Applied Mathematics & Information Sciences
An International Journal

Channel Access Controlling in Wireless Sensor Network using Smart Grid System

Ruo Hu
Guangdong Polytechnic Normal University, Guangzhou, 510665 P. R. China
E-mail: hu68@163.com

Received: 19 jan. 2012; Revised 22 Apr. 2012; Accepted 08 Jul. 2012

Abstract: In this paper, a new approach using self-organizing Smart Grid systems is proposed to solve wireless sensor network dynamic channel-assignment. It concerns distribution among Grids whose task is to assign personal station to frequencies with respect to well known constraints. Grids only know their variables and the constraints affecting them, and have to negotiate to find a collective solution. The approach is based on a macro-level management taking the form of a hierarchical group of Grids in the network and handling all RACNs (Regional Radio Access Control Network) in a localized region regardless of the operating band. The approach defines cooperative self-organization as the process leading the collective to the solution: Grids can change the organization by their own decision to improve the state of the system. Our approach has been tested on Shanghai benchmarks of Channel Access Problem. The results obtained are equivalent to those of current existing methods with the benefits that our approach shows more efficiency in terms of flexibility and autonomy.

Keywords: Wireless Sensor Network, Access Control, Optimization Problem..

1 Introduction

A Wireless Sensor Network (WSN) is a sensor Wireless Network including semantics of sensor data and context information, and relationships between the semantics by using Semantic Web technologies. Most of Wireless Sensor Network (WSN) has been developed based on related Semantic Web model and the related Semantic Web model provides a secure and powerful support.

With growth in the demand of Wireless Sensor Network (WSN), the efficient use of available spectrum is becoming increasingly important. The studies of a Channel Access problem (also called a channel assignment problem) in cellular mobile systems are so abundant [1-5]. Various Web service techniques, including constraint satisfaction, simulated annealing, neural networks, taboo search, and genetic algorithms, have been applied to this problem.

An overview of the Channel Access problem is as follows: For an existing set of, geographically divided, regions (called cells—typically hexagonal), frequencies (channels) must be assigned to each cell according to the number of call requests. Three types of electro-magnetic separation constraints exist.

Co-channel constraint: the same frequency cannot be assigned to pairs of the cells that are geographically close to each other. Adjacent channel constraint: similar frequencies cannot be simultaneously assigned to adjacent cells. Co-site constraint: any pair of frequencies assigned to the same cell must have a certain separation.

The goal is to find a Channel Access that satisfies the above constraints using a minimum number of frequencies (more precisely, using the minimum span of the frequencies). It must be noted that there exist several variations of Channel Access problems. The benchmark problems provided by the EUCLID-project Combinatorial Algorithms for Network Military Applications (CANMA) project are well-known in the constraint satisfaction/ optimization research community. This type of problem arises from a military application, and geographical information including cells is not described in the problem specification. Constraint satisfaction/optimization techniques can solve this type of problem quite efficiently.

The objectives of this paper are twofold. First, present and formulate the problem of Channel Access. Second, establish a perspective of resolution based on the application of Hierarchical Smart Grids System (HSGS) for an intelligent resources management that allows inserting dynamically the new links in the basin of the network.

Unlike centralized conventional methods our approach provides a wireless sensor network management framework, which deals with intelligent behavior which is the product of cooperative activity of several Grids to fill the limits of classical Web service for solving this complex problem. Through a passage of individual behavior to collective behavior characterized by a wireless sensor network control of wireless sensor network among entities (Grids) governed by simple rules. Instead of representing each call as a variable, we represent a cell as a variable that has a very large domain. Furthermore, we determine the variable value step by step instead of determining a variable value at one time. To each cell is associated a cooperative Grid that handles the assignment of a frequency. Within a Radio Area Network-RACN (Radio Access Control Network) and at each step, a Grid is elected by all its neighbors. The election is based on empirical rules for calculating the degree of separation of a Grid, the degree of saturation and the improvement claimed by the neighbors for an assignment. The elected Grid assigns the smallest frequency in the spectrum that meets all its constraints. In the case of a non permitted assignment, the Grid may be served by a neighboring RACN, through a mechanism of cooperation between supervisor Grids of both RACNs. If no proposal has been received, the supervisor Grid can make a Taboo Search for an improvement in the overall assignment in the associated RACN.

