International Conference on Computational Science and Information Management (ICoCSIM)
Vol. 1 (2012) 205-213

An Improved of Channel Allocation for WLAN Using Vertex Merge Algorithm

Handrizal[1], Muhammad Zarlis[2] A.Noraziah[3], Ahmed N. Abdalla[4],

[1]AMIK TUNAS BANGSA, Pematangsiantar
[2]Faculty of Computer Science & Information Technology, University North Sumatera
[3]Faculty of Computer Systems & Software Engineering, University Malaysia Pahang
[4]Faculty of Electric and Electronics Engineering, University Malaysia Pahang

Abstract

Graph colouring is a useful algorithm for channel allocation on wireless local area network (WLAN). Through this algorithm, each access point (AP) that adjacent will be given different channels based on colours available. Degree of saturation (Dsatur) is the popular algorithms being used for channel allocation in this domain. However, this algorithm has its weaknesses in terms of minimum number of channel required. In this study, channel allocation called Vertex Merge Algorithm (VMA) is proposed by considering only channel allocation on WLAN. It is based on logical structure of vertex/access point in order to a colouring the graph. Each vertex on the graph will be arranged based on decreasing number of degree. The vertex in the first place on the set will be given a colour, and then these vertices are merged with not adjacent vertex. This process will be continued to repeat until all vertices are given colour. The assignment provides a minimum number of channels required. A series of experiment was carried out by using one computer. Vertex Merge Algorithm (VMA) simulation is developed under Linux platform. It was carried out in PHP programming integrated with GIMP for open and edit image. The experimental results showed that the proposed algorithm work successfully in channel allocation on wireless local area network (WLAN) when no failures occurred.

Keywords: Graph Colouring, Vertex Merge, Spread Spectrum, WLAN, Channel Allocation.

1. Introduction

The spectacular development of network and internet has a big impact to the companies in various types and sizes. The advanced wireless technologies support the development of network, internet and intranet capability for the mobile workers, isolated area and temporary facilities. Wireless networking expands and increases the capability of computer networking. The new technologies enable the wireless networking as one of access in higher velocity and qualified for the computer network and internet.

Wireless local area networks (WLANs) have gained importance in the recent years as an Internet-access technology. As competition has driven down costs of WLAN equipment, wireless Internet access mechanisms are increasingly available in numerous public hot spots like coffee-shops, airports, and hotels. Today numerous public places such as airports, cafeterias, and even complete city centres are equipped with numerous access points (APs) to offer almost ubiquitous wireless connectivity. At the same time the increased density of WLAN access points has started to highlight the negative effects or shortcomings of the original IEEE 802.11 standards. Most importantly, no standard channel allocation method exists for WLAN access points. This has led to the situation where large majority of APs is using default channel settings, leading to highly inefficient use of the already crowded spectrum in the ISM bands. This situation is especially critical in the 2.4 GHz band, due to the small number of non-overlapping WLAN channels available, and coexistence problems with several other wireless technologies.

ISM bands are unlicensed frequency bands [1]. These bands can be used freely and therefore there is only a slight control over them, so when selecting a channel to build a WLAN we can expect that other devices may be using it. Although different spread spectrum techniques are defined (DSSS or FHSS) in order to minimize the effect of interferences and although the legal limits for low power transmissions are respected, the coexistence of different types of devices in nearby channels can seriously degrade the performance of a WLAN [5].

The problem gets worst in the 2.4GHz ISM band, where according to European regulatory bodies, 13 channels are defined, whose carriers go from 2.412 (channel 1), to 2.472GHz (channel 13), see Fig.1. Consecutive carriers are spaced 5MHz, whereas the spread signal bandwidth is about 24MHz, so we only have as much as three non-overlapping channels (e.g. 1, 6 and 11). It seems clear that in regions with a great density of nodes, three channels shall not be enough.

