Inter-operator agreements based on QoS metrics for improved revenue and spectrum efficiency

L. Giupponi, R. Agusti, J. Pérez-Romero and O. Sallent

Presented is the analysis of inter-operator agreements to exchange radio resources in a multi-operator scenario, to improve radio resource usage and operator revenue. The establishment of these agreements increases user perception of the service and reduces churning rate.

Introduction: The perspective of beyond 3G (B3G) systems is that of heterogeneous networks, where the availability of different radio access technologies (RATs) introduces a new dimension in the radio resource management problem: instead of performing the management of radio resources independently for each RAT, some form of global management can be envisaged. Joint radio resource management (JRRM) is a suitable process to manage dynamically and co-ordinatedly radio resources of different RATs. JRRM strategies may be activated within single or multiple operator networks in order to support multiple objectives, e.g. avoiding disconnections due to lack of coverage in the current RAT, blocking due to the overload in the current RAT, possible improvement of QoS by changing the RAT and support of users' and operators' preferences. In a multi-operator context JRRM exploits the complementary characteristics existing both spatially and temporally among traffic patterns of different operators. In this sense, radio resource trading among operators can be considered, through the establishment of inter-operator agreements, towards a more efficient overall radio resource usage. In [1] the authors presented an inter-operator JRRM strategy, involving technical, economic and regulatory considerations. From the technical perspective, the framework proposed in [1] is based on a fuzzy neural JRRM [2, 3]. A user that would be blocked by a given operator can be transparently served through another operator, which leads to a more efficient usage of radio resources and to an improvement of operator revenue. From the economic perspective, [1] shows that all parties involved in the process benefit. The operator 'renting' radio resources, referred to as the serving operator (S-operator), takes advantage of this exchange in the short term, in terms of revenue coming from the service provision for a user that belongs to another operator. On the other hand, the operator 'borrowing' radio resources, referred to as home operator (H-operator), benefits in the long term since its user, instead of being blocked, is provided with service and consequently is not motivated to migrate to another operator, which is also known as 'churn'. From the regulatory perspective, some dysfunctions that may arise in real markets can be overcome (e.g. difficulties for some operators to find suitable sites to deploy infrastructure and to provide enough capacity) and anti-competitive behaviours can be disincentived [4].

In this Letter we take [1] as a basis and propose a new revenue sharing model for JRRM in a multi-operator context. The proposed solution allows the application of a business model that can be fairly applied under all traffic conditions and is based on the blocking as a major indicator of the degree of satisfaction perceived by the users, which can eventually be related to the churning rate. This allows better quantifying of the long-term benefits obtained by the operators involved in the trading process than the approaches considered in [1].

Inter-operator revenue sharing models: The transaction between H-operator and S-operator has to be transparent to the user involved in the trading process. Consequently, the price charged to the user should be independent of the operator providing service, and equal to the price p charged by the H-operator. Then, it is assumed that the revenue generated by the user is shared between the two involved operators, so that the H-operator keeps a revenue $(1-\alpha)p$ from this user, while the S-operator receives αp, where $0 \leq a \leq 1$. Depending on the value selected for α, two different business models are considered in [1]: (i) SOGAR, where the S-operator receives 100% of the income (i.e. $\alpha = 1$) and (ii) SRBL, where α equals the normalised load of the S-operator (i.e. $\alpha < 1$). When the traffic demand is high, SOGAR results in a fairer distribution of income among co-operative operators than the SRBL business model, since it guarantees higher revenue to the operator that provides service to the users. In fact, it is adequate for operators which have deployed appropriate infrastructure in accordance to their market share, whereas SRBL brings more benefits to those operators whose infrastructure does not fit the actual market share. On the other hand, SRBL was found to be fairer than SOGAR when operators are characterised by low traffic demand. In this situation, the exchange of resources among operators is only activated to face sporadic overload situations and consequently the revenue can be shared among operators based on a factor $\alpha < 1$, depending on the particular load situation.

It has to be considered that a revenue sharing model could be acceptable by the involved parties if it is fairly applied in all circumstances. Certainly, fairness in the agreement has a direct relation to how one operator deploys its infrastructure based on its traffic demand. Considering this, a novel revenue sharing model is proposed here based on keeping a direct relation with the perceived QoS. The QoS metric is defined through a single parameter, the blocking probability P_b, which inherently captures the traffic conditions against infrastructure deployment and capacity trade-off, so that a unique business model can be fairly applied under all traffic conditions. Note that blocking can also be eventually related to the user's churning rate $C(P_b)$ based on the following expression from [5]:

$$C(P_b) = \frac{1}{1 + e^{\chi(\beta - P_b)}} \tag{1}$$

where β is the percentage value of blocking corresponding to which the churning is 0.5. Depending on the value of χ different variations of the churning rate can be modelled, reflecting different user behaviours and other non-technical factors (e.g. influence of operator's promotions and incentives over user behaviour, etc.).

The new revenue sharing model capturing the user service perception is called 'shared revenue based on blocking' (SRBB). According to this model, the long-term benefits gained by an operator are related to the blocking and eventually to the churning, so that, from the S-operator perspective, an adequate way of sharing the revenue between H- and S-operator is by setting $\alpha = C(P_b)$, where P_b is the H-operator blocking probability. With this setting, if the H-operator has normally a high blocking, reflecting that its infrastructure is not sufficient for its market share, most of the revenue of the transferred calls will be kept by the S-operator, thus keeping the fairer behaviour of the SOGAR model. In turn, if the blocking probability is reduced, meaning that the operator has deployed an adequate infrastructure for its users, so that only in sporadic cases users should be transferred to other operators, the revenue will be shared between the H- and the S-operator, thus keeping the fairer behaviour of the SRBL model.