The rest of this paper is organized as follows. In Section II, we review the research contributions in the area Channel Access. In Section III, we formulate the Channel Access problem. In Section IV, we describe our resolution approach to this problem that utilizes hierarchical Smart Grid system. Section V is reserved to show experimental evaluations using standard benchmark. Finally, Section VI concludes our work with a comparison to other current research and a projection for future issues.

2 Related Work

The current challenges in radio networks are: to ensure an efficient and full use of radio frequency resources and multimedia applications, Connect at best anywhere, anytime and with any network. Customize the more powerful features stimulated by the increasing consumers' demand. Find solutions for the mobile business. And tend toward several access technologies whose assignment is local and continuously and independently updated, rendering impossible any overall control. This lead to a very interesting and pertinent issue for radio spectrum is dynamic spectrum assignment problem.

This problem is one of the most studied problems in the literature, particularly multiple variants algorithms are proposed for solving this problem [1,5].

The problem starts from some networks initial connections (namely robust) to develop progressively the subsequent connections according to the operational change of communication needs and taking into account the constraints of disturbances with all initial connections.

Constraint satisfaction techniques are a board family of greedy algorithm that guarantees an exhaustive search in the search space of a complete solution. But in some cases it can be impossible or impractical to solve these problems completely and the time and effort required to the search may be prohibitive, and the most straightforward way for solving such problems using constraint satisfaction techniques would be to represent each call as a variable (belonging to the domain of available frequencies), then to solve the problem as a generalized graph coloring problem [3]. However, solving real-life, large scale problems' using this simple formulation seems rather difficult without avoiding the symmetries between calls within one cell [2].

Unlike greedy methods, meta-heuristics seek to find an optimal solution with a good compromise in a reasonable time. These techniques are nowadays widely used; such as the following techniques that have become popular: Simulated Annealing (SA), Taboo Search (TS), and Genetic Algorithms (GAs).

The taboo search technique is based on the intelligent search and embraces more efficient and systematic forms of direction of search.

The Simulated Annealing technique (SA) is a stochastic computational technique used for solving big optimization problem such as Channel Access problem, by determining the global minimum value of an objective function with various degrees of freedom subject to the problem in a reasonable amount of time. This technique is more efficient than the Taboo search technique; its advantages are its generality and its capability to move to states of higher energy. On the other hand the Taboo Search (TS) presented her does not support this feature. This is why TS cannot run away from likely local minima and normally results inferior configurations [4].

Another way of the problem resolution consists of representing a cell as a variable that has a wide area of values, and tries to determine the value of this variable step by step instead of determining a value for this variable at one time.

Recently, neural networks have been considered one of these ways for the channel assignment problems. The advantages of the algorithm are its inherent parallelism, its property to detect areas of different problem difficulty without heuristics, and the possibility of extending the algorithm to 'soft' interference criteria. One major disadvantage of a neural network is that it gives the local optimal value rather than the global optimal value. And the solution varies depending on the initial values. [5]

Genetic Algorithms (GA) have an advantage over Neural Networks or Simulated Annealing in that genetic algorithms are generally good in finding very quickly an acceptably good global optimal solution to a problem [1]; even if, genetic algorithms do not guarantee to find the global optimum solution to the problem. In this algorithm, the cell frequency is not fixed before the assignment procedures as in the previously reported channel assignment algorithm using neural networks. But the Genetic algorithms are expensive in computing time, as they handle multiple solutions simultaneously.

3 Channel Access Problem Formulation

A Channel Access problem can be formalized as follows:

Let $T = \{t_1, t_2, \cdots, t_n\}$ be a set of n transceivers (TRXs), and let $F_i = \{f_{i1}, f_{i2}, \cdots, f_{ik}\} \subset N$ be the set of valid frequencies that can be assigned to a transceiver $t_i \in T, i = 1, \cdots, n$ (the cardinality of Fi could be different to each TRX). Furthermore, let $S = \{S_1, S_2, \cdots, S_m\}$ be a set of given sectors (or cells) of cardinality m. Each transceiver $t_i \in T$ is installed in exactly one of the m sectors and is denoted as $S(t_i) \in S$.

