# Survey of Client Tracking In Mobile Mesh Networks

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*Abstract*— Mobile Computing has fast become an important new paradigm in today's world of networked computing systems. Ranging from wireless laptops to cellular phones and WiFi/Bluetooth-enabled PDAs to wireless sensor networks, mobile computing has become ubiquitous in its impact on our daily lives. Mobile ad hoc networks (MANETs) are ideal for situations where a fixed infrastructure is unavailable or infeasible. Today's MANETs, however, may suffer from network partitioning. This limitation makes MANETs unsuitable for applications such as crisis management and battlefield communications, in which team members might need to work in groups scattered in the application terrain. In this paper, we take a representative survey of the current work that has been done in this area. We define several terms and concepts and then show how they are being utilized in various research works. Some literature studies on improving the network topology in wireless mesh networks, Wireless sensor covering and Localization techniques are done..*(Abstract)*

*IndexTerms*— coverage, nodes, wireless sensor networks..*(keywords)*

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## 1. Introduction

As numerous wireless networks evolve into the next generation to produce higher services, a key technology, wireless mesh networks (WMNs), has emerged recently. In WMNs, nodes are comprised of mesh routers and mesh clients. every node operates not only as a number but also as a router, forwarding packets on behalf of alternative nodes that may not be among direct wireless transmission range of their destinations. A WMN is dynamically self-organized and self-configured, with the nodes within the network mechanically establishing and maintaining mesh connectivity among themselves. This feature brings several benefits to WMNs such a slow up-front various, simple network maintenance, robustness, and reliable service coverage.

Conventional nodes (e.g.,phones,desktops, laptops, PDAs, etc.) equipped with wireless network interface cards (NICs) will connect on to wireless mesh routers. Customers while not wireless NICs will access WMNs by connecting to wireless mesh routers through, as an example, Ethernet. Thus, WMNs can greatly facilitate the users to be always-on-line anyplace anytime. Moreover, the gateway/bridge functionalities in mesh routers modify the mixing of WMNs with varied existing wireless networks like cellular, wireless sensing element, wireless-fidelity (Wi-Fi), worldwide inter-operability for microwave access (WiMAX), WiMedia networks. Consequently, through an integrated WMN, the users of existing network may be given otherwise impossible services of those networks.
WMN could be a promising wireless technology for various applications, e.g., community and neighborhood networks, broadband home networking, enterprise networking, building automation, etc. it's gaining vital attention as a attainable approach for money strapped internet service providers (ISPs), carriers, and others to roll out strong and reliable wireless broadband service access during a approach that needs least up-front investments. With the aptitude of organization and self configuration, WMNs are often deployed incrementally, one node at a time, as needed. As a lot of nodes are installed, the reliability and connectivity for the users increase consequently.

Deploying a WMN is not too difficult, because all the required components are already available in the form of ad hoc network routing protocols, IEEE 802.11 MAC protocol, wired equivalent privacy (WEP) security, etc. Several companies have already realized the potential of this technology and offer wireless mesh networking products. A few test beds have been established in university research labs. However, to make a WMN be all it can be, considerable research efforts are still needed. For example, the available MAC and routing protocols applied to WMNs do not have enough scalability; the throughput drops significantly as the number of nodes or hops in a WMN increases. Similar problems exist in other networking protocols. Consequently, all existing protocols from the application layer to transport, network MAC, and physical layers need to be enhanced or re-invented.

Mobile Adhoc Networks are collective arrangement of mobile nodes that may communicate with each other without the help of any centralized point. Adhoc networks build sensible and effective use of multihop radio relaying and radio communication channel. It’s vital for one mobile host to enlist the aid of different hosts in forwarding a packet to its destination, due to the restricted range of each mobile node’s transmissions. With the improvement of technology, this network may be managed by end users instead of single authority and that they may be used for terribly sensitive applications. In adhoc networks, node quality is a very important issue due to adhoc characteristics like multihop nature, dynamic network topology, shared medium, limited bandwidth and security etc. Thus, there\'s requirement of effective quality management scheme i.e. seamless mobility in adhoc networks. Seamless mobility provides easy accessibility and effective communication among nodes present within the network.

## 2. Challenges

There are a number of issues which affect the reliability of Ad-hoc networks and limit their viability for different scenarios; lack of centralized structure within MANET requires that each individual node must act as a router and is responsible for performing packet routing tasks; this is done using one or more common routing protocols across the MANET. Performing routing tasks requires memory and computation power, however mobile devices feature physical size and weight limitations essential for their mobility, this reduces the available memory and computational resources as well as limiting battery power.

MANETs containing more nodes require greater processing power, memory and bandwidth to maintain accurate routing information; this introduces traffic overhead into the network as nodes communicate routing information, this in turn uses more battery power. Wireless technologies use a shared communication medium; this causes interference which degrades network performance when multiple nodes attempt to transmit simultaneously. Techniques such as Distributed Coordination Function (DCF) are used to limit the impact of channel contention upon network performance, DCF uses carrier sense multiple access with collision avoidance (CSMA/CA) and channel switching to reduce interference however larger MANETs feature more interference.

