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TDMA based Minimized Conflict Resolution Channel Assignment in Wireless Mesh Network

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Abstract-Wireless Mesh Networks (WMNs) are being used in wide areas of applications from last few decades. Channel Assignment (CA) is one of the major issues in these networks which need special attention from the research community. In this paper, we have designed an algorithm for CA to minimize the conflicts in these networks. We have formulated the CA problem by minimizing the conflict during simultaneous transmissions from multiple interfaces. To minimize the conflict over CA, we have used the graph coloring algorithm and tested the performance of the proposed algorithm using NS-2 simulation.

Index Terms- Wireless Mesh Networks ; Graph coloring ; conflict resolution**.**

1. INTRODUCTION

WMNs is very popular as it provides economical and scalable internet connectivity to the entire network [1]. It consists of mesh routers and mesh clients. As described in Fig. 1, each node is not only act as host but also act as a router that forward packets to those nodes that are not directly connected and not within the range of the destinations. Mesh clients are basically mobile phones; laptop, wireless devices etc. and they are mobile in nature. The mesh clients have only one network interface. Mesh routers are stationary in nature. Mesh client connected to the mesh router through the wireless network interface cards (NICs). The clients without NICs can connect through Ethernet so that it provide Line of Sight (LoS), to minimize loss of packets. The main feature of WMNs is self organized and self configure that provide reliability. WMNs uses 802.11 technologies to interconnect all the backbone. It uses spectrum-band so that it is less expensive, but the main issue of 802.11 is of Quality of Service (QoS) as in WMNs there is collision and interference in the links.

1.1 Basic issue of design

A main issue of design is its capacity. Interference is one of the main issues for degradation of capacity. If there is only one interface and the number of channel are more than the interfaces; then there is chance of interference. Whenever there is interference in the packet, then the delivery ratio of the packet will be reduced. QoS can also be provided on the basis of Time Division Multiple Access (TDMA), this guaranteed link bandwidth is allocated with the fixed number of slot over frames. A fixed number of slots is assign to each link and during each slot the number of non-conflicting link send data simultaneously. The particular bandwidth is provided to each slot. The main goal is to find out the minimum slot require to transmit the frame requested end to end rates, if the length of TDMA frame is variable than minimize the number of frame and maximize the concurrent throughput of end-to-end flows and if the length of the frame is fixed minimum length TDMA scheduling maximize the frame available for best effort wireless access, So minimum length TDMA scheduling has minimum utilization [2]. 802.11 is used schedule MAC access to provide QoS. Another solution to resolve interference is using of multiple channels. Interference can be minimized by non-interfering channels for neighboring wireless transmissions. But it requires addressing the overall channel to use for the particular transmission.

CA can be done by two ways: Dynamic CA, in this

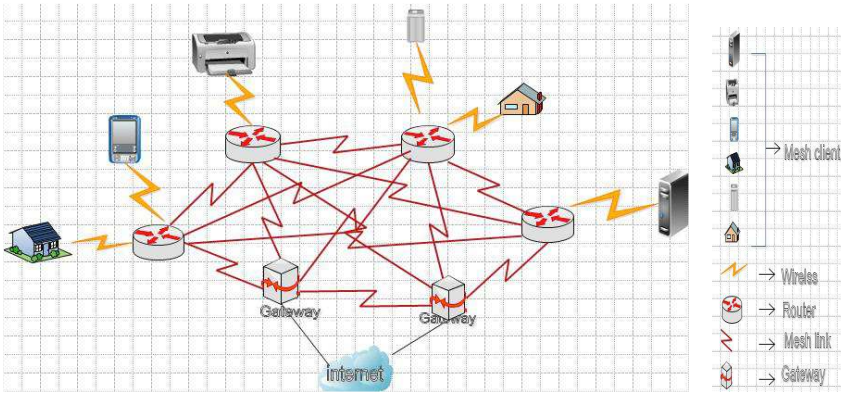

Fig. 1. Architecture of WMNs

approach channel is frequently changes on the interface. This CA requires very fast switching at a very fast scale [3-6]. But these changes are unsuitable to the hardware so delay in packets occur. It might be of milliseconds but it might be higher than the typical packet transmission. Some dynamic CA requires MAC protocol which is also unsuitable for the hardware.

