses specific ABS dedicated to this kind of adaptation. According to 3GPP specifications, the adaptation will be processed inside the RNC (Radio Network Controller). It is the role of RNC to translate QoS attributes to radio bearer (RB) characteristics.

To keep the coherency of the model, we retained for this kind of adaptation similar mechanisms than those used previously at DiffServ network border (cf. paragraph II.B). However, RNC replaces the PEP and the OMC/R

(Operation and Maintenance Center/Radio) replaces the PDP. The mechanisms developed for this stage are more or less similar to the mechanisms developed for DiffServ network and obey to the following sequence.

- The OMC/R consults the ABS local warehouse hosted by the visited network looking for adequate ABS for the commercial service waiting to be forwarded through the air.
- The warehouse transmits the selected ABS to the RNC so that it starts the adaptation. If ABS is not available locally, OMC/R asks the service provider for the ABS.
- The OMC/R requests ABS from the service provider specifying the targeted commercial service and the requested QoS characteristics. The adequate ABS are selected by the service provider and sent back. The RNC uses the newly received ABS to adapt the commercial service.

1) Allocation of QoS parameters to each commercial service: The RNC is aware of all the commercial services which are running locally. Moreover the RNC knows about the network performance (available canals, grade of service, probabilities of dropping and rejecting calls). The RNC may then generate a table of QoS parameters to attribute to each commercial service. The RNC will provide each commercial service with resources according to radio resources availability and proportionally to the requests. Then the RNC generates the table of the QoS parameters to attribute to each managed commercial service.

2) First search for the adequate ABS: The selection of an ABS by the RNC depends on the identity of the commercial service asked by the user and the parameters of quality of service. In fact, the specifications of the ABS already stored and used by the adaptation node are known by this last one. In case the RNC finds the adequate ABS for the commercial service, the ABS is instantiated and activated to be then executed by “Start process”. However, if the RNC does not find locally the adequate ABS, it passes its request to the OMC/R. The OMC/R looks for the required ABS.

3) Localization of hosted ABS: The OMC/R consults the ABS local warehouse at the visited network. Only ABS which may adapt the commercial service requiring adaptation will be selected. To select an ABS, the data used to establish such a correspondence are :

- The identity of the commercial service and one of the identities of the commercial services which may be adapted by ABS of the warehouse.
- The QoS parameters to which the commercial service should comply (as specified inside the table) and the QoS parameters as specified inside the signaletic file of the ABS.

For ABS hosted by the visited network, the warehouse transmits it to the RNC which starts the adaptation of the targeted commercial service. The specifications of the downloaded ABS are also supplied by the warehouse to the adaptation node.


```
<?xml version="1.0" encoding="ISO-8859-1" ?>
- <AdaptationBearerService>
    <Name>ABS_for_a_Video_at_64kbit/s</Name>
    <Identifier>ABS_RNC1</Identifier>
  - <TargetServComm>
      <Service name="ServComm_Video_phone" Identity="CS1" />
      <Service name="ServComm_Video_mail" Identity="CS2" />
    </TargetServComm>
    <ProfileofAdaptation>Adaptation_at_the_RNC</ProfileofAdaptation>
    <Adaptation_Place>RNC</Adaptation_Place>
    <priority value="1" />
  - <Adaptation_Envelope>
      <Parameter1 type="Bitrate" value="64kbit/s" />
      <Parameter2 type="Delay" value="500ms" />
    </Adaptation_Envelope>
    <AdaptationMode>Compression_at_64kbit/s_of_a_video</AdaptationMode>
    <Physiqual_Resources>
      <Resources name="ABS_Size" value="2ko" />
      <Resources name="Requested_RAM_during_adaptation" value="10ko" />
      <Resources name="Requested_CPU_during_adaptation" value="2%" />
    </Physiqual_Resources>
</AdaptationBearerService>
```


Figure 5. Signaletic file of an ABS useful at RNC

4) ABS download from the service provider: The OMC/R requests from the service provide an ABS for the RNC compliant with the following parameters :

- The identification of the RNC where the adaptation will take place.
- The targeted commercial service and the QoS parameters to comply with.

