Pinky Devi al. International Journal of Recent Research Aspects ISSN: 2349-7688, Vol. 1, Issue 2, September 2014, pp. 120-123

Comparative analysis of three models to improve channel propagation for indoor mobile network using different constraints

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Abstract— **When the network environment is defined then some physical properties of the network are set like propagation type. The network is described under defined constraints to obtain efficient output from it and all these constraints depend upon network topology, its type and type of communication performed in the network. This paper work is going to focus on the communication analysis for an indoor mobile network and to discuss about the physical network set up criteria in case of local and wide area network deployment requirements. This is an adhoc network which is limited to small area like a room or the building. Constraint programming is the study of system which depends upon various constraints. The solution for a constraint satisfaction problem is the set of variable value assignments which satisfies in CSP (constraint satisfaction programming) all candidates of the set of constraints. In this paper to predict the signal processing in indoor topological environment the application of constraint satisfaction programming is used and distance, density and energy parameters are used to define the constraints. For the optimization of CSP Branch and Bound algorithm is used. In this work noisy channels are also included and then reduction of bit error rate is predicted and improvement in channel propagation is done. The presented work will be performed on Rayleigh propagation model in indoor environment..**

Keywords— **Indoor mobile network, Fading, Constraint satisfaction problem & algorithms, BER**.

I. Introduction

Many research activities are devoted to design of mobile communication systems. The use of radio communication for voice and data allows the change or creation of communication services more easily in buildings [1]. For indoor data and voice communications for example within an office building, a warehouse, a hospital, a factory the use of radio is an attractive proposition. It would free the users from the cords tying them to particular locations inside these buildings and thus offering true mobility which is convenient and sometimes even necessary. It would also minimize wiring in a new building drastically and would provide the flexibility of changing or creating various communication services in existing buildings without the need of expensive and time consuming rewiring. The challenge is to offer such type of services to the majority of people within a building not just a selected few and this would certainly involve a sophisticated local radio communication system whose engineering would require the knowledge of spatial and temporal statistics of the signal attenuation, multipath delay spread and even impulse response of the indoor radio channel involved [2].

Radio wave signal strength attenuation when the propagation distance increasing and apart from the distance fact there are four propagation mechanisms which affect the signal attenuation of radio waves. They are refraction, reflection, diffraction and scattering. In different scenes the main mechanisms which affect radio propagation are different. In case of outdoor environment the main mechanisms are reflection and refraction which affect radio propagation and there are many other random facts like moving people, cars and changing weather which increased the complexity of radio propagation. But in case of indoor environment the spatial structure is more complex as compared to outdoor environment and it makes the phenomenon of multipath and signal delay more obvious. The main factors which affect the indoor radio propagation are walls and indoor obstacles. Studies show that there is no linear relationship between the radio wave attenuation and floors number in multistoried buildings and the reasons are reflection between the buildings and diffraction generated by the windows [3].

II. INDOOR MOBILE NETWORK

The investments are highly related to the spectrum availability and associated authorization options in case of indoor mobile network [4]. A radio reproduction model which is also known as the Radio Wave Propagation Model is a factual mathematical formulation for the characterization of radio wave propagation as a function of frequency, distance and energy etc. To envision the behavior of propagation for all similar links under similar constraints a single model is usually developed and such models predict the path loss along a link or the effective coverage area of a transmitter. The ITU indoor generation model for indoor fading is a radio reproduction model which finds the path loss within a room or a closed area in a building delimited by walls of any kind. Sufficient for appliances designed for indoor use, the total path loss an indoor link may experience can be calculated by this model. This model is applicable only for the indoor environments. It is reported that about 2 to 3% of calls and 90% of data services occur indoor.The

good radio coverage is the basis for the guarantee of the required quality of services, thus it is extremely significant to investigate the radio propagation in indoor environments. In initial stages of cellular networks the indoor radio coverage was usually given by the outdoor signals penetrating from Macrocells or Microcells. With the development of wireless cellular networks the indoor radio coverage is normally provided by the indoor base stations or access points, e.g. pico base stations (PBSs) and femto access points (FAPs). Hence the indoor radio coverage should be reinvestigated from a newer perspective. Due to the complexity of radio propagation environments and various propagation mechanisms, in reality, the instantaneous path loss is combination of the mean path loss, the large scale fading and the small scale fading. Those models which tackle the large scale fading are called large scale fading models and those which tackle small scale fading are called the small scale fading models.
In case of indoor environment the commonly used radio propagation modeling methods can be mainly divided into the following four types:-