Static CA: Due to difficulty in the dynamic CA, static CA approach is required [7-9]. Whenever there is any change in the network the static CA technique can be changed. These changes are infrequent enough that the CA delay. If there is one radio interface per router than this one radio interface has to assign to all other channel to preserve network connectivity.

For this type of connectivity a separate antenna is require. The main problem of static channel approach is to do communication with single radio to multiple radio nodes. The main objective of this approach is to assign for minimize the overall network interference. This CA is done through the coloring of graph.

The rest of the paper is organized as follow. The related work is discussed in Section II. In Section III we have discussed problem formulation, and Section IV describes the implementation details. Finally, in Section V we conclude the article and provide future directions.

2. REALATED WORK

Djukic et al. [10] 802.11 offers the multi-channels which benefit the single node for the on-demand routing protocol. For avoiding the interference in between the whole network the protocol assigns the different value to different channels. This protocol is working on the TDMA. The route is discovered so that QoS is maintained. The source node sends the packet according to the QoS so that the delay will be reduced and the loss of packet will not occur and there should not be any jitter in the packet. Shacham et al. [11] proposed the protocol design scheme. For the knowledge of the route to the nearest gateway data flow is established between client and the gateway. Qiang et al. [12] have given the brief on the capacity of the network. In the wireless network the gateway is deployed which is based on the linear programming based algorithm. That will improve the overall capacity problem of the network. TDMA is one of the best methods for the QoS. But it is also called a stop-and-go queuing.

Kamal et al. [13] have given a brief on the throughput of the network. That work in the impact of the interference in the network like the conflict present in the network and work on the upper and the lower bound on the network for improvement of the throughput of the network. Djukic [14] has given a brief on the QoS that is provided through the TDMA. It includes all the network delay that occurs in the network which is because the inbound and outbound link of the network. It proposed an algorithm that can reduce the scheduling delay and it is called a conflict free TDMA schedule. It takes the scheduling delay as a cost. It finds the transmission order to minimize and maximize the delay. Prakash et al. [15] have given a brief on the link scheduling in the mesh network which work on the TDMA MAC protocol. It uses the concept of coloring to overcome the conflict or minimize the conflict. As coloring of graph is the vertex coloring of the conflict graph which represents a conflict-free TDMA schedule. It uses the edge coloring concept. That is some time called distributed edge-coloring and the minimum number of color require is at most n+1 where n is the maximum degree of the graph. And this edge coloring scheduling is used in the link scheduling method.

Djukic[16] has given a brief on the centralized TDMA scheduling algorithm. As centralized is used to collect the overall information and place that information in the centre to overcome the conflict. It uses the coloring of graph concept to minimize the conflict in the network. A minimum vertex color shows the minimum length schedule. The type of vertex coloring conflict has called the primary conflict. This is able to define the conflict-free scheduling condition in term of the edge coloring for the topology graph. But this does not define the secondary conflicts, which does not share the nodes.

Whenever the network is so large that the single network can't handle it by own or can't schedule the entire network than distributed TDMA is used. Bandwidth is provided according to the pair wise node. Salonidis et al. [17] defines that the secondary conflict is removed with the help of the multiple orthogonal channels. With the help of synchronized TDMA mesh protocol the algorithm controls the feasibility of link bandwidths by applying a local conditions on a tree topology. The conflict line secondary is removed from the edge coloring and by reversing the direction of link transmission. It finds out the trade-off between the degrees of the topology. It uses tree topology and finds out it is mostly used in the network.

Some algorithm assumes that links can be scheduled multiple times in the frame. But in the standard does not have the explicit mechanism to allow this. The overhead of multiple transmissions in the frame is so larger than even the technique proposed in the 802.16 standard, which schedule transmission without spatial re-use. Wei et al. [18] defines the 802.16 algorithm which creates a multi hop mesh network. To get high speed 802.16 mesh networks, it develops resource allocation extensions. It proposed an algorithm to increase the utilization power of the network. As interference is the major issue in the network, 802.16 proposed algorithms for minimizing the conflict. It uses a cross layer design for awareness of the network. It will increase the throughput the network. Lin et al. [19] have given a

brief on TDMA based on the IEEE 802.16 for the accessing and for the scheduling of the algorithm. They proposed an algorithm that is a collision free algorithm that provides the high quality of the multimedia network that uses the 802.16 standard. It uses the relay strategy for the mesh node. It works on the utilization of the network i.e. it's work to increase the utilization power of the network.

