Challenging the Monopoly of Mobile Termination Charges with an Auction-based Charging and User-centric System (AbaCUS)

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Abstract—**Nowadays, in mobile communication only the Mobile Network Operator (MNO) of the callee is able to terminate his calls. Thus, in the MNOs call-termination market there is only one player profiting from call-termination rates; in turn this market is considered to be a de facto monopoly since the early days of the introduction of commercial mobile communication services. Given this monopoly fact, the only solution against a potential speculation by MNOs was the regulation of termination rates. However, since the initiation of mobile communications, many issues on mobile terminal devices and network infrastructure have changed. Furthermore, today the mobile networks infrastructure does not support only voice services but data as well. In such an environment multiple MNOs could terminate a call. However, in this case the caller has to set only his final cost preference without any knowledge on MNOs termination rate charging policies. Therefore, this paper considers those changes and challenges the monopoly of the MNOs call-termination by proposing an Auction-based Charging and User-centric System called "AbaCUS", which overcomes the monopoly obstacle of this market. The key characteristic of the auction proposed for AbaCUS is the honest bid that participants are "forced" to make. Finally, this work is expected to show that MNOs will benefit by the existence of a call-termination-free market through the establishment of Quality-of-Service (QoS)-guaranteed services.**

Index Terms — **Call-termination, termination rates, auction, mobile network operators, monopolies, QoS, charging**

I. Introduction

The total cost of each call placed by a subscriber of a Mobile Network Operator (MNO) is split into two parts. The first part determines the amount the caller's provider is charging in order to provide the service to the calling party. The second part, which is a considerably big amount of the total calling cost, includes the amount that the provider of the callee will charge the caller's MNO, in order to terminate his call into his network. Subscribers of MNOs rarely consider the termination cost that their operator is charging other networks, when delivering an incoming call to them before they establish their contract. Furthermore, a significant raise of termination rates from MNOs will increase the communication cost for all the MNOs subscribers. However, it will rarely have a negative impact and dissatisfy the customer base of an operator. Given that fact, MNOs termination-service as well as MNOs termination rates are considered to be a monopoly [5]. Thus, the national telecommunication regulation authorities are usually regulating these rates across the world (Europe [13][18], North and South America [12][1], and Asia [40]). The problem of the monopolistic call-termination market is also large for users that wish to receive calls in a location that is different from the home location, where the service was registered (roaming). Roaming users has to pay high prices in order to receive a call [38]. Thus, the International Telecommunication Union (ITU) has put effort toward the solution of this problem [21][22][23].

There is a rich literature on how regulation of this market is affecting it [7] as well as selected research on the topic of the proper selection of termination rates [3] [33]. Furthermore, effort has been put into the analysis of business strategies, which MNOs follow, concerning their termination rates [17][25]. The customer base of a single MNO is significantly smaller compared to the set of total customers in every other MNO, Fixed Network Operator (FNO), or Voice-over-IP (VoIP) provider. Thereby, the majority of calls that a MNO has to terminate in his network originate from foreign networks. Thus, for many years MNOs revenue is coupled with high termination rates applied. This is the main motivation for MNOs to keep regulation in this monopolistic market as low as possible.

Assuming that a caller has a complete and always up-to-date knowledge of every pricing plan of each available to him MNO, the use of dual-Subscriber Identity Module (SIM) card devices [4][8] could be an option against high termination rates due to the following reasons: (1) A user subscribes with his dual-SIM device simultaneously in two MNOs. Usually MNOs provide lower rates for calls between their customers (in cases those calls might also be for free), since in that case there is no termination fee involved. Furthermore, in the past, a Mobile Subscriber Integrated Services Digital Network Number (MSISDN) corresponds only to a subscriber of a specific MNO. So, a caller (2) identifies by the callee's MSISDN, which MNO is serving him, and thus (3) selects the cheaper option among his MNOs in order to complete the call. However, since the Mobile Number Portability (MNP) was introduced, there is not a unique MNO that the MSISDN can belong to. Nowadays, a callee can establish a new contract with any available MNO and still can be reached by the same MSISDN. Thus, the caller needs to have prior knowledge of which MNO is serving the callee in order to be able to select in the dual-SIM device the MNO, which provides the cheaper calling rate for a specific MSISDN. Beside the callee's MNO lack of transparency, high contract operations costs are an additional obstacle for callers wanting to use dual-SIM devices in order to minimize their out coming calls cost. Thus, dual-SIM devices require contracts with more than one MNO and do not affect the termination charges monopoly.