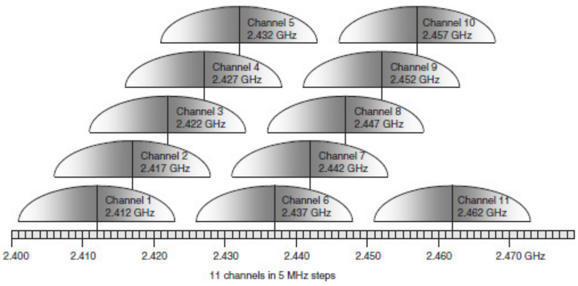


Fig.1. WLAN channel allocation [2]

With the common WLAN technology, only three non-overlapping channels are available, see Fig.2 [2][3], and no standard mechanism exists for the access points to dynamically select the channel to be used as to minimize interference with other APs.

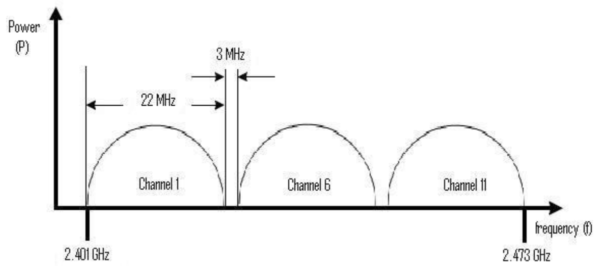


Fig.2. WLAN non-overlapping channels [2]

To use WLAN systems with overlapping channel (e.g., channel 1 and 2) in the same physical space would cause interference between the systems. WLAN systems using overlapping channel should not be co-located because there will almost always be a drastic or complete reduction in throughput. Because the centre frequencies are 5 MHz apart, and the centre frequencies for non-overlapping channels must be at least 25 MHz apart, channel should be co-located only if the channel numbers are at least five apart.

2. Colouring in channel allocation

In this section we shall formulate the channel allocation problem for WLAN in terms of graph-theoretic colouring problem. First we recall shortly the statement of the colouring problem based on graph theory [4] that is of interest in the channel allocation context.

Suppose we are given a simple graph $G = (V,E)$, that is, a graph consisting of a set of vertices V , and set of edges E connecting the vertices so, that loops (edges connecting a vertex to itself) and multiple edges between vertices are not allowed. Then a vertex colouring of G is a map: $V (G) \rightarrow F$, where F is a set of colours, usually some small subset of positive integers. We shall call a colouring admissible, if $C(V_i) = C(V_j)$ for all adjacent $V_i$and V_j(that is, for those vertices connected by an edge). We call an admissible colouring minimizing |C(V)| an optimal colouring. The number of colours used by the optimal colouring is called the chromaticnumber of the graph.

2.1 Interference graphs

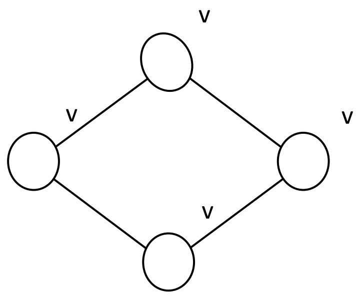
We shall now formulate the channel allocation problem in terms of the terminology introduced in the previous section. Given a collection $\{v_i\}$of access points, we shall form an interference graph $G = (V_G, E_G)$ as follows. The vertex set V is simply identified with the set $\{v_i\}$. The set of edges E is constructed as the union of those pairs $\{v_k, v_l\}$of vertices, that correspond to access points $v_k$and $v_l$that would interfere with each other's radio traffic should they be assigned to use the same channel. Finally, we let *F*, the set of "colours", to be the collection of channels available to the access points. Now the channel allocation problem is simply finding of an admissible colouring of *G* with the colour set *F*. We shall call a colouring admissible, if $C(v_i)=C(v_j)$ for all adjacent $v_i$and v_j(that is, for those vertices connected by an edge). We call an admissible colouring minimizing $\{C(v)\}$an optimal colouring.

Naturally the size of the colour set is greatly technology and legislation dependent. In most European countries, *F*= {1, 2…13} for WLAN technologies, of which the subset *F'*= {1, 6, 11} corresponds to the non-overlapping channels.

