

Equitable access to spectrum in further development of the Geneva 2006 frequency plan

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Abstract. Since the frequency plan of the Regional Radiocommunication Conference Geneva 2006 has come into force, many attempts have been made towards its enhancement. The preliminary results, however, seem not to be compliant with elementary principles of distribution justice. Therefore, the planning principles which lead to the observed imbalance will be scrutinized. Furthermore it will be shown that the utilization of spectrum can be advanced in a balanced way when the same (necessary) condition for “equitable access”, which has been used by a group of middle European countries for the construction of the original frequency plan, is applied to plan refinements as well. The necessary condition mentioned consists simply in the parity of the number of coverages (constituted of disjoint allotments) configured in the plan for each country. In order to be able to plan enhancements, the concept of coverage number has to be generalized to the case of incomplete coverages of potentially overlapping allotments. The computation of coverage numbers is straightforward and renders the concept of coverage number parity a useful tool to be applied as a necessary condition in testing a frequency plan variant for equitable access.

1 Introduction

During the preparation of the Regional Radiocommunication Conference 2006 (RRC06) it has been copiously and controversially discussed how a fair distribution of the spectral resources among the participating countries could be achieved (Puigrefagut, 2004). The report of the first Session of the Regional Radiocommunication Conference 2004 (RRC04), at least, contains some general remarks in a short paragraph on “equitable access” (ITU, 2004) as well as a reference to article 44 of the ITU Constitution (ITU, 1992). Specific reg-

ulations, however, have not been formulated. The conferences’ Final Acts (ITU, 2006) neither put equitable access on record nor otherwise refer to distribution justice. According to the description of the software that has been programmed for the RRC06 (O’Leary, 2006), the only principle that has been made use of in frequency plan synthesis was to meet a maximum number of coverage requirements while simultaneously limiting the interference load. This could have incentivized the countries to increase the probability of plan entries for their own account by flooding the software with requirements. To avoid an “arms race” in the process of requirement posting, a group of CEPT countries had been meeting consecutively with the aim to counteract by coordinated action the deficiencies with respect to distribution justice, which are featured by the ITU planning procedure. The idea to quantify the degree of equitability by direct comparison of the spectral resources used by the countries involved, however, had to be discarded. On one hand it proved hardly possible to quantify the consumption of spectrum. On the other hand, a straight uniform distribution would not even have been adequate, considering that real coverage requirements of neighboring countries can differ appreciably. An absolute notion of justice would have been helpful, but, as a matter of principle, cannot be provided in spite of all strenuous efforts of political philosophy. However, there is a way out in recognizing that absolute justice can be replaced by what could be called a relative definition, by accepting a situation as just when all parties involved reach a consensus on that (which insight is the constituting element in the famous theory of J. Rawls (Rawls, 1975)). Thus the countries eventually agreed on an equal number of coverages as a basic prerequisite for any fair distribution of spectral resources. For the sake of verifiability, it has been required that the allotments which constitute a nationwide coverage may not overlap. The amount of spectrum used for the realization of the coverages, e.g. the number of channels consumed, deliberately has not been taken into account in the evaluation of equitable access. Thus it has been facilitated to configure



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the allotments according to specific regional needs like internal administrative borders, speech communities, coherent areas of communication, topographic constraints, and existing transmitter networks. Merely, in cases where it was impossible to meet all requirements along a border with the available spectrum, the parties involved had to settle on necessary reductions of the requirements. For those countries which have submitted to this planning principle, the frequency plan, naturally, is completely balanced with regard to the number of coverages. It is, however, not necessarily balanced with regard to the amount of spectral resources consumed. This circumstance is of basic importance when it comes to extending the rights of spectrum usage beyond the Geneva 2006 frequency plan.