Fortunately, there are two significant updates, compared to the early days of mobile communications, which enable the operation of an efficient MNO-independent call-termination solution. This solution will have an impact toward the termination rates monopoly, since MNOs will loose the control of their subscriber's call-termination procedure. Those updates are (1) the infrastructure update and (2) the mobile data introduction. In more detail, the majority of the newest mobile terminal devices, *e.g.*, Smart Phones, can equally register in almost every network across the world, irrespective of the device vendor. Nowadays, Smart Phones are the rule and not the exception between mobile subscribers mobile terminal choice according to Nielsen [36]. Such devices have sufficient computational power, multiple network interfaces, provide positioning information, and can also support cross-platform applications, which are fully integrated within the device's User Interface (UI). Thus, several procedures, like computational calculations or an exchange of data between the caller and the callee, can take place prior to a call without the calling parties experiencing any difference during the calling procedure. Furthermore, mobile data charges are nowadays decreasing [27], mobile data rates are higher and expected to be improved in the future within the next generations mobile communication networks [34].

Thus, the problem to be solved reads as: (a) an MNO-independent call-termination system against the mobile termination charges monopoly, and (b) additionally a fair charging system where the one who pays can influence the price and the QoS perceived level. In today's environment, the novel Auction-based Charging and User-centric System termed "AbaCUS" for mobile networks was developed. It aims at overcoming the monopoly obstacle of the mobile termination rates market, providing a fair charging solution. Furthermore, this paper expects to show that the unregulated adoption by MNOs of such a solution will have a positive impact for both end-users and MNOs. The former by selecting the MNO to terminate a call with a given QoS at a given price, and the latter is facilitated through the call-termination of other MNOs subscribers.

The remainder of this paper is structured as follows. Related work is discussed in Section II, followed in Section III by the high-level system architecture of AbaCUS, which introduces three major system components. Finally, Section IV summarizes this paper, draws conclusions, and presents future work.

II. Related Work

Since the early years of mobile communications, the scientific community as well as regulation authorities has invested a large effort [17][3][7], in order to reduce negative effects of the termination rates monopoly. However, the attempt to overcome negative effects of this monopoly is focused (a) on charging solutions mainly targeted at the paying party of the termination rate or (b) on regulation rules that need to be enforced by respective regulation authorities at operational MNOs. Thus, (1) the Calling Party Pays (CPP) principle with a strong regulator presence, (2) the Receiving Party Pays (RPP) principle, and (3) a national roaming approach, aim to eliminate negative effects of the monopolistic termination rates market. However, in all cases the monopoly in this market still remains since only the MNO of the callee can terminate his calls and profit from it.

A. *The Calling Party Pays (CPP) Principle*

The CPP principle is the most commonly used termination charging approach among MNOs around the world, especially in the European markets [20]. Within CPP principle the caller has to pay call-termination charges and there is no contribution from the callee. This principle is the root of the monopoly problem in the mobile termination rates market. Thereby, strict regulations are applied in order to avoid the MNOs speculation due to their dominant position (*e.g.,* in March 2009 the regulations in India were amended so that termination rates for all types of domestic call, fixed or mobile, were reduced from the equivalent of some 0.006 US$ per minute to 0.004 US$ per minute [24]). However, regulating this market simply reduces these monopoly's negative effects, while the heart of the problem is still beating, since only the callee's MNO can terminate his calls and collect the price for it. Defining and applying regulations is a time-costly procedure for regulators, which MNOs often use in order to avoid/postpone a new regulation. Thus, a more efficient way to overcome negative effects of a monopolistic/regulated market is essential.

B. *The Receiving Party Pays (RPP) Principle*

In North America and some parts of Asia the RPP instead of the CPP principle is applied. In contrast to the CPP principle, in RPP the callee is asked to pay for the termination cost or in some cases to share a part of this cost with the caller. Initially this approach sounds fair, especially in the scope of the callee payment for the call-receiving service, while he is mobile and not located in his home network. Furthermore, a subscriber is free to compare termination rates of each MNO and to make his choice before the establishment of a contract with a MNO. Thereby, the mobile termination rates market seems to allow for competition. However, the question of how a callee could avoid payments for unwanted calls (*e.g.,* advertisements, tele-sales, or polls) is raised. The answer is that it is the callee's responsibility to distinguish, which call is important and should be accepted and which should be rejected. This is only one of the RPP side effects [25] that feared to slow-down the mobile sector in the past. The RPP principle may add an extra degree of freedom in the mobile call charges, since the termination rate is not a part of the total cost that the caller has to pay. However, it is also adding a considerably big overhead for consumers such as the provider-selection decision, while considering the callee role.