2.2 Adjacency Matrix

Suppose G is a graph with m vertices, and suppose the vertices have been ordered, say, $v_i, v_j, \ldots, v_m$. Then the adjacency matrix $A(G) = [a_{ij}]$ of the graph G is the $m \times m$ matrix defined by

$$a_{ij} = \begin{cases} 1, & \text{if } v_i v_j \in E_G \\ 0 & \text{if } v_i v_j \notin E_G \end{cases}$$



	v_1	v_2	v_3	v_4
v_1	0	1	1	0
v_2	1	0	0	1
v_3	1	0	0	1
v_4	0	1	1	0

Fig. 3:Graph G with the matrix adjacent

The adjacency matrix A of a graph G does depend on the ordering of the vertices of G, that is, a different ordering of the vertices yields a different adjacency matrix. However, any two such adjacency matrices are closely related in that one can be obtained from the other by simply interchanging row and columns. On the other hand, the adjacency matrix does not depend on the order in which the edges (pairs of vertices) are input into the computer.

3. Proposed Vertex Merge Algorithm

The problem of approximate vertex coloring is a much studied one and the number of available algorithms is vast. After considerable review effort it is decided to create a new algorithm which it is call the Vertex Merge algorithm (VMA). The algorithm is fundamentally deterministic, as opposed to many randomized algorithms proposed. This is necessary as the access points must naturally agree on the channels allocated. VMA used some heuristic method to select a vertex to be colored, which it then colors using the first color consistent with the coloring problem statement. The heuristic used by the VMA is to find the subset of vertex with highest "degree", that is, the vertex with largest number of differently edge neighbours. If this subset contains only one vertex, it is chosen to be colored. If more than one vertex remains in the set, the selection is then made in the order of decreasing number of uncolored neighbours [6].

3.1 Algorithm

The following is a step by step VMA

- Arrange the vertex by decreasing order of degrees
- Choose the first uncolored vertex from the set
- Color the chosen vertex with the least possible color
- Merge the vertex with the first non-neighbor vertex
- Color the chosen vertex with the same color. If there is no more non-neighbor vertex, return to step 2
- If the entire vertex is colored, stop. Otherwise, return to Step 2

3.2 Example

We demonstrate the steps of the algorithm with a small example. The input graph is shown below in Fig. 4 with $n = 6$ vertices labeled $V = \{1, 2, 3, 4, 5, 6\}$. The algorithm required3 coloring of the vertices using the set of colors $\{1, 2, 3\}$ represented by red, green and blue respectively.

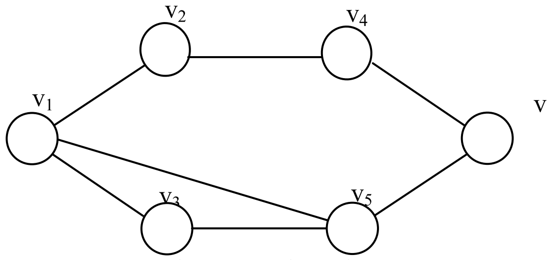


Fig. 4: Example graph

- Arrange the vertex by decreasing order of degrees. Vertex with highest degree is $v_1$and v_5 then v_2, v_3, v_4, v_6 each with 2 degree. Then the sequence is $\{v_1, v_5, v_2, v_3, v_4, v_6\}$
- Choose the first uncolored vertex from the set. This causes vertex v_1 to be colored with color 1 (see Fig.5).

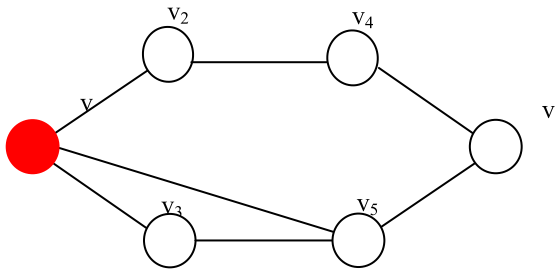


Fig. 5: Example graph with first step VMA

- Merge with the first non-neighbor vertex, in this case the vertex are not neighbor with v_1 are v_4. Thus that the v_1 merger into v_4.Then $v_1$same color with v_4 (see Fig.6)

