Auto Organization and Optimization in Heterogeneous Wireless Mesh Networks

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Abstract*-- In this paper, new models and algorithms are used for control and optimization of a class in Hierarchical Heterogeneous Wireless Network, under real-world physical constraints. Flocking Algorithm and a Particle Swarm Optimizer are implemented in this paper. We first develop a non-convex mathematical model for Hierarchical Heterogeneous Wireless Networks. Second, we propose a new Flocking algorithm for self-organization and control of the backbone nodes in this network by collecting local information from end users. Third, we employ Particle Swarm Optimizer, a widely used artificial intelligence algorithm, to directly optimize the Hierarchical Heterogeneous Wireless Networks by collecting global information from the entire system. A comprehensive evaluation measurement during the optimization process is developed. In addition, the relationship between network and Flocking Algorithm, Our novel framework is examined in various dynamic scenarios. Experimental results demonstrate that Flocking algorithm and Particle Swarm Optimizer both outperform current algorithms for the self-organization and optimization of Hierarchical Heterogeneous Wireless Networks.

***Keywords*— Wireless Mesh Networks, Heterogeneous Wireless Mesh Networks, channel selection, automatic configuration, quality of service, routing.**

I. INTRODUCTION

A Wireless Mesh Network (WMN) is a communications network made up of radio nodes organized in a mesh topology. Wireless mesh networks often consist of mesh clients, mesh routers and gateways. The mesh clients are often laptops, cell phones and other wireless devices while the mesh routers forward traffic to and from the gateways which may, but need not, connect to the Internet. The coverage area of the radio nodes working as a single network is sometimes called a mesh cloud. Access to this mesh cloud is dependent on the radio nodes working in harmony with each other to create a radio network. A mesh network is reliable and offers redundancy. When one node can no longer operate, the rest of the nodes can still communicate with each other, directly or through one or more intermediate nodes. The animation below illustrates how wireless mesh networks can self form and self heal. Wireless mesh networks can be implemented with various wireless technology including 802.11, 802.15, 802.16, cellular technologies or combinations of more than one type.

Wireless mesh networks are being developed actively and deployed widely for a variety of applications, such as public safety, environment monitoring, and city-wide wireless Internet services. They have also been evolving in various forms using multi radio channel systems to meet the increasing capacity demands by the abovementioned and other emerging applications. However, due to heterogeneous and fluctuating wireless link conditions, preserving the required performance of such Wireless mesh networks is still a challenging problem. For example, some links of a Wireless mesh networks may experience significant channel interference from other co existing wireless networks. Some parts of networks might not be able to meet increasing bandwidth demands from new mobile users and applications. Links in a certain area e.g a hospital or police station might not be able to use some frequency channels because of spectrum etiquette or regulation.

Multi-channel wireless mesh network architecture (called Hyacinth) equips each mesh network node with multiple 802.11 network interface cards (NICs). The authors show that the intelligent channel assignment is critical to Hyacinth's performance, present distributed algorithms that use only local traffic load information to dynamically assign channels and to route packets, and compare their performance against a centralized algorithm that performs the same functions through a simulation study. It adopts a model for autonomic computing is presented, which shows how self-managing autonomic capabilities can be achieved in an evolutionary manner. Further, it describes initiatives for industry standards that are necessary to carry out these applications of autonomic computing within open system architecture for heterogeneous environments.