C. The National Roaming (NatRoam) Principle

The NatRoam approach is partially used in countries of Latin America (*e.g.*, TIM Brazil [41]). However, MNOs that offer NatRoam services inside larger countries (*e.g.,* within Brazil), offer a limited selection freedom among other MNOs, which are usually branches of the same company. Furthermore, switching to a different MNO is allowed only in deferent regions of the country, where the subscriber's MNO does not operate its own network infrastructure. Additionally, the user that is on NatRoam has also to pay for every incoming call, exactly like in the international roaming case. Thus, NatRoam today has no influence on the termination rate market.

D. The Successfulness of a Broad NatRoam Adoption

Even in case that NatRoam was broadly allowed, or enforced by the regulator [10], the price that the caller would have to pay in the CPP scenario would not be influenced by the caller, unless the caller could notify the callee to switch on a preferable MNO. In the RPP case the callee would also have to establish a contract with each MNO in his location, in order to be able to register his device to any of them. In any case the Number Lookup Service (NLS) queries, prior to a call (for every call), through the Signaling System No. 7 (SS7) network to the Home Location Register (HLR) of the MNO, in order to find the MNO that is currently reaching a Mobile Subscriber Integrated Services Digital Network-Number (MSISDN), would be mandatory. This procedure is costly since these NLS costs vary from 0.038 to 0.0038 € per look-up [28]. Therefore, an on-demand solution, which addresses the termination rates monopoly, is proposed within AbaCUS.

E. Auctions in the E-commerce Market

Before the 17th century auctions [26] were not the common way to buy and sell goods, resources, or services. All what the seller had to do was to set the price, and the buyer would either select to purchase the goods or not. In case that goods/resources were limited, the rule "first-come, first-served" (FCFS) was usually applied. Nowadays, where the e-trading market is growing dramatically, auctions prove to be a powerful tool for competition as well as for the increment of companies' profit. A considerably large number of people buy and sell all kind of goods using online trading Web sites (*e.g.,* via Ebay [9]). Furthermore, companies often use auctions to sell their services (*e.g.,* GoogleAdds [16]), while maximizing their profit. Governments use auction mechanisms in order to offer limited resources (*e.g.,* spectrum or frequencies [11]). Thus, during the last decades the scientific community as well as market leaders has put a lot of effort on creating and analyzing auctions with different rules. Those rules can be either simple or complex, and the auction can take place in one or multiple rounds. However, the target in every case is to increase either the revenue of the seller or the social welfare, avoiding at the same time problems like the bidder's curse [42]. Since the demand for real-time-decision-making auction mechanisms have increased in recent times, on-line auctions [30], [19] became popular. Many variations of well-known type of auctions (*e.g.*, English [6], Dutch [33], or Vickrey's [2] auctions) argue to be optimal for goods, services, or resources, when on-line trading is addressed.

F. MNOs Subscribers Willingness to Pay for QoS

During this work here an Internet survey [37] among approximately two hundred MNOs subscribers was performed, who belong to a diverge location, age, sex, social, and educational background. As results in Table 1 show, it is observed that 58% of subscribers would not mind to pay more for a guarantee (QoS). 74% of those subscribers would not mind to experience a below average sound quality communication, if the total price of the call would be less than originally priced. 71% of the called would be honest, if they had to rate the quality of their call after the end of it. However, only 26% of the callers would be honest on such a rating request, if they had prior knowledge that this would affect the cost of their call. Finally, 61% of the callers are tolerant in time delays concerning their call establishment waiting-time.

TABLE 1: INTERNET USERS'S SURVEY RESULTS

Per cent of callers that willing to pay extra for better QoS	58%
Per cent of callers that willing to accept poor QoS for a lower price	74%
Per cent of honest call receivers	71%
Per cent of honest callers	26%
Percent of delay tolerant callers	61%

III. ABACUS' HIGH LEVEL SYSTEM ARCHITECTURE

AbaCUS defines an approach where the CPP principle is applied. In AbaCUS a call can be terminated by every MNO who provides network coverage in a specific location and who is willing to terminate any mobile communication subscriber's call, irrespective of the provider the callee belongs to. Since the modern mobile terminal devices are multiband-compatible, there does not exist any technological boundary for this functionality anymore. Furthermore, no SIM change is required from the callee so there is no SIM-lock [35] interference with the AbaCUS call-termination MNO-independent system. Similarly to roaming users, who can use the same device for domestic as well as abroad usage without replacing their SIM card, in AbaCUS the callee can receive a call by any MNO that provides network coverage in his location, without the need of additional equipment.