The mobility of nodes is also a major factor within MANETs due to limited wireless transmission range; this can cause the network topology to change unpredictably as nodes enter and leave the network. Node mobility can cause broken routing links which force nodes to recalculate their routing information; this consumes processing time, memory, device power and generates traffic backlogs and additional overhead traffic on the network.

Energy consumption is an issue in the ad-hoc networks, to reducing energy cost of data communication in wireless ad hoc networks; Energy-Efficient routing is an effective mechanism. Generally, routes are discovered considering the energy consumed for end-to-end (E2E) packet traversal. But this should not result in finding less reliable routes and overusing a specific set of nodes in the network decreases the lifetime of the network. Energy-efficient routing in ad hoc networks is complete only with the consideration of reliability of links and residual energy of nodes. Considering the residual energy of nodes in routing can avoid nodes from being overused and can eventually lead to an increase in the operational lifetime of the network.

Security of MANETs is another major deployment concern; due to the mobility and wireless nature of the network malicious nodes can enter the network at any time, the security of the nodes and the data transmitted needs to be considered.

Numerous challenges must be overcome to realize the practical benefits of ad hoc networking. These include effective routing, medium (or channel) access, mobility management, power management, security, and quality of service (QoS) issues, mainly pertaining to delay and bandwidth management. Cost-effective resolution of these issues at appropriate levels is essential for widespread general use of ad hoc networking.

However Ad-Hoc networks show great potential in situations where internet access is not a key requirement or infrastructure is not available; including disaster or military scenarios or in low power wireless sensor networks or vehicles which only need to communicate with each other.

## 3. Literature Survey

Identified several pieces of key literature in the field of Ad-hoc and wireless mesh network. Some literature study on improving the network topology in wireless mesh networks, Wireless sensor covering and Localization techniques are done.

### 3.1Mobile client tracking techniques in wireless mesh networks

Wireless Mesh Networks (WMNs) are emerging as a promising solution for next generation broadband wireless Internet access in recent years. A WMN consists of two varieties of nodes, namely, mesh routers (MRs) that have minimal quality, and mesh clients (MCs) which will be extremely mobile. Each WMN has one or more gateways that are special MRs connected to the internet. The set of MRs forms a wireless mesh backbone that routes network traffic and provides lastmile broadband web access to MCs. as a result of MCs might be extremely mobile, mobility management is vital for the proper operation of the WMN. Mobility management consists of location management and handoff management. Location management keeps track of the location information of mesh clients, through location registration and location update operations. Handoff management maintains ongoing connections of mesh clients whereas they're moving around and changing their points of attachment. Mobility management has been studied intensively for cellular networks and mobile ip networks. A large sort of mobility management schemes and protocols are projected for these types of networks over the past years. For an analogous reason, location management protocols planned for mobile ad hoc networks (MANETs) are typically not applicable to WMNs. A basic distinction between WMNs and MANETs is that WMNs have a quasi-static routing infrastructure consisting of MRs, whereas MANETs lack such an infrastructure.

Yinan Li et al.[1] proposed a methods that offers a complete solution to location management in wireless mesh networks, and considers the effect of the integration on the overall network cost incurred by location management and packet delivery. To achieve these goals, they introduced LMMesh: a routing-based location management scheme with pointer forwarding for WMNs.

LMMesh integrates routing-based location update and pointer forwarding into one scheme that exploits the benefits of each ways, whereas avoiding their drawbacks. A well known advantage of routing-based location update is that it enables the propagation of location information of MCs to the regarding parties using regular information packets originated from the MCs. This approach avoids the communication overhead
of explicit location update messages. Routing-based location update, however, doesn't work well for MCs that don't have active network sessions or MCs that don't seem to be sending data packets. Pointer forwarding could be a resolution for location management that uses explicit location update messages. It works for those MCs that routing based location update does not work well, at the expense of extra signaling cost for the location update messages.

The contributions of this work are (a) the authors formulated the interaction between routing-based location update and pointer forwarding and analyze the impact of this integration on the overall network communication cost incurred; (b) They proposed a design notion of optimal pointer forwarding when integrated with routing-based location update by dynamically identifying the optimal pointer forwarding chain length for each MC based on the MC’s service and mobility characteristics to minimize the network communication cost; (c) Finally they developed an analytical model based on stochastic Petri net techniques for performance analysis. The update of location information and the maintenance of host specific routes in the basic routing-based schemes solely rely on packet routing, they are essentially opportunistic. Specifically, for idle mobile hosts that are not sending any data packets, their location information may become outdated and consequently their host-specific routes may become obsolete. This leads to a major performance deficiency of these routing-based schemes. LMMesh proposed in this paper uses pointer forwarding to solve the above problem, and at the same time, minimizes the overall network traffic incurred by mobility management and packet delivery.