5) ABS selection by service provider: The server provider consults the parameters of the OMC/R request before going through signaletic files of the ABS looking for a correspondence between :

- The identity of the targeted commercial service given as a parameter of OMC/R request and the identities of commercial services which each ABS may adapt according to its signaletic file content.
- The QoS parameters which the targeted commercial service should comply with and the QoS parameters specified inside the signaletic file of each ABS.

Finally, at RNC node, the received ABS is instantiated and activated to adapt the targeted commercial service (this association was set up at the service provider node).

The sequence integrates the «Network Initiated Service Request Procedure», specified in the UMTS recommendations of which we extend to integrate our model. The messages from 18 to 23 represent the extension to adapt the stream of the commercial service to the radio resources.

III. SIMULATIONS AND RESULTS

UMTS system drops of the excess in packets or bits by metering and shaping the flows and scheduling them according their classifications. We adapt the services at the edges of the networks and at terminal level according to the user contract, profile and preferences and information contained inside the signaletic file.

Our first experimentations will deal with comparing our model with the UMTS drop approach. We based our experimentation on a platform of supply of telecommunications services developed in the computer science department of ENST-Bretagne. The commercial service used concerns the download of images at a fixed periodicity. The conditions of our experimentations are the following :

- The images are transferred at a low frequency of few images per second (2 - 5).
- We use a filter of luminance and colors to simulate the drop on the images. This filter reduces the luminance of images and the levels of colors.
- The images are adapted by a compression algorithm implemented according to the JPEG standard. The compression ratio depends on the bitrate assigned on the network.
- We adapt and drop the images when the traffic load increases on the network.
- We increase the traffic load by increasing the periodical image download service invocation. The compression ratio for the image to be adapted is calculated according to the available resources for each stream. The parameters of filtering used for the drop is set according to the available resources for the concerned stream.

A. *Peak Signal Noise Ratio (PSNR)*

The PSNR is used to measure the rendered visual quality of the images at reception [16]. It is a statistical major metric usually used to determine the quality of the images. It is then possible to compare the quality of the initial images with regard to the same images restored by compression or drop. The PSNR depends on the mean squared error (MSE). The unity of the PSNR is the decibel (dB).

$$PSNR = 10.Log_{10}\left(\frac{nb\_pixels}{\sum (x_{res}(n) - x_{original}(n))^2} \cdot 255^2\right) \quad (1)$$

nb_pixels is the total number of pixels
x(n) is the value of the pixel at location (n)

An image with a PSNR lower than 25 dB is of a lower quality than the average of the acceptable quality. Over 30 dB, the images acquire a quality considered as being good and often perceived as being equivalent to that of the original image.

The experimentation gave results which show that the PSNR of an adapted image is always higher than that of the same image having undergo a drop, for whichever load of traffic on the network and for an equivalent consumption of resources. We also notice that the PSNR decreases when the network load increases. This what was predicted as the bandwidth assigned to the commercial service decreases.

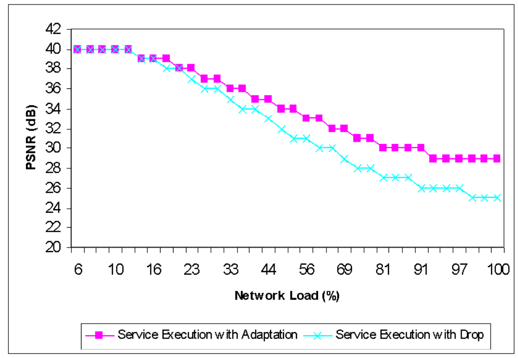


Figure 6. PSNR

B. *Bit Error Ratio (BER)*

The BER is the measurement of the transmission unreliability of a communication channel or network. It stands for the number of erroneous bits divided by the total number of transmitted bits.

$$BER = \frac{\text{number of erroneous bits}}{\text{total number of transmitted bits}} \quad (2)$$

The results of our experimentations show that, for an image adapted according to our approach, the BER at reception is lower than that the one for an image which undergo a drop, for whichever traffic load on the network. The experimentations take place with an equivalent resources consumption and an identical canal noise. These results show that an image which undergo a drop is more sensitive to the noise of the canal than an adapted image. We also notice that the BER increases according to the traffic load on the network. The reason of that is the interference with other users and the competition to access to the resources.