The set of constraints is represented by a m*m matrix called matrix of compatibility: $M = \{(\mu_i, \sigma_i)\}_{m*m}$ .The two elements μ_{ij} and σ_{ij} of a matrix entry $M(i, j) = (\mu_{ij}, \sigma_{ij})$ are numerical values greater than or equal to zero and they represent the mean and standard deviation respectively, of a Gaussian probability distribution used to quantify the interferences ratio (C/I) when sector i and j operate on a same frequency. Therefore, the higher the mean value is, the lower interferences are, and thus it will have a superior communication quality.

A solution to the problem lies in assigning to all the TRXs (ti) a valid frequency from its domain (Fi), in order to minimize the following cost function:

$$C(p) \sum_{t \in T} \sum_{u \in T, u \notin t} C_{sig}(p, t, u) \qquad (1)$$

Where the Csig will compute the co-channel interferences (Cco) and the adjacent-channel interferences (Cadj) for all sector t and u, in which the transceivers t and u are installed, that is, s(t) and s(u), respectively.

The $p \in F_1 \times F_2 \times \cdots \times F_n$ denotes a solution (or frequency plan), where $p(t_i) \in F_i$ is the frequency assigned to the transceiver ti. Moreover, $\mu_{s_t s_u}$ and $\sigma_{s_t s_u}$ are the interference matrix values at the entry M(st, su) for the sectors st and su. In order to obtain the Csig cost from Equation (1), the following conditions are considered:

$$\begin{cases} K & \text{if} \quad S_t = S_u, |p(t) - p(u)| < 2 \\ C_{co}(\mu_{S_t,S_u}, \sigma_{S_t,S_u}) & \text{if} \quad S_t \neq S_u, \mu_{S_t,S_u} > 0, |p(t) - p(u)| = 0 \\ C_{adj}(\mu_{S_t,S_u}, \sigma_{S_t,S_u}) & \text{if} \quad S_t \neq S_u, \mu_{S_t,S_u} > 0, |p(t) - p(u)| = 2 \\ 0 & \text{otherwise} \end{cases} \qquad (2)$$

where K, being a very large value, is defined in the configuration file of the network. The K value makes it undesirable to allocate the same or adjacent frequencies to TRXs that are installed in the same sector. In our approach to solve this problem, this restriction was incorporated in the creation of the new solution (frequency plan) produced by the algorithm. Therefore, we assure that the solution does not have this severe penalty, which causes the most undesirable interferences as shown in [1] and [3].

4 Resolution Approach and Development

The approach comes in the form of a group of Grids in the network where each regional network is overseen by a supervisor Grid. That it combines a Grid to each cell called a station Grid.

4.1 Station Grid

A Grid can be defined as a computer system located in an environment and which can act autonomously and flexibly to achieve the objectives for which it was designed.

To each link li is associated a Grid Ai responsible of assigning a value fi in its domain Di.

Two data are sufficient to characterize the Grid outside its environment:

First, the frequency value of the corresponding link: The Grid chooses among the values in the frequency domain corresponding to this link: for each Ai in A, the

$f_i \in D_i$, where Di is the frequency domain of li.

Second, the difficulty of a Grid defined as a quantitative measure that reflects the current status of this Grid. It is the decision criterion used to choose a Grid. It is represented in the form of two essential and sufficient entities that are the degree of separation and the degree of saturation, and it is the criterion used to select the elected Grid.

These two entities are intuitively and experimentally determined.

For any Grid $A_i \in A$, we note $D(A_i)$ the degree of separation of the corresponding link li as the sum of the incident constraints values to stations.