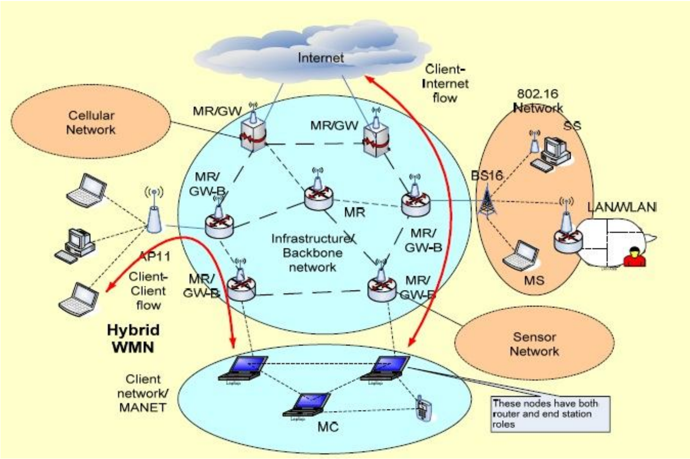

Fig.1. Heterogeneous Wireless Mesh Network Infrastructure

II. AUTO ORGANIZATION& OPTIMIZATION

Due to the increasing number of devices and services, efforts are being made so that network installation, administration, and maintenance do not become unmanageable to the administrator. Therefore, research works have addressed these issues. In a project for a community wireless mesh self-organized network is presented. This work presents a case-study for multi hop networks, showing how limitations can be overcome and how wireless devices affect mesh performance.

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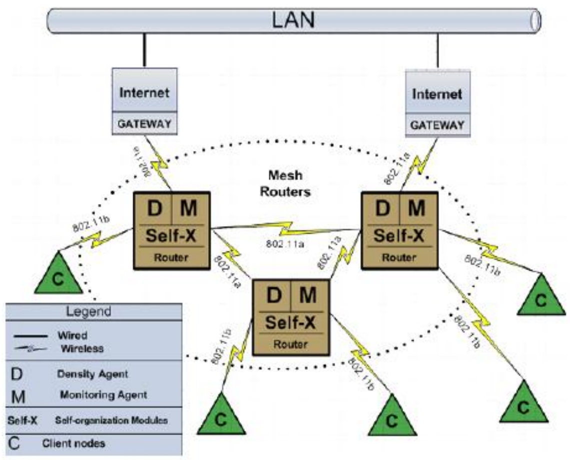

Fig. 2. Architecture of Auto organization

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III. PROBLEM DEFINITION

Resource allocation algorithms can provide theoretical guidelines for initial network resource planning even though their approach provides a comprehensive and optimal network configuration plan, they often require global configuration changes, which are undesirable in case of frequent local link failures greedy channel assignment algorithm can reduce the requirement of network changes by changing settings of only the faulty link. However, this greedy change might not be able to realize full improvements, which can only be achieved by considering configurations of neighboring mesh routers in addition to the faulty links. Fault tolerant routing protocols, such as local re-routing or multi-path routing, can be adopted to use network-level path diversity for avoiding the faulty links. However they rely on detour paths or redundant transmissions, which may require more network resources than link-level network reconfiguration.

Even though many solutions for Wireless mesh networks to recover from wireless link failures have been proposed, they still have several limitations as follows. First, resource-allocation algorithms can provide theoretical guidelines for initial network resource planning. However, even though their approach provides a comprehensive and optimal network configuration plan, they often require global configuration changes, which are undesirable in case of frequent local link failures. Next, a greedy channel-assignment algorithm can reduce the requirement of network changes by changing settings of only the faulty links. However, this greedy change might not be able to realize full improvements, which can only be achieved by considering configurations of neighboring mesh routers in addition to the faulty link. Third, fault-tolerant routing protocols, such as local re-routing or multi-path routing, can be adopted to use network-level path diversity for avoiding the faulty links. However, they rely on detour paths or redundant transmissions, which may require more network resources than link-level network reconfiguration.

To overcome the above limitations, Autonomous Network Reconfiguration System that allows a multi radio Wireless mesh networks to autonomously reconfigure its local network settings channel, radio, and route assignment for real time recovery from link failures. In its core, autonomous network reconfiguration system is equipped with a reconfiguration planning algorithm that identifies local configuration changes for the recovery, while minimizing changes of healthy network settings.

