An Application to LTE-Advance Network Design Based on Particle Swarm Optimization Algorithm

Jui-Chuan Cheng, Te-Jen Su, Hao-Wei Hung, Chien-Liang Chiu

***Abstract*—As the rapid developing of mobile communication, the Long Term Evolution Advanced (LTE-Advanced) with high speed transmission is becoming the mainstream of mobile communication system, and the technique of relay plays an important role among all. Relay Node (RN) has advantages including low power, lower cost and system deployment easily which can enhance system capacity, coverage area, and reduce network deployment cost. How to increase the range of coverage effectively but also give consideration to reduce the cost is a great challenge.**

This paper adopts Particle Swarm Optimization with Time Varying Acceleration Coefficients (PSO-TVAC) which has distributed memory and contiguous range searching function, that applies to Evolved NodeB (eNB) and Relay Node to deploy network in particular area for lower cost of network deployment and ensure the area coverage. The simulation results show that the proposed PSO-TVAC compares with Setcover Algorithm and PSO in deployment with eNBs, eNBs and RN case respectively, the deployment cost can be reduced 13%.

***Keywords*—LTE, PSO, Relay**

I. Introduction

In order to offer a good quality of communication services , setting up base stations constantly to increase the user capacity and signal coverage is necessary to the telecom company. The effective data transmission rate decreases progressively while distance increasing between users and base stations; and this causes the low transmitting rate and worse signal quality in the intersection area of base stations. Furthermore, signals in urban area might decline seriously and reducing the coverage, which may affected by the buildings. How to increase the range of coverage effectively but also give consideration to reduce the cost is a great challenge.

According to coverage range, the base station eNB can be classified as Macrocell (1km~25km) and small cell (12m~1km). Small Cell makes up for Macrocell shaded area or enhance the signal and build communications services in low-cost way. Relay Node in LTE-Advanced that derived from a kind of Relay technique [1-4] which compares to the Small Cell that has the advantages of low power, low cost and flexible deployment, can be used to assist the base station to achieve optimal network planning for best quality of telecom service, thereby reducing network costs [5-7].

Hierarchical Cell Structures (HCS) Network is a layered operation architecture, each network flow resource allocation for different areas, whereby the effective use of system resources, and this way to base station with better capacity and choice of services to clients, and to achieve the best quality of service (QoS). There are two major problems under non-uniform flow distribution in urban areas: base stations were built where pre-selected and excessive coverage between base stations (overlap). These problems can be solved in the following way [8]:

- Macro-cell fixed position class to ensure coverage. Without the default Micro-cell fixed candidate regions and grid services area as a configurable Micro-cell candidate for base stations.
- Small-cell Base station configuration plus the distance limitation, reduction of excessive overlap

Instead of using expensive base stations for deployment, this paper refers to the concept of HCS that using the base stations and relay stations with Setcover Algorithm for network deployment. In order to find the most effective deployment of base stations and repeaters in a particular region, PSO-TVAC algorithm is applied to achieve the best possible coverage with improved signal quality and throughput.

II. Method Analysis

A. *Deployment Considerations*

The question of the coverage that how to make use of minimum resource to create the best coverage environment is a quite important topic in the network planning [9]. A simple example as shown in Fig. 3, in a particular area, UE ={1,2,3,4,5}, C ={{1,2,3} ,{1,4} ,{3,4} {4,5} }, where UE is a user end and C is the range that eNB/RN covers. In order to achieve best coverage rate and the most low-cost cost, the best deployment of eNB/RN is built and chosen{{ 1, 2, 3 },{4,5} }.

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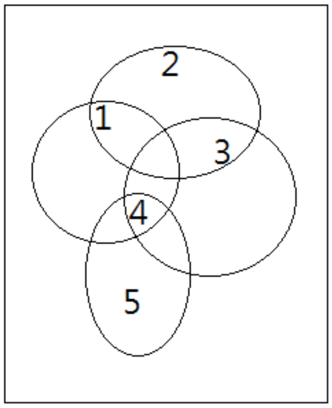