The tradeoff between the signaling cost for location management and the service cost for packet delivery is explored by LMMesh by dynamically determining the optimal threshold for the forwarding chain length that minimizes the overall network cost. LMMesh is optimal on a per-user basis and is adaptive to the changing mobility and service behaviors of an MC, as the optimal forwarding chain length is dynamically determined for the MC based on its mobility and service characteristics. LMMesh can be used in either single-gateway or multi-gateway WMNs. It is scalable as the mobility management role is dynamically
shared among the gateways and among the MRs such that no single gateway or MR would become a bottleneck.

Michael J. Neely et al.[2] proposed a methode to investigate optimal routing and adaptive scheduling in a wireless mesh network composed of mesh clients and mesh routers. To achieve this goals, here develops an optimal algorithms for transmission scheduling, routing, and flow control in an ad-hoc wireless mesh network.The authors assumes that

mesh clients have peak and average power constraints and have little knowledge of the network topology beyond their immediate set of current neighbors.
The mesh routers are stationary wireless nodes distributed throughout the network area. These nodes are typically more powerful than the mesh clients, and are responsible for keeping track of mobile client locations and for performing operations of routing and packet delivery.

They also assumed that the system operates in slotted time. Every timeslot, data exogenously arrives to the clients in packetized form, and all packets are assumed to have the same bit length. Each packet must be delivered to its own desired destination client. In the most basic model, the source clients transmit their data to the nearest mesh router, and the mesh routers send the data over multi-hop paths to reach a mesh router node that is currently in range of the destination client. Finally they assumed is that each mesh router has two radios that operate simultaneously over independent channels. The first radio is used for uplink (client-to-router) and downlink (router-to-client) communication, while the second is used for router-to-router communication. Thus, the system of router-to-router communication links can be viewed as an independent backbone network that supports multi-hop data transfer, but where the destination of each packet in this backbone is potentially changing over time. We develop a simple dynamic routing algorithm that combines backpressure and differential backlog concepts of together with shortest path routing. The algorithm works in conjunction with flow control and scheduling algorithms implemented at the client nodes, and maintains low network delay while ensuring network stability and fairness under general client mobility models. In particular, we develop a notion of instantaneous capacity regions and show that throughput and fairness guarantees can be achieved with respect to these regions while maintaining end-to-end average delay that is independent of the timescales of the client mobility process.

The analysis and design methodology of this paper is based on adaptive queuing and Lyapunov optimization techniques. Such techniques were perhaps first applied to wireless networks in the landmark by Tassiulas and Ephremides, where Lyapunov drift is used to develop a joint optimal routing and scheduling algorithm. The Tassiulas-Ephremides algorithm introduced techniques of backpressure routing and maximum weight link scheduling, and was shown to yield network stability whenever input rates are within the network capacity region. Lyapunov drift has since become a powerful technique for the development of stable scheduling strategies for satellite and wireless systems computer networks and switches and ad-hoc mobile networks.

This paper applies the backpressure, Lyapunov networking, and multi-receiver diversity techniques described in the work above to the special case problem of a mesh network with mesh clients and routers. While these techniques were developed for more general scenarios, this paper is likely the first to use them directly within the mesh network paradigm. Further, there are several new aspects of this work that are not considered elsewhere, including the introduction of a time varying capacity region and the development of analytical stability and delay guarantees for mesh clients with arbitrary (possibly non-ergodic) mobility patterns.

Anjum Naveed et al.[3] introduced a Cluster-based Multipath Topology control and Channel assignment scheme (CoMTaC)which explicitly creates a separation between the channel assignment and topology control functions, thus minimizing flow disruptions.

The first phase of CoMTaC employs a two step topology control scheme that is initiated during network startup. In first step, the constituent nodes are grouped into clusters of small radii (in terms of hop distance). Within each cluster, a common channel (default channel) is used by all member nodes on one of their interfaces (default interface). Nodes bordering multiple clusters have their second interface tuned to the default channel of highest priority cluster, resulting in inter cluster connectivity. The use of a default channel within the cluster and the inter cluster connectivity provides an efficient broadcasting facility that incurs significantly low overheads. The second step of the topology control scheme aims at identifying multiple feasible paths (in terms of hop distance and interference), thereby enhancing the initial bare-bones connectivity established in the first step. We employ a technique that constructs the spanner of the underlying network graph and makes use of the nondefault interfaces of each node for establishing the alternate paths. The resulting multiple paths can be exploited to improve the network capacity.