Figure 1 illustrates the key elements of AbaCUS. A caller is flexible to use the voice-service provider of his choice, such as VoIP, MNOs, and FNOs, in order to place a call. The caller can reach the callee by dialing directly his MSISDN. In this case the host MNO will collect the call-termination rate. However, a competitive MNO may generate a virtual MSISDN and allow to the callee to register in his network. Thus, the caller may dial the virtual MSISDN and reach the callee. In that case the guest MNO will profit from the termination rate. Multiple

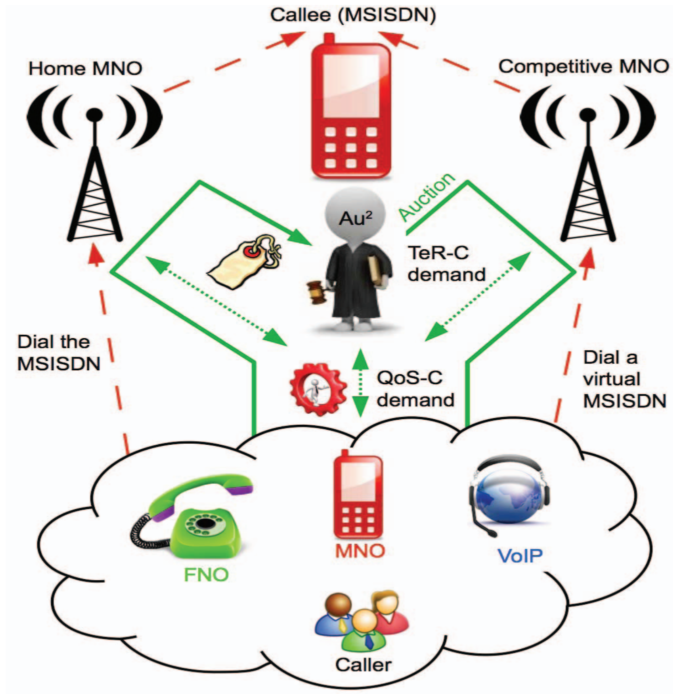

Fig. 1: Key Elements of AbaCUS

MNOs can participate in an auction, where the caller will request to place a call, reach a callee in a specific location, and demands a certain QoS-guarantee for the duration of this call. This demand is expressed by QoS Classes (QoS-C), which contain parameters related to the sound quality and the network-access waiting-time. MNOs bidding in the auction will reply to this request by proposing their charging demand. The charging demand is expressed by the Termination Rate Classes (TeR-Cs), which contain a potential start-up cost and the desired charging rate. Finally, on a referee role during the AbaCUS auction is the Auction Authority (Au^2), which receives call requests from callers and from MNOs the selected TeR-C preference per QoS-C.

A. *QoS Classes (QoS-C)*

Table 2 summarizes the ten QoS-Cs defined in AbaCUS. The reason for the distinction among these ten classes has been taken in order to reach a compromise on a combination of sound quality needed and the importance of a call, while taking in account diverse QoS demands that a caller might have. Thus, in the `Critical` call class the caller has a network-access priority in network congestion situations (*e.g.,* during a concert where the network could be overloaded). Furthermore, such a call demands the maximum sound quality. The `Excellent` call class demands a relatively high sound quality. However, the urgent network-access factor is missing from this class. Such a QoS-C can be selected for example by journalists, who are correspondents in various events, when the task due to high mobility demands has to be completed with the use of mobile communication networks. The next two classes, `Important` and `High`, demand an urgent call setup, and a high sound quality. The difference between those two classes is the customer satisfaction priority provided by the MNO. Such classes are used in situations, where a small amount of information has to be delivered fast. The next three QoS-Cs, `Normal`, `Medium`, and `Low`, correspond to a good sound quality with no special network-access priority assigned. Such calls include non-commercial calls used for social-purposes. The MNO will prioritize the network access, and any resource allocation according to the respective class of a call. The last three QoS-Cs, `Best-effort`, `Fault-tolerant`, `Poor`, correspond to a potential low sound quality due to lack of any resource allocation provisioning. Such calls should be done in case of a low cost demand, where the caller expects that the duration of a call will not be long, since the call might be interrupted or additional costs will be applied for longer calls. Furthermore, potential call-dropping in case of a higher class call request and in a limited resources environment should be tolerated by the caller, when a call in those classes is requested. A priority access policy between those classes will be taken by MNOs. In such a priority access policy the higher a call is ranked, the higher network-access priority the caller will receive. Exception of the rule is the `Excellent` QoS-C, where the main priority is the sound quality. However, even for lower QoS-Cs, such as `Poor`, the sound quality might be good in case that there are sufficient network resources; but no additional resource allocation provisioning will be taken by the MNO.