For each Ai in A, $D(A_i) = \left\{ \sum_{i=j} C_{ij} \quad where \quad C_{ij} \in C \right\}$,

The degree of saturation at step p is determined from the banned intervals for those links that are not yet assigned. It can be deduced by the number of unsatisfied constraints.

For $A_i \in A$, NIS(Ai) is the number of unsatisfied constraints with its value fi:

$$NIS(A_i) = \left\{ \sum_{i \neq j} C_{ij},\ for \quad each \quad A_j \quad such \quad as \quad f_i \neq 0 \quad and \quad C_{ij} \neq 0 \right\}$$

At step p and for each Ai in A, D_SATp(Ai) = NIS(Ai)

The Grid who has the greatest degree of saturation will be considered as the most on difficulty.

Each Grid operates in a physical environment; it is its frequency domain. Even though these domains may be identical between several Grids, these domains are not shared.

Similarly a Grid has an unshared copy of constraints that allows it to be independent of other Grids.

The social Environment consists of all neighbors of an Grid from which it has only a partial view. It knows about its neighbors only their values and their difficulties. It has no idea about its neighbors' constraints, views, and domains. The communication is performed by sending messages and a mailbox is associated with each Grid that stores the received messages from other Grids.

The neighborhood of a Grid Ai is defined by all Grids connected by a constraint to this Grid.

For each Ai in A, $V(A_i) = \{A_j \in A / C_{ij} \neq 0, C_{ij} \in C\}$ .Any change of view leads to an immediate update of the state of constraints. The Grid will be in a consistent state at any time.

Behavior:

The behavior of a Grid takes place in three phases:

One the one time and through the communication mechanism between the Grid and its neighbors that is supposedly in place and robust, conducted by messages, where each message reaches in a finite time. And that each Grid always handles the messages it receives, the Grid manages to know the degree of saturation and values of Grids in its neighborhood. Then decide if it moves or not. At the end of a movement, the corresponding environment is maintained.

The Grid is autonomous, homogeneous in its behavior than its performance with those neighbors.

Consistency between the view of the Grid and its local constraints is permanent. Any change of view leads to an immediate update of the state of constraints.

Thus a Grid will be able to calculate the degree of saturation as soon as he knows the value of the Grids in its neighborhood. These conditions are not blocking the measure in which Grids communicate their information once they have them.

Note here that, through cooperation, the random does not play a role as might be the case for other methods. This is not to randomly select an Grid to explore more options. But rather to select a Grid from among those Grids considered equals which all lead to a good solution. So the Grid with the greatest difficulty will try to improve its situation since he was elected. This phase marks one of the aspects of cooperation: Grids let act the Grid the greatest difficulty if it isn't the elected.

The next phase is only possible for a Grid elected at the previous phase. The elected Grid will select and assign a value that considers the best for him and his neighbors from his private domain of values. And one that minimizes the sum of local cost constraints, based on its current information.

At the end of this phase, the Grid deactivates: he reported to his neighborhood and his supervisor that he will not participate in the next election as one of its neighbors have not been elected. This egalitarian policy for the election allows any neighbor with the less difficulty to have the opportunity to be elected. While it is disabled, if one of its neighbors is elected, the Grid is still invited to the assignment session: such deactivation is a result of the last phase.

Once booted, the Grids will carry out the cycle (election, decision and assignment) but they can not finish themselves. It is the supervisor Grid who will take over this task when the execution time limit is reached or a termination criterion is achieved: an overall objective corresponding to the results already known for this problem.

The behavior of an Grid can be presented as follows:

Step 1:

//determine all of these neighbors

Determine $V(A_i)$;

$V(A_i) = \{A_j \in A\ (j \neq i) / C_{ij} \neq 0\}$

//calculate its degree of separation for an Grid Calculate $D(A_i)$;

For all $A_j \in V(A_i)$ $(j \neq i)$

A_i *sends* $D(A_i)$ *to* A_j;

Ai Receives $D(A_j)$;