1. Empirical models:
Empirical models are commonly extracted from channel measurements conducted at some typical places. They are extracted by fitting the measurement data with some simplified mathematical formulas or distribution functions. Thus, empirical models are normally very easy to implement and have very low computational load. However, because empirical models are extracted from measurements conducted only at some typical places they get some general channel characteristics without taking into account the specific propagation environments. The widely used empirical models for indoor environment are the one-slope model, wall and for factor models, COST231 multi-wall model and linear attenuation model etc.

2. Stochastic models:
Stochastic models are most commonly used to model the random aspects of radio channels with random variables, e.g. fading characteristics of radio channels. Stochastic models require very small information of the propagation environment. For radio propagation channels existing fading types are the large scale fading and the small scale fading. The large scale fading characterizes the signal strength variation over large distances and the small scale fading characterizes the rapid fluctuations of the received signal strength over very short travel distances. The large scale fading and the small scale fading are usually modeled with the use of stochastic models. The large scale fading is also well known as the shadow fading. The most commonly used small scale fading models include the Rayleigh fading model, the Rice fading model etc and the large scale fading models include the Log-normal fading model etc.

Rayleigh fading model

The Rayleigh fading model is widely used for modeling multipath fading when there is no LOS path. When NLOS the received signal amplitude is distributed by using the Rayleigh distribution as given below

$$P_\alpha(\alpha) = \frac{2\alpha}{\Omega}\exp(-\frac{\alpha^2}{\Omega}), \qquad \alpha \geq 0$$

Where $\Omega = \overline{\alpha^2}$ is the average power of the fading [5].

3. Deterministic models:
Deterministic models simulate real physical propagation phenomenon of the radio waves. Deterministic models are based on the Maxwell's equations which describe the behavior of electromagnetic field and take into account the specific propagation environments. Thus they usually contain a high level of accuracy. Deterministic models taken into account the specific propagation environments so they are also called site-specific models. The predicted results given by the deterministic models are deterministic, i.e. the predicted results are always same no matter how many times you rerun it if there is nothing changed in the simulated scenarios. The high accuracy of deterministic models depends strongly upon the accuracy of databases of the simulated scenarios. Ray-optical models and Finite-Difference Time-Domain (FDTD) models are the two commonly used deterministic propagation models.

4. Semi-deterministic models:
Semi-deterministic models are the combinations of both deterministic models and stochastic models or empirical models. Hence semi-deterministic models benefit from both deterministic models and stochastic models or empirical models. Semi-deterministic models usually require less computational time and lower computational load than deterministic models, but possess high level of accuracy than stochastic models or empirical models. The existing semi-deterministic models include the Dominant model, the Motif model and the Geometry-based Stochastic Channel Models (GSCMs) etc.

III. CONSTRAINT SATISFACTION PROBLEM

In last few years, the constraint satisfaction programming (CSP) technique has obtained high attention among experts from many years due to its potential for solving problems. The constraint satisfaction programming approach has been most commonly used in many academics and research parlance to tackle wide range of search problem.CSP problem is known as NP-complete problem. It is difficult to find a polynomial time algorithm until it has proved P=NP, but we have developed some algorithm to accelerate the process to find the solution of CSP.
It is well defined by finite set of variables, a set of domain and constraints. All CSPs are characterized by the inclusion of a finite set of variables, a set of domain values for each variable and a set of constraints which are only satisfied by assigning particular domain values to the problem's variables. The CSP deals with the set of values from its domain to the variable so that no constraint is violated. A CSP problem includes some variables, and valid values for those variables (call them domain of the variables) and conflict tables. We must find out a solution to assign values to all the variables and those values must satisfy the conflict tables. There are currently two branches of constraint programming named constraint satisfaction and constraint

solving. Constraint satisfaction deals with the problem which is defined over finite domain while constraint solving algorithms are based on mathematical techniques. The constraint satisfaction programming offers its basic algorithm like as Backtracking and Branch and Bound algorithm to solve and optimize the problem [6]. Constraints satisfaction algorithm can be viewed as an iterative procedure which repeatedly assigns domain value to the variables.