Figure 1. Coverage UE by eNB/RN

B. *Setcover Algorithm*

- Confirm coordinate (xu, yu) of users distribution.
- Analyze the user intensive block, regard square of 10 x 10 as a unit for user's intensity analysis, calculating the number of users within the block, in accordance with the number of users in the block for intensity level, the high intensity area has high priority to build the base station.
- Build base station in the central point of user intensive block, confirm whether the capacity of the users of this base meets the condition (Cu>0)&(Cmax) ,If unsatisfied with the condition, then back to step 2. Where Cu is the number of users covered by the base station, Cmax is the maximum users that can provide for a base station.
- Confirm users number and coordinates that has not been covered, if they meet NUE=0 then end processes, if not, performing calculations NUE and base station distances. Where NUE is the user that has not been covered by a base station.
- Calculate NUE and base station distance: if NUE$\neq$0 , calculate the distance between NUE and the base station (du), if du<(R+r) , build a relay node in distances (R+r) from base station coordinates (xi,yi) to NUE, otherwise, under the condition de ≧ (R1+R2) deployment of base station. Where R is the radius of a base station coverage, r is the radius of a relay node coverage and de is the distances between base stations 1 and base stations 2.

The setcoverage algorithm flow chart is shown in Fig. 2

C. *PSO-TVAC*

Particle swarm optimization is a population based stochastic optimization technique that is inspired by social behavior of bird flocking or fish schooling. It is easily implemented in most programming languages and has proven both very effective and quick for a diverse set of

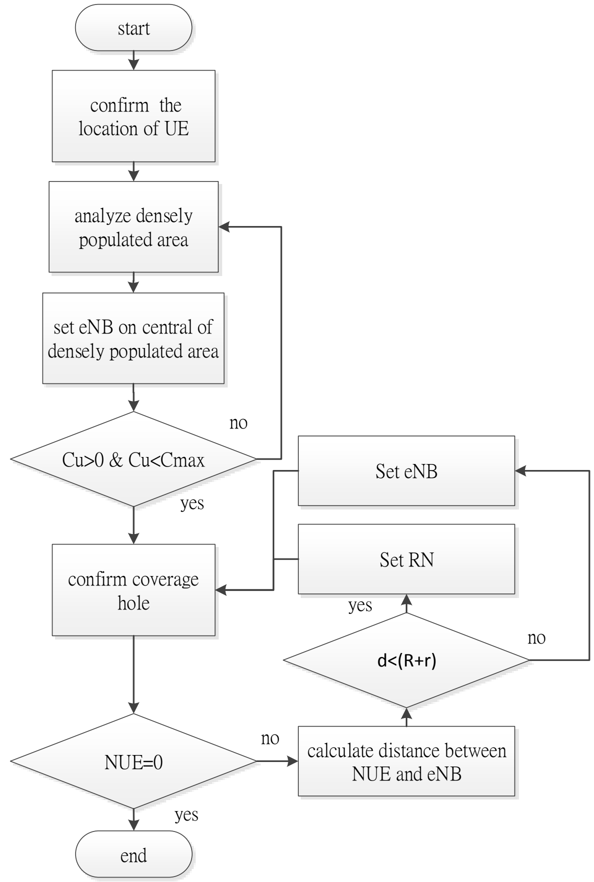


Figure 2. Setcoverage Algorithm Flowchart

optimization problems. Particle Swarm Optimization is modeled as follows [10]:

$$v_{id}(t+1) = wv_{id}(t) + c_1 rand()_1 (p_{id} - x_{id}) + c_2 rand()_2 (p_{gd} - x_{id}) \quad (1)$$

$$x_{id}(t+1) = x_{id}(t) + v_{id}(t+1) \quad (2)$$

where

$v_{id}(t+1)$: velocity of particle *i* at iteration *t*+1

$v_{id}(t)$: velocity of particle *i* at iteration *t*

$x_{id}(t+1)$: position of particle *i* at iteration *t*+1

$x_{id}(t)$: position of particle *i* at iteration *t*

c_1 : cognitive parameter

c_2 : social parameter

$rand()_1$: random number uniform distribution *U(0,1)*

$rand()_2$: random number uniform distribution *U(0,1)*

p_{id} : *pbest* position of particle *i*

p_{gd} : *gbest* position of swarm

w : inertia weight

The PSO-TVAC enhance the global search in the early part of the optimization and to encourage the particles to converge toward the global optimum at the end of the search. With a large cognitive parameter and small social parameter at the beginning, particles are allowed to move around the search space, instead of moving toward the population best. However, a small cognitive parameter and a large social parameter allow the particles to converge to the global optimum in the latter part of the optimization. Under this development, the cognitive parameter c_1 starts with a high value c1max and linearly decreases to c_{1min}. Whereas the social parameter c_2 starts with a low value c_{2min} and linearly increases to c_{2max}. This modification can be mathematically represented as follows:

$$c_1(t) = (c_{1\max} - c_{1\min})(\frac{T_{\max} - t}{T_{\max}}) + c_{1\min} \qquad (3)$$

$$c_2(t) = (c_{2\min} - c_{2\max})(\frac{T_{\max} - t}{T_{\max}}) + c_{2\max} \qquad (4)$$

The PSO algorithm flow chart is shown in Fig. 3

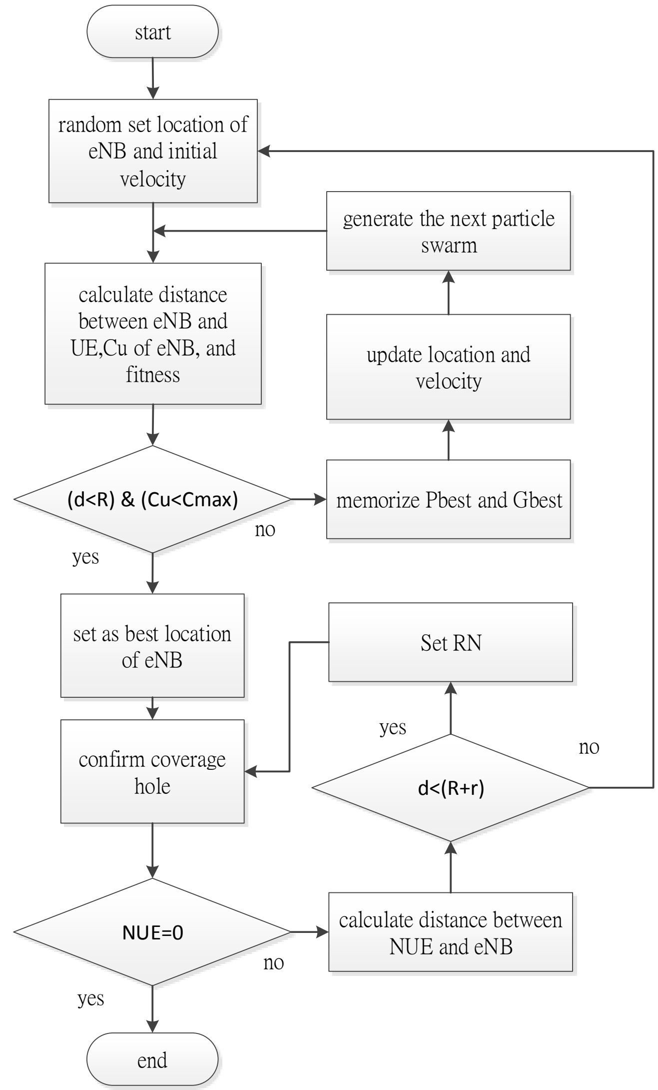


Figure 3. PSO Flowchart

III. Experimental Results

This paper, planning in the length and width of the 100 Km square area within the random set of 200 users, as shown in Fig. 4. In order to meet the four objectives of construction: the network coverage, network capacity, service quality and cost goals, under the limit of above conditions, Setcover Algorithm, PSO and PSO-TVAC is applied in (1) Base station deployment and (2) Base station and relay node deployment situations, respectively. The PSO and PSO-TVAC parameters are shown in Table 1.

The experimental results in Table 2 - 3 and Fig. 5 - 7 indicated that the cost ratio of deployment planning with base stations and relays by the presented PSO-TVAC method is relatively inexpensive among all.