Once the network topology has been constructed as outlined above, the second phase of CoMTaC focuses on channel assignment. A new interference estimation mechanism is proposed which measures the interference with relatively higher accuracy and has lower overheads in comparison to existing mechanisms. Our scheme takes into account, the interference from external sources (i.e. neighboring wireless network deployments) to decide on the allocation of the default channels within the clusters. To measure the interference experienced by the non-default channels, we make use of the average link layer queue length within the interference domain. They also incorporate the concept of partially-overlapping channels to further improve spatial reuse and enhance network throughput. They evaluate the proposed scheme through simulations in Qualnet simulator. In comparison to existing channel assignment schemes CoMTaC demonstrates a 200 percentage upturn in the aggregate throughput.

The cluster-based topology of CoMTaC ensured basic network connectivity with intrinsic support for broadcast. Multipath topology was constructed which took advantage of the inherent multiple paths that exist in a typical WMN by constructing a spanner of the network graph. The dynamic distributed channel assignment scheme of CoMTaC employed a novel interference estimation mechanism based on the average link-layer queue length within the interference domain.

### 3.2 Sensor Covering

In recent years there has been increasing interest within the field of wireless sensor networks. A wireless sensor network consists of variety of wireless sensor nodes. Wireless sensor networks are used to monitor a given field of interest for changes within the environment. They're terribly helpful for military, environmental, and scientific applications to name some. One in every of the foremost active areas of analysis in wireless sensor networks is that of coverage. Coverage in wireless sensor networks is sometimes outlined as a measure of how well and for the way long the sensors area unit able to observe the physical area. In addition to coverage it's necessary for a sensor network to keep up property. Property may be outlined because the ability of the device nodes to achieve the info sinks. If there's no available route from a sensor node to the info sink then the data collected by that node can't be processed. Every node incorporates a communication vary that defines the world during which another node may be placed so as to receive knowledge will be break away the sensing vary that defines the world a node can observe. The 2 ranges could also be equal however area unit usually totally different.

C. Huang et al.[4] proposed one of the first papers on three dimensional coverage. They assume that the sensors' coverage ranges are shaped in a sphere. They approach the coverage problem not by looking at the coverage of each point in the field of interest; rather they determine whether each sphere is covered. If each of the spheres has sufficient k-coverage then the entire field must be k-covered as well. If a sphere has at least k other spheres covering its entire area then the area within the sphere is k+1 covered. They reason that if the area within the sphere is k-covered then the area bordering the sphere must be at least k-covered. An algorithm is then presented which determines whether a sphere is k-covered or not. This algorithm can be fully distributed so that each sensor can determine its own coverage. The authors state that if one sphere is located entirely within another sphere then those spheres will have no intersection. The smaller sphere would need to have its coverage increased by one but that does not seem to be covered in the algorithm. The algorithm does appear to mathematically feasible but it would appear that calculating the spherical caps which are the intersections of the sphere with decent precision could be very tricky for some sensor nodes. The authors did not run any simulations to test their theory so its implementation is dubious.

S. Alum and Z. Haas [5] took on the problem of three dimensional coverage and connectivity in their paper. They attempted to determine what is the best way to place nodes in a three dimensional space to ensure coverage with the fewest number of nodes. They also wanted to determine the minimum ratio of transmission range to sensing range. They note the similarity between this problem and the sphere packing problem which was how to arrange non-overlapping spheres in a space so that the maximum number of spheres could fit. The Voronoi cell in 3D which is a polyhedron is used as a base model for the sensors' coverage. The ratio of the volume of that area that is actually being covered by the polyhedron to the maximum area that can be covered by a polyhedron is the volumetric quotient of the polyhedron. Finding the highest total value for the polyhedron is the key to the solution. The authors then compute the volumetric quotient using several different types of polyhedrons to show that a truncated octahedron is the best space filling shape. They then calculate the minimum transmission ranges for each polyhedron to show that the cube has the lowest minimum transmission range while the truncated octahedron has the highest. A simulation is run to validate the findings. The paper succeeds as an excellent academic exercise however the practicality of this strategy appears to be limited. If the nodes are static then it would be very difficult to place them in the precise locations to conform to these shapes. Mobile sensor nodes could conceivably arrange themselves in such a formation but it appears to be a very complex task which may be better served by increasing node density in the area.

D. Pompili et al.[6] addressed the deployment of sensor nodes of underwater. They examine the problem first in two dimensions where the sensors are anchored on the ocean floor, then in three dimensions where the sensors float in the water. In addition to finding the minimum number of sensors required for coverage the authors also consider node failures and how many redundant nodes are needed to compensate for node failures. For the two dimensional deployment they propose a triangular grid of equilateral triangles. They calculate the trajectory of sinking objects in order to increase the predictability of deployment. They proposed three different deployment strategies for the three dimensional coverage: sensors floating randomly in the ocean, sensors arranged randomly on the ocean floor, or sensors arranged in a grid formation at assigned depths. Their findings indicate that the sensors arranged in a grid pattern give the best coverage ratio with a fixed number of sensors. The findings of the authors are not a surprise as a deterministic deployment should have better coverage than any type of random deployment.