TABLE 2: QoS-C LIST

QoS-C	Call set-up priority	Minimum sound quality expected
`Critical`	1st	Maximum
`Excellent`	4th	Maximum
`Important`	2nd	High
`High`	3rd	High
`Normal`	5th	Good
`Medium`	6th	Good
`Low`	7th	Good
`Best-effort`	8th	Low with possible disconnections
`Fault-tolerant`	9th	Low with possible disconnections
`Poor`	10th	Low with disconnections expected

B. *Termination Rate Classes (TeR-C)*

Table 3 summarizes the ten TeR-Cs defined in AbaCUS. Initially each TeR-C corresponds to the respective QoS-C. In that scope, the charging schema (charging rate, call set-up cost) of each TeR-C is selected to be reasonable for the respective QoS-C. However, each MNO has the freedom to provide a QoS-C service at any TeR-C. Furthermore, a single TeR-C can be used for multiple QoS-Cs. The choice of a MNO to assign a TeR-C for each QoS-C will be influenced by the monitoring of his network load and potential competition strategies. In order to accomplish these TeR-Cs, each MNO has to provide to the Au^2 a set of virtual MSISDNs per TeR-C, which the caller will receive from the MNO who is selected to terminate the call and eventually dial-in, in order to be connected to the callee. Those ten TeR-Cs include:

- The `Premium` class. Consists of a call set-up cost aggregated to a premium-charging rate, equivalent to nowadays satellite network access charges
- The `VIP` class. Consists of a call set-up cost, aggregated to a high charging rate, equivalent to nowadays added value service charges
- The `Gold` class. Consists of an equivalent to the average market's mobile call rate, aggregated to a call set-up cost
- The `Silver` class. Consists of a high charging rate without any additional costs
- The `Bronze` class. Charges normal rates
- The `Economy` class. Charges a low rate, similar to a typical long distance landline call
- The `Low` class. Consists of a standard call set-up cost and a low rate after the third minute of a call*
- The `Budget` class. Consists of a low call set-up cost and a low rate after the third minute of a call*
- The `Special` class. Charges a standard call set-up cost equivalent to the toll free numbers cost
- The `Free` class. Charges a low call set-up cost that is lower than the previous one

TABLE 3: TER-C LIST

TeR-C	Set-up cost	Rate
`Premium`	Standard	Premium
`VIP`	Standard	High
`Gold`	Standard	Normal
`Silver`	-	High
`Bronze`	-	Normal
`Economy`	-	Low
`Low`*	Standard	Low rate after the 3rd minute
`Budget`*	Low	Low rate after the 3rd minute
`Special`	Standard	-
`Free`	Low	-

Since AbaCUS is an auction-based system, monetary-based auction bidders are allowed to bid in one pre-defined currency in order to be able to compare bids always with a standard way. For example, a bid of one United States Dollar (US$) compared to a bid of one Swiss Franc (CHF) would be higher in June 2010, but the same bid in June 2012 would be lower because the exchange rate between those two currencies has changed [39]. So, all bidders of a monetary-based auction should always use the same monetary unit. In the AbaCUS auction the "monetary unit" is the TeR-C. Thus, each TeR-C is the same for every MNO. However, the value of the set-up and the low set-up cost as well as the value of the low, the normal, the high, and the premium rate, will be selected by MNOs representatives and approved by the regulation authority. Thus, MNOs will agree to use the selected TeR-Cs.