End For

//if the Grid A_i *is the largest* $D(A_i)$ *then it is the elected*

If $\{ \forall A_j \in V(A_i), D(A_i) > D(A_j) \}$

Then A_i *is elected;*

A_i: $f_i \leftarrow f$ *such as*

$f = \min \{f_i, \forall f_i \in D_i / \forall A_j \in V(A_i)$ *such as*

$f_j \neq 0$ *and* $|f_i - f_j| > C_{ij}$ $(C_{ij}$ *is true*$)\}$;

//affects the frequency f, Di the A_i *frequency Domain*

A_i *sends* f_i *to all* $A_j \in V(A_i)$;

A_i *deactivates;*

go to step 3;

Else

Receives f_j

//receives the frequency of the elected Grid

go to step 2;

End If

Step 2:

Calculate $D\_SATp(A_i)$

//the degree of saturation on step p

For all $A_j \in V(A_i)$ *such as* $f_i = 0$ $(j \neq i)$*:do*

A_i *sends* $D\_SATp(A_i)$ *to* A_j;

A_i *receives* $D\_SATp(A_j)$;

End For

If $\{ \exists A_j \in V(A_i) / D\_SATp(A_j) > D\_SATp(A_i) \}$

Then Go to Step 2;

Else If $\{ \exists A_j \in V(A_i) / D\_SATp(A_j) = D\_SATp(A_i) \}$

If $\{D(A_i) > D(A_j)\}$ *then* A_i *is elected ;*

A_i: $f_i \leftarrow f$ *such as*

$f = \min \{f_i , \square \forall f_i \in D_i / \forall A_j \in V(A_i)$ *such as* $f_j \neq 0$ *and* $|f_i - f_j| > C_{ij}$ $(C_{ij}$ *is true*$)\}$;

//affects the frequency f_i, D_i *the* A_i *frequency Domain*

A_i *sends* f_i *to all* $A_j \in V(A_i)$;

A_i *deactivates;*

go to step 3;

Else

Go to Step 2;

End If

End If

Else

A_j is elected;

A_i: $f_i \leftarrow f$ such as

$f = \min \{f_i, \square\ \forall f_i \in D_i / \square\ \forall A_j \in V(A_i)$ such as

$f_j \neq 0$ and $|f_i - f_j| > C_{ij}$ (C_{ij} is true)};

//affects the frequency f, D_i the A_i frequency Domain

A_i sends f_i to all $A_j \in V(A_i)$;

A_i deactivates;

go to step 3;

End If

Step 3:

//Elimination of the Grid

Exit;

4.2 Supervisor Grid

The supervisor Grid is first in charge of the cooperation between other neighbors RACNs supervisor Grids. Second, the supervisor Grid oversees the management of assignments by:

Initializing Grids associated to stations: called station Grids.

Sending all RACN data associated to station Grids: associated Frequency Domain, re-use matrix, stations rentals.

Holding and collecting responses (until triggering a timeout). In case of a non permitted assignment within its RACN, the Grid may resort to another supervisor Grid.

The supervisor Grid can communicate with other resources outside of its frequency domain through a cooperation procedure similar to all supervisor Grids of various RACNs.

In the case of a blockage, a Taboo search is performed on the overall allocation to achieve an optimal allocation of all stations of the associated RACN.

This part will be considered in details in our forthcoming publications.

5 Results

We have tested our approach of Hierarchical Smart Grids System (HSGS) simulated at a RACN level for the Channel Access problem (FAP), such

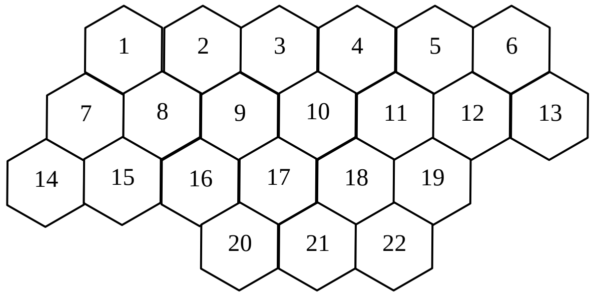

Figure 1. geometry of Shanghai.

as it is modeled on the web page of the site of the Research Institute of Tongji University dedicated to an area on Shanghai. (http://fap.zib.de/ problems/ Shanghai/), which have been used widely in previous researches.

