Wireless World Research Forum
(WWRF)

Planning the Reconfigurable Radio Network –
Scenarios, Requirements and Methods

## 1 WG or SIG to which this Contribution is submitted:

**WG6: Reconfigurability**

## 2 State which of the categories a) – f) on the front page of the CfC this Contribution is addressing:

**a: Contribution towards the already identified research areas within WG6**

## 3 Title of research item

# Planning the Reconfigurable Radio Network — Scenarios, Requirements and Methods

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## 5 Subject area (WG/SIG and subtopic (as of CfC) where appropriate)

This paper aims to offer new perspectives in the specific areas of reconfigurable networks design and joint radio resource management. The techniques and methods based on the assumption of typical scenarios will ease the deployment of radio network in the area of reconfigurability.

## 6 Relevance of the topic to the above subject area

This topic has been chosen because reconfigurability is one of the key concepts which will dominate the world of telecommunications in the following years. Reconfigurable networks will be the prevalent kind of networks that will facilitate the introduction and implementation of the composite radio concept. Thanks to the characters owned by the reconfigurable devices in the radio network and terminal side, planning and management of a reconfigurable radio network will be different to classical methods. We are studying the typical scenarios happening under the reconfiguration context with respect to Dynamic Network Planning and Radio Resource Management and investigating proper techniques suitable for them. Therefore, the results of our research will reveal whether the effective combination of dynamic network planning and management of reconfigurable networks will be accompanied by reduction of the deployment cost.

## 7 Preferred presentation form:

**Speech**

## 8 Paper presentation

### 8.1 Introduction

Reconfigurability constitutes one of the major concepts that will prevail in the following years in the world of telecommunications. Its impact on many system aspects, ranging from the terminal to the network side is notice worthy. This paper presents some first thoughts and high level descriptions of the relevant problems that will be tackled within the IST E2R project. It aims, in particular, to investigate whether, with the support of reconfigurability and flexible network reconfiguration, the cost for network deployment and operation can be decreased, while significantly enhancing efficiency of user traffic handling. Its structure is as follows: First some primary objectives of the research process are presented. Second is the technical approach, i.e. the scenarios being anticipated, the high level descriptions of the problems anticipated and the solution methods. Third are some expected results and conclusions.

### 8.2 Technical Approach

The work that will support our research can be split into phases:

The first phase which is already close to revealing some results has to do with the identification of the requirements that reconfigurability poses, considering some typical scenarios for the network planning and management issues. These requirements are set by the respective scenarios that are envisaged to occur in the near future, when B3G systems become applicable. The second phase is implementation and performance evaluation. Based on the identified scenarios and requirement, we set the limitations for the optimization methods which encapsulate the capabilities of the reconfigurable devices which support specific radio interfaces in the allowed spectrum.

#### 8.2.1 Scenarios and Requirements

The characteristics of the scenarios foreseen for the investigations of dynamic network planning and joint radio resource management will take into consideration the coexistence of WLAN, UMTS and GSM/GPRS:
The user traffic changes over the spatial and the temporal dimension. To deploy the radio network, the network operators have to take the potential dynamic features bestowed by the

reconfigurable capabilities and the management functions covering the cooperating radio networks.

The dynamic features that can be managed by the radio network are listed as the follows:

- Flexible spectrum allocation and sharing between operator and radio access technologies (RATs)
- Power allocation scheme for multi-cell/Multi-layer radio networks
- Joint radio resource management functions, e.g., horizontal, vertical, diagonal and even hybrid handover[1]
- Traffic engineering thanks to the joint optimization between the radio network and the involving entities from the service providers, e.g., service class based traffic scalability
- Changes of capabilities of the entities in the radio network, e.g., function reallocation of radio entities; implementation parameter changes, for instance the vertical angle of the antenna, etc.

An envisaged scenario where JRRM techniques in the framework of heterogeneous networks could bring benefits to the overall efficiency is that of a changing traffic and changing environment scenario, represented by e.g. the user's activity along a day. Changing environment stands for the user being at home, at office, in a meeting, on the move from one place to another, etc. Movements from outdoor to indoor environment (e.g. from outside to company building) or vice versa may also occur. Changing traffic stands for the fact that, during daytime, hot spot traffic areas can move, and services required by users are also evolving. For example, during the day the traffic may be concentrated on business areas, with services related to business requirements, while during the evening the residential or entertainment areas (restaurant, cinemas, etc.) will be more loaded, with different required services.