C. The Auction Authority (Au^2) and the AbaCUS Auction

In the domain of online trading and in the scope of a real-time decision-making feature, where the internally applied auction mechanism of the AbaCUS protocol belongs to, a single-round auction — due to urgent export result demand — is needed. Thus, a modified Vickrey's auction is proposed. The geographical area that is covered from the MNOs networks is split into square grids, which cover an area with a size similar to the Global System for Mobile Communications (GSM) cells [32] (the square grids are smaller in the areas that MNOs network is dense). In the AbaCUS auction each MNO proposes periodically the desired TeR-C and virtual MSISDNs pairs for a given QoS-C in a specific square grid, if an update is needed. The MNO may set his choice based on the current network load and/or any pre-allocated resources provisioning planning criteria, such as reserved resources in order to satisfy a potential `Critical` QoS-C request. Each MNO has no knowledge, neither can guess, the TeR-C's selection per QoS-C chosen by other MNOs in the same grid since MNOs do not have an insight on their competitor's network status and their provisioning policies. In order to ensure that MNOs are not interested only in specific QoS-Cs, a TeR-C proposal for every QoS-C is needed; otherwise MNOs cannot participate in the AbaCUS auction. When a termination rate request will be received, the Au^2 will select the MNO, which demands the lowest desirable termination rate for the given QoS-C, but it will return to the caller the second lower TeR-C for the respective QoS-C, if this TeR-C is at most higher by the next TeR-C. In any other case the Au^2 will return the lowest offer. Furthermore, in case of a draw the MNO, who won most of the past two auctions in a given grid, will be the winner of the AbaCUS auction. Also, in a draw case an MNO is not allowed to win more than two times in a row. The Au^2 will select another MNO with the same TeR-C offer in that case. If the winner of an auction cannot be defined by the above rules, the Au^2 will select randomly one of the winning MNOs. In this selection each MNO has an equal probability to be selected. Like that initially winning MNOs cannot dominate in future auctions.

The draw case, when more than two MNOs participate, is formally described as follows: All participating MNOs of the AbaCUS auction belong to the set S. The size of this set is $|S| = m$.

$$S = \{MNO_1, MNO_2, \ldots, MNO_i, \ldots, MNO_m\} \text{ , where } i \in (1, m)$$

The winner of the n^{th} auction is $winner(n) = MNO_j$. If $winner(n-1) = winner(n-2) = MNO_i$ it should also be

$j \neq i$ and $P(winner(n) = MNO_j) = \frac{1}{|S|-1} = \frac{1}{m-1}$,

where $P(winner(n) = MNO_j)$ is the probability that the winner of the auction is the MNO_j.

If $winner(n-1) \neq winner(n-2)$ holds true $j \in (1, m)$ and $P(winner(n) = MNO_j) = \frac{1}{|S|} = \frac{1}{m}$.

*Those classes introduce a charging scheme, where the caller will pay a low rate only, if the call exceeds the duration of three minutes, which is typical phone call duration in many countries [14].

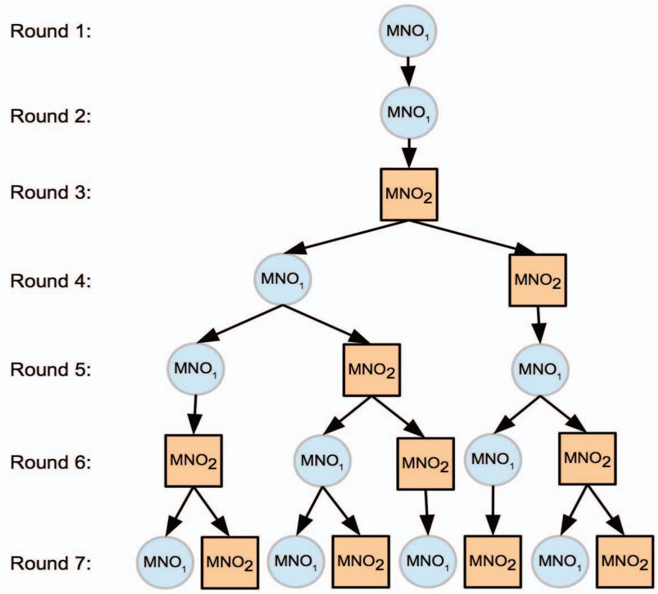

Fig. 2: Possible Winning Sequences in a Constant Draw Scenario

Figure 2 illustrates an example of potential winning version results of several AbaCUS auction rounds. In order to show the diverse winners distribution in case of sequential draws in this scenario two MNOs always make the same offer. As it is shown, the initially competitive MNO_1 will not dominate AbaCUS auctions in case that MNO_2 becomes equally competitive at a later point. However, it is always possible that the Au^2 might reject the winning offer if the last is larger than the caller's threshold. In that case, the caller will continue the call without choosing an alternate MNO to terminate his call. That will result in more competitive future offers from these MNOs, in order to profit from the call termination; and callers will pay lower termination rates.