2 The traditional approach to further development

The traditional approach to extending the rights of spectrum usage consists in identifying such possibilities for the implementation of new channels or transmitters, which preserve the integrity of the existing plan entries of the neighboring countries concerned. This is exactly what is implied by “article 4” of ITU (2006), as well as the corresponding regulations in earlier international agreements like e.g. the Final Acts of the 1984 band II planning conference (ITU, 1984). In consequence, the parties regard the resources allocated to them as their property, which they can make use of, rearrange and optimize quite freely as long as no harm is done to the resources allocated to the neighbor. Only in cases when extension potentials of different countries are mutually exclusive, they have to be negotiated. Since the rights of the others are preserved in these revisions, it can be stated that the traditional “article 4” coordination procedures are a matter of Pareto optimization. However, the achievable gain might differ considerably between countries, and this is the reason why the justice of the approach may be duly questioned.

Following the approach, a country can make use of the more extension possibilities the more resources it has consumed in the construction of the original coverages. Anyone who has configured lots of small allotments with individual frequencies in the original plan, generally, can extend the frequency usage to the allotments nearby without substantially changing the interference situation in the neighboring country. Anyone who has succeeded in configuring a small allotment such that it contains a high-power transmitter assignment in the original plan, ordinarily can extend the frequency usage to nearby allotments without doing harm to the neighboring countries’ rights of spectrum usage, especially when excess interference is compensated by a reduction of the radiated power of the primary assignment. On the contrary, anyone who has been conservative in the consumption of spectral resources by configuring comparatively large allotments in the original plan (e.g. to pave the way for the neighboring country to fulfill regional needs by small allot-

ments), finds himself at a disadvantage: large allotments cannot, because of self-interference, be enlarged still more, if by all means the possibility to implement broadcast-type transmitter networks has to be sustained. Thus it is evident that the bare Pareto principle in the traditional coordination approach is prone to enhance unjust distribution of resources, incentivizes countries to misuses like “strategic planning”, and may give rise to perversions like coordination races.

3 A modified approach

The unfair consequences of traditional coordination strongly encourage looking for other (still pareto-optimal) solutions for the plan enhancement problem which will preserve equitable access. The search can be aided by having a look on the basic flaw of the traditional approach. It consists in abandoning in the enhancement process the principle which has been used to establish an original plan which is regarded as equitable, the parity of coverage number irrespective of the amount of allocated resources, and replacing it by the (implicit) principle of ownership of the resources allocated in the first step, which allows to exploit their extension potentials, which have not been taken into account in the equity assessment of the original plan. From that it can be concluded that for a more balanced plan enhancement procedure the principle of coverage number parity should be strictly retained and applied also to the extended plan. As immediate consequence we note that if a country succeeds in freeing spectral resources by adroit rearrangements, these resources are no longer owned by that country, but have to be used to improve the plan of all neighbors concerned in an equitable way. The fundamental difference to the traditional approach is that all extension potentials will be distributed equitably, not the mutually exclusive ones only. Especially it is ensured that the gain from the release of “hidden assets” will be to the benefit of all parties concerned.

4 Quantification of equitable access

It has been argued that the coverage number parity principle may constitute a necessary condition for the establishment of equitable access. However, the potentials for extensions of the frequency plan do in general not tend to be evenly distributed geographically. This means that one cannot expect extensions to again form complete coverages of disjoint allotments as in the original plan. Hence, the concept of coverage number has to be generalized to the case of incomplete coverages of potentially overlapping allotments. In doing so it does not make too much sense to schematically sum up covered areas. Areas of geometrically equal size may, for several reasons, not have the same weight in the calculation:

- First of all, areas far from the border should be excluded from the calculation. If we assume that beyond a certain

distance D channels can be reused without negative impact on the respective allotments, we find that frequencies to be used inside a country a distance D apart from the borders can be regarded as public goods with respect to the countries as legal bodies. Such use of frequencies does not draw on the resources of the other legal bodies and consequently there is no need for legal restrictions. Any change in the number of coverages in the inner part of a country does not affect the possibility of frequency usage of the neighboring countries. Thus, to verify equitable access for a pair of countries, only those areas are included which consist of points not farther away from the common border than D . With respect to these areas, which may be termed the mutual coupling zones, frequencies no longer behave as public goods but as common public resources instead, the usage of which may be mutually exclusive.