In this changing environment and changing traffic scenario, the different RANs must adapt to these load and services variations during daytime. In case the user moves from outdoor to indoor environment (e.g. from outside to company building) or vice versa, outdoor coverage could be ensured by a 2G and 3G systems, indoor coverage could also be ensured by WLAN. The user needs to change RAT to access new services or to ensure service continuity when a RAT is no more available. JRRM mechanisms must be defined to allow an operator with different RANs to move some users from the most loaded RAN to the less loaded RAN. The main requirement is to optimise the use of radio resources while offering the best QoS to users. This transfer must be seamless, transparent for the users, the users' terminal must be reconfigured while operating, the operator needs to know which terminals are multi-mode and the load status of the RANs.

As Network Planning is tightly connected with Radio Resource Management, the following two phases evolve simultaneously and their results are interdependent. These phases constitute problems at the same time, which will be solved through simulations.

### 8.2.2 High level Dynamic network planning (DNP) problem description

[1] The hybrid handover is defined here as a combination of the aforementioned handover schemes

Like the classical network planning approach, we dimension our methods by specifying the input parameters and the objectives (outputs).
The inputs of this problem are composed of:

(i) the services, target QoS levels, demand, traffic intensity, etc. More specifically, of interests are the applications (services) offered in the service area, the quality levels through which each service can be offered, the RATs through which each service can be offered and the demand per service and service area portion. Moreover, required are the utility volume and the resource consumption, when a service is offered at a certain quality level, through a certain RAT.
(ii) the list of the candidate element sites to deploy the RF sets
(iii) the additional capabilities that can be used in the network (alternate RATs that can be activated in candidate element sites, resources that can be assigned to a RAT, other spectrum issues, reconfigurability of each element, etc)
(iv) the cost associated with each decision.

The problem should provide as output the network configuration pattern, i.e. the number of elements and sites selected, the RATs per element, the resources per element, etc.
The output (configuration) should optimize an objective function associated with the number of BSs, the RATs per BS and the resources per RAT/BS. The reconfigurability for each radio element in each candidate site must be analysed and modelled with the comparison to the dimensioning of the traffic. For instance, a certain soft value of the absorbed traffic intensity can be modelled within the integer programming model which is set as the objective functions for the task of planning.

This problem will be solved through the appropriate optimization functionality that is already at its first level of design. This refers mainly to the respective mid-term algorithms, necessary for dynamic network planning issues. Simulations for dynamic networks taking into account multi-standard radio network elements must be performed and the requisite recommendations for network planning must be deduced. Automatic network planning is another use-case for reconfigurable, multi-standard network elements, i.e. autonomous selection of carrier frequencies, etc.

### 8.2.3 High level JRRM problem description

This problem has also a specific set of inputs and certain objectives (outputs).
The input is composed of:

(i) Services, target Qos levels, demand pattern, etc.
(ii) Snapshots of the radio network layout and status in terms of the coupling structure and supporting RATs
(iii) The additional capabilities that can be used in the network, (alternate RATs that can be activated in element sites, resources that can be assigned to a RAT, other spectrum issues, etc)
(iv) Profile of the terminal with indicating the capability of processing simultaneous calls
(v) The cost associated with each management decision. This means that RAT alterations may lead to performance improvements but may also be associated with significant overhead (signaling cost for downloads). These cost factors should be considered for making the application in an end-to-end reconfigurability context feasible. Moreover, stability and reliability issues should be integrated, for making the automated reengineering of networks viable.

The objective of the problem is to implement advanced radio resource management in heterogeneous wireless-access environments. The optimisation functionality that will be developed will provide as an output the target QoS levels per service/RAN and the demand splitting per RAT.

### 8.3 Expected results / Conclusions

The results after the completion of our work should include the following:
(1) Feasibility and gain analysis of Dynamic Network Planning.
(2) Proposal of network deployment in typical environment with service requirement and user behaviour.
(3) Proposal of network reconfiguration approaches supporting dynamic air interface triggering and traffic splitting policy
(4) Mechanisms of jointly designed radio parameter tuning (JRRM) and the network planning.

In conclusion, dynamic network planning and resource management problems can be tackled in a way, so that network deployment can become cost-effective and offer innovative services while reducing difficulties that exist in today's telecommunication systems. At a next level, the problems described here will be mathematically formulated and some first indicative results will be presented to prove the effectiveness of our work.