Himanshu et al. [20] have given brief on the problem of capacity in WMNs. It uses various strategies to reduce or minimize the interference. As the number of interfaces are less than the numbers of channels. They work on centralized and distributed algorithm for minimization. It proposed a semi defined program by using linear programming to get the lower bound on the network. Salonidis et al. [21] have given a brief on the dynamic CA for the improvement of the network and which will increase the throughput of the network. They proposed Asynchronous Multichannel Coordination Protocol. It does not only increase the throughput but also reduce the starvation in the network. They exponentially derivate and lower bound the throughput of the network. Zhang et al. [22] have given brief on introduction about the assignment of channel, this CA is done for the improvement of the throughput by using co-channels; it proposed an algorithm which works according to the bandwidth of the network. It also uses the bottleneck capacity of the network.

Hertz et al. [23] have given a brief introduction for assignment of channel for minimizing the interference. Tabu search is one of the algorithms proposed by them for minimization. Tabu search is based on the coloring of graphs. First it finds the network than give color to the network; when the network is whole get colored than it uses the chromatic number of concepts to minimize the color. The minimum number of colors on the network shows the minimum conflict in the network. Alan et al. [24] have given brief on CA by distributed algorithm. This algorithm uses the greedy approach for the max k-cut problem. This is the polynomial time distribution which guarantees the minimization of conflict. It partitions the vertices into the block and work with the max bisection in the graph.

3. PROBLEM FORMULATION

Displayed equations should be numbered consecutively, with the number set flush right and enclosed in parentheses. The equation numbers should be consecutive within the contribution Communication model: we consider communication model as the undirected graph where the wireless mesh router are stationary in nature and each routers have radio interfaces. An edge (m, n) in this graph is considered as communication link and m is linked with the n.

Conflict model: It describes the various links present that can interfere with the particular link present in the same network. As wireless link are broadcast in nature so the chance of interference increases, because transmission along communication may interfere the other link in the same network. As described in Fig. 2, if two links are interfered than the transmission cannot be succeed at the same time on the same channel.

In static CA, the interference is depends on the traffic on the link. The set of pair of communication links that interferes with other link can be called as conflict

graph. In the conflict model transmission range is equal to interference range. Communication link I interferes with J, K, and L. And link J interfere I and L not with K.

In WMNs, we want to assign a unique channel to each link so that it minimizes the network interference. The objective of our problem is to minimize the network-interference by assigning unique channel that will improve the network capacity. It will maximize the overall network throughput.

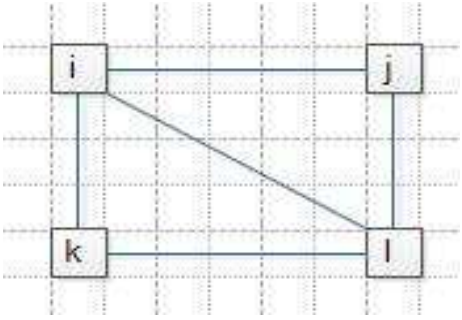

Fig. 2. Conflict Model

4. PROPOSED SOLUTION

AODV routing protocol: AODV Routing is a routing protocol for WMNs and other wireless ad hoc

networks. This protocol is mostly used because it has advantage of fast convergence, and self repair property. It uses the destination sequence number for each route entry. When the node requests it get the destination sequence number and the route information [26]. The distance of the node is measure by counting the number of hops. The destination node uses the Routing Request Packet (RRP) that come first in the network. This routing protocol does not provide the QoS [27]. For the better QoS we use the coloring of graph concept that will minimize the conflict in the network. We simulate this in NS2 and minimize conflict in the network.Some silent feature of our approach: Centralized approach is suitable for use with 802.11-based network without requirement of fast channel switching or any form of MAC protocol. It minimizes the network interference.

Centralized algorithm for minimize conflict in network: We use centralized algorithm because it is easy to manage. One centralized node manages entire network. This provides more optimization and it can easily upgrade. In centralization we use the coloring of graph concept. That will minimize the conflict in the network. Color the graph such that no two adjacent nodes have same color. The number of minimum color require in the graph will show the probability of conflict. Number of channel assigned depends upon color occur in the network.