These problems are formulated based on an area in Shanghai. The network consists of 21 cells as shown in Figure 1.

Our experiments were conducted on an Intel Pentium Inside (with 4 GB of RAM). There are many variations for setting constraints and demands and several competing teams of researchers have worked on the same instances of problem. We present in Table 1 the parameter setting used in some approaches and adopted by ours evaluations.

Table 1. Specify for Shanghai problems.

Instance	N_c	acc	C_{ii}	Demand Vector
P1	12	2	5	Case
P2	7	2	5	Case
P3	12	2	7	Case
P4	7	2	7	Case
P5	12	2	5	Case
P6	7	2	5	Case
P7	12	2	7	Case
P8	7	2	7	Case
P9	12	2	5	Case
P10	12	2	5	Case

In this table, “Nc” means the square of required distance for co-channel constraints, assuming that the distance between adjacent cells is 1. For example, if Nc = 12, while cell 1 and cell 5 can use the same frequency (the distance is 4), cell 1 and cell 4 cannot (the distance is 3). “acc” represents the separation required for adjacent channel constraints, and “Cii” represents co-site constraints. The demand vectors used in the table are as follows (case 3 and case 4 are obtained by multiplying 2 and 4 to case 1, respectively):

Case 1: (8 24 8 9 8 16 19 51 78 27 13 15 32 15 35 58 27 8 10 12 8)

Case 2: (5 6 5 9 11 24 31 26 32 41 41 44 20 32 26 16 15 31 20 21 26)

Table 2. Comparaison of solution quality.

Insta-nce	Lower bounds	CS	NN	SE	HSGS
P1	426	426	426	461	425
P2	426	426	426	446	426
P3	532	532	535	535	532
P4	532	532	532	5323	532
P5	257	257	284	284	257
P6	252	252	271	271	252
P7	308	308	311	311	310
P8	308	308	311	311	308
P9	855	855	…	…	855
P10	1713	1713	…	…	1713

Case 3: (14 51 17 16 15 31 35 103 153 57 25 31 61 29 71 112 57 17 20 25 17)

Case 4: (31 101 32 31 31 61 71 207 306 111 51 61 123 61 143 227 111 32 42 51 31).

Table 2 shows the results obtained with our approach. We consider the theoretical lower-bounds as it represented in [1,5], and we use the best solution obtained so far. Ours results are compared with results of the best tree methods, from seven reported methods. The tree methods are: First, a Constraint Satisfaction (CS) method and second a Neural Network (NN).the third a Simulated Annealing (SA). The last row in the table shows our results.

Table 4. Comparaison of solution quality

Instance	CS	NN	SE	HSGS
K1	169	169	179	165
K2	421	434	474	409
K3	618	632	674	595

To the extent of the authors' knowledge, the best published results for these problems have been obtained by FASoft. FASoft is an integrated package of various methods for solving Channel Access Control problems, such as heuristic sequential methods, methods using constraint satisfaction techniques, Simulated Annealing, GA, Tabu search, etc. We show the results obtained with Simulated Annealing (SA) and Tabu search (TS). These two methods are the most efficient among the various components of FASoft. Furthermore, we show the best results obtained with a set of heuristic Sequential methods (SE), and the results obtained with Neural Networks (NN), and the results obtained with a constraint satisfaction method (CS) ("..." in the table means that the result is not reported).

As shown in the Table 2, our algorithm obtains optimal solutions for all instances. Moreover, this method can obtain better or equivalent solutions compared with existing methods for all problem instance, To examine the efficiency of the proposed algorithm in larger-scale problems, we show the evaluation results for the benchmark problems. There are 7*7 symmetrically placed cells (49 cells in all) in these problems. Problem parameters are described in Table 3, where "Cij" is the minimal frequency separation between any pair of cells whose distance is less than $\sqrt{N_c}$, except for adjacent cells. The demand vector is:

(18 13 12 14 12 21 24 26 17 20 22 17 10 19 26 22 28 10 16 17 21 15 18 14 21 28 29 24 31 14 19 27 26 13 10 26 29 11 17 23 25 20 26 12 23 26 28 19 15). This vector is randomly generated from a uniform distribution between 10 and 30. There are 976 calls in total. Table 4 shows the results obtained with our new method (hybrid Taboo search). For comparison, we show the results that obtained using neural networks (NN), and the best results obtained with a constraint satisfaction method (CS).