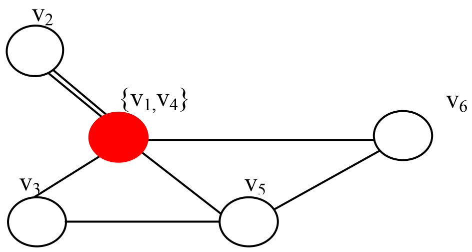


Fig. 6: Example graph with second step VMA

- If there is no more non-neighbor vertex, choose first uncolored vertex from the set:
  - Now sequence uncolored vertex which have the highest degree is $\{v_5, v_2, v_3, v_6\}$
  - Choose the first uncolored vertex from the set. This causes vertex v_5 to be colored with color 2 (see Fig. 7)

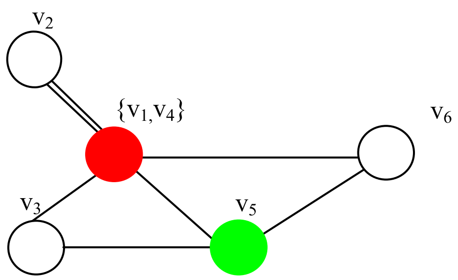


Fig. 7**:** Example graph with third step VMA

  - Merge with the first non-neighbor vertex, in this case the vertex are not neighbor with $v_5$are v_2, so that the v_5 merger into v_2. Then v_2 same color with v_5(see Fig. 8).

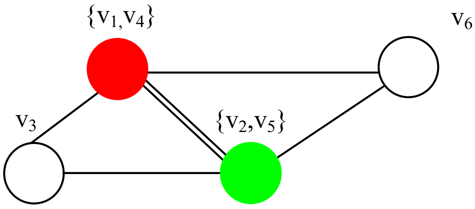


Fig. 8: Example graph with fourth step VMA

- If there is no more non-neighbor vertex, choose first uncolored vertex from the set:
  - Now sequence uncolored vertex which have the highest degree is $\{v_3, v_6\}$
  - Choose the first uncolored vertex from the set. This causes vertex v_3 to be colored with color 3 (see Fig. 9).

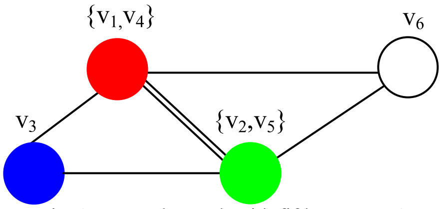


Fig. 9: Example graph with fifth step VMA

  - Merge with the first non-neighbor vertex, in this case the vertex are not neighbor with v_3 are v_6, so that the v_3 merger into v_6. Then v_3 same color with v_6 (see Fig. 10)

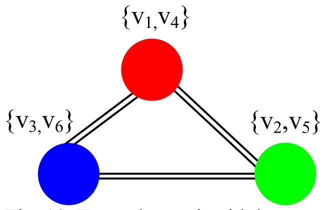


Fig. 10: Example graph with last step VMA

- If all vertex are colored, thus the algorithm terminates and the final coloring is given by $C(v_1,v_4) = 1$, $C(v_2, v_5) = 2$, $C(v_3, v_6) = 3$. Finally, V_G, is colored using the smallest color that is chromatic number is 3.

Of course the number of colors needed to solve the vertex coloring problem for the interference graph is of great interest. This is especially important in the case of WLAN, as the number of colors available is only three, supposing that it is want usage only non-overlapping channels. From the example graph, it is required 3 colors for coloring the graph. It means that required 3 channels for WLAN, which is channel 1, channel 6 and channel 11.