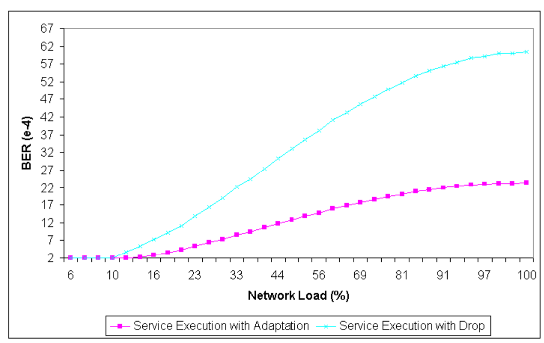


Figure 7. BER

C. *Bit Loss Rate (BLR)*

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The BLR is a measure of the rate of loss in bits at reception. This rate is the ratio between the number of received bits and the number of bits which constitute the original image. This rate stands for the relative gain obtained by the reconstruction of the compressed image at reception.

$$BLR = 100 \times (1 - \frac{\text{number of bits received}}{\text{total number of bits}}) \qquad (3)$$

The experimentations show that at reception, the BLR for an adapted image is lower than that of a dropped image, for whichever load on the network and for an equivalent consumption of resources (cf. figure 8). As predicted when the bandwidth assigned to the commercial service decreases, We notice that the BLR increases with traffic load.

The BLR is low for a traffic load less than[1] 10 %. In that case, the bitrate assigned on the network corresponds to the bandwidth of commercial service.

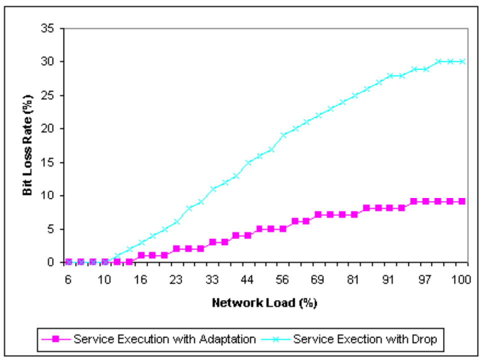

Figure 8. Bit Loss Rate

IV. CONCLUSION

We developed an end-to-end model to adapt the commercial services in UMTS all along the transfer path. Instead of classical UMTS drop approach, we develop a model which try as much as possible to keep compliant with the final user contract, preferences and profile. Our model provides commercial services with smooth adaptation instead of dropping data without worrying about the impact on the user application. Our purpose is to master the application degradation and improve the performance of the requested services.

The adaptation depends on the place where it is required (radio network, terminal, DiffServ network, service provider). Adaptation bearer services (ABS) are specific to each of the stages where the adaptation may be required according to resource availabilities and depend on the parameters of QoS.

The perspectives of our work is to integrate into the model a mechanism to select strategies to impact the grade of services to be adapted and then to comply not only with the final user satisfaction but also help the operator define strategies according to its network status.

In another respect, we are specifying a model to enrich the multimedia data flow by integrating the management of indeterminism and synchronisation between the different components of the same application. This work is based upon a mathematical modelisation of mandatory properties of the flows. The idea is to verify at each control point (where we already adapt the flow to the available resources) the required properties and to set up compensation approaches, especially for synchronisation issues. For this purpose we retain in our present work dynamic compensation techniques to manage indeterminism and desynchronisation.

The idea is to show the feasibility of not only adapting the multimedia flow but also to enrich the management of the QoS and available resources by managing fundamental properties. Among various interesting properties to take into account such as liability, dependability, real-time, safety, we retained to work on one major property : synchronisation. We will publish soon our encouraging results.

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