Probability of Conflict = minimum number of color obtained / number of nodes

Conflict Resolution Algorithm

Inputs: Adjacency Matrix
Outputs: Minimum number of colors
$for(i=1;i\le n;i++)$
$for(j=1;j\le n;j++)$
Assign o to all index of adjacency node
End for
End for
$for(i=1;i\le e;i++)$
Assign value 1 to each l and k of the adjacency node
$for(i=1;i\le n;i++)$
Assign color to each node according to no adjacent nodes have same color
End for
End for
$for(i=1;i\le n;i++)$
Display color of nodes
End for

4.1 Complexity

The complexity of the conflict resolution algorithm depends on the number of edges present in the network. When the number of edges are equal to the corresponding nodes, the complexity should be n^2 and if the number of edges are greater than the corresponding nodes, the complexity depends on edges and it should be en.

Scenario of CA through Coloring as shown in Fig. 3 shows the minimized conflict through CA, i.e., when the two adjacent nodes use the same channel there is chance of interference. We use the coloring of graph problem to minimize that interference. Assign color to each nodes according to no adjacent nodes have same color, the nodes that have same color can use the same channel because they are not adjacent to each other, according to this it minimize the interference; by minimizing the interference the capacity of the network is also increased.

5. PERFORMANCE ANALYSIS

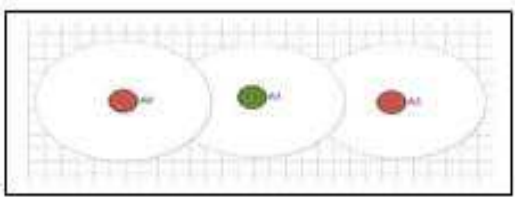

Fig. 3. CA by coloring problem

We have simulated the designed algorithm on ns-2 on 25, 30 and 50 nodes and find out the minimum number of color required by the 25, 30 and 50 nodes network. According to the color concept, we have evaluated the following metric defined as:

PoC= minimum number of color obtained / number of nodes

When we have worked on 25 nodes, it gives 2 minimum color required and after calculating PoC for 25 nodes, we got 0.08.
Then we start working on 30 and 50 nodes and it also required minimum 2 color so PoC for 30, PoC = 0.06 and for 50, PoC = 0.04.

Fig. 4 shows the analysis of PoC with respect to the number of nodes.

As shown in Fig.4, with different thresholds values of PoC is decreased continuously. With an increase in number of nodes and variation in thresholds, PoC is decreased.
Fig. 5 shows the successful transmissions with number of requests and number of channels. With an increase in number of channels and number of requests, the successful transmissions are increased and get saturated after some time as shown in the

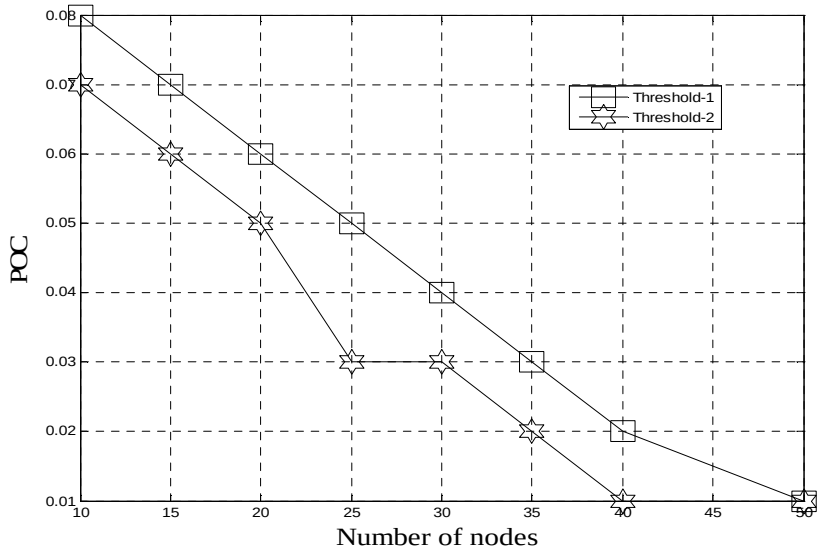

Fig. 4: Variation in PoC with number of Nodes

Fig. 6 shows the number of successful transmission with number of requests and probability of conflicts. As shown in the figure, even with an increase in number of conflicts and number of requests, the successful numbers of transmissions are increased