Benefits of CSP:

- Standard representation pattern
- Generic goal and successor functions
- Generic heuristics (no domain specific expertise).

Applications:

- Cryptography
- Airline schedules
- Computer vision - image interpretation
- Scheduling your MS or PhD thesis exam

IV. DIFFERENT CSP ALGORITHMS

A. Backtracking:

The Backtracking is the basic algorithm for solving CSP. In each step, find a valid value to assign to current variable.

I. If a valid value is found then assign it to current variable and go to next step.

II. If there is no any valid value then back-track to the last variable to assign another value and expect another value of the last variable can lead to success of finding valid value for current variable.

III. A valid value for the current variable is a value that is not conflict with any assigned variable.

For example, in the Chart 1 Variable C cannot find valid value and then backtrack to Variable B to change the value, then again check Variable C. In search space backtracking is a Depth-First Search algorithm. Time complexity: O (bd), when b is average tightness of the constraints which is the branching factor of the searching tree and d is the number of variables, the depth of the searching tree.

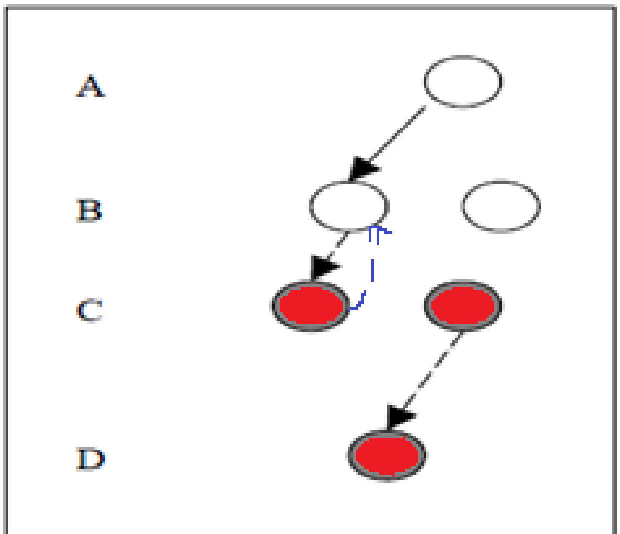

Chart 1: Different

B. Branch & Bound algorithm:

For the optimization constraint satisfaction programming provides an optimization algorithm which is called branch and bound algorithm. Branch and Bound strategy includes two mechanisms first is a mechanism to generate branches when searching the solution space and second is a mechanism to generate a bound so that many branches can be terminated. Branch and Bound algorithm uses breadth-first search with pruning and a queue as an auxiliary data structure. Branch and Bound algorithm starts with considering the root node and then apply a lower-bounding and upper bounding technique to it. A bound is nothing but a global variable which is defined according to the minimization or maximization problem which depends upon the case that either problem needs minimum or maximum value of the function. Once the bound match an optimal solution has been found and the algorithm is finished. If the bound does not match then algorithm runs on the child nodes. In wireless indoor propagation the Branch and Bound algorithm is used to find that particular set of frequency, distance, density and energy at which the propagation loss is minimum. This procedure will carry on until and unless a minimum value is found and reverse of this procedure is used to find the maximum value .A constraint satisfaction problem is defined as tuple (X, D, C, and f) where

- x is a finite set of variables
- d is a finite set of domains, one domain is assigned for each Variable
- C is the finite set of constraints that restrict certain value assignments

Domains of variables are frequency, distance, density and energy [7].

V. CONCLUSION

In this paper a brief survey of basic solving techniques behind constraint programming has been studied out. An overview of main technique of solving the constraint optimization problem i.e. branch and bound algorithm has been used. With the use of constraint satisfaction algorithm there are various wireless indoor propagation models used for channel communication. Besides, many radio propagation simulators provide only the mean power prediction but it has been seen that on system performance fading has also an important impact. So the fading information was extracted based on the Ray-Leigh model and then an accurate prediction of the BER was achieved. The prediction of the BER has been tackled for three parameters which are distance, density, energy. It is known the BER depends not only upon the mean power, but also on the fading severity and on the correlations among diversity branches for diversity systems.

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