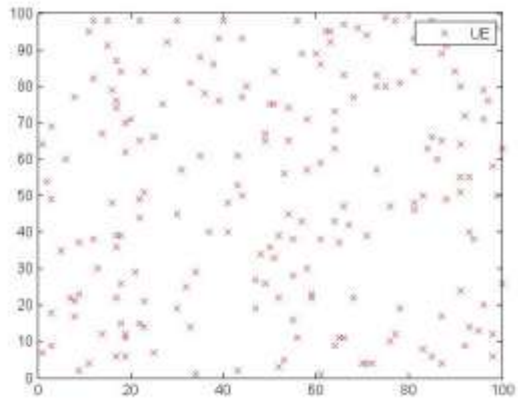
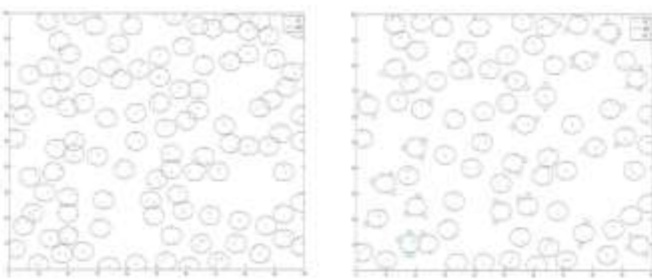
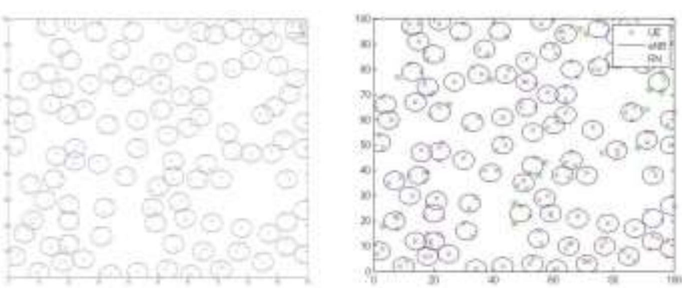


Figure 4. UE Location



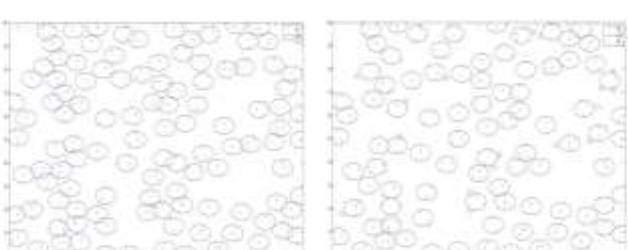
(a) (b)

Figure 5. PSO-TVAC in (a) eNB (b) eNB and RN



(a) (b)

Figure 6. PSO in (a) eNB (b) eNB and RN



(a) (b)

Figure 7. Setcover Algorithm in (a) eNB (b) eNB and RN

TABLE I. PSO AND PSO-TVAC PARAMETERS

Parameter	PSO	PSO-TVAC
Scenarios range	100x100(km)	
UE number	200	
eNB radius range	3.5(km)	
RNradius range	1(km)	
eNB cost	10(unit)	
RN cost	2.5(unit)	
iteration	300	
particle number	100	
w	1	
c1	1.2	
c2	1.2	
eNB Transmit Power	47dBm	
RN Transmit Power	48dBm	
cmax	6 (UE unit)	
c1 initial		2
c1 final		0.5
c2 initial		0.5
c2 final		2

TABLE II. COST COMPARISON IN eNBS

Cost eNBs	PSO-TVAC	P SO	Setcovering Algorithm
eNB number	102	107	112
cost	1020 (unit)	1070 (unit)	1120(unit)

TABLE III. COST COMPARISON IN ENBS AND RN

Cost eNB and RN	PSO-TVAC	PSO	Setcovering Algorithm
eNB number	75	83	90
RN number	52	33	17
cost	880 (unit)	912.5 (unit)	942.5(unit)

IV. Conclusion

In this paper, we have presented an application to LTE-Advance network design based on PSO-TVAC algorithm that combined with LTE-Advanced relay technology to optimize the system deployment, that meet customer service needs, and to achieve the goal of low-cost, flexible deployment. By comparing simulation results, using PSO-TVAC algorithm optimizes base stations and relays for network planning, the deployment costs are relatively lower, and can be reduced 13.7%. The demonstrated examples are compared favorably with other available methods, which illustrate the better performance of the proposed PSO-TVAC methodology.

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