We are inspired by dynamic models in nature (e.g., flocking and swarming) as they can be applied to the control and self-organization of HHWNs. Our proposed approaches use a Flocking Algorithm (FA) and a Particle Swarm Optimizer (PSO) to deliver optimized dynamic network behavior. The FA-based approach produces optimal solutions from local interactions, is completely distributed and shows constant time complexity, which is especially useful for large-scale HHWNs and real-time applications. The PSO-based approach produces optimal solutions in a stochastic manner, using global network information, which reduces the risk of trapping in local minima while delivering satisfactory computational efficiency.

To overcome the above limitations, we propose an Autonomous network Reconfiguration System that allows a multi-radio Wireless mesh networks to autonomously reconfigure its local network settings channel, radio, and route assignment for real-time recovery from link failures.

It is equipped with a reconfiguration planning algorithm that identifies local configuration changes for the recovery, while minimizing changes of healthy network settings. Briefly, autonomous network reconfiguration first searches for feasible local configuration changes available around a faulty area, based on current channel and radio associations. Then, by imposing current network settings as constraints, autonomous network reconfiguration identifies reconfiguration plans that require the minimum number of changes for the healthy network settings.

The operation of Autonomous network reconfiguration system in every mesh node monitors the quality of its outgoing wireless links at every 10 sec and reports the results to a gateway via a management message. Second, once it detects a link failure, detector node triggers the formation of a group among local mesh routers and one of the group members is elected as a leader, for coordinating the reconfiguration, the leader node sends planning request message to a gateway. Then, the gateway synchronizes the planning requests if there are multiples request and generates a reconfiguration plan for the request. The gateway sends a reconfiguration plan to the leader node and the group members. Finally, all nodes in the group execute the corresponding configuration changes, if any, and resolve the group.

Next, Autonomous network reconfiguration also includes a monitoring protocol that enables a Wireless mesh networks to perform real-time failure recovery in conjunction with the planning algorithm. The accurate link-quality information from the monitoring protocol is used to identify network changes that satisfy applications new Quality of service demands or that avoid propagation of Quality of service failures to neighboring links. The monitoring protocol periodically measures wireless link-conditions via a hybrid link-quality measurement technique, based on the measurement information, autonomous network reconfiguration detects link failures and or generates Quality of service aware network reconfiguration plans upon detection of a link failure.

Wireless mesh networks (WMNs) are comprised of nodes with multiple radio interfaces and provide broadband residential internet access or connectivity to temporal events. Our goal is to simplify the network deployment of such a mesh network, and towards that we are presenting procedures for automatic configuration and optimization of the network. We first present an architecture framework that supports the integration of key mechanisms to ensure the optimization of the performance of a wireless mesh network. Secondly, we present three key mechanisms, namely auto configuration, channel assignment and quality of service (QoS) enforcement based on QoS routing. We provide a method for automatic mesh start-up, joining a node into an existing mesh network and automatic repair of temporary connectivity outage, targeting at simplifying the node configuration as much as possible. The second mechanism supports an efficient algorithm for joint channel selection and topology control, supporting different target objective expressed as utility functions. The third mechanism supports QoS, by allowing routing and admission control decisions, in order to ensure that all flows are handled with the demanded QoS.

IV. ARCHITECTURE FRAMEWORK

The system presents a general framework for providing automatically configured, optimized and QoS-aware wireless mesh networks. The framework is composed of several key mechanisms that could work as standalone in order to provide their basic functionality to a network, but when they interwork they achieve maximum performance. These mechanisms can be grouped into three general procedures that are the following:

- Auto configuration
- Channel Assignment
- QoS enforcement.

In this framework we are considering a centralized architecture, since all the decisions are been taken in the Network Manager, which is a central network node. This node communicates with the mesh routers and they exchange the needed information to execute the mechanisms and take decisions for the optimization of the mesh network performance. When the network is initialized, the network manager should perform a network discovery in order to identify the nodes that belong to the network and assign IP addresses to them in order to be able to communicate and exchange commands and to exchange data.