- Secondly, the total areas of the mutual coupling zones can differ considerably, as is illustrated by the situation along the L-shaped borderline between Alsace-Lorraine in France and Rheinland-Pfalz/Baden in Germany. A certain channel used in a small allotment in France can render the same channel unusable in a much larger area in Germany. A certain channel hypothetically used in the entire mutual coupling zone of country A with respect to country B will render this channel unusable in the entire mutual coupling zone of country B with respect to country A. Hence it seems natural to value, respectively, complete coverages of the mutual coupling zones as equal. In consequence coverages of equal fractions of the coupling zones have to be valued as equal.
- Thirdly, according to different number of inhabitants, areas, although of the same size, may be of different economical importance.
- Lastly, the degree of restrictions which a transmitter network implementation may be subject to in different areas might be different.

Altogether, if the interpretation of “equitable access” as “parity of coverage number irrespective of the amount of resources consumed” is to be reflected in a quantitative definition of an “effective coverage number”, this coverage number has to be additive with respect to extensive variables. This means, for example, that the contribution of two disjoint allotments (with comparable network implementation conditions) to the effective coverage number has to be the same as that of a single alternative allotment consisting of the union of the two. This renders the coverage number a linear expression in inhabitant number and area size. Furthermore, inhabitants and area sizes have to enter the calculation as relative values, as fractions of the corresponding values of the respective mutual coupling zone.

To keep the discussion simple, it will be assumed that network implementation in all areas of interest is of the same

degree of complexity. This avoids the introduction of “implementation factors” in the expression for the contribution of allotments to the coverage number. Let

- D := minimum reuse distance; the minimum distance between co-channel allotments which prevents harmful mutual interference; for the UHF part of the Geneva 2006 frequency plan a value of approximately 120 km is adequate,
- A_{ij} := area size of the coupling zone of country i with respect to country j ,
- N_{ij} := number of inhabitants in the coupling zone of country i with respect to country j ,
- A_{ijk} := area size of partial area k of coupling zone A_{ij} ; the partial areas k neither have to be disjoint nor have to constitute a complete coverage of the coupling zone; the partial areas are constituted by the nonempty intersections of all allotments in country i with the coupling zone A_{ij} ; if the same partial area has different frequency allocations it has to be taken into account separately for each allocation,
- N_{ijk} := number of inhabitants in partial area above.

Then the expression:

$$C_{Aij} := \frac{\sum_k A_{ijk}}{A_{ij}} \quad (1)$$

represents the effective number of area coverages in country i . It may be verified that C_{Aij} reduces to the customary number of coverages in the coupling zone when the partial areas are disjoint and carry the same number of frequency allocations.

Likewise the expression:

$$C_{Nij} := \frac{\sum_k N_{ijk}}{N_{ij}} \quad (2)$$

represents the effective number of coverages of inhabitants in country i . It also reduces to the customary number of coverages under the conditions given above. With these definitions, two necessary conditions for equitable access with respect to country i and j can be formulated:

$$C_{Aij} := C_{Aji} \quad (3)$$

and

$$C_{Nij} := C_{Nji} \quad (4)$$

If area coverage and inhabitants coverage is treated interchangeably, then for the sake of simplicity the two conditions (3) and (4) could be replaced by the single condition of equality of a linear combination of the respective area and inhabitant-coverage numbers.

5 Application remarks

It is evident that the parity of coverages concept cannot be used to resolve conflicts in coordination negotiations formally. The concept can only be used to rule out a certain class of “unfair” frequency plans early in the coordination process. The plans that pass the test may nevertheless not be acceptable, for example when the local distribution of coverage does not meet the requirements of one of the countries. Nevertheless, by avoiding at an early stage the pursuit of planning variants that would not be accepted by one of the parties, frequency coordination procedures can be considerably “abridged”. The fact that the concept proposed is not just another variant of Pareto optimization but that it notably is compliant with John Rawls’ Maximin principle should encourage its application in forthcoming international negotiations on frequency usage.

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