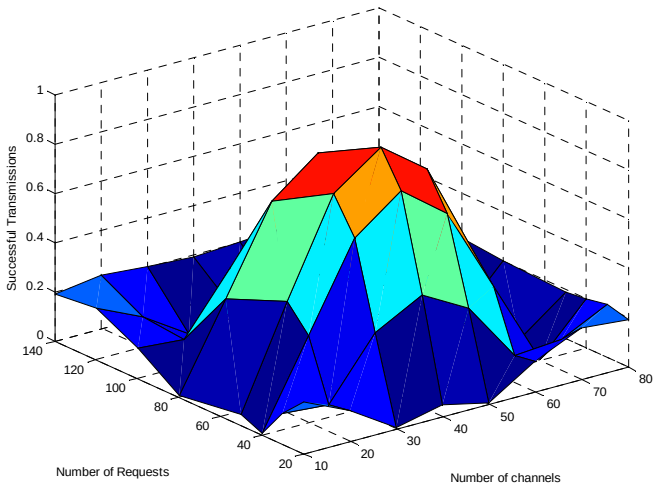

Fig.5: Successful transmissions with number of requests generated and number of channels

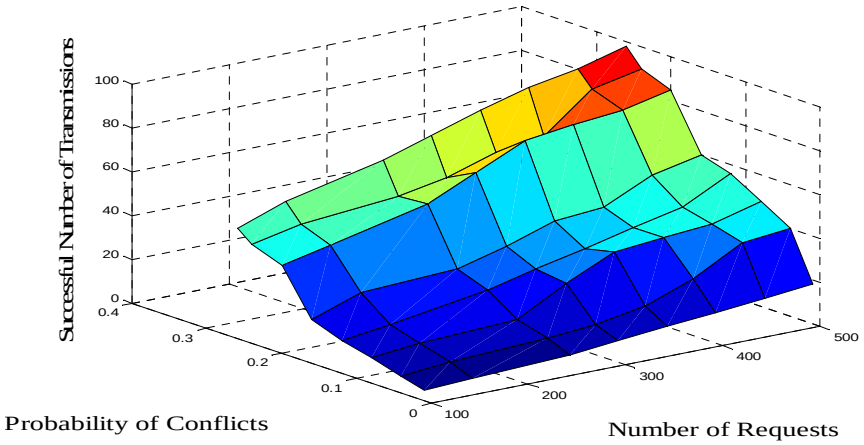

Fig.6: Number of Transmission with probability of conflicts

6. CONCLUSION AND FUTURE DIRECTIONS

In this paper, we have analyzed on static CA on centralized algorithm based on coloring of graph problem. Using simulation on NS2 with the coloring of graph problem scenario, we find out the minimum number of colors used for CA. We have assigned the same channel to those nodes having same color. The PoC is calculated using minimum number of colors that shows the minimum conflict in the graph. In future, we will consider to assign multiple channels to each link using multiple radios.

References

[1] Akyildiz, F. Ian and W. Xudong, "A Survey on Wireless Mesh Networks." *Communications Magazine, IEEE*, 2005.

[2] P. Djukic and S. Valaee, "Quality-of-Service Provisioning in Multi-service TDMA Mesh Networks.", 2007

[3] L. Wu, C. Lin, Y. Tseng, and JP. Sheu, "A New Multi-channel MAC Protocol with On-demand CA for Multi-hop Mobile Ad-hoc Networks." *Parallel Architectures, Algorithms and Networks*, 2000.

[4] J. So and N. Vaidya, "Multi-channel MAC for Ad-hoc Networks: Handling Multi-channel Hidden Terminals Using a Single Transceiver." *ACM MobiHoc*, 2004.

[5] P. Bahl, R. Chandra, and J. Dunagan, "SSCH: Slotted Seeded Channel Hopping for Capacity Improvement in IEEE 802.11 Ad-hoc Wireless Networks." *ACM Mobi-Com*, 2004.

[6] J. Shi, T. Salonidis, and E. Knightly, "Starvation Mitigation through Multi-channel Coordination in CSMA Multi-Hop Wireless Networks." *ACM MobiHoc*, 2006.