Performance evaluation: The proposed framework is evaluated in a multi-RAT, multi-cell, multi-user and multi-operator scenario. Operators are differentiated by their infrastructure deployment and market share. The market share is characterised by x, which represents the relation between the number of users of one operator and the total number of users in the scenario. Similarly, infrastructure share is denoted as y, which is the ratio between the cost of one operator's infrastructure and the total cost of the scenario infrastructure. For the sake of simplicity we consider a scenario characterised by two operators, OP1 and OP2. The parameters involved in (1) are $\chi = 2$ and $\beta = 4\%$. Details about simulation scenario, traffic, mobility, propagation models and performance metrics can be found [1].

Fig. 1 shows blocking and churning rate as a function of the market share x (i.e. x% of the users subscribed to OP1 and the rest to OP2) in a scenario with 300 users. OP1 and OP2 are characterised by the same infrastructure deployment (i.e. $y = 50\%$). A situation in which no inter-operator agreements have been established (no inter-operator agreements – NIOA) is compared to SRBB. It can be observed that SRBB benefits the users in terms of blocking and consequently in terms of perceived QoS, which results in a reduction of churning. For example, in the NIOA case, when $x = 67\%$ OP1 experiences a blocking of 6.78% and consequently a churning of 0.99. In turn, in the SRBB case, OP1 blocking decreases to 0.61%, which results in a churning of 0.001. Similar considerations can be made observing the blocking and churning rate as a function of the infrastructure share y in Fig. 2 for $x = 50\%$. In this case, when $y = 40\%$, (i.e. OP1 has 40% of the infrastructure) OP1 experiences a blocking of 6.7% in the NIOA model, which results in a churning of 0.99. On the other hand, SRBB benefits OP1 in terms of blocking reduction, resulting in a churning of 0.0006.

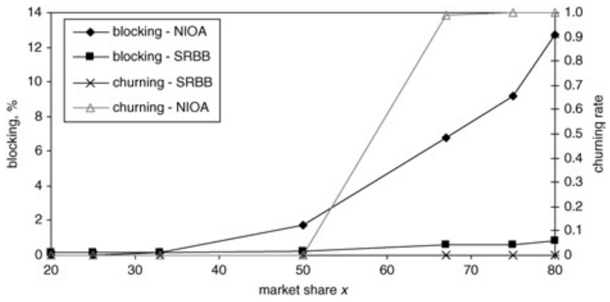

Fig. 1 *Blocking and churning rate against market share x*

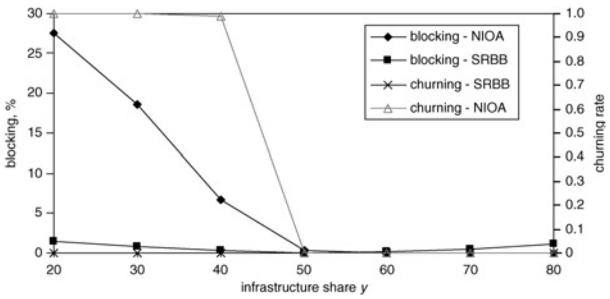

Fig. 2 *Blocking and churning rate against infrastructure share y*

Fig. 3 shows the comparison in terms of operator profit (computed as the difference between the revenue coming from the users and the infrastructure cost [1]) between the SRBB and NIOA models for different traffic conditions (i.e. 300 and 150 users), as a function of the market share x. When the scenario is more loaded (i.e. 300 users case), the blocking is high, and so is the churning. Consequently $\alpha \rightarrow 1$, which results in benefits in the short term for the operator characterised by low market share with respect to its deployment (i.e. in Fig. 3 low values of x), and long-term benefits for the operator with reduced infrastructure with respect to its market share (in Fig. 3 high values of x). On the other hand, when the scenario is less loaded (i.e. 150 users case), the trading process is activated only in sporadic situations, the blocking in the scenario is low and the churning takes values lower than 1, so that the revenue from a user is shared based on a value $\alpha < 1$. Similar considerations can be made about profit results as a function of y, but they have not been shown because of space constraints.

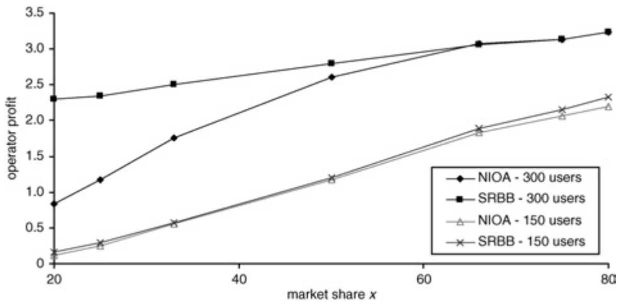

Fig. 3 *Operator profit against market share x*

To sum up, the SRBB revenue sharing model results in a fair model since it captures the operators' situations in terms of traffic conditions, infrastructure share and market share. Additionally, both the operators take advantage of the trading process, the S-operator in the short term, as is shown in Fig. 3, and the H-operator in the long term, as is shown in Figs. 1 and 2.

Conclusion: We have presented a JRRM approach in which users experiencing blocking in the home operator can be served by an alternative operator in a transparent way. A revenue sharing model between the operators participating in the trading process has been presented as a function of the service quality experienced by the users and of the churning rate. Simulation results show that both operators take advantage from this approach.

Acknowledgment: This work was performed under project E2R2/E3, which has received research funding from the Community's Sixth/Seventh Framework programme. This Letter reflects only the authors' views and the Community is not liable for any use that may be made of the information contained therein. The contributions of colleagues from E2R2/E3 consortium are acknowledged. This work has also been supported by the Spanish Research Council under COGNOS grant (ref. TEC2007–60985).

30 November 2007
Electronics Letters online no: 20083431
doi: 10.1049/el:20083431

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