Table 3 Specification for basic problems.

Instance	N_c	C_{ij}	acc	C_{ii}
K1	6	1	1	4
K2	6	2	3	6
K3	6	3	4	8

Since the optimality of the obtained solution is guaranteed, and the execution time for these instances is very short, our approach obtains much better solutions than those of NN and CS for all instances and a very high quality solutions are obtained within a reasonably short running time.

6 Conclusions and Future Issues

In this algorithm, we represent a link as a variable with a very large domain, and determine the variable value dynamically and step by step. Which is handled by a computer system located in the environment and can act autonomously and flexibly to achieve the objectives for which it was designed. Furthermore, we have developed a powerful cell-ordering heuristic and introduced the limited discrepancy search to cope with large-scale problems.

Experimental evaluations using real standard benchmark problems showed that for most of the problem instances, our approach can find better or equivalent solutions compared with existing current optimization methods. These results imply that paradigm of wireless sensor network is capable of solving realistic application problems, if we choose the appropriate problem representation, and provides a conceptual framework for modeling and simulating a complex system.

Furthermore, it is particularly well-suited to this problem and offers distinct advantages compared to existing methods. It incorporates an extra macro-level management and handling all RACNs in a localized region regardless of the operating band, where each regional network is overseen by a supervisor. It shows more efficiency in terms of flexibility and autonomy. It is continuously adaptable for a new insertion if a reallocation of radio frequency resources must be made. Since the system can be added to, modified and reconstructed, without the need for detailed rewriting of the application. This system also tends to be rapidly self-recovering and failure proof, usually due to the heavy redundancy of components and the self managed features. We can say that our approach is justified by: Adapting to reality, cooperation, the integration of expertise incomplete, modularity, effectiveness and reliability. Our future works also include evolutionary Smart Grid algorithms that are stronger, introducing the hybrid genetic algorithms with iterative improvement of search.

Acknowledgements

The work is supported by the National Natural Science Foundation of China (NNSF of China) (10771039) and supported by the Ministry of Science and Technology Innovation Fund Projects (07C26216402072).

References

[1] L. Cherbakov, G. Galambos, R. Harishankar, S. Kalyana, and G. Rackham, *Impact of Service Orientation at the Business Level*, IBM Systems Journal, Vol. 44, No. 4, 2005, pp. 653-668. doi:10.1147/sj.444.0653

[2] L. Zeng, B. Benatallah, A. Ngu, M. Dumas, J. Kalagnanam and H. Chang, *QoS-Aware Middleware for Cloud computing Composition*, IEEE Transactions on Software Analysis, Vol. 30, No. 5, May 2004, pp. 311-327. doi:10.1109/TSE.2004.11

[3] BIGSF, *Government Web Application Integrity*, The Business Internet Group, San Francisco, 2003.

[4] S. Bhiri, O. Perrin and C. Godart, *Ensuring Required Failure Atomicity of Composite Cloud computing*, Proceedings of the International World Wide Web Conference (WWW'05), Chiba, 2005, pp. 138-147.

[5] J. Cardoso, A. Sheth, J. Miller, J. Arnold and K. Kochut, *Quality of Service for Data streams and Web Service Processes*, Web Semantics: Science, Services and Agents on the World Wide Web, Vol. 1, No. 3, April 2004, pp. 281-308. doi:10.1016/j.

Hu Ruo, Man, 1968-11, Associate professor. Major Research Areas are: Information System Security, Concept Network. The main journal published: Computer Science, Computer Application Research, Computer Engineering, Journal of Tsinghua University, Computer Engineering and Applications. Special Issue of Sensor Letters, Applied Mechanics and Materials.