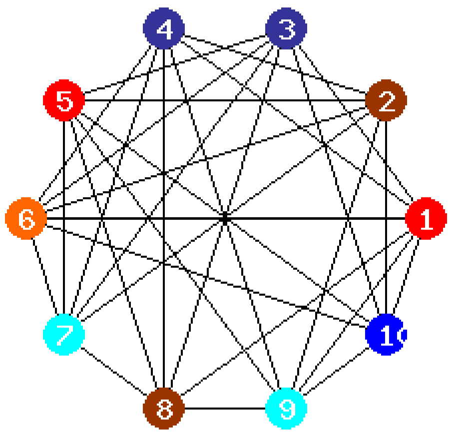
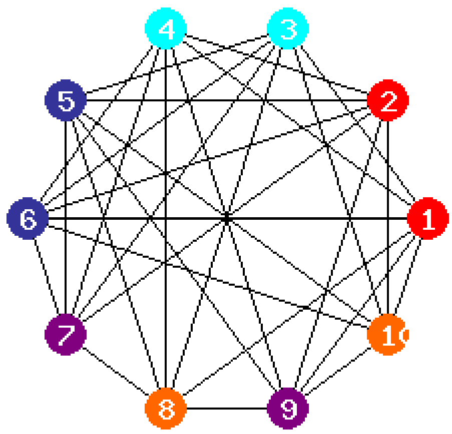
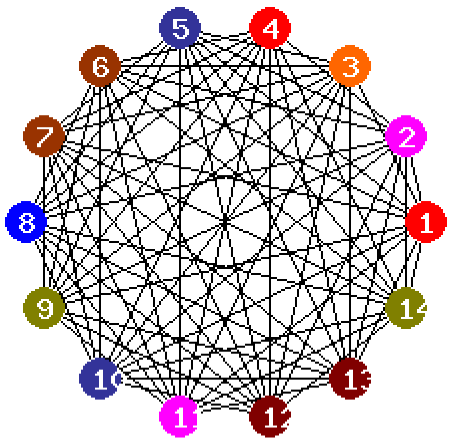
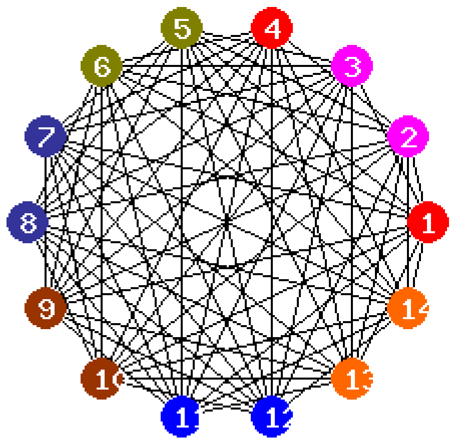
4. Result and Discussion

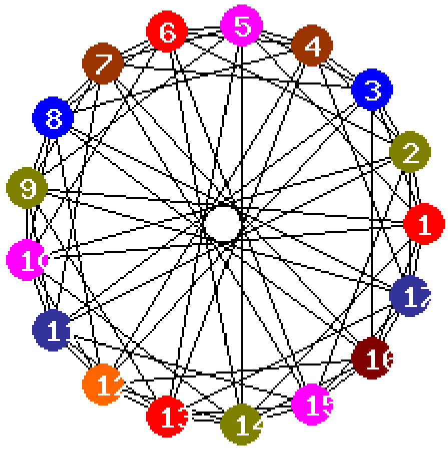
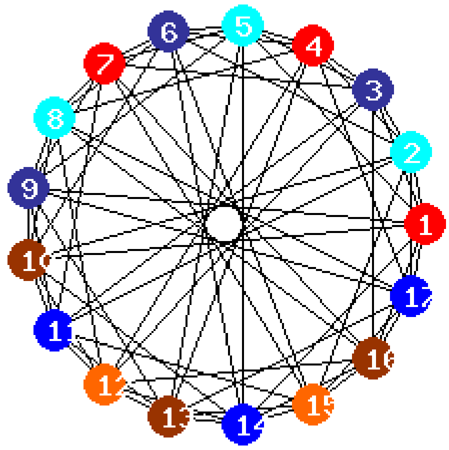
In this section, it is simulation the VMA compare with Dsatur algorithm by input three complex graphs that is graph1 with $n = 10$ vertices labelled $V = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$, graph2 with $n = 14$ vertices labelled $V = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14\}$, and graph3 with $n = 17$ vertices labelled $V = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17\}$. In the each graph, vertex equal the access point (AP).

4.1 Result Simulation

Result simulation input three complex graphs will be shows in Table 1.