In this auction each MNO has interest to propose the lowest profitable TeR-C, since like that chances to be the auction's winner increase not only for the present, but for near future auctions as well. Additionally, the MNO positioned in the second place of the auction is not allowed, by the rule "one TeR-C higher than the lowest one", to "force" the Au^2 to reject the second lower TeR-C offer due to an unreasonable high TeR-C selection for each QoS-C. The latter results from the fact that, if the second ranked MNO's offer is higher than the next available TeR-C, the original offer will be selected. However, it might happen that the TeR-C to be used is the next higher than the one that the dominating MNO has initially requested. Thus, the dominating MNO might receive a higher TeR-C than the one requested, while at the same time the caller will pay less than the original callee's MNO would demand (win-win situation).

In Table 4, a scenario, where two MNO compete, is shown. MNO_1 and MNO_2 may either be honest *(H)* and propose a reasonable TeR-C or lie (*L*) and propose a higher than their real preference TeR-C. Those two possible strategies result in a behavior of MNOs, which is similar to the prisoner's dilemma case [29]. In case that both MNOs are lying (*L-L* case) and make a high offer, the Au^2 will most likely have to reject any TeR-C selection, since the original cost for the call will be probably lower than the proposed one. Thus, none of the MNO_1, MNO_2 will be the winner of the auction. In cases *H-L* or *L-H* the Au^2 will select the lowest TeR-C. So, none of these MNOs has interest to lie and offer a higher TeR-C than he can afford, fearing that their competitors might be honest.

TABLE 4: ABACUS AUCTION STRATEGIES

MNO_1-MNO_2	L-L	L-H
MNO_1-MNO_2	H-L	**H-H**

D. *The AbaCUS Protocol*

Figure 3 illustrates the AbaCUS protocol. The caller may initiate the call either through an FNO, a VoIP operator, or a MNO, as far as AbaCUS messages can be exchanged between calling parties *(e.g.,* both caller and callee could be mobile users and all the AbaCUS messages are exchanged between their Smart Phones).

Steps 1-2: The first step to be taken prior to a call is that the caller could request from the callee's device the approximate current location area (1) since precise location information is not mandatory. The positioning information will be provided to the caller by the callee's device. Furthermore, the SIM information (2) as well as the International Mobile Equipment Identity (IMEI) (3) of the device will be requested. Those three information will become part of the Callee Data (CD). The callee will generate and add into the CD a random pass KEY that will be used for the service request identification purpose at a later poin.

Step 3: The caller will send a service request to the Au^2. The service request contains the CD, the preferred QoS-C that the caller wishes for the specific call, and his TeR-C tolerance. The Au^2 (as described in the Subsection C) will provide the MNO that could terminate the call and the respective TeR-C, only if this is at most equal to the caller's TeR-C tolerrance. In every other case, the call will be placed within the default provider by calling the callee directly.

Steps 4-6: In case of an acceptable TeR-C, the Au^2 will forward the CD, the caller's MSISDN, the virtual MSISDN to be used, the requested QoS-C, and the IP addresses of the caller and the callee to the winner of the AbaCUS auction. Afterwards the respective MNO will initiate the Temporary MNO Switch Request (TMSR) by sending a respond to the callee with the pass KEY who previously generated as a proof that this is not a fake TMSR. The device tries to connect to the host MNO. Since the MNO received the CD from the Au^2 in step 4, his infrastructure will allow for the SIM card and IMEI-pair to register in his network only through Base Stations (BSs) being located near by the location that is defined in the CD. Furthermore, the host MNO delivers to the callee any incoming call from the caller to the virtual MSISDN. Also, the callee will get access only for incoming calls by the specified MSISDN. Outgoing calls, while the callee remains registered within the host network, will not be allowed since he will not be able to pay for them.