[7] A. Raniwala, K. Gopalan, and T. Chiueh, "Centralized CA and Routing Algorithms for Multi-channel Wireless Mesh Networks." *ACM SIGMOBILE Mobile Computing and Comm. Rev*., 2004.

[8] A. Raniwala and T. Chiueh, "Architechture and Algorithms for an IEEE 802.11-Based Multi-channel Wireless Mesh Network", *IEEE INFOCOM*, 2005.

[9] MK. Marina and S. Das, "A Topology Control Approach to Channel Assignment in Multi-radio Wireless Mesh Networks." *Broadband Networks (Broadnets)*, 2005.

[10] P. Djukic, and S. Valaee, "Delay Aware Link Scheduling for Multi-hop TDMA Wireless Networks.", IEEE/ACM Transactions on Networking (TON), 2009.

[11] N. Shacham and P. King., "Architectures and Performance of Multichannel Multihop Packet Radio Networks", *IEEE Journal on Selected Area in Communication*, 1987.

[12] Huang, S.qiang, and Q.Zheng. "Research of Capacity Optimizing Model on Wireless Mesh Networks.", *Computer Science and Information Technology, 2009. ICCSIT 2009. 2nd IEEE International Conference on. IEEE*, 2009.

[13] J. Kamal, P. Jitendra , P. Venkat, and Q. Lili," Impact of Interference on Multi-hop Wireless Network Performance.", *ACM MobiCom*, 2003.

[14] P. Djukic and S. Valaee,"Delay Aware Link Scheduling for Multi-hop TDMA Wireless Networks.", *IEEE/ACM Transactions on Networking TON*, 2009.

[15] Gandham, Shashidhar, M. Dawande, and R. Prakash, "Link Scheduling in Wireless Sensor Networks: Distributed Edge-coloring Revisited.", *Journal of Parallel and Distributed Computing*, 2008.

[16] P. Djukic and S. Valaee, "Delay Aware Link Scheduling for Multi-hop TDMA Wireless Networks.", *IEEE/ACM Transactions on Networking*, 2009.

[17] Salonidis, Theodoros, and L. Tassiulas, "Distributed Dynamic Scheduling for End-to-end Rate Guarantees in Wireless Ad-hoc Networks.", *ACM international symposium on Mobile ad hoc networking and computing. ACM*, 2005.

[18] Wei, Y. Hung, "Interference-aware IEEE 802.16 WiMax Mesh Networks.", *Vehicular Technology Conference*, 2005.

[19] B. Han, J. Weijia, and L. Lidong, "Performance Evaluation of Scheduling in IEEE 802.16 Based Wireless Mesh Networks.", *Computer Communications IEEE*, 2007.

[20] G. Himanshu**,** Subramanian, A. Prabhu, "Minimum Interference CA in Multiradio Wireless Mesh Networks.", *Mobile Computing, IEEE Transaction*, 2008**.**

[21] Shi, Jingpu, T. Salonidis, and W. Knightly, "Starvation Mitigation through Multi-channel Coordination in CSMA Multi-hop Wireless Networks.", *ACM international symposium on Mobile ad hoc networking and computing. ACM*, 2006.

[22] Tang, Jian, G. Xue, and W. Zhang, "Interference-aware Topology Control and QoS Routing in Multi-channel Wireless Mesh Networks.", *ACM international symposium on Mobile ad hoc networking and computing. ACM*, 2005.

[23] Hertz, Alain, and D. Werra, "Using Tabu Search Techniques for Graph Coloring.", 1987.

[24] Frieze, Alan, and M. Jerrum, "Improved Approximation Algorithms for Max k-cut and Max Bisection.", *Integer Programming and Combinatorial Optimization. Springer Berlin Heidelberg*, 1995.

[25] P. Gupta and P.R. Kumar, "The Capacity of Wireless Networks,", *IEEE Trans. Information Theory*, 2000.

[26] Perkins, E. Charles, and E.M. Royer. "Ad-hoc On-demand Distance Vector Routing.", *Mobile Computing Systems and Applications, IEEE*, 1999.

[27] Liu, Ling, "Improvement of AODV Routing Protocol with QoS Support in Wireless Mesh Networks.", *Physics Procedia*, 2012.