Table 1: Input graph for simulation

Input	Output	
	Dsatur	**VMA**
graph1		
Number of Channel	*χ(G) = 6* *C*(1,5)=channel 1, *C*(7,9)=channel 4, *C*(3,4)=channel 7, *C*(2,8)=channel 9, *C*(10)=channel 11, *C*(6)=channel 13.	*χ(G) = 5* *C*(1,2)= channel 1, *C*(3,4)=channel 4. *C*(5,6)=channel 7 *C*(7,9)=channel 10, *C*(8,10)=channel 13.
graph2		
Number of Channel	*χ(G) = 8* C(1,4)=channel 1, C(2,11)=channel 3, C(9,14)=channel 5, C(5,10)=channel 7, C(6,7)=channel 9, C(8)=channel 11, C(12,13)=channel 12, C(3)=channel 13.	*χ(G) = 7* C(1,4)=channel 1, C(2,3)=channel 3. C(5,6)=channel 5 C(7,8)=channel 7, C(9,10)=channel 9 C(11,12)=channel 11, C(13,14)=channel 13.

graph3		
Number of Channel	*χ(G) = 8* C(1,6,13)=channel 1, C(5,10,15)=channel 3, C(2,9,14)=channel 5, C(11,17)=channel 7, C(4,7)=channel 9, C(3,8)=channel 11, C(16)=channel 12, C(12)=channel 13.	*χ(G) = 6* C(1,4,7)=channel 1, C(2,5,8)=channel 4, C(3,6,9)=channel 7 C(10,13,16)=channel 9, C(11,14,17)=channel 11, C(12,15)=channel 13.

4.2 Discussion

From the simulation results of the three graphs in the Table 1can be seen that:

A. For input graph1 can be shows that output the simulation given difference result for all algorithms, which are required 6 colors for Dsatur algorithm and 5 colors for VMA. Its means required 6 channels for Dsatur algorithm and 5 channels for VMA. That is:

1. Dsatur algorithm :
   - channel 1 for AP_1 and AP_5
   - channel 4 for AP_7 and AP_9
   - channel 7 for AP_3 and AP_4
   - channel 9 for AP_2 and AP_8
   - channel 11 for AP_{10}
   - channel 13 for AP_6
2. VMA :
   - channel 1 for AP_1 and AP_2
   - channel 4 for AP_3 and AP_4
   - channel 7 for AP_5 and AP_6
   - channel 10 for AP_7 and AP_9
   - channel 13 for AP_8 and AP_{10}

B. For input graph2 can be shows that output the experiment given difference result for all algorithms, which are required 8 colors for Dsatur algorithm and 7 colors for VMA. Its means required 8 channels for Dsatur algorithm and 7 channels for VMA. That is:

1. Dsatur algorithm :
   - channel 1 for AP_1 and AP_4
   - channel 3 for AP_2 and AP_{11}
   - channel 5 for AP_9 and AP_{14}
   - channel 7 for AP_5 and AP_{10}
   - channel 9 for AP_6 and AP_7
   - channel 11 for AP_8

- channel 12 for AP_{12} and AP_{13}
- channel 13 for AP_3

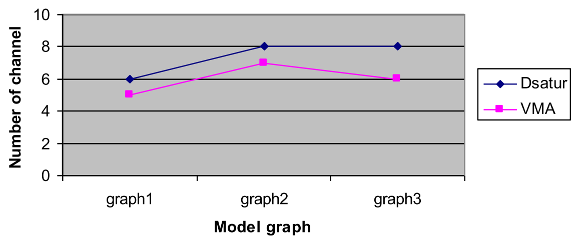
2. VMA :
   - channel 1 for AP_1 and AP_4
   - channel 3 for AP_2 and AP_3
   - channel 5 for AP_5 and AP_6
   - channel 7 for AP_7 and AP_8
   - channel 9 for AP_9 and AP_{10}
   - channel 11 for AP_{11} and AP_{12}
   - channel 13 for AP_{13} and AP_{14}