The Topology manager collects the (periodically transmitted) data from the routers about active connections, monitors the WIFI associations, ARP tables etc., and collects the statistics per connection. All this information is gathered at the Network Manager. The mesh router transmits only information about active links and the link candidates that it is able to sense. When the Network Manager requests scanning information, the mesh routers switch some interfaces to scanning. The unused interfaces can scan without problems, but when an interface is used (i.e. to create a link) we can apply an algorithm which tries to establish an alternative path, and when it succeeds, it configures the interface and starts the scanning and sends the information to the Network Manager

A. Auto Configuration

The auto configuration component in a wireless mesh network provides a method for automatic mesh start-up, joining a node into an existing mesh network and automatic repair of temporary connectivity outage. The main objective of this component is to simplify the node configuration process as much as possible. The auto configuration provides our network with methods to set up transmission parameters, while joining a node into an operational mesh network, to merge two disjoint networks, and to sustain the network transmission in case of link or node failure. The main goal is to automatically create a fully operational network without requirement of any manual configuration of the mesh nodes.

They are able to forward routing information through multiple interfaces and provide better integration with wired networks. The underlying auto configuration method is applicable to networks with technology heterogeneity and it is independent of the routing protocol in use. To optimize the routing it can automatically partition the IP addresses space into subnets. After establishing the link with the first interface the node sends the request for IP address, channel assignment and other radio parameters for every of its mesh interfaces. The Network Manager also keeps track about the current state of all nodes in the mesh network.

B. Channel Assignment

Channel assignment in wireless mesh networks influences the contention among wireless links and the network topology or connectivity between mesh nodes. Indeed, there is a tradeoff between minimizing the level of contention and maximizing connectivity. The channel assignment module allows finding an optimized mesh topology in terms of offered throughput, packet transmission delay or network resilience. It describes a utility-based framework for joint channel assignment and topology control in multi-rate multi radio wireless mesh networks, and uses a greedy algorithm for solving the corresponding optimization problem. Key features of the proposed approach are the support for different target objectives, which are expressed as utility functions of the MAC layer throughput, and the efficient utilization of wired network gateways, while guaranteeing that for every mesh node exists a path to a gateway.

A wireless mesh network has a set of nodes N. Each mesh node has multiple radio interfaces. The gateway nodes have wired network connections. It addresses is to assign channels to mesh nodes and define node pairs that have a communication link, while ensuring that all nodes have a path to at least one gateway. Channel assignment alone does not fully define the node connectivity, since an interface's transmission rate depends on the destination interface it communicates with; the transmission rate, the throughput that is achieved by that link, as well as all other links in the same transmission range that operate on the same channel.

B.Qos Enforcement

The goal of the QoS enforcement component in a wireless mesh network is twofold. On one hand, this component computes routes and selects gateways for the Internet flows, such as to ensure the QoS levels demanded by the traffic flows. Indeed, mesh networks are primarily used for Internet access, so, gateway selection plays a crucial role in determining the overall network performance and ensuring the optimal utilization of the mesh infrastructure. For instance, if too many mesh nodes select the same gateway as egress point to the Internet, congestion may increase excessively on the wireless channel or the Internet connection of the gateway can get overloaded. This is especially important in the heterogeneous mesh networks targeted by the EU-MESH project, because low-speed Internet gateways may easily become a bottleneck, limiting the achievable capacity of the entire network. On the other hand, the QoS enforcement component should also implement admission control to determine whether to accept or reject an incoming flow based on the available capacity of the mesh network. It is intuitive to observe that the ability of correctly performing admission control depends upon how much accurate the mesh network capacity is inferred.