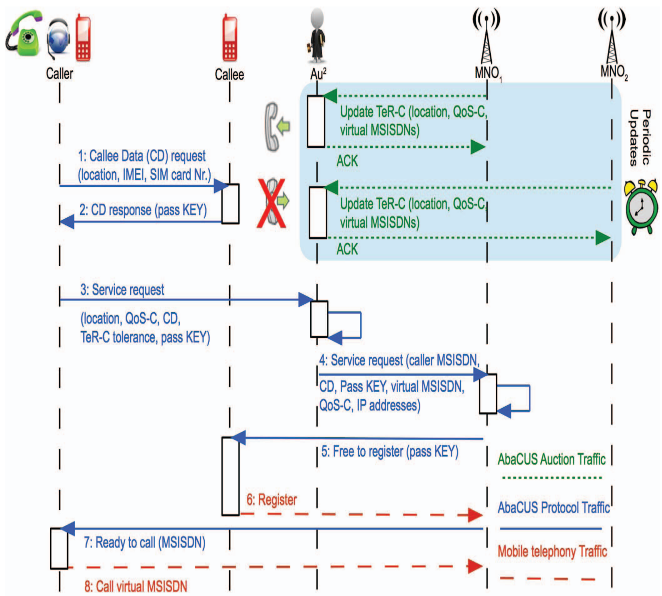

Fig. 3: The AbaCUS Procedure

Steps 7-8: Finally, in the last steps the host MNO will notify the caller with a virtual MSISDN that the caller's terminal has to dial "silently" (without the user noticing that), in order to complete the call. This number, due to safety reasons, will be accessible only by the given MSISDN and it will expire, if not used within a short period (*e.g.,* ninety seconds, sufficient amount of time to complete the 6-step SIM network registration process [31]). Then, the connection will be established.

For the exchange of all AbaCUS messages, either a third party software on the call participating parties terminals, or a firmware process could be equally used. Furthermore, during the call-establishment waiting period the caller could get access to personalized multimedia content like music, news feed, or advertisements.

IV. Summary, Conclusions and Future Work

Summarizing, in this work it was shown that technical limitations of the past, which enforced the mobile termination cost monopoly, can be overcome. Also, the breaking apart of this monopoly will be an opportunity for MNOs rather than a threat. In the proposed termination rates market, MNOs have the opportunity to maximize the utility of their infrastructure by providing services to call receivers, who did not have access until now. Furthermore, MNOs have the opportunity to provide premium quality services for callers, using existing infrastructure through the pre-allocation of their network resources to customers that are willing to pay more for a better and guaranteed QoS service [15] showed that paying for QoS can increase networks' utilization.

Concluding, within AbaCUS the caller, who is the party paying the termination rate, is also the one to chose which MNO will terminate his call, determining a significantly fair approach, since the party paying is able to influence the total cost of the call. Table 5 summarizes the benefits of AbaCUS achieved compared to the CPP principle, the RPP principle, and the national roaming cost solution. AbaCUS supports an auction procedure for every call separately, establishing like that a dynamic, live, and on-demand competition in the mobile termination rates market. QoS-guaranteed services are also supported in AbaCUS. Furthermore, the caller has to set only his preference without any knowledge on MNOs termination rate charging policies. MNOs can act independently, since it is optional to participate in AbaCUS auctions or adopt other approaches.

The AbaCUS auction is designed in a way that MNOs can profit by using the system only by adopting an honest bidding policy, while potentially lying MNOs will not affect the smooth operation of the system.

Finally, regulation authorities in an AbaCUS moderated market will have an observer role instead of their juristic role today. Less regulation demands will result in a competitive market with all those benefits that the AbaCUS approach implies.

Given the survey results achieved, it is shown that AbaCUS is an approach with a strong potential to be accepted by MNOs subscribers, since the majority of subscribers are positive toward a potential price and QoS correlation. Thus, an accurate mechanism in order to protect dissatisfied users that paid, but never perceived the expected QoS, is needed. Furthermore, the exploration of further auction types to be used by Au^2 will follow. The efficiency of AbaCUS in other markets, like the VoIP and the fixed telephony market, will be examined.

Table 5: Approaches Against the Mobile Termination Rates Monopoly

	Auctions support	QoS support	Competition is allowed	Agreement needed
CPP	No	No	No	-
RPP	No	No	Partially	-
NetRoam	No	No	Partially	Yes
AbaCUS	**Yes**	**Yes**	**Yes**	**No**

Finally, selected practical issues demand for an answer, such as the accounting for call-related data for each call terminated by a host MNO. Furthermore, the system prototyping procedure is an ongoing work and the evaluation of the system will follow. Last but not least, the evaluation of the AbaCUS auction effectiveness has been done in an analytical way. Thus, the economic advantage from a revenue's point of view for AbaCUS-friendly MNOs compared to independent MNOs will be presented by a call-termination simulation environment in future work.

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