Carbunar et al.[7] utilized Voronoi diagrams as a means of detecting and eliminating redundancy while preserving coverage. The authors also tackle the problem of detecting the boundaries of coverage in a sensor network. The authors used what they call a Multiplicative Weighted Voronoi Diagram (MWVD) in which the sites are assigned weights which are used instead of the Euclidean distance in determining how the closest site to a point. The addition of weights allows the Voronoi diagram to be used with heterogeneous sensor nodes. They define the redundant sensor elimination (RSE) solution which selects sensors to deactivate. The simulations run by the authors show that RSE detects all redundant sensors. To find the boundaries of coverage in a sensor network, the sensors whose Voronoi cell is not covered by its sensing range must be found. If there are points in the Voronoi cell not covered by the sensing range of a node that implies there are no other sensors that cover those points. Those points exist in a coverage hole and the sensors that border that coverage hole are boundary sensors. The results of the simulations show that RSE is able to detect all of the sensor boundary nodes in the network. The RSE protocol shows very promising results in the simulations but a true test would be having it implemented in an actual deployment.

Hefeeda and Ahmadi [8] propose a coverage protocol that works for both deterministic and probabilistic sensing models. They also consider connectivity and energy efficiency while designing the protocol. They call it the Probabilistic Coverage Protocol or PCP. They define an area as having probabilistic coverage if the probability of every point in the area being covered is greater than or equal to a given threshold parameter. The least covered point is defined as the point with the lowest probability of being covered. The PCP protocol will build a triangular structure that ensures that the probability of the least covered point being sensed equal to or greater than the threshold value. It does this by computing the maximum separation possible between sensors and ensuring that the edges do not exceed this value. The authors prove that PCP will generate a connected network. They then prove that the protocol will converge according to a given formula with every point having a probability of being sensed at least equal to the given threshold. The authors run multiple simulations to validate the operation of their protocol.

Cheng et al.[9] attempt to refine the disjoint set cover approach . They point out a potential problem with the earlier work is that the number of sensors in a disjoint set is unlimited. When the sensors need to report their data to the base station a bandwidth bottleneck may result. Some of the sensors will not be able to report their data to the base station during the reporting cycle. Assuming the existence of a flat network, the only way to resolve this problem is to factor in bandwidth constraints when creating the sets. They utilize disjoint set covers in order to solve the minimum breach problem. The minimum breach problem is defined as dividing the sensors into disjoint sets so that each set has no more than a given number of sensors while the overall breach does not exceed a certain threshold. The authors develop two heuristics to solve this problem and run simulations to test the relative performances. The simulations show that increasing sensors in a network while keeping the bandwidth constant does not improve coverage. When bandwidth is increased along with the number of sensors the breach rate is decreased. This paper does a good job of identifying a flaw in the earlier work and helping to correct it, however their algorithm would likely lead to fewer disjoint set covers being computed so the sensors would likely be active more often than in the earlier methods.

Kar and Banerjee address the issue of optimal node placement in [10]. They deploy sensors in what they call an r-strip. This is a line of homogeneous sensors with sensing radius r placed such that the distance between two of the sensors is exactly r. The strips are overlaid to cover an entire area. The algorithm does provide connected coverage with the minimum number of sensors for the field of interest but is impractical for actual deployments. Placing sensors such that they are exactly r distance apart is usually not possible. Actual sensors do not have exactly the same sensing ranges.

Wang, Hu, and Tseng address the issue of obstacle in the sensing range in [11]. Their approach is to partition a field into smaller regions and address coverage in each of these regions separately. Sensors are deployed in rows if there are no obstacles in an area. If an obstacle exists then extra sensors may be placed at the edge of the obstacle to ensure coverage. The simulations run by the author prove that the algorithm will provide coverage in the presence of obstacles. The biggest problem with the authors' approach is that it assumes a deterministic placement of the nodes which may not be practical and is hard to accurately deploy. It also assumes homogeneous sensors with a uniform sensing range. This is not supported by actual sensors.

In [12] the authors utilize Voronoi diagrams as part of a fuzzy logic systems used to control the movement of sensors from a random deployment. A fuzzy logic system is one which is designed to take continuous or analog input values and output a discrete or digital value. The input value is analyzed against a set of rules by an inference engine. The engine uses these rules to compute the output. The Voronoi diagram is used to help calculate an ST-FACTOR for the node. The STFACTOR is used by the inference engine to determine if the node should move itself. The authors experiments show that the algorithm will provide coverage of 93 percentage or greater after three iterations.One shortcoming of this algorithm is that a node must be able to communicate with other nodes in order to be able to move. If a node on the outer edge of the coverage area had only one neighbor and that neighbor died then the network would not move another node to re-establish communication with the outlying node. Another problem with the algorithm is that it does not provide k-coverage for k > 1. The lack of redundancy of the deployed network limits its usefulness in areas that are not easily redeployed.

Zou and Chakrabarty authored one of the first papers utilizing probabilistic coverage in [13]. Their model is a randomly deployed, heterogeneous cluster based sensor network. The cluster heads run what is called the Virtual Force Algorithm (VFA). VFA determines if two sensors are too close to each other and if they are then it tells them to exert negative forces on each other to push them away until they are at the optimal distance. The simulation run by the authors shows an improvement in coverage and energy efficiency as opposed to random deployment. The major weakness of this algorithm is related to the cluster head model. If the cluster head fails for any reason then the other nodes may lose connectivity with the network if another cluster head is not within reach. Since this is a homogeneous network the number of cluster heads is limited so if they are not sufficiently spread out in the random deployment then the redundancy of the network may be limited.

### 3.3 Localization Technique

Mobile wireless sensor networks (MWSNs) are a specific category of WSN within which mobility plays a key role within the execution of the application. In recent years, mobility has become a very important area of analysis for the WSN community. Though WSN deployments were never visualised to be totally static, mobility was initially considered having many challenges that required to be overcome, as well as connectivity, coverage, and energy consumption, among others. However, recent studies are showing mobility during a a lot of favorable light. Instead of complicating these problems, it's been incontestable that the introduction of mobile entities will resolve a number of these issues. Additionally, mobility permits sensing element nodes to focus on and track moving phenomena like chemical clouds, vehicles, and packages.

One of the foremost vital challenges for MWSNs is that they want for localization. So as to know sensor data during a spatial context, or for correct navigation throughout a sensing region, sensor position should be known. Because sensor nodes is also deployed dynamically (i.e., dropped from an aircraft), or could change position throughout run-time (i.e., when connected to a shipping container), there is also no means of knowing the location of every node at any given time. For static WSNs, this can be not the maximum amount of a problem as a result of once node positions are determined, they're unlikely to alter. On the opposite hand, mobile sensors should often estimate their position that takes time and energy, and consumes alternative resources required by the sensing application. Moreover, localization schemes that give high-accuracy positioning information in WSNs cannot be utilized by mobile sensors, as a result of they usually need centralized processing, take too long to run, or create assumptions regarding the setting or configuration that don't apply to dynamic networks.

Any existing location discovery approach consists of 2 basic phases: (1) distance (or angle) estimation and (2) distance (or angle) combining. Many strategies for estimating the distance between 2 nodes (first phase) exist.
_ Received Signal Strength Indicator (RSSI) techniques measure the ability of the signal at the receiver. Based on the known transmit power, the effective propagation loss is calculated. Theoretical models enable us to translate this loss into a distance estimate. This methodology has been used primarily for RF signals.
_ Time based methods (ToA,TDoA) record the time-of-arrival (ToA) or time-difference-of-arrival (TDoA). The propagation time will directly be translated during a distance, based on the known propagation speed. These strategies are applied to several different signals, such as RF, acoustic, infrared and ultrasound ones.
_ Angle -of -Arrival (AoA) based systems to be precise don't measure distance. Instead they estimate the direction of the received signal and use straightforward geometric relationships to calculate node positions. They tend to evaluate

each received signal strength and time based approaches for our localization technique. Many alternatives also exist for the second part of mixing the distance measurements into actual node locations.
The most basic and intuitive methodology is named hyperbolic trilateration. It locates a node by calculating the intersection of three circles.
Triangulation is used once the direction of the node rather than the distance is estimated, as in AoA systems. The node positions are calculated during this case by using the trigonometry laws of sines and cosines.
_ The third methodology is most likelihood (ML) estimation. It estimates the position of a node such the variations between the measured distance and the distance from the estimated position to the known nodes are reduced.

Tian He et al.[14],proposed APIT, a novel localization algorithm that is range-free .This APIT scheme performs best when an irregular radio pattern and random node placement are considered, and low communication overhead is desired.

Many localization algorithms for sensor networks have been proposed to provide per-node location information. With regard to the mechanisms used for estimating location, we divide these localization protocols into two categories: *range-based* and *range-free*. The former is defined by protocols that use absolute point-to-point distance estimates (range) or angle estimates for calculating location. The latter makes no assumption about the availability or validity of such information. Because of the hardware limitations of WSN devices, solutions in range-free localization are being pursued as a cost-effective alternative to more expensive range-based approaches.
This paper makes three major contributions to the localization problem in WSNs. First, we propose a novel range-free algorithm, called APIT, with enhanced performance under realistic system configurations. Second, though many different protocols have been proposed to solve the localization problem in a range-free context, no prior work has been done to compare them in realistic settings. This paper is the first to provide a realistic and detailed quantitative comparison of existing range free algorithms to determine the system configurations under which each is optimized. We perform such a study to serve as a guide for future research. Third, no attempt has previously been made to broadly study the impact of location error on various location-dependent applications and protocols. This paper provides insight into the effect of localization accuracy on application performance degradation and identifies bounds on the estimation error tolerated by applications.

They called their novel area-based range-free localization scheme, as APIT. APIT requires a heterogeneous network of sensing devices where a small percentage of these devices (percentages vary depending on network and node density) are equipped with high-powered transmitters and location information obtained via GPS or some other mechanism. We refer to these location-equipped devices as **anchors**. Using beacons from these anchors, APIT employs a novel *area-based* approach to perform location estimation by isolating the environment into triangular regions between beaconing nodes (Figure 1). A node's presence inside or outside of these triangular regions allows a node to narrow down the area in which it can potentially reside. By utilizing combinations of anchor positions, the diameter of the estimated area in which a node resides can be reduced, to provide a good location estimate.

Juan Liu et al.[15], introduced an iterative least-squares (ILS) approach to node localization, in which location information progressively propagates from anchor nodes to other nodes. The iterative approach has been studied by others, for example, as in multilateration. What are new about their approach is the introduction of an error control and a robust formulation of the localization problem so that the algorithm is less sensitive to noise and computes the location information incrementally.

(1) Error control in iterative localization. They observed that many iterative methods such as multilateration may suffer from adverse effects of error propagation and accumulation, as nodes being localized and becoming new anchors for other free nodes. This could lead to unbounded error in localization for large networks. The effect of error propagation is less prominent in global methods such as MDS or SDP, since global constraints tend to balance against each other. However, global methods are less amendable to distributed implementation in an ad hoc network. This paper introduces a local error control mechanism to determine and use reliable location data, and filter out outliers that may contaminate the entire network.
(2) Robust least-squares localization. At each iteration of localization, the authors computed a location estimate using a robust least-squares (RLS) formulation. Compared to the traditional least-squares (LS), RLS is more stable against measurement noise. The authors developed an incremental algorithm for the LS/RLS method that incorporates a new sensor measurement into the location estimation without the need to recompute from scratch with all the previous measurements. This greatly improves the computational efficiency and allows any time implementation, which can terminate at any time and still provide usable information. The incremental, or any-time, aspect is particularly

desirable in resource-constrained, decentralized networks where nodes are limited in on-board energy and computation. In contrast, most of existing techniques assume that all the relevant sensor data for estimation are available at the processing node, and perform localization in a batch mode. Furthermore, the incremental computation is efficient and lightweight, and can be implemented on mote-class sensor nodes such as the Berkeley motes.

A number of incremental methods, such as Kalman filter based approach [16] or particle filtering, have been proposed. Compared to these methods, our approach is computationally more efficient. The computational complexity of the Kalman filter based on multilateration approach that can be a lot higher due to the need to maintain estimate prediction and Kalman gains. In this paper, author focus on designing light-weight algorithms that can be implemented on sensor nodes such as the Berkeley motes.

Authors also defined a distance constraint graph (DCG), in which vertices are sensor nodes, and edges represent distance constraints between pairs of nodes. Any pair of nodes that can reliably sense each other's signal (hence form range estimate), and can communicate with each other, either directly or via some intermediate nodes, are called mutually immediate neighbors in DCG.

To control the error propagation, we propose a mechanism to keep track of estimation error and determine which neighbors have reliable location information and which don't. This mechanism filters out outliers, preventing them from propagating further. To keep track of estimation error, authors first consider the simplified problem of localizing a node t given N, the set of neighbors in DCG with known locations. The localization error comes from two sources:

1. Vertex errors
2. Edge error

H.T. Kung et.al[17] proposed a new method, called snap-inducing shaped residuals (SISR), to automatically identify “bad nodes” and “bad links” arising from these errors, so that they receive less weight in the localization process. In particular, SISR snaps “good nodes” to their accurate locations and gives less emphasis to other nodes. While the mathematical techniques used by SISR are similar to those in robust statistics, SISR’s exploitation of the snap-in effect in localization appears to be novel.

In this paper, the authors considered the problem of using 802.11 radio ranging to localize ad-hoc nodes in an outdoor, open-space environment. When the terrain is flat and nodes can all hear each other well, solving the problem ought to be relatively easy. However, this may not be the case in real-world applications. For example, a node in a pit, with a faulty antenna, or at the edge of radio range to other nodes may incur large errors in its distance measurements due to weak signal from the node or received by the node. In addition, heterogeneous radio equipment may also introduce inconsistency in measurement errors. Such errors can create asymmetric ranging measurements between nodes and, often, are non-Gaussian in nature. Just a few such instances can drastically affect a localization solution.

Authors proposed a technique to cope with the presence of a relatively small number of possibly large, non-Gaussian errors in ranging measurements. The method, called “least squares with snap-inducing shaped residuals,” or snap-inducing shaped residuals (SISR) for short, emphasizes those computed node locations which match well with ranging measurements, while de-emphasizing others. That is, localization based on SISR will favor those computed locations which represent good matches for a majority of measurement data, even if these locations may mean a large deviation from a minority. Authors performed analysis, simulation and field experiments to provide insights and validation on how SISR works. The two major contribution of this paper are:

1. The SISR technique to provide accurate localization for those nodes which have sufficient, good measurement data, even in the presence of large errors in measurement data for other nodes. SISR’s effectiveness is validated via simulation and outdoor field experimentation.

2. RSSI-distance modeling and field validation of the model of a particular 802.11 radio in an open, outdoor environment.

The goal of extracting geometry information from a network of wireless nodes is similar to that of self localization in wireless sensor networks. Existing solutions fall into two major categories: range-free and range-based localization. Typically, range-free localization methods utilize node connectivity and hop-count information along with geometric constraints to determine node locations. Aiming at providing more accurate localization results, range-based localization methods acquire pair wise distance measurements between wireless nodes and use this information to derive a localization solution. Typical ranging techniques include measuring time-of-arrival (TOA) and received signal strength indications (RSSIs).

A major issue for range-based localization schemes is error in distance (ranging) measurements. Whitehouse et al. [18] have indicated that the errors of RSSI-based RF ranging do not follow a Gaussian distribution, implying that conventional least squares optimization schemes are particularly susceptible to such errors. Without properly taking this into account, localization results can be drastically altered or biased by only a few bad measurements. Error mitigation in range-based wireless localization has recently received some attention in the literature, with several groups proposing iterative and incremental distributed localization algorithms. Liu et al. [19] use an explicit error management approach to prevent error propagation during incremental localization, and propose a modified least-squares objective function that includes a perturbation term such that the difference in measurement data can be minimized in an average sense, resulting in less sensitivity to errors. Other research efforts have taken a different tack, focusing on identifying and exploiting rigid network topologies to defend against flip and discontinuous flex ambiguities in a localization solution.

In this paper, they assumed a dense network with a large number constraint, where flip and flexing ambiguities are less likely to happen. Like SISR, other methods such as semidefinite programming (SDP) and multidimensional scaling (MDS) have taken a centralized approach to the localization problem. Centralized approaches can be adopted in ad-hoc networks with an additional step of collecting data to a master node, but, in comparison with distributed methods, have advantages such as fewer information exchanges between individual nodes and more efficient computation. Reducing inter-node communication messages is especially significant for a wireless adhoc network, since wireless medium is shared. SDP maps the localization problem to a convex optimization problem and is able to locate nodes in the presence of errors, but does not consider discounting the outliers. Similarly, MDS-based techniques are robust against some forms of measurement errors. By replacing all-pairs ranging measurements with a multi-hop shortest path distance, some of overestimated distances are excluded or reduced in the localization process. However, this strategy does not perform well for non-convex topologies, where ends of a curved topology can be deformed due to overestimation by the shortest path distance.

SISR is a non-linear least squares-based optimization method, with a twist. To cope with errors, SISR exploits geometric information to improve the robustness of estimation algorithms. Given that each node can have only one location, SISR dampens the effect of inconsistent distance measurements while rewarding and amplifying that of consistent distance estimates. With a sufficient amount of consistent data (i.e., good range estimates), SISR is able to determine node locations accurately by ignoring the polluting effects of bad measurements. The SISR estimator is similar to those found in “robust statistics” , the study of outlier rejection problems and techniques. Although similar, the SISR estimator differs from those previously proposed in robust statistics in some important details. These differences make SISR localization results more accurate for snapped-in nodes and also make the convergence of the method more robust. More importantly, to our knowledge, SISR appears to be the first work in applying robust statistics in localization and in using “snap-in” for good nodes as a localization objective. Robust statistics has been used in image processing and pattern recognition, for such applications as object velocity estimation from a sequence of images, anisotropic diffusion, and bilateral filtering. The SISR approach is applicable to other localization approaches beyond the range-based one described above. This is because the principle of placing emphasis on computed locations which match well with measurement data is a universal notion applicable to any localization method. To provide a validation of this point, we consider briefly the use of SISR in TDOA (time-differenceof-arrival) based localization. In TDOA, a speaker is localized by measuring the difference in propagation time of acoustic signals. The location can be solved with a set of non-linear equations describing the distance relationships between the speaker and multiple microphone sensors. The measurement of the difference in arrival time is usually achieved by applying cross-correlation on recorded signals. However, this often suffers from environmental noises that corrupt the waveforms of the recorded signals. In our simple test scenario with five sensor nodes, one of them gives erroneous measurements because of its low signal-to-noise ratio. Simulations show that the SISR estimator can still successfully localize the speaker within 2 meters when the errors vary between 0 to 50%.

## 4. Conclusion

In this paper we have attempted to give a broad overview of the work that has been done to address the tracking of client, coverage problem and localization in wireless networks. The coverage problem can be approached in many different ways. The needs of a particular deployment will heavily influence the coverage scheme chosen. Many papers focus on a specific problem while others attempt to provide more general solutions that can be used for many deployment types. However, there are still many fundamental problems that must be solved . This paper can be used as a starting point or a summary into what has been done so far.

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