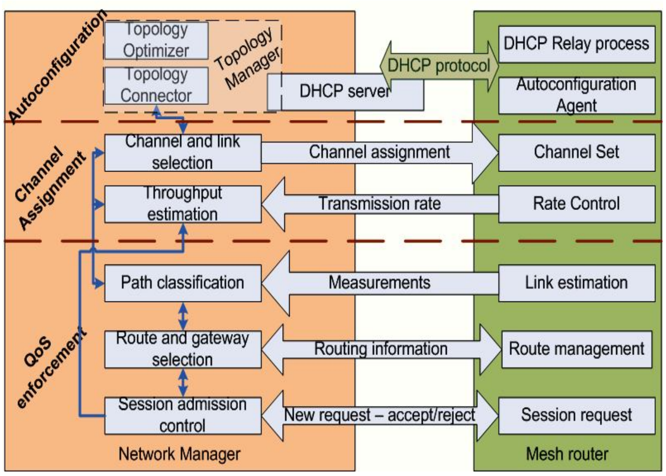

Fig. 3. Architecture framework

V. METHODOLOGY

There are two methodologies used for implementing and optimizing the performance and auto organization of the Heterogeneous Wireless Mesh Network. These are as follows:

- Particle Swarm Optimizer
- Flocking Algorithm

A. Particle Swarm Optimizer

In PSO, each individual, referred to as a particle, is denoted as part of a solution to the optimization problem and is assigned a randomized velocity. The particle changes its position and velocity gradually by following its own local optimum and the global optimum, in other words, according to its own experience and the whole swarm experience. Therefore, it is a stochastic global optimization algorithm. Compared with other evolutionary algorithms, PSO has some appealing features including easy implementation, few parameter tuning and a fast convergence rate. It has been used in a wide variety of applications such as neural network learning, pattern recognition, data mining, controller design, and circuit optimization. Based on the velocities the roaming particles are controlled outside the search space. Particles move toward new positions. This process repeats until either the maximum number of iterations is reached or the stopping criterion is satisfied.

B. Flocking Algorithm

The objective with respect to the control of HHWNs is to minimize the network energy by relocating the positions of the backbone nodes and adapting to the network dynamics under real-world physical constraints. Two algorithmic methods—FA and PSO—are proposed to solve the energy minimization problem such that the HHWN is autonomously self-organized and optimized. There is a strong rationale behind using these two different approaches. The relationship between HHWNs and flocking is described by the following analogs:

- **Entity -** Terminal nodes (leaders) lead the backbone nodes (followers) in HHWNs; in FA, each agent or assigned leader leads its neighboring agents.
- **Control object -** Backbone nodes are the control objects in the HHWN, while each agent (except the group leader) needs to be controlled in FA.
- **Interaction -** In an HHWN, each backbone node interacts with its neighboring backbone nodes, assigned terminal nodes, and physical constraints, e.g., geographic constraints and undesired weather conditions. In FA, each agent only interacts with its neighboring agents.
- **Optimum -** In an HHWN, the energy, which includes the costs of connectivity (the links between backbone nodes) and coverage (the links between backbone nodes and terminal nodes), needs to be minimized under physical constraints; each agent in FA interacts with its neighboring agents in order to make the whole flocking group reach an optimal state, where the whole system is well self-organized and optimized.

VI. PERFORMANCE AND RESULTS

We demonstrate that the proposed methodology shows merits in the following scenarios. Public safety environment monitoring and city wide wireless Internet services. It avoids propagation of Quality of service failures to neighboring links. It is Suitable for dynamic network reconfiguration. It detects a long-term failures, real time link failure and local link failure and recovers the network. PSO produces superior performance but results in a slow convergence speed and only favors the dynamics of backbone nodes in the x-y plane. FA is capable of delivering fast convergence speed while achieving satisfactory solutions for an HHWN. Furthermore, with the use of FA, the backbone nodes can move flexibly in 3Dspace by taking into account the repulsion force from the physical constraints (e.g., mountains). It includes a link-association primitive and it can learn available channel capacity by associating with idle interfaces of neighboring nodes.

VII. CONCLUSION

Performance this word says how the software is works, the ability of the software, the accuracy of the software and activity of the software. This project presents new models and algorithms for control and optimization of a class of next generation communication networks: hierarchical heterogeneous wireless networks, under real-world physical constraints. An HHWN is characterized by directional wireless links connecting backbone nodes at the upper layer and dynamic terminal nodes at the bottom layer.