C. For input graph3 can be shows that output the experiment given difference result for all algorithms, which are required 8 colors for Dsatur algorithm and 6 colors for VMA. Its means required 8 channels for Dsatur algorithm and 6 channels for VMA. That is:

1. Dsatur algorithm :
   - channel 1 for $AP_{1,}$ AP_6 and AP_{13}
   - channel 3 for $AP_{5,}$ AP_{10} and AP_{15}
   - channel 5 for AP_2, AP_9 and AP_{14}
   - channel 7 for AP_{11} and AP_{17}
   - channel 9 for AP_4 and AP_7
   - channel 11 for AP_3 and AP_8
   - channel 12 for AP_{16}
   - channel 13 for AP_{12}
2. VMA :
   - channel 1 for AP_1, AP_4 and AP_7
   - channel 4 for AP_2, AP_5 and AP_8
   - channel 7 for AP_3, AP_6 and AP_9
   - channel 9 for $AP_{10,}$ AP_{13} and AP_{16}
   - channel 11 for $AP_{11,}$ AP_{14} and AP_{17}
   - channel 13 for AP_{12} and AP_{15}

From the discussion can be shows comparison between Dsatur and VMA in graphic on Table 2.

Table 2: Comparison between Dsatur algorithm and VMA



From the table 2 can be shows that number of channel required on VMA less than Dsatur algorithm.

5. Conclusion

In this study, it is introduced a new graph model which it is call the Vertex Merge Algorithm (VMA) for improved channel allocation problems on wireless local area network. The problem of minimizing the number of channels required to eliminate interference is a graph coloring problem. Results from the simulation study reveal that the new graph model can provide reduce the channel required on WLAN. It is forms a good basis for developing efficient graph coloring algorithms, because of its aims to reduce the colorrequired and better result compare with Dsatur algorithm.

References

1. Al Mamun, K.M.A. et.al. 2009. An Efficient Variable Channel Allocation Technique for WLAN IEEE 802.11 Standard, in Proceedings Conference on Circuits, Communication and System, pp.92-95.
2. André, M., G. Pesant and S. Pierre, 2005. A Variable Neighborhood Search Algorithm for Assigning Cells to Switches in Wireless Networks. J. Comput. Sci., 1: 175-181.
3. Diestel, R., 2010. Graph Theory. Springer-Verlag.
4. Duan, Z. et.al. 2010 Optimal Channel Assignment for Wireless Networks Modelled as Hexagonal and Square Grids. International Conference on Networks Security Wireless Communications and Trusted Computing.
5. Handrizal, A.Noraziah and A.N. Abdalla, 2009. Comparison between Direct Sequence Spread Spectrum (DSSS) And Frequency Hopping Spread Spectrum (FHSS). Proceedings of ICSECS'09.
6. Handrizal, A.Noraziah and A.N. Abdalla, 2011. Comparison between Vertex Merge Algorithm and Dsatur Algorithm. Journal of Computer Science, pp 664-670.
7. Juhos and Jano, I. 2006. Increasing the efficiency of graph coloring algorithms with a representation based on vector operations. J. Software, pp: 1.
8. Koster, A.M.C.A. and X. Mu˜noz, 2010. Graphs and Algorithms in Communication Networks, Texts in Theoretical Computer Science. An EATCS Series, Springer-Verlag Berlin Heidelberg, DOI 10.1007/978-3-642-02250-0 1
9. Ming, H. et.al. 2009. Hierarchical genetic algorithm fordynamic channel units allocation in td-cdma/tdd system. International Journal of Wireless & Mobile Networks (IJWMN), Vol 1, No 2. pp.103-116.
10. Mishra, A., 2005. Weighted coloring based channel assignment for WLANs. Mobile Computer Communications Review (MC2R), 9: 3.
11. Riihijarvi, J., 2005. Frequency allocation for WLANs Using Graph Coloring techniques. Proceedings of second annual conference of WONS'05.
12. Riihijarvi, J. et.al. 2006. Performance Evaluation of Automatic Channel Assignment Mechanism for IEEE 802.11 Base on Graph Coloring, in Proceedings The 17th Annual IEEE International Symposium on Personal, Indoor and Mobile Communications, pp.1-5.