First, we propose a mathematical modeling method for the self-organization and optimization of HHWNs by taking into account physical constraints in terms of minimum distance threshold, power limitations, and capacity of backbone nodes. Second, using only local information, we develop new flocking rules and a corresponding algorithm to autonomously assure, control, and optimize network performance in a practical way. Associate physical constraints checking algorithms are also developed. Third, we use Particle Swarm Optimization, a stochastic global optimization algorithm, to optimize an HHWN directly with a hybrid evaluation function and using global information. Experimental results confirm that our flocking algorithm and PSO both perform well for the optimization of an HHWN in terms of performance metrics such as energy cost, loss of connections, and number of SD connections.

It enables a multi radio WMN to autonomously recover from wireless link failures. It generates an effective reconfiguration plan that requires only local network configuration changes by exploiting channel, radio, and path diversity. It effectively identifies reconfiguration plans that satisfy applications QoS constraints.

V. REFERENCES

[1] Cui.X, Gao.J, and Potok.T.E, (2006) "A Flocking Based Algorithm for Document Clustering Analysis," J. Systems Architecture, vol. 52, pp. 505-515.

[2] Dongsoo S. Kim, and Seok K. Hwang, (Nov. 2007) "Swarm Group Mobility Model for Ad Hoc Wireless Networks", TR ECE-07-01.

[3] Gazi.V and Passino.K.M, (Apr. 2003) "Stability Analysis of Swarms," IEEE Trans. Automatic Control, vol. 48, no. 4, pp. 692-697.

[4] Hong.X, Gerla.M, Pei.G, and Chiang.C.C, (1999) "A Group Mobility Model for Ad Hoc Wireless Networks," Proc. Second ACM Int' Workshop Modeling, Analysis and Simulation of Wireless and Mobile Systems, pp. 53-60.

[5] Jadbabaie.A, Lin.J, and Morse.A.S, (June 2003) "Coordination of Groups of Mobile Autonomous Agents Using Nearest Neighbor Rules," IEEE Trans. Automatic Control, vol. 48, no. 6, pp. 988- 1001.

[6] Kyu-Han Kim, Kang G. Shin,(April 2011) IEEE, ACM "Self-Reconfigurable Wireless Mesh Networks", IEEE/ACM Transactions On Networking, Vol.19, No. 2,page no 393.

[7] Liu.Q, Jia.X, and Zhou.Y, (2010) "Topology Control for Multi-Channel Multi-Radio Wireless Mesh Networks Using Directional Antennas," Wireless Networks, vol. 17, pp. 41-51, doi: 10.1007/s11276-010-0263-1.

[8] Llorca.J, Milner.S.D, and Davis.C.C, (2010) "Molecular System Dynamics for Self Organization in Heterogeneous Wireless Networks,"EURASIP J. Wireless Comm. and Networking, in press

[9] Llorca.J, Milner.S.D, and Davis.C.C, (Nov. 2008) "A Convex Optimization Method for Autonomous Self-Organization in Dynamic Wireless Networks," Proc. IEEE Military Comm. Conf. (MILCOM).

[10] Milner.S.D, Llorca.J, and Davis.C.C, (Apr.-June 2009) "Autonomous, Reconfiguration and Control in Directional Mobile Ad Hoc Networks," IEEE Circuits and Systems Magazine, vol. 9, no. 2, pp. 10-26.

[11] Milner. S et al., (2005) "Self-Organizing Broadband Hybrid Wireless Networks," J. Optical Networking, vol. 4, pp. 446-459.

[12] Shi.Y and Eberhart.R.C, (1999) "Empirical Study of Particle Swarm Optimization," Proc. Congress Evolutionary Computation, pp. 1945-1949.

[13] Vicsek.T et al., (1995) "Novel Type of Phase Transition in a System of Self-Driven Particles," Physical Rev. Letters, vol. 75, no. 6, pp. 1226-1229.

[14] Zhang.H.T and Chen.G, (2007) "Small-World Network-Based Coordinate Predictive Control of Flocks," Proc. IEEE Third Int'l Scientific Conf. Physics and Control.

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